Department of AGRICULTURE FISHERIES & FORESTRY - AUSTRALIA

BYCATCH OF SEA TURTLES IN LONGLINE FISHERIES – AUSTRALIA

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FINAL REPORT

Fisheries Resources Research Fund, Agriculture, Fisheries and Forestry, Australia

University of Wollongong
Centre for Maritime Policy

Bycatch of Sea Turtles in Pelagic Longline Fisheries – Australia

Fisheries Resources Research Fund 2002
Agriculture, Fisheries and Forestry Australia

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Citation:

Robins, C. M., Bache, S. J. and Kalish, S. R. (2002) *Bycatch of Sea Turtles in Pelagic Longline Fisheries – Australia*. Bureau of Rural Sciences Final Report to the Fisheries Resources Research Fund, Agriculture, Fisheries and Forestry – Australia, Canberra.

Executive summary

Bycatch has become one of the most significant issues affecting fisheries management, and of particular concern is the bycatch of sea turtles by commercial fisheries. Even though turtles are rarely caught in most fisheries, some species are considered vulnerable to local and even global extinction because of declining numbers. In addition, turtles are charismatic creatures whose fate arouses public concern, hence, their incidental capture may indirectly have negative socio-economic impacts upon the fishing industry. Although some populations face other threats that far outweigh mortality resulting from fishing operations where turtles are a bycatch, the reduction of mortality from all sources is important for depleted populations.

In the past, prawn trawlers were considered to cause more deaths than any other gear type and be a major contributor to the global sea turtle decline. However, the introduction of turtle exclusion devices is expected to reduce the mortality events greatly. Many other types of fisheries catch, and sometimes kill, sea turtles as bycatch. More recently, however, pelagic longline fisheries have been implicated in significant numbers of turtle deaths and as these fisheries expand the probability of sea turtle mortality from their operations increases.

Australian pelagic longline fishing operations, the Eastern Tuna and Billfish Fishery and the Southern and Western Tuna and Billfish Fishery, may incidentally catch around 400 sea turtles per year. The variation around this estimate, however, is wide due to lack of accurate data. Interview data indicates an average catch rate of 0.024 turtles per 1000 hooks with a standard deviation of 0.027. A high proportion of turtles taken in these fisheries, possibly more than 60%, are believed to be leatherbacks. The species identifications of the hard-shelled sea turtles are unknown. The mortality rate of sea turtles caught by Australian longliners is unknown but expected to be relatively low for leatherbacks.

The estimated sea turtle catch by Australian pelagic longliners is considerably less than some other longline fisheries around the world, including those in the Mediterranean, and U.S. longliners in the Atlantic and the Pacific. Nevertheless, there is still a pressing need for the issue of sea turtle bycatch in Australian longline fisheries to be addressed. This is especially in light of the United States practice of extending domestic law to foreign fishing states through the use of trade embargos. U.S. concern over and action to mitigate sea turtle bycatch in its longline fisheries is well progressed and provided for under force of law. The north Pacific Ocean pelagic fishing grounds have already been closed to United States longliners, a proposal has been made to close a large area of the north Atlantic fishing grounds, and restrictions have been placed on other fisheries in response to the unacceptable mortality of sea turtles.

In relation to the Australian domestic scene, requirements exist to protect marine species under the Environment Protection and Biodiversity Conservation Act (EPBC). Bycatch approvals and mitigation requirements will, in the future, be provided through the approval of Fisheries Management and Bycatch Action Plans, and in the creation of Recovery Plans. Though the EPBC Act imposes comparable high standards upon fishing in Commonwealth waters, U.S. trade regulations have in the past required not only enactment, but also implementation of national laws if States wish to export to U. S. markets.

While there seems to be little opportunity for Australian fishers to reduce sea turtle capture rates at present, given the current lack of information, sea turtle survival could possibly be increased. Many fishers had already adopted reasonable handling techniques, although most felt that

handling guidelines outlined on a brochure and further explained in a video would benefit their operations. Thus, the printing of sea turtle handling guideline brochures and production of a video is highly recommended. In conjunction with improved handling techniques, the use of equipment – line-clippers and dip-nets – to reduce further sea turtle injury is recommended. The trialling of de-hooking devices is also recommended for interested fishers.

Many Australian longline fishers who were interviewed demonstrated an interest in becoming involved in sea turtle monitoring and/or research. Australian fishers already complete extensive daily logsheets, including sea turtle catch information which, although unverified, do provide information on turtle captures. There is the possibility of improving the quality and the usefulness of this information. There are a number of possible ways for this to occur: additional and extensive training in completing the current logbook captures of sea turtles to a more useful level; supply of, and training in, the completion of specialist sea turtle logbooks; increase in observer programs on board commercial vessels; and cooperative research activities. For any activity that involves fishers gathering scientific data, there is a need for the fisher to understand the importance of the research activity and receive adequate training in scientific protocols and techniques. Results of all data monitoring and research programs should be disseminated to the fishing industry in a timely manner so the information could be used during their fishing operations.

As a result of their migratory nature most species of sea turtles are an internationally shared resource and all countries involved must do their best to prevent sea turtles stocks from declining further. This includes addressing the incidental catch and death of sea turtles during commercial fishing operations.

Acknowledgements

This work was funded through the Fisheries Resources Research Fund of the Department of Agriculture, Fisheries and Forestry – Australia. Thanks are due to the commercial fishers from the Australian Eastern Tuna and Billfish Fishery and the Southern and Western Tuna and Billfish Fishery who provided information on sea turtle interactions during their fishing operations and to the many turtle and fishery scientists around the world who provided information and opinions on sea turtle interactions with longline fishing gear.

Reviewing of the draft report by Dr R I T (Bob) Prince, (Western Australian Marine Turtle Project, Wildlife Research Centre, Dept CALM, Western Australia), Mr Hans Jusseit (Executive Director, East Coast Tuna Boat Owner's Association Inc), Ms Ingrid Holliday and Mr Andrew McNee (Australian Fisheries Management Authority), Dr John Kalish and Dr James Findlay (Bureau of Rural Sciences) and Dr Nathan Evans (University of the South Pacific, Fiji); production of maps by Mr David Barratt (Bureau of Rural Sciences), editing by Dr Penny Olsen (Australina National University) and cover design by Ms Racheal Bruhn (Racheal Brühn Design) was greatly appreciated.

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Introduction

Bycatch

In recent years, bycatch has become one of the most significant issues affecting fisheries management, both nationally and globally. Not only can bycatch have significant biological and ecological impacts, but it is also perceived as waste of a biological resource, making it an ethical issue (Andrew and Pepperell, 1992; Hall *et al.,* 2000). In 1994, the Food and Agriculture Organisation of the United Nations (FAO) estimated conservatively that 27 million tonne of fish products were discarded globally every year. It is recognised that trawl fisheries tend to have higher discard levels than any other fishing gear type with an estimated 37.2% of total global discards resulting from trawling activities (Alverson *et al*., 1994). This is due primarily to the non-selective nature of trawl gear (Kennelly, 1995).

The bycatch of sea turtles by commercial fisheries is of particular concern. Even though turtles are rarely caught in most fisheries, some species are considered vulnerable to local and even global extinction because of declining numbers. In addition, turtles are charismatic creatures whose fate arouses public concern (Harris and Ward, 1999), hence, their incidental capture may indirectly have negative socio-economic impacts upon the fishing industry (Bache *et al.,* 2000).

Sea turtles

There are only seven species of sea turtle, six living in Australian waters: the loggerhead sea turtle *Caretta caretta*, green sea turtle *Chelonia mydas*, hawksbill sea turtle *Eretmochelys imbricata*, olive ridley sea turtle *Lepidochelys olivacea*, flatback sea turtle *Natator depressus* and leatherback sea turtle *Dermochelys coriacea*. The remaining species, the Kemp's ridley *Lepidochelys kempii* occurs only in the Gulf of Mexico and northwest Atlantic (Limpus, 1998).

Widespread concern at the alarming declines in sea turtle numbers in recent years is reflected in their high conservation status. They are classified by various listing agencies as threatened or endangered, both nationally and globally (Crowder *et al*., 1994; Bisong, 2000). Various countries, including Australia, the United States, and the group of Mediterranean coastal States (UNEP, 1999) have drafted recovery plans that attempt to address the issue of declining sea turtle populations.

Worldwide, in addition to natural impacts, there are many diverse anthropogenic events that result in the death of sea turtles (Appendix 1). The relative importance of mortality rates during the different life-history phases (from hatchling to adult) to the recovery of turtle populations is not always agreed upon. Nevertheless, the consensus is that there is a need to minimise, to the greatest extent possible, the negative effects of human activities on sea turtles throughout all phases of their life history.

Bycatch of sea turtles by commercial fishing operations

Some sea turtles may migrate vast distances from their feeding areas to home rookeries where they nest. However, individual species do not generally follow a common migratory route. Nevertheless, it has been shown that sea turtles 'do not wander aimlessly at the mercy of currents;

rather, they make very deliberate journeys to specific geographical targets' (Limpus *et al.,* 1992: 355). During these migrations sea turtles are subject to many threats, including interactions with fishing operations. The potential impact of the interaction is dependent on the type of fishing operation, the distribution of the gear and, of course, the distribution, migration route and sea turtle species. These interactions can result in mild inconvenience, to death or injury leading to death of individual turtles.

The influence of fishing operations on turtle populations depends on the status of the population in question, the rate of mortality as a result of the interaction, the impact of other activities on that particular stock and other factors such as life stage of the turtles removed by capture (Western Pacific Regional Fishery Management Council, 2002). However, the fact remains that all species of sea turtles are under threat in many parts of the world, and increased mortality may result in a lowered chance of recovery for depleted stocks. Even though some populations face other threats that far outweigh mortality resulting from fishing operations where turtles are a bycatch, the reduction of mortality from all sources is important for depleted populations.

In order to adequately address the issue of the mortality of sea turtles as a result of non-target commercial fishing operations it is necessary to quantify the incidental capture rate by each fishery (Wetherall, 1997). Many commercial fisheries in the world, using various fishing techniques, in coastal waters and on the high seas, have been documented to incidentally capture sea turtles (Hillestad *et al.,* 1981, Crouse, 1984 and Oravetz, 1999). In addition, many fisheries that would be expected to also take significant numbers of sea turtles have not yet been documented. In the past, prawn trawlers were considered to cause more deaths than any other gear type and be a major contributor to the global sea turtle decline. However, the introduction of turtle exclusion devices is expected to reduce the mortality events greatly (Oravetz, 1999). Gillnet fisheries, notably in the Chilean and Peruvian fisheries, have also been shown to cause substantial sea turtle mortality (Eckert, 1997). In Brazil the coastal gill net fishery takes more turtles than do the trawl fisheries (Oravetz, 1999). Historically, driftnets have been held responsible for many turtle deaths (Eckert, 1997). Entanglement in fishing gear like lobster pot lines and capture in purse seines set around fishery aggregation devices and logs also occurs (Hall, 1996). Although the extent of the problem is not known, bottom longlines also have the potential to catch reef dwelling turtles (Oravetz, 1999). More recently, pelagic longline fisheries have been implicated in significant numbers of turtle deaths and as these fisheries expand the probability of sea turtle mortality from their operations increases (Gerosa and Casale, 1999; Oravetz, 1999; Chaloupka and Limpus, 2001).

Project background and methodology

The possibility of sea turtles interacting with longline gear in Australian waters has been recognised for almost a decade (Miller, 1993). The magnitude of the problem, however, is unknown. Indeed, there is a pressing need for the issue of sea turtle bycatch in Australian longline fisheries to be addressed. This is especially so in light of the United States practice of extending domestic law to foreign fishing states through the use of trade embargoes. In the United States, in response to a level of sea turtle mortality that is unacceptable under U.S. legislation, a significant area of the north Pacific Ocean pelagic longline fishing grounds has been closed to longliners, a proposal has been submitted to close a large area of the north Atlantic fishing grounds, and a range of restrictions have been placed on other fisheries (Federal Register: April 10, 2002; Vol. 67, No. 69). In relation to the Australian domestic scene, requirements to protect marine species under the Environment Protection and Biodiversity Conservation Act (EPBC Act) will impose comparable high standards upon fishing activities, and any responsible activity, in Commonwealth and State waters.

To address the pressing need for information on the Australian situation, this report documents available information on sea turtle bycatch in Australian pelagic longline fisheries. Information was obtained from observer programs and logbooks, through fisher and scientist interviews, and from the available literature.

Since 1996, sea turtle interactions have been reported by Australian pelagic longlining fishing skippers (fishing masters) in logbooks. This information is currently the most comprehensive data available on sea turtle captures by Australian longline vessels. Unfortunately, these data remain unverified and, hence, without supporting information such as that collected by independent observers, are open to criticism. There have been a small number of observer programs conducted on domestic and international longliners in Australian waters that have reported sea turtle interactions. Fisher interviews were conducted with 45 longline fishers on the East and West coasts of Australia between October 2001 and March 2002. Fishers answered questions on the numbers of turtles caught, species distributions, fishing gear configurations, fishing methods, possible mitigation measures and their experiences with sea turtles while longlining.

In this report, scientific research, policy responses and legal information relating to longline turtle bycatch, based on evidence from North, Central and South America, the Mediterranean and elsewhere, is related to the Australian situation. The report documents published and grey literature as well as data, opinions and assumptions. There has been no attempt to report on sea turtle population models. The possible usefulness of mitigation measures and policy responses adopted overseas are examined in order to establish a set of monitoring and mitigation measures that may be suitable for implementation in Australian domestic fisheries.

Sea turtle interactions with pelagic longlines

Longline catch estimates

Various longline fisheries in the world have been noted in the literature to catch sea turtles incidentally and some of these data are collated here. These data only represent a subset of the global bycatch, as a number of other longline fisheries would also be expected to have a sea turtle bycatch, but that has not yet been reported. There may also be longline fisheries that do not incidentally catch sea turtles, or those with catches so rare that they are not recorded. Sea turtle catch covers all sea turtles interacting with the fishing gear. It includes those released alive and unharmed, those released injured and survive, those released injured and die, and those that die at the time of capture. 'Sea turtle catch' should not be confused with 'sea turtle mortality'. There is also little mention of recaptures of the same turtles more than once when estimating total catches by a fishery. In some cases, estimated sea turtle catch implies the number of individual turtles caught, when it may actually be the number of sea turtle capture events with some turtles being caught more than once.

The method of estimation of turtle captures, the time frames considered, the type of estimates reported and the definition of fisheries used by different researchers are not consistent. Some fisheries are reported independently in different documents and methods used to interpret these documents are not interchangeable. Consequently, estimates of sea turtle catches from the various documents cannot be combined and each must be considered separately. Together, however, they are useful in demonstrating the scale of the problem.

The accuracy of the data ranges from anecdotal, non-confirmed information to verified observer data. Irrespective of the detail of the information, it is evident that the mortality of sea turtles from longline fishing gear is a global problem that must be addressed.

Canadian swordfish longline

The Canadian longline fishery, extending from Georges Bank to the Flemish Cap in the north Atlantic, incidentally catches sea turtles. A comparison of catches between different longline fishing gear showed that 66 turtles were captured over 10 sets with an average of 1440 hooks per set, to give an estimated 4.6 turtles per 1000 hooks. Turtles were the fifth most common species caught and loggerheads were the only species of sea turtle reported (Stone and Dixon, 2001).

Longline fleets in the western temperate Pacific

Observer reports in the western temperate Pacific estimated an annual turtle take of 1490±376 turtles (0.06 turtles/1000 hooks) by vessels fishing with shallow-night sets, 129±79 turtles (0.007 turtles/1000 hooks) by the deep-day setting fresh tuna vessels and 564±345 turtles (0.007 turtles/1000 hooks) by the deep-day setting freezer vessels (Oceanic Fisheries Programme, 2001).

Spanish surface longline fishery in the West Mediterranean

The Spanish longline fishery, that targets swordfish, catches large numbers of loggerheads in the West Mediterranean (Laurent *et al.,*1993). Greenpeace observers on board these vessels in the early 1990s, and fisher interviews, indicate that this fishery had a very high sea turtle capture rate of around 9.8 turtles per day per vessel. This possibly equates to more than 20 000 sub-adult loggerhead turtles capture events every year (Aguilar *et al.,*1995).

European longline fishing fleets in the Mediterranean

In 2000, observer reports were used to estimate the catch rate and, when effort estimates were available, the total catch of sea turtles by longliners in the Mediterranean. In the Greek swordfish fishery, the sea turtle catch rate was estimated to be 0.63±0.38 turtles per 1000 hooks, or 6 158±3 521 sea turtles annually. In the Italian swordfish fishery, the estimated catch rate per thousand hooks was 0.22±0.12 and 0.71±0.14, in the northern and southern Ionian Sea, respectively. The Spanish catch rate from the swordfish fishery was estimated to be 1.15±0.73 turtles per thousand hooks. In the albacore fishery sea turtle catch rates per thousand hooks varied from 0.50±0.19 to 0.20±0.06 from the Italian fleet and was found to be 3.27±4.03 from the Spanish fleet (Laurent *et al*., 2001).

Longline fisheries in the Ionian Sea, Greece

Fisher records by longliners based in Kefalonia Island, Ionian Sea, Greece, give an estimated average of 0.2 turtles caught per trip (or 7.7 turtles per year per vessel). This equates to possibly 80 turtles caught annually by this fleet of 10 vessels. If this estimated catch rate is applied to all fishing fleets in the Ionian Sea, excluding amateur and small-scale coastal vessels, up to 280 turtles may be caught every year. All but one turtle caught (a total of 157), was identified as a loggerhead. The majority of turtles taken were immature animals (Panou *et al.,* 1999).

U.S. longline fisheries in Atlantic waters

Observer records were used to estimate the 1998 sea turtle capture by U.S. longliners in the Atlantic Ocean. An estimated 728 (95% CI of 337–1 824) sea turtles were caught by these vessels and of these, 708 (95% CI of 324–1 788) were assumed to have died as a result of the interaction event. Most of these were caught on the Grand Banks fishing grounds. Out of the 20 turtles caught while an observer was present, 15 were identified as loggerheads, four as leatherbacks and one as a hawksbill (Yeung, 1999).

There were a total of 112 and 87 sea turtles captures reported by observers in the U.S. longline fisheries in Atlantic waters in 1999 and 2000, respectively. A total of around 2000 turtles were estimated to have been caught by the whole fleet in both years. In 1999 there were similar numbers of loggerheads and leatherbacks, but in 2000 there were twice as many loggerheads as leatherbacks (Yeung, 2001).

U.S. longline fisheries in Northeast Atlantic waters

Estimates of turtle catches by longliners in the Northeast Atlantic have been made, based on Northeast Fisheries Science Center observer data. Gerrior (1996) reported on available data from 1991, 1992 and 1993. It was found that the longliners, targeting swordfish, tuna and shark, have a substantial incidental catch of sea turtles (leatherbacks, loggerheads, green and hawksbills). Over the three years and a total of 54 observed trips 85 turtles were caught. Of these 65% were leatherbacks, 18% loggerheads, 12% greens, 1% hawksbills and 4% were unidentified. The nature of the capture ranged from hooking in different parts of the body, including internal, to entanglements with the monofilament line and mainline.

U.S. longline fisheries in the western North Atlantic Ocean

The U.S. longline fisheries in the western North Atlantic Ocean generally target swordfish at night using lightsticks or tuna in the day without lightsticks. Logbook records from 1992–1995 indicated an average annual leatherback catch of 316 and a loggerhead catch of 334. Both species were more abundant during summer and autumn and catch varied by area (Witzell, 1999).

From logbook records for the period 1992–1999, between 293 and 2 439 loggerhead sea turtles and 308 and 1 054 leatherbacks were estimated to have be taken annually by U.S. longliners in the Western North Atlantic (National Marine Fisheries Service, 2001e).

Mexican longline fishery in the Gulf of Mexico

In 1994 and 1995 scientific observers monitored the catch of target and bycatch species on Mexican longliners in the Gulf of Mexico. They reported an average sea turtle catch rate of 5 turtles per 100 trips. Most of the turtles were entangled in the monofilament fishing line and 66.7% were released alive. During the study, 18 leatherbacks (85.7%), 2 hawksbills (9.5%) and one loggerhead (4.8%) were caught (Ulloa Ramírez and González Ania, 1998).

Longline fisheries in Uruguayan and Brazilian waters

There is some, mainly anecdotal, information on sea turtle and fishery interactions in Uruguayan and Brazilian waters. There have been leatherback and loggerhead strandings, which cannot unequivocally be linked to fisheries, but were assumed to be a result of negative fishery interactions. In addition, there was evidence that over a two-week period one longliner in Brazil caught between 70 and 75 turtles, 70% of which were loggerheads and 30% leatherbacks (Fallabrino *et al.,* 2000).

A capture rate of 1.8 turtles per 1000 hooks for longliners in the South West Atlantic Ocean (Uruguayan waters) in 1994 and 1996 was estimated from observer cruises. The turtles caught were loggerheads and leatherbacks. Most were released alive (98.1%) but with the hook still embedded (Achaval *et al.,* 2000).

Japanese longline fleet in the Atlantic U.S. Fishery Conservation Zone

The estimated incidental capture of 330 turtles per year (126 in the Atlantic and 204 in the Gulf of Mexico) by the Japanese longline fleet in the Atlantic U.S. Fishery Conservation Zone was obtained using observer and logbook records from 1978 to 1981. The catch rate varied by area, with 0.7388 caught per 1000 hooks in the Atlantic from a total of 17 million hooks set, and 1.8047 per 1000 hooks in the Gulf of Mexico from 11 million hooks set. It was noted that most leatherbacks were entangled or hooked in the flipper-shoulder area whereas many loggerheads ate the bait and became mouth hooked (Witzell, 1984).

Japanese research and training vessels

In 1988 and 1989 a questionnaire was sent to 72 Japanese research and training vessels. Of the 41 respondents, 61% reported an incidental catch of sea turtles, mainly on tuna longliner and bottom trawlers. In answer to a question on the condition of the turtle on capture, 58 % of the respondents reported that turtles were alive and released and 42% reported that they were dead (Nishimura and Nakahigashi, 1990).

Longline fishery in Antigua/Barbuda

The longline fishery in Antigua/Barbuda is estimated to catch over 100 loggerheads and leatherbacks per year (Fuller *et al.,* 1992 cited in National Marine Fisheries Service, 2001c).

Surface longline fishery around the Azores

The swordfish longline fishery around the Azores, a surface fishery (hooks are set at 15 to 50 metres), has an incidental catch of sea turtles. The most common species hooked or entangled was the loggerhead, but an occasional leatherback was also caught. A mean catch rate for loggerheads of 0.27 turtles per 1000 hooks was estimated from observer data, equating to an estimated annual catch of 4190 individuals (Ferreira *et al.,* 2001).

U.S. vessels in the Hawaiian longline fishery

An observer program has been in place in the Hawaiian longline fishery since 1994 as a result of the Biological Opinion issued under the Endangered Species Act. This data, along with logbook data from 1994 to 1997, was used to estimate total turtle captures and mortality by species. It was assumed that if the turtle was internally hooked the mortality rate would be around 30% and if externally hooked it would not die. Catch estimates ranged between 150 and 558 per year, with mortality of between 23 and 103 individuals (Kleiber, 1998).

Observer data from 1994 to 1999 indicated that between 88 and 139 leatherbacks may be taken annually from the Hawaiian–based longline fishery and of these between 7 and 12 were killed each year. The estimated annual take of loggerheads was between 371 and 501, with an estimated annual mortality of between 64 and 88 individuals. Olive ridleys were also caught, with an estimated annual take of between 107 and 164 individuals, of which, between 36 and 55 were assumed to die as a result of the capture. The annual catch of green turtles were estimated to be between 37 and 45, with mortality between 5 and 6 per year (McCracken, 2000).

Costa Rican longline fishery

Arauz *et al.* (2000) reported on observer data from 2 longline fishing cruises in Costa Rica's Exclusive Economic Zone during 1998. The incidental catch was relatively high, with 34 turtles caught from 1750 hooks set by an industrial vessel (CPUE = 19.4 turtles/thousand hooks) and 26 turtles caught from 1804 hooks set by a research vessel (CPUE = 14.4 turtles/thousand hooks). The industrial vessels turtle catch was 55% olive ridleys and 45% green sea turtles and the total mortality was 8.8%. The research vessel caught only olive ridleys, all of which were released alive. It was noted that although the mortality rate at release was quite low, in reality it may be substantially higher as a result of fishers trying to retrieve hooks from turtles.

More recent estimates from this fishery, but in a different area, using observer data collected from August 1999 to February 2000, are reported in Arauz (2000). These data indicate that olive ridleys were commonly hooked, with an estimated 6.4 turtles caught per 1000 hooks. This species is second only to the target fish, maji-maji (mahi-mahi). There were also smaller numbers of green turtles.

Portuguese deep pelagic longliners targeting black-scabbard fish

Dellinger and Encarnaçâo (2000) estimated that at least 500 sea turtles were taken annually by deep pelagic longliners based at Madeira Island, Portugal, targeting black-scabbard fish (*Aphanopus carbo*). This estimation was based on fishermen questionnaires and by quantifying catch at local harbours and from onboard data sheets.

Australian longline fisheries

There are two fisheries in the Australian Fishing Zone that target pelagic fish using longlines – the Eastern Tuna and Billfish Fishery (ETBF) and the Southern and Western Tuna and Billfish Fishery (SWTBF). Both these Commonwealth fisheries are managed by the Australian Fisheries Management Authority (AFMA).

Eastern Tuna and Billfish Fishery

The ETBF extends along the east coast of Australia from Cape York, Queensland (143º30'E) to the South Australian–Victorian border (141ºE). The most common fishing method used in this fishery is pelagic longlining that generally targets yellowfin tuna (*Thunnus albacares*), bigeye tuna (*T. obesus*) and broadbill swordfish (*Xiphias gladius*). There are also a small number of purse-seine and pole-and-line operations that targets skipjack tuna (Caton, 2002).

In the 1950s Japan began pelagic longlining off the eastern Australian coastline. After the declaration of the Australian Fishing Zone in 1979, access to these waters by foreign fleets became increasingly more restrictive until access was ceased in November 1997. Australian longliners started fishing occasionally off New South Wales in the mid-1950s. Over time these operations have increased and fishing grounds have expanded to the northern and southern waters of Queensland and further offshore. During the late 1990s fishing operations primarily targeting broadbill swordfish increased significantly out of Mooloolaba, a port in southern Queensland. These operations range past the 200-mile Australian Fishing Zone and hooks are often set around seamounts (Caton, 2002).

Fishing operations are variable by area and the species targeted. Various operational details of the ETBF that may be relevant to turtle bycatch, catch estimates of target species and effort from logbooks for the fishing areas and the whole fishery are in Table 1. For this analysis the far north zone was considered to be north of 18º, the northern zone between 18 and 30º and the southern zone south of 30º. The distribution of fishing effort for 2001 is in Figure 1.

Table 1 Operational details of the ETBF for 2001

Operational details	Far Northern Zone	Northern Zone	Southern Zone	Whole ETBF
Number of active vessels				**Around 150**
Vessel length				**10-42 m (av. 20m)**
Days fished	1432	7347	3593	**12 269**
Total hooks ('000)	860	7147	3243	**11 250**
Aver. hooks per set ('000)	540	960	924	**897**
Aver. mainline length (km)	30	49	47	**46**
Percent sets during the day	60	30	30	**35**
Yellowfin catch (t)	286	1303	606	**2194**
Bigeye catch (t)	87	732	235	**1053**
Swordfish catch (t)	23	1128	250	**1401**
Other species catch (t)	113	1189	554	**1858**

Sources: AFMA logbook data compiled by Phil Sahlquist, Bureau of Rural Sciences.

Southern and Western Tuna and Billfish Fishery

The SWTBF extends from Cape York, Queensland (143º30'E) across the northern coastline, down the western coastline of Western Australia and east to the South Australian–Victorian border (141ºE), with effort only in Western Australia and South Australian waters. The main target species are bigeye tuna (*Thunnus obesus*), yellowfin tuna (*T. albacares*) and broadbill swordfish (*Xiphias gladius*) (Caton, 2002).

Since November 1997, the Japanese longliners, fishing in the area since the mid-1950s, were denied access to the Australian Fishing Zone. The domestic fishery has been developing rapidly in recent years, increasing from 16 vessels in 1994 to 48 vessels in 2000 (Caton, 2002).

Fishing operations are variable by area and the species targeted. Various operational details of the SWTBF that may be relevant to turtle bycatch, catch estimates of target species and effort from logbooks for the main ports and the whole fishery are in Table 2. The distribution of effort for 2001 is in Figure 1.

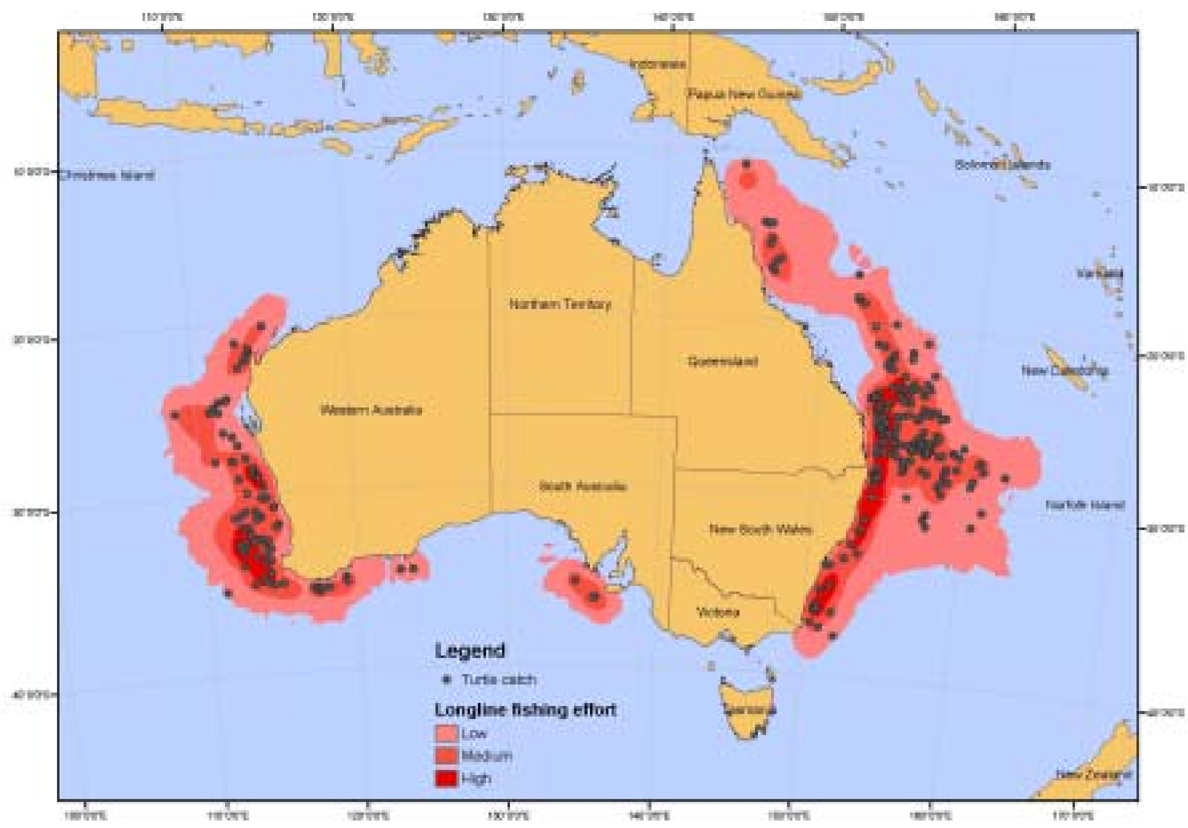


Figure 1 Reported sea turtle catches from 1997-2001 with 2001 effort (AFMA logbooks)

Table 2 Operational details of the SWTBF for 2001

Operational details	Western Australia	South Australia	Whole SWTBF
Number of active vessels			**44**
Vessel length			**16-34m (av 23m)**
Days fished	4670	745	**5415**
Total hooks (‘000)	5353	830	**6183**
Aver. hooks per set (‘000)	1130	1084	**1123**
Aver. mainline length (km)	52	46	**51**
Percent sets during the day	12	7	**11**
Yellowfin catch (t)	507	2	**509**
Bigeye catch (t)	268	81	**349**
Swordfish catch (t)	1318	111	**1429**
Other species catch (t)	162	52	**213**

Sources: AFMA logbook data compiled by Phil Sahlquist, Bureau of Rural Sciences.

Sea turtle catch rate estimates

The estimation of turtle catch per unit effort, and subsequently, total turtle catch, for longline fisheries around the world ranges from very rare encounters to sea turtles being among the most commonly caught species.

Australian situation

Logbook data

Since 1997, Australian pelagic longline skippers have been required to report all sea turtle interactions in logbooks. A total of 272 turtles were reported from 1997 to 2001 (Table 3), with an average catch rate of 0.004 turtles per thousand hooks. This equates to one turtle caught for each 250 000 hooks or on average one turtle every 250 days fishing, if the assumption of 1000 hooks are set per day is made. Sea turtles were reported as being caught across the fishing grounds of the Australian longline fisheries (Figure 1).

Table 3 Number of sea turtles and effort reported in AFMA logbooks (1997-2001)

Year	Eastern Tuna and Billfish Fishery		Southern and Western Tuna and Billfish Fishery	
	Reported turtles	**Total hooks (‘000)**	**Reported turtles**	**Total hooks (‘000)**
1997	35	6 177	0	519
1998	39	9 657	0	1 042
1999	31	10 202	24	3 529
2000	34	9 504	34	6 220
2001	48	11 250	27	6 183

Each year, 70 to 90% of skippers of vessels fishing in the ETBF and the WTBF reported in logbooks that they did not catch sea turtles (Figure 2). This zero catch rate may be due either to the fisher not reporting the catch or to no turtles actually being caught. It is reasonable to expect a mix of the two, although without verified catch data it is not possible to determine the actual proportions.

Of the fishers reporting a turtle bycatch in the ETBF and SWTBF most report catching 1 or 2 sea turtles per year. There has, however, been up to nine reported in one year by an individual.

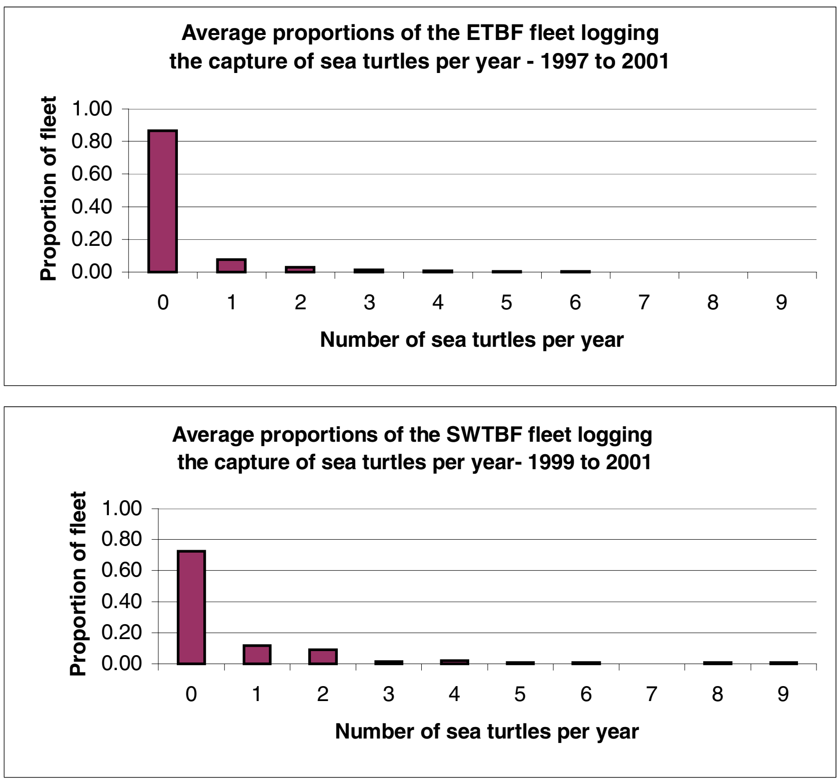


Figure 2 Average proportions of the fleet logging sea turtles per year (1997-2001)

Interview data

Skippers from the ETBF and SWTBF, interviewed in 2001, reported a sea turtle catch per year that ranged from 0 to 20. Twenty-six fishers from the ETBF were interviewed (19 personally interviewed and 7 providing information through their vessel owners).Nineteen SWTBF fishers were personally interviewed. Most fishers from the ETBF reported catching less than 3 turtles per year, whereas most fishers in the SWTBF reported catching less than 6 turtles per year (Figure 3). The average annual sea turtle catch rate from fisher interviews was 2.4 turtles per year in the ETBF and 3.6 turtles per year in the SWTBF. Although these data are not precise they do provide a rough indication of the sea turtle catch rate of vessels by fishery.

A comparison of fisher interviews with logbook reported catch of sea turtles, reveals a discrepancy indicating the inadequacy of logbook data. Few fishers who were interviewed indicated they never caught turtles, while a substantial number of fishers reported no catch of sea turtles in log records.

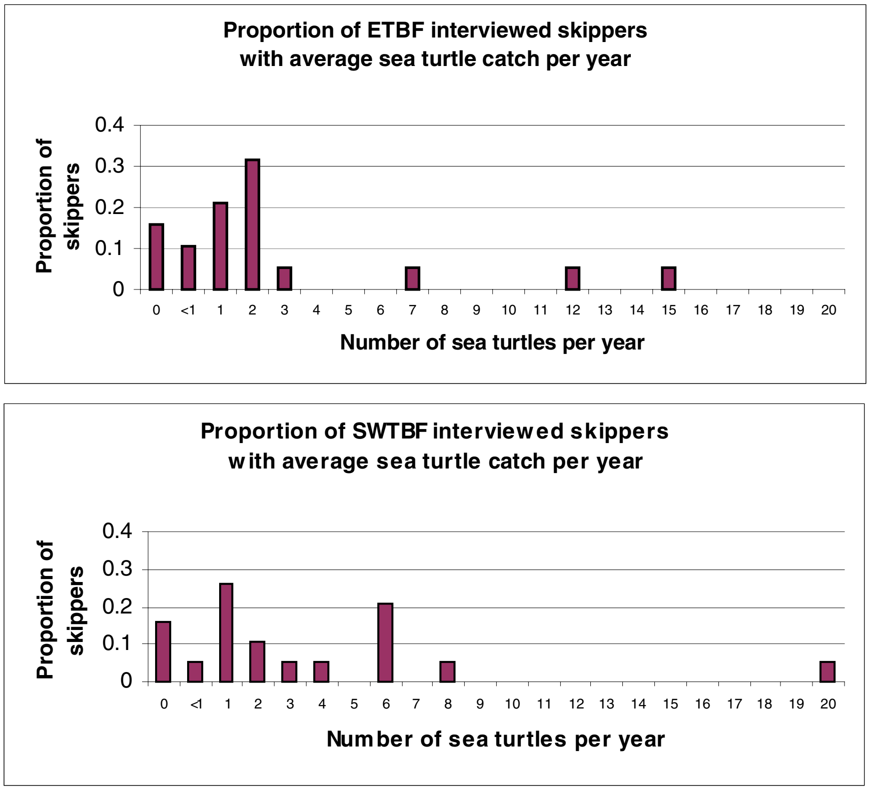


Figure 3 Proportion of interviewed skippers with average annual turtle catch

Observer data

From 1979 to 1997 Australian observers were placed on foreign fleets, primarily Japanese longliners, fishing in Australian waters. From 1991 to 1996 the estimated total number of hooks observed was almost 13 million with a total of 14 sea turtles reported as captured (Source: AFMA observer program) (Figure 4). Fishing operations for these vessels differed in some ways from the current domestic fleet operationally, spatially and temporally so that a direct comparison of sea turtle catch rates is not reasonable. These data do, however, provide a rough indication of the relatively low catch rates in the Australian Fishing Zone by the Japanese longline fleet.

In 1995 and 1996 an observer program focusing on tuna and billfish, but also reporting on other species that were caught, was conducted in the northern section of the ETBF off Cairns (known as 'Area E'). In 1995, scientific observers monitored a total of 22 712 hooks over 44 days, with mostly pilchard as bait. They reported one turtle as being caught. During the second survey in 1996, a total of 20 493 hooks over 34 days were observed, with a mix of different baits (pilchard, fish, squid). No turtles were reported as caught (Campbell *et al*., 1997). These data also support the above statement regarding the relatively low incidence of sea turtle longline catches in this area of the Australian Fishing Zone.

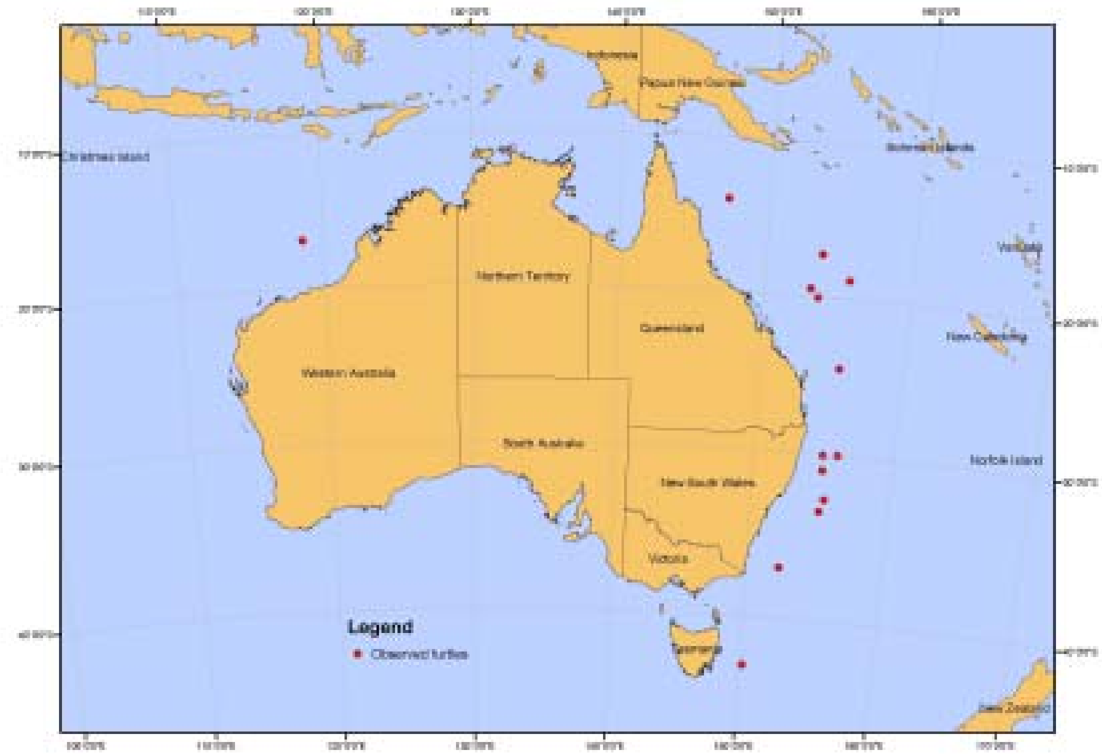


Figure 4 Turtles observed taken by foreign longliners fishing in Australian waters (1991 – 1996)

Sea turtle catch rates estimated by fishing grounds

As would be expected given the variable spatial nature of fishing activities and the distribution of sea turtles, many longline fisheries around the world have been shown to have areas that differ in turtle catch rate. An example being the Spanish longline fishery in the Mediterranean which changes spatially over the fishing season from small catches centred southwest of Ibiza and southwest of Majorca to an expanding area of capture in the hotter months of the year (Camiñas and De La Serna, 1995).

Australian situation

Sea turtle catch rates and the total number of turtles caught by broad fishing zones in the ETBF and SWTBF were estimated from the fisher interviews. The fishing zones in the ETBF used for this analysis were the far northern zone (north Queensland – north of 18º), the northern zone (central and southern Queensland – 18º to 30º) and the southern zone (New South Wales – south of 30º). The SWTBF was not separated as a number of boats fish across the whole fishery.

Estimated catch rate

Although the estimated average sea turtle catch rate for the northern zones of the ETBF was higher than the far northern and the southern zone of this fishery and the SWTBF, the differences were not significant (one-way Anova - p>0.05). The average sea turtle catch rate estimated from fisher interviews was 0.024 turtles per 1000 hooks, with a standard deviation of 0.027. Commonly, there are around 1000 hooks in each set so this catch rate equates to one turtle caught every 40 days fishing by one vessel.

This non-significant difference may be due to the inaccurate nature of the data and warrants further investigation. Different catch rates would be expected due to a number of reasons, including the distribution of sea turtles and operational aspects of the longline activities, which could include the depth of the gear, use of lightsticks, type of bait, and the concentration of fishing effort. These operational differences are discussed in more detail below. Both the ETBF and the SWTBF have developed and changed substantially in recent years, so further changes are also expected over time.

Estimated total catch

An estimated sea turtle catch rate of 0.024 turtles per thousand hooks equates to an estimated total catch of 402 individuals (with 95% confidence limits of 360 to 444) in the ETBF and SWTBF. This extrapolation (catch rate multiplied by total effort in the fisheries) assumes the skippers who were interviewed were an adequate and random sample of the whole fleet. A comparison of estimates based on fisher interviews with those from logbooks records indicates that the logbook data, reporting 272 sea turtles as being caught over 5 years (1997-2001), are inadequate for the determination of sea turtle catch rates.

The confidence interval surrounding each estimate from the fisher interviews should be considered an underestimate as it takes into account the sample size but not the possible inaccuracy of the data from fisher interviews. Consequently, these estimates should not be treated as definitive. Further research or monitoring is needed before estimates of turtle catch in these fisheries could be assumed accurate. Nevertheless, the estimates do provide evidence that sea turtle bycatch in Australian longline fisheries is relatively low compared to many other longline fisheries. It is important to note that these estimates of total sea turtle catch are not estimates of the possible number of sea turtles dying as a result of these fishing operations. Sea turtle mortality is discussed in detail below.

Season of capture

Various fisheries exhibit a temporal variation in the likelihood of incidental captures of sea turtles, and in some cases this has been linked to temperature. Camiñas and De La Serna (1995) found that sea turtle catch rate by longliners in the Western Mediterranean decreased in the colder months of the year, December to April. Loggerhead catch by longliners in the Azores was found to be highest in July with another peak in October and November (Ferreira *et al.,* 2001). Observer reports from U.S. longliners fishing in the western North Atlantic Ocean from 1992 to 1995 indicated seasonal variation in the catch of both loggerheads and leatherbacks (Witzell, 1999). These patterns, however, may have been confounded by other factors such as the distribution of target fish and consequently, fishing effort.

Australian situation

Sea turtle catch per unit effort (turtles/1000 hooks) reported in Australian logbooks does not indicate a recurring temporal variation (Figure 5). This, however, may be a result of incompleteness of data.

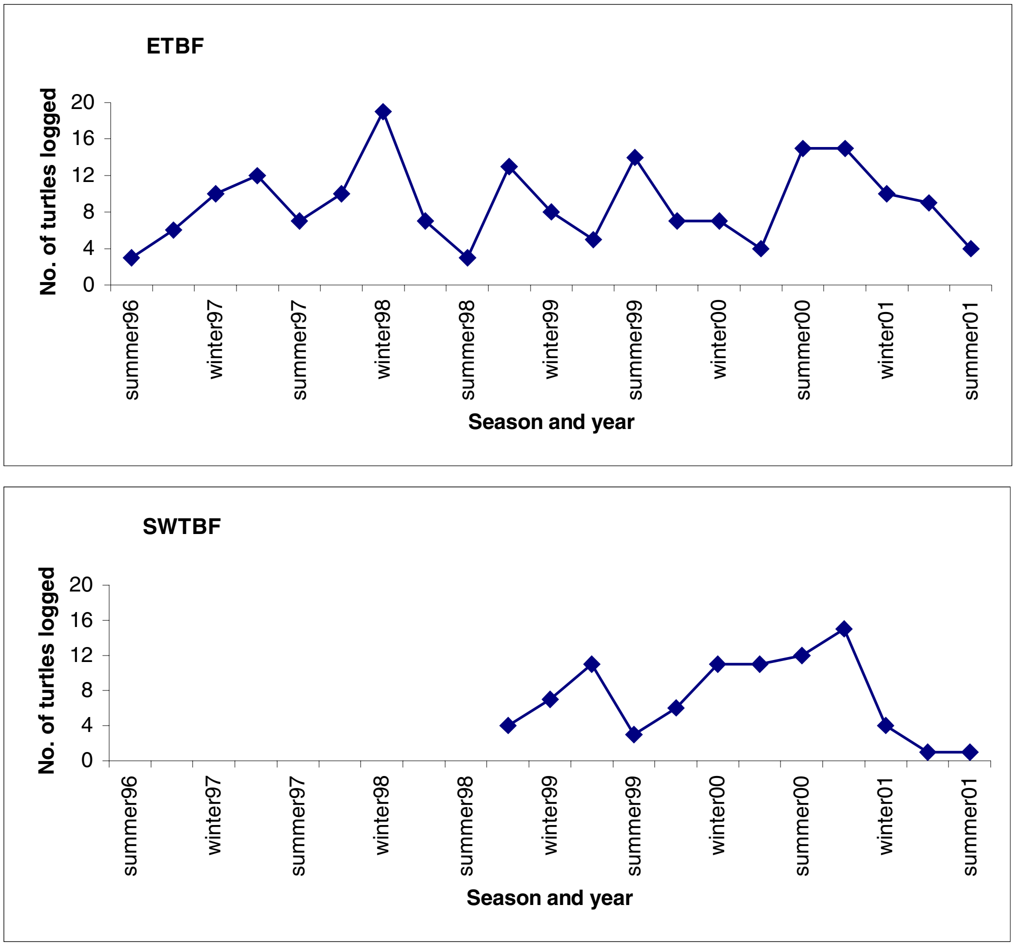


Figure 5 Seasonal catch of sea turtles reported in ETBF and SWTBF logbooks

Species composition

Species composition of the sea turtle catch is not wholly dependent on the numbers of each species in the area that is fished by the longline gear. There are a variety of other factors that are likely to be important including the bait that was used, the gear configuration and turtle behaviour.

Australian situation

Eastern Tuna and Billfish Fishery

The most common species reported as caught in the ETBF longline fisheries was the leatherback (Figure 6). Logbook records from 1997 to 2001 indicated that 66% of the turtles identified were reported to be leatherbacks. This may be an underestimate, however, as 70% of all reported turtles were not identified to the species level and an unknown proportion of these may be leatherbacks. On the other hand, fishers may be more likely to record leatherbacks to the species level as they are so easily identified.

Very few of the hard-shelled turtles were reported as identified to the species level in the ETBF logbooks. Out of the 56 turtles reported to the species level, eight were greens (14%), six were loggerheads (11%), five were hawksbills (9%) and the remainders were leatherbacks. Figure 7 is a photograph of a hawksbill captured during longline operations in the ETBF and photographs of a loggerhead and a small green turtle taken by AFMA observers currently working in the ETBF.

Fisher interviews in the ETBF (excluding in the far north) indicated that around 60% of annual turtle catch were suspected to be leatherbacks. Most fishers knew the species or could describe it. Comments on turtles they had caught included: ‘looked like an upturned tinny (small boat)’, ‘black turtle with stripes running down it’s back’, and ‘huge turtle about 2 metres long’. Out of the 19 fishers interviewed in the northern and southern zones in this fishery, 5 reported that they didn’t identify any of the turtles they caught, 3 reported catching no turtles, 8 reported that either most or all turtles caught were leatherbacks and 3 reported most or all turtles were the hard-shelled species (Figure 8). Fishers in the far north reported catching mainly green turtles, although these data are not used here.

Figure 6   Leatherback turtle caught by a prawn trawler and released alive in 1972.
Source: Tony Tomlinson, MG Kailis Gulf Fisheries.

Figure 7 Hawksbill caught in the ETBF (Source: Mr Jim Driscoll); loggerhead turtle and green turtle caught in the ETBF (Source: AFMA Observer Program)

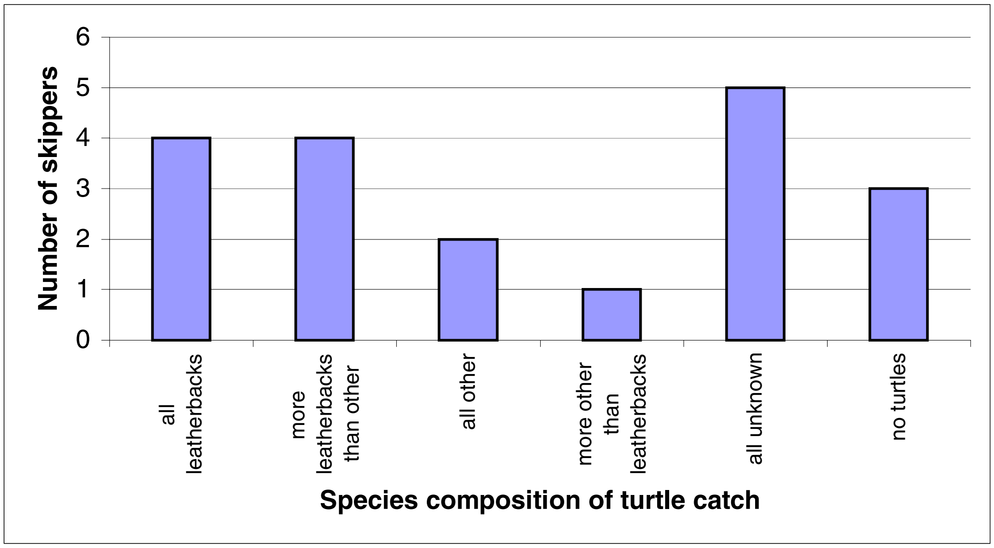


Figure 8 Species composition reported by interviewed skippers in the ETBF

Southern and Western Tuna and Billfish Fishery

The leatherback was also the species most commonly reported as caught in the SWTBF. Logbook records indicated that 90% of the turtles identified were reported to be leatherbacks. This may be an underestimate, however, as 41% of all reported turtles were not identified to the species level and an unknown proportion of these may be leatherbacks. On the other hand, fishers may be more likely to record leatherbacks to the species level as they are so easily identified. Of the 50 sea turtles reported as identified to the species level in the SWTBF there were four loggerheads (8%) and one olive ridley (2%) with the remainder being leatherbacks.

Fisher interviews indicated that around 66% of the annual turtle catches were suspected to be leatherbacks. Most fishers knew the species or could describe it. Out of the 19 fishers interviewed in this fishery, only 3 reported that they didn't identify any of the turtles caught, 3 reported catching no turtles, 10 reported that either most or all turtles caught were leatherbacks and 3 reported most or all turtles were the hard-shelled species (Figure 9).

Estimated species composition

In 2001, identification keys and handling guidelines designed for Australian trawler operators (Appendix 4) were distributed to Australian longline fishers. No complementary training, however, was provided to these fishers. Very few skippers who were interviewed reported that they had confidence in identification skills using the guidelines, although a small number assumed they could already identify sea turtles correctly. Without further training, observer coverage, or photographs of the turtles the validity of sea turtle species identifications should be questioned, especially for the hard-shelled species.

Nevertheless, available data indicates that at least 60% of sea turtles that are caught in both of the Australian pelagic longline fisheries could be leatherbacks. Because of greater difficulties in identification, the proportions of the hard-shelled species should not be assumed from these data. Without further investigation it is not possible to determine sea turtle species composition with more accuracy.

A relatively easy research project, with the aim of verifying the species taken, would be to provide fishers with a disposable camera to take photos of captured turtles. This could possibly form a part of the larger sea turtle monitoring project proposed in the recommendations at the end of this report. A research project conducted in the Northern Prawn Fishery (Robins *et al*., 2002) demonstrated the importance of verifying species identifications even with trained fishers and also established the reliability of these types of cameras for data collection.

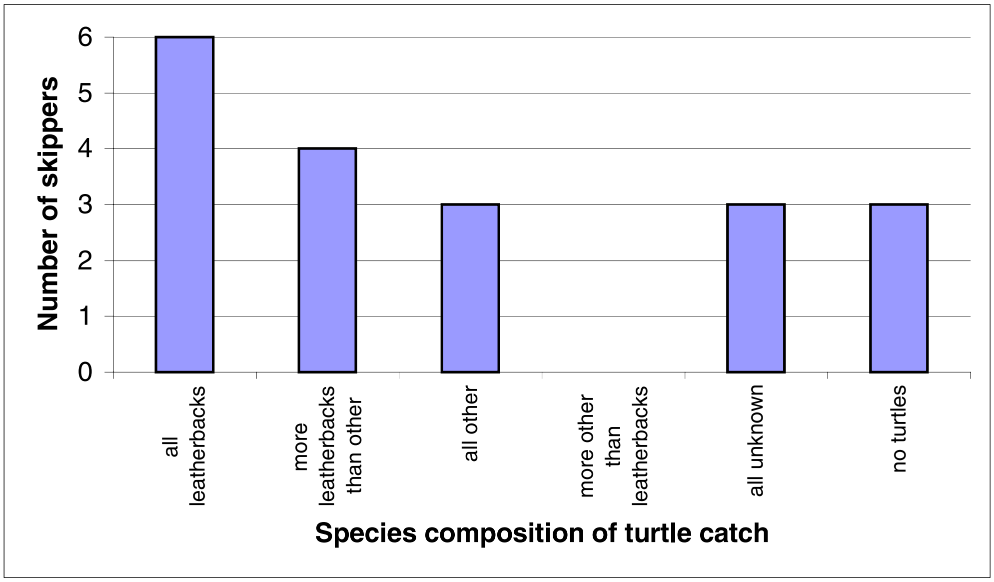


Figure 9 Species composition reported by interviewed skippers in the SWTBF

Size distribution

The size or age composition of mortalities in relation to size or age at maturity is fundamental to the understanding of species' population dynamics (Wetherall, 1997). Consequently, the collection of data on the size of sea turtles captured, and possibly dying, as a result of longline operations is important. A potential problem is that very large turtles may not have been retrieved due to their size, possibly biasing the data.

Data on the sizes of sea turtles that were incidentally caught on longline gear is available for some fisheries, including:

- Observers in the western North Atlantic Ocean from 1992–1995 reported that the mean estimated carapace length of leatherbacks was 160 cm and mean curved carapace length of loggerheads was 55.9 cm (Witzell, 1999).
- An observer project in 1998 on longliners in the Azores reported that the curved carapace length of the 45 measured turtles ranged from 41.3 to 65.4 cm, with a mean of 52.2 and standard deviation of 5.5. The loggerheads caught by the longliners were in the largest size classes of sea turtles in the Azores (Ferreira *et al.,* 2001).
- An observer program in 1999 and 2000 in the Mediterranean on Italian longliners targeting swordfish and albacore found a difference between average sizes of captured loggerhead turtles depending on the fish targeted. Vessels targeting swordfish, therefore setting deeper of

up to 60m and using larger hooks, tended to catch larger turtles than the vessels fishing for albacore that use smaller hooks and set them shallower at 20m or less (Laurent *et al*., 2001).

- A general selection for large size by longline operations was also noted by Gerosa and Casale (1999), who found that surface longliners in the Mediterranean tended to catch more sea turtles from the large size classes.
- In 1999 and 2000, observers working for the Sea Turtle Restoration Project in Costa Rica found that the average length of olive ridleys and green turtles caught by the longliners fell within the normal adult size range. The minimum sizes were smaller than those caught by the coastal shrimp trawling operations and those on the nesting beaches (Arauz, 2000).
- Fisher records in the Ionian Sea, Greece, indicated that most turtles caught by the longline fleets were immature animals (Panou *et al*., 1999).

Australian situation

Observer records often provide accurate size measurements of landed sea turtles, but the size of sea turtles that are not brought to the deck must be estimated with the turtle still in the water. Potentially, logbook records could request length measurements, but fishers would need to be trained and again only landed turtles could be accurately measured.

At present, there is no provision, or instructions, in the Australian logbook for recording size measurements or size estimates. Although, they could be reported in the comments section if the fisher was instructed on measuring techniques and also considered them important enough to report.

Hooking status

The most likely way a sea turtle is hooked – hooking status – depends on factors such as the type of fishing gear and the behaviour of specific turtle species. Turtles can be lightly hooked (hook is taken in the mouth and, in general, is visible), deeply hooked (hook is further down the throat and generally not visible), entangled (line wrapped around the turtle but the hook is not involved), externally hooked (hooked to the neck or flipper), or possibly both entangled and externally hooked. The hooking status may be important when evaluating the probability of whether a turtle will die as a result of a hooking event. As listed below, hard-shelled turtles are often noted as being commonly hooked in the mouth as a result of actually biting the bait, while leatherbacks are mostly reported as being entangled in the fishing line or externally hooked in the shoulder or flipper.

Hard-shelled species

A study on the gut contents of dead driftnet-caught loggerheads in the North Pacific showed that while in the pelagic stage they were opportunistic feeders that consumed food items floating at or near the surface of the water. They did, however, search deeper at times if prey items were concentrated at lower depths (Parker *et al.,* 2002). This feeding strategy may make loggerheads particularly vulnerable to capture in longline gear. Assuming the strategy applies to all loggerheads in this stage of their lives, it is not surprising that most loggerheads caught by longlines are hooked, rather than entangled, although the nature of the hooking event varies. This has been noted in many fisheries, including:

- An observer and logbook project in a surface longline fishery in the Azores in 1998 reported on situation of capture. They found that out of 60 loggerheads, 54 (90%) were hooked in the mouth, 3 (5%) were gut-hooked, 2 (3%) were externally hooked (one in the eye and one in the front flipper) and one didn't have the location of the hook identified. Only one turtle was dead on capture, it was found to have the line wrapped around its head, and all but 4 turtles had hooks removed before release (Ferreira *et al*., 2001).
- Loggerheads caught by the United States longline fleet in the Western Atlantic frequently become hooked in the mouth or throat through eating the bait. These turtles are generally released alive but their ultimate fate is unknown (Witzell, 1996).
- Observers on board U.S. longliners in the western North Atlantic reported that out of the 27 observer loggerheads – 25 were mouth hooked and 2 externally hooked (Witzell and Cramer, 1995).
- Observers in the North-East Atlantic waters from 1991 to 1993 reported that out of the 4 turtles identified as loggerheads 3 were internally hooked (Gerrior, 1996).
- Observer reports in the Mediterranean on Italian longliners in 1999 and 2000 found that 85% of loggerhead turtles were hooked internally, 1% were hooked externally and the remaining 14% were entangled. It was possible in around half of the cases to remove the hook from the turtle before release. Observers onboard Greek longliners found that 100% of loggerheads were internally hooked (36% in the jaw or mouth with the hook visible and 64% with the hook not visible). Spanish longliner observers found that 93% of loggerheads that were caught were internally hooked rather than entangled (1.5%) or externally hooked (5.5%). Of the hooked turtles just over half were released with the hook still in place (Laurent *et al*., 2001).
- Logbooks and observer reports were used to evaluate the capture of sea turtles by Japanese longliners fishing in the Atlantic Ocean. It was found that loggerheads tended to eat the bait and become mouth-hooked, while the leatherbacks tended to become externally hooked in the flipper-shoulder area or become tangled in the branchline (Witzell, 1984).

There are only a few reports on the hooking status for the other hard-shelled species, but these also document the high mouth-hooking rate for these species, including:

- The Sea Turtle Restoration Project observed 9 longline fishing excursions within the Costa Rican EEZ in 1999 and 2000. They found that most olive ridleys were hooked in the mouth (87.4%): 214 had the hook removed and 2 were deeply hooked; some were hooked in the flipper (10.5%); a small number were entangled in the line (1.62%) and very few were externally hooked in the neck (0.9%). It was found that green turtles ingested the hook less often than olive ridleys (66%) and more were externally hooked (33%) (Arauz, 2000).
- Observers in the North-east Atlantic waters from 1991 to 1993 reported that one hawksbill and 8 green turtles were hooked in the mouth. These, along with 4 loggerheads and a green turtle with no hooking status reported, were all of the hard-shelled turtles reported (Gerrior, 1996).
- Observer records from 1994 to 1999 in the Hawaiian-based longline fishery record an incidental take of 32 olive ridleys. All were hooked, 14 externally and 18 internally (Western Pacific Regional Fishery Management Council, 2002).

Leatherbacks

The likelihood of a leatherback swallowing a longline bait is considered to be low due to the fact that they do not naturally feed on squid or fish, the most common longline bait (Witzell, 1984). Leatherbacks have occasionally been reported to ingest bait but, as expected, this is rare (Skillman and Balazs, 1992). By contrast, the high proportion of leatherbacks externally hooked or entangled has been noted in several longline fisheries around the world. Examples include:

- Observers monitoring turtle catches on Mexican longliners in the Gulf of Mexico reported that 85.7% of turtles caught were leatherbacks and most of these were entangled (Ulloa Ramírez and González Ania, 1998).
- Witzell (1996) found that the United States longline fleet in the Western Atlantic Ocean caught a significant number of leatherbacks, with an internal hooking rate of around 2%. Of the around 78% of the turtles classed as non-hooked (entangled), between 10 and 15% also had a hook externally embedded.
- Logbooks and observer reports were used to evaluate the capture of sea turtles by Japanese longliners fishing in the Atlantic Ocean. It was found that leatherbacks tended to be externally hooked in the flipper-shoulder area or become tangled in the branchline (Witzell, 1984).
- Trials onboard chartered-longliners in the Atlantic by the U.S. NMFS show that no leatherbacks had ingested baits. Leatherbacks were also observed swimming around the floats without being hooked or entangled (Swimmer, 2001 *pers. comm.*).

Australian situation

Australian logbook records from 1997 to 2001 suggest that almost all turtles identified as leatherbacks that had a situation of capture recorded in the comment section were either entangled or externally hooked. The exception was two leatherbacks that were reported as ‘hooked’, so it is not possible to know if these were externally or internally hooked. Most (94%) of the unidentified turtles that had a situation of capture recorded in the comments section were recorded as externally hooked or entangled, with only two turtles reported as internally hooked, one in the mouth and one internally. In addition, one unidentified turtle was reported as breaking off. Of the six hard-shelled turtles with the situation of capture recorded, four were reported as mouth hooked and two as externally hooked.

Fisher interviews conducted with Australian longline fishers in 2001 also indicated the high occurrence of turtles identifies as leatherbacks being externally hooked or entangled. A majority of the fishers noted that all or nearly all leatherbacks that they have caught were hooked or entangled, generally around the shoulder or front flippers; although two skippers indicated that all turtle caught had been mouth hooked. A small number of fishers made the point that in some cases it was impossible to determine if the hook was externally embedded or if the turtle was just entangled. One fisher who was interviewed reported that he had noticed that occasionally the hook was not embedded but the skin was gathered in the hook-gape and if the turtle was brought close enough it was possible to lean down and ‘pop’ the hook out of the skin without inflicting any injury.

There were a number of reports that the hard-shelled turtles were most commonly mouth or internally hooked. There were also reports of these species also being entangled, although much more rarely with the exception of fishers from far North Queensland. These fishers reported that the turtles captured by their vessels are always entangled.

Why are turtles attracted to longline gear?

Bait

Sea turtle species that naturally hunt and consume the types of prey used on longline hooks, or food that resembles the bait, may be attracted by these baits, coincidentally see and take the bait, or may be attracted by other sections of the longlines. If turtles take the bait they obviously have a high chance of becoming internally hooked. However, leatherbacks that do not usually eat longline bait as food are attracted for different reasons.

Lightsticks

If the leatherback is not seeking the longline bait, then the question of why they are caught on longline gear remains. One probable cause is the increased use of chemical lightsticks – a luminous tube attached to the line used to attract swordfish and tuna. Unfortunately, lightsticks are thought to also attract leatherbacks. It is expected that the turtles are enticed to the illumination because it simulates natural prey, then become entangled or foul-hooked while searching around the gear (Skillman and Balazs, 1992). Supporting this idea, Davenport (1988) suggested that when diving to the dark depths of the oceans leatherbacks find their prey using the flashes of blue/green bioluminescent light emitted by their gelatinous prey-animals.

United States observer data in the western North Atlantic Ocean from 1992 to 1995 revealed that leatherback and also loggerhead catch rates are higher for vessels using lightsticks, than for those that did not use them. This indicates that turtles other than leatherbacks may also be attracted to lightsticks (Witzell, 1999). An observer program in the Mediterranean found that 88% of turtles caught by the Greek swordfish longline fleet were hooked in a line with a lightstick and 12% were hooked in a line alongside a lightstick (Laurent *et al*., 2001). In contrast, Skillman and Kleiber (1998) did not find a correlation between lightstick use and turtle captures for the Hawaiian longline fishery. They did note, however, that very high observer coverage would be required to detect an effect given the noisy background in the statistical test.

NMFS and other U.S. research bodies are currently investigating the relationship between lightsticks and sea turtles. Any significant differences between the visual capabilities of sea turtles and pelagic fish may help in designing a better lightstick, ideally one that continues to attract fish without having an effect on sea turtles. This research has already shown that tunas are sensitive to low light levels, especially at night. The eyes of turtles, on the other hand, are less sensitive to very low light levels. The adoption of low intensity lightsticks, possibly electronically instead of chemical, may be successful in reducing sea turtle catch by longliners (Lars *et al*., 2001).

The use of lightsticks on hooks is still under development in some longline fisheries, notably in the Mediterranean. Therefore, a ban on further use of this potentially turtle-attracting devise may still be possible (Laurent *et al*., 2001). In 2001, to prevent the targeting of swordfish, a lightstick ban was imposed on the Hawaiian longline fishery, which are typically taken on shallow-set gear that also catches substantial numbers of loggerhead turtles (Federal Register: June 12, 2001; Vol. 66 No. 113).

Floats

NMFS observer data from United States longline fleets show that significantly higher numbers of leatherbacks and loggerheads are caught by the branch-lines set closest to the float rather than on the other lines (National Marine Fisheries Service, 2001d). This could imply that the turtles are attracted to floats or the float-lines or, as the shallower hooks are nearest to the float-lines, that shallow hooks are more likely to catch sea turtles (Kleiber and Boggs, 2000). In order to allow a hooked turtle to reach the surface regulations United States longliners fishing in the Atlantic must prevent 'gangions (hook-lines) from being attached next to floatlines or the mainline, except at a distance twice the length of the average gangion length in the set' (National Marine Fisheries Service, 2001b:19). NMFS estimates that this may result in a 22% reduction in loggerhead catches and a 24% reduction in leatherback captures.

Australian situation

Lightsticks are commonly used by Australian pelagic longline fishers when targeting specific species, primarily swordfish and bigeye. As such they are used in conjunction with a certain bait type and in specific areas. It is worth noting, however, that the target species, bait types and areas referred to here are general conventions and are not strict rules, with some fishers using lightsticks in other situations.

In 2001, logbook gear sheets show that lightsticks are almost always used on gear set in southern Queensland and out wide in northern New South Wales. Operations further north and further south rarely set gear with lightsticks or have fewer lightsticks in each set.

Fishers targeting swordfish generally place a lightstick above each hook and use squid as bait, whereas fishers targeting tuna species use lightsticks less typically and they commonly use live fish as the bait. Similar use of lightsticks was reported in the west: lightsticks are typical in the north and on either every second to every hook; and used less often in the south and on fewer hooks in the set. Lightsticks were used in South Australian waters, but not often and on fewer hooks in the set. A small number of fishers reported trialing dyed bait, mostly blue, but occasionally red as well. Fishers reported this was to increase their target catch, but it was believed it also decreased bird, and possibly turtle, bycatch. This, however, is speculative.

Many Australian fishers use the most common tube-lightstick, which is attached to the hook-line, either above every hook or in various configurations as decided by the fisher. Tube-lightsticks come in different colours and there are different methods of attaching them to the line. Some fishers are currently testing other types.

A number of fishers noted that they had observed leatherbacks swimming around their longline floats without becoming entangled. Most, but not all, fishers reported that their hook-lines were set at least 40 metres away from the floats so that they did not consider there would be a problem with turtles becoming entangled due to attraction to floats. Some fishers noted that it is possible for hook-lines to move closer to the float-lines if forced, for example, by a large fish.

In 2002, AFMA observers onboard ETBF vessels reported the capture of two sea turtles. Both were caught on relatively shallow hooks within the set: one on the hook closest to the float and the other on the second hook from the float (Scott, *pers comm*. 2002).

It would be useful, and relatively easy, for data relating to circumstances around turtle captures to be collected from the Australian longline fisheries. Examples of the type of data that may be useful include lightstick design and colour and the proximity of the hooked turtle to the float line. With a better understanding of the interaction between sea turtles and longline operations it may be possible to develop management strategies that allow fisheries to continue to operate successfully while reducing sea turtle take.

Recapture rate

There have been cases in which sea turtles have been found with multiple hooks embedded and/or connecting line. This indicates that they did not die as a result of the longline hooking events, though the time between each hooking is not known. This was proven from tagged turtles, but not quantified, in the Spanish longline fishery. Observers noted that there were some turtles carrying more than one hook were captured (Aguilar *et al.,* 1995). Observers on United States longliners in the western North Atlantic Ocean from 1992 to 1995 report that some loggerheads were seen trailing multiple gangions and so had continued to actively feed in the same area after being hooked (Witzell, 1999). Tomas *et al.* (2001) reported a case where a tagged turtle was found with an attached hook and several metres of line. When x-rayed, a further 2 hooks were detected inside the turtle. All hooks were surgically removed. Consequently, there is a problem of estimating catch rates when multiple captures occur. Multiple recaptures may cause catch rates to be overestimated, although the impact is expected to be minor (National Marine Fisheries Service, 2001c).

In addition these cases demonstrate that some turtles carrying hooks and injuries from previous catches survive capture by longline vessels. If turtles caught by longline vessels were tagged before release and their injuries noted with the tag details, if they were subsequently recaught, there would be further evidence on the survival chances of hooked turtles.

Australian situation

There are no data to suggest that turtles are repeatedly caught during longline operations in Australian waters. In order to estimate the recapture rate it would be necessary for fishers to tag captured turtles before release and also to report captured turtles that have previously been tagged.

Hook type

Hook type may affect sea turtle catch rate or mortality. Circle hooks are used by some fishers to improve the chance of hooking a fish in the jaw rather than internally (Kleiber and Boggs, 2000). Studies and practical fishing knowledge of different styles of hooks in relation to billfish and tuna catches indicate that it may be possible to reduce turtle mortality through a change in the style of the hooks (National Marine Fisheries Service, 2001e).

To evaluate effects of hook type on sea turtle bycatch, Bolten *et al.* (2001) conducted an experiment in a swordfish fishery in the Azores. They found that hook type did not influence the number of turtles caught, but there were significant differences between hook types with respect to hooking status – that is, where the turtle was hooked. Circle hooks tended to result in less serious injuries, which may have positive implications for the probability of survival. However, the use of circle hooks to reduce turtle mortality is still open to debate because of factors such as the difficulty in removal and the possibility of a drop in target catch (National Marine Fisheries Service, 2001d).

The advantages of corrosible hooks and crimps that corrode quickly once ingested are widely debated. Some hold the opinion that corrosible hooks may improve the survival rate of hooked turtles. Others believe that corrosible hooks may increase the chance of infection, thereby reduce the survival rate. An advantage of corrosible gear could be that any trailing line attached to a corrosible hook would pull free faster than from non-corrosible gear (stainless steel), thereby preventing the turtle from swallowing the line or becoming entangled (Kleiber and Boggs, 2000).

United States researchers are currently considering the benefits and disadvantages of corrosible hooks and crimps. There is a proposal that only corrosible hooks and/or crimps be used on U.S. Atlantic longliners (Federal Register: April 10, 2001; Vol. 67 No. 69). NMFS is working on design standards and specifications and plan to conduct a workshop in 2002 that will assess the impacts of corrosible gear on sea turtles (National Marine Fisheries Service, 2002d).

Australian situation

A mix of hook styles – circle hooks, tuna hooks, and J hooks – sometimes within the same set, is used in the Australian longline fishery. The hooks are either galvinised (corrosible) or stainless (non-corrosible). The choice of which style to use can depend on the target catch, personal preference, hook availability and/or cost. The galvanised hooks are more expensive.

Although, there have been no firm recommendations on which hook types may reduce sea turtle mortality, the use of circle hooks to reduce the ingestion of hooks by turtles is encouraging. Continuation of this type of research is recommended. It may be beneficial for fishers to record which style of hook caught each sea turtle they report. Although for Australian fishers the resultant dataset will most likely be too small for rigorous statistical analysis, due to the rarity of capture of sea turtles, it may provide an indication of the effects of hook type on the catch of sea turtles in the Australian fisheries.

Australian fishers hold differing opinions on the benefits and disadvantages of corrosible gear. The life of corrodible crimps when line was submerged in salt water was considered by a couple of interviewed fishers to be as short as a fortnight to a month. Results of the U.S. trails should be monitored by the Australian authorities as the results should be applicable to all longline fisheries that use these types of hooks.

Depth

Shallow versus deep sets

The relationship between sea turtle catch rate and depth of hook has been explored as an option in reducing sea turtle take in longline fisheries. It has been discovered that loggerheads rarely dive deeper than 75 feet and, consequently, captures may be reduced if longlines are deeply set (Altonn, 2001). The vertical habitat of turtles was further examined when two loggerheads and two olive ridleys were fitted with satellite transmitter and depth recorders following capture by the Hawaiian-based longline fishery. The loggerheads made relatively shallow dives and tended to spend about 40% of their time at the surface and 90% of their time above 40 m. In contrast, the olive ridleys spent only 20% of their time at the surface and 40% deeper than 40 m (Polovina *et al.,* 2002). Observer reports from the Western Tropical Pacific Ocean from 1990 to 2000 suggested that shallow-set gear would be expected to catch more turtles than deeply-set gear (Oceanic Fisheries Programme, 2001). Observer data also indicate that all loggerheads caught in the Hawaiian-based longline fishery were in shallow sets (Polovina *et al.,* 2002).

After a number of years of closures and regulations in the Hawaiian longline fishery, on 12 June 2001 an emergency interim rule implementing temporary measures, including those related to depth, was announced (Fisheries Register: June 12, 2001; Vol. 66 No. 113). Measures were effective from June 2001 to December 2001, then extended to 9 June 2002 (Federal Register: December 10, 2001; Vol. 66). These regulations, in so far as they related to depth, included: a ban on the targeting of swordfish north of the equator in the Pacific; a requirement that the deepest point between any two floats is at least 100 m beneath the surface of the ocean; a requirement that the float line suspending the main longline beneath a float be at least 20 m long; and a requirement that at least 15 branchlines are deployed between any two floats. These regulations prevent the setting of shallow longline gear, typically used to catch swordfish, to avoid or minimise the takes of loggerhead turtles in this longline fishery.

A further emergency interim rule, effective from the 5 April 2002, a notification of restrictions, and a request for comments, was cited in the Federal Register: April 5, 2002 (Vol. 65, No. 66). This prohibits Hawaii longliners from fishing north of 26º North latitude and prevents vessels that fish north of the equator from retaining more than 10 swordfish per fishing trip. These regulations are expected to geographically remove longline operations from loggerhead turtles habitat and to remove economic incentives to use shallow set gear, thereby are designed to minimise the take of loggerhead turtles.

Depth of hooks within a set

The position of the hook within the set may be related to turtle catch rates for that hook. Hawaiian observer data show that the shallowest hooks in a set, those closest to the floats, caught significantly more leatherbacks and loggerheads than hooks in other positions within the set. These types of observations could imply that the turtles are attracted to floats or the float-lines, as mentioned previously. Alternatively, the shallower hooks may be more likely to catch sea turtles due to their depth (Kleiber and Boggs, 2000).

Observer records from the Western Tropical Pacific Ocean further demonstrated a possible relationship between position of the hook within the set and sea turtle. Shallower hooks in the deeper-set gear, meaning actual hook position in the line, tended to catch more turtles than the other hooks within that set encounters (Oceanic Fisheries Programme, 2001).

An observer program on Italian longliners in the Mediterranean showed that most turtles caught during fishing for albacore, which has hooks set down to approximately 20 m, were caught in the top 5 m of the water column. It was also reported that on Italian longliners in the Mediterranean observers found that around 41% of all turtles captured were caught on the hooks set closest to the float (Laurent *et al*., 2001).

Inability to reach the surface

If a sea turtle cannot reach the surface of the water to breath, obviously, it's chance of drowning or becoming comatose increases. Although, sea turtles can intentionally remain submerged for considerable lengths of time, the stress of hooking and struggling against forced submergence may raise the risk of drowning (Kleiber and Boggs, 2000). Such mortality could also occur if a turtle was caught along side, or entangled with, a large fish on the next hook (Ferreira *et al.,* 2001). This situation was noted in a turtle caught and killed during an observer program in the Mediterranean (Laurent *et al*., 2001).

So as to reduce the mortality of sea turtles through drowning, the United States placed restrictions on gear configuration on U.S. longliners fishing in the Atlantic, requiring sufficient slack line to allow the turtle to surface. The regulation, which came into effect on 1 August 2001, requires that 'for longline sets in which the combined length of the float-line plus the gangion is 100 metres or less, the length of the gangion must be at least 110% the length of the float-line'. This regulation does not apply to sets over 100 metres in depth (Federal Register: July 12, 2001; Vol. 66, No. 135).

The success of this type of measure in reducing sea turtle take depends on environmental conditions, the fishery of concern and the fish targeted. This type of regulation becomes more difficult for deeply set gear because the hook-line distance from the floats need to be very long in order to reach the surface and account for the sag in the mainline. A lower sea turtle catch rate, however, is generally apparent in gear that is set at deeper levels so measures of this type become less critical.

Australian situation

Longline fishers in the ETBF and the SWTBF tend to set the gear at maximum depths of between 20 and 100m. Occasionally gear is set to depths greater than 150m. In far north Queensland the most common depth is 60 to 100m, in southern Queensland and northern New South Wales most gear is set at between 40 and 60m maximum depth, and in southern New South Wales gear is commonly set slightly shallower, at 40m. The most common depth in Western Australia and South Australia is from 60 to 100m. South Australian sets, however, are generally set deeper more often than in Western Australia. (Source: AFMA logbook data)

As mentioned previously, most, but not all, fishers reported that their hook-lines were set at least 40 metres away from the floats and, consequently, did not consider that there would be a problem with turtles becoming entangled if attracted to floats. Some fishers noted that it is possible for hook-lines to be moved closer to the float-lines if forced, for example by a large fish.

Some longline operations in Australian waters are configured in such a way that a turtle would have difficulty in reaching the surface if hooked on the deepest hooks. These operations, however, are not typical. Vessels targeting swordfish, for example, tend to have very short float-lines and occasionally even have extra small floats between the main floats to keep the gear high in the water column so there would be a very low chance of a turtle being held under the surface.

Handling techniques

The adoption of correct recovery techniques is important in reducing post-hooking or entanglement injury when handling longline captured sea turtles (Balazs *et al.,* 1995). Crew awareness and training in turtle handling can reduce sea turtle mortality, as noted by observers in the Western and Central Pacific (Oceanic Fisheries Programme, 2001). Handling guidelines have been prepared for some fisheries in the world (Appendix 4) including U.S. longline vessels fishing in the Atlantic and the Pacific. U.S. vessels must have sea turtle safe handling guidelines posted in the wheelhouse and are required by law to follow them.

The guidelines were designed for U.S. longline fisheries by Balazs *et al.* (1995) but should be equally applicable to other longline fisheries. Most other guidelines follow these same general outline:

1. Equip the vessel with ‘cut-out’ doors (to minimise distance to water to reduce trauma when retrieving turtles).
2. Scan mainline in advance during gear retrieval for turtles (to reduce the chance that the turtle will be further traumatised by pulling it along the surface).
3. Ensure the vessel does not get ahead of the mainline (to increase the probability of sighting a turtle and reduce the chance of it being dragged).
4. Slow down when a turtle is sighted and move towards it (to minimize tension on the line thereby reducing trauma to the hooked turtle).

5. Gently retrieve the turtle close to the boat while keeping it in the water (to minimise further damage to the turtle).
6. Once alongside determine the best course of action depending on size, hooking status, species and condition.
7. If possible, bring turtle on board using a safe method (generally not by the line) then remove hook, if visible, or cut off as close as possible and, if the turtle is comatose, apply resuscitation procedures.
8. If the turtle is too large to bring on board – attempt to remove hook and all of the line.
9. Release the turtle head-first with the vessel stationary.

Handling requirements for the U.S. Hawaiian longline fishery (as cited in the U.S. Federal Register March, 28, 2000; Vol. 65, No. 60) are:

- All turtles brought on board must be handled in a manner that will minimize injury and possibly promote post-hooking survival;
- Comatose turtles must be retrieved immediately with a minimum chance of further injury;
- Large turtles that are unable to be retrieved without causing further injury must have as much line removed as possible with the line-clipper;
- Comatose or apparently dead turtles must be placed in the shade, kept damp (possibly a damp towel draped over the eyes, carapace and flippers), placed right-side up and have the hindquarters raised at least 6 inches (15 cm) for between 4 and 24 hours. Higher elevations are possibly needed for larger turtles. A reflex test, gently touching the eye or pinching the tail, should be performed every 3 hours;
- Turtles should be returned to the sea away from the deployed gear with the vessel stationary and the engine in the neutral gear; and
- The turtle must be safely away from the vessel before engaging the propeller and continuing operations.

Australian situation

Many fishers who were interviewed felt that they had already adopted good sea turtle handling guidelines. A small number admitted they thought that the best thing to do was to remove the sea turtle from the line as quickly as possible, so they generally cut the line immediately. Most, however, did attempt to cut the line as close to the turtle as possible. The length of line left trailing on the turtle varied from a couple of centimetres to at least 10 metres. A number of fishers believed the line would often fall off the turtle on release, or the crimp would dissolve quickly enough not to endanger its life. A small number of fishers actively retrieved mouth-hooked turtles to remove hooks, although some could not do this safely, especially during rough weather. Fishers in far north Queensland reported that all turtles captured were entangled and it was relatively easy to retrieve them onto the deck to check health status before release. The possibility of a sea turtle, or members of the crew, becoming injured if the turtle is not adequately restrained while on the deck should be considered. This is especially so in rough weather and/or when working with large turtles.

The guidelines for retrieval of hooked and entangled sea turtles from Balazs *et al.* (1995) generally apply in Australian fisheries. There seems no reason why they cannot be routinely adopted, although many are already considered good fishing practice and already used.

Every Australian longline skipper we interviewed agreed that handling guidelines would be useful when they interacted with sea turtles. Draft guidelines for potential use in Australian longliners, in line with the U.S. guidelines, is provided in Appendix 4. In conjunction with handling guidelines there should be a species identification chart with photographs.

Most of Australian fishers who were interviewed also expressed an interest in a sea turtle video for the crew. This video should cover sea turtle handling guidelines, identification and other data collection information, as well as a section on general sea turtle information. The latter section is an essential component, to increase awareness by the fishers of the importance of becoming involved in sea turtle conservation (Robins *et al*., 2002).

On-board equipment

In conjunction with guidelines it may be necessary for fishers to use equipment, including a dip-net of some type to retrieve the turtle, line clippers to remove line off an entangled or hooked turtle, and de-hooking devices to remove hooks. Dip-nets, or other methods to safely bring turtles onto the deck are often necessary to prevent further injury to the turtle. Hauling sea turtles to the deck using the line may result in increased tissue damage by the hook (Ferreira *et al.,* 2001), possibly piercing the esophagus or stomach, or pulling organs from connective tissue and killing the turtle (National Marine Fisheries Service, 2001d).

United States fisheries off the west-coast States and in the Western Pacific, including the Hawaiian-based pelagic longline fishery, are required to possess and use line clippers and dip-nets that meet a minimum standard under their permit conditions. This final rule was effective from 27 April 2000 and was cited in the Federal Register: March, 28, 2000 (Vol. 65, No. 60). A similar interim final rule for the Atlantic U.S. pelagic longline fisheries was posted in the Federal Register: March, 30, 2001 (Vol. 66, No. 62). Although, this requirement has been in place since 13 October 2000 (National Marine Fisheries Service, 2002b).

Dip nets

Dip nets to safely lift small turtles onto the deck for hook and line removal come in various types and sizes. Minimum standards for U.S. longliners, as documented in the Federal Register: March, 28, 2000 (Vol. 65 No. 60) are:

- A pole or handle that reaches at least 6 ft (1.8 m);
- a pole that is able to support at least 100 lbs (45.4 kg) without breaking or distorting;
- a net-head with a hoop net of at least 31 inches (79 cm) inside diameter;
- a net-head with a depth of at least 38 inches (96.5 cm) and
- that mesh size must be no more than 3 inches (7.6 x 7.6 cm).

Line cutters

Attempting to bring very large turtles, mostly leatherbacks, on board is not recommended due to possible injuries to the turtle and to the crew. In these cases, it is suggested that line-clippers be used to remove the line from the animal. Line-clippers are generally a cutting device secured to a long pole. Minimum standards applied in U.S. longline fisheries are documented in the Federal Register: March, 28, 2000 (Vol. 65, No. 60) and the Federal Register: March, 30, 2001 (Vol. 66, No. 62). A diagram of a line clipper taken from the former report is in Appendix 4. The line clipper standards are:

- a protected cutting blade – a curved and recessed cutting blade that is contained in a holder that will minimize direct contact of the blade with sea turtles and users;
- the cutting blade edge must be capable of cutting 2.0–2.1 monofilament line or braided mainline;
- an extended reach of at least 6 ft (1.8 m);
- the blade must be secure on the handle or pole.

De-hookers

De-hookers, of which many designs are available, are used on hooked turtles that are brought on deck and also, if connected to a pole, may be used to remove hooks from externally-hooked turtles in the water. De-hookers, in conjunction with line clippers, may be beneficial in removing gear from captured sea turtles. Currently, extensive research is being conducted by the NMFS on developing and testing de-hookers to remove both internally ingested and externally foul-hooked hooks. The proposed rule for the Atlantic longline fishery, evaluated by the National Marine Fisheries Service (2002a), notes that the adoption of de-hookers should be further considered pending the completion of these studies. NMFS, however, encourages fishers to use these devices on a voluntary basis.

Sea turtles have a complex digestive structure and so removal of internal hooks is dangerous to the turtle and difficult for the person trying to remove the hook. In addition, it is possible for hooks to pass through the turtle without causing substantial damage (Aguilar *et al.* 1995; National Marine Fisheries Service 2001c).

An Australian publication of Ocean Watch Australia (Anon., 1998) (see Appendix 4), suggests that hooks that are in the soft tissue of the turtle's mouth should be pushed through and cut off. If this is not possible it recommends that the hook be removed by sharply hitting a piece of conduit that has been slid down the line into the turtle's throat, thereby dislodging the hook before releasing the animal. In order to prevent further damage to the turtle this technique is not recommended without adequate training by experienced turtle scientists or veterinarians. Although this technique may warrant further investigation as it has been shown to be successful with wild birds and domestic pets (Limpus, 2002 *pers. comm.*).

Australian situation

Line clippers, de-hookers and, in some cases, dip-nets may be useful for reducing the mortality of sea turtles as a result of Australian longline operations. The adoption of this equipment should either be mandatory or at least highly recommended.

A high proportion of Australian longline fishers who we interviewed expressed an interest in using a line clipper. They considered that it may be useful for their fishing operations, to help in releasing not only turtles, but also other unwanted bycatch species. One fisher already used a line clipper - a knife tied to a stick. A small number considered that a line clipper would not be useful because sea turtles were caught so infrequently, and it would get stored away or lost with other unused equipment on the vessel.

Establishment of a minimum standard for line clippers would be advantageous and it seems logical to consider the standard adopted on U.S. longliners, except, perhaps, for the minimum length requirement. Some Australian longliners are very close to the water-line and are able to reach hooked bycatch by hand, others are a number of metres off the surface of the water. The line clipper should be modified to suit the vessel but be capable of cutting the line close to the hook under typical fishing operations.

The research on de-hooking devices being conducted by U.S. researchers and fishers should be monitored by Australian managers and possibly adopted if shown to increase post-release survivability. In addition, it may be reasonable for interested Australian fishers to test possible designs themselves.

Dip-nets may be less useful given the large size of most turtles captured by Australian longline gear. Some fishers, however, may wish to acquire a type of dip-net if they felt it would be useful for their operations. Further monitoring on the size of sea turtles may identify areas where small turtles are caught and consequently where dip-nets would be useful. As with line clippers, the U.S. standard could be used as a guide, although the fishers will most likely have a better idea of what will work on their vessel.

Expected mortality

Generally, turtles are hardy, robust animals that recover quickly from most superficial, and many substantial, injuries (National Marine Fisheries Service, 2001e). Nevertheless, accurate estimation of post-hooking survival for longline caught sea turtles are important when developing fishery management plans and, ultimately, for the worldwide conservation of sea turtles (Parker *et al.,* 2001). Without adequate mortality estimates it is difficult to understand the effect of the longline fishery catch of sea turtles on sea turtle populations (Laurent *et al*., 2001).

Estimating mortality rates

The chance that a longline captured sea turtle will die is dependent on many factors: hooking status (entangled and released with no trailing line, entangled and released with trailing line, externally hooked, mouth hooked, internally hooked); if hooked, the depth of penetration; time on the line; whether it can reach the surface to breath; size and species of the sea turtle; environmental conditions at time of capture; turtle behaviour on capture (for example, the level of stress); and how it was handled by the fisher during the capture and prior to release (National Marine Fisheries Service, 2001e). In addition, the percentage of sea turtles caught by longliners that die as a result of the capture is extremely difficult to predict, with many turtles released alive but possibly dying at a later time. Data with respect to survival rates is limited, sometimes making it necessary to make unsubstantiated and questionable assumptions. It is equally difficult to nominate a reasonable time frame post-release. If the turtle dies a month later or longer, should it be automatically considered to have been as a result of the longline capture.

It has been reported from many longline fisheries that all, or almost all, hooked sea turtles are released alive (Achaval *et al.,* 2000; Arauz, 2000; Ferreira *et al*., 2001; Laurent *et al*., 2001; Oceanic Fisheries Programme, 2001). Their eventual fate is unknown (Witzell, 1996), and mortality estimates made by research programs around the world vary widely (Swimmer *et al.,* 2002a). Hooking injuries may alter a sea turtle’s diving ability, diving pattern or feeding ability which could ultimately result in it’s death.

Deep ingestion of a hook (deeply hooked) may eventually kill a sea turtle – perhaps puncture vital organs (Parker *et al*., 2001), cause infection, or pull organs from their connective tissue. There have been studies, however, that do not support the assumption that deep hooking results in mortality. Aguilar *et al.* (1995) reported a 29% post-hooking survival rate of sea turtles that had been captured by Spanish longline vessels between 1986 and 1991. These turtles had been transferred to recuperation facilities following the hooking event. There were records for 38 turtles of which: 11 died, six expelled the hook between 53 to 285 days after capture and without obvious injury to the turtle, 15 were released without expulsion of the hook, and six remained under observation.

The Aguilar *et al*. (1995) study has provided a basis for the estimation of mortality rates elsewhere including in United States studies. One such study, conducted by Skillman and Kleiber (1998), on the Hawaiian longline fishery, used a mortality estimate of 15.1% of all estimated takes from 1994 and 1995. This rate was based on the following assumptions:

- 4% of turtles caught were dead on retrieval (from observer data);
- 86.6% of captured turtles were hooked, rather than entangled (from observer data);
- 46.6% of those hooked had ingested the hook (from observer data); and
- post-hooking mortality of 29% for hooked turtles was based on the Aguilar *et al,* (1995) study.

When estimating mortality for the following year, 1996, Skillman and Kleiber (1998) used:

- the condition of turtles on release from observer data: turtles that had ingested a hook were assumed to have a 29% mortality rate;
- dead turtles were assigned a death rate of 1;
- turtles reported as 'OK' were assumed to live, and were assigned a death rate of 0;
- entangled turtles were assumed to live, and were assigned a death rate of 0;
- turtles with an unknown condition were assigned average death rates.

A similar mortality calculation was also used by McCracken (2000), who concluded that 17.5% of captured loggerheads would die from the longline encounter. These estimates have been noted to be likely to underestimate mortality rates, due to the assumption that all lightly hooked turtles were considered to live (National Marine Fisheries Service, 2001d).

A review of post capture mortality of sea turtles caught incidentally in the North Atlantic by United States longliners was conducted by the National Marine Fisheries Service (2001e; Part III, Chapter 4). This review, which considered available data on mortality rates and adopted a risk-averse approach, suggested a 50% mortality rate for all captured turtles. This relatively high mortality rate took into account the possibility of fishers not being as diligent as observers in removing hooks and trailing line from turtles.

In January 2001 NMFS (National Marine Fisheries Service, 2001d) recommended mortality estimates of:

- 0% for entangled turtles with no hook, that were untangled before release
- 27% for sea turtles with minor injuries (entangled turtles with an external hook, that were disentangled or de-hooked before release);
- 27% for sea turtles with moderate injuries (sea turtles entangled and externally hooked and trailing gear on release, or turtles that were hooked in the beak or mouth but not trailing gear);
- 42% for serious injuries (turtles hooked in the mouth or beak and released with the hook intact and trailing gear, or turtles that had swallowed the hook) and
- 100% for lethal injuries

These classifications were criticised as too high by fishers at the NMFS Technical Gear Workshop in January 2001. Fishers at this workshop also held the opinion that mortality rates were reduced following the adoption of recommended handling techniques and the use of dip-nets, line clippers and de-hookers (Anon., 2001c).

A Decision Memorandum, issued by U. S. NMFS on 16 February 2001 (cited in National Marine Fisheries Service, 2001d), recommended that assumed mortality rates should be:

- 0% for turtles that have not been hooked, do not show any signs of injury and have been completely disentangled;
- 27% for turtles that are hooked externally or entangled, with the line left on the animal;
- 50% for turtles that have been mouth hooked or ingested the hook; and
- 100% for turtles returned to the water dead.

These complex decisions and assumptions, often based on little evidence, and lack of agreement over mortality rates make it evident that there is an urgent need for further work on survival of turtles following capture by longline vessels.

Hooking criteria

The accurate estimation of mortality rates is reliant on guidelines for categorising the severity of the hooking event. It is reasonable to assume that lightly hooked turtles, generally mouth or externally hooked, have a greater chance of survival than deeply hooked turtles, meaning hooked further down the digestive tract. However, problems arise when attempts are made to correlate capture experience to survival. This implies the use of the severity of the hooking event, as commonly used to estimate mortality, may not be the only factor that should be considered.

Work and Balazs (2002) demonstrated that the severity of the hooking event might not be adequate to estimate the probability of mortality. They conducted necropsies on turtles, with different levels of hook injury, killed by longliners in the Northern Pacific.

As a means to estimate post-hooking survival rates, Parker *et al.* (2001) used satellite telemetry. From 1997 to 2000, 54 transmitters were deployed on loggerhead, olive ridley and green turtles that had been hooked by Hawaii-based longliners. Around a third of the turtles produced few or no transmissions, due to either the death of the turtle or failure of the technology. Analyses showed no significant difference between deeply or lightly hooked turtles with respect to duration or distance travelled, and a mortality rate was estimated at between 20% and 40%. Polovina *et al.* (2000) attached satellite transmitters to nine loggerheads taken in the Hawaiian longline fishery, four were lightly hooked and five deeply hooked. All turtles moved in a westerly direction with signals received from 2.2 to 6.9 months after release and turtles travelling from 1 311 to 5 199 kms. There was no difference reported between the lightly hooked and the deeply hooked turtles.

Entangled turtles

An assumption made by many scientists is that entanglement will not generally kill a sea turtle (Skillman and Kleiber, 1998). Witzell (1996) reported that the United States Western Atlantic longline fleet did not adversely affect leatherback populations as almost all leatherbacks interacting with longline gear were either externally hooked or entangled and were predicted to survive. In February 2001, NMFS issued a Decision Memorandum that if sea turtles were captured by entanglement and all line was removed before release it was reasonable to assume the turtle would not die (National Marine Fisheries Service, 2001d). However, if a hook was involved or gear was not completely removed, NMFS predicted a mortality rate of 27%.

Mortality could result from turtles being released trailing a significant length of fishing line. Tomas *et al.* (2001) reported an incident in which a turtle with an imbedded hook with line still attached was found with a smaller turtle entangled in the line. There is also the possibility of the turtle becoming snagged on fixed or floating objects in the water. Trailing fishing lines could interfere with feeding and breeding activities, affect the turtles mobility, and result in wounds and infection (National Marine Fisheries Service, 2001e). A further danger of trailing line, especially from an ingested hook, is the chance that the turtle will swallow the line. This could cause internal damage and may result in death (National Marine Fisheries Service, 2001d).

Hoey (2001), in his comments on the interim guidelines for determining serious injury of sea turtles taken incidentally by longlines, noted that a distinction needs to be made between lighter recreational fishing line and monofilament line used in longline gear. Monofilament line, which is relatively thick and strong but light in weight, does not tend to knot or tangle and, if tension is removed, will probably lose any tangles. In cases when a sea turtle is entangled without an embedded hook, Hoey (2001) predicted a high likelihood that the line will fall away when cut off the mainline. The high possability of a turtle being easily untangled once cut free, due to the nature of longline gear, was also noted by a number of Australian longline fishers who were interviewed. Recreational fishing line, on the other hand, will tend to remain tangled on the sea turtle.

Mortality examples

Examples of available mortality-related data and information are:

- The Sea Turtle Restoration Project observed nine longline fishing excursions within the Costa Rican EEZ and found that it was possible to release all turtles alive. They found it was possible to remove the hooks from all externally hooked turtles and to remove line from entangled turtles and release them unharmed. However, it was noted that although mortality at capture during observer trips was nil, the turtles' ultimate fate was unknown. Unfortunately for the turtles, fishers interviewed indicated that usually they would not attempt to remove hooks but either pull the hook out or cut the line, thereby getting rid of the problem as quickly as possible. This obviously would result in a far higher mortality rate than predicted if observer data alone was considered (Arauz, 2000).
- Greenpeace observers working on Spanish surface longliners in the Western Mediterranean in 1990 and 1991 reported that four out of around 1000 captured turtles, almost all loggerheads, were discarded dead. The removal of hooks was only possible with around 15% of individuals. It was also noted that some turtles had been caught more than once as they had other hooks attached. A mortality rate of between 20 and 30% was suggested as reasonable for longline hooked loggerheads (Aguilar *et al.,* 1995).
- Alexander Sutton, an American distant-water fishing-captain, reported personal opinions as a longline fisherman at an expert workshop on longline-sea turtle interactions in 1994. He noted that in eight years of experience longlining he had never seen a dead turtle on his longline gear and he doubted that any captured turtles would ultimately die as a result of the capture (Williams *et al.,* 1996).
- Observer reports from the Western tropical and sub-tropical Pacific Ocean from 1990 to 2000 reported that 26% of the 93 turtles caught by longline vessels were dead after capture and a

further 14% injured, stressed or barely alive. An additional two turtles were retained by the crew and eaten (Oceanic Fisheries Programme, 2001).

- In 1994 and 1995 scientific observers monitored the catch of target and bycatch species on Mexican longliners in the Gulf of Mexico. They reported an average sea turtle catch rate of five turtles per 100 trips. Most of the turtles were entangled in the monofilament fishing line and had an estimated survival rate of 66.7% (Ulloa Ramírez and González Ania, 1998).
- In 1988 and 1989 a questionnaire-based survey was sent to 72 Japanese research and training vessels. Of the 41 respondents 61% reported an incidental catch of sea turtles, mainly on tuna longliners and bottom trawlers. In answer to a question on the condition of the turtle on capture, 58 % of the respondents reported that turtles were alive and released and 42% reported that they were dead (Nishimura and Nakahigashi, 1990).
- Gerosa and Casale (1999) suggest a 10% probable mortality rate of sea turtles at the time of capture by longliners in the Mediterranean. This estimate excludes death at a later date from the injuries sustained.
- An observer program in the Mediterranean in 2000 reported that 70% of sea turtles hooked by the Greek longline fishery were released with a hook deep within the digestive tract (Laurent *et al*., 2001).

Australian situation

Most fishers who were interviewed reported that they had never seen a dead turtle on their longline gear. Two fishers reported seeing a dead hard-shelled turtle and one a dead leatherback in their gear. Most logbook records (98%) report a health status and, of these, very few turtles (4%) were returned to the water dead.

Observers on Japanese longliners in the 1990s reported that two out of 14 captured turtles were returned dead. All of the turtles identified as leatherbacks were released alive. In addition, there are few stranding records from the eastern and western coasts of Australia, of turtles beached or found floating in the ocean either injured or dead, that exhibit injuries consistent with being caught in longline gear. In 2002, both of the two turtle caught while an observer was onboard an ETBF longliner were released alive, although one retained a hook (Scott, 2002 *pers. comm.)*.

An average of two leatherbacks have been autopsied each year in Western Australian since the 1970s, with only one leatherback having swallowed what appeared to be longline monofilament fishing line (Prince, 2001 *in prep.*). In 2001, a loggerhead was rescued in Moreton Bay, Queensland, with what appeared to be a longline hook embedded in its mouth, the source of which is unknown (Limpus, 2001 *pers. comm.*).

Although few verified data on mortality rates exist, for a number of reasons, it may be reasonable to assume that in Australia mortality is relatively low for leatherbacks, the most commonly caught species. This is predicted because:

1. available data from other fisheries supports this assumption;
2. leatherbacks are rarely internally hooked;
3. longline gear will generally allow the turtle to reach the surface;
4. most fishers have adopted reasonable handling techniques.

The mortality rate would be expected to decrease if fishers possessed the appropriate equipment and knowledge to release entangled leatherbacks free of fishing line and hooks.

While reasons 1, 3, and 4 also apply for the less commonly caught hard-shelled turtles, it would be unreasonable to make the same assumption of low mortality for these turtles. Although a high percentage are reported in logbooks to be released alive their eventual fate is unknown given that many may be carrying hooks. Further research is needed before any definitive conclusion can be drawn on sea turtle mortality rates as a result of capture by Australian longline fishers.

Legal and regulatory setting

International legal and declaratory action

The highly migratory nature of sea turtles and widespread use of longline gear in national waters and on the high seas mean that bycatch issues are not the responsibility of any one country. The multinational nature of the problem makes the issue difficult to remedy and international cooperation is required to mitigate the impact of these fisheries on sea turtles. Impetus for action to combat the bycatch of numerous endangered marine species comes from both conservation and fisheries agreements. Australia has an obligation under a range of agreements to mitigate the bycatch of sea turtles.

As well as its international obligations, Australia and Australian fishers also have an economic incentive to minimise sea turtle longline bycatch. This relates to the U.S.'s past use of import embargoes to extend domestic actions and policies abroad, in particular in relation to marine wildlife bycatch. In addition to traditional action in intergovernmental forums and trade incentives, there have been a series of resolutions issued by scientific and expert based bodies, calling for a reduction in sea turtle capture in longline fisheries worldwide.

Conservation Agreements relevant to Australian sea turtle bycatch

Convention for the Conservation of Migratory Species of Wild Animals

The primary international conservation agreement relevent to turtle longline bycatch is that of the Convention for the Conservation of Migratory Species of Wild Animals (CMS) or Bonn Convention. Australia has been a party to this agreement for nearly two decades. The CMS was formed in response to the need to take particular action to conserve and protect migratory species due to their transboundary nature and its primary intention is to prevent such species from becoming endangered. It provides a framework for countries to cooperate towards a common goal of conservation of migatory species including the faciliation of intergovernmental agreements of treaties.

Under the CMS, species may be listed under one of two provisions (Table 4). These are:

- Appendix 1 species are those considered endangered and where the taking of these species is strictly prohibited. States within the species range must also, where appropriate, encourage the species' recovery and that of their habitats, and remove obstacles to migration and mitigate threats.
- Appendix 2 species are those with an unfavourable conservation status. Under Article IV, States are encouraged to create agreements that restore such migratory species to a favourable conservation status or to maintain their status

The word "agreement" is defined and explained in such a manner that any arrangements generated under Article IV may be binding or non-binding in nature, as is the want of negotiating States. Binding agreements require signature and ratification, and would provide a similar framework to that of a stand alone convention. They also commonly contain a funding formula and, hence, are able to provide a separate secretariat to administer and further implement the agreement. Appended to such agreements are Action or Conservation and Management Plans. These Plans contain the more specific management activities and are used to prioritise, monitor and track parties' conservation efforts. Appended Plans are intended to be living documents, refined over time to reflect best practice management and to guide the evolution of conservation measures in regard to the listed species.

Table 4 Sea turtle species listed under the Convention for the Conservation of Migratory Species of Wild Animals

Taxon	Common name	Date of entry
<u>APPENDIX I</u>		
TESTUDINATA (Cheloniidae)		
Caretta caretta	Loggerhead turtle	1979
Chelonia mydas	Green turtle	1979
Eretmochelys imbricata	Hawksbill turtle	1979
Lepidochelys kempii	Kemp's ridley turtle, Atlantic ridley turtle	1979
Lepidochelys olivacea	Ridley turtle, olive ridley turtle	1979
TESTUDINATA (Dermochelyidae)		
Dermochelys coriacea	Leatherback turtle, leathery turtle	1979
<u>APPENDIX II</u>		
TESTUDINATA (Cheloniidae)		
Chelonia depressa (=Natator depressus)	Flatback turtle	1979

At the last Conference of the Parties to CMS in November 1999 specific acknowledgement was made of the problem for migratory species that is posed by incidental capture in fishing operations. Resolution 6.2 on bycatch highlighted the problem of bycatch, particularly in relation to seabirds, turtles and marine mammals. It reaffirmed the obligation of all Parties to reduce the incidental capture of migratory species and called for strengthened measures for bycatch mitigation.

Over the last two years three new bycatch related accords have been negotiated and a range of CMS sponsored and/or organised training programs conducted. The particular agreement of relevance to Australia and sea turtles is 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 attached Conservation and Management Plan (CMS, 2001). Concluded and opened for signature on the 23rd June 2001, this Plan now has nine signatures, with a potential membership of more than 40 nations. Australia was one of the original signatories of the Memorandum of Understanding, and Conservation and Management Plan, which became active on 1 September 2001. The IOSEA MoU is a non-binding agreement, though it nonetheless carries a strong commitment by Parties to comply with and give effect to included measures. It contains a commitment to consider a timeline for its transformation into a formal treaty at the first meeting of parties, likely to be held late in 2002.

The issue of bycatch is addressed in both the Memorandum of Understanding itself and the appended Conservation Management Plan. The latter considers a range of issues, including habitat protection, management of direct harvest and trade, reduction of indirect threats, research, education, information exchange and capacity building. The first Objective is to "reduce direct and indirect causes of marine turtle mortality".

Activities under the plan that relate specifically to fisheries bycatch include:

- the identification and documentation of threats, including determination of those marine turtle populations affected by incidental capture;
- reduction to the greatest extent practicable of the incidental capture and mortality of marine turtles in the course of fishing activities;
- the development and use of gear, devices and techniques to minimise incidental capture of marine turtles in fisheries, such as gear modification and seasonal and spatial closures;
- the development of monitoring, control and surveillance procedures and training programs to promote the implementation of bycatch mitigation measures;
- information exchange and technical assistance;
- liaison and coordination with fisheries industries and management bodies with responsibilities in national waters and on the high seas; and
- the development and implementation of net retention and recycling schemes to minimise marine debris and ghost fishing.

Convention on International Trade in Endangered Species of Wild Fauna and Flora

Though not of direct relevance to the incidental capture of marine turtles, the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) is important to sea turtle conservation through its efforts to ensure there is not an unsustainable take and international trade in listed species. The CITES is intended to prohibit or regulate trade in endangered species according to the appendix under which they are listed. All species of sea turtles are listed in Appendix I of CITES, indicating that they are provided complete protection under this accord. The only significant issue of note in recent years in regards to CITES and sea turtles is that of trade in hawksbill turtle shell that is popular as jewelry and hair accessories, particularly in Japan where the substance is referred to as bekko. To date the two thirds majority needed to reopen the bekko trade has not been mustered in either of the last two meetings where Cuba has requested the “downlisting” (or assigning of a lower level of restriction on the trade in) of its population of hawksbill sea turtles. Notification has been given that the downlisting of the “Cuban population” of hawksbill sea turtles will be proposed again at the next Conference of the Parties to be held late in 2002. This submission has now been withdrawn pending further consultation.

(Australian Department of Foreign Affairs and Trade. Convention on the Conservation of Migratory Species of Wild Animals. Australian TreatySeries 1976, No. 26. AGPS: Canberra.

Australian Department of Foreign Affairs and Trade. Convention on International Trade in Endangered Species of Wild Flora and Fauna. Australian Treaty Series 1991, No. 32. AGPS: Canberra)

Fisheries Agreements relevant to Australian sea turtle bycatch

United Nations Law of the Sea Convention

Australia was one of the original parties to the United Nations Law of the Sea Convention (LOSC) when it entered into force in 1994. These regimes deal with most matters related to oceans and seas, and provides rules for the regulation of uses thereof. The LOSC includes provisions relating to the conservation and management of living marine resources both in States’ Exclusive Economic Zone (EEZ) and on the high seas.

Part V relating to the EEZ grants sovereign rights to coastal States for the purpose of exploration, exploitation, conservation and management of natural resources within their EEZ. States are empowered to determine the level of take of living resources in their EEZ, and to ensure proper conservation and management measures in relation thereto. In terms of bycatch, Article 61: 4 specifically requires that: 'In taking such [fisheries management] measures, the coastal State shall take into consideration the effects of species associated with, or dependent upon, harvested species with a view to maintaining or restoring populations of such associated or dependent species above levels at which their reproduction may become seriously threatened.'

In this regard the coastal State has the right to make laws and regulations for, inter alia:

- the determination of species that may be harvested and the establishment of catch quotas (for example, quotas on a stock or species basis, or vessel quotas, or seasonal or temporal catch limits);
- the season and areas open for fishing, and the size, types and amount of gear, or size, types and number of vessels;
- emplacement of restrictions on the age and size of species taken;
- requirements for and the use of observers or trainees on board fishing vessels; and
- the landing of all or part of the catch by foreign vessels in ports of the coastal State.

United Nations Food and Agriculture Organization Code of Conduct for Responsible Fisheries

The other major international agreement relating to bycatch, to which Australia is an active member, is the United Nations Food and Agriculture Organization (FAO) Code of Conduct for Responsible Fisheries. The FAO Code of Conduct was finalised and adopted in September 1995. Although a non-binding instrument, the Code of Conduct has strict bi-annual reporting mechanisms and, as such, considerable moral suasion is applied to States to comply. The Code considers the impacts of fisheries on the marine and aquatic environment, and several of its articles relate specifically to bycatch issues.

The general principles of the Code require that fisheries management measures ensure the protection not only of target species but also of non-target, associated or dependent species. States should ensure the use of selective fishing gear and minimise waste, discards and catch of non-target species (fish and non-fish), and reduce the impacts of fisheries on species associated or dependent upon the target species. States are urged to apply the precautionary principle in conserving, managing and exploiting fisheries resources.

In particular, Article 7.69 requires fisheries management authorities to promote the development and use of selective gear and efficient operational methods. Operational examples of bycatch reduction cited include the establishment of exclusion zones or closed seasons in certain areas and the use of technical measures such as gear modifications to prevent smaller unwanted species or individuals being trapped in the gear. Both States and fishers are encouraged to research gear selectivity. States are also required to improve their understanding of the status of fisheries by collecting appropriate data and exchanging information with all relevant groups.

Resolutions

IUCN Resolution on incidental capture of marine turtles in pelagic longline fisheries, 1998

In recognition of the threats posed to the long-term survival of sea turtles by longline fisheries worldwide, and the obligations derived from instruments such as the Convention on Biological Diversity, LOSC, CMS and the World Conservation Congress, in 1998 the International Union for the Conservation of Nature (IUCN) developed a resolution specifically addressing the incidental capture of marine turtles in pelagic longline fishery operations.

In its 1998 Resolution the IUCN community requested that the FAO, in cooperation with IUCN members, States and regional fisheries bodies, conduct a technical consultation to assess the magnitude of the incidental catch and mortality of marine turtles in pelagic longline fisheries worldwide. It further requested two actions in relation to International Plans of Action, which are formed as non-binding arrangements under the FAO Code of Conduct. International Plans of Action are negotiated agreements that deal with a particular fisheries issue, for example, the International Plans of Action for reducing incidental catch of seabirds in longline fisheries. They have regular reporting mechanisms and if a country considers that the particular issue is of direct relevance to them then a National Plan of Action is developed.

The IUCN Resolution urged all countries involved in developing a National Plan of Action on Seabirds and similar initiatives to ensure that measures prescribed thereunder do not negatively impact on marine turtles, which they state are also seriously threatened by longlining. They also requested that any mitigation measures developed to reduce the impact of longlining on seabirds and marine turtles are consistent and integrate with each other.

In addition, all States and relevant agencies were urged to develop an International Plan of Action addressing the impacts of longline fisheries on marine turtles. This was to be based on the outcomes of the technical consultation prescribed earlier. The IUCN community also urged all States and regional fisheries management organisations, in accordance with internationally established legal obligations, to take all possible measures for the immediate assessment of the magnitude of the incidental capture of marine turtles in pelagic longline fisheries worldwide and to reduce the incidental capture of marine turtles to the lowest levels possible. Several of these recommendations have been consistently pursued by major U.S. non-government organisations.

Annual Symposium on Sea Turtle Biology and Conservation, Resolutions 2000

The Annual Symposium on Sea turtle Biology and Conservation is a gathering of between 800 and 1000 of the world’s sea turtle experts, researchers, students, volunteers and government officials. In 2000 a resolution was passed urging governments and fisheries organisations to implement the use of adequate technologies which have been proven to reduce the incidental capture and mortality of sea turtles in longline fisheries operations. It also urged increased collection and distribution of information so as to allow the evaluation of the impacts of incidental capture on sea turtles and other threatened species captured in fisheries (Epperly and Frazier, 2000)

The Resolution also called for the prevention of the expansion of fisheries activities until further research has been conducted to determine the affect that these fisheries have on sea turtles and other marine species. Finally, the Resolution called for all nations who have not adopted the FAO Code of Conduct on Responsible Fisheries to do so.

ASIH Resolution Supporting Protection of the Pacific Population of Leatherback Turtles,2000

The Resolution Supporting Protection of the Pacific Population of Leatherback Turtles was issued by the American Society of Ichthyologists and Herpetologists in recognition of the uniqueness of the leatherback turtle as the only surviving member of the Family Dermochelyidae, and of their rapidly declining population. They urged all responsible industries, authorities and governments to take immediate action to reverse the observed population declines, and to ensure the continued survival of the Pacific populations of leatherback turtles.

Leatherback International Survival Conference - Leatherback Taskforce Resolution, 2002

Recognising the significance of the decline in leatherback sea turtles, in particular, the Pacific population, and desiring to save the leatherbacks from extinction, delegates to the Leatherback International Survival Conference passed a resolution that calls on the United Nations, and countries: 'to institute a moratorium on pelagic longline, gillnet and other fisheries harmful to Pacific leatherback turtles until such activities can be conducted without harm to the species, and provide allocations of transitional aid to affected fishers and communities.' Their resolution also asks for emergency funds to implement necessary conservation actions for the survival of the species (Source: *Environmental News*, 26 April 2002).

Not all delegates signed the resolution, as government officials were not so authorised and industry representatives would not sign a document requesting a moratorium on their operations. The diversity of participation does, however, indicate recognition of the problem and a widespread desire to find a solution.

Trade embargoes and marine wildlife bycatch

As already noted, highly migratory marine wildlife species cross national jurisdictions and the high seas such that activities in one jurisdiction may affect the overall status of the species worldwide. Those States with strict conservation laws frequently feel that they are shouldering an unfair burden, both in terms of responsibility for the conservation of marine wildlife and in terms of the impact these laws and regulations have on their related industries' competitiveness in domestic and global markets. To combat this perceived inequality, some countries opt to take one of two trade-based responses – multilateral or unilateral actions.

The first involves multilateral action negotiated at the international level, commonly trade measures applied through multilateral environmental agreements and regional fisheries management organizations. This has already occurred in particular relation to the bycatch of seabirds in longline operations, in the Convention for the Conservation of Antarctic Marine Living Resources and the FAO International Plan of Action on seabirds, as well as with respect to the incidental capture of dolphins in purse-seine nets in the Eastern Tropical Pacific. No formal intergovernmental or and regional fisheries management organizations attention has been afforded to sea turtle bycatch in longline operations. The second trade related option available involves unilateral action by one single country in order to affect some aspect of the quality or production method of an imported good. Both actions may come under scrutiny in regard to their compatibility with the rules of the world trading regime as established under the auspices of the World Trade Organisation (WTO).

Though the importance of the incidental take of marine wildlife is recognised by several regional fisheries management authorities and multilateral environmental agreements, the most significant action in regard to sea turtle longline bycatch reduction may well occur initially through U.S.

import embargo action. The U.S. has on several occasions unilaterally applied trade sanctions to further its environmental agenda by influencing the management policies of other countries and to 'level the playing field' for its industry. Though the application of embargoes is irregular and its impact on Australia varies from product to product, U.S. trade and sanction policies will continue to have a major influence on Australian fisheries.

Interestingly, the use of U.S. unilateral trade action has also precipitated multilateral negotiations and cooperative action. In regard to prawn embargoes this action has led to the creation of a sea turtle conservation treaty between Latin, South, North American and Caribbean States in the western hemisphere, and contributed to the conclusion of negotiations for a Memorandum of Understanding on Marine Turtle Conservation in the Indian Ocean and South-East Asia.

Multilateral trade action and the GATT

The interaction of WTO agreements and multilateral environmental agreements remains largely unresolved. This is one topic that was raised for further consideration at the first preparatory meeting of the Doha Round of trade negotiations held early in 2002. Article XX of the General Agreement on Tariffs and Trade (GATT) contains those articles that may be potentially acceptable grounds for commercial discrimination. In relation to the environmental impacts of fisheries, Article XX sub-sections (b) and (g) set out certain provisions. These read:

> Subject to the requirements that such measures are not applied in a manner which would constitute a means of arbitrary or unjustifiable discrimination between countries where the same conditions prevail, or a disguised restriction on international trade, nothing in this Agreement shall be construed to prevent the adoption or enforcement by any contracting party of measures:
>
> (b) necessary to protect human, animal or plant life or health; and
>
> (g) relating to the conservation of exhaustible resources if such measures are made effective in conjunction with restrictions on domestic production or consumption.

A country wanting to use Article XX has two hurdles to clear. First, it must establish the provisional justification for using Article XX by showing that sub paragraph (b) or (g) applies. Second, it must establish a final justification by showing that the measure in question does not contravene the *chapeau,* or introductory paragraph.

Two disputes that specifically consider the issue of marine wildlife bycatch have been heard under the WTO regime. The first of these is the tuna-dolphin controversy, which preceded the creation of the WTO and was heard under the GATT. Although raising a number of important issues, the structure of dispute settlement has been altered and the reasoning of the Dispute Settlement Body has advanced significantly since this case. The second case, that of the turtle-shrimp dispute, discussed in detail below, has most in common with the issue of longline sea turtle bycatch. The turtle-shrimp case relates to U.S. use of unilateral trade embargos in relation to shrimp (prawn) trawler sea turtle bycatch. Before outlining the turtle-shrimp dispute, to place the case in context, the application of unilateral sanctions by the U.S. is first considered (World Trade Organisation 1998a and b, 2001a and b).

Unilateral trade action

Trade sanctions, though rarely a first choice policy tool, have been used on many occasions to encourage one State to adopt or alter its behaviour to meet with the expectations of a foreign State or group of States.

In the marine arena, U.S. use or threat of trade embargoes has occurred in relation to:

- the Pelly Amendment prohibition on the importation of fish products in relation to Japanese whaling;
- the emplacement of yellowfin tuna import embargoes on nations that purse-seine for yellowfin tuna by a method of ‘setting on dolphins’, resulting in cetacean bycatch;
- the enactment of a trade embargo statute to support the UN resolutions on large-scale driftnetting; and
- the use of trade embargoes in regard to sea turtle bycatch in prawn trawling operations.

In addition to traditional trade embargoes, labels are sometimes used by a variety of countries or international organisations to reflect the environmentally safe (or otherwise) status of certain products. In particular, environmental or eco-labels have become commonplace in the U.S. and such schemes can in effect be as trade restrictive as outright embargo action. One of the best known of these is the dolphin safe label, used to indicate that no dolphins were ‘set-on’ in harvesting the tuna contained in the package so marked. So popular was this scheme in the U.S. that canneries backed its translation into law, such that in order to display the label a series of statutory requirements had to be met. Another scheme run by an non-government organisation in the U.S. is that of turtle-safe shrimp (Figure 10).

Due to the heavy restrictions placed upon U.S. longliners in regard to sea turtle take the establishment of such a scheme in the U.S. is likely to have the broad support of both the environmental lobby and fishermen’s associations. Moreover, with a turtle-safe label already established for prawn trawling, the extension of such a label to other fisheries would be rapid and relatively simple.

Figure 10 Turtle-Safe Shrimp Logo

Shrimp - trawl embargo by the U.S.

As already stated, the scenario most relevant to sea turtle longline bycatch was in relation to the incidental capture of sea turtles in shrimp trawls. U.S. extension of domestic legislation into the international arena occurred through the threat and eventual implementation of embargoes prohibiting the import of shrimp from countries that did not have sea turtle conservation measures equivalent to those of the U.S. Turtle-shrimp bycatch began as a domestic issue in the early 1980s, when the U.S. government introduced a requirement that all domestic shrimpers use gear modifications to reduce the mortality of sea turtles incidentally caught in shrimp trawls. In November 1989 this law was expanded through the enactment of section 609, so as to apply to all shrimp sold on the U.S. market.

Section 609 placed two requirements upon the U.S. government. The first required negotiation with foreign nations for the development of measures to ensure sea turtle protection in shrimp harvesting operations. The second created a process whereunder nations or fisheries desiring to export shrimp into the U.S. must be certified by the U.S. government. Without certification of an equivalent program to the U. S. the exporting country would be prohibited from exporting shrimp and derived products into the U.S. Equivalence was, by and large, interpreted to mean that those countries with prawn trawl fisheries that interact with sea turtles must use turtle excluder devices in their nets (Table 5) (Departments of Commerce, Justice and State, the Judiciary and Related

Agencies Appropriations Act of 1999, Pub. L. No. 101-162, 103 Stat. 1988, 1037 (1989), §609, Conservation of Sea Turtles: Importation of Shrimp).

Australia was among the countries originally embargoed. Though these restrictions have been lifted in regard to the Northern Prawn Trawl Fishery and the Spencer Gulf Prawn Fishery, they still apply to the East Coast Trawl Fishery and all of the Western Australian fisheries.

Table 5 U.S. Turtle-safe shrimp certification

Section 609 certification is available to:

- countries with a fishing environment that does not pose a threat of incidental takings of sea turtles because of:
  - a) an absence of the species within its jurisdiction,
  - b) exclusive use of harvest methods which do not pose a threat to sea turtles, or
  - c) whose commercial harvest occurs exclusively in areas where sea turtles do not occur; or
- harvesting nations that provide documentary evidence of the adoption of a regulatory program governing the bycatch of turtles in shrimp trawling operations to the effect that:
  - a) requirements to use turtle excluder devices (TEDs) are comparable in effectiveness to those in the US – that is a 97 percent turtle exclusion rate, and
  - b) credible enforcement including monitoring, compliance & appropriate sanctions

Australian situation

Disruptions to international trade activity have the potential to significantly and increasingly impact upon the Australian fishing industry. Of particular concern in Australia in regard to turtle longline bycatch are the SWTBF, and the ETBF, both of which are expected to expand their operations in the future. Currently, these fisheries have a combined annual value more than $50 million, the vast majority of which are export earnings to the U.S. and Japan (Caton, 2002).

Furthermore, evidence suggests that Australian tuna longline fisheries may have what U.S. authorities would consider to be a potentially significant take of sea turtles. Australia's ability to preempt or respond to any threat of trade action is vital in light of the possible use of trade measures.

Future action

Since the turtle shrimp case additional information in regard to the impact of longline fisheries on several species and, in particular, on Pacific populations of sea turtles has emerged. Should a similar situation arise and case occur in regard to sea turtle longline bycatch, many of the same arguments would be heard and much of the same reasoning applied. Given the fact that the U.S. has been making fairly consistent efforts to engage the international community in longline sea turtle bycatch mitigation efforts, there is sufficient evidence to suggest that any U.S. unilateral action, no matter how unpopular, may be found to be in compliance with the WTO.

The issue of sea turtle longline bycatch has been raised internationally in the FAO forum, both in regard to its consideration in the preparation of National Plan of Action on seabird documents, and in relation to the possibility of a more detailed consideration of the sea turtle longline bycatch issue through a consultation or the creation of a separate International Plan of Action on sea turtles. No consensus on this issue was reached.

Legal and regulatory action in the United States and Australia

Although many countries have data collection schemes and laws to prevent deliberate capture or handling of sea turtles, or even general bycatch mitigation arrangements, there have been very few regulatory or legislative schemes established specifically to mitigate or eliminate longline sea turtle bycatch. The only jurisdiction where such action has been taken is the U.S.

United States of America

Over the past several years, the problem of the incidental capture of sea turtles in longline fisheries has become a central issue in U.S. fisheries management and conservation policy (Crouse, 1998 and 1999). Over the last two years the U.S. has closed a significant portion of its Western Pacific longline fishery and has championed the issue of control of the incidental take of sea turtles in the international arena.

Domestic U.S. developments have occurred in both the courts and legislature as well as through research into gear development to mitigate the incidental take (Gerrior, 1996). There has been consideration by the U.S. of the potential use of sanction action (embargo), and these discussions are likely to intensify. As such an understanding of and attention to the developments in U.S. will help to anticipate any U.S. action prior to its occurrence.

In the U.S. there are two separate longline fisheries, dealt with as distinct entities, having potentially significant interactions with sea turtles. These are the Atlantic highly migratory pelagic fishery and the Hawaii-based pelagic longline Pacific fishery. A basic chronology of each of these fisheries is provided in Appendix 2. Sea turtle longline bycatch efforts in the U.S. are driven by provisions of two main statutes, the Endangered Species Act and the Magnuson Stevens Fisheries Conservation and Management Act.

U.S. Endangered Species Act

The U.S. Endangered Species Act (ESA) provides that each U.S. Federal agency is required to ensure that particular agency action (such as the granting of permission to fish) does not jeopardise the continued existence of threatened, endangered or listed species, or critical habitat. To do so, these Federal agencies must assess the impact that the nominated activity will have upon an endangered or threatened species using the best scientific and commercial data available.

Endangered Species Act Biological Opinion

This assurance and assessment is done through a formal process referred to as an ESA section 7 consultation, which results in a Biological Opinion. A Biological Opinion includes in it an assessment of the health of the species and populations thereof, and the impact that the particular proposed or occurring activity will have upon the species or a group of species in the future.

Reasonable and Prudent Alternatives

If “jeopardy” or adverse impact is found for an agency action, then reasonable and prudent alternatives must be devised. As suggested by the name, then reasonable and prudent alternatives are a series of alternative actions. They provide advice to the government on its actions so as to ensure that the proposed activity will not jeopardise listed species or habitat and thereby violate the requirements of the ESA.

Reasonable and prudent alternatives must be:

- consistent with the intended purpose of the action;
- within the scope of the Federal agency's authority and jurisdiction;
- economically and technologically feasible;
- approved by the Fish and Wildlife Service or the National Marine Fisheries Service (NMFS) Director as being measures that will avoid the likelihood of jeopardising the continued existence of listed species or avoid the destruction or adverse modification of designated critical habitat.

Incidental Take Statements

In cases where some incidental take is unavoidable, an Incidental Take Statement must be included in the Biological Opinion. They are issued so as to allow for a no jeopardy finding, that is, allowing agencies to undertake otherwise prohibited acts so long as they comply with the instruction contained therein. An Incidental Take Statement will firstly specify the permissible amount of take and mortality of the species. Further instructions come in the form of Reasonable and Prudent Measures and associated Terms and Conditions. Reasonable and Prudent Measures are non-discretionary actions deemed necessary or appropriate in order to minimise the impact of incidental takings. The Terms and Conditions elaborate on the Reasonable and Prudent Measures, and the agency must comply with these in order to implement the Reasonable and Prudent Measures. For example, in the 29 March 2001 Biological Opinion for the Western Pacific (Hawaii-based) pelagic longline fishery a series of then Reasonable and Prudent Alternatives were suggested. These options were intended to act as one alternative, not five independent alternatives. They are: the restrictions on the use of swordfish style fishing, time area closures for tuna style fishing, limited access permit restrictions, fishing technique and gear modification research, and reduction of the harmful effects of fishing gear interaction. In addition an Incidental Take Statement was issued. The estimated permissible take and mortality and three Reasonable and Prudent Measures each with a series of Terms and Conditions are provided in Table 6.

Conservation Programs

In addition to the compulsory components of a Biological Opinion, section 7 of the U.S. ESA directs Federal agencies to further the objectives of the Act by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are contained in the Biological Opinion. These are discretionary agency activities which may usefully assist in fulfilling obligations established under section 7. For example, actions to minimise or avoid adverse effects of a proposed action, to help implement recovery plans, or to develop information.

Reiteration

Reiteration of formal consultation and revision of a Biological Opinion is required where:

1. the amount or extent of the incidental take specified in the operative Incidental Take Statement is exceeded (requiring immediate initiation of formal consultations);
2. new information reveals that agency action may affect listed species or critical habitat in a manner or extent that is not considered in the current Biological Opinion;
3. the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in the Biological Opinion; or
4. a new species is listed or critical habitat designated that may also be affected by the action.

Magnuson-Stevens Fisheries Conservation and Management Act

In addition to ESA measures, U.S. longline bycatch rules are issued also under the Magnuson-Stevens Fisheries Conservation and Management Act (FCMA (section 305(c), and 50 CFR Part 660). This is the statute that creates fisheries management plans under which most U.S. fisheries are managed, and it is this authority that NMFS relies upon in implementing the requirements of Biological Opinions through rule making in the federal register. In addition when an issue is pursued through litigation and a Court Order is issued, FCMA rule making is used to implement this.

Table 6 29 March 2001 Biological Opinion limits, measures and terms and conditions for the Western Pacific pelagic longline fishery

Species	Annual estimated incidental take	Annual estimated incidental mortality
Green turtle	14	9
Leatherback turtle	26	12
Loggerhead turtle	0-5	0-2
Olive ridley turtle	67	59

Reasonable and prudent measures	Terms and conditions
Data collection on capture, injury and mortality as well as life history information	Continuation or establishment of observer programs in Hawaii based longline fisheries-data to include information on the turtle catch, gear and set, life history, tags on turtles. Also data assessment on an at least quarterly basis
	Coordinate with the Forum Fisheries Agency observer program to collect the same above information.
Establishment of a system to determine basic bycatch data in the troll and handline fisheries	Due to a series of legal impediments NMFS will need to develop an anonymous survey to gather data.
At sea disposal of sea turtle mortalities unless otherwise requested by NMFS	Prohibition on the consumption, landing, sale, offloading, transhipping or keeping below deck of dead turtles without specific permission.

Hawaiian Pelagic Fishery Developments

As seen through the interaction of Rule making to other events, the Hawaii Pelagics fishery developments have been heavily influenced by a series of court cases. The initial allegation in *Centre for Marine Conservation et al.v NMFS et al.*(CMCvNMFS) was that NMFS violated federal law in connection with the incidental taking of sea turtles by the Hawaii-based pelagic longline fishery. The lawsuit alleged that the Biological Opinion was inaccurate and that NMFS had violated the Endangered Species Act by failing to adequately protect sea turtle species, and in particular, were endangering the continued existence of the leatherback turtle population which had become severely depleted over time due to the impacts of the longline fishery and other factors. The suit also alleged that the NMFS' failure to prepare an Environmental Impact Statement for the fishery violated the National Environmental Policy Act.

Subsequent court action resulted in the partial closure of the Hawaiian longline swordfish fishery. This was anticipated to result in an annual loss in landings of approximately $US17.6 million. Unsurprisingly one aspect of the response to this decision and related gear modification requirements has been the call for extension of this U.S. domestic law to countries whose longline fisheries bycatch includes sea turtles. Indeed, in the June 14 2001 Biological Opinion, NMFS was instructed to:

> "focus efforts on the broader impacts that occur to loggerhead and leatherback populations throughout the Atlantic by using its available legal authorities to pursue bilateral or multilateral agreements for the protection and conservation of sea turtles with other nations whose commercial longline fleets may affect sea turtle conservation (p126 of the BO)."

Australian legal framework

Similar to the U.S. scheme, Australia's national bycatch focus is found in two statutes: the Fisheries Management Act 1991 and the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act).

Environment Protection and Biodiversity Conservation Act

Australian requirements to protect marine species are provided under the Environment Protection and Biodiversity Conservation Act, which imposes high standards upon fishing in Commonwealth waters. The EPBC Act functions through the identification of six matters of national environmental significance. Those relevant to commercial fishing are:

- listed threatened species and ecological communities including in world heritage areas;
- listed migratory species; and
- Commonwealth marine areas.

Taking of an action (that is project, development, undertaking, activity or series of activities) that will affect a matter of national significance is an offence unless some form of exemption or authorisation is granted under the EPBC Act. Penalties for taking an action that will have a significant impact on, for example, a migratory species, without some form of statutory approval, may attract a civil penalty of up to $550 000, or a criminal penalty of $46 200, or in extreme cases up to seven years imprisonment.

The application of protected species provisions under the Commonwealth legislation as they apply to Commonwealth and state fisheries management beyond their physical jurisdiction but within Australian waters have been traditionally ill defined. The EPBC Act partially removed this uncertainty in section 23 where provision is made to accommodate the intention of Offshore Constitutional Settlement fisheries arrangements. This prohibits the taking of an activity, without approval, in state/NT or Commonwealth waters in respect of a fishery managed under Commonwealth law that is likely to have a significant impact on the environment. Conversely, fishing managed under state law is exempt from EPBC Act requirements in terms of NES triggers even when in Commonwealth waters.

The EPBC Act establishes four categories of protected species, all of which are relevant to commercial fishing, as follows:

- listed threatened species;
- listed migratory species;
- cetaceans; and
- certain taxa of marine species.

The EPBC Act imposes a series of requirements on actions, affecting the species within the classifications above, that are to be met before the bycatch of these species will be deemed not to be illegal. The EPBC Act is structured in such a way that a species can be listed under one category only. For example, a species that is migratory is not eligible to be treated as a marine species. Migratory species are defined as all those species listed under specific international agreements, which includes the Convention on the Conservation of Migratory Species of Wild Animal (see Table 5).

At the time of listing 'threatened species' are allocated into one of several categories. The categories are:

(a) extinct;	(b) extinct in the wild;
(c) critically endangered;	(d) endangered;
(e) vulnerable;	(f) conservation dependent

The same obligations relating to protection and recovery apply to all categories except extinct and conservation dependent species.

Marine Turtle Listings

All marine turtles that occur in Australian waters are special category listed under the EPBC Act. The loggerhead turtle is considered endangered and the hawksbill, flatback, green, olive ridley and leatherback sea turtles are all categorised as vulnerable species.

As such, all sea turtle species for the purposes of the EPBC Act' regulatory framework fall under the conditions applying to listed threatened and migratory species. Recklessly killing or injuring a member of a listed threatened or migratory species or community in Commonwealth areas is an offence. In addition, an offence is created if a person takes, trades, keeps or moves a member of a threatened or migratory species in a Commonwealth area. Strict liability applies to these provisions, that is, an offence is created regardless of intent or fault. An action is, however, not considered to be an offence if it meets one of several criteria, including:

- taken by a holder of an active permit;
- provided for in a recovery plan;
- taken in accordance with an accredited management plan;
- taken in a humane manner to relieve or prevent suffering by an individual of a listed threatened species; or
- the action is necessary to prevent a risk to human health or an emergency involving serious threat to human life or property.

Fishery Management Plans

The Commonwealth Minister for the environment may accredit fishery management plans under the EPBC Act. If such are not accredited, then individual fishers will need to obtain permits to cover the take of listed species. In regards to threatened and migratory species, reporting requirements exist for those fisheries not covered by an accredited management plan. A separate provision applies for accreditation of fisheries management plans which provides that the Minister may accredit a plan of management within the meaning of the Commonwealth Fisheries Management Act or made by a State or self governing territory if s/he is satisfied that two requirements are met.

These are that:

- the plan requires perons engaged in fishing under the plan to take all reasonable steps to ensure that relevant species are not killed or injured as a result of the fishing; and
- the fishery to which the plan relates does not, or is not likely to, adversely affect the conservation status of a species or a population of that species.

The Commonwealth Fisheries Management Act also provides that plans of management for a fishery must include actions to reduce to a minimum incidental catches of other commercial and non-target species.

Amendments to the EPBC Act also provide for Commonwealth regimes (as distinct from management plans existing under law) to be accredited for the purposes of bycatch, if 'the plan or regime requires the persons engaged in fishing under the plan or regime to take all reasonable steps to ensure that members of listed threatened species are not killed or injured as a result of the fishing.' The effect of these amendments is to allow for accreditation of Bycatch Action Plans created under the Commonwealth Bycatch Policy (see Appendix 3 for summary of the Tuna Bycatch Action Plan).

National and Commonwealth fisheries bycatch policies

National and Commonwealth fisheries bycatch policies were released in late-1999 and mid-2000. These were formulated to address the direct and indirect impacts of fisheries on aquatic environments. Both policies describe the problems and issues associated with bycatch and set out a series of underpinning principles. Broadly stated these principles are based on developing cooperative approaches to protect and manage marine resources, including bycatch. The guiding principles also include reference to precautionary decision-making and the sustainable use and management of fisheries. The three policy sub-objectives of the Commonwealth Plan are to:

- reduce bycatch;
- improve protection for vulnerable species; and
- arrive at decisions on the acceptable extent of ecological impacts.

Bycatch Action Plans

The bycatch policies also provide a framework for the development of bycatch action plans. Checklists to assist in the preparation of bycatch action plans are included in the Commonwealth Policy (see Appendix 3). The lists are intended to help identify and define specific bycatch issues and actions to address those issues. The policies also provide information on the bycatch actions being taken at the Commonwealth, and state/territory level.

Permits by the Minister

Where no such accreditation has taken place, the EPBC Act also provides for the granting of permits by the Minister. In order to issue a permit the Minister must be satisfied that one of four conditions is met. Of these four conditions only one relates to bycatch. The relevant provision requires that the impact of the action must be incidental to, and not the purpose of the action. Several additional and subsidiary conditions must also be met. These are that:

- the taking must not adversely affect the conservation status of the species/population;
- the action must not be inconsistent with a wildlife conservation or recovery plan; and
- the permit holder must take all reasonable steps to minimise the impact of the action on that species.

Recovery Plans

In regard to the second of these, under the EPBC Act recovery plans are required to be formulated and to come into force for between two and five years depending on the category of threat to which a species is assigned. The intention of a recovery plan is the improved health of a species. The intention is not to prohibit activities, but to emplace conditions so as to ensure that the recovery of the species or some other conservation goal is not impeded. A Commonwealth agency must implement and may not act in a manner that contravenes a recovery plan. The Commonwealth has, to date, created a draft recovery plan for marine turtles in Australia.

Draft Recovery Plan for Marine Turtles in Australia

The Draft Recovery Plan for Marine Turtles in Australia was prepared in 1998. The overall objective of the draft recovery plan is to reduce adverse impacts on Australian stocks of marine turtles and, in doing so, promote their recovery. The plan also outlines specific objectives for marine turtles in Australia which include, *inter alia*, a reduction in marine turtle mortality and increase in their natural survivorship where possible; management of factors affecting marine turtle nesting; and identification, monitoring and protection of critical marine turtle habitats.

Actions in the draft recovery plan directed towards the reduction of bycatch in fisheries include:

- legislating for mandatory use of TEDs in all vessels in the Northern Prawn Fishery; and
- developing a bycatch reduction programme for several predominantly trawl and gillnet fisheries in Western Australia, Queensland and the Northern Territory.

The public draft version of the Recovery Plan released in 1998 does not identify longline bycatch as a threat to marine turtles. However, in light of the emergence of longline/turtle interactions as an issue of considerable concern, the issue of longline sea turtle bycatch will likely make mention in the final Recovery Plan. Following extensive review and public consultation it is currently being considered by the Minister for the Environment and Heritage, for approval.

Strategic Assessments

Also under the EPBC Act are provisions requiring the conduct of strategic assessments for all Commonwealth fisheries within five years of the Act coming into force. A strategic assessment is an assessment of actions that may be carried out under a proposed policy, program or plan. It allows for the early assessment of the cumulative impacts.Bycatch is specifically included as an issue to be considered as part of the overall strategic assessment. The Terms of Reference (see Appendix 3) require assessment of the ecologically sustainable nature of the fishery in terms of its impacts on non-target species and bycatch and the ecosystem (including habitats) in general. Strategic Assessments, conducted by AFMA, will also meet the requirements of Schedule 4 of the Wildlife Protection Regulation of Exports and Imports Act 1982 (WP (REI) Act). The tuna strategic assessment will be out for comment in 2002.

Management alternatives

There are various management alternatives that could be implemented to reduce the catch and mortality of sea turtles by longline fishing operations. Irrespective of the management measures adopted there are several fundamental elements if they are to be successful, including: evaluation of the scale of the issue; definition of objectives; consideration of any factors that may result in the objectives not being met; monitoring before and after the scheme is put into effect to evaluate effectiveness; and deciding on the course of action if the measures are not meeting expectations or changes are necessary. A possible alternative, not listed here, is 'no action'. This, however, is not recommended given the possible national and international implications of ignoring the issue of sea turtles interacting with Australian longline gear. Alternative measures that could be considered are:

Fishery closure

At present there is only one management option that will absolutely prevent sea turtles interacting with longline operations – complete closure of the fishery. The differentiation between a whole fishery closure and an extended area closures is debatable. Some closures considered to be fishery closures, could equally be considered as area closures if fishers are able to move to another location to fish.

An example where this option has been implemented is the United States Hawaiian-based swordfish fishery. Following many years of discussions, workshops, Environment Impact Statements, Biological Opinions and court cases, District Judge David Ezra issued an order in March 2001 banning targeting of swordfish by United States longliners from the equator to the North Pole in the Pacific Ocean. Also closed was a 1.9 million square mile fishing ground south of Hawaii to Hawaiian longliners targeting tuna during April and May (Anon, 2001d). A proposed rule to close the northeast distant statistical reporting area (NED), 2 630 thousand square nautical miles of fishing grounds that includes the Grand Banks and other fishing locations, to U.S. longliners was offered for public comment in the Federal Register: April 10, 2002 (Vol. 67, No. 69). It is estimated that this closure would reduce leatherback and loggerhead captures in this fishery by 58 and 67%, respectively. The lead-up to this proposed fishery closure is documented in the next section under Area Closures.

This approach has been questioned with various reasons put forward why it may not be an appropriate management option. Reasons include: will the displaced vessels move to other fisheries, possibly where turtles are also caught (Anon., 2001a); do vessels from other nations catch, and kill, significant numbers of turtles in the closed area (Anon, 2000); will vessels from other nations replace the banned vessels, or increase their effort, thereby not actually reducing turtle mortality in the area (National Marine Fisheries Service, 2001b); does the management want to destroy the fishing industry and negatively affect other related industries; and will the ecologically sustainable development objectives of fisheries management be met (Anon., 2000). A further negative of this approach is that if a fishery is closed down then research on reducing the sea turtle catch and reducing the mortality rates that may ultimately allow the fishery to reopen will be vastly restricted. This has already been demonstrated with the Hawaiian longline fishry where scientists have resorted to conducting sea turtle satellite tagging research in relation in longlines in other countries (Swimmer *et al*. 2002b). This relevance of this issue, however, is debatable.

Australian situation

Australian waters have been closed to foreign fishing vessels for many years now so any closure would not be in danger of foreign vessels legally entering and replacing the domestic removals. Regardless of this, fisheries closures are a last resort option. If commercial fisheries are to continue there should be an emphasis on alternate ways to reduce turtle capture and mortality, and effective means to implement such solutions.

Reduction of effort

An across the fishery reduction of fishing effort may reduce sea turtle take depending on the distribution of the effort reduction in relation to the distribution of the sea turtle catch rates. An expected outcome would also most likely be a reduction in target catch. A more reasonable approach, that may reduce sea turtle catch but result in less impact on the fishery, may be for a targeted reduction of effort, either spatially or temporally (Kleiber and Boggs, 2000).

Australian situation

A reduction in effort over the ETBF and SWTBF is not expected to result in a proportional reduction in sea turtle catch. This is due, in part, to the suspected aggregated nature of sea turtle catch over the fishing grounds. One possible negative outcome for an across-the-fleet reduction in effort could be an effort decrease in less productive areas resulting in an increase in fishing effort in more productive target catch areas. These areas may also be more productive areas for sea turtle catch, ultimately resulting in an increase in sea turtle catch and a decrease in fishery profit. This management approach is not recommended.

Area closures

There is a logical relationship between sea turtles, in addition to many other sea creatures, and environmental conditions. Some marine animals tend to aggregate in, or as a result of ocean currents are drawn to, areas where their food sources gather. Up-welling or convergence zones are often where there are interactions between current systems and are areas of high biological productivity. Such fronts are expected to provide productive feeding sites for foraging turtles: eating both floating prey and prey attached to floating objects (Parker *et al.,* 2002). These areas are often also productive for target species, like broadbill swordfish, and consequently concentrate fishing effort. Waters off the eastern United States, with complex circulatory and thermodynamic systems, are productive fishing grounds and areas of high turtle catch (Witzell, 1999).

Sea turtle satellite tracking results from the North Pacific suggest the possible usefulness of area and/or seasonal closures to reduce sea turtle capture by longline gear. In 1997 and 1998 the nine loggerheads caught by longliners in the central North Pacific that were fitted with satellite transmitters travelled westward along convergent fronts and against prevailing currents (Polovina *et al.,* 2000). This study was extended to include all data from 1997 to 2000. Transmitters were attached in total to 26 juvenile loggerheads and 10 juvenile olive ridleys caught by the Hawaiian-based longline fishery. The loggerheads tended to travel westward, moving north and south seasonally through the area from 28° to 40°N in waters from 15°–20°C. Fronts, eddies and geostrophic currents were found to be important forage and migration habitats for this species. Olive ridleys, on the other hand, mainly occupied habitats further south (8°–31°N) and in warmer waters (23°–28°C). They also tended to be associated with major ocean currents, both eastward and westward (Polovina *et al.,* 2002).

If there are areas containing high concentration of sea turtles, in which longliners also fish, there is the opportunity for area closures that may significantly lower the interaction of sea turtles and longlines. This targeted reduction in effort might significantly reduce turtle take, without negatively impacting on the fishery as would be experienced with a complete fishery closure. A confounding factor is that these areas of high turtle catch may also be areas of high target species catch. Consequently, this approach would require flexibility on a spatial and temporal scale (Kleiber and Boggs, 2000).

A reduction in effort on fishing grounds and during seasons of high turtle catch was noted by Laurent *et al*. (2001) as potentially the most effective management measure that could be implemented in the Mediterranean. The problem of defining the most appropriate closures within the ever-changing pelagic environment, and when implementation would also be an issue, may be very difficult. Nonetheless, Oravetz (1999) in his examination of incidental capture of sea turtles by fisheries lists the reduction of longline effort on areas of sea turtle concentration as a possible method to reduce turtle take.

The United States used this management strategy when pelagic longlining operations were temporarily closed from 10 October 2000 through to 9 April 2001 in a 55 970 square nautical mile L-shaped area of the Northeast Distinct Statistical Reporting Area (NED), which includes the Grand Banks and other fishing grounds in the north Atlantic Ocean (National Marine Fisheries Service, 2001b). It was found that within this area of the fishing ground sea turtles congregate at that time of year, and so a closure was deemed the most appropriate way to protect large numbers of sea turtles. Following the tabling of a Biological Opinion by NMFS in June 2001 (National Marine Fisheries Service 2001d), an emergency-rule closure for the whole NED area was effective from 15 July 2001 through 9 January 2001 (Federal Register: July 13, 2001; Vol. 66 No. 135). This was followed by an emergency rule further extending the closure to 8 July 2002 (Federal Register: December 13, 2001; Vol. 66 No. 240) and a proposed permanent closure of the whole fishery (as reported in the Fishery Closure section above).

Australian situation

Unfortunately, all Australian longline fishers interviewed indicated that they were not aware of any areas of high sea turtle catch within their fishing grounds. Nevertheless, this does not preclude the possibility of area closures in the future if such areas could be identified. Further research into the spatial and temporal aspects of sea turtle catch by longline vessels is needed before area closures should be considered. In addition, the decision to establish any closure – seasonal or spatial – should consider not only the bycatch of sea turtles, but also its effect on the target catch.

Tactical operational modifications

There are various operational changes that fishers could adopt that may reduce sea turtle take. Factors that have been shown to, or may, affect sea turtle take and/or mortality, including:

Move after encountering a turtle

There have been some documented instances where sea turtle catches tend to aggregate. Consequently, there have been recommendations in some fisheries for fishers to move after encountering their first turtle to reduce the likelihood of catching more turtles. An evaluation of the proposed final rule for Atlantic fisheries (National Marine Fisheries Service, 2002d) suggests that such action might decrease the sequential catches of sea turtles and should be considered pending further investigation. Meanwhile, NMFS encourages fishers to move 1nm before deploying gear following an interaction with a sea turtle on a voluntary basis.

Float line distance

In cases where hooks are set under, or close to floats, sea turtle catch may be reduced if the distance between the first hook-line and the float-line is increased (Kleiber and Boggs, 2000). The success of this modification depends on whether the turtles are actually being attracted to gear by the float, which is indicated by preliminary studies.

Depth

If it is assumed that sea turtles are less likely to be caught by deeper hooks, as has been demonstrated for various longline fisheries, then setting gear deeper is an obvious gear modification that may reduce sea turtle take. Unfortunately, for this approach to be successful the target catch must not also be significantly reduced (Kleiber and Boggs, 2000). However, this option may be viable if there are alternative target catches.

Guarded hook

An idea suggested by Balazs and Pooley (1994) was the possibility of designing a hook that could be disabled at shallow depths but become active at greater depths. The success of this type of approach would depend on the sea turtles being less likely to be caught at greater depths, and vice versa for the target catch. At this stage this approach is untested.

Time and length of set

It may be possible to change the time of setting and hauling of longline gear to reduce the chance of sea turtle capture. Unfortunately, the vulnerability of sea turtles to capture at different times of the day is not known. Related to time of set is also the possibility of reducing soak-time to lower sea turtle captures and reduce stress of turtles. The success of this approach would depend on the catch characteristics of the target catch. For example, if the target catch are caught within the first few hours of the shot and sea turtles caught throughout the whole time the gear is in the water, then this approach may be successful in maintaining fish catch and reducing turtle catch. However, if catch of the target fish increases with soak-time then this approach may disadvantage the fishers (Kleiber and Boggs, 2000).

It may be possible to reduce turtle capture through modification of soak time. One recent study found, in regard to loggerheads, a concentration observed in the last quarter of each set. This suggests that at least for some species there may be a correlation between soak time and level of take, and that modifying either the length of the mainline or the total soak time may lead to a reduction in capture (Watson, 2002).

Reducing sea turtle mortality

Since October 2000 United States longliners have been required to carry and use two pieces of equipment that may increase a hooked sea turtles' chance of survival (Anon., 2001b). These are a dip net and a line clipper, as discussed previously. The dip-net is a mesh net on the end of a long pole used to bring small turtles onto the deck without inflicting further injury onto the turtle. Further injury may be a result of trying to land the animal by pulling it in using the line. If it is not possible to retrieve the turtle the line clipper, a long pole with an attached protected cutting blade, may allow the fisher to cut the fishing line close to the hook while the turtle is still in the water. This may prevent the turtle becoming further entangled by the line or the line becoming tangled with something else and endangering the turtles' life. There has been reported evidence that trailing line can endanger sea turtles. De-hookers would also be beneficial if hooks could be removed. There are various designs of de-hookers that could be used on turtles that have been retrieved onto the deck and also turtles still in the water.

In 2001, line clippers and de-hookers were found to be very effective for removing gear from leatherbacks caught by experimental chartered longliners in the Atlantic (Swimmer, 2001 *pers. comm.*). The preferred lengths of the pole for line clippers and de-hookers were at least 8 foot (2.4 metres) and 12 foot (3.6 metres), respectively.

Australian situation

Addressing the problem of sea turtle interactions with longline gear through changes in fishing operations while ensuring no negative impact on target species catch, would be the easiest and most likely the least costly alternative. The choice of operational modifications, however, is diverse and may not be applicable to all sections of the industry. The fisher is possibly the best person to decide what changes may work better with his fishing operations.

In Australia, the question of whether to move after encountering a turtle is up to the discretion of the individual fisher. If a fisher feels this may reduce the catch on successive days it may be a relatively easy way to reduce further captures. Most interviewed fishers, however, did express opinions that sea turtles that they had captured in the past did not seem to be in a specific area or linked to specific conditions.

Most, but not all, fishers reported that their hook-lines were set at least 40 metres away from the floats, so did not consider there would be a problem with turtles becoming entangled due to attraction to floats. It may be possible for fishers that do not configure gear in this way to trial moving hooks further away from floats to determine the effect on target catch and also possibly turtle catch.

A principle problem with modifying the depth of gear in Australian longline fisheries is a reduction in main target catches, especially in northern sections of the fisheries and out wide from the coastline. In these grounds the target catch is swordfish – requiring the use of lightsticks, shallow gear and squid bait. If these operational methods were changed than a significant decrease in target catch may be encountered.

There is no information of the most common time of set that results in higher catches of sea turtles. The only way to determine if there is a correlation is through the use of hook timers. Taking into account the rarity of capture of sea turtles a considerable number of hooks would need to be fitted with hook timers to catch enough turtles to make a firm recommendation. The effect of reducing soak time may be an operational modification that could reduce turtle take. The effect on target catch would also need to be considered.

Fishers, including skippers and crew, should be aware of the best way to handle captured turtles so the sea turtle has the best chance of survival following a longline hooking event. In conjunction with guidelines the use of specific equipment, including a dip-net of some type to retrieve the turtle, line clippers to remove line off an entangled or hooked turtle and de-hooking devices to remove hooks, would be expected to reduce injuries to sea turtles.

Fisher involvement

A common position of many Australian longline fishers who were interviewed was that they did not want to catch or kill sea turtles. Many, in fact, demonstrated a genuine interest in sea turtle biology and conservation with requests for more information and wishing to pass this information to their crews. Most of the fishers who were interviewed had previously expressed an interest in bycatch so this group is not assumed to be entirely representative of the attitudes of all fishers in the longline fleets. Nevertheless, it does show that some fishers may have the necessary enthusiasm to become involved in sea turtle research. A similar attitude was reported in Williams *et al.* (1996:46) by an American longline captain, who quoted, 'There is a certain friendliness towards sea turtles by man, even fishermen, that I cannot account for'. This is not surprising given that sea turtles – along with dolphins, dugongs and whales to name a few – are generally considered to be a 'species of public concern' (Harris and Ward, 1999:2) and that fishers are also members of the public. Species of public concern hold a favoured status for various reasons including conservation status, anthropocentric reasons, charismatic features especially when young, or even as a result of featuring in a popular movie. This type of attitude amongst fishers who impact, even in a small way on sea turtles, will improve the plight of the sea turtle. If fishers are willing to address the issue of sea turtle mortality in their fishery, every sea turtle that otherwise would have died on a hook, in a net or drowned on a rope might reproduce and endow the world with more sea turtles. In addition, conducting research in cooperation with fishers may increase turtle conservation awareness throughout the whole fleet.

U.S. regulations require Western Pacific longline fishers to attend annual protected species workshops that cover mitigation, handling and release techniques of turtles and seabirds. Since 2000, NMFS have been successfully conducting these workshops. The workshops have been well attended and considered to be a benefit to the fishers, scientists and managers (Anderson, 2000). Fishers completing the workshop are issued with a Protected Species Workshop Certificate.

In 2002, the Western Pacific Regional Fishery Management Council sponsored the Western Pacific Sea Turtle Cooperative Research and Management Workshop in Hawaii. This gathering of experts agreed that there was a need to promote international efforts to involve fishers in sea turtle research including monitoring, tagging and the collection of genetic samples (Kinan, 2002).

Monitoring of turtle take

Sea turtle captures in commercial fishing operations should be monitored for a number of reasons - the most obvious of which is the collection of data to quantify the extent of the issue. For finer scale studies monitoring will allow for a determination of relationships between turtle captures and environmental or operational factors, and will also increase awareness by fishers of the issue and possibly encourage a reduced take or the use of better handling techniques. It may be possible for a monitoring program, if comprehensive enough, to identify variables that affect the probability of capture of a sea turtle by longline gear, thereby indicating possible mitigation measures.

Monitoring is most commonly undertaken through logbook programs. Unfortunately, logbooks are generally unverified so may not be as reliable as other methods. The inadequacy of logbook data for monitoring sea turtle catches was clearly demonstrated here when compared to data from fisher interviews. An often-preferred alternative is the use of scientific observers. Monitoring programs in the United States pelagic longline fleet demonstrated that the sea turtle catch rate estimated from observer data was significantly higher than corresponding catch rates reported in the fishers logs (Johnson *et al.,* 1999). The United States recovery plans for sea turtles in the Pacific recognise that a reliable method to monitor sea turtle take is with unbiased observer programs (National Marine Fisheries Service and United States Fish and Wildlife Service, 1998a-f). It is recommended that observer programs continue in the long-term due to possible differences in catch rates and other factors between years (Ferreira *et al.,* 2001; Skillman and Kleiber, 1998). Consequently, relatively high observer coverage is mandatory for many U.S. longline fisheries.

Scientific observer programs have been used extensively in fisheries throughout the world to monitor fisheries, verify logbook records and collect scientific samples. In some cases they also encourage compliance with existing rules by the fishers. Observer programs involve scientifically trained and fishery-independent observers recording and sampling catches, target catch and/or bycatch, on fishing vessels during normal fishing operations. Rare species that are infrequently caught create a problem in that high observer coverage is necessary to achieve a reasonable estimation of catch rates. This should be especially considered when planning observer programs where rare species are of concern. In order to meet research objectives observer programs must be methodically and meticulously planned and undertaken. There is considerable experience in conducting observer programs in various Australian research and management organizations, including the Australian Fisheries Management Authority (AFMA), the Commonwealth Scientific Industrial Research Organisation (CSIRO), the Bureau of Rural Sciences (BRS) and State organisations. In addition, other nations, in particular the U.S., have extensive experience in conducting observer programs concentrating on rare and endangered species.

Research

Research on board longliners offers a possible means to collect biological and other related data on sea turtles while in the pelagic environment. The use of trained fishers to collect biological data has been shown to be effective in Australian trawl fisheries (Robins, 1995; Robins *et al*., 2002) and there seems to be no logical reason why longline fishers could not participate in similar sea turtle research projects.

The willingness of United States longline fishers to cooperate with environmentalists and scientists in addressing the problem of turtles captured in their fishing gear has been noted in various reports. A Hawaiian Longline Association representative indicated their support for collaboration in at-sea research at a workshop regarding reducing sea turtle bycatch in the Hawaiian longline fishery (Anon., 2001e). An article in National Fisherman, a United States fishing magazine also outlines fisher involvement and interest in sea turtle conservation. This has included participation in workshops and with scientific research. The advantages of conducting offshore research in cooperation with fishers, particularly with respect to reduced costs compared to traditional research charters, was also noted (Kelley, 1995).

Scientific partnerships between commercial fishing industries and scientists have been made in various other fisheries, including in Irish waters (Davenport *et al.,* 2001), with Canadian fishers in the Atlantic (James, 2000), in Costa Rican waters (Arauz *et al*., 2000) and with U.S. fishers (Kelley, 1995). A non-profit organization in Spain, Foundation for the Conservation and Recovery of Marine Life (CRAM), conducts scientific research and also rehabilitates longline caught sea turtles in cooperation with commercial fishers (Pont Gasau and Algre Ninou, 2000). An observer project conducted in the Azores showed that collaboration with fishers could result in positive results in regard with sea turtle conservation (Prieto *et al.,* 2000).

The involvement of commercial fishers in sea turtle research can also be a public relations and educational opportunity. This is not only with respect to fishers learning about sea turtles and increasing sea turtle conservation awareness throughout the fishing community, but also fishers being a part of conservation efforts will show others, such as the general public and governments, that fishers have an interest in endangered animal conservation.

The importance of fishers being genuinely interested in sea turtle conservation if data they collect is to be considered reliable was highlighted in a project in Australia's Northern Prawn Trawl Fishery (Robins *et al*., 2002). This project also noted that data might not be as reliable if the result of the project may negatively impact on the fishery or on the fisherman's success. It would be expected that a fisher might be more likely to report incorrect data if he considers that the data will result in him losing his livelihood. It could be assumed that data on numbers of turtles caught, if high, may be underestimated or that mortality rate, if high, may be lowered. Therefore, without independent verification, like an observer program, the total number reported as being caught and also the rate of mortality would be expected to be minimum estimates. The collection, however, of some biological data may still be possible. For example, the fisher could tag, collect genetic sample, identify species, photograph and measure a sample of turtles caught on the vessel without divulging the total number of turtles caught. The fisher would be more confidant that results would not harm his fishing operations while invaluable data could still be gathered.

Before fishers are employed, either on a voluntary or a remunerated basis, they must receive adequate training in experimental protocols and data collection requirements. Experienced turtle scientists who are aware of the limitations of this method of data collection and sympathetic to the fishers' position as a fisher, and not a scientist, should provide training. The objectives of the project and methods adopted must be realistic and obtainable without significantly impacting on the fishing operations of the vessel. The fisher should have a genuine interest in sea turtle conservation and be made aware of the importance of the data he is collecting through knowledge about the plight of the sea turtle and also aspects relevant to his fishery. There is the possibility that untrained or uninterested fishers may provide incorrect data, either unintentionally or intentionally, thereby jeopardising the research projects. There must be recognition of these possible problems with this type of research so quality control procedures can be put into place.

Australian situation

Many Australian longline fishers who were interviewed demonstrated an interest in becoming involved in sea turtle monitoring and/or research. There are a number of possible ways for this to occur: more extensive training in completing the current logbook captures of sea turtles to a more useful level; supply of, and training in the completion of, specialist sea turtle logbooks; increase in observer programs on board commercial vessels; and/or cooperative research activities.

Australian fishers already complete extensive daily logsheets, including sea turtle catch information, which although unverified, do provide information on turtle captures. It may be possible to make the turtle information collected by logbooks more extensive so data is adequate for more detailed analysis. Problems, however, arise when logsheets become so cumbersome, difficult to complete and take a long time to fill out, then accuracy may decrease. If fishers, however, were told what type of data would be most useful they would be more likely to report this information.

Another possible solution may be for volunteer fishers to be trained in sea turtle reporting and complete a specialist sea turtle log that lists other related information. Considering the rarity of capture of sea turtles in Australian longline fisheries the completion of a specialist log should not become a burden. It may only be a couple of records per year. Information that could be included is the time of capture, position of hook in relation to floats and lightsticks, approximate depth of hook the turtle was caught on, hook type, lightstick type and colour, and sea turtle's condition on release (hook situation and length of trailing line). The collection of various environmental factors could also be useful. The photographing of all hooked turtles, possibly with a disposable camera, would verify species identifications.

Currently, there are no general observer programs in the Australian longline fisheries. There are, however, plans to implement a one-year pilot study in the SWTBF in mid-2002 by the Bureau of Rural Sciences. This project will be collecting target and bycatch data including those on sea turtle interactions and possibly tag captured turtles. There is also currently a sea-bird mitigation trial being conducted in the ETBF that is using observers to record sea bird captures as well as other species. Further observer programs are planned for Australian longline pelagic fisheries.

There are numerous possibilities for research that could be conducted onboard commercial fishing vessels, as described further in the next section. All of these types of research activities could benefit the industry by providing a solution to the sea turtle issue; increasing awareness of sea turtle conservation in the fleet; and improving public opinion on the fishing industry. These activities could be combined with the volunteer sea turtle specialist log project, mentioned above. All of the activities would not be difficult or arduous if fishers were provided with equipment and given the right training and support.

A factor that applies for any activity that involves fishers gathering scientific data is the need for the fisher to be aware of the importance of the research activity and receive adequate training in scientific protocols and techniques. Possibly the best way for these objectives to be met would be small-group fisher workshops organised at home-ports. Volunteer fishers could be invited through AFMA logbook officer communications or commercial fishing networks currently in place. Fleet-wide workshops will need to be short, no longer than half a day preferably, and provide the opportunity for all the fishers to attend if they wish by taking into account that fishers would be unable to attend when they are at sea. An alternative would be to make attendance at workshop compulsory, as is the case for U.S. longline fishers.

Sea turtle research related to longline fisheries

Despite their worldwide popularity, relatively little is known about sea turtles compared to some other animals. Information on their distribution, abundance and ecology in the open ocean is still lacking (Witzell, 1999). A major impediment to sea turtle research is that they spend most of their lives under the surface of the seas and oceans, only coming ashore to nest. There is the possibility that research and data collection could be undertaken on board commercial fishing vessels, either by scientists, observers or the fishers themselves. However, research on board commercial fishing vessels, that ultimately may allow a fishery to continue to be viable while not impacting on sea turtle populations, is not possible if a fishery is completely closed. Exceptions occur when commercial fishing vessels are chartered in order to conduct the research or when experimental fishing is allowed on condition that the research is undertaken.

There are many potential areas of research not covered in this report that could be, and in some some cases already is, used to tackle the issue of sea turtle captures on longline gear, for example, laboratory studies on the clinical, pathological and physiological effects of hooking. Also not specifically addressed in this section are the many questions on interaction between sea turtles and longline operations that could be answered through research projects involving environmental and biological data. Examples include the relationships between oceanographic data, gear configuration, fishing techniques and sea turtle catch and mortality rates. Various workshops have been conducted that draw on research components of the sea turtle and longline fishery issue, including handling guidelines (Balazs *et al.,* 1995), hooking mortality (Balazs and Pooley, 1994), industry involvement (Williams *et al.,* 1996), gear modifications (Anon., 2001d; Bolten *et al.,* 2000), and sea turtle catch reduction (Anon., 2001e; Kleiber and Boggs, 2000).

Detailed descriptions of possible research activities, examples of experimental designs, methods, objectives, protocols and also risks are in U.S. research permit documents (National Marine Fisheries Service, 2001c; National Marine Fisheries Service, 2002c). This information could be used for planning research projects in other fisheries, including Australian fisheries. There should be consultation, cooperation and coordination during all stages of any research project. This includes with the fishing industry, sea turtle and fishery scientists and fisheries managers. Substantial research on sea turtle bycatch has been conducted, and already completed, by individuals and organizations, in both Australia and further afield. Any research project on Australian longliners should utilise this expertise and complement projects that are already ongoing.

Research activities that could be undertaken on Australian longliners include:

General biology and population modelling

All of the research types listed here will contribute to knowledge of sea turtle population dynamics. However, priority areas include distribution, movements, life history and mortality data. The fundamental need to conduct research that improves the understanding of sea turtle population dynamics was recognised during an expert workshop convened in 1993 by NMFS to develop a research plan to assess sea turtle hooking mortality (Balazs and Pooley, 1994).

If sea turtles are to be protected, commercial fisheries managers will need first to evaluate the effect the fisheries are having on turtles and base policy decisions on sound knowledge. The development of population estimation models and related data should have a high priority if fisheries management plans designed to reduce the impact of fisheries on sea turtles hope to be successful. Obviously, if they are to be realistic and useful, models must be based on accurate data and reasonable assumptions about sea turtle populations throughout their life cycle.

The most common method of abundance estimation is the counting of nesting females. This method can yield nesting counts that are very accurate, but when these are extrapolated to population estimates, various, often grossly inaccurate, assumptions about the rest of the population must be made. In most cases it is necessary to make suppositions about life history parameters, that include natural survival rates, fishing mortality rates, growth rates, biological parameters, migration routes and rates, reproduction and maturation parameters, some of which are based on actual data and others educated guesses (Wetherall, 1997). Misconceptions or incorrect assumptions often result in estimates with wide error ranges.

It is preferable to use multiple methods of population estimation simultaneously. Complementary methods often used are stranding rates, incidental capture by fishing operations, aerial surveys and ecological research (Morreale, 1996). Sometimes it is difficult to estimate nesting female deaths and the number of eggs taken, especially when the practice is banned but continues (Wetherall, 1997). The most common data sources from commercial fishing operations are logbook and observer records. The former are generally unverified and the latter reliable but scarce. Unfortunately, many fishery research programs do not collect data on sea turtles (Arauz, 2000).

Research on nesting beaches, compared to foraging grounds, has been a priority in the past (Limpus and Reed, 1985). Bjorndal (1999b) estimates that 90% of literature on sea turtle is based on research carried out on nesting beaches even though turtles only spend 1% of their time there. The reasons for this are not only the emphasis put on research projects for conservation of nesting females and hatchlings, but also the ease and lower cost of such research. Clearly, there is a need for increased emphasis on research of sea turtles while they are away from the nesting beaches, including their pelagic stages (Bolten and Balazs, 1995 from Bjorndal *et al.,* 2000). Also, research on critical habitats, including, but not restricted to, nesting sites, is essential to ensure that sea turtles have adequate resources for survival in perpetuity (Bjorndal, 1999).

One factor that is generally fundamental in population dynamics is the size or age composition of mortality events in relation to size at maturity (Wetherall, 1997). Observer records often provide accurate size measurements of landed sea turtles but can only estimate the size of sea turtles that are not brought to the deck. Logbook records may request length measurements but fishers will need to be trained and again only landed turtles can be measured.

Irrespective of the problems it is still imperative to model sea turtle populations. Scientists from many organizations continue to improve, update and refine sea turtle population models. These models can indicate possible effects of differing mortality events, predict acceptable or allowable take levels (Anon., 2001e) and many other results that may prove invaluable when planning management programs.

Conventional tagging

Even though information on the movements of sea turtles is improving each year through research, which includes tagging programs, there is still much to be learnt about this highly migratory animal. External flipper tags allow the identification of individual turtles. This enables researchers, when they catch a tagged turtle or are provided with details of the turtle captured or seen by another interested party, to determine where the turtle was tagged and dispersal rate to that point . Information can be obtained on migration pathways, relationships between nesting beaches and foraging grounds, and mortality events. In addition, it is possible to use morphometric data gathered from individuals over time to estimate biological parameters such as growth rates (Balazs, 1999).

There are other methods of tagging that include shell marking and micro-chipping (PIT tagging). Conventional tagging, however, remains one of the fundamental activities used by scientists throughout the world to study sea turtles. As with tagging programs for any species of animals the return or recording of tag details and collection of data after the turtles has been tagged is essential for a successful tagging program (Balazs, 1999).

Extensive tagging programs operate throughout the world. Queensland Environment Protection Authority , with help from other interest groups, conduct extensive tagging programs in Australia east coast waters and have done so since 1968 (Limpus *et al.,* 1992). Similar programs operate down the Australian west coast through the Western Australian Marine Turtle Project, which has been operating since 1986 (Prince, 1998). Various non-government organizations and other interested parties also conduct tagging programs.

Conventional tagging is a research activity that could be undertaken by longline fishers. Given the lack of knowledge about sea turtles in their pelagic phase and the lack of information about mortality rates it would be extremely valuable to not only tag longline caught turtles before their return to the water but also record any tagged turtles that are caught.

Satellite tagging

Research programs on turtles at sea have increased in recent years due to improvements made in electronic technologies and battery design. Equipment such as Time-Depth-Recorders, Heart-Rate-Monitors, Temperature Loggers, VHF and Sonic Telemetry, and Satellite Tags including Pop-Up Satellite Tags, has enabled scientists to collect detailed data while the turtle is away from nesting beaches. Eckert (1998 and 1999a,b) describes some of these methods with respect to sea turtle research.

In recent years, satellite telemetry has been used to examine foraging and migration routes in relation to longline fishing (Polovina *et al*., 2002) and estimate the mortality rate of longline caught sea turtles (Parker *et al.,* 2001). To date there have been some issues with inconclusiveness of results due to problems with interpretation (Western Pacific Regional Fishery Management Council, 2002). This is primarily with respect to the difficulty of differentiating between equipment failure and turtle death. Nevertheless, Bjorndal *et al.* (1999a), who tested the feasibility of using satellite telemetry to evaluate mortality rate of longline caught turtles, strongly recommended that this type of research be continued and possibly integrated with oceanographic data.

The attachment of satellite transmitters to sea turtles during previous research projects by NMFS has demonstrated that little discomfort or stress is experienced by the sea turtle during attachment and after release (National Marine Fisheries Service., 2002c).

Pop-up satellite archival tags

Pop-up Satellite Archival Tags (PSATs), that have been used primarily on large pelagic fish, are designed to collect data on depth, temperature, and position while the animal is alive, and are released if the animal dies and sinks. After the tag releases from the animal it will transmit data to an overhead satellite. These tags can facilitate the estimation of post-hooking survival rates and determination of migration patterns in relation to environmental conditions. This type of data may help to identify areas where sea turtles are likely to be encountered and where closure may result in fewer turtle interactions with longline gear (Swimmer *et al*., 2002a).

Obviously, it is only possible to apply PSATs to sea turtles in fisheries that do catch sea turtles. Therefore, as a result of restrictions to reduce sea turtle take in Hawaiian-based longliners, it has been necessary for United States researchers to travel further afield. In 2001, United States observers were trained to fit PSATs, but only one turtle has been tagged (Lars *et al.,* 2001). This internally hooked turtle was at liberty for 82 days and traveled almost 2 000 nautical miles before shedding the tag (Swimmer *et al*., 2002a). The University of Hawaii and NMFS are currently using PSATs to quantify mortality rates of longline caught sea turtles in the Costa Rican longline fishery in collaboration with the Costa Rican Sea Turtle Restoration Project (Swimmer *et al*., 2002a and b). In 2002, four turtles caught on longline gear and three free-swimming turtles were fitted with PSATs which were programmed to release after 6 or 12 months. Scientists are awaiting results from this study and planning further studies.

PSATs have the capability of being released if the turtle becomes entangled. The design of suitable PSATs and their attachment to sea turtles has required considerable expertise, but the method of attachment is now considered to be relatively simple even for scientifically-inexperienced fishers (Swimmer *et al.*, 2002a). The technique is considered to be safe for the researcher and for the turtle, both during the attachment phase and after release, and suitable for co-operative projects with fishers.

Unfortunately the possibility that projects of this type will be conducted in Australian waters from Australian longliners is not likely given the high cost of this type of research and the low numbers of turtles caught. If an area could be found where turtles are reliably caught, this type of research may become more viable. Alternatively, observers or possibly individual fishers could be trained adequately enough to tag and release the animals themselves. This type of research onboard Australian longliners would be highly beneficial to research projects and should be considered if it becomes possible.

Passive Integrated Transponder (PIT) tagging

In circumstances where conventional tags have been found to be inefficient, PIT tagging can be adopted. These tags are microprocessors sealed in glass that allows individuals to be identified. They can achieve the same results as conventional tags. An advantage of PIT tags is that they are rarely lost or damaged, unlike some other tags. A disadvantage is the person recapturing the turtle cannot identify it without a compatible PIT-tag reader (Balazs, 1999).

PIT tagging and PIT-tag reading of captured sea turtles would be a relatively easy activity for observers or fishers with the correct equipment and training (Balazs, 2002 *pers. comm.*). In 2000, trained fishers from the Irish tuna fishery successfully PIT tagged two leatherbacks that were captured during fishing operations (Davenport *et al.,* 2001). It was reported that conventional tagging would have been too dangerous and not effective, while satellite tagging would not be feasible. The insertion of PIT tags into sea turtles has been found to produce various indications of pain, from a marked response to barely seeming to notice (National Marine Fisheries Service, 2002c). The length of discomfort, however, is usually short and no post-tagging infection was noted during previous studies.

Genetic studies

In recent years there have been studies on determining genetically distinct populations and gene flows of sea turtles using mitochondrial DNA (mtDNA) techniques. These methods allow the inference of gene flow, thereby defining stocks and determining the relationship between nesting beaches and foraging grounds, and can be used in conjunction with conventional tagging projects (Fitzsimmons *et. al*., 1999)

A study by Laurent *et al.* (1993) demonstrated the usefulness of genetic studies using mitochondrial markers in relation to commercial fisheries. In a study of Mediterranean and Atlantic Ocean populations of loggerheads it was found that these nesting female populations were genetically different, but that loggerheads of Atlantic origins were found in the Mediterranean. This implies that the Spanish longline fishery in the Mediterranean, that catches large numbers of loggerheads, may have an impact on the Atlantic loggerhead population. Another study examining foraging populations of sea turtles harvested in south east Indonesia reveals that a portion of these are from populations that nest in Northern Australia (Dethmers and Broderick, 2002). These studies clearly demonstrate the global nature of sea turtle conservation.

Currently, NMFS is conducting a study on genetic stock identities for Pacific sea turtles (Anon., 2001e). While the University of Queensland, University of Canberra and University of Florida are conducting extensive genetic research on sea turtles in the world's oceans (Limpus, *2002 pers. comm.*).

It is possible to obtain a genetic sample (tissue biopsy) relatively easily using a coring device. This is a sharp-edged, circular metal punch that can be used on turtles on the deck or attached to a longer pole for turtles in the water. The corer is pushed into the animal's skin slightly, targeting the shoulders or carapace of leatherbacks, to take a tissue sample. This is then placed in a preservation jar to be analysed by participating scientists. The collection of tissue samples is not expected to cause additional stress or discomfort to the turtle (National Marine Fisheries Service, 2001c; National Marine Fisheries Service, 2002c). Alternatives include the use of curved surgical scissors or cutting clip to remove a small sample from the edge of the flipper.

Gear and operational modifications (mitigation)

There is a critical need for the development of fishing gear and/or strategies that reduce the capture and mortality of sea turtles by commercial fishery operations, as noted in National Marine Fisheries Service and United States Fish and Wildlife Service (1998d). An additional objective should be to retain viable fishing performance so the fishery can remain economically feasible (National Marine Fisheries Service, 2002c). TEDs have been a successful in doing this in trawl fisheries, but as yet there has been no 'magic solution' for longline operations.

Over recent years various research programs around the world have focused on ways to reduce sea turtle catch and mortality as a result of longline operations through gear modifications. In addition, research has been conducted on improving sea turtle population estimation and evaluating management alternatives (Lars *et al.,* 2001). Research onboard commercial or research longliners, especially in areas of high turtle take, is fundamental to the development of gear and operational modifications as an alternative to restrictive measures, such as closures. Research projects have been conducted on U.S. commercial longliners in the Atlantic (National Marine Fisheries Service, 2002b) and in the Pacific (National Marine Fisheries Service, 2002c). The importance of these types of cooperative scientific experiments is noted in the Atlantic U.S. 2001 Biological Opinion (National Marine Fisheries Service 2001d) and reiterated in the environmental assessment for the issuance of scientific research permits (National Marine Fishery Service, 2001c and National Marine Fisheries Service, 2002c).

In conjunction with research in the field on commercial and research longliners, many organizations are involved with sea turtle research in the laboratory, such as physiology and behavioural studies that may ultimately reduce the sea turtle take by longline fisheries. One example is research on the olfactory capability of sea turtles being conducted by NMFS in collaboration with the University of South Carolina (Vogt *et al*., 2002 and Swimmer *et al*., 2002c). This may result in the development of changes to the bait that reduces the probability of capture of a sea turtle. Organizations involved in research involving sea turtle mitigation include the National Marine Fisheries Service, University of Honolulu, University of Florida, University of South Carolina, University of North Carolina, Harvard Medical School and Woods Hole Institute of Oceanography.

Research projects currently being conducted include evaluating visual, olfactory and auditory factors that cue the turtle to take the bait or attract the turtle to the bait or line. Consequently, it may be possible to reverse these cues on longline gear to cause the turtle not to take the bait or not be attracted to the bait or line. An important consideration is that altered bait must still attract the target catch of swordfish and tuna. Research projects include:

- Blue-dyed squid bait – Food colour preference studies conducted in 1984 on captive Kemp's ridley hatchlings suggested that they had a preference for certain coloured food (Fontaine *et al.,* 1985). The least preferred colour being blue-dyed shrimp. More recent research has shown that captive green turtles avoid eating squid that has been dyed blue for 8 to 10 days (Lars *et al.,* 2001). Further research is needed on wild caught turtles and turtles of different species before any recommendation could be made. In 2001, the at-sea experiments conducted by NMFS in the Atlantic showed no difference in turtle interactions between blue-dyed bait and control bait (Swimmer, 2001 *pers. comm.*). Research on blue-dyed bait is continuing (Anon., 2002; Swimmer *et al.,* 2002c).
- Different tasting bait – Bait has been soaked in various substances (garlic, cilantro, bitter and sour substances, urea and wasabi oil) and offered to captive green turtles (Lars *et al.,* 2001). All marinated squid were eaten.
- Artificial baits – A mixture of artificial baits trialed with captive turtles proved unsuccessful in preventing turtles taking the bait (Lars *et al.,* 2001).
- Potential repellent – The determination of chemical compounds that may work as a repellent when used on the bait has not been successful (Swimmer, 2001 *pers. comm.*).

Research on gear configuration factors that may reduce the catch of turtles on longline gear without affecting the target catch, includes:

- The effect of moving the hook more than 40 fathoms away from the float (Lars *et al.,* 2001; National Marine Fisheries Service, 2002b; National Marine Fisheries Service, 2002c).
- The use of 'stealth' fishing gear that is less detectable to the turtle, including changes in float design and colour (blue on the bottom), dark coloured lines, dulled hardware and lightstick design (battery-powered, narrow frequency, yellow light emitting diode-based, and down-welling) (Lars *et al.,* 2001, National Marine Fisheries Service., 2002c).

- The effect of fishing at different depths or at different times (Lars *et al.,* 2001).
- The effect of hook design (Bolten *et al.,* 2001; Lars *et al.,* 2001; National Marine Fisheries Service, 2002c).
- Sound sources that may repel turtles away for fishing gear (Lars *et al.,* 2001).
- Responses of turtles to light-sticks and branch-lines (Kleiber and Boggs, 2000).

A further area of research is in reducing the mortality of sea turtle once captured by longline gear. The primary method is the use of tag, both conventional and satellite remote sensing (as described earlier), in order to determine the survivability of post hooked turtles with regard to a range of hooking parameters.

Recommendations

Handling guidelines and species identification charts

RECOMMENDATION

- **Handling guidelines and species identification charts be laminated and distributed to all Australian longliners, possibly through the logbook system, for hanging in the wheel house, galley and anywhere else the crew considers to be appropriate.**

- **Fishers receive handling training, including resuscitation techniques, at port workshops.**

- **An instructional video on sea turtle handling guidelines, species identification and awareness of the sea turtle conservation issues be**

Appropriate handling of sea turtles following capture through longline operations may reduce capture-related stress, injury and mortality. There are general practices that should be followed when handling sea turtles and also best practices specific to longline caught turtles. Safe handling practices, including the turtle being correctly restrained whilst on the deck, is also important for crew safety.

Fishers should receive handling training at workshops. A video covering handling guidelines, species identification and awareness of sea turtle conservation issues should be produced and available on all Australian longliners. This video could be produced in conjunction with industry representatives and internationally recognised sea turtle scientists.

Monitoring of turtle take

RECOMMENDATION

- **Provide information to fishers on sea turtle data that would be most useful to report in logs.**
- **Introduce a voluntary sea turtle specialist log for interested fishers, including photographing captured turtles.**
- **Routinely conduct observer programs in Australian longline fisheries.**

Australian fishers already complete extensive daily logsheets, including sea turtle catch information, which, although unverified, provide information on turtle captures. If fishers were told what type of data would be most useful they would be more likely to report this information.

To increase the collection of useful data on sea turtles it may be possible to train volunteer fishers in sea turtle reporting and have them complete a specialist sea turtle log that lists other related information. Information that could be included is the time and location of capture, position of hook in relation to floats and lightsticks, approximate depth of hook the turtle was caught on, hook type, lightstick type and colour and sea turtle condition on release (hook situation and length of trailing line). The collection of various environmental factors could also be useful, as would photographing turtles to confirm the species identification.

Considering the significance of sea turtle conservation and the lack of reliable data, observer programs should be routinely conducted in Australia longline fisheries. Observer data could be used to monitor target catch and bycatch, collect data on the operational aspects of the vessel, collect environmental and oceanographic data, train fishers in handling techniques and identification skills, and collect data and samples for sea turtle programs.

Results of all data monitoring programs should be disseminated to the fishing industry in a timely manner so the information could be used in their fishing operations. Data should be provided to research bodies that intend to analyse it further.

Fisher training and research

RECOMMENDATION

- **Sea turtle research include the formation of a strategy group to coordinate sea turtle activities.**

- **Sea turtle research program be implemented in Australian longline fisheries that should include including morphological measurements, conventional tagging, PIT tagging, satellite and archival tagging, genetic samples, and fishing operational modifications**

- **Home-port workshops be conducted to train fishers in scientific protocol, data collection and increase sea turtle conservation awareness throughout the fishing community.**

- **Research activities should not significantly impact on fishing operations.**

A sea turtle strategy group should be formed to advise on appropriate programs that could be implemented in Australian longline fisheries. Programs should complement, or be a part of current sea turtle research programs, and set realistic protocols and goals that are achievable by participating fishers without significantly impacting on their fishing activities.

Considerable expertise has been gained by other nations that should be utilised in designing Australian activities. A possible mechanism to achieve this would be attending the Second International Fishers Forum 2002 in Honolulu, Hawaii, from the 19 to 22 November 2002, hosted by the U.S. Western Pacific Regional Fishery Management Council. The first forum was hosted by New Zealand in November 2000 and focused on methods to solve the incidental catch of seabirds by longline fishing gear. The second forum will also include discussion on sea turtle biology and behaviour, and on reducing negative interactions between sea turtles and longliners.

There are numerous possibilities for research that could be conducted onboard commercial fishing vessels, including morphological measurements, conventional tagging, PIT tagging, satellite and archival tagging, genetic samples, and fishing operational modifications. These types of research activities would benefit the industry by possibly providing a solution to the sea turtle issue; increasing awareness of sea turtle conservation in the fleet; and improving public opinion of the fishing industry. These activities could be combined with the volunteer sea turtle specialist log project.

A factor that applies for any activity that involves fishers gathering scientific data is the need for the fisher to be aware of the importance of the research activity and receive adequate training in scientific protocols and techniques. This could be achieved through conducting small home-port workshops. These workshops should be short, motivate fishers, and be available to all interested fishers. Results of research programs should be disseminated to the fishing industry in a timely manner so the information could be used in their fishing operations

Recovery planning

RECOMMENDATION

- **That Australia complete and publish its Sea Turtle Recovery Plan.**
- **That the issue of longline sea turtle bycatch be discussed and appropriate actions enunciated in the Recovery Plan.**

Australia began the process of sea turtle recovery planning in 1998 when Environment Australia published and called for public comment on the Draft Recovery Plan for Marine Turtles in Australia. Since then, progress has been slow and the document is yet to be translated into a Recovery Plan as provided for under the Environment Protection and Biodiversity Conservation Act.

The publication of the plan will provide an opportunity to take a holistic approach to managing the various threats to sea turtle populations, as well as to raise the awareness of the threats. Moreover, Recovery Plans provide one avenue of emplacing statutory requirements upon the public in regard to the impact of their activities upon threatened species.

In 1998 there was little recognition in Australia or abroad of the potential impact of longline fishing operations on sea turtle populations. Since the time of publication of the draft recovery plan, the issue of sea turtle longline bycatch has risen in prominence, and the fact that longline fishing has an impact on sea turtles has been revealed. As such, and in accordance with evidence included in this report, the issue of longline sea turtle bycatch should be included in the final Recovery Plan.

U.S. technology and laws

RECOMMENDATION

- **Developments in both U.S. laws and gear modifications should be closely monitored in order to prevent any US action from negatively impacting on Australian longline fisheries.**

- **Where applicable to the Australian situation gear modifications developed abroad to minimise sea turtle capture and mortality should be considered for adoption in Australian fleets.**

- **Monitoring of any potential U.S. and international organisation application of eco-labels to longline fisheries, in particular in relation to sea turtle bycatch.**

The United States has used trade embargoes on a number of occasions with the intent of both leveling the playing field for its domestic fish producers and extending its domestic environmental policies abroad. Australian fisheries were disadvantaged when section 609 embargo provisions on countries that did not have equivalent sea turtle bycatch mitigation standards to the U.S. in regard to prawn trawl operations was introduced.

A similar situation now exists in the U.S. in regards to sea turtles as it did prior to the enactment of the shrimp embargo law, in that such a move is likely to have the broad support of both the environmental lobby and fishermen's associations.

Given that a significant portion of Australia's longline catch is destined for the U.S. market, close monitoring of possible embargo action is necessary. This is especially so in light of comments regarding the possible extension through regulatory (rather than the slower legislative option) of extant sea turtle embargo laws to the issue of longline fishing.

In addition to close monitoring Australia should ensure that it maintains best practice operations in regard to bycatch minimisations in its fisheries, both in order to comply with Australian laws as well as to pre-empt any possible trade action taken.

Australian fishers should be aware of the possible use of labels to promote products caught in a certain way, such as those deemed to be environmentally friendly or 'eco-safe'. In addition, fishers that act to mitigate sea turtle capture and/or mortality may like to consider whether labeling schemes will have any benefit for the marketing of their product.

Equipment

RECOMMENDATION

- **Australian longliners carry line cutters to release hooked sea turtles without trailing line and, possibly also dip-nets to retrieve small hooked turtles for treatment.**
- **Fishery managers monitor de-hooking studies by NMFS while interested Australian fishers trial these devices.**

It is recommended that it be made a requirement for Australian longliners to carry line clippers to enable fishers to cut the fishing line off captured sea turtle as close as possible to the hook. There are a number of different designs of line clippers but all should be long enough to reach the animal from the fish door (so length depends on the design of the boat), strong enough not to break off in rough weather, and have an enclosed blade. The safety aspects of an enclosed blade should be emphasised, not only for the turtle but also the crew. The fisher should be allowed to choose from a selection of designs or create one to suit his particular vessel.

As dip-nets are vital for safe retrieval of small turtles it is recommended that fishers also carry this equipment. Although, whether this should be a requirement or an option should be discussed further with the fishers. Similarly for de-hooking devices.

Regional action

RECOMMENDATION

- **Australia should participate in appropriate forums to encourage a harmonised and regional response to mitigating longline sea turtle bycatch, including were applicable the fishing industries.**

It is recommended that Australia pursue an extension of its own longline sea turtle bycatch minimisation strategies to regional and international conservation and fisheries agreements. In particular, this applies to those countries that are believed to have turtles from populations that nest or forage in Australia migrating through their waters or living in areas where they fish.

In regard to conservation arrangements, the most appropriate forum to pursue such action in is that of the Conservation and Management of Marine Turtles and their Habitats of the Indian Ocean and South-East Asia. Actions might include:

- encouragement of other countries in the Indian Ocean and South East Asian region to join this agreement;
- strong support for the conversion of this Memorandum of Understanding into a binding treaty;
- the inclusion of specific ‘actions’ for minimising sea turtle capture and mortality in longline fisheries in the appended Conservation and Management Plan; and
- finally, when appropriate, transfer of technology to other Parties.

Also, it is recommended that Australia pursue increased consideration of sea turtle longline bycatch in the various international fisheries management organisation to which it is a Party. Various of these regional bodies already have working groups that are tasked with consideration of associated and dependant species and could be encouraged to include the issue of sea turtle longline bycatch. This will also act to ensure that, as with the U.S., Australia is not disadvantaged by its neighbours’ and trade competitors’ lack of comparable standards.

Conclusions

Australian pelagic longline fishing operations incidentally catch sea turtles. The best available data suggest that the catch may be as high as 400 sea turtles per year, although, the variation around this estimate is wide due to lack of accurate data. Fisher logbook records indicate a much lower level of sea turtle bycatch and many fishers reported no captures of sea turtles. The proportion of fishers claiming to catch no sea turtles was not as high during fisher interviews, although a small number of fishers reported that they had never hooked a turtle, primarily those fishing more southerly fishing zones. Interview data indicates an average catch rate of 0.024 turtles per 1000 hooks.with a standard deviation of 0.027 in the ETBF and WTBF.

A high proportion of turtles taken in these fisheries, possibly more than 60%, are believed to be leatherbacks. The species identifications of the hard-shelled sea turtles are less reliable or unknown. Some fishers in southern Queensland, however, adequately described hawksbill as the second most common species seen. Other fishers believed that they had captured loggerheads and still others believed that they had caught green turtles. Given that all species of sea turtles are listed under Australian law as threatened, and these threats should be addressed, the species composition of bycatch is of particular importance. Unless a monitoring program is conducted in these fisheries, correct species identifications will remain a mystery.

The mortality rate of sea turtles caught by Australian longliners is unknown but expected to be relatively low for leatherbacks and also possibly low for the other species. Most leatherbacks, and some hard-shelled turtles were reported as alive and vigorous on release. A small number of fishers routinely retrieved hard-shelled turtles that had been hooked and removed the hook prior to release. Although the rate of mortality following release of all injured sea turtles is unknown.

The estimated sea turtle catch by Australian pelagic longliners is considerably less than some other longline fisheries around the world, including those in the Mediterranean, and U.S. longliners in the Atlantic and the Pacific. Nevertheless, there is still a pressing need for the issue of sea turtle bycatch in Australian longline fisheries to be addressed. This is especially in light of the United States practice of extending domestic law to foreign fishing states through the use of trade embargos. U.S. concern over and action to mitigate sea turtle bycatch in its longline fisheries is well progressed and provided for under force of law. The north Pacific Ocean pelagic fishing grounds have already been closed to United States longliners, a proposal has been made to close a large area of the north Atlantic fishing grounds, and restrictions have been placed on other fisheries in response to the unacceptable mortality of sea turtles.

In relation to the Australian domestic scene, requirements exist to protect marine species under the Environment Protection and Biodiversity Conservation Act. Bycatch approvals and mitigation requirements will, in the future, be provided through the approval of Fisheries Management and Bycatch Action Plans, and in the creation of Recovery Plans. Though the EPBC Act imposes comparable high standards upon fishing in Commonwealth waters, U.S. trade regulations have in the past required not only enactment, but also implementation of national laws if States wish to export to U. S. markets.

While there seems to be little opportunity for Australian fishers to reduce sea turtle capture rates, given the current lack of information, sea turtle survival could possibly be increased. Many fishers had already adopted reasonable handling techniques, although most felt that handling guidelines outlined on a brochure and further explained in a video would benefit their operations.

Thus, the printing of sea turtle handling guideline brochures and production of a video is highly recommended. In conjunction with improved handling techniques, the use of equipment – line-clippers and dip-nets – to reduce further sea turtle injury is recommended. The trialling of de-hooking devices is also recommended for interested fishers.

Many Australian longline fishers who were interviewed demonstrated an interest in becoming involved in sea turtle monitoring and/or research. Australian fishers already complete extensive daily logsheets, including sea turtle catch information which, although unverified, do provide information on turtle captures. There is the possibility of improving the quality and the usefulness of this information. There are a number of possible ways for this to occur: additional training in completing the current logbook captures of sea turtles to a more useful level; supply of, and training in, the completion of specialist sea turtle logbooks; increase in observer programs on board commercial vessels; and cooperative research activities. For any activity that involves fishers gathering scientific data, there is a need for the fisher to understand the importance of the research activity and receive adequate training in scientific protocols and techniques. This could be achieved through relevant scientists conducting small home-port workshops.

A sea turtle strategy group should be formed to advise on appropriate programs that could be implemented in Australian longline fisheries. The considerable expertise of other countries already conducting research on sea turtle interactions with longline operations should be utilised in designing Australian activities. The programs should complement, or be a part of, current sea turtle research programs, and set realistic protocols and goals that can be achieved by participating fishers without significantly impacting on their fishing activities. Results of all data monitoring and research programs should be disseminated to the fishing industry in a timely manner so the information could be used in their fishing operations.

To improve catch statistics, a possible approach is for volunteer fishers to be trained in sea turtle reporting and complete a specialist sea turtle log that lists other related information. Information that could be included is the time and location of capture, position of hook in relation to floats and lightsticks, approximate depth of hook the turtle was caught on, hook type, lightstick type and colour, and sea turtle condition on release (hook situation and length of trailing line). The collection of various environmental factors could also be useful, as would photographs of captured turtles to confirm species identifications. This information may indicate possible sea turtle mitigation techniques the fishers could implement during their fishing operations. In addition, considering the significance of sea turtle conservation and the lack of reliable data, observer programs should be routinely conducted in Australia longline fisheries. Observer data could be used to monitor target catch and bycatch, collect data on the operational aspects of the vessel, collect environmental and oceanographic data, train fishers in handling techniques and identification skills, and collect data and samples for sea turtle programs.

There are numerous possibilities for scientific research that could be conducted onboard commercial fishing vessels, including morphological measurements, conventional tagging, PIT tagging, satellite and archival tagging, genetic samples, and fishing operational modifications that may reduce sea turtle take or reduce mortality while maintaining viable fisheries. These types of research activities would benefit the industry by possibly providing a solution to the sea turtle bycatch issue, increasing awareness of sea turtle conservation in the fleet, and improving public opinion of the fishing industry. The amount of information able to be collected would be substantially less if fishers were not involved in these research projects.

Looking at the bigger picture, in order to slow the decline of sea turtle populations, the many anthropogenic mortality events that impact on sea turtles need to be reduced. With such a highly migratory species that does not recognise national territorial boundaries, the alleviation of threats must be a multi-level partnership that crosses economic, cultural and national boundaries, but takes into account their inherent differences. Sea turtles are an internationally shared resource and all countries involved must do their best to prevent sea turtles stocks from declining further. Eckert (1999b:8) quoted that ‘for turtle conservation programs to succeed every effort must be made to involve all relevant sectors and stakeholders in planning and, ultimately, in implementation’.

Given that sea turtles are a long-lived and complex species that face many threats throughout all stages of their life, they will not recover from declining populations easily or quickly. Even if all anthropogenic mortality events miraculously ceased tomorrow the positive effect on the populations would not be seen for many years, possibly decades. This does not imply, nor does it excuse a choice to do nothing today, as every individual that survives increases the chances for the species. What it does imply is that we need to adopt a long-term strategy, in which we vigorously pursue recovery actions and continually monitor sea turtle populations to assess their status.

References

Achaval, F., Marín, Y. H. and Barea, L. C. (2000) Incidental Capture of Turtles with Pelagic Longline. In: *Proceedings of the 18th International Symposium on Sea Turtle Biology and Conservation*, *Mazatlan, Sinaloa Mexico 3–7 March.* Abreu-Grobois, F. A., Briseño, R. Márquez, R. and Sarti, L. (Compilers), 261.

Achaval, F. and Yamandu H. M. (1998) Incidental Capture of Sea Turtles in Swordfish Long Line Fishery. In: *Proceedings of the 17th Annual Sea Turtle Symposium.* Epperly, S. P. and Braun, J. (Compilers). U.S. Dept. Commer. NOAA Tech. Memo. NMFS-SEFSC-415, 294 pp.

Aguilar, R., Mas, J. and Paster, X. (1995) Impact of Spanish Swordfish Longline Fisheries on the Loggerhead Sea Turtle *Caretta caretta* Populations in the Western Mediterranean. In: *Proceedings of the 12th Annual Workshop on Sea Turtle Biology and Conservation.* Richardson, J. L. and Richardson, T. H. (Compilers). U.S. Dept. Commer. NOAA Tech. Memo. NMFS-SEFSC-361, 1–6.

Alverson, D. L., Feeberg, M. H., Murawski, S. A. and Pope, J. G. (1994) A Global Assessment of Fisheries Bycatch and Discards. *FAO Fish. Tech. Paper* 339. 233pp.

Altonn, H. (2001) Study Finds Deep-set Lines Could Spare Most Turtles. Starbulletin Sunday, July 22, 2001.

Anderson, C. (2000) NMFS Workshops for Longliners Well Attended. *Pelagic Fisheries Research Program,* October–December 2000, 7.

Andrew, N. L. and Pepperell, J. G. (1992) The Bycatch of Shrimp Trawl Fisheries. *Oceanogr. Mar. Biol. Annu. Rev*., 30, 527–565.

Anon. (1998) *Circle of Dependence. Protected Species Handling Manual*. Ocean Watch, Australia, 29pp.

Anon. (1999a) Marine Turtles – An Introduction. *A.M.C.S. Bull. (Turtle Insert),* 20(4), 1–3.

Anon. (1999b) And They Have Tears in Their Eyes: Marine Turtles – Connecting and Reflecting Our Actions Across the Earth. *A. M.C.S. Bull. (Turtle Insert),* 20(4), 4–9.

Anon. (2000) EIS Delay Closes Prime Swordfish Grounds. *Pacific Islands Fishery News,* Winter 2000, 1–4.

Anon. (2001a) Feds Asked to Provide Science Behind Proposed Fishery Closure. *Western Pacific Regional Fishery Management Council, Press Release* February 14 2001, 2pp.

Anon. (2001b) NOAA Fisheries has Longline Fishermen Continue Carrying Simple Tools to Untangle Sea Turtles. *NOAA Media Release*, NOAA 2001-R108, 1pp.

Anon. (2001c) Report of the NMFS Technical Gear Workshop to Reduce the Incidental Capture of Sea Turtles in the Atlantic Pelagic Longline Fishery. January 17-18, 2001, Silver Spring, Maryland. *U.S. Dept. Commer. NOAA* U*npublished report*, 29pp.

Anon. (2001d) Saving the Pacific Leatherback Turtle? *Pacific Islands Fishery News,* Spring 2001, 1–3.

Anon. (2001e) Working Group on Reducing Turtle Bycatch in the Hawaii Longline Fishery. Report of the Second Meeting, January 9-10, 2001, Hubbs-Sea World Research Institute, San

Diego. *University. Of Hawaii, Joint Institute of Marine and Atmospheric Research, Pelagic Fisheries Research Programme Unpublished report*, 18pp.

Arauz, R. (2000) Impact of High Seas Longline Fishery Operations on Shark and Sea Turtle Populations in the Economic Exclusive Zone of Costa Rica. *Sea Turtle Restoration Project Unpublished report,* 18pp.

Arauz, R., Roderiguez, O., Vargas, R. and Segrura, A. (2000) Incidental Capture of Sea Turtles by Costa Rica's Longline Fleet. In: *Proceedings of the 19th Annual Symposium on Sea Turtle Conservation and Biology.* Kalb, H. and Wibbels, T. (Compilers). U.S. Dept. Commer NOAA Tech. Memo. NMFS-SEFSC-443, 62–64.

Bache, S. (2000) International Bycatch Policy — Options for Sea Turtle Conservation. *International Journal of Marine and Coastal Law* 15(3), 333–353.

Bache, S. (2001a) A Primer on Take Reduction Planning under the MMPA. 44 *Ocean and Coastal Management* 221–240.

Bache, S. (2001b) Sea Turtle Bycatch Mitigation in the Hands of International Institutions: Demystifying the WTO and FAO. In: *Proceedings of the 21st International Symposium on Sea Turtle Biology and Conservation,* February 24–28 2001, Philadelphia, US. (in press).

Bache, S. (2002a) A View of the InterAmerican Convention on Sea Turtle Protection and Conservation from Down Under. In: *Proceedings of the 20th Annual Symposium on Sea Turtle Biology and Conservation*, Mosier, A., Foley, A. and Brost, B. (Compilers) US Dept. Commer. NOAA Tech. Memo. NMFS-SEFSC-477, 121–125.

Bache, S. (2002b) Turtles, Tuna and Treaties: Strengthening the Links Between International Fisheries Management and Marine Species Conservation. *International Journal of Wildlife Law and Policy 5,* 49–64.

Bache, S., Haward, M. and Dovers, S. (2000) *Economic, Environmental and Trade Instruments — Their Impact on Australian Fisheries Policy*. Report to the Fisheries and Aquaculture Policy Branch of the Department of Agriculture, Forestry and Fisheries — Australia, July 2000.

Balazs, G. H. (1999) Factors to Consider in the Tagging of Sea Turtles. In: *Research and Management Techniques for the Conservation of Sea Turtles.* Eckert, K. L., Bjorndal, K. A., Abreu-Grobois, F. A., Donnelly, M. (Editors). IUCN/SSC Marine Turtle Specialist Group Publication No. 4, 101–109.

Balazs, G. H. and Pooley, S. G. (1994) Research Plan to Assess Marine Turtle Hooking Mortality: Results of an Expert Workshop Held in Honolulu, Hawaii, November 16–18, 1993. U.S. *Dept Commer NOAA Tech. Memo. NMFS-SWFSC-201*, 165 pp.

Balazs, G. H., Pooley, S. G. and Murakawa, S. K. K. (1995) Guidelines for Handling Marine Turtles Hooked or Entangled in the Hawaii Longline Fishery: Results of an Expert Workshop Held in Honolulu, Hawaii, March 15–17, 1995. *U.S. Dept. Commer*., *NOAA Tech. Memo. NMFS-SWFSC-222*, 41 pp.

Bjorndal, K. A. (1999) Priorities for Research in Foraging Habitats. In: *Research and Management Techniques for the Conservation of Sea Turtles.* Eckert, K. L., Bjorndal, K. A., Abreu-Grobois, F. A., Donnelly, M. (Editors). IUCN/SSC Marine Turtle Specialist Group Publication No. 4, 235 pp.

Bjorndal, K. A., Bolten, A. B. and Martins, H. R. (2000) Somatic Growth Model of Juvenile Loggerhead Sea Turtles *Caretta caretta*: Duration of Pelagic Stage. *Marine Ecology Progress Series* 202, 265–272.

Bjorndal, K. A., Bolten, A. B. and Riewald, B. (1999a) Development and Use of Satellite Telemetry to Estimate Post-Hooking Mortality of Marine Turtles in the Pelagic Longline Fisheries. *SWFSC Admin. Rep. H-99-03C.*

Bjorndal, K. A., Wetherall, J. A., Bolten, A. B. and Mortimer, J. A. (1999b) Twenty-Six Years of Green Turtle Nesting at Tortuguero, Costa Rica: An Encouraging Trend. *Cons. Biol*. 13, 126–134.

Bisong, S. (2000) The WTO Panel Decision on the U.S. Shrimp Embargo: Another Ruling Against U.S. Enforcement of Species Protection in Trade. *Natural Resources Journal* 40(3), 699–726.

Bolten, A. B. and Balazs, G. H. (1995) Biology of the Early Pelagic Stage – The Lost Year. In: *Biology and Conservation of Sea Turtles*. Bjorndal, K. A. (Editor). Smithsonian Institution Press, Washington DC, 575–581.

Bolten, A. B., Martins, H. R. and Bjorndal, K. A. (Editors) (2000) Workshop to Design an Experiment to Determine the Effects of Longline Gear Modification on Sea Turtle Bycatch Rates.*US Dept. Commer*., *NOAA Tech. Memo. NMFS-OPR-19*, 50 pp.

Bolten, A. B., Martins, H. R., Bjorndal, K. A. and Gordon, J. (1993) Size Distribution of Pelagic-Stage Loggerhead Sea Turtles (*Caretta caretta*) in the waters around the Azores and Madeira. *Arquipelago* Life and Marine Sciences 11A, 49–54.

Bolten, A. B., Martins, H. R., Isidro, E., Ferreira, R., Santos, M., Giga, A., Riewald, B. and Bjorndal, K. A. (2001) Results of an Experiment to Evaluate Effects of Hook Type on Sea Turtle Bycatch in the Swordfish Longline Fishery in the Azores. *Unpublished report,* 3pp.

Bolten, A. B., Wetherall, J. A., Balazs, G. H. and Pooley, S. G. (Compilers) (1996) Status of Marine Turtles in the Pacific Ocean Relevant to Incidental Take in the Hawaii-Based Pelagic Longline Fishery. U.S. *Dept. Commer., NOAA Tech. Memo. NMFS-SWFSC-230*, 167 pp.

Brady, S. and Boreman, J. (1997) Distribution and Fishery Bycatch of Sea Turtles off the Northeastern United States Coast. In: *Fisheries Bycatch: Consequences and Management*. Alaska Sea Grant College Program Report No. 97-02, University of Alaska, Fairbanks.

Burger, J. and Garber, S. D. (1995) Risk Assessment, Life History Strategies, and Turtles: Could Declines be Prevented or Predicted? *Journal of Toxicology and Environmental Health* 46, 483–500.

Camiñas, J. A. and De La Serna, J. M. (1995) The Loggerhead Distribution in the Western Mediterranean Sea as Deducted from Captures by the Spanish Longline Fishery. *Scientia Herpetologica* 1995, 316–323.

Campbell, R., Whitelaw, W. and McPherson, G. (1997) *Domestic Longline Fishing Methods and the Catch of Tunas and Non-Target Species off North-Eastern Queensland*. Report to Eastern Tuna and Billfish Management Advisory Committee, Australian Fisheries Management Authority, April 1997.

Caton, A. (Editor) 2002 *Fishery Status Reports 2000-2001: Resource Assessments of Australian Commonwealth Fisheries*. Bureau of Rural Sciences, Canberra.

Chaloupka, M. and Limpus, C. (2001) Trends in the Abundance of Sea Turtles Resident in Southern Great Barrier Reef Waters. *Biol. Cons.* 102(3), 235–249.

CMS (2001) Conservation of Marine Turtles of the Indian Ocean and South-East Asia. *CMS Bulletin* 14.

Crouse, D. (1984) Incidental Capture of Sea Turtles by Commercial Fisheries. Abridged from Report to the Centre for Environmental Education March 1982. *Smithsonian Herpetological Information Service* 62, 8pp.

Crouse, D. (1997) Pacific Leatherback Postscript. *Marine Turtle Newsletter* 76,12–14.

Crouse, D. (1998) After TEDs: What Next? In: *Proceedings of the 18th International Symposium on Sea Turtle Biology and Conservation*, *Mazatlan, Sinaloa Mexico 3–7 March.* Abreu-Grobois, F. A., Briseño, R. Márquez, R. and Sarti, L. (Compilers), 105–106.

Crouse, D. (1999) The Consequences of Delayed Maturity in a Human-Dominated World. *American Fisheries Society Symposium* 23, 195.

Crouse, D. T., Crowder, L. B., Caswell, H. (1987) A Stage-Based Population Model for Loggerhead Sea Turtles and Implications for Conservation. *Ecology* 68(5), 1412–1423.

Crowder, L. B., Crouse, D. T., Heppell, S. S. and Martine T. H. (1994) Predicting the Impact of Turtle Excluder Devices on Loggerhead Sea Turtle Populations. *Ecol. Applic*. 4, 437–445.

Davenport, J. (1988) Do Diving Leatherbacks Purse Glowing Jelly? *British Herpetological Society Bulletin* 24, 20–21.

Davenport, J., Maltings, L. and Flannery, K. (2001) PIT-Tagging of Leatherbacks Caught in the Irish Tuna Fishery. *Marine Turtle Newsletter* 93, 37.

Dalzell, P. (2000) Fishing, Turtles and the Law: Recent Events in the Hawaii-Based Longline Fishery. *Fisheries Information Newsletter* 93.

Dellinger, T. and Encarnaçâo, H. (2000) Accidental Capture of Sea Turtles by Fishing Fleet Based at Madeira Island, Portugal. In: *Proceedings of the 19th Annual Symposium on Sea Turtle Conservation and Biology.* Kalb, H. and Wibbels, T. (Compilers). U.S. Dept. Commer. NOAA Tech. Memo. NMFS-SEFSC-443, 218.

Dethmers, K. and Broderick, D. (2002) Commercial turtle Harvests in Australasia: Assessing the Extent of their impact using MTDNA Markers. In: *Proceedings of the 22nd Annual Symposium on Sea Turtle Biology and Conservation,* April 4–7 2002, Miami Florida, US. (in press).

Dobbs, K. (2001) General Impacts of Human Activities on Marine Turtles. In *Marine Turtles in the Great Barrier Reef World Heritage Area*. Great Barrier Reef Marine Park Authority, Townsville, Australia.

Eckert, S. A. (1997). Distant Fisheries Implicated in the Loss of the World's Largest leatherback Nesting Population. *Marine Turtle Newsletter* 78, 2–7.

Eckert, S. A. (1998) Perspectives on the Use of Satellite Telemetry and Other Electronic Technologies for the Study of Marine Turtles, With Reference to the First Year Long Tracking of Leatherback Sea Turtles. In: *Proceedings of the 17th Annual Sea Turtle Symposium.* Epperly, S. P. and Braun, J. (Compilers). U.S. Dept. Commer. NOAA Tech. Memo. NMFS-SEFSC-415, 294 pp.

Eckert, S. A. (1999a) Data Acquisition Systems for Monitoring Sea Turtle Behaviour and Physiology. In: *Research and Management Techniques for the Conservation of Sea Turtles.* Eckert, K. L., Bjorndal, K. A., Abreu-Grobois, F. A., Donnelly, M. (Editors). IUCN/SSC Marine Turtle Specialist Group Publication No. 4, 235 pp.

Eckert, K. L. (1999b) Designing a Conservation Program. In: *Research and Management Techniques for the Conservation of Sea Turtles.* Eckert, K. L., Bjorndal, K. A., Abreu-Grobois, F. A., Donnelly, M. (Editors). IUCN/SSC Marine Turtle Specialist Group Publication No. 4, 235 pp.

Epperly, S. and Frazier, J. (2000) Resolutions of the Members of the 20th Annual Symposium on Sea Turtle Biology and Conservation. *Marine Turtle Newsletter* 88, 22–26.

Fallabrino, A., Bager, A., Estrades, A. and Achaval, F. (2000) Current Status of Marine Turtles in Uruguay. *Marine Turtle Newsletter* 87, 4–5.

Ferreira, R. L., Martins, H. R., Da Silva, A. A. and Bolten, A. B. (2001) Impact of Swordfish Fisheries on Sea Turtles in the Azores. *Arquipelago. Life and Marine Sciences* 18A, 75–79.

Fitzsimmons, N., Moritz, C. and Bowen, B. W. (1999) Population Identification. In: *Research and Management Techniques for the Conservation of Sea Turtles.* Eckert, K. L., Bjorndal, K. A., Abreu-Grobois, F. A., Donnelly, M. (Editors). IUCN/SSC Marine Turtle Specialist Group Publication No. 4, 235 pp.

Fontaine, C. T., Marvin, K. T., Williams, T. D., Browning, W. J., Harris, R. M., Williams-Indelicato, K. L., Shattuck, G. A. and Sadler, R. A. (1985) The Husbandry of Hatchling to Yearling Kemp's Ridley Sea Turtles (*Lepidochelys kempi*). *U.S. Dep. Commer. NOAA Tech. Memo. NOAA-TM-NMFS-SEFC*-159, 34pp.

Frazer, N. B. (1992) Sea Turtle Conservation and Halfway Technology. *Cons. Biol*. 6, 179–184.

Frazier, J. and Bache, S. (2002) Sea Turtle Conservation and the Big Stick — The Effects of Unilateral U.S. Embargoes on International Fishing Activities In: *Proceedings of the 20th Annual Symposium on Sea Turtle Biology and Conservation*, Mosier, A., Foley, A. and Brost, B. (Compilers) US Dept. Commer. NOAA Tech. Memo. NMFS-SEFSC-477, 118–121.

Fuller, J. E., Eckert, K. L. and Richardson, J. I. (1992) Wider Caribbean Sea Turtle Recovery Team and Conservation Network (WIDECAST), Sea Turtle Recovery Action Plan for Antigua and Barbuda. *Caribbean Environmental Programme, United Nations Environment Programme, Technical Report* 16, 88pp.

Gerosa, G. and Casale, P. (1999) *Interaction of Marine Turtles with Fisheries in the Mediterranean*. RAC/SPA, Tunisia, 59pp.

Gerrior, P. (1996) Incidental Take of Sea Turtles in Northeast U.S. Waters. In: *Pelagic Longline Fishery–Sea Turtle Interactions. Proceedings of an Industry, Academic and Government Experts, and Stakeholders Workshop, Silver Springs, Maryland, 24–25 May 1994*. Williams, P., Anninos, P. J., Plotkin, P. T. and Salvini, K. L. (Compilers). U.S. Dept. Commer. NOAA Tech. Memo. NMFS-OPR-7, 14–31.

Hall, M. A. (1996) On Bycatches. *Reviews in Fish Biology and Fisheries* 6, 319–352.

Hall, M. A., Alverson, D. L. and Metuzals, K. I. (2000) By-catch: Problems and Solutions. *Mar. Pollut. Bull.* 41 (1-6), 204–219.

Harris, A. and Ward, P. (1999) *Non-target Species in Australia's Commonwealth Fisheries. A Critical Review*. Bureau of Rural Sciences, Canberra.

Heppell, S. S., Limpus, C., Crouse, D. T., Frazer, N. B. and Crowder, L. B. (1996) Population Model Analysis for the Loggerhead Sea turtle, *Caretta caretta*, in Queensland. *Wildlife Research* 23, 143–159.

Hillestad, H. O., Richardson, J. I., McVea Jr., C. and Watson Jr., J. M. (1981) Worldwide Incidental Capture of Sea Turtles. In: *Biology and Conservation of Sea Turtles. Proceedings of the World Conference on Sea Turtle Conservation*. Bjorndal, K. A. (Ed.). Smithsonian Institutional Press, Washington, D.C., 489–495.

Hoey, J. J. (2001) Comments on SEC Initial Draft Criteria, In *Stock assessments of Loggerhead and Leatherback Sea turtles and an Assessment of the Impact of the Pelagic Longline Fishery on the Loggerhead and Leatherback Sea turtles of the Western North Atlantic*. National Marine Fisheries Service Southeast Fisheries Science Centre. U.S. Dept. Commer. NOAA Tech. Memo. NMFS-SEFSC-455, 343pp.

Hutchinson, J. and Simmonds, M. (1991) A Review of the Effects of Pollution on Marine Turtles. *A Greenpeace Ecotoxicology Project.*

James, M. C. (2000) Distribution and Conservation of the Leatherback (*Dermochelys coriacea*) in Atlantic Canada: Research Partnerships with the Fishing Community. In: *Proceedings of the 19th Annual Symposium on Sea Turtle Conservation and Biology.* Kalb, H. and Wibbels, T. (Compilers). U.S. Dept. Commer. NOAA Tech. Memo. NMFS-SEFSC-443, 62–64.

Johnson, D. R., Yeung, C. and Brown, C. A. (1999) Estimates of Marine Mammal and Marine Turtle Bycatch by the U.S. Atlantic Pelagic Longline Fleet in 1992–1997. *U.S. Dept. Commer. NOAA Tech. Memo. NMFS-SEFSC*-418, 70pp.

Kelley, K. (1995) Longliners Try to get a Fix on Turtle Bycatch. *National Fishermen* May, 20–22.

Kennelly, S. J., (1995) The Issue of Bycatch in Australia's Demersal Trawl Fisheries. *Rev. Fish. Biol. Fish*. 5, 213–234.

Kinan, I. (Editor) (2002) Proceedings of the Western Pacific Sea turtle Cooperative Resaerch and Management Workshop. February 5–8 2002, Honolulu, Hawaii, USA, 300pp.

Kleiber, P. (1998) Estimating Annual Takes and Kills of Sea Turtles by the Hawaiian Longline Fishery, 1991–97, from Observer Program and Logbook Data. *SWFSC Administrative Report H-98-08,* 21pp.

Kleiber, P. and Boggs, C. (2000) Workshop on Reducing Sea Turtle Takes in Longline Fisheries Maimi, August 31–September 1, 1999. *SWFSC Admin. Rep*. H-00-09, 16pp.

Laurent, L., Camiñas, J. A., Casale, P., Deflorio, M., De Metrio, G., Kapantagakis, A., Margaritoulis, D., Politou, C. and Valeiras, J. (2001) *Assessing Marine Turtle Bycatch in European Drifting Longline and Trawl Fisheries for Identifying Fishing Regulations.* Project-EC-DG Fisheries 98-008, Joint Project of BIOINSIGHT, IEO, IMBC, STPS and University of Bari, Villeurbanne, France, 267pp.

Laurent, L., Lescure, J., Excoffier, L., Bowen, B., Domingo, M., Hadjichristophorou, M., Kornaraki, L. and Trabuchet, G. (1993) Genetic Studies of Relationships Between Mediterranean and Atlantic Populations of Loggerhead Turtle (*Caretta caretta*) with a Mitochondrial Marker. *Animal Biology and Pathology* 316, 1233–1239.

Lars, M., Boggs, C. and Brill, R. (2001) NMFS Honolulu Laboratory Research to Reduce Bycatch of Sea Turtles. In: *Report of the 14th Meeting of the Standing Committee on Tuna and Billfish, 9–16 August 2001, Noumea, New Caledonia*. Anon. (2001). Secretariat of the Pacific Community, Noumea, New Caledonia, 5.

Limpus, C. (1998) Overview of Marine Turtle Conservation and Management in Australia. In *Marine Turtle Conservation and Management in Northern Australia. Proceedings of a Workshop Held at the Northern Territory University, Darwin, 3–4 June 1997, Centre for Indigenous Natural and Cultural Resource Management and Centre for Tropical Wetlands Management, Northern Territory University, Darwin*. Kennett, R., Webb, A., Duff, G., Guinea, M. and Hill, G. (Editors).

Limpus, C. J., Miller, J. D., Parmenter, C., Reimer, D., McLachlan, N. and Webb, R. (1992) Migration of Green (*Chelonia mydas*) and Loggerhead (*Caretta caretta*) Turtles to and from Eastern Australian Rookeries. *Wildl. Res*. 19, 347–358.

Limpus, C. J. and Reed, P. C. (1985) The Green Turtle, *Chelonia mydas*, in Queensland: A Preliminary Description of the Population Structure in a Coral Reef Feeding Ground. In *Biology of Australian Frogs and Reptiles*. Grigg, G, Shine, R. and Ehmann, H. (Editors.) Royal Zoological Society of New South Wales, 47–52.

Loder, N. (2000) Researchers Take U.S. government to Court Over Threat to Turtles. *Nature* 405, 495

McCracken, M. L. (2000) Estimation of Sea Turtle Take and Mortality in the Hawaiian Longline Fisheries. *SWFSC Admin. Rep. H-00-06*, 29pp.

Margaritoulis, D. (2001) The European Marine Turtle Project: Assessing Marine Turtle Bycatch in Mediterranean Fisheries*. 21st International Symposium on Sea Turtle Biology and Conservation, Philadelphia, U.S. A., 24–28 February 2001.*

Miller, J. D. (1993) Longline Fishery Interactions with Sea Turtles in Australia: A Brief Overview. In: *Research Plan to Assess Marine Turtle Hooking Mortality: Results of an Expert Workshop Held in Honolulu, Hawaii, November 16–18 1993*. NOAA- SWFSC Administrative Report H-93-18, 76–80.

Morreale, S. J. (1996). Distribution and Ecology of Sea Turtles in the Western Atlantic Ocean. In: *Pelagic Longline Fishery–Sea Turtle Interactions. Proceedings of an Industry, Academic and Government Experts, and Stakeholders Workshop, Silver Springs, Maryland, 24–25 May 1994*. Williams, P., Anninos, P. J., Plotkin, P. T. and Salvini, K. L. (Compilers). U.S. Dept. Commer. NOAA Tech. Memo. NMFS-OPR-7, 59–61.

National Marine Fisheries Service (1999) Our Living Oceans. Report on the Status of U.S. Living Marine Resources, 1999. *U.S. Dept. Commer. NOAA Tech. Memo. NMFS-F/SPO*-41.

National Marine Fisheries Service (2001a) *Draft Biological Opinion on the Authorisation of Pelagic Fisheries under the Fishery Management Plan for the Pelagic Fisheries of the Western Pacific Region.* National marine Fisheries Service. March 2001.

National Marine Fisheries Service (2001b) *Environmental Assessment and Regulatory Impact Review for an Emergency Rule to Reduce Sea Turtle Bycatch and Bycatch Mortality in the Atlantic Pelagic Longline Fishery*, July 5, 2001.

National Marine Fisheries Service (2001c) *Environmental Assessment Issuance of Scientific Research Permit #1324 to National Marine Fisheries Service – Southeast Fisheries Science Centre*, August 9, 2001.

National Marine Fisheries Service (2001d) *Reinitiation of Consultation on the Atlantic Highly Migratory Species Fishery Management Plan and its Associated Fisheries*, June 8, 2001.

National Marine Fisheries Service (2001e) Stock assessments of Loggerhead and Leatherback Sea turtles and an Assessment of the Impact of the Pelagic Longline Fishery on the Loggerhead and Leatherback Sea turtles of the Western North Atlantic. *NOAA Tech. Memo. NMFS-SEFSC-455*, 343pp.

National Marine Fisheries Service (2002a) *Proposed Rule to Reduce Sea Turtle Bycatch Mortality in Highly Migratory Species Fisheries, Regulatory Adjustment to the Atlantic Tunas, Swordfish, and Sharks Fishery Management Plan*. National Marine Fisheries Service, March 2002.

National Marine Fisheries Service (2002b) *Stock Assessment and Fishery Evaluation for Atlantic Highly Migratory Species 2002.* National Marine Fisheries Service, March 2002.

National Marine Fisheries Service (2002c) *Final Environmental Assessment, Issuance of Scientific Research Permit #1303 to the National Marine Fisheries Service – Honolulu Laboratory*. National Marine Fisheries Service. February 2002.

National Marine Fisheries Service and U.S. Fish and Wildlife Service (1998a) *Recovery Plan for U.S. Pacific Populations of the East Pacific Green Turtle (Chelonia mydas)*. National Marine Fisheries Service, Silver Spring, MD.

National Marine Fisheries Service and U.S. Fish and Wildlife Service (1998b) *Recovery Plan for U.S. Pacific Populations of the Leatherback Turtle (Dermochelys coriacea)*. National Marine Fisheries Service, Silver Spring, MD.

National Marine Fisheries Service and U.S. Fish and Wildlife Service (1998c) *Recovery Plan for U.S. Pacific Populations of the Olive Ridley Turtle (Lepidochelys olivacea)*. National Marine Fisheries Service, Silver Spring, MD.

National Marine Fisheries Service and U.S. Fish and Wildlife Service (1998d) *Recovery Plan for U.S. Pacific Populations of the Loggerhead Turtle (Caretta caretta)*. National Marine Fisheries Service, Silver Spring, MD.

National Marine Fisheries Service and U.S. Fish and Wildlife Service (1998e) *Recovery Plan for U.S. Pacific Populations of the Hawksbill Turtle (Eretmochelys imbricata)*. National Marine Fisheries Service, Silver Spring, MD.

National Marine Fisheries Service and U.S. Fish and Wildlife Service (1998f) *Recovery Plan for U.S. Pacific Populations of the Green Turtle (Chelonia mydas)*. National Marine Fisheries Service, Silver Spring, MD.

Nishimura, W. and Nakahigashi, S. (1990) Incidental Capture of Sea Turtles by Japanese Research and Training Vessels: Results of a Questionnaire. *Marine Turtle Newsletter* 51, 1–3.

Oceanic Fisheries Programme (2001) A Review of Turtle Bycatch in the Western and Central Pacific Ocean Tuna Fisheries. *A Report Prepared for the South Pacific Regional Environmental Programme (SPREP).* Secretariat of the Pacific Community, New Caledonia, May 2001.

Oravetz, C. A. (1999) Reducing Incidental Catch in Fisheries. In: *Research and Management Techniques for the Conservation of Sea Turtles.* Eckert, K. L., Bjorndal, K. A., Abreu-Grobois, F. A., Donnelly, M. (Editors). IUCN/SSC Marine Turtle Specialist Group Publication No. 4, 235 pp.

Panou, A., Tselentis, L., Voutsinas, N., Mourelatos, C. H., Kaloupi, S., Voutsinas, V. and Moschonas, S. (1999) Incidental Catches of Marine Turtles and Surface Longline Fisheries in the Ionian Sea, Greece. *Contributions to the Zoogeography and Ecology of Eastern Mediterranean Region* 1, 435–445.

Parker, D. M., Cooke, W. and Balazs, G. H. (2002) Dietary Components of Pelagic Loggerhead Turtles in the North Pacific Ocean. In: *Proceedings of the 20th Annual Symposium on Sea Turtle Biology and Conservation*, Mosier, A., Foley, A. and Brost, B. (Compilers) US Dept. Commer. NOAA Tech. Memo. NMFS-SEFSC-477, 369 pp.

Parker, D. M., Balazs, G. H., Murakawa, S. K. K. and Polovina, J. P. (2001) Post-hooking Survival of Sea Turtles Taken by Pelagic Longline Fishing in the North Pacific. In: *Proceedings of the 21st International Symposium on Sea Turtle Biology and Conservation,* 24–28 February 2001, Philadelphia, US. (in press).

Polovina, J. H., Balazs, G. H., Howell, E. A., Parker, D. M., Seki, M. P. and Dutton, P. H. (2002) Forage and Migration Habitat of Loggerhead (*Caretta caretta*) and Olive Ridley (*Lepidochelys olivacea*) Sea Turtles in the Central North Pacific Ocean. *Fish. Oceanog,* (in review).

Polovina, J. J., Kobayashi, D. R., Parker, D. M., Seki, M. P. and Balazs, G. H. (2000) Turtles on the Edge: Movement of Loggerhead Turtles (*Caretta caretta*) Along Oceanic Fronts, Spanning Longline Fishing Grounds in the Central North Pacific, 1997–1998. *Fish. Oceanogr.* 9(1), 71–82.

Pont Gasau, S. and Alegre Ninou, F. (2000) Work of the Foundation for the Conservation and Recovery of Marine Life. *Marine Turtle Newsletter* 87, 5–7.

Prieto, R., Ferreira, R. and Silva, A. (2000) Turtle Bycatch Study in the Longline Fisheries of the Azores. In: *Workshop to Design an Experiment to Determine the Effects of Longline Gear Modification on Sea Turtle Bycatch Rates.* Bolten, A. B., Martins, H. R. and Bjorndal, K. A. (Editors) NOAA Tech. Memo. NMFS-OPR-19, 50 pp.

Prince, R. I. T. (1998) Marine Turtle Conservation: The Links Between Populations in Western Australia and the Northern Australian Region. People and Turtles. In *Marine Turtle Conservation and Management in Northern Australia. Proceedings of a Workshop Held at the Northern Territory University, Darwin, 3–4 June 1997, Centre for Indigenous Natural and Cultural Resource Management and Centre for Tropical Wetlands Management, Northern Territory University, Darwin*. Kennett, R., Webb, A., Duff, G., Guinea, M. and Hill, G. (eds).

Robins, C. M., Goodspeed, A. M., Poiner, I. R. and Harch, B. D. (2002) Monitoring the Catch of Turtles in the Northern Prawn Fishery. *Fisheries Research and Development Corporation Draft Final Report*, October 2002.

Robins, J. B. (1995) Estimated Catch and Mortality of Sea Turtles from the East Coast Otter Trawl Fishery of Queensland, Australia. *Biol. Conserv*. 74(3), 157–167.

Ruckdeschel, C., Shoop, C. R. and Zug, G. R. (2000) Sea Turtles of the Georgia Coast. *Occas. Publ. Cumberland Isl. Mus*., Georgia, 100 pp.

Skillman, R. A. and Balazs, G. H. (1992) Leatherback Turtle Captured by Ingestion of Squid Bait on Swordfish Longline. *Fish. Bull*. 90(4), 807–808.

Skillman, R. A. and Kleiber, P. (1998) Estimation of Sea Turtle Take and Mortality in the Hawaii-Based Longline Fishery, 1994–96. *NOAA Tech. Memo. NMFS-SWFSC-257*, 52pp.

Spotila, J. R., Dunham, A. E., Leslie, A. J., Steyermark, A. C., Plotkin, P. T. and Paladino, F. V. (1996) Worldwide Population Decline of *Dermochelys coriacea*: Are Leatherback Turtles Going Extinct? *Chelonian Conservation and Biology* 2(2), 209–222.

Spotila, J. R., Reina, R. D., Steyermark, A. C., Plotkin, P. T. and Paladino, F. V. (2000) Pacific Leatherback Turtles Face Extinction. *Nature* 405, 529–530.

Stone, H. H. and Dixon L. K. (2001) A Comparison of Catches of Swordfish, *Xiphias gladius*, and Other Pelagic Species from Canadian Longline Gear Configured with Alternating Monofilament and Multifilament Nylon Gangions. *Fish. Bull*. 99, 210–216.

Swimmer, Y., Brill, R. and Musyl, M. (2002a) Quantifying Sea Turtle Mortality with PSATs. *Pelagic Fisheries Research program* 7(2), April–June 2002, 1–5.

Swimmer, Y. Brill, R. and Musyl, M. (2002b) Use of Pop-Up Satellite Archival Tags to Quantify Mortality of Marine Turtles Incidentally Captured in Longline Fishing Gear. Marine Turtle Newsletter 97, 3–7.

Swimmer, Y., Brill, R., Mailloux, L., Higgins, B., Vieyra, M., Anderson, D. and Vogt, R. (2002c) Behavioural and Genetic Components of Marine Turtle Olfaction: An Investigation Aimed at Reducing the Incidental Bycatch of Marine Turtles in Longline Fishing Gear. In: *Proceedings of the 22nd Annual Symposium on Sea Turtle Biology and Conservation,* April 4–7 2002, Miami Florida, US. (in press).

Tomas, J., Dominici, A., Nannarelli, S., Forni, L., Badillo, F. J. and Raga, J. A. (2001) From Hook to Hook: The Odyssey of a Loggerhead Sea Turtle in the Mediterranean. *Marine Turtle Newsletter* 92, 13–14.

Ulloa Ramírez, P. A. and González Ania, L. V. (1998) Incidence of Marine Turtles in the Mexican Longline Tuna Fisheries in the Gulf of Mexico In: *Proceedings of the 18th International Symposium on Sea Turtle Biology and Conservation*, *Mazatlan, Sinaloa Mexico 3–7 March.* Abreu-Grobois, F. A., Briseño, R. Márquez, R. and Sarti, L. (Compilers), 110.

UNEP (1999) *Action Plan for the Conservation of Mediterranean Marine Turtles*. Adopted within the framework of the Barcelona Convention for the Protection of the Marine Environment and the Coastal region of the Mediterranean, Malta 27–30 October 1999.

Vogt, R. G., Vieyra, M. and Anderson, D. (2002) New Discoveries in the Olfactory Capability of Sea Turtles. *Pelagic Fisheries Research Program* April–June 7(2), 6–9.

Watson, J. (2002) Experiments in the Western Atlantic to Evaluate Sea Turtle Mitigation Measures in the Pelagic Longline Fishery. In: *Proceedings of the 22nd Annual Symposium on Sea Turtle Biology and Conservation,* April 4–7 2002, Miami Florida, US. (in press).

Western Pacific Regional Fishery Management Council (2002) *Measures to Reduce the Incidental Catch of Sea Turtles in the Pelagic Fisheries of the Western Pacific Region. A Regulatory Amendment Under the Pelagic Fishery Management Plan of the Western Pacific Region.* Western Pacific Regional Fishery Management Council, January 31, 2002.

Wetherall, J. A., Balazs, G. H., Tokunaga, R. A. and Yong, M. Y. Y. (1993) Bycatch of Marine Turtles in North Pacific High-Seas Driftnet Fisheries and Impacts on the Stocks. *North Pacific Commission Bulletin* 53, 519–538.

Wetherall, J. A. (1997) Mortality of Sea Turtles in the Hawaii Longline Fishery: A Preliminary Assessment of Population Impacts. *SWFSC Admin. Rep. H-97-07,* 51pp.

Williams, P., Anninos, P. J., Plotkin, P. T. and Salvini, K. L. (1996) Pelagic Longline Fishery–Sea Turtle Interactions. Proceedings of an Industry, Academic and Government Experts, and Stakeholders Workshop, Silver Springs, Maryland, 24–25 May 1994. U.S. *Dept. Commer. NOAA Tech. Memo. NMFS-OPR-7,* 77pp.

Witzell, W. N. (1984) The Incidental Capture of Sea turtles in the Atlantic U.S. Fishery Conservation Zone by the Japanese Tuna Longline Fleet, 1978–81. *Marine Fisheries Review* 46(3), 56–58.

Witzell, W. N. (1996) The Incidental Capture of Sea Turtles by the U.S. Pelagic Longline Fleet in the Western Atlantic Ocean. In: *Pelagic Longline Fishery–Sea Turtle Interactions. Proceedings of an Industry, Academic and Government Experts, and Stakeholders Workshop, Silver Springs, Maryland, 24–25 May 1994.* Williams, P., Anninos, P. J., Plotkin, P. T. and Salvini, K. L. (Compilers). U.S. Dept. Commer. NOAA Tech. Memo. NMFS-OPR-7, 32–38.

Witzell, W. N. (1999) Distribution and Relative Abundance of Sea Turtles Caught Incidentally by the U.S. Pelagic Longline Fleet in the Western North Atlantic Ocean, 1992–1995. *Fish. Bull.* 97(1), 200–211.

Witzell, W. N. and Cramer, J. (1995) Estimates of Sea Turtle Bycatch by the U.S. Pelagic Longline Fleet in the Western North Atlantic Ocean. U.S. *Dept. Commer. NOAA Tech. Memo. NMFS-SEFSC-359*, 14pp.

Work, T. M. and Balazs, G. H. (2002) Necropsy Findings in Sea Turtles Taken as Bycatch in the North-Pacific Longline Fishery (under review).

World Trade Organization (1998a), *United States – Import Prohibition of Certain Shrimp and Shrimp Products,* WT/DS58/R (15 May 1998), reprinted in 37 I.L.M. 832.

World Trade Organization (1998b) Appellate Body, *United States - Import Prohibition of Certain Shrimp and Shrimp Products*, WT/DS58/AB/R, 12 October 1998, reprinted in 38 I.L.M. 118.

World Trade Organisation (2001a), *United States - Import Prohibition of Certain Shrimp and Shrimp Products, Recourse to Article 21.5 by Malaysia*, WT/DS58/RW, 15 June 2001.

World Trade Organisation (2001b) *United States - Import Prohibition of Certain Shrimp and Shrimp Products, Recourse to Article 21.5 of the DSU by Malaysia*, WT/DS58/AB/RW, 22 October 2001.

Yeung, C. (1999) Estimates of Marine Mammal and Marine Turtle Bycatch by the U.S. Atlantic Pelagic Longline Fleet in 1998. U.S. *Dept. Commer. NOAA Tech. Memo. NMFS-SEFSC-430*, 26pp.

Yeung, C. (2001) Estimates of Marine Mammal and Marine Turtle Bycatch by the U.S. Atlantic Pelagic Longline Fleet in 1999–2000. *U.S. Dept. Commer. NOAA Tech. Memo. NMFS-SEFSC-467*, 43pp.

APPENDIX 1

Threats faced by sea turtles

All species of sea turtle have high egg and hatchling mortality, but low adult mortality, excluding human-induced mortality events (Limpus, 1998). Historically, sea turtle conservation focused on the early stages of their life (Hillestad *et al*., 1981). By reducing the harvest of turtle eggs and increasing the preservation of nesting beaches, more hatchlings have the chance to make it to the water for their first swim.

The magnitude of adult mortality tends to remain somewhat hidden, with many deaths occurring in the oceans and few bodies being recovered. However, when considering declining populations it has been noted that in some cases the adult and sub-adult components of the population may make the greatest contribution to the recovery of the species (Crouse *et al*., 1987; Panou *et al*., 1999; Western Pacific Regional Fishery Management Council, 2002). This was demonstrated by Heppell *et al.* (1996:143) when modelling loggerhead population on the east coast of Australia. They found that for this stock the 'survival in the first year of life is relatively less important in these long-lived and slow-maturing animals'. They also predicted that the current anthropogenic-induced sources of adult and sub-adult loggerhead mortality, including significant kills by commercial fishing gear, could drive this stock to extinction in less than a century. Spotila *et al*. (1996), when considering leatherbacks, argued that egg and hatchling; also and adult protection is vital for the survival of the species.

Frazer (1992) suggests that rather than only looking at sea turtle conservation as an issue of too few turtles, thereby solving the problem by releasing more hatchlings in the oceans, effort should also be concentrated on addressing each contributing factor separately, thereby reducing the negative impacts of human activities on turtle populations. These anthropogenic threats are varied. Examples from Hutchinson and Simmonds (1991), Wetherall *et al*. (1993), Burger and Garber (1995), Limpus (1998a), National Marine Fisheries Service (1999), Anon. (1999b), Ruckdeschel, *et al.* (2000), and Dobbs (2001) include:

- sea negative effects of pollution (pesticides, heavy metals, organochloride compounds, sewage effluent) both sourced from the land and from boats, including pollution affecting feeding grounds and contributing to increases in disease;
- ingestion of, and possibly entanglement in, plastic and other debris, including plastic bait bands, possibly causing injury, internal blockages, drowning, ulcers and toxic effects;
- deaths from recreational fishing, including hooking and entanglement in fishing line;
- ingestion of, and coating in, oil droplets and tar in the water and on beaches, possibly causing choking, inhibition of movement and sublethal effects;harvesting of meat and eggs for human consumption – commercial, subsistence and for ceremonial purposes;
- harvesting for leather and oil;
- shark netting and hooking programs along beaches;
- use of shells and other parts of the turtles for sale as souvenirs, including tortoiseshell (bekko) and stuffed specimens;
- deliberate killing, injuring and harassing sea turtles for fun or sport;

- predation of eggs and hatchlings and destruction of beach dunes by feral, domestic and native animals;
- nesting habitat loss and modification through coastal development that prevents females nesting or causes mortality to hatchlings, including changing beach architecture, beach erosion and erosion contro, introduction of exotic vegetation and shading nest sites;
- dredging and sand mining;
- degradation of foraging habitats, including coral reefs and seagrass beds;
- dynamite fishing;
- marina, docking and jetty development;
- human activity on nesting beaches, including recreational vehicles and furniture, tourists disrupting nesting females and collapsing nests, injuries from discarded refuse, beach cleaning, compaction of sand, and formation of tracks;
- light pollution on nesting beaches;
- mining and exploration, including underwater explosions;
- oil rigs causing an increase in predation of hatchlings as a result of attracting predators and also hatchlings beneath them;
- entrapment in water intake mechanisms of power plants; and
- religious, ceremonial and other traditional uses;
- deaths from commercial fishing – longlines, trawls, gillnets, lobster pot lines, pound-nets, purse seines;
- entanglement in discarded nets (ghost fishing), including trawl gear, set nets and the now-banned drift nets, possibly causing drowning, changes in movement and behaviour and injury;
- boating strikes, including propeller and vessel collisions – recreational and commercial.

APPENDIX 2

History of sea turtle regulation in the US

Atlantic Pelagic Fishery for swordfish, tuna, shark and billfish (HMS)

Date	Action
12 May 1998	Formal consultations under section 7 of the Endangered Speciesct A reinitiated as part of the preparation of the HMS-Fishery Management Plan and Billfish Amendment.
1999	Data revealed that the pelagic longline component of the fishery for swordfish and tuna greatly exceeded the number of loggerhead and leatherback sea turtles that had been expected to be taken – resulting in reinitiation of section 7 consultations.
23 Apr 1999	Formal consultations leading to a Biological Opinion on the HMS proposed rule to implement the final HMS-Fisheries Management Plan. The Biological Opinion found the HMS fishery was likely to lethally and non-lethally take large numbers of threatened and endangered sea turtles.
19 Nov 1999	NMFS reinitiated formal section 7 consultation following reports that the loggerhead take had exceeded that anticipated in the previous Incidental Take Statement.
15 Dec 1999	Proposed rule for bycatch reduction published. Proposed a prohibition of pelagic longline fishing at certain times and in certain areas to reduce a range of bycatches in pelagic longline fisheries targeting HMS.
30 Dec 1999	Supplementary Environmental Impact Statement identifying and analysing proposed rule for bycatch reduction of 15 Dec 99.
28 Feb 2000	Internal NMFS MOU noting that a new Biological Opinion was required as the fishery had again exceeded the number of turtles expected to be taken.
26 Apr 2000	NMFS publishes supplementary information and a revised summary Interim Regulatory Flexibility Analysis for the proposed rule for bycatch reduction of 15 Dec 1999.
30 Jun 2000	Section 7 consultation considering the effects of implementation of the Interim Final Rule of 19 Dec 1999. Resultant Biological Opinion finding that the HMS fishery is likely to jeopardise the continued existence of both leatherback and loggerhead sea turtles, and may adversely affect several other sea turtle and marine mammal species. It included two alternative Reasonable and Prudent Alternatives and in a new Incidental Take Statement with several identified non discretionary Reasonable and Prudent Measures with Terms and Conditions to minimise this effect. Overall it required a reduction in the take of both loggerhead and leatherback species by at least 75% of current rates by 2001.
19 Jul 2000	NMFS announces intent to prepare a supplemental Environmental Impact Statement to address the 30 Jun 2000 Biological Opinion.
7 Sep 2000	Request to reitinerate section 7 consultations due to further need for analysis of sea turtle data, post hooking mortality estimates and population modelling.
13 Oct 2000	Emergency rule issued to reduce turtle bycatch and mortality (expires 9 Apr 2001) - requires the possession and use of line clippers and dipnets on vessels and sea turtle resuscitation/handling guidelines.
16 Feb 2001	Decision memorandum on mortality of sea turtles in pelagic longline fisheries.
30 Mar 2001	Interim Final Rule extending the Oct 13 Emergency Rule requiring possession and use of line clippers and dip nets on all vessels and sea turtle resuscitation/ and handling guidelines.

30 Mar 2001	NMFS issues Biological Opinion. This includes one Reason and Prudent Alternatives prescribing 4 measures (prohibit sword fishing style methods; limited access permit restrictions; fishing techniques & and gear modification restriction; and reducing harmful effect of fishing gear interactions).
10 Apr 2001	Mar 30 Interim Final Rule operational – no expiry date, will operate indefinitely.
31 May 2001	Draft copy of the final supplement Environmental Impact Statement concluded.
14 Jun 2001	Section 7 consultation leading to a Biological Opinion. Proposesing the continuation of the Mar 30 Interim Final Rule. Again jeopardy was found for the pelagic longline HMS fishery's effect on the continued existence of loggerhead and leatherback turtles. The Biological Opinion contained a single Reasonable and Prudent Alternative that was to be implemented in its entirety, as well as an Incidental Take Statement containing two Reasonable and Prudent Measures involving data collection and education, as well as reporting requirements, observer coverage, technical analysis and a sea turtle injury workshop.

Western Pacific (Hawaii-based) pelagic longline fishery (PLF)

Date	**Action**
1991-1994	Data gathered from compulsory log book entries and voluntary observers suggested a potentially significant level of sea turtle interaction or take.
Feb 1994	Mandatory observer program instituted.
24 Feb 1999	Lawsuit filed against the NMFS by Centre for Marine Conservation (CMS) and Sea Turtle Restoration Project (STRP) for violations of sections 7 and 9 of the ESA and the National Environment Protection Act.
23 Nov 1999	U.S. District Court (Hawaii) issues an injunction on Hawaii-based PLF; Order issued by the U.S .District Court in *CMC v NMFS*. NMFS issues Emergency Interim Rule to implement the injunction establishing area closures in the Hawaii-based longline fishery. Also order for NMFS to analyse special and temporal data in relation to fishing and bycatch.
24 Nov 1999	CMS and STRP file second lawsuit against NMFS.
26 Nov 1999	U.S. District Court of Hawaii entered Order in *CMC v NMFS* directing NMFS to require, within 4 months of the date of entry of the Order, every vessel in the Hawaii-based PLF to carry and use line clippers and dip nets for disentangling and retrieving turtles from longline gear.
23 Dec 1999	Emergency Rule issued by NOAA/NMFS becomes effective.
27 Dec 1999	NMFS issues emergency closure notice to prohibit vessels registered for use under a Hawaii longline limited access permit from fishing with longline gear within a certain area. NMFS also prohibits vessels landing or transhipping catch in certain areas and under certain conditions..
20 Jan 2000	Informal consultation under the Endangered Species Act concluded; Regional Administration determined that fishery activities conducted under above rule are not likely to adversely affect endangered or threatened species or critical habitat.
28 Mar 2000	Final Rule for gear requirements line clippers and dip nets; and use of specific methods for handling, resuscitation and release of sea turtles. Effective 27 Apr 2000.
5 May 2000	NMFS presented its findings on the 23 Nov Order to the court – recommending modifications to the 1999 time area closure.
18 May 2000	Memorandum indicating catch estimates had likely exceeded anticipated incidental take levels in the Hawaii fishery for Olive Ridley turtles.

7 Jun 2000	Section 7 consultations reinitiated.
20 Jun 2000	Court hears arguments of the parties from 24 Nov 1999 filed case.
23 Jun 2000	US District Court, Hawaii issues Order Modifying Provisions of the Initial Order of Injunction.
26 Jun 2000	Judge Ezra issues Order clarifying the 23 Jun Order. Together these required NMFS to establish within 30 days a different set of longline area closures, fishing effort restrictions and 100% observer coverage for the entire fishery.
26 Jun 2000	NMFS extends the 23 Nov 1999 Emergency Rule to 27 Dec 2000.
6 Jul 2000	Earthjustice Legal Defense Fund, on behalf of CMC, STRP and the Recreational Fishing Alliance, issue a 60 day notice of intent to sue to NMFS for alleged violations of sections 7 and 9 of the Endangered Species Act.
21 Jul 2000	Court Order issued amending the injunction and staying the Order pending further consideration and action.
4 Aug 2000	Court issues Order Further Amending Order Modifying Provisions of the Initial Order replacing the 23 December Interim Rule. This includes: area closures; limits on the number of sets in certain months; limits swordfish landings in certain areas; up to 100% observer coverage in certain areas; and bans the use of lightsticks in certain areas. Such action is required by NMFS within three days of the decision coming into effect (Aug 7). Also Order requires NMFS to complete an Environmental Impact Statement by 1 Apr 2001.
25 Aug 2000	NMFS issues Emergency Interim Rule effective from 23 Dec 1999, implementing the Jun 23 court Order and June 26 court clarification. Replaces the Rule issued on 23 Dec and extended on 26 Jun. This Rule imposes fishing gear restrictions, and time and area closures, and requires increased observer coverage. Expires 21 Feb 2001.
7 Sep 2000	Reinitiation of section 7 consultation.
10 Oct 2000	NMFS issues an Emergency Rule establishing limited time and area closures and requiring all vessels in the Hawaii-based PLF to carry and use line clipper and dipnets.
3 Nov 2000	NMFS issues replacement Emergency Interim Rule.
4 Dec 2000	Draft Environmental Impact Statement for the Pelagics FMP.
22 Feb 2001	NMFS issues replacement Emergency Interim Rule.
15 Mar 2001	Judge Ezra eases restrictions on the Hawai'i-based PLF.
19 Mar 2001	NMFS issues replacement Emergency Interim Rule.
29 Mar 2001	Section 7 consultation and Biological Opinion issued. Concluded a “No Action” alternative that projects the continuation of current management actions without change consistent with that option in the Draft Environmental Impact Statement for Pelagics Fisheries Management Plan.
30 March 2001	Final Environmental Impact Statement presented to the Judge by NMFS.
30 March 2001	Federal court decision shutting down the Hawaii longline fishery targeting swordfish and restricting operation of the Hawaii longline tuna fishery.
2 Apr 2001	Partial lifting of the Hawaii longline closure following consultations and an agreement between District Judge David Ezra and attorneys for all parties. The Judge’s new order allows for Hawaii longline vessels targeting tuna to operate in the Pacific except during April and May between the equator and 15 degrees north and 145 and 180 degrees west longitude. The prohibition on swordfish vessels remains in place. Intent is to reduce the take of loggerheads by 100%, leatherbacks by 82-85%, olive ridleys by 52-69%, and greens by 89-91%. The Fisheries Management Council

	recommended allowing the swordfish fishery to operate on an experimental basis for 3 to 5 years to allow for the development of gear and methods that would reduce sea turtle bycatch therein.
2 May 2001	Environmental Non-Government Organisations file a suit to prevent the relocation of Hawaiian vessels to the Californian coast.
21 May 2001	Scientific and Statistical Committee (SSC) of the Western Pacific Fisheries Management Council urges the Fish and Wildlife Service and NMFS to implement recovery plans for marine turtles. SSC also critical of the March 29 Biological Opinion.
12 Jun 2001	Emergency Interim Rule, notification of restrictions: – area closure of the longline fishery; imposition of additional sea turtle handling guidelines and resuscitation measures; requires requirement for all vessel operators to attend an annual protected species workshop. Implements 30 March 2001 Court Order. Includes requirements to deploy lines such that there is a certain sink depth and gear configuration; prohibition of the use of lightsticks; time area closures; attendance at protected species workshops; possession of bolt cutters to aid in the removal of hooks from turtles where appropriate; certain response action if a turtle is found to be hooked or entangled, including resuscitation. Expires 10 December 2001.
10 Dec 2001	Emergency Interim Rule and extension of closure date of 12 Jun Rule. Expires 8 Jun 2002.

APPENDIX 3

Australian regulatory specifications relevant to sea turtle bycatch

Approvals criteria of "significance" for certain listed species

Extinct in the wild species

An action has, will have, or is likely to have a significant impact on extinct in the wild species if it does, will, or is likely to:

- adversely affect a captive or propagated population or one recently introduced/ reintroduced to the wild, or
- interfere with the recovery of the species, or its reintroduction into the wild.

Critically endangered and endangered species

An action has, will have, or is likely to have a significant impact on a critically endangered or endangered species if it does, will, or is likely to:

- lead to a long-term decrease in the size of a population, or
- reduce the area of occupancy of the species, or
- fragment an existing population into two or more populations, or
- adversely affect habitat critical to the survival of a species, or
- disrupt the breeding cycle of a population, or
- modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline, or
- result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat, or
- interfere with the recovery of the species.

Vulnerable species

An action has, will have, or is likely to have a significant impact on a vulnerable species if it does, will, or is likely to:

- lead to a long-term decrease in the size of an important population of a species, or
- reduce the area of occupancy of an important population, or
- fragment an existing important population into two or more populations, or
- adversely affect habitat critical to the survival of a species, or
- disrupt the breeding cycle of an important population, or
- modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline, or
- result in invasive species that are harmful a vulnerable species becoming established in the vulnerable species' habitat, or
- interferes substantially with the recovery of the species.

An important population is one that is necessary for a species' long-term survival and recovery. This may include populations that are:

- key source populations either for breeding or dispersal,
- populations that are necessary for maintaining genetic diversity, and/or
- populations that are near the limit of the species range.

Listed migratory species
An action has, will have, or is likely to have a significant impact on a migratory species if it does, will, or is likely to:

- substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles),
- destroy or isolate an area of important habitat of the migratory species, or
- result in invasive species that is harmful to the migratory species becoming established* in an area of important habitat of the migratory species, or
- seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of the species.

*An area of important habita*t is:

- habitat utilised by a migratory species occasionally or periodically within a region that supports an ecologically significant proportion of the population of the species, or
- habitat utilised by a migratory species which is at the limit of the species range, or
- habitat within an area where the species is declining.

Listed marine species and cetaceans
An action has, will have or is likely to have a significant impact on the environment in a Commonwealth marine area if it does, will, or is likely to:

- result in a known or potential pest species becoming established in the Commonwealth marine area, or
- modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity in a Commonwealth marine area results, or
- have a substantial adverse effect on a population of a marine species or cetacean including its life cycle (eg breeding, feeding, migration behaviour, and life expectancy) and spatial distribution, or
- result in a substantial change in air quality or water quality (including temperature) which may adversely impact on biodiversity, ecological integrity, social amenity or human health, or
- result in persistent organic chemicals, heavy metals, or other potentially harmful chemicals accumulating in the marine environment such that biodiversity, ecological integrity, social amenity or human health may be adversely affected.

http://www.ea.government.au/epbc/assessapprov/referrals/significanceguide.html

Recovery plans under the EPBC Act

Chapter 5 - Conservation of biodiversity
Part 13 - Species and communities
Division 5 – Plans

Section 270. Content of recovery plans
(1) A recovery plan must provide for the research and management actions necessary to stop the decline of, and support the recovery of, the listed threatened species or listed threatened ecological community concerned so that its chances of long-term survival in nature are maximised.

(2) In particular, a recovery plan must:

(a) state the objectives to be achieved (for example, removing a species or community from a list, or indefinite protection of existing populations of a species or community); and
(b) state criteria against which achievement of the objectives is to be measured (for example, a specified number and distribution of viable populations of a species or community, or the abatement of threats to a species or community); and
(c) specify the actions needed to achieve the objectives; and (ca) identify threats to the species or community; and
(d) identify the habitats that are critical to the survival of the species or community concerned and the actions needed to protect those habitats; and

(e) identify any populations of the species or community concerned that are under particular pressure of survival and the actions needed to protect those populations; and
(f) state the estimated duration and cost of the recovery process; and
(g) identify interests that will be affected by the plan's implementation; and organisations or persons who will be involved in evaluating the performance of the recovery plan; and

(h) specify any major benefits to native species or ecological communities (other than those to which the plan relates) and will be affected by the plan's implementation; and

(j) meet prescribed criteria (if any) and contain provisions of a prescribed kind (if any).

ToRs for the strategic assessment of Commonwealth managed fisheries

The ToRs require the following information to be presented in SAs of fisheries:

1. *A comprehensive description of the fishery including information about* the agency responsible for the management of the fishery, the species caught, the fishing methods employed, the area fished (including a map), the number of operators, and current and historic fishing effort

2. *A description of the environment likely to be affected by the fishery* including a description of the significant environmental characteristics of the area likely to be affected by the fishery. This should include information about marine protected areas, components of biodiversity, threatened and other protected species, description of seagrass and benthic communities, important features such as coral reefs, seamounts and estuaries, and other aspects of the biophysical environment potentially affected by the fishery.

3. *Proposed management arrangements for the fishery including* a comprehensive description of legislation and policies relevant to the management of the fishery being managed, the environmental impacts of those instruments and the agencies responsible for administering them.

The assessment of the management arrangements must identify: international agreements relevant to the management of the fishery, the specific management arrangements to be applied to the fishery, any management plan for the fishery, or bycatch action plan , regulations and any strategic research plan for the fishery, and elements of the fishery's management regime that are aimed to ensure that the fishery operates in an ecologically sustainable manner.

4. *Environmental assessment of the fishery* must include information about the ecologically sustainable nature of the fishery in terms of its impacts on target species, non-target species and bycatch and the ecosystem (including habitats) in general. The environmental assessment must also do the following:

i describe the potential impacts of the fishery on the environment (including information on the degree of confidence with which the impacts can be predicted and quantified);
ii analyse the nature and extent of the potential environmental impacts including whether they are likely to be short or long-term impacts;
iii assess whether any environmental impacts are likely to be unknown, unpredictable or irreversible;
iv analyse the significance the potential impacts; and
v refer to the technical and other data used in assessing the environmental impacts of the fishery.

5. *Management measures and safeguards to ensure ecological sustainability* must include a detailed analysis of the specific elements of the management regime that has been proposed for the fishery to ensure that it is ecologically sustainable. This aspect of the SIA must identify and describe specific measures intended to prevent or minimise ecological damage or impacts resulting from the fishery. Specific measures to protect target and non-target species and the ecosystem must be identified and distinguished. Details of compliance measures and penalties for non-compliance must be identified and described. Mechanisms for reviewing the fishery and its operations and management must also be identified. Where possible, the assessment should identify and discuss alternative and feasible management arrangements.

6. *Information sources must be stipulated* in the assessment and in particular, the source of the information, how recent it is, how its reliability was tested and any uncertainties in the information must be identified.

Checklist for developing a Bycatch Action Plan

The following checklist may assist those involved in the preparation of Bycatch Action Plans to define the specific bycatch issues and identify appropriate actions.

1. What is the issue? (For example: threat to an endangered species, unsustainable bycatch or catch of by-product species, public perception of waste, lack of good quality data, benthic habitat impact, contamination, market forces, type of fishing operation, lack of community and fisher awareness). What is the order of priority for dealing with the issues?

2. Is the issue species specific, fishery specific, fishing method-based, or regional in nature? Does it relate to a change in the management status of the region in which the fishery operates (e.g. the declaration of a marine protected area)?

3. Is the issue primarily due to the nature of the fishery (e.g. prawn trawling where there is a high bycatch) or the management regime under which that fishery operates (e.g. where a bag limit or quota system may require the discarding of some of the landed catch)?

4. What information and/or analyses are available on:

- the status of fish stocks concerned (both target and bycatch, by fishery/area);
- the economic benefits of reducing discards;
- the status and the vulnerability of other populations interacting with the fishery/method concerned, and the impacts of that fishery;
- the survival of discards (including those that are not actually hauled on board, but escape during fishing activities);
- the conservation significance of the issue and its: impact on biodiversity (ecosystem, species or genetic); impact on foodwebs; impact on interacting fisheries (recreational and commercial), stock and biological community structure; impact on trade and the economy; impact on the environment.

5. Are there specific strategies already in place in other areas, which minimise the possibility of taking vulnerable species (e.g. turtles, seabirds and other), and how effective are these strategies in minimising fisheries interactions?

6. Which groups are affected by the issue - who needs to be involved in addressing the issue and implementing the suggestions?

7. Are there engineering solutions (mitigation measures) for the bycatch issues? Are they being implemented? Are they effective? If not, why not?

8. Are there international obligations (treaties and conventions) or trade issues which must be considered? How should they be considered?

9. Are there any existing Commonwealth/State/Northern Territory policies and/or initiatives to address the issue and, if so, are they effective? Could they be extended to other jurisdictions?

10. Are there legislative obligations (Commonwealth, State or Northern Territory)? Have these been satisfied?

11. Are there existing industry codes of practice? Are they being applied? Are they working? Are they effective?

12. Are current management or sectoral practices, or other factors, leading to increased bycatch or capture of lower-value by-product species which are then discarded (e.g. the inability to store bulky, low-value bycatch aboard vessels)? Can more appropriate practices be identified and implemented, or solutions found to other causative factors?

13. Are there cumulative impacts on the same species from different fisheries and non-fisheries sources?

14. What management options are available and what would be the impact of each of these on the seafood industry, consumers and other groups? Will raising awareness and conducting education programs need to be considered and can these fit into existing frameworks such as Coastcare and the Fisheries Action Program?

15. Who should pay?

Source: National Policy on Fisheries and Bycatch

APPENDIX 4

Sea turtle handling guidelines and associated documents

1. Australian trawl fishers sea turtle handling guidelines

2. U.S. longline fisheries sea turtle handling guidelines

3. Western and Central Pacific longline fisheries sea turtle handling guidelines

4. Instructions by the Blue Water Fisherman Association sent to their fishers in the Atlantic and Pacific (National Fisherman, May 1995, p. 22)

5. Portugal handling guidelines notes

6. Advice given in Anon. (1998) and in the Pacific Island News (Winter 2000 p. 6).

7. Possible Australian sea turtle handling guidelines adopted from the U.S. guidelines

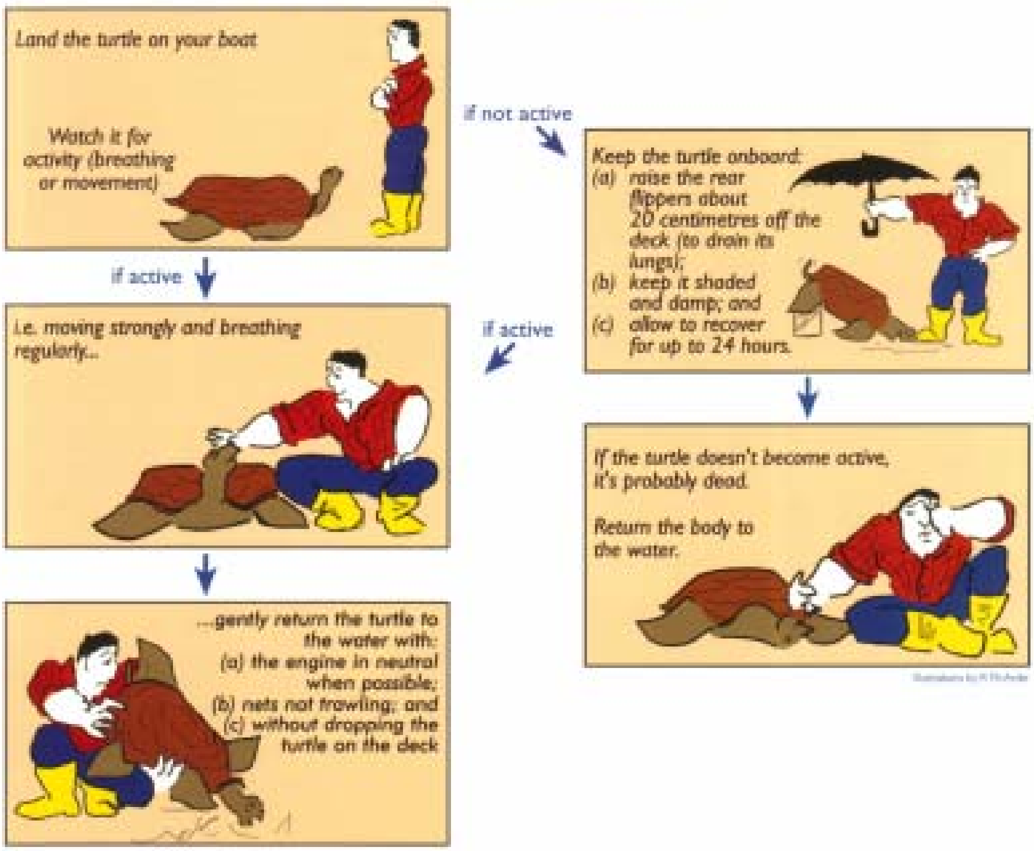
8. Line clipper reported in Federal Register: March 28, 2000 (Vol. 65 No. 60)

9. Western Australian Marine Turtle Project identification and photograph guidelines

1. Australian trawl fishers sea turtle handling guidelines

Turtle Recovery Procedures

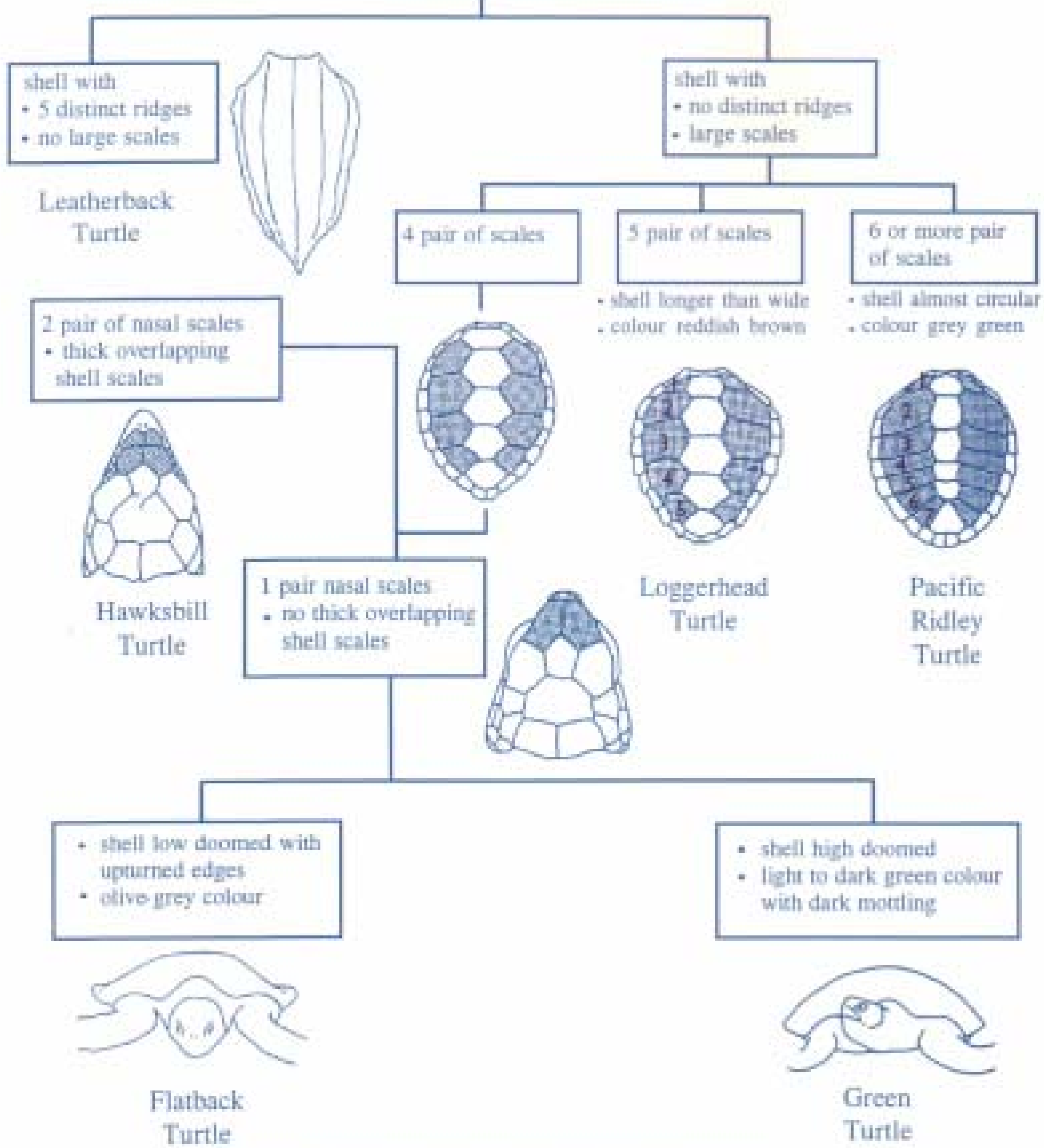
Sea turtles caught in trawl nets may be stressed. Most are conscious and able to swim away after removal from the net, but some may be tired or appear lifeless. Turtles that appear lifeless are not necessarily dead. They may be comatose. Turtles returned to the water before they recover from a coma will 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:



Additional information

All records of turtle catches and deaths are important. If you catch a sea turtle record when, where, what species and what condition it was in when released. Record any tag numbers that may be on the front flippers of the turtle. This information should be recorded on your compulsory fishing log book or passed on to the Southern Fisheries Centre, telephone: (07) 3817 9500.

Guide to Sea Turtle Identification



Note: The colour of the shell may vary within species.

For more information contact the Southern Fisheries centre on (07) 3817 9500

Sea Turtle Identification Chart

(Photos courtesy of Department of Environment)

Hawksbill Turtle

Green Turtle

Loggerhead Turtle

Leatherback Turtle

Flatback Turtle

Pacific Ridley Turtle

Code of Fishing Ethics: The Capture of Sea Turtles

Sea turtle mortality is caused by a number of factors including direct harvest by indigenous people, ingestion of marine debris, predation by introduced animals, fungal and bacterial infections of eggs, entanglement in shark nets, boat propellor strikes and incidental capture in fishing gear. Although trawl related mortality is minimal, the commercial fishing industry still needs to assist in the conservation of endangered sea turtles.

By following this code of fishing ethics, fishers can assist in minimising the impact of their trawling operations on sea turtles. Individual fishers are encouraged to adhere to the code of fishing ethics.

Refrain from trawling within 2 to 3 nautical miles of 'major' turtle nesting beaches during turtle nesting season.
Why: to minimise the possibility of nesting turtles being caught in trawl nets.

Limit trawl shots to less than 90 minutes in areas of high turtle numbers.
Why: to minimise mortality of turtles caught in trawl nets. Turtles caught in trawl nets have better chance of surviving if trawl shots are less than 90 minutes.

Apply recovery procedures when appropriate. Return lively turtles to the water as soon as possible. Why: to help the recovery of turtles accidentally caught in trawl nets thereby minimising unnecessary mortality.

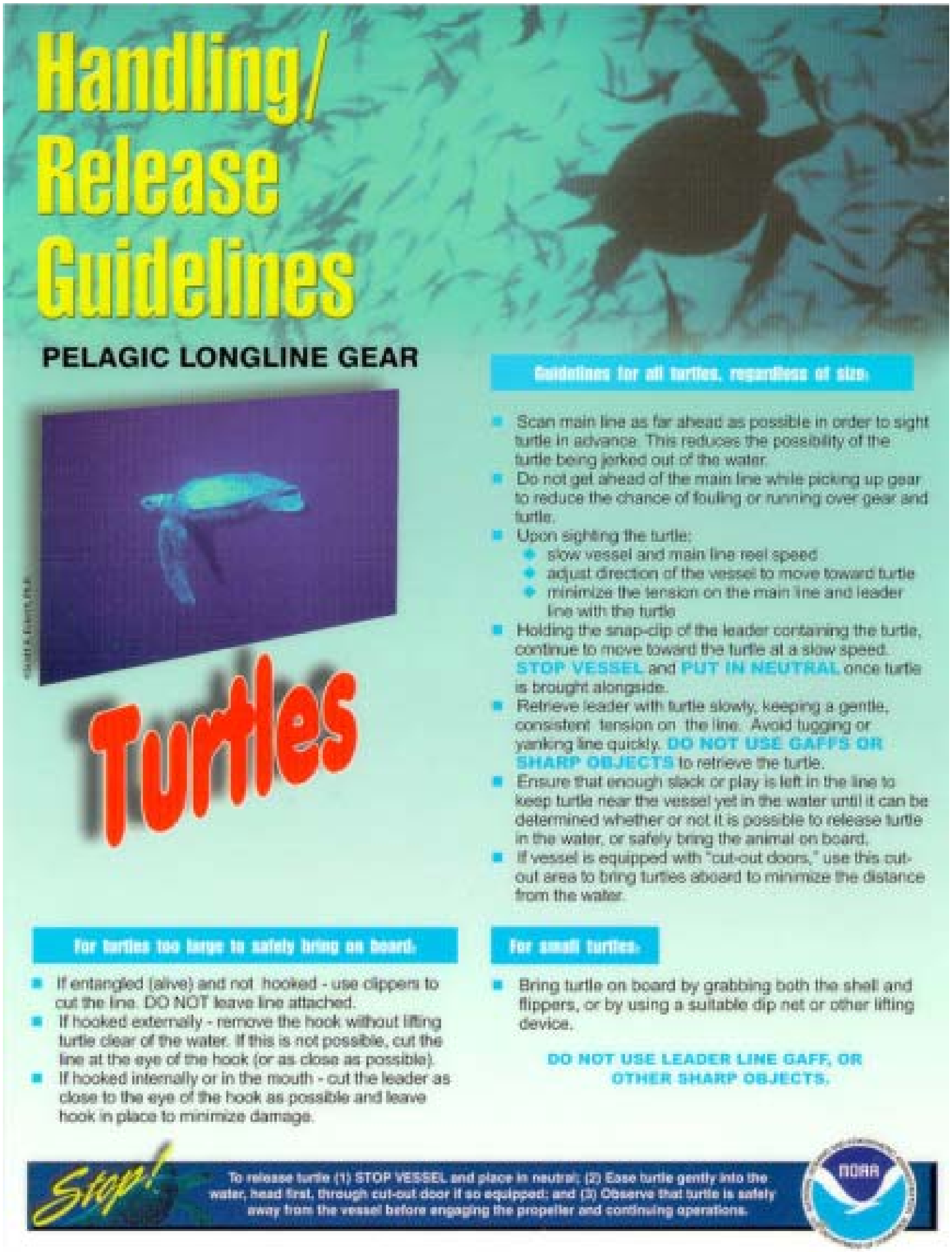
Forward information on tagged or marked turtles caught to Southern Fisheries Centre.
Why: to help find out about basic turtle biology such as distance moved and life spans.

Participate in research programs monitoring the incidental capture of turtles in trawl nets. Why: to assist the collection of data to determine if trawling does/does not affect sea turtles.

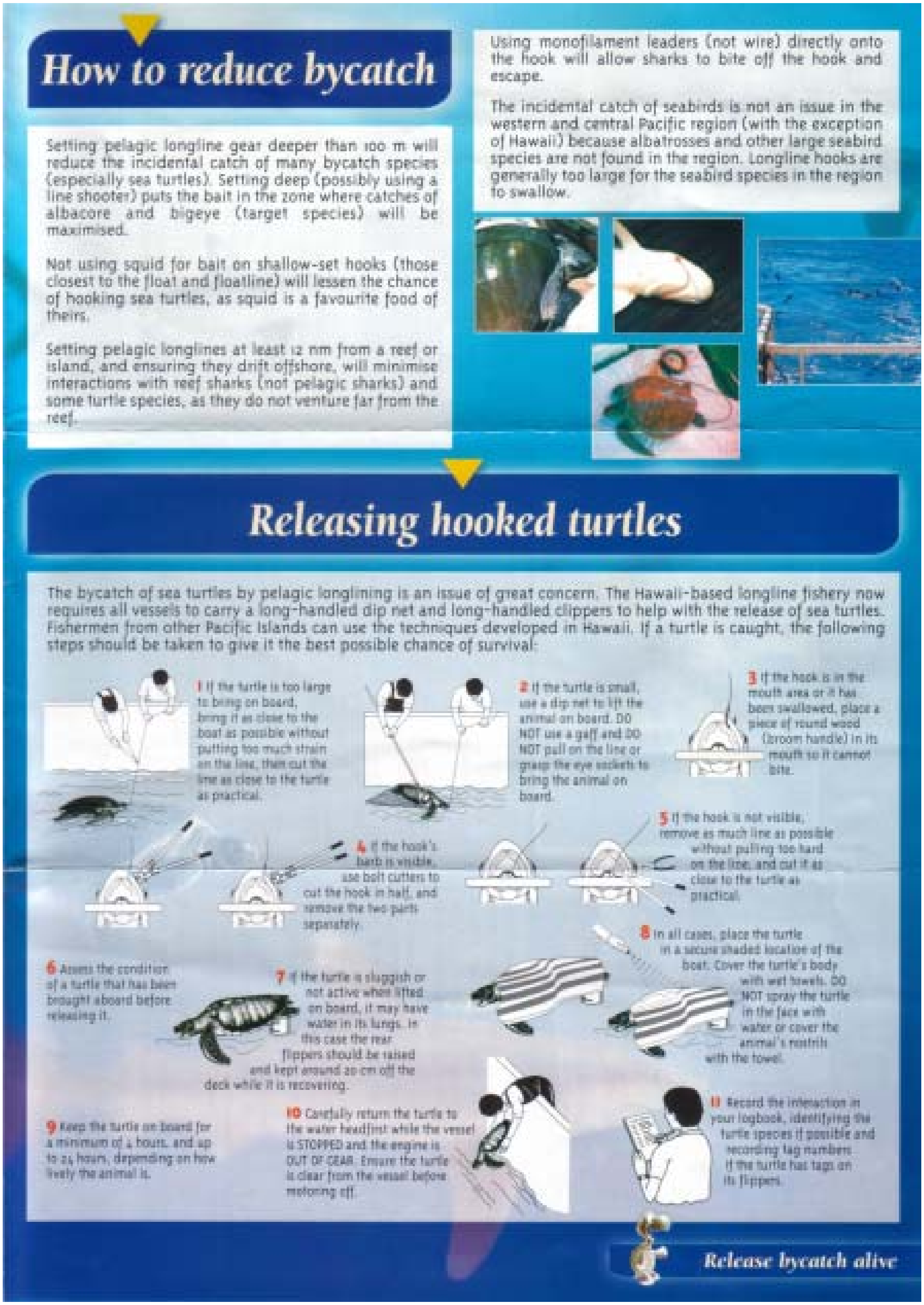
Participate in research programs trialing by-catch excluding equipment. Why: through fishers participating in these trials an excluder device which is most suitable to your fishing grounds is more likely to be developed, something which will advantage fishers and turtles.

For further information contact:
QCFO (07) 3262 6855
or
Southern Fisheries Centre (07) 3817 9500

2. U.S. longline fisheries sea turtle handling guidelines
(www.nmfs.noaa.gov/sfa/hms/TurtleHandlingColor.JPG)



3. Western and Central Pacific longline fisheries sea turtle handling guidelines



How to reduce bycatch

Setting pelagic longline gear deeper than 100 m will reduce the incidental catch of many bycatch species (especially sea turtles). Setting deep (possibly using a line shooter) puts the bait in the zone where catches of albacore and bigeye (target species) will be maximised.

Not using squid for bait on shallow-set hooks (those closest to the float and floatline) will lessen the chance of hooking sea turtles, as squid is a favourite food of theirs.

Setting pelagic longlines at least 12 nm from a reef or island, and ensuring they drift offshore, will minimise interactions with reef sharks (not pelagic sharks) and some turtle species, as they do not venture far from the reef.

Using monofilament leaders (not wire) directly onto the hook will allow sharks to bite off the hook and escape.

The incidental catch of seabirds is not an issue in the western and central Pacific region (with the exception of Hawaii) because albatrosses and other large seabird species are not found in the region. Longline hooks are generally too large for the seabird species in the region to swallow.

Releasing hooked turtles

The bycatch of sea turtles by pelagic longlining is an issue of great concern. The Hawaii-based longline fishery now requires all vessels to carry a long-handled dip net and long-handled clippers to help with the release of sea turtles. Fishermen from other Pacific Islands can use the techniques developed in Hawaii. If a turtle is caught, the following steps should be taken to give it the best possible chance of survival:

1 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.

2 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.

3 If the hook is in the mouth area or it has been swallowed, place a piece of round wood (broom handle) in its mouth so it cannot bite.

4 If the hook's barb is visible, use bolt cutters to cut the hook in half, and remove the two parts separately.

5 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.

6 Assess the condition of a turtle that has been brought aboard before releasing it.

7 If the turtle is sluggish or not active when lifted on board, it may have water in its lungs. In this case the rear flippers should be raised and kept around 20 cm off the deck while it is recovering.

8 In all cases, place the turtle in a secure shaded location of the boat. Cover the turtle's body with wet towels. DO NOT spray the turtle in the face with water or cover the animal's nostrils with the towel.

9 Keep the turtle on board for a minimum of 4 hours, and up to 24 hours, depending on how lively the animal is.

10 Carefully return the turtle to the water headfirst while the vessel is STOPPED and the engine is OUT OF GEAR. Ensure the turtle is clear from the vessel before motoring off.

11 Record the interaction in your logbook, identifying the turtle species if possible and recording tag numbers if the turtle has tags on its flippers.

Release bycatch alive

4. Instructions by the Blue Water Fisherman Association sent to their fishers in the Atlantic and Pacific (National Fisherman, May 1995, p. 22)

If you catch a turtle

The Blue Water Fishermen's Association, which represents a large number of longline boats, sent the following instructions to its members:

- Slow down or begin to stop vessel at first sighting of a turtle on the line.
- Alert crew to man the rail in case needed. Two long gaffs should be available to recover the opposite side of the mainline as soon as possible.
- Stop vessel within range of sea turtle.
- Gently bring turtle alongside.
- If a tangle exists, gaff up other side of mainline and attach to vessel or float ball to isolate vessel and turtle from any tension on remaining gear in water.
- Work tangle off turtle. If a hook is involved, cut line as close to hook as possible.
- Remove all line from turtle.
- Have crewman available to stand by with turtle identity guide and paper. Record as much information about turtle as necessary, including: length, width, weight, any sores or peculiarities and tag numbers, if tagged.
- Immediately following clearance of turtle and securing remainder of gear in the water, properly record all pertinent information concerning this interaction in your daily log. Include: specifics of turtle (above) and details of interaction (whether tangled or hooked; position on gear/mainline/ball drop/gangion; probable depth of segment involved; observations in area; other vessels interacting in area).
- Move! If you have more than one sea turtle interaction in a haulback or on consecutive days, or if by observation or radio communication you learn that interactions have occurred on this particular edge or piece of water.

5. Portugal handling guidelines notes

Information was provided by Telma Ferreira from the University of Madeira, Portugal.

'What to do when you catch a turtle', is a brochure that was designed for usage in boats that contains detailed instructions on what to do when a sea turtle is accidentally caught and how to recover comatose turtles. The translated information is something like:

- If you find a turtle stranded in a net, rope, etc., please remove it
- If a turtle gets hooked in your longline fishing gear please remove the hook and let it go. Don't leave the hook in the animal.
- Turtles that are captured by your longline gear may seem to be dead but they aren't. If you're not sure, put the turtle in your boat with the head lower than the lungs, to let the water get out... Keep the turtle wet in the shade; it can take about 24h to recover.
- All records of captured injured or dead turtles are important. If you find a tagged, wounded or dead turtle please let us know.

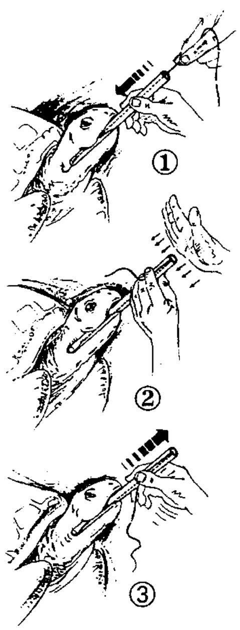
Leaflet on how to recover sea turtles (both sides)
Size: 12x29cm waterproof cardboard; August 98, 1000x)

6. Advice given in Anon. (1998, p18) and in the Pacific Island News (Winter 2000, p6).

[redacted]

- If a turtle is hooked, pressure should be taken off the line and the animal brought on board the vessel if possible
- If the hook has been swallowed deeply, the line can be cut and the animal released, as the hook will dissolve.
- If the hook is in the soft tissues of the mouth, it can be pushed through and cut off.
- If this is not possible, then the line should be cut about 1 meter from the hook.
- Thread a 60 cm piece of thin piping or similar conduit over the line.
- Allow the conduit to slide down the throat of the animal until it rests against the hook (figure 1).
- Hit the conduit sharply (figure 2).
- Remove the hook (figure 3).

From Protected Species Handling Manual, *as reprinted in* Fork Length.



Winter 2000

Sea turtles are also found in some of the state's river estuaries and thus may come into contact with gillnets. Ocean Watch is unaware of any reports of this happening. If a turtle becomes entangled in a gillnet the same recovery procedure as recommended for prawn trawls should be followed.

All records of turtle catches and deaths are important. If you catch a sea turtle please record when, where, what species and what condition it was in when released. Record any tag numbers that may be on the front flippers of the turtle. This information should then be sent to the appropriate researchers.

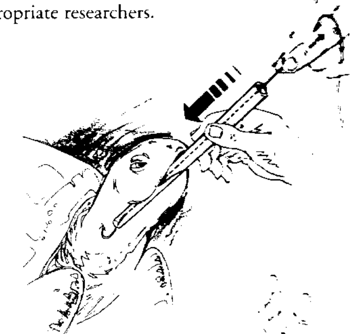
Hooked turtles

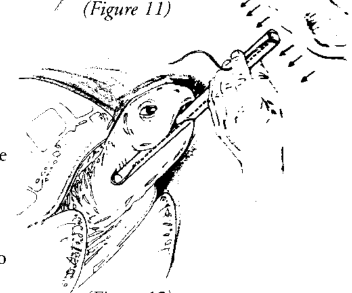
As mentioned above some turtles are scavengers and may take baits on hooks. Turtles have been recorded to take both commercial drop line hooks and recreational angling hooks. As with most other wildlife interactions the incidence of these hookings is very low.

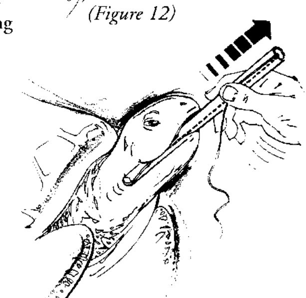
If a turtle is hooked pressure should be taken off the hook and line and, if possible, the animal brought on board the boat. If the hook has been swallowed deeply the line should be cut and the animal released as the hook will dissolve.

If the hook is in any soft tissues in the mouth it should be pushed through and cut off. If this is not possible then the following method should be used. Cut the line off about 1 metre above the hook and thread the line through a 60cm piece of conduit. Allow the conduit to slide down the throat of the animal until it rests in the hook *(Figure 11)*. Hit the top of the conduit sharply so as to dislodge the hook and then withdraw both the hook *(Figure 12)* and conduit before releasing the animal *(Figure 13)*.

Hooked animals may have also been trapped under water for a time. If this is the case, or if the animal is otherwise showing signs of stress, then the turtle recovery procedures described above should be used.


(Figure 11)


(Figure 12)


(Figure 13)

18

7. Possible Australian sea turtle handling guidelines adopted from the U.S. guidelines

Sea Turtle Handling Guidelines

Pelagic Longline Gear

1 Scan main line ahead to spot turtle.
2 When a turtle is sighted:
 - slow vessel and mainline reel speed,
 - move towards turtle,
 - minimise tension on line with the turtle.
3 When turtle is alongside:
 - stop vessel and put in neutral,
 - retrieve leader slowly (constant tension),
 - do not jerk line or use a gaff.
4 Determine best method of release.

Small turtles

1 If possible, and safe, bring the turtle on board:
 - use a dip-net or by grasping shell and flippers with hands,
 - do not retrieve using the line.
2 Remove gear if possible:
 - cut all line off turtle,
 - remove hook if external or can be seen,
 - in necessary hold mouth open using a wooden stick (not metal),
 - cut line as close as possible to all hooks that cannot be removed.
3 Record information in logbooks including health of the turtle.
4 Release active turtles head first into the water with the boat stationary.
5 Place inactive turtles in a quiet and safe position on the boat:
 - until active or definitely dead
 - for up to 24 hours,
 - ensure turtle cannot slip around and cause injury to itself or the crew.

Large Turtles

1 Remove gear while turtle is in water:
 - cut line as close to hooks as possible,
 - if entangled remove all line.
2 Record information in logbooks including health of the turtle.

8. Line clipper reported in Federal Register: March 28, 2000 (Vol. 65 No. 60)

Federal Register / Vol. 65, No. 60 / Tuesday, March 28, 2000 / Rules and Regulations 16349

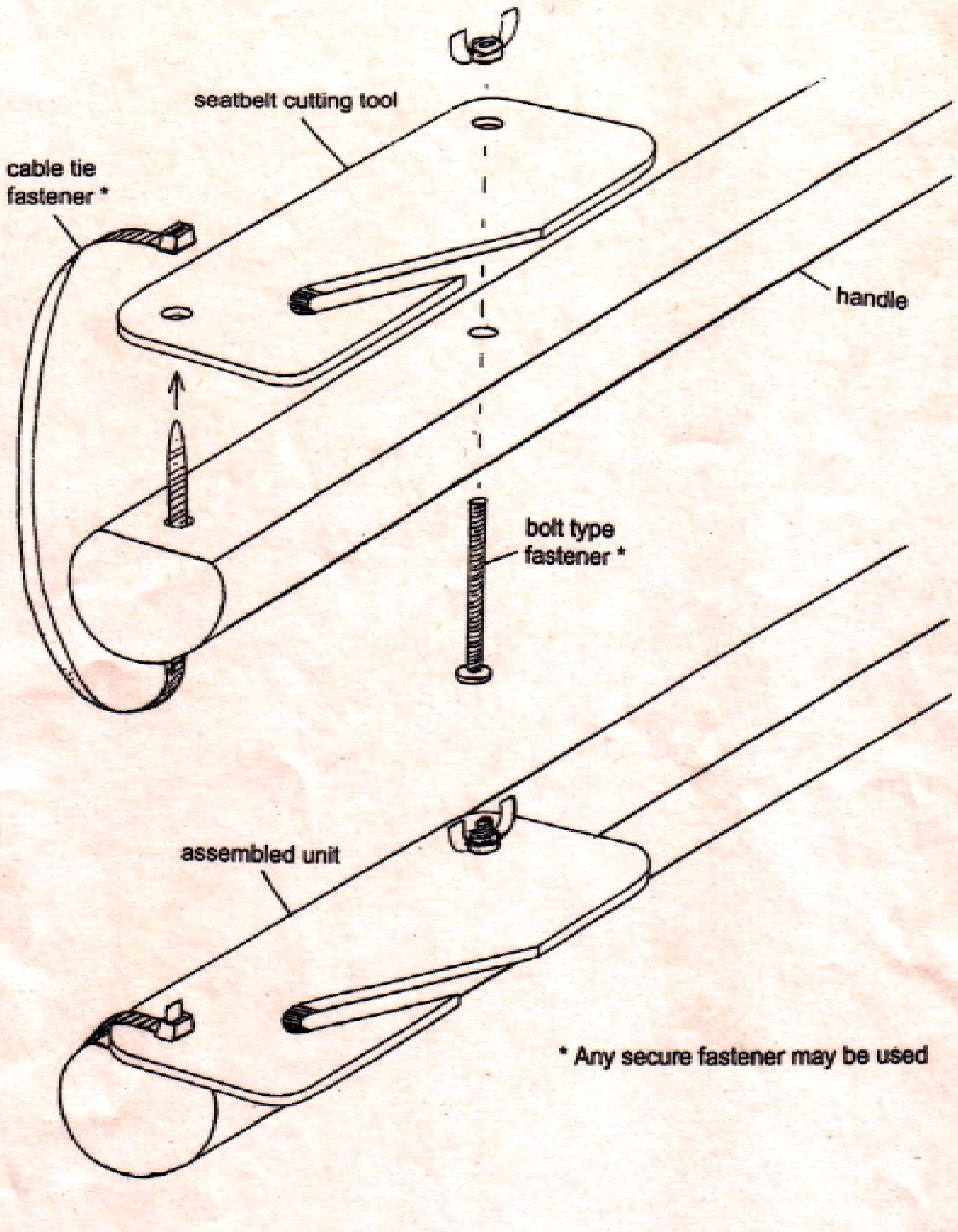


Figure 1 – Sample Fabricated Arceneaux Line Clipper

[FR Doc. 00–7695 Filed 3–24–00; 1:18 pm]
BILLING CODE 3510–22–F

9. Western Australian Marine Turtle Project identification and photograph guidelines

WESTERN AUSTRALIAN MARINE TURTLE PROJECT

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TAKING PHOTOGRAPHS TO CONFIRM SEA TURTLE IDENTIFICATIONS

The key to the live adult turtles provided in the project leaflet should be fairly straightforward to use. **However**, it is most desirable to confirm diagnoses of the uncommon species, perhaps being seen by you for the first time, and particularly in places where occurrence of the species has not previously been reliably recorded.

Real specimens are the best museum vouchers, but, in the case of large animals like marine turtles, collections are not usually practicable. A good series of photographs clearly showing identifiable characteristics is the next best documentation to obtain. This also applies for salvage of the dead.

If you have a camera (with flash for night use particularly), **the series of photographs to take** includes:

1) A close-up of the head taken from forward and above to clearly show the prefrontal scale pattern (on top between nostrils and eyes).

2) A fairly-full frame photo of the shell (carapace) taken from above to one side clearly showing the costal scale pattern.

In addition to the above two, which are essentials:

3) A photo of the whole animal from one side, fairly full frame;

4) A photo from the rear and above of the shell which shows general relationships of the main scales;

5) A side shot of the head showing the scale pattern around the eye;

6) A photo of the extended foreflipper, upper surface;

7) A photo of the underside of the whole animal.

Because photos will be required for retention it is best to take at least two of each particular photo as specified. This is preferable to making extra prints from single negatives after initial film processing.

Recognition for photos retained will be ensured. Please attach suitable documentation of time and place, etc

[TURTLE PROJECT • AUGUST1997]

DEPARTMENT OF CONSERVATION AND LAND MANAGEMENT • WESTERN AUSTRALIA

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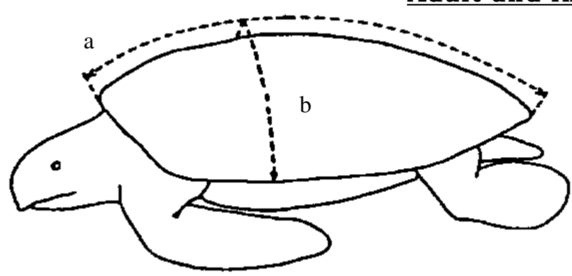
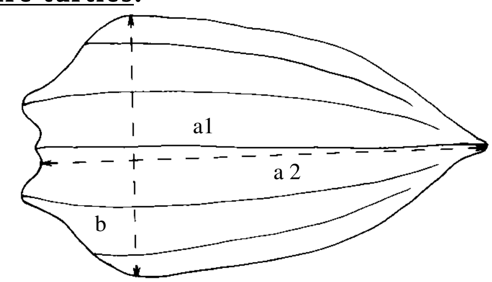
1. LINEAR MEASUREMENT OF SEA TURTLES

The standard measurements of sea turtles are usually made on the carapace (dorsal shell; back). While slightly different measurement methods have been used by various researchers, the following methods in standard use within the Queensland Turtle Research Project have been adopted for use in the Western Australian Marine Turtle Project.

Adult and immature turtles:



Hard-shelled



Leatherback

Curved carapace measurements:

Made using a flexible fibreglass tape measure (to $\pm$ 0.5 cm; 5 mm) laid over the curve of the shell. **Please remove** any large barnacles preventing a correct measurement.

a. **Curved carapace length (CCL)**: Measured in hard-shelled turtles along the midline from the junction of the skin and carapace above the neck to the posterior edge of the junction of the post-central scales. If there is a notch along this junction of the post-central scales then the CCL measurement is made to the anterior edge of the notch, always measuring along the midline of the carapace. With Hawksbill turtles only, the length of the "V" of this elongated notch is also measured. **Leatherback turtles must be measured along the midline ridge to the tip of the posterior projection of the carapace (*a1*),** and **from the closest edge of the trough beside the midline ridge to the tip (*a2*)**.

b. **Curved carapace width (CCW)**: Measured perpendicularly to the midline axis of the carapace between the outer extremities of the marginal scales. When making this measurement, repeat it at several positions to obtain the greatest value. For turtles having a carapace that is reflexed upwards near the marginal scales (especially flatback turtles) this measurement is made with the tape measure stretched tightly between the outer extremities of the marginal scales, i.e. it is not in contact with the surface of the carapace for the full width. **Leatherback turtles are measured to the lateral ridge on each side (third from midline)**.