Tactical Research Fund:
Evaluating the impact of fishing on marine turtles relative to other impacts

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Fisheries Research and Development Corporation

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Non-Technical Summary

2009/083 Tactical Research Fund: Evaluating the impact of fishing on marine turtles relative to other impacts

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OBJECTIVES:

1. Review the literature regarding existing research on spatial distribution and causes of mortality in the Eastern Tuna and Billfish Fishery (ETBF), Western Tuna and Billfish Fishery (WTBF), Northern Prawn Fishery (NPF) and East Coast Trawl Fishery (ECTF).
2. Review the literature regarding management and mitigation measures in place.
3. Analyse turtle distribution and movement patterns and overlap with fishing distribution. Estimate mortality resulting from interactions.
4. Review relevant turtle stock assessments and report on all known anthropogenic impacts on turtle mortality.
5. Assess alternative management options to respond to the estimated level of turtle mortality.
6. Identify research gaps needed to inform fisheries management options to mitigate turtle interactions in these fisheries.

NON TECHNICAL SUMMARY:

OUTCOMES ACHIEVED TO DATE

The mitigation strategies adopted in the Commonwealth NPF and the Queensland ECTF has resulted in reduced catches of marine turtles to virtually insignificant levels compared with other anthropogenic threats. These fisheries can demonstrate their commitment to solving the problem of marine turtles negatively interacting with their fishing gear. The negative impact of some commercial fisheries around the world, including trawl and other gear types, may still be of concern.

The ETBF is considered to have no significant impact on marine turtles of any one species compared to other anthropogenic threats. While this one fishery, however, may not be having an impact on marine turtle stocks, it shouldn't be considered in isolation. The combined impact of all of the longline fisheries across the Pacific Ocean may be significant. Consequently, the implementation of a mitigation plan with a high chance of reducing the impact of each individual fishery is still important. The implementation of a mitigation strategy for the ETBF is assisted by the documentation of a range of information needed for the advancement of the plan. Various practical aspects of the mitigation plan need clarification.

Due to low fishing effort expended in the WTBF currently, there seem few reasons to consider implementing a turtle mitigation plan. Although if this changes in the future, the WTBF will have the knowledge gained through the adoption of a plan in the ETBF on which to base their strategy.

The six species of marine turtles living in Australian waters encounter a diverse array of threats across their range. Anthropogenic threats can include: harvesting of adults and eggs for food, incidental capture in fishing gear, entanglement in ghost nets and debris, coastal development, pollution, beach destruction and feral animal predation. In recent years, other anthropogenic activities, such as the expansion of oil and gas industry infrastructure, accelerating coastal development and the pervasive plastic debris problem, has placed significant additional pressure on already depleted stocks. The future impact of climate change may add another level of negative impact on marine turtle stocks.

Although bycatch from Australian commercial fishing operations is exceeded by many other threats, the reduction of the impact from all sources of mortality is imperative for declining populations. The NPF and the ECTF, prawn trawl fisheries, have had turtle mitigation plans based on Turtle Exclusion Devices (TEDs) in place for around ten years. Pelagic longline fisheries, the ETBF has a mitigation plan in operation, and the WTBF is considered to not require a mitigation plan.

All available evidence since TEDs have been mandatory in the NPF and ECTF demonstrates that the turtle mitigation strategies adopted have resulted in a reduction in trawl-related catch and mortality of marine turtles. Indirect evidence that their mitigation plans have been successful is the trend since 2001 that the eastern Australian loggerhead turtle sub-population seems to be rebuilding.

The ETBF and WTBF have been shown to have a minor impact on marine turtle stocks compared to other anthropogenic impacts, especially bearing in mind the expected low mortality rates. But these fisheries cannot be considered in isolation. The collective impact on marine turtles of pelagic longline fishing occurring across all oceans poses a significant risk to their survival. Especially so for loggerhead turtles and leatherback turtles, as both these species are highly migratory and can cross the jurisdictional boundaries of many countries and into the fishing grounds of Australian and international longline fisheries.

There have been numerous lessons learnt from the history of the NPF and ECTF that were fundamental to their success in marine turtle bycatch mitigation and which should be considered in developing and implementing management plans for other fisheries. These include: fishery-specific research so mitigation measures developed elsewhere can be adapted to the specific fishery; industry involvement in research, development and trialling of the mitigation measures; and having a mechanism for further development of the mitigation measures to improve their efficiency in terms of bycatch mitigation and fishery performance.

As all species of marine turtle are considered at least vulnerable to extinction, mitigating the impacts of commercial fisheries may be essential to marine turtle conservation efforts. Although there have been turtle bycatch success stories in fisheries in Australia and around the world, the issue of marine turtle bycatch in commercial fisheries has not been solved. There must be a consideration of the impact of commercial fisheries on marine turtles across their whole geographic range and across all gear types, not just the impact of an individual fishery.

KEYWORDS: Marine turtles, longline, prawn trawl.

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Background

Marine turtle bycatch

It has been widely suggested that commercial fishing activities have been, and continue to be, a considerable contributor to the well documented decline in marine turtle populations (Hays *et al.* 2003, Lewison *et al.* 2004, Wallace *et al.* 2010). Estimated marine turtle interaction rates for individual commercial fisheries around the world vary greatly, from a few interactions to thousands of interactions annually (Robins *et al.* 2002b, Lewison and Crowder 2007, Williams *et al.* 2009, Gilman *et al.* 2010).

Marine turtle interaction estimates are reliant on many factors associated with the fishing operations (fishing effort and the number of vessels, fishing gear used, area fished, mitigation measures and release techniques adopted) and on marine turtle characteristics and dynamics (migratory pathways and behaviours, feeding and breeding habitats, species and size-class distributions, feeding behaviours).

Mortality estimates as a result of the interaction are extremely difficult to determine with any certainty, except for the obvious 'turtle died during the interaction' situations, and are probably even more wide-ranging than the interaction estimates. In some cases it is impossible to decide if an animal died as a result of the interaction. This is especially so if the turtle died some time after the interaction occurred (Robins *et al.* 2002a). A related issue, modified behaviour post-release, is an increase in susceptibility to a threat following an interaction event. For example, an animal released from a trawl net may need to remain near the surface to recover and so is under increased threat from boat strike, shark attack or capture in another trawl net (Robins 2002). These types of delayed mortality events make the predictability of the impact of commercial fisheries on marine turtles complicated and challenging.

Australian fisheries

Australian fisheries with a relatively long history of recognising and tackling marine turtle bycatch concerns include the Northern Prawn Fishery (NPF), the East Coast Trawl Fishery (ECTF), the Eastern Tuna and Billfish Fishery (ETBF) and the Western Tuna and Billfish Fishery (WTBF).

There are some Australian commercial fisheries that interact with turtles, but do not have turtle mitigation plans. Evidence that turtle bycatch exists can be through observer and logbook programs, anecdotal reports and/or evidence of injuries or death that can be traced back to a fishery (for example, stranded turtles with gear attached). There is a pressing need for these fisheries to be recognised, reviewed and mitigation plans put in place, probably including fisher training in handling and release techniques to minimise mortality and injury to the animals.

Another group of fisheries are those that interact with marine turtles, but not in a negative manner. An example of a fishery that does interact with marine turtles, but there is no evidence that turtles are harmed in any way as a result of the interaction, is the tunnel-net fishery in Moreton Bay, Qld (Limpus 2009). Although turtles can, and do, go into the nets they are prevented from entering the codend by a grid. In addition the gear is under observation continuously so turtles are immediately released. Interestingly, these fishers have been assisting Queensland Department of Environment and Resource Management (DERM) Officers with their Turtle Research Program. The scientists have been using the net as a sampling mechanism to capture turtles to conduct monitoring activities (flipper tagging and morphological measurements) (David Kreutz OceanWatch Australia, personal communication 2010).

A further group of fisheries are those that do not interact with turtles at all. An example would be a fishery using a small mesh size so that a turtle cannot become entangled.

For fisheries where the impact on turtles is unknown, an independent observer program with adequate sample sizes is useful in determining whether interactions do occur. A further question when a fishery is shown to interact with marine turtles is whether the interactions are causing a negative impact to the turtles or to the turtle population.

Northern Prawn Fishery

The NPF is a commonwealth fishery with otter trawl nets targeting prawns in the waters from Cape York, Queensland to Cape Londonderry, Western Australia. Three species, the white banana prawn (*Fenneropenaeus merguinsis*), brown tiger prawn (*Penaeus esculentus*) and grooved tiger prawn (*P. semisulcatus*) account for over 80% of the target catch. The NPF traditionally has two seasons: the banana prawn season of short day-time shots targeting aggregating prawn schools, and the tiger prawn season of longer, night-time shots. Most vessels target banana prawns early in the year and when catches decline switch to targeting tiger prawns. All species however, are caught during both seasons (Wilson *et al.* 2010).

In 2009, 55 vessels fished in the NPF over 7990 total days of effort, with 2146 days in the banana prawn season and 5844 days in the tiger prawn season. Fishing effort is down from a high in 1981 of 43,419 fishing days and 286 active vessels as a result of fleet restructures and management arrangements. Turtles have always been caught in the NPF and as a consequence, in 2000, Turtle Exclusion Devices (TEDs) were made compulsory (Wilson *et al.* 2010).

East Coast Trawl Fishery

The Queensland ECTF extends from Cape York, Queensland to the Queensland – New South Wales border and consists of multiple sectors targeting various species of prawns, scallops and fish. Approximately 600 vessels operate in waters from the shallows close to the coastline to deeper waters on the continental shelf. Gear types include beam and otter trawl and semi-pelagic fish trawls with around 95% of the total harvest from the otter trawl sector. The ECTF has a history of management measures including limited entry, area closures and boat and net size restrictions. In recent years the fishery has also been subject to restricted fishing time per vessel (limits on operating time). Marine turtles are encountered in the ECTF and TEDs were introduced into the fishery in a stepwise manner from 1999 to 2002. (Robins 2002).

Eastern Tuna and Billfish Fishery

The ETBF is a Commonwealth fishery consisting of pelagic longlining, with some minor-lining (trolling, rod and reel, handline), in the waters from Cape York, Queensland to the Victorian – South Australian border. The key target species are broadbill swordfish (*Xiphius alalunga*), albacore (*Thunnus alalunga*), bigeye tuna (*T. obesus*), yellowfin tuna (*T. albacares*) and striped marlin (*Tetrapturus audax*) so it is a mixed swordfish fishery and tuna fishery. In 2009, 8.82 million hooks and 164 lines were set in the longline and minor-line sectors, respectively. There were 55 active longline vessels and 11 active minor-line vessels. Management arrangements in the ETBF have changed considerably over time with a restructure package implemented in 2006 resulting in a reduction in vessels and fishing effort. Marine turtles are occasionally encountered and mitigation plans are in development (Wilson *et al.* 2010).

Western Tuna and Billfish Fishery

The WTBF is a Commonwealth fishery that encompasses waters from Cape York, Queensland to the Victorian – South Australian border along the western coastline. However, fishing only occurs in Western Australian waters. In 2009, there were three pelagic longline vessels and one minor-line vessel targeting broadbill swordfish (*X. alalunga*), bigeye tuna (*T. obesus*) and yellowfin tuna (*T. albacares*). There were 528,038 hooks set in the longline sector and an unknown number of minor-line lines set. The WTBF currently operates under transitional provisions while the process of allocating statutory fishing rights (SFRs) is completed. Marine turtles are rarely encountered (Wilson *et al.* 2010).

Other anthropogenic impacts

All species of marine turtles - leatherback turtle (*Dermochelys coriacea*), hawksbill turtle (*Eretmocchelys imbricata*), loggerhead turtle (*Caretta caretta*), green turtle (*Chelonia mydas*), flatback turtle (*Natator depressus*), olive ridley turtle (*Lepidochelys olivacea*) - in all of the areas in which they live are subjected to a diverse range of threats in varying degrees. Some sub-populations of turtles, including the Eastern Australian loggerhead turtle (Limpus 2008) and Hawaiian green turtle (Balazs and Chaloupka 2004), are showing positive signs of recovery, but others continue to decline at an alarming rate.

Some sources of mortality are natural and some man-made (i.e. anthropogenic). The number of mortalities due to natural events are often difficult, or even impossible, to change and some argue that we should not consider attempting to address these threats. Few would disagree that we have an obligation to try to address the anthropogenic sources of mortality on all endangered animal species, including the charismatic marine turtle.

All anthropogenic impacts affect the breeding success of sea turtles, whether directly through individual injury and/or mortality or through the degradation and/or destruction of nesting sites or feeding grounds. While some of the examples of anthropogenic activities listed in Table 1 may not occur within Australia, or if they do, to a minimal extent, the migratory nature of sea turtles renders them susceptible to these activities in waters of all the countries through which they migrate.

If we focus on only one source of anthropogenic mortality, whether it is commercial fishing or egg poaching, and ignore all other sources there may be no discernable impact on the species of concern or sub-population of the species. Additionally, the cost of addressing that one source may well have been better spent in another area that had a chance of having an impact on the recovery of the species.

The first logical step in assisting an endangered species to recover would be to list all known sources of anthropogenic mortality and their scales. The next obvious step would be to determine the possibility of reducing each threat and the relative costs of achieving this. This would be followed by an evaluation of what can be practically done and the probable impact to the population of addressing each threat, then prioritising the chosen actions, and finally implementing the changes to reduce the threats. An examination of whether the chosen and implemented actions have resulted in the predicted impact on the population of concern would complete the process.

Table 1 Anthropogenic activities that negatively impact on marine turtles

Harvest for meat (subsistence, ceremonial and commercial)	Egg harvest for human consumption	Harvesting for leather and oil
Stuffed specimens	Shells and other turtle parts for souvenirs	Boat strike (tourism and recreational fishing)
Bycatch in commercial fisheries	Recreational fishing (hooking and entanglement)	Bycatch in artisanal fisheries
Entanglement in ghost nets and debris	Poaching and illegal trade	Coastal development
Beach maintenance	Religions and ceremonial uses	Dynamite fishing
Shark netting and hooking programs	Activities on nesting beaches (vehicles, furniture, umbrellas)	Marine, jetty and docking development
Sand dredging	Egg predation by feral pests	Sand mining
Chemical pollutants causing disease (pesticides, heavy metals, organochloride compounds, sewage effluent)	Light pollution (light horizon disorientation and hatchling traps where predation increases)	Beach infrastructure causing nesting habitat loss
Oil and gas industry infrastructure	Power plant water intake mechanisms	Hatchling predation by feral pests
Degradation of foraging habitats	Ingestion of tar and oil droplets	Ingestion of debris (i.e. plastics)
Pollution affecting feeding grounds	Destruction of dunes by feral animals	People and animals disturbing nesting females

Questions that can complicate the decisions are:

- Which source of mortality results in what could be considered a ‘key threatening take’ to the endangered population?
- Do we concentrate on the highest risk to the populations and ignore those that are considered a low risk?
- Are there moral reasons to address some threats and not others?
- Is there an obligation for every threat to be mitigated regardless of level?
- Are there any rights (for example, traditional or financial) that should over-ride the right of an endangered species to be allowed to recover?
- Are there indirect impacts of addressing a threat that may change the decision to address that threat?
- Should financial aspects be a consideration (for example, should the threats that are less costly to address be considered before the more costly threats)?

Need

International and national concern

Bycatch or incidental catch, including non-target species and discarded individuals of target species, is a conservation concern for fisheries around the world (Lewison *et al.* 2009). Marine turtles have been singled out as vulnerable species warranting special attention due to being a long-lived oceanic vertebrate with particular issues relevant to commercial fishing industries. The highly migratory nature of marine turtles and the fact that commercial fisheries fish in both national waters and on the high seas means that these animals are rarely the responsibility of one nation. The multinational nature of the marine turtle issue makes the problem difficult to solve as it requires international cooperation along with national mitigation and recovery plans (Robins *et al.* 2002a).

International conservation status

Widespread concern at the alarming declines in marine turtle numbers is reflected in their high conservation status. They have been listed under various international conservation listing agencies, including:

- The Convention for the Conservation of Migratory Species of Wild Animals (CMS or Bonn Convention). The flatback turtle is listed in Appendix II. This is defined as "migratory species that have an unfavourable conservation status or would benefit significantly from international co-operation organised by tailored agreements". All other species are listed under Appendix I which is defined as "migratory species that have been categorised as being in danger of extinction throughout all or a significant proportion of their range". (http://www.cms.int/documents/appendix/cms_app1_2.htm#appendix_I, downloaded on 5 November 2010).

- The International Union for the Conservation of Nature (IUCN) Red List of Threatened Species. This agency is "widely recognised as the most comprehensive, objective global approach for evaluating the conservation status of plant and animal species" (http://www.iucnredlist.org/about/red-list-overview, downloaded on 5 November 2010). The leatherback turtle, hawksbill turtle and Kemp's ridley turtle are listed as critically endangered, the green turtle and loggerhead turtle as endangered, the olive ridley turtle as vulnerable and the flatback turtle as data deficient. (IUCN 2010. IUCN Red List of Threatened Species. Version 2010.4. <www.iucnredlist.org>. Downloaded on 05 November 2010).

- The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). This is "an international agreement between governments. Its aim is to ensure that international trade in specimens of wild animals and plants does not threaten their survival" (http://www.cites.org/eng/disc/what.shtml, downloaded on 5 November 2010). All species of marine turtles are listed under Appendix I, indicating that "they are threatened with extinction and CITES prohibits international trade in specimens of these species except when the purpose of the import is not commercial" (http://www.cites.org/eng/app/index.shtml, downloaded on 5 November 2010).

Various conservation and fisheries agreements have called for appropriate measures to be adopted to address the issue of marine turtle encounters by commercial fisheries.

- The Food and Agriculture Organisation of the United Nations (FAO). The FAO hosted the Expert Consultation on Interactions between Sea turtles and Fisheries within an Ecosystem Context (Rome, 9 to 12 March 2004) and the Technical Consultation on Sea Turtles Conservation and Fisheries (Bangkok, 29 November to 2 December 2004) and produced 'Guidelines to Reduce Sea Turtle Mortality in Fishing Operations' (FAO Fisheries Department 2009).
- Western and Central Pacific Fisheries Commission (WCPFC). Of particular relevance to marine turtles are Australia's obligations under the Conservation and Management Measure (CMM) CMM-2008-03 (Appendix 4).

Domestic conservation status

- 'Due to increasing threats to marine turtles, all six species which occur in Australian waters are listed under the Australian Government's Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act). The loggerhead turtle and olive ridley turtle are listed as endangered under this Act which means that the species may become extinct if the threats to its survival continue. The green turtle, leatherback turtle, hawksbill turtle and flatback turtles are listed as vulnerable which means that they may become endangered if threats continue.' (http://www.environment.gov.au/coasts/species/turtles/index.html, downloaded on 8 November 2010)
- The Recovery Plan for Marine Turtles in Australia recognised the high conservation status of all six species of marine turtle in Australian waters. 'The overall objective of the Plan is to reduce detrimental impacts on Australian populations of marine turtles and hence promote their recovery in the wild' (Environment Australia 2003 p10). The main threats recognised are commercial fishery bycatch, indigenous harvest within Australian waters and in neighbouring countries, predation of eggs by native and introduced animals, coastal development, deteriorating water quality, marine debris and loss of habitat.
- Turtle species are listed in Australian State and Territory legislation (Table 2).

Need for a review

In order to develop or modify a bycatch management plan for a commercial fishery the initial step is often a review of the issue. In the case of species that are subject to other anthropogenic threats, a review of all human activities that impact on the species of concern is vital to ensure appropriate decisions can be made. As with any management decision in commercial fisheries, including mitigation plans, there is a need to evaluate success or failure of the management measure to determine if objectives have been met, if modifications need to be made or if there are new research findings that may influence changes to the plan. The NPF and ECTF marine turtle mitigation plans were implemented around 10 years ago, while the ETBF is currently implementing a plan and WTBF is considered to not requiring a plan.

This report documents the history of the NPF, ECTF, ETBF and WTBF with respect to marine turtle interactions and mitigation. It evaluates the success or failures of the mitigation programs already in place, reviews the status of plans in development and suggests possible improvements. This report also reviews the status of all species of marine turtles found in Australian waters and lists the scale of other anthropogenic threats faced by these species.

Table 2 Marine turtle conservation status under State and Territory legislation

State	Legal basis	Species	Status
Queensland	Nature Conservation Act 1992	Flatback turtle Green turtle Hawksbill turtle Leatherback turtle Loggerhead turtle Olive ridley turtle	Vulnerable Vulnerable Vulnerable Endangered Endangered Endangered
New South Wales	Threatened Species Conservation Act 1995	Flatback turtle Green turtle Hawksbill turtle Leatherback turtle Loggerhead turtle Olive ridley turtle	Protected Vulnerable Not listed Vulnerable Endangered Not listed
Victoria	Advisory List of Threatened Vertebrate Fauna in Victoria 2003	Flatback turtle Green turtle Hawksbill turtle Leatherback turtle Loggerhead turtle Olive ridley turtle	Not listed Not listed Not listed Critically endangered Not listed Not listed
Tasmania	Threatened Species Protection Act 1995	Flatback turtle Green turtle Hawksbill turtle Leatherback turtle Loggerhead turtle Olive ridley turtle	Not listed Vulnerable Not listed Vulnerable Endangered Not listed
South Australia	National Parks and Wildlife Act 1972	Flatback turtle Green turtle Hawksbill turtle Leatherback turtle Loggerhead turtle Olive ridley turtle	Not listed Vulnerable Not listed Vulnerable Vulnerable Not listed
Western Australia	Wildlife Conservation Act 1950	Flatback turtle Green turtle Hawksbill turtle Leatherback turtle Loggerhead turtle Olive ridley turtle	All species are rare or likely to become extinct
Northern Territory	Territory Parks and Wildlife Conservation Act 2000	Flatback turtle Green turtle Hawksbill turtle Leatherback turtle Loggerhead turtle Olive ridley turtle	Data deficient Not listed Data deficient Vulnerable Endangered Data deficient

Objectives

1. Review the literature regarding existing research on spatial distribution and causes of mortality in the ETBF, WTBF, NPF and Queensland ECTF.
2. Review the literature regarding management and mitigation measures in place.
3. Analyse turtle distribution and movement patterns and overlap with fishing distribution. Estimate mortality resulting from interactions.
4. Review relevant turtle stock assessments and report on all known anthropogenic impacts on turtle mortality.
5. Assess alternative management options to respond to the estimated level of turtle mortality.
6. Identify research gaps needed to inform fisheries management options to mitigate turtle interactions in these fisheries.

Methods

This report was compiled following a literature review of available papers and documents on the fisheries of concern (NPF, ECTF, ETBF and WTBF) on marine turtle bycatch within Australia and around the world, and on anthropogenic impacts on each species of marine turtle residing within Australian waters. This ranged from historical documents to recent research papers.

SeaNet Extension Officers from OceanWatch Australia Pty Ltd interviewed a number of fishers to gather anecdotal information on marine turtle catch prior to and post mitigation plans being put in place, mitigation actions performed on vessels and their opinions on the success or failures of the mitigation plans. These interviews were conducted on an ad hoc basis and not all fishers in each fishery were interviewed. Results of the interviews are presented as a list of anecdotal comments.

Fisheries management documents such as Code of Practices and Workplans were obtained from the Australian Fisheries Management Authority (AFMA) website www.afma.gov.au and from Primary Industries and Fisheries Queensland website www.dpi.qld.gov.au.

Results

1 Australian fishery history

Northern Prawn Fishery

Marine turtle catch history

1960s to 1980s

From the early days of the NPF, marine turtle bycatch was recognised but it wasn't officially documented until the 1980s. NPF fishers of today, who were in the fishery from the start in the 1960s, recall that marine turtles have always been seen in NPF trawl nets.

1988

In 1988, a study by the Commonwealth Scientific Industrial and Research Organisation (CSIRO) examined data from various research surveys to look at marine turtle catch in the NPF (Poiner *et al*. 1990). They estimated that between 1979 and 1988 there was an annual marine turtle catch of 5730 ± 1907.

1989/1990

The fishers, scientists and managers of the NPF have conducted many cooperative fisheries research projects on target catch, by-product and bycatch, including marine turtles (Brewer *et al.* 2008). Including in 1989 and 1990, when the CSIRO used trained fishers to gather scientific data during their fishing operations. This included prawn species catch and composition, fishing grounds with environmental factors such as temperature and depth, and marine turtle catch and species identification (Poiner and Harris 1996). They estimated that between 5000 and 6000 marine turtles were incidentally caught from August to November each year (i.e. during the tiger prawn season) and of these, 39% may have died as a result.

Mid-1990s to 2000

Various research projects (Brewer *et al*. 1998; Brewer *et al*. 2004) had been on-going in the NPF since mid-1990 and by 2000 significant knowledge had been gained by researchers and fishers on many aspects of TED and Bycatch Reduction Device (BRD) usage, including design/refinement, technical operation and the likely impact on target and non-target species. Fishers wishing to become involved were able to trial different styles of TEDs and BRDs and, with the assistance of gear technologists from the Australian Maritime College, modify and further develop the devices to suit their own fishing operations. TEDs trialled included those with declination-grids (Super Shooter, Nordmore grid, AusTED, NAFTED) and a combination of BRDs (fish-eye, square-mesh windows).

Late 1990s

In the late 1990s, the Northern Prawn Fishery Management Advisory Committee (NORMAC) set up the TED and BRD Subcommittee in anticipation of the introduction of TEDs and BRDs. This group, comprised of a range of stakeholders, was tasked with recommending suitable designs for the fishery and conditions of use. They based their recommendations on results from research projects that trialled different devices in the NPF and in other fisheries (Brewer *et al*. 2004).

2000

On the 15 April 2000, all NPF vessels were required to fit TEDs and BRDs in their nets. Initially the mandatory adoption of these devices was not readily accepted by some fishers and various complaints were received about loss of target catch and difficulty of use. Eventually after a few months of use, the fishers seemed to accept that TEDs and BRDs would become a regular part of their gear and modified their fishing operations accordingly (Brewer *et al*. 2004). The reduction target was 5% of the average 1989 and 1990 estimated level of marine turtle bycatch and mortality (from Poiner and Harris 1996). This equated to a maximum annual catch of 286 turtles (NORMAC 1998).

1998 to 2001

Taking advantage of the introduction of TEDs, a project was conducted to evaluate the effectiveness of TEDs in reducing marine turtle bycatch (Robins *et al*. 2002b). Voluntary fishers were trained in marine turtle identification, measuring and tagging; scientific data collection (turtle catch by position and date, health and other relevant factors; and also various environmental factors); and resuscitation and release techniques. Fisher data was verified using observer data. Data was collected 18 months prior to the mandatory introduction of TEDs and 18 months after the introduction of TEDs. It was demonstrated that in the years just prior to the introduction of TEDs the annual turtle interaction rate was approximately 1000 turtles during the banana prawn season and 4000 during the tiger prawn season. It has been suggested that the difference between this estimate (4000 during the tiger prawn season) and the previous estimate (5000 to 6000 for the tiger prawn season) may be due to a reduction in fishing effort. On the other hand, the estimated catch rate increased from 0.0509 turtles per trawl to 0.0754 turtles per trawl with the later study. This was considered to be possibly attributable to gear operational changes and/or adoption of new technologies over that decade.

Following the introduction of TEDs the estimated catch for the banana prawn fishery and the tiger prawn fishery, respectively, was as low as 20 turtles per year and 100 turtles per year for the whole fleet. Or an interaction rate of 0.007 turtles per trawl for the banana prawn season and 0.009 turtles per trawl during the tiger prawn season. The small numbers still caught were assumed to be taken during the winching up of the gear and so had a very good chance of survival due to the short length of time spent in the gear, or turtles that were small enough to fit through the TED grid (Robins *et al.* 2002b).

2001

During the tiger prawn season of 2001 (August to November) an observer program (monitoring 1612 trawls or 5% of total effort) was conducted to assess the impact of TEDs and BRDs on fishing operations in the NPF, including both changes in target and bycatch rates and economic impacts (Brewer *et al*. 2004). These data were also used to verify fisher-collected data in Robins *et al*. 2002b. Data was collected on all major species groups caught, including turtles. It was estimated that the marine turtle catch rate reduced from about 0.05 per trawl in 1989/90 (~5300 per year for the entire fleet) (Poiner and Harris 1996) to 0.0006 per trawl (~30 per year) after the introduction of TEDs and BRDs. Of these animals, it is believed that only three to five turtles are likely to drown and another 15 may suffer some other adverse effects.

2003 to 2009

The Crew Member Observer Program (CMOP), a bycatch monitoring program using trained fishers to collect data on threatened endangered and protected species, sawfish species and 'at risk' other elasmobranch, teleost and invertebrate bycatch species, started in 2003 (FRDC Project Number 2002/035, Fry *et al*. 2009). The Program was managed by CSIRO from 2003 to 2007, AFMA from 2007 to 2008, and NPF Industry Inc from 2009. From 2003 to 2008 the program monitored bycatch levels, including marine turtles, over 10,402 trawls. Over those years 47 turtles were recorded as caught. Turtle catch is also reported as estimated numbers per km^2 but as pre-TED catches are only reported in the scales of turtle catch per trawl, turtle catch per day or total catch it is impossible to compare between the different reporting methods.

<u>2002 to 2009</u>

Various research surveys over a range of years recorded NPF marine turtle interactions. From 2002 to 2009, the NPF Prawn Population Monitoring Survey monitored 4184 trawls with ten turtles caught. From 1975 to 2005, there were 12,019 trawls monitored during CSIRO Scientific Surveys and CSIRO/AFMA Scientific Observer Trips, with 162 turtles reported as being caught (Fry *et al*. 2009).

Annual NPF Data Summaries report Scientific Observer Program effort and turtle catches. This was no turtles caught over 84 days for 2006 (Raudzens 2007), no turtles caught over 118 days for 2007 (Ciccosillo 2008), four turtles caught over 141 days for 2008 (Evans 2009) and no turtles caught over 144 days in 2009 (Evans 2010).

<u>2006 to 2009</u>

Annual NPF Data Summaries report the CMOP effort and turtle catches. There were two turtles caught over 65 days for 2006 (Raudzens 2007), 14 turtles caught over 362 days for 2007 (Ciccosillo 2008), five turtles caught over 120 days for 2008 (Evans 2009) and 27 turtles caught over 397 days in 2009 (Evans 2010).

<u>2009</u>

In 2009, the CMO was taken over by an industry-based organisation, 'NPF Industry Pty Ltd, an incorporated body owned by the fishing operators of Australia's Northern Prawn Fishery. The company was formed in 2007 to represent the interests of NPF operators and to promote the on-going sustainable development of the fishery'. It is expected that this program will monitor bycatch levels in the NPF into the future at a reasonable cost and with adequate accuracy (<u>www.npfindustry.com.au/</u>, downloaded 1 August 2010).

Under EPBC Act (1999) conditions, AFMA provides summary reports of fishery interactions with endangered species as determined by logbooks to the Department of the Environment and Water, Heritage and the Arts (DEWHA) on a quarterly basis. Table 3 lists the interactions reported since 2007 for the NPF.

Table 3 Marine turtle interactions in the NPF reported to DEWHA by AFMA

Fishery	Date	Interactions by species	Total	Mortality
NPF	2009	1 hawksbill 7 green 2 flatback 1 olive ridley 28 unclassified	39	Nil
	2008	2 hawksbill 2 loggerhead 8 flatback 3 olive ridley 4 unclassified	19	Nil
	2007	1 loggerhead 7 green 10 flatback 6 olive ridley 31 unclassified	55	Nil

In order to determine the success or failure of the adoption of TEDs in the NPF available data from various sources have been used to estimate total turtle interactions before and after TEDs (Table 4). It was necessary to estimate the turtle total catch, turtle mortality and catch rate of turtles per day in cases when these statistics were not provided. Assumptions made were that four trawls occurred per day and that the project data was representative of the fleet.

Table 4 Estimated marine turtle catch, mortality and catch rate in the NPF

Reference	Years Considered	Source of data	Estimated turtle catch	Estimated turtle mortality	Catch rate (turtles/day)
Poiner *et al.* 1990	1979 to 1988 Pre-TED	Data from research surveys	5730±1 907 annually	344±125	0.16 t/d (both seasons)
Poiner and Harris 1996	1989 and 1990 Pre-TED	Voluntary fisher data collectors	5000 – 6000 annually (tiger prawn season only)	39% (14% death and 25% injured or comatose)	0.20 t/d (tiger prawn season)
Robins *et al.* 2002b	1998 (tiger prawn season) and 1999 (both seasons) Pre-TED	Voluntary fisher data collectors and independent observers	5000 annually (1000 banana prawn season and 4000 tiger prawn season)	22%	0.24 t/d (banana prawn season) 0.30 t/d (tiger prawn season)
Robins *et al.* 2002b	2000 (both seasons) and 2001 (banana prawn season) Post-TED	Voluntary fisher data collectors and scientific observers	120 annually (20 banana prawn season and 100 tiger prawn season)	Too low to estimate given available data	0.007 t/d (banana prawn season) 0.009 t/d (tiger prawn season)
Brewer *et al.* 2004	2001 Post-TED	Scientific observers and trained fishers	30 annually	3 - 5 drown and 15 suffer some adverse effects	0.002 t/d
Fry *et al.* 2009	2003 - 2008 Post-TED	Crew Member Observer Program	47 turtles over 10 402 trawls	Not reported	0.014 t/d
Fry *et al.* 2009	2002 - 2009 Post-TED	NPF Prawn Population Monitoring Survey	10 turtles over 4184 trawls	Not reported	0.010 t/d
Fry *et al.* 2009	1975 - 2005 Pre and Post-TED	CSIRO Scientific Surveys and CSIRO/AFMA Scientific Observer Trips	162 turtles over 12 019 trawls	Not reported	Not calculated
Raudzens 2007	2006 Post-TED	NPF Industry Crew Monitoring Observer Program	2 turtles over 65 days	Not reported	0.031 t/d (tiger prawn season)

Table 4(con't)Estimated marine turtle catch, mortality and catch rate in the NPF

Ciccosillo 2008	2007 Post-TED	NPF Industry Crew Monitoring Observer Program	14 turtles over 362 days	Not reported	0.039 t/d (tiger prawn season)
Evans 2009	2008 Post-TED	NPF Industry Crew Monitoring Observer Program	5 turtles over 120 days	Not reported	0.042 t/d
Evans 2010	2009 Post-TED	NPF Industry Crew Monitoring Observer Program	27 turtles over 397 days	Not reported	0.068 t/d

Distribution of marine turtle catch

Figures 1 and 2 show the June 1998 to July 2001 fishing effort for the banana prawn and the tiger prawn seasons, respectively (from Robins *et al*. 2002b). A vessel was considered to be fishing for banana prawns if 50% or more of the daily catch were banana prawns, all other days were considered to be in the tiger prawn season.

Figures 3 and 4 show the total marine turtle catch by fishing season from June 1998 to July 2001, without TEDs. Figures 5 and 6 show the total marine turtle catch by fishing season from June 1998 to July 2001, with TEDs.

Clearly demonstrated by these maps and, noted in Robins *et al*. 2002b, was that more turtles tended to be caught in areas of high fishing effort. More recently, Fry 2009 (p 51), reported that since TEDs have been routinely adopted the 'highest catches were in areas with highest fishing effort; around Groote (tiger prawn season) and Weipa (banana prawn season)'. Also clearly evident is that TEDs have been successful in reducing marine turtle catch in the Northern Prawn Fishery.

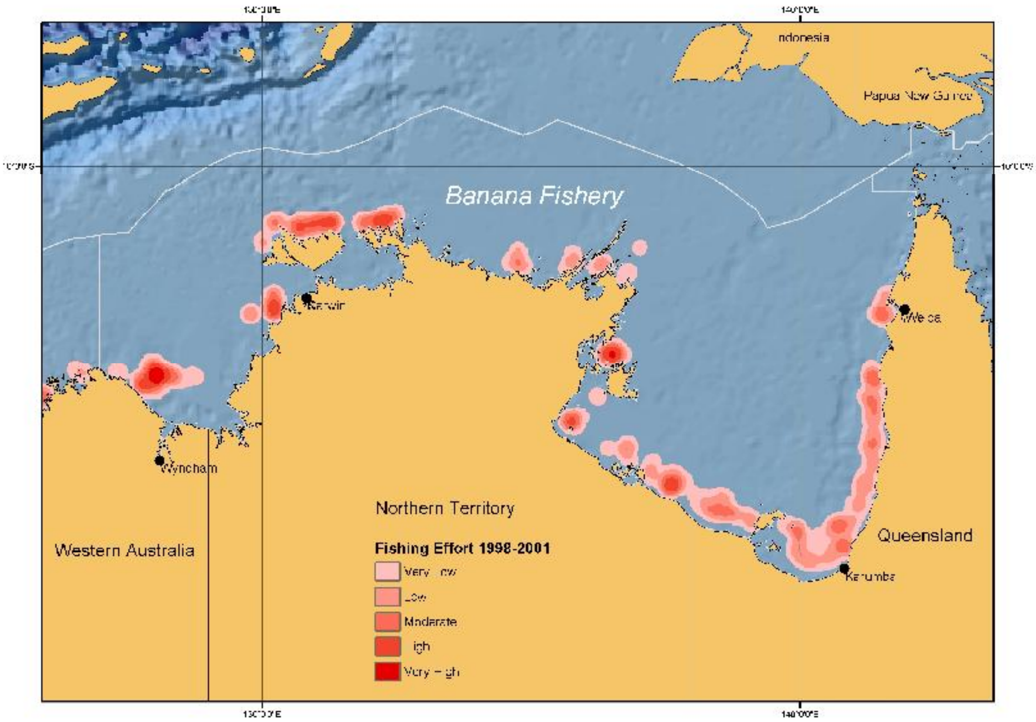

Figure 1 NPF banana prawn season effort from June 1998 to July 2001

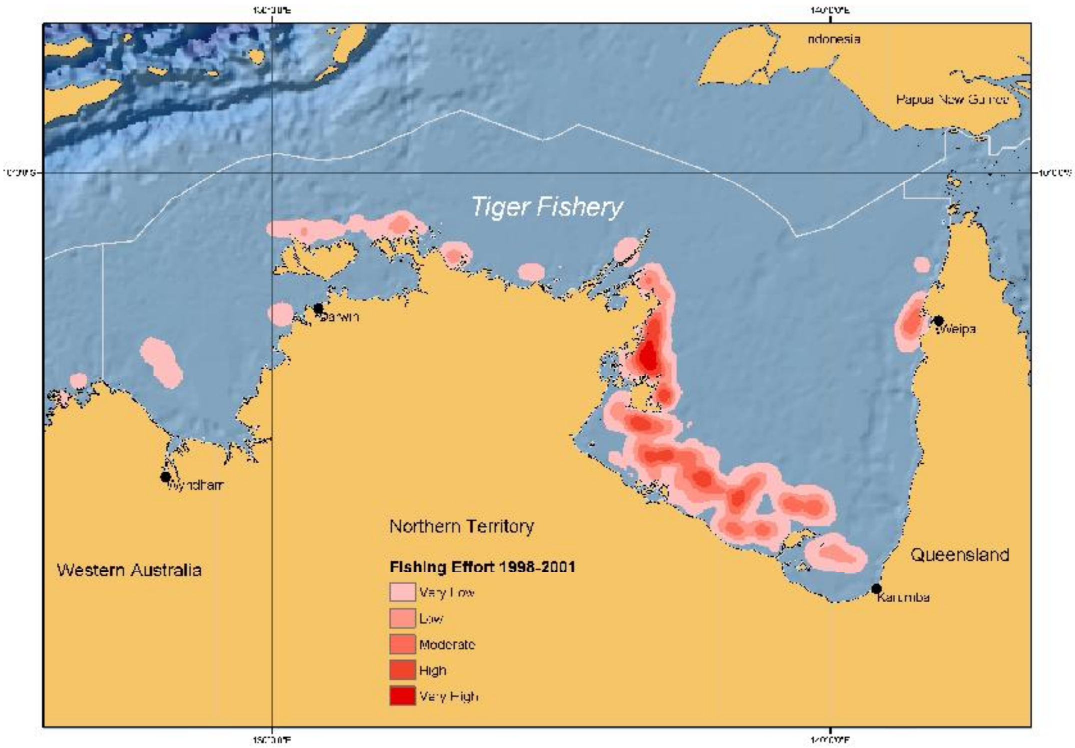

Figure 2 NPF tiger prawn season effort from June 1998 to July 2001

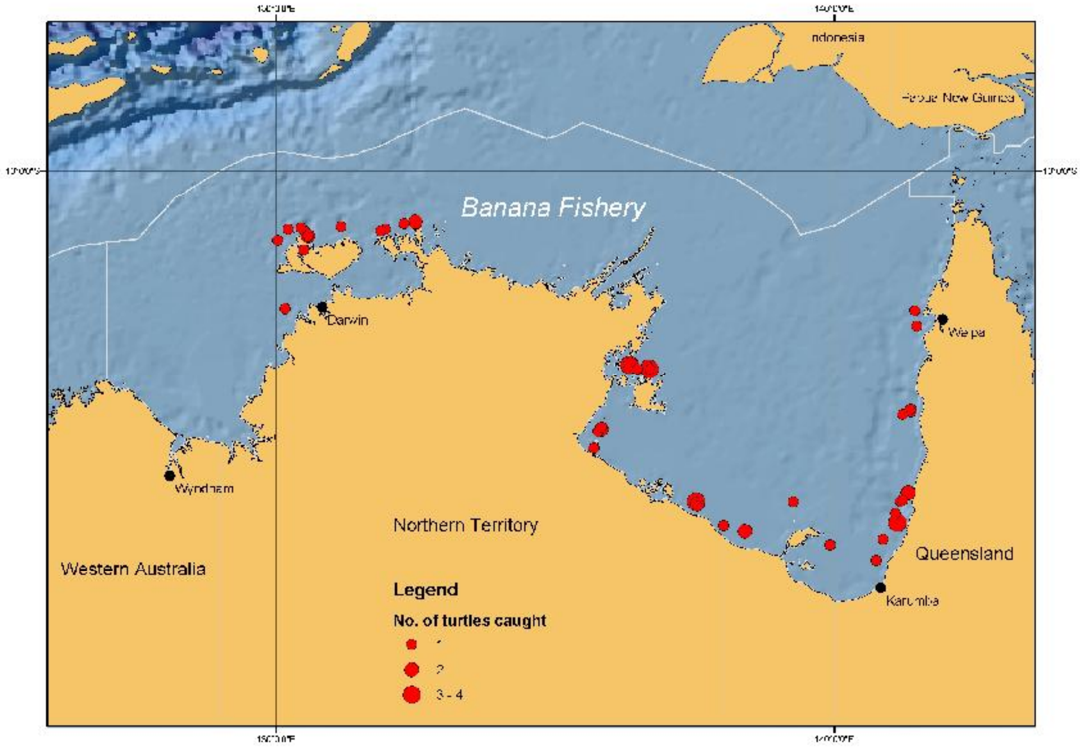

Figure 3 *Sea turtle catch during the NPF banana prawn season before TEDs June 1998 to July 2001*

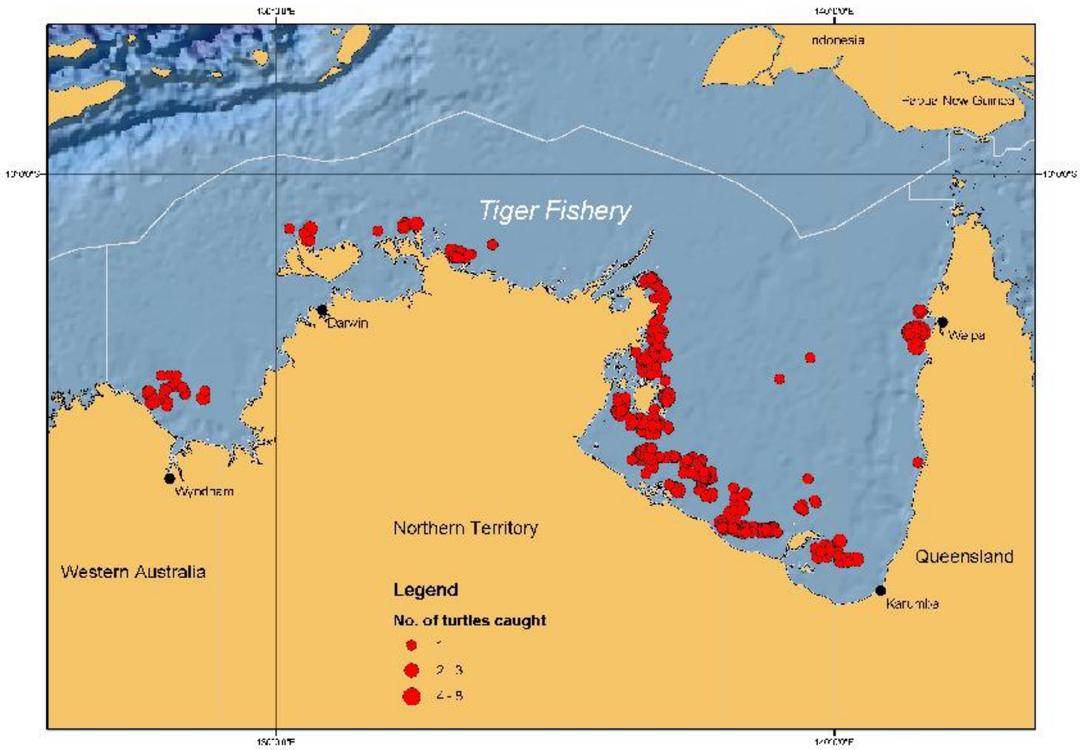

Figure 4 *Sea turtle catch during the NPF tiger prawn season before TEDs June 1998 to July 2001*

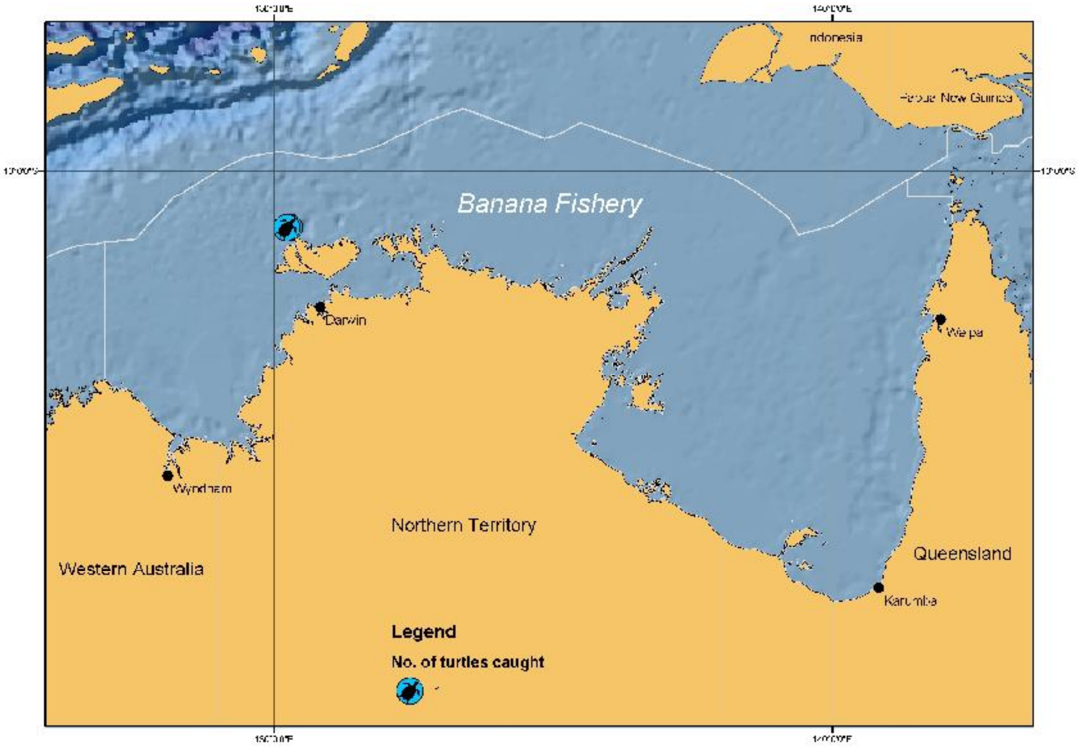

Figure 5 *Sea turtle catch during the NPF banana prawn season after TEDs June 1998 to July 2001*

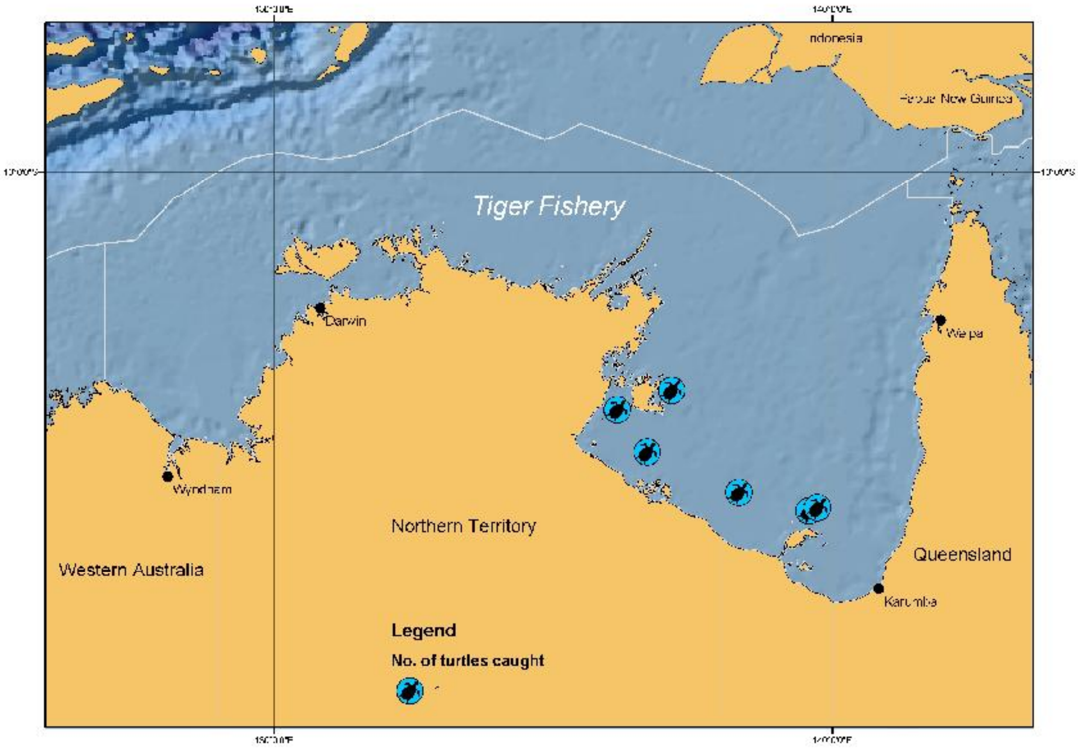

Figure 6 *Sea turtle catch during the NPF tiger prawn season after TEDs June 1998 to July 2001*

Marine Turtle Species Composition

All six species of turtles seen in Australian waters have been encountered in the NPF. The species most rarely caught has been the leatherback turtle. In 1972, a photograph was taken of a live leatherback turtle on the deck of a NPF trawler and a fisher trained in turtle identification reported catching a leatherback turtle in 1997. There has been no validated identification of leatherback turtles being caught in recent years.

Robins *et al*. (2002b) reported that the most common species caught was the flatback turtle at around 60%, followed by the olive ridley turtle at around 30%, loggerhead turtle at 6% and small numbers of green turtles (3%) and hawksbill turtles (2%) (Figure 7). These proportions are based on 637 photos of captured turtles taken from 1998 to 2001. An earlier study (Poiner and Harris 1996) reported similar proportions of flatback turtles (63%), but fewer olive ridley turtles (13%) and more loggerhead turtles (11%). The difference may be a result of the earlier study identifications not being verified using photographs, a change in turtle species composition on the NPF grounds, or changes in fishing methods and/or fishing grounds (Robins *et al*. 2002b).

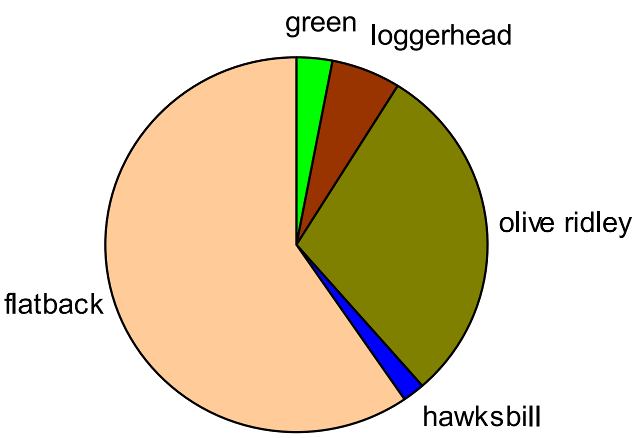

Figure 7 Species composition in the NPF from Robins et al. 2002b

Fisher opinions

All fishers interviewed said that TEDs have been very successful in stopping the catch of turtles and, because of that and other clear economical, product quality and crew safety benefits, the industry had wholeheartedly embraced their use. All were unanimous in saying that there were no changes needed.

<u>Pre-TEDs:</u>

“Before TEDs we would catch some turtles.”

“If the turtles needed to recover we put them on a slope, backside up and head down, to help them recover before releasing.”

“We had turtles, sharks and stingrays to deal with and it was often hard and dangerous for the crew.”

Post-TEDs:

“There are no turtles, no stingrays, and no sharks – so the crew don’t have to wrestle with large animals and it’s less dangerous.”

“TEDs mean less soft and broken prawns, so a much better product.”

“Scientists say turtle catch has been reduced by 99% but it’s actually 100% - scientists just don’t like saying 100%.”

“TEDs have been embraced by industry to the point where they’ll complain if they’re not set in the net properly. So we set the angles correctly and they’re overhauled every year – it’s a big investment to industry but obviously it pays off.”

“TEDs need to be set at the correct angle or product will be lost – so there’s a big incentive to get them set right.”

Suggested changes:

“No, TEDs work fine and net makers are experienced in setting them up right in the net – we don’t want or need any changes.”

“No! We’ve spent a lot of time and money getting this just right and industry likes it, don’t change it.”

Other factors related to marine turtle catches

Since there has been a requirement to report turtle interactions in the AFMA logbooks there has been, and continues to be, some turtle interactions logged by fishers. Robins *et al*. (2002b) noted an alarming level of under-reporting. For example, in 1999 there were 883 turtles reported in logs but according to observer and trained fisher reports an estimated 5208 turtles may have been caught. The inadequacy of using logbook reported catches of turtles to estimate total catches is also clearly evident in all NPF Data Summaries in recent years (Raudzens 2007; Ciccosillo 2008, Evans 2009 and 2010). See Table 5 for a comparison of logged turtle catches with CMO and Observer reported turtle catches.

Table 5 NPF marine turtle catches reported in logbooks, by crew member observers and by scientific observers from 2006 to 2009

Year	Reference and Fishery Info	Program	Fishing days	Total turtles	Estimated catch rate (turtles/day)
2009	Evans (2010) Whole year	Logbooks	7984	46	0.006
		CMO	397	27	0.068
		Observers	144	0	0.000
2008	Evans (2009) Whole year	Logbooks	7903	27	0.003
		CMO	120	5	0.042
		Observers	141	4	0.028
2007	Ciccosillo (2008) Tiger prawn season	Logbooks	4829	25	0.005
		CMO	362	14	0.039
		Observers	118	0	0.000
2006	Raudzens (2007) Tiger prawn season	Logbooks	6983	8	0.001
		CMO	65	2	0.031
		Observers	84	0	0.000

East Coast Trawl Fishery

Marine turtle catch history

Early 1990s

In the early 1990s, following many years of research by the Queensland DERM Turtle Research Group, the eastern Australian sub-population of loggerhead turtles was found to be in serious decline. It was observed that over the previous 25 years the number of nesting loggerhead turtles had reduced by around 80%. The key contributors to the decline were suspected to be foxes preying on eggs and hatchlings and trawling operations in the ECTF drowning turtles (Robins 2002).

1991 to 1996

In the following years, 1991 to 1996, fishers and scientists worked together as part of the Sea Turtle Bycatch Monitoring Program (STBMP) to gather baseline data on the issue. 'The work was undertaken to determine if the size and composition of sea turtle bycatch in this fishery was of the scale required to significantly contribute to observed declines in nesting numbers of the east Australian sub-population of nesting loggerhead turtles' (Robins 2002, p 45). Interested fishers provided catch information in a research logbook that was matched to the corresponding effort data collected in Queensland Fisheries Service logbooks.

1993

Turtle bycatch estimates based on data, provided by a sample of 50 participating fishers, were calculated after the first two years of the program. The ECTF was estimated to interact with approximately 5300 marine turtles or an average catch rate of 0.068 turtles per day (Robins 1995).

1990s

A number of related research projects developing and trialling TEDs and BRDs in the ETBF, Torres Strait Trawl Fishery and the NPF were conducted in the 1990s. These were conducted by cooperative research teams of various combinations from Queensland Department of Primary Industries (Qld DPI), Northern Territory Department of Primary Industries and Fisheries (NT DPI&F), CSIRO and Australian Maritime College (AMC).

After many years of discussion and negotiations that started in the early 1990s, eventually in 1996 the United States placed an embargo on fisheries that did not comply with their regulations regarding the use of TEDs. This provided an impetus for Australian trawl fisheries, including the ECTF, to resolve the issue of which TEDs would be the most effective for the Australian fisheries. It was felt that it was inappropriate to directly transfer the technology for the type of TED developed in the United States to Australian trawl fisheries due to the different size of gear and method of operation. So soft-type TED technology was initially considered. These are devices with flexible grids and no metal frames (Shiode and Tokai 2004).

The Morrison soft TED was trialled in Moreton Bay, Queensland (Robins-Troeger 1994). This TED consists of exclusion nets attached inside the trawl net with an escape opening. It was found that the effect of the TED on catches of prawns and bycatch was variable depending on locations and seasons, but no turtles were caught in the net containing the TED.

The AusTED (Australian Trawling Efficiency Device), containing flexible and soft grids, was developed and trialled in the ECTF in the early 1990s. It was a TED and BRD system designed using various United States ideas adapted to suit Australian conditions and fishing operations. The intention was to reduce the amount of bycatch landed and maintain profitability while being easy and safe to operate. The AusTED consisted of 5 main components: an accelerator funnel, a flexible grid, a panel of large meshes, flexible net opening hoops, and a clear PVC escape gap cover (Mousey *et al*. 1995). The AusTED trials were successful with a reduction in total bycatch, release of large rays and turtles and the target catch of prawns not significantly reduced (Robins-Troeger *et al*. 1995). It was considered easy to use with no additional safety issues for the crew. The conclusion was that although promising, the device required further refinement before it could be considered acceptable by the fleet (Mousey *et al*. 1995).

1994

The AusTED II, released in 1994, was a modification of the original AusTED with the aim of designing a more effective but simpler system. It was constructed in two sizes – small and large. During trials in the ECTF and NPF, the AusTED II was found to be successful in releasing large animals (rays and turtles) and reducing bycatch, but losses in catches of prawns and byproduct were area dependant (McGilvray *et al*. 1999). It was noted that it was important to develop an efficient and pragmatic system. It was also seen as essential that the fishing industry have confidence in the research results (Robins and McGilvray 1999).

Also in 1994, DPI Fisheries Service published a guide for fishers on marine turtle handling and release procedures and using TEDs ("Code of Fishing Ethics: The Capture of Marine Turtles") (Zeller 2003).

1996

In 1996, (the same year the United States placed the import embargo on fisheries not using TEDs) an extensive education and communication program on TEDs and BRDs commenced for fishers of the ECTF, Torres Strait Trawl Fishery and NPF. This project (FRDC Project No. 1996/254) 'aimed to inform, develop and encourage the use of TEDs and BRDs by working collaboratively with the prawn trawling industry of northern Australia' (Robins *et al*. 2000 p ii). Strategies adopted included informal and hands-on port workshops, industry meetings, informal wharf visits, distribution of bycatch newsletters and videos, loans of TEDs and BRDs from a gear library, at-sea assistance by gear technologists during field tests and incentive awards. The project demonstrated the effectiveness of a focused extension program in raising the awareness of sensitive issues such as turtle bycatch in the fishing industry. Over 30% and 60% of prawn trawl operators of the ECTF and NPF, respectively, participated and workshops were attended by over 400 interested persons (fishers, netmakers, conservationists, industry personnel). Performance trials were conducted for over 750 trawls. These demonstrated the effectiveness of TEDs in releasing large animals, but prawn loss and bycatch reduction was found to be variable dependant on factors such as setting of the TED in the trawl net.

1991 to 1996

Pre-TED levels of marine turtle bycatch, as estimated from the entire 1991 to 1996 STBMP, were approximately 5900 encounters annually. In total, an estimated 150 loggerhead turtles, 100 green turtles, 40 flatback turtles, 10 olive ridley turtles and 10 hawksbill turtles potentially died as a result of an interaction during ECTF operations. Around 60% to 80% of turtles (pooled across all sectors) were predicted to be immature animals using approximate size at maturity as a guide. Approximately 10% of the ECTF fleet provided data (Robins 2002).

1999 to 2002

TEDs and BRDs were made mandatory in the ECTF in a step-wise approach from 1999 to 2002 with a target of 95% reduction in marine turtle catch (QFMA 1998). The initial definition of a TED was considered quite broad and unlikely to achieve the 95% target. With limited observer coverage in the years directly following the adoption of TEDs, the determination of if the target was met was considered not possible (Robins 2002).

2000

An extensive study of the impact of bycatch reduction devices in the ECTF was started in 2000 (FRDC Project No. 2000/170). Courtney *et al*. (2007) described bycatch species composition and catch rates achieved using gear fitted with TEDs and BRDs compared with control gear in various sectors of the fishery and provided information on the biology and distribution of permitted species. So few turtles were caught during the projects no estimates were made on turtle catch or mortality rates.

2003

In 2003, the allowable TED specifications were tightened in order to attempt to improve their effectiveness. Nevertheless, the ECTF logbooks demonstrated that the mitigation target of 95% reduction was met following the adoption of TEDs. In the years 2001 – 2005, the reported average number of interactions was 14 turtles per year (Queensland Department of Primary Industries and Fisheries 2006).

Also in 2003, a Species of Conservation Interest logbook (SOCI01) was introduced into the ECTF for recording information on interactions with marine species protected under Australian and State laws. Before this, turtles were recorded in the general logbook.

2005

There were 11 turtles reported in the SOCI01 logbook in 2005 with one fatality (Queensland Department of Primary Industries and Fisheries 2006).

2006

In 2006, the Queensland Government adopted the 'Taking Bycatch off our Beaches' program. Funding was available to assist the fishing industry in reducing bycatch and lessening its impact on the marine environment.

2008

Over the years the Queensland DPI&F worked closely with the fishers of the ECTF to address issues concerning the viability of the industry. This was demonstrated when a trawl industry meeting in 2008 led to the development of a Trawl Action Plan that aimed to identify mechanisms to lessen the regulatory burden faced by the industry and to increase flexibility, and therefore improve profitability. Following industry consultations at port meetings, one of the proposed changes was an amendment of the TED specifications in the Management Plan for the fishery.

2009

In 2009, there were three interactions with marine turtles reported in ECTF logbooks, all flatback turtles and all released alive. The effectiveness of TEDs in releasing marine turtles was acknowledged (Queensland Government 2010a). The 2009 performance measure relevant to marine turtles that 'more than 5% of boats in the fishery have non-compliant TEDs' was not triggered. Only five boats (< 2% of the East Coast Otter Trawl fleet T1, T2) were prosecuted for contravening a condition of an authority regarding TED or BRD use' (Queensland Government 2010b, p 18'). There were two turtles reported in 2008 (Queensland Government 2010a), six in 2007 and an average of 14 per year during the years 2001 to 2006 (Queensland Government 2008).

<u>2010</u>

On 1 February 2010, amended TED regulations in the ECTF became effective. They offered additional protection to marine turtles with more specific TED specifications. The amended specifications were in line with the strict TED specifications applied in the United States. These changes enabled the fishery to meet strict United States accreditation standards and allowed the ECTF to gain access to the United States markets. The accreditation of the ECTF signified the adoption of world's best practice with regard to TED design.

In conjunction with the amended TED regulations, Fisheries Queensland introduced the Trawl Bycatch Reduction Project to assist fishers in reducing their bycatch rates through the use of more effective TEDs and BRDs. This project included:

1. A Square mesh codend and turtle excluder device rebate scheme,
2. Testing for new and improved BRD designs and
3. An extension and education program

(http://www.dpi.qld.gov.au/28_14252.html,downloaded 15 September 2010).

The $1m rebate scheme was implemented to help the fishers of the ECTF change to alternative, more effective devices to reduce bycatch. Many operators took advantage of the TED rebate with 1080 new compliant TEDs claimed as part of the scheme. By December 2010, 115 Square Mesh Codends had been purchased for use in the scallop fishery and the scheme continues until May 2011 (Darren Roy QPIF, personal communication 22 October 2010).

Fishery independent trawl surveys (i.e. research surveys) and commercial fisher trials have been conducted testing modified mesh codends in both the scallop and shallow water prawn sectors, and the deepwater prawn sectors for the later method. To encourage update, Fisheries Queensland supplied codends to the industry for trial. Results for all trials have been promising with positive feedback from the participating fishers. Trials have been conducted in the United States on a modified TED. Unfortunately, the TED failed the test in 2010. It was tested using captive-bred marine turtles ready for release. To be successful a TED must release the turtles within a certain time-frame during 25 turtle-runs. Two turtles were captured and minor changes were suggested. There are plans to retest the TED design in 2011 (Darren Roy QPIF, personal communication 22 October 2010).

A $375,000 extension and education program is underway with the intention to increase the uptake of improved TEDs and BRDs by providing independent expert technical advice through personal contact and via post visits, preparation of a gear library, net maker engagement, and publication of a technical information guide on TEDs (FRDC and Queensland Government 2010).

Distribution of marine turtle catch

The waters of the east coast of Australia provides feeding grounds for all of the species of turtles seen in Australian waters with numerous significant nesting grounds for the green turtle, hawksbill turtle, loggerhead turtle and flatback turtle. Some of the largest marine turtle sub-populations in the world reside in these waters and the Great Barrier Reef World Heritage Area makes up a signification proportion of these waters (Robins 2002).

As demonstrated by Figure 8, marine turtle catch in the ECTF is relatively higher in inshore areas known to have high densities of turtles on feeding grounds. The Moreton Bay sector accounted for 54% of encounters, the tiger prawn sector accounted for 23% and the banana prawn sector for 6%. These sectors fish inshore waters close to the coastline. The offshore ground sectors (Eastern king prawn, scallop, red spot king prawn) account for less than 5% of total encounters (Robins 2002).

Robins (2002) reported that catches by species as reported by trained fishers (1991 – 1996) and prior to the use of TEDs, concurred with their known distribution. Information by species included:

- There were higher catches of flatback turtles in northern Queensland (Figure 9),
- Green turtles were caught throughout the east Coast (Figure 10),
- Loggerhead turtles were caught mainly in south Queensland (Figure 11),
- More olive ridley turtles were caught in northern Queensland waters (Figure 12),
- Hawksbill turtle catches were low throughout the east Coast (Figure 13).

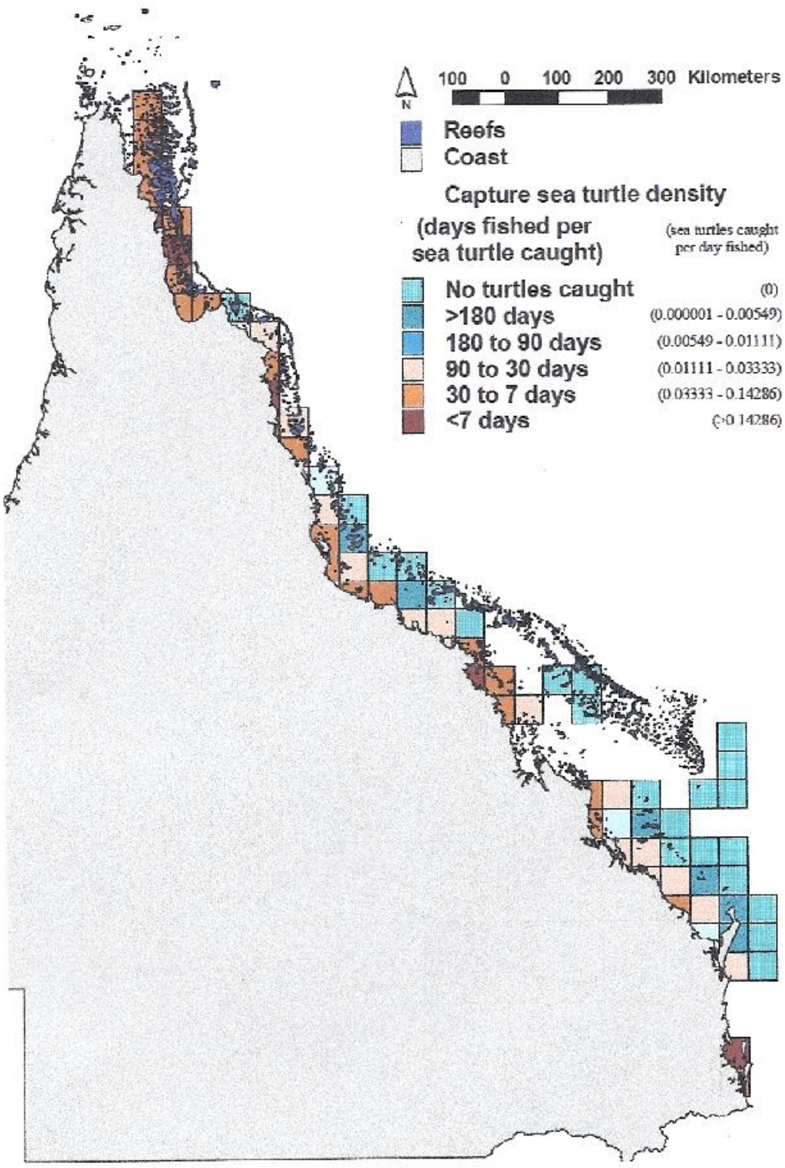

Figure 8 ***Observed marine turtle CPUE per CFISH grid (30^2nm) for all species.*** *Marine turtle CPUE presented as days fished per marine turtle caught (and turtles caught per day fished) (Source Robins 2002). Data from STBMP 1991 to 1996.*

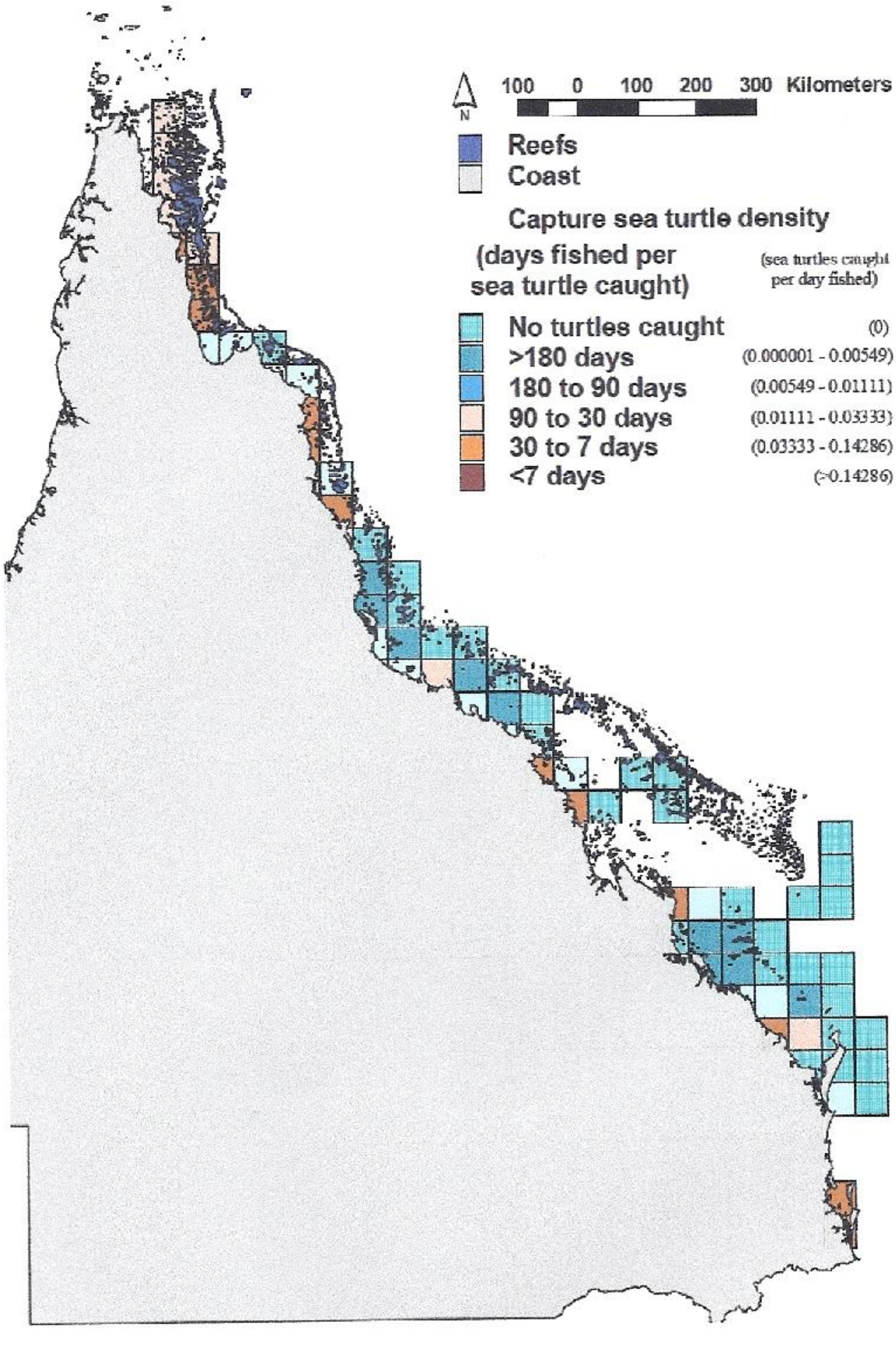

Figure 9 ***Observed green turtle CPUE per CFISH grid (30^2nm).*** *Marine turtle CPUE presented as days fished per marine turtle caught (and turtles caught per day fished) (Source Robins 2002). Data from STBMP 1991 to 1996.*

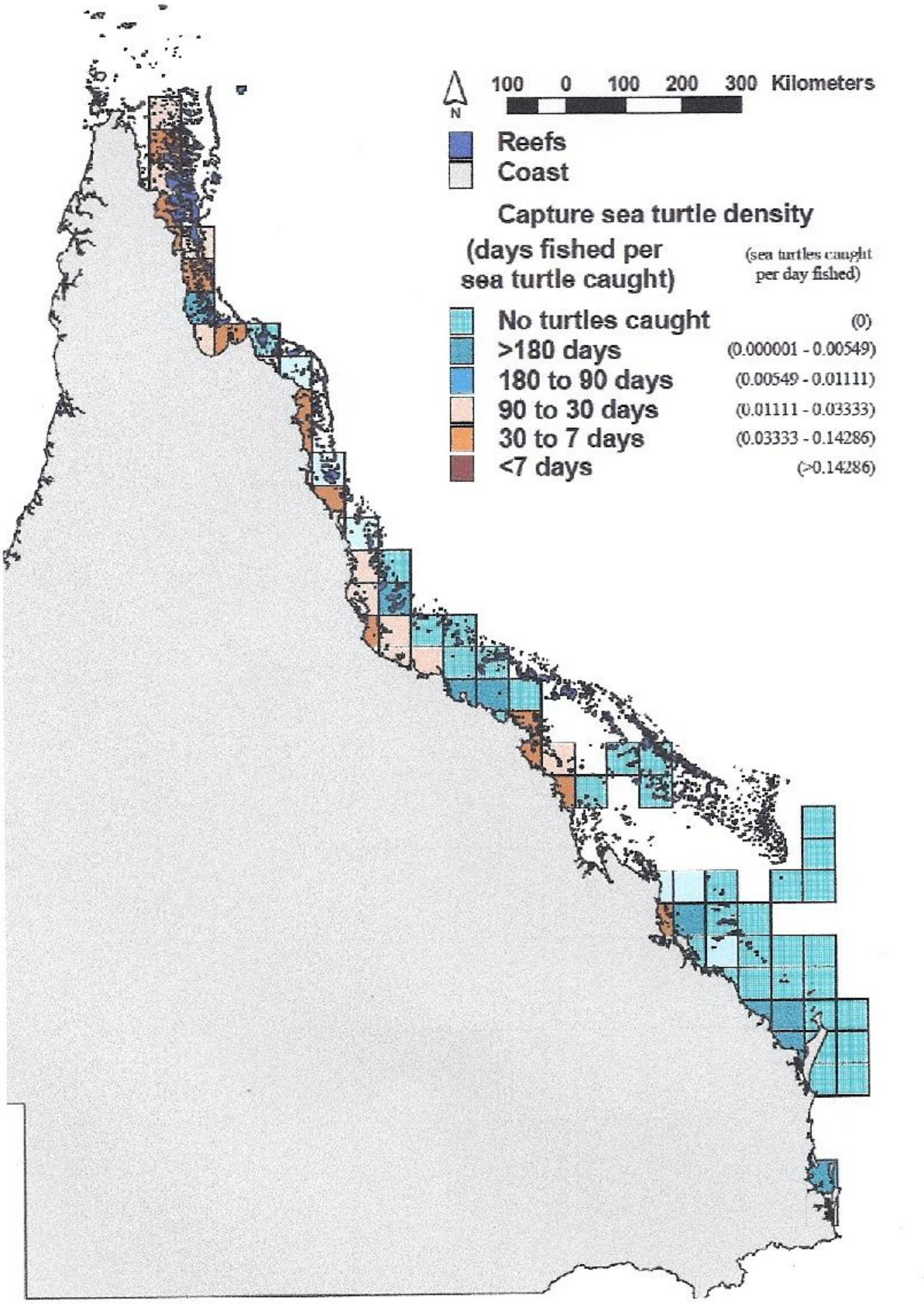

Figure 10 ***Observed flatback turtle CPUE per CFISH grid (30^{2}nm).*** *Marine turtle CPUE presented as days fished per marine turtle caught (and turtles caught per day fished) (Source Robins 2002). Data from STBMP 1991 to 1996.*

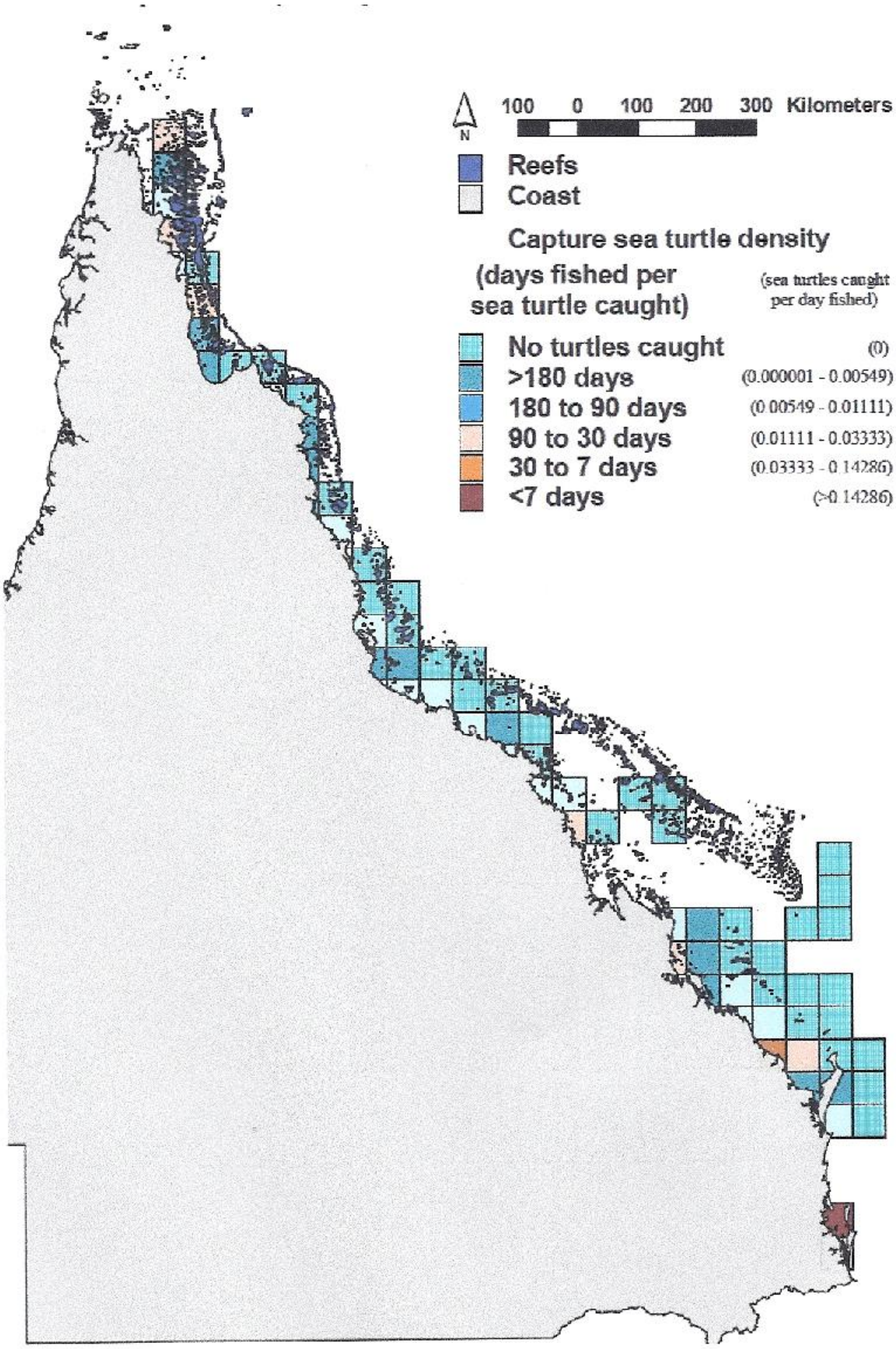

Figure 11 ***Observed loggerhead turtle CPUE per CFISH grid (30^2nm).*** *Marine turtle CPUE presented as days fished per marine turtle caught (and turtles caught per day fished) (Source Robins 2002). Data from STBMP 1991 to 1996.*

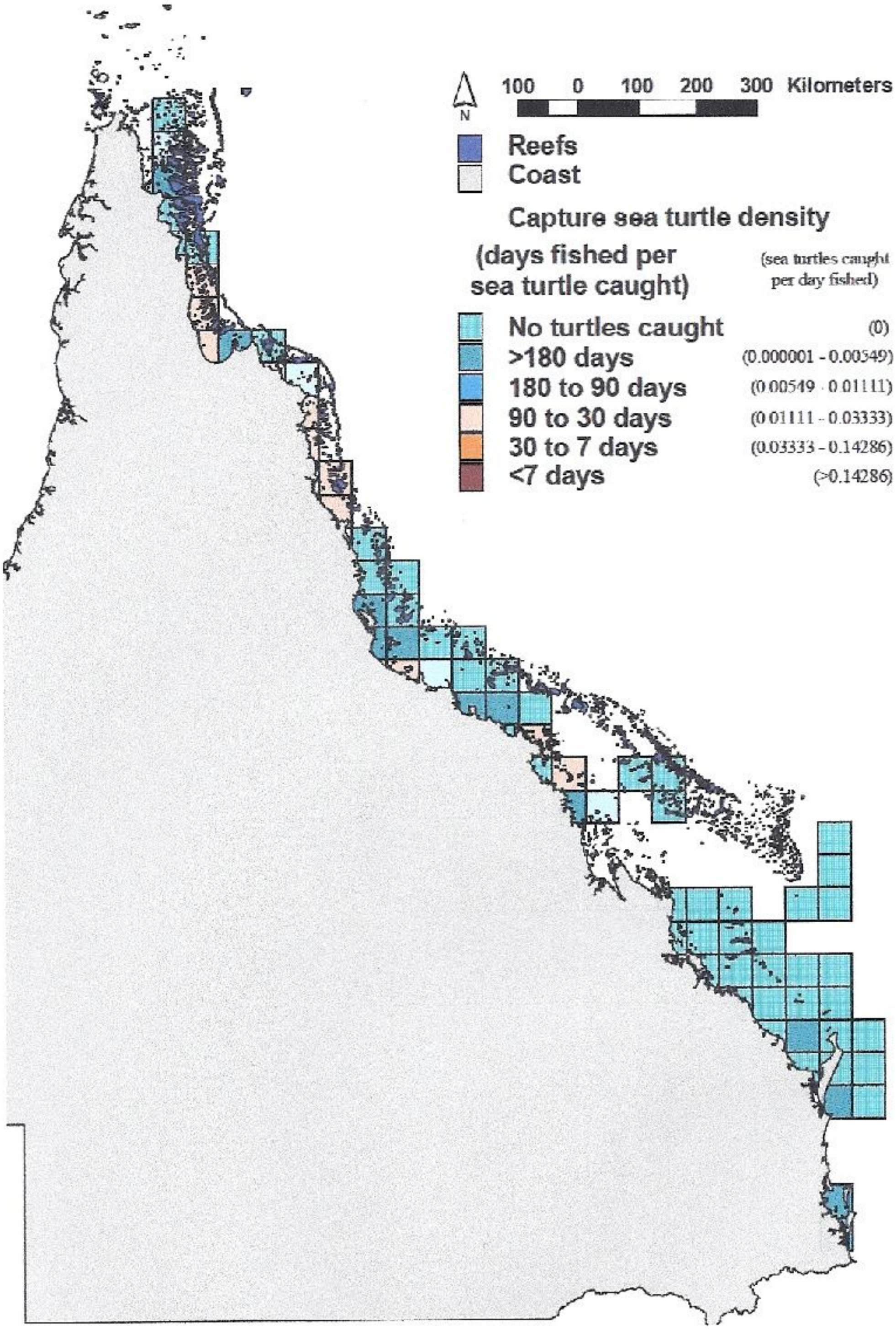

Figure 12 ***Observed olive ridley turtle CPUE per CFISH grid (30^2nm)***. *Marine turtle CPUE presented as days fished per marine turtle caught (and turtles caught per day fished) (Source Robins 2002). Data from STBMP 1991 to 1996.*

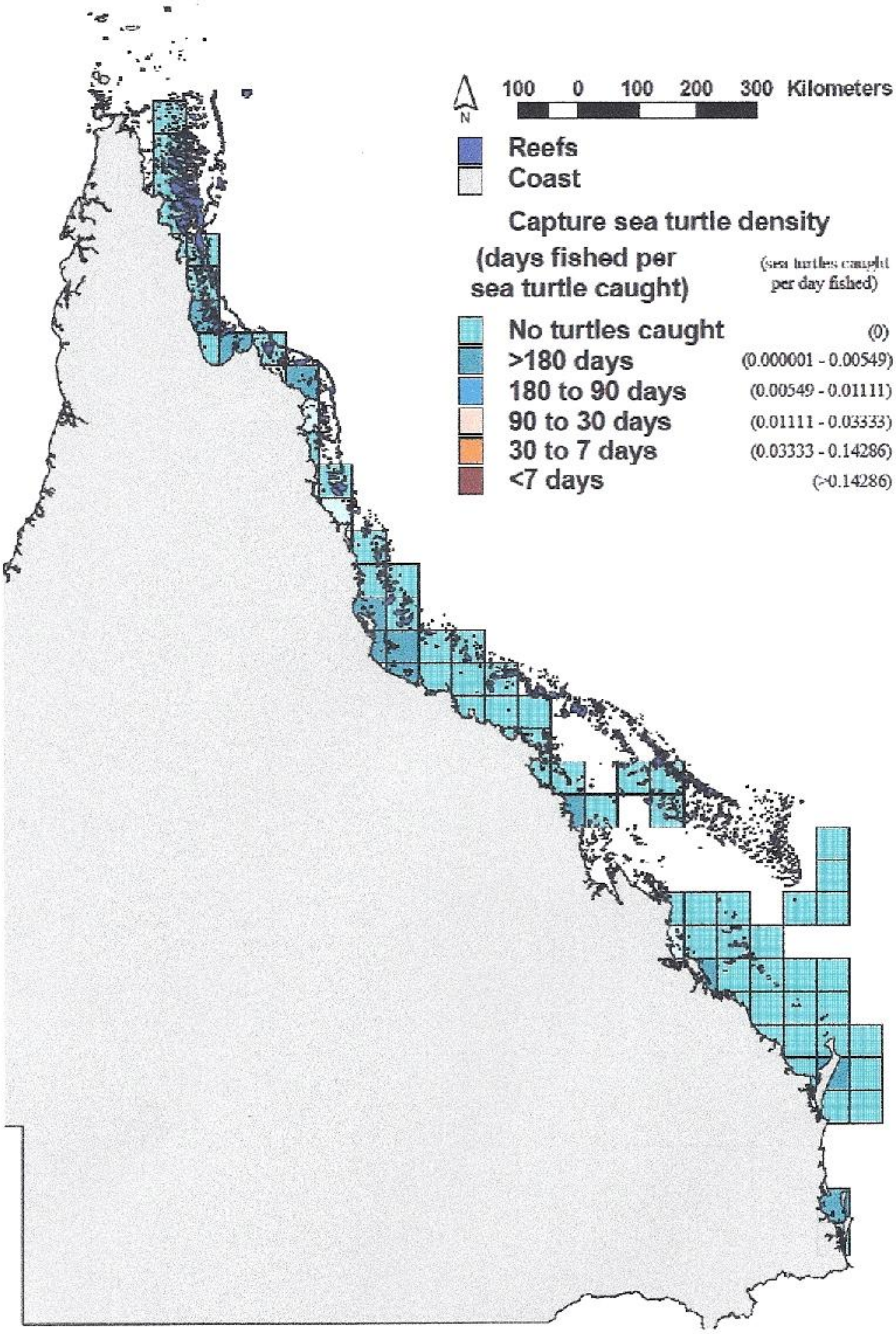

Figure 13 ***Observed hawksbill turtle CPUE per CFISH grid (30^2nm).*** *Marine turtle CPUE presented as days fished per marine turtle caught (and turtles caught per day fished) (Source Robins 2002). Data from STBMP 1991 to 1996.*

Marine turtle species composition

The ECTF was reported to have a very high chance of negatively impacting on the endangered loggerhead turtles of eastern Australia. This is due to a high level of effort in the fishery overlapping with densely populated nesting and feeding grounds of this species in eastern Australian waters (Robins 2002).

The STBMP from 1991 to 1996 determined a species composition of approximately 50% loggerhead turtles, 27% green turtles and 16% flatback turtles, 6% olive ridley turtles and 1% hawksbill turtles (Robins 2002) (Figure 14). There has only ever been one report of a leatherback turtle interacting with fishing operations in this fishery (Zeller 2003).

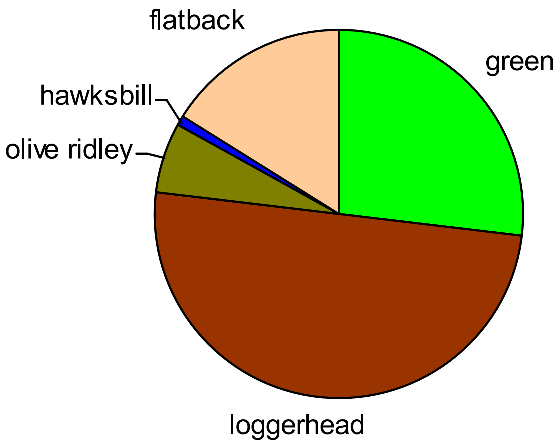

Figure 14 Species composition in the ETBF from Robins 2002

Fisher opinions

"Deepwater catch no turtles but TEDs useful for large-things."

"In both longline and trawl fisheries and is confident he knows what to do for experience – some crew have training from Seanet Staff."

"Gear builder – have solved scallop problems with TEDs – working with fishers and Southern Fisheries Centre (QDPI)."

"Pre-TED – I fished mainly deep – so few turtles - 12 turtles in many years only - post TED - 0 turtles caught."

"Some concerns with new regs - concerns about scallop net TEDs."

"Some lack of communication with science and managers."

"Some fishers are just boat drivers and don't understand gear or fishery issues."

Other factors related to marine turtle catch

The number of vessels in the fleet declined from around 1400 licensed operators in the early 1980s to just 520 in 2004. These reductions in fishing vessels and consequently fishing effort would have resulted in a decrease in the impact of the fishery on bycatch rates, including the catch of marine turtles.

Eastern Tuna and Billfish Fishery and Western Tuna and Billfish Fishery

Marine turtle catch history

<u>1950s</u>

Japanese longliners operated off the eastern and western coasts of Australia in the 1950s with an occasional turtle interaction reported by Australian observers. In 1997, these foreign fleets were excluded from the Australian Fishing Zone (Wilson *et al.* 2010).

<u>Early 1980s</u>

Commercial longliners commenced fishing for tuna and billfish off the eastern coast of Australia in 1981. A small number of marine turtles were anecdotally reported as being caught each year.

A few years later, 1986, domestic longliners began fishing the waters of the WTBF (Wilson *et al.* 2010). Fishers reported, anecdotally and via logsheets, that turtles were occasionally caught during their fishing operations (Robins *et al.* 2002a).

<u>1993</u>

In 1993, an Expert Workshop was held in Hawaii by the United States National Oceanic and Atmospheric Administration (NOAA). Miller (1993) noted that there was a possibility that there was an incidental catch of marine turtles in the tuna fishery off the east coast of Australia. Even though it was recognised that a turtle bycatch did exist, there was scant information on interaction or mortality rates.

<u>Late 1990s</u>

In the late 1990s, the issue of marine turtle bycatch during longline fishing operations was becoming increasingly in the spotlight. This was especially so in light of tough United States measures placed on their own vessels and that of the United States practice of extending domestic law to foreign fleets through the use of trade embargos. Previously the most damaging fishing gear type to most serious declines in marine turtle populations was prawn (shrimp) trawl (Magnuson *et al.* 1990). That problem was all but solved in most parts of the world with the largely global, with some exceptions, successful adoption of TEDs. Longline fishing had become the latest commercial fishery to be targeted as believed to be contributing to the decline of marine turtle populations (Robins *et al.* 2002a).

<u>2001</u>

In 2001, the Department of Agriculture, Fisheries and Forestry commissioned a review of available information on marine turtles and longline fisheries (Robins *et al.* 2002a). Fisher interviews were used to estimate a catch rate of 0.024 turtles per 1000 hooks (standard deviation of 0.027) for the ETBF and the WTBF. Or, assuming 1000 hook per set, one turtle interaction for every 40 days of fishing. Differences in catch rates were recognised in different sections of the ETBF fishery (far north Queensland, central and southern Queensland, New South Wales) and the WTBF but this difference was not significant. This non-significant difference may be due to the lack of data and inaccurate nature of the data used to determine catch rates. Different catch rates, however, could be expected considering the distribution of turtle stocks and operational aspects of the fishing activities (light-stick use, deployment of the gear and type of bait) and concentration of fishing effort. This catch rate equated to an estimated total turtle catch in the ETBF and WTBF of 402 individuals using 2001 effort data (with 95% confidence limits of 360 to 444).

2004

A project, funded by FRDC in 2004, Robins *et al.* (2007) adopted the recommendations of the previous study including:

- Attendance of as many fishers as possible from the Australian pelagic longline fleets at workshops covering marine turtle conservation awareness, marine turtle handling and logbook data collection.
- Production of a DVD outlining marine turtle handling and logbook data collection guidelines, with distribution to all Australian pelagic longline vessels.
- The collection of biological data and samples by trained volunteer fishers from the Australian pelagic longline fleets to be used in national and international research projects, including research using morphological measurements, conventional tagging, Platform Transmitter Terminal tagging, genetic samples, and fishing operational modifications in a specialised marine turtle logbook.
- Testing a selection of dip-nets, line-cutters and dehookers in the Australian pelagic longline fisheries and recommending approaches and/or designs most suitable for Australian longline operations.
- To produce an educational DVD, suitable for all ages, covering marine turtle ecology.

2006

As a result of trials on the most suitable dehookers and line-cutters for the Australian fleet, SeaNet Australia, AFMA, Threatened Species Network through the Natural Heritage Trust funding, purchased and distributed safe release kits (pole dehooker, pole line cutter, turtle-safe deck dehooker, instruction DVD '*Hooks Out Cut the Line*') to all Australian pelagic longliners. The provision of this equipment was expected to help reduce injury to bycatch species as a result of an interaction, including turtles.

By 2010, very few of the original dehookers and linecutters remained on vessels (David Kreutz.OceanWatch Australia, personal communication 2010).

2006/2007

Observers on board ETBF vessels report the occasional catch of marine turtles. In the ETBF, the most recent observer data to be analysed for the ETBF Resource Assessment Group (RAG) was 2006/2007 and there were so few marine turtle interactions that year, total interactions were not estimated (Dambacher 2007). Estimated total marine turtle interactions for 2004/2005 and 2005/2006 were 222 and 244, respectively (Dambacher 2005, Dambacher and Moeseneder 2006).

Observers in the WTBF report occasional marine turtle interactions, although, no total turtle catches have been estimated. Catches are expected to be very low due to the small fleet size and consequently low effort.

2009

Turtle interaction reported by ETBF fishers in logbooks have been 15 turtles in 2009, 9 in 2008, 17 in 2007, 19 in 2006, 35 in 2005, 48 in 2004, 41 in 2003 and 49 in 2002 (AFMA). Turtle interactions reported by WTBF fishers have been 10 turtles in 2009, 5 in 2008, 1 in 2007, 4 in 2006, 6 in 2005, 7 in 2004, 24 in 2003 and 39 in 2002 (AFMA).

2010

Under EPBC Act (1999) conditions AFMA provides summary reports of fishery interactions with endangered species as determined by logbooks to DEWHA on a quarterly basis. Table 6 lists the interactions reported since 2007 for the ETBF and WTBF.

Table 6 Turtle interactions in the ETBF and WTBF reported to DEWHA by AFMA

Fishery	Date	Interactions by species	Total	Mortality
ETBF	Jan to Mar 2010	1 leatherback 2 loggerhead 3 green 1 unclassified	7	1 green (unknown health) 1 unclassified
	2009	5 leatherback 1 hawksbill 5 loggerhead 1 green 3 unclassified	14	1 loggerhead
	2008	3 leatherback 3 loggerhead 2 olive ridley	8	
	2007	5 leatherback 2 hawksbill 2 loggerhead 6 green 2 unclassified	15	1 hawksbill 1 green
WTBF	Jan to Mar 2010	1 leatherback 1 loggerhead	2	
	2009	6 leatherback 2 hawksbill 2 loggerhead	10	
	2008	1 leatherback 1 loggerhead 1 unclassified	3	1 leatherback 1 unclassified
	2007	1 hawksbill	1	

Distribution of marine turtle catch

Logbook data collected in the ETBF and WTBF are considered to be inadequate to estimate marine turtle catch (Robins *et al.* 2002a) as there is evidence that while some fisher's record their turtle catch accurately, others do not record any interactions at all. Logbook data, however, may be adequate for determining where marine turtle interactions occur in the fishery. Figure 15 clearly shows that for the years 1997 to 2001 marine turtles interacted with Australian fishing operations throughout the entire fishery with catches occurring more frequently in high fishing effort areas.

At this stage there is no recognised 'turtle hot spots' with respect to Australian longline fisheries. It may be reasonable to predict, however, that concentrations of turtles may occur where their food sources are more abundant, which for the same reason may be also where the target fish are more abundant and so where more fishing effort occurs. This would be primarily on or near sea mounts. Reports of turtle interaction events are not frequent enough to actually determine any particular hot-spot.

In these grounds, water edges (i.e. temperature and current breaks) that would be likely to impact on aggregated food sources are not geographically stable, either seasonally or inter-annually. So therefore areas that may contain so-called turtle-hot spots may move continuously. If there are indeed any turtle hot-spots they will be virtually impossible to spatially or temporally locate.

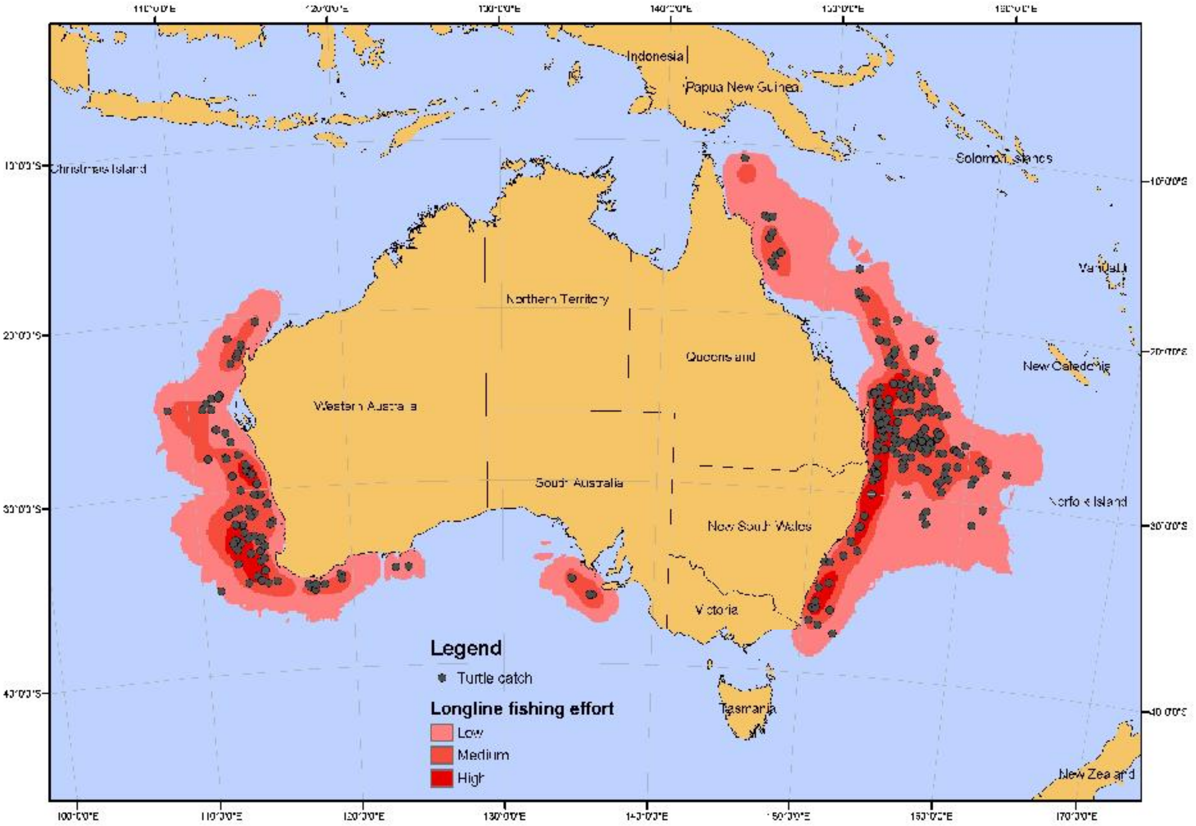

Figure 15 ***ETBF and WTBF AFMA logbook reported marine turtle interactions from 1997 to 2001 with 2001 effort*** *(Robins et al. 2002a)*

Additionally, the turtles found in these pelagic zones can also be moving significant distances, as demonstrated by the four ETBF-caught satellite tagged turtles (Figure 16).

The majority of the shelled turtles caught in the ECTF that have had their lengths measured were juveniles that are in the pelagic phase of their lives. These animals are believed to be moving across vast tracks of ocean during this phase of the life cycle. Other turtles caught, as demonstrated by the satellite track of an adult green turtle (Figure 17), may be adults on breeding migrations and so too may not follow any turtle hot-spot routes.

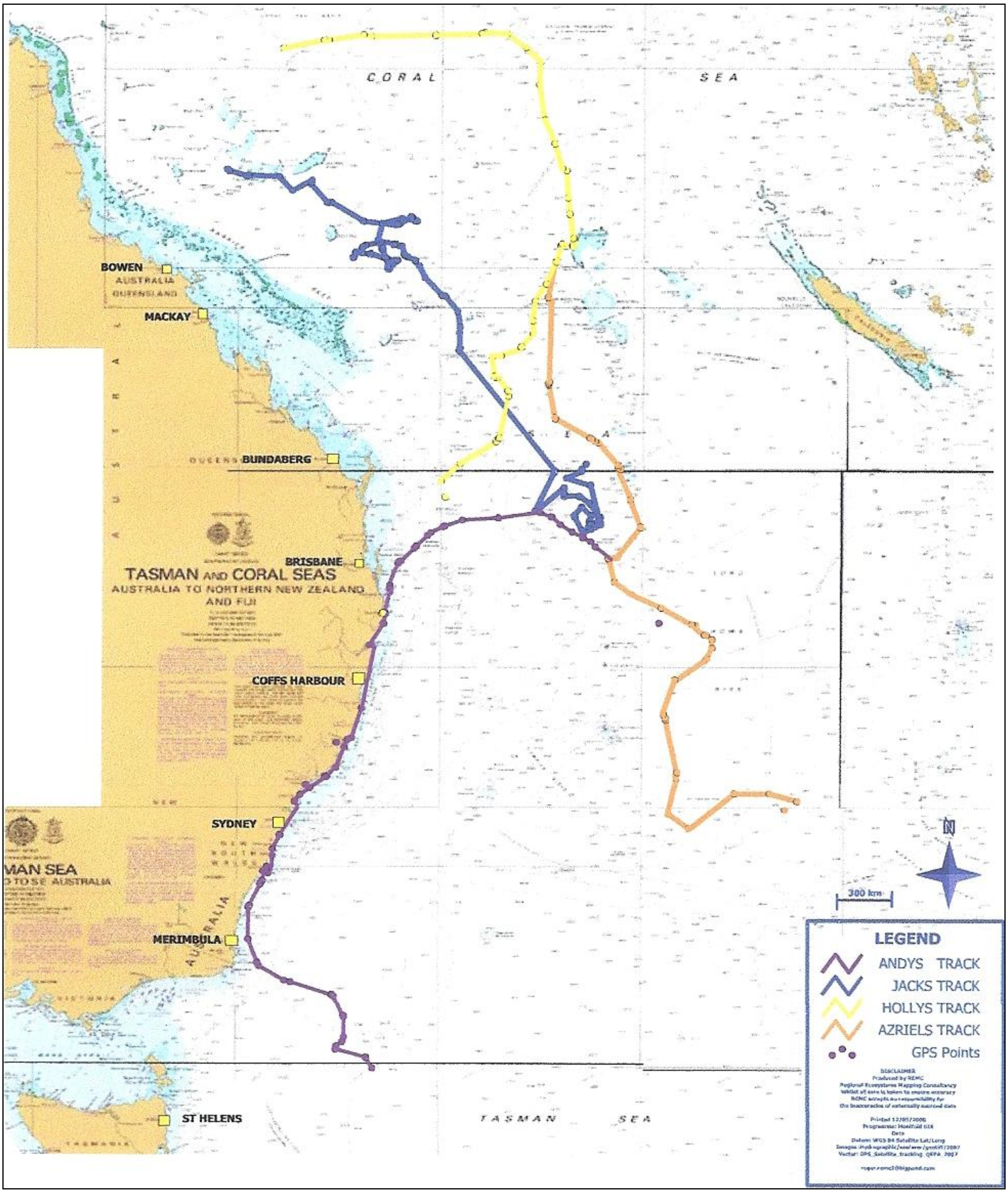

Figure 16 ***Satellite tracks for four ETBF-caught marine turtles*** *(Start of track is near the dot of the same colour – position of capture)*

Dean the Green's progress

Satellite telemetry results for Dean the Green (adult male green turtle, K40464): location of good quality fixes in red. Dates shown on Dean's route are in year/month/day format, i.e. '20020805' is 5 August 2002.

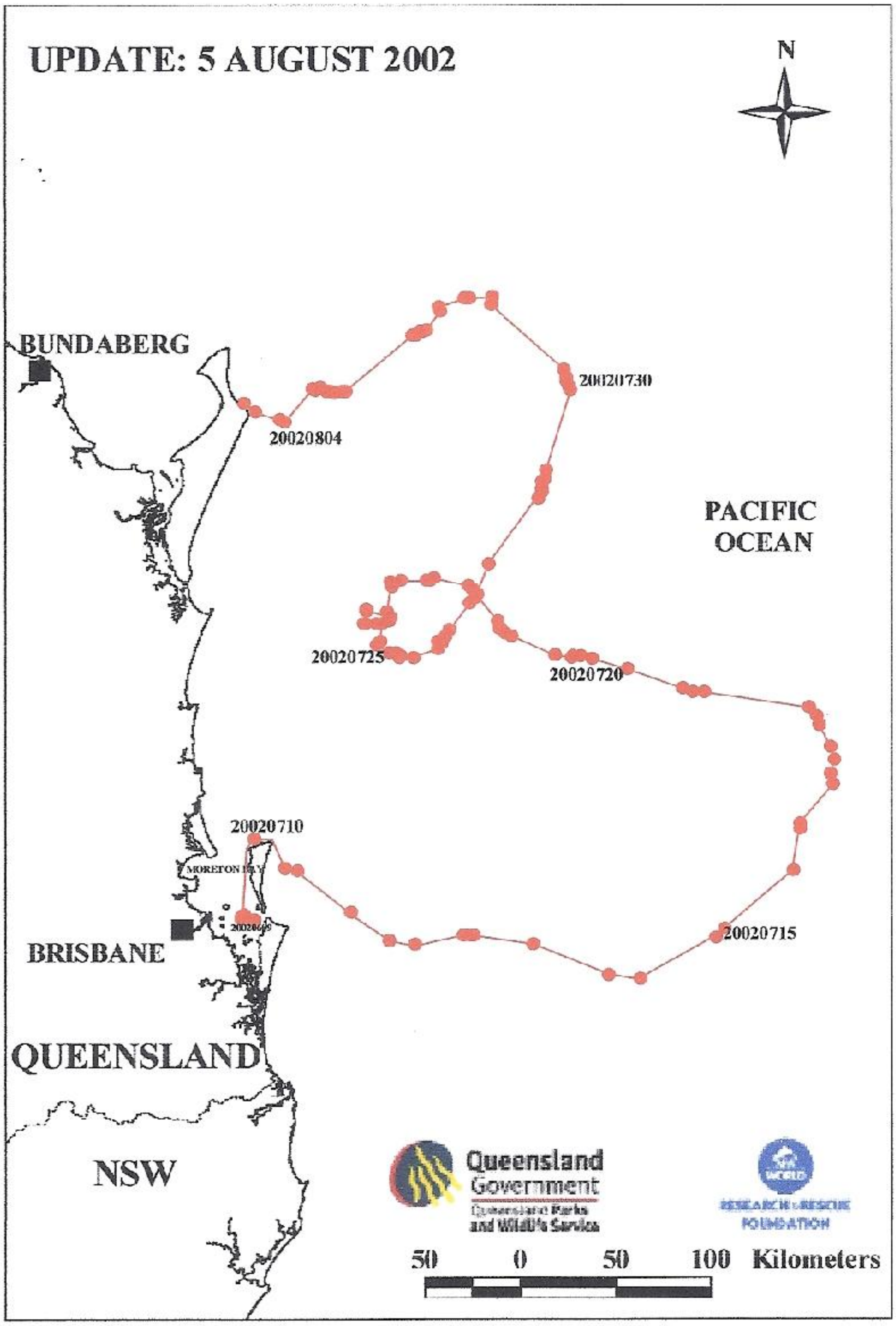

Figure 17 ***Dean the green turtle*** *(Source http://www.derm.qld.gov.au/media/wildlife-ecosystems/wildlife/turtle/turtle.pdf , downloaded 28 November 2010)*

Marine turtle species composition

Both the ETBF and the WTBF overlap with known marine turtle habitats. Each sector of the fisheries, however, is expected to interact with different species proportions and with different abundance levels of each species. One species occurring in Australian waters, the flatback turtle, is not expected to interact with longline fishing operations as they only live within the Australian continental shelf.

A consideration when using logbook reported turtle catch is that species identification is not verified so may be unreliable. It would be reasonable to assume that turtles identified as leatherback turtles are actually leatherback turtles due to their vastly different appearance to the shelled turtles. But turtles not identified at all may also be leatherback turtles. The identifications of the shelled species (green turtles, hawksbill turtles, olive ridley turtles and loggerhead turtles) should be considered as suspect due to non-verification of identifications and lack of fishers that have undertaken formal training and verification in identification skills. Some fishers would have learnt from previous FRDC Programs and some fishers would have been trained by observers but as there is no verification, data remains unreliable.

From 1997 to 2001, 61% of logged (by fishers) turtles were unidentified and 39% were reported to species level. Of all turtles logged, 30% were reported as leatherback turtles, but it could be expected that some of the unidentified turtles would also be leatherback turtles. If only the turtles that are identified are considered for species identification purposes, then the most reliable estimate would be 66% of turtles caught were leatherback turtles (AFMA Logbook Data).

For the years 2002 to 2007, only 22% of logged turtles were not identified, so 78% were reported to species level. 49% of turtles were reported as leatherback turtles, but some unidentified turtles would also be leatherback turtles. So the most reliable estimate from logbooks would be the percentage of leatherback turtles (63%) within the turtles that were identified to the species level (AFMA Logbook Data).

Of interest is the notable increase in fishers attempting to identify their turtle catches to the species level in their logbooks, from 39% (1997 to 2002) to 79% (2002 to 2009). It could be surmised that this change was a result of a general improvement in fisher awareness and desire to 'get it right' for the benefit of the fishery, possibly as a result of training through previous projects and from observers.

Robins *et al.* (2002a) reported using fisher interviews that at least 60% of turtle captures in the ETBF and WTBF were leatherback turtles. The other species included green turtles, loggerhead turtles, olive ridley turtles and hawksbill turtles.

As observers are trained in turtle species identification with photographs to verify their identifications, these data are much more reliable for estimate of species composition. Observer data from 2001 to 2007 report that the species composition was 52% leatherback turtles, 19% green turtles, 16% loggerhead turtles, 8% olive ridley turtles, 3% hawksbill turtles. There were 62 turtles in total but one was not identified by species (AFMA Observer Program) (Figure 18).

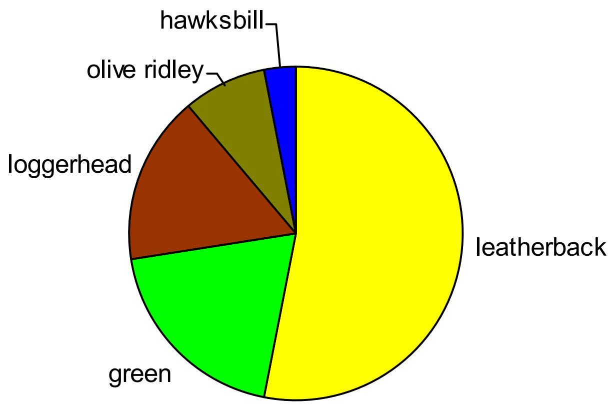

Figure 18 Species composition in the ETBF from AFMA observer data 2001 to 2007

Fisher opinions

“No training done and don’t really know correct procedures except keep on deck with head down for a few hours (told by crew) - want compulsory handling workshops from turtle scientists not AFMA.”

“New to northern area – never seen a turtle but have spoken to other fishers and expect to catch some. Wants to know what to do.”

“No dehookers or line-cutters on board.”

“Only line-cutter on boat – likes it.”

“Want dehooker also for removing hooks for fish but don’t know whether they are broadly available.”

“Variations in quality of circle hooks – have wrecked cheap ones – very off-putting and make me want to not use them.”

“Owners always get info – we don’t always – actual fisher needs to know info about turtles.”

“Permit holder – happy to assist turtle research in any way.”

Factors influencing marine turtle catch

Annual longline effort in the ETBF of 8.82 million hooks in 2009 increased from 8.06 million hooks in 2008, but has fallen from a peak of 12.4 million hooks in 2006. This was as a result of decreasing target species catch rates, the exchange rate between the Australian dollar and United States dollar, operating costs and a reduction in permits as a result of the 2006 restructure (Wilson *et al.* 2010).

The total effort in the WTBF was around half a million hooks in 2009, down from over six million hooks in 2001. Consequently, the total number of marine turtle interactions in the ETBF and WTBF will likely have fallen since the earlier years when effort was higher. The number of turtle interactions, however, may not be linear to fishing effort (so may not decrease in a proportional manner) as not enough is known on the relationship between turtle distribution and fishery distribution.

There have been other operational changes in the ETBF and WTBF that are likely to impact on marine turtle interaction rates. These include an almost fishery-wide switch from tuna hooks and J-hooks to a more turtle-friendly hook, the circle hook. Circle hooks have been shown all over the world to reduce the catch of marine turtles due to the shape and features of the hook. It is impractical in the ETBF or WTBF to scientifically test the impact of circle hooks on marine turtle interactions due to the rare nature of turtle captures in these fisheries. Reported positives of using circle hooks include:

- A reduction in external hooking events. This is due to the space between the barb and the shank of a circle hook being narrower than a similar sized tuna or J-hook. So there is less chance for a part of the marine turtle's body slipping into the hook and the turtle becoming externally hooked.
- A reduction in serious injury to a turtle, such as deep oesophageal or stomach hooking, during an interaction event. If a circle hook is swallowed it will tend to not engage as it is pulled from the stomach into the mouth of the animal. Unlike a tuna or J-hook which often gut or deep-hooks an animal, the circle hook will tend to hook on the edge of the mouth. Hooks are easier to remove safely and turtles are not considered likely to die as a result of this type of hooking event.
- It is believed the rate of turtle hooking will be reduced due to the width of the hook compared with the width of the turtle mouth.

In recent years many fishers of the ETBF have changed their fishing operations to sometimes target albacore rather than broadbill swordfish. This is primarily as a result of a management decision to steer away from swordfish due to stock concerns. Changes to gear included setting hooks much deeper, not using light-sticks and changing to circle hooks. A likely side-effect of these changes considering research results elsewhere in the world is a reduction in the likelihood of interacting with marine turtles.

2 Management and mitigation measures in legislation

Various documents and reports record information on the mitigation measures that are currently in place in the NPF, ECTF, ETBF and WTBF. These include Management Plans, Mitigation Plans, Bycatch Workplans, Ecological Risk Assessments, and obligations under international agreements. Each piece of legislation or report is reviewed below and relevant sections from the documents are boxed. Appendix 4 contains more complete copies of the documents.

Northern Prawn Fishery

Gear Directive (NPF Directives No 133)

Since 15 April 2000, the NPF has had a gear restriction that requires the use of an authorised TED. The definition of a TED used in the Gear Directive is comprehensive and as such has been successfully accepted by the NPF industry for a number of years. The Gear Directive (NPF Directives No 133) is documented in Appendix 4.

Ecological Risk Management Report (AFMA 2009b)

The two actions, below, relevant to marine turtles have already been adopted by the NPF industry for some time and have shown to be effective, as such no additional actions are suggested.

The Ecological Risk Management Report for the Northern Prawn Fishery (AFMA 2009b) notes that turtle mitigation has been successfully addressed in the NPF with the adoption of TEDs in 2000. Two actions relevant to marine turtles are listed, these are: - Operators to continue to report all interactions with Threatened, Endangered, Protected (TEP) species to AFMA. (AFMA to report all interactions to DEWHA); - All operators to adhere to current BRD and TED requirements, and continue to minimise interactions with all TEP species.

Bycatch and Discarding Workplan

The 'Northern Prawn Fishery Bycatch and Discarding Workplan 1 July 2009 – 30 June 2011' lists the following objectives to address the NPF bycatch and discarding issues (AFMA 2009a).

The objectives are reasonable for all TEP species and there is no evidence to reject the assumption that marine turtles are already covered through the adoption of TEDs. No additional turtle-specific actions need to be considered.

1. Respond to key high risk species and take steps to increase the knowledge of all high risk species and their interactions with the fishery. 2. Develop a longer-term response plan for all remaining high risk species based on scientific advice. 3. Develop measures to further reduce TEP interactions. 4. Develop and implement cost-effective strategies to pursue continual improvement in bycatch-reduction.

5. Assess relative changes in bycatch due to bycatch mitigation and target species management measures.

6. Provide six monthly progress reports to the Environment Committee, complete an annual review of the workplan and biannually renew the workplan.

The Workplan, however, notes that 'one group being sea turtles is already effectively addressed through TEDs' (AFMA, 2009a, p 12).

2010 Northern Prawn Fishery Operational Information (turtle relevant parts listed in Appendix 4)

While the Operational Information is comprehensive, it does not include turtle handling and release procedures that should be adopted when a turtle is landed on the deck. Although turtle catches are no longer common, it is still important to maximize a turtle's chance of survival and to minimize the risk of injury to the animal and the crew. This is especially relevant as marine turtles are still being caught, although in significantly lower numbers than before TEDs were adopted. New crew members may not be aware of the handling and release techniques that were routinely adopted by the fishers when they were still interacting with a substantial number of turtles.

As outlined in the Operational Information, fishers of the NPF can apply for a scientific permit if they design a TED or BRD that doesn't meet the prescribed specifications, but they believe will improve the efficiency of the devices.

Industry Code of Practice for Responsible Fishing, Northern Prawn Fishery 2004

Information given in the Code of Practice, outlined below, is simple and concise but should include guidelines on turtle handling and release. References to other documents are not adequate when a simple diagram that is already in use throughout the world could be included. As new crew come into the fishery, it is important for the handling and release diagram to be included in induction documents, such as the Code of Practice, that will be read by crew, and not just in reports that have been filed away or thrown out.

Fishers should identify and use gear, technology, and practices which reduce the capture and mortality of bycatch species and benthic impacts. Fishers should communicate on these to other fishers through industry associations and other extension services.

HANDLING AND RELEASING

Where the incidental capture of turtles and sea snakes occur, fishers should observe and implement protocols in accordance with the Commonwealth's Turtle Recovery Plan, the NPF Bycatch Action plan and the AFMA Crew Awareness Program.

East Coast Trawl Fishery

Fisheries Act 1994 Fisheries (East Coast Trawl) Management Plan 1999

The current specifications of a TED in the Fisheries Management Plan are in line with the United States legislation and considered to be appropriately specific and detailed for the ECTF. Sections of the Management Plan are in Appendix 4.

Eastern Tuna and Billfish Fishery

Management Plan 2010

The ETBF Management Plan does not consider marine turtle bycatch except to state that 'all reasonable steps are taken to minimise interactions'.

Part 2 Specific ecosystem requirements

2.1 Ecological risk management plan

(1) As soon as practicable after the commencement day, AFMA will establish an ecological risk management plan for the fishery.

(2) The plan must require action to ensure that:

(a) information is gathered about the impact of the fishery on by-catch species; and

(b) all reasonable steps are taken to minimise interaction with sea birds, marine reptiles, marine mammals and fish of a kind mentioned in sections 15 and 15A of the Act; and

(c) the ecological impacts of fishing operations on habitats in the area of the fishery are minimised and kept at an acceptable level; and

(d) by-catch is reduced to, or kept at, a minimum and below a level that might threaten by-catch species.

(3) AFMA will review the plan from time to time to ensure it remains appropriate for maintaining ecologically viable stocks of the quota species and an ecologically sustainable fishery.

Management Arrangements Booklet 2011 Fishing Season

The ETBF Management Arrangements Booklet 2011 Fishing Season lists reporting guidelines for all protected species.

Bycatch and Discarding Workplan (both ETBF and WTBF)

The 'Australian Tuna and Billfish Longline Fisheries Bycatch and Discarding Workplan November 1, 2008 to October 31, 2010' acknowledges the existence of marine turtle bycatch in these fisheries (AFMA 2008). It notes that while their bycatch is low compared to many other longline fisheries in the world, 'reductions in mortality from all sources is important for the long-term viability of these species' (AFMA 2008 p 6). The proposed action list for 2008 - 2010 relevant (or partly relevant) to marine turtles is:

1. Make the carriage of line-cutters and dehookers compulsory on ATBLF vessels

The carrying of line-cutters and dehookers has been a successful mitigation measure in various fisheries around the world to reduce injury to animals, including the United States longline fisheries. The implementation of this measure in the ETBF is currently under consideration (Trent Timmis AFMA, personal communication 2011).

One issue of concern is the definition of a dehooker and line-cutter, and consequently which tools would be mandatory. There are a number of different dehookers on the market but not all are suitable for longline fishing operations. In 2003 and 2004, fishers of the ETBF trialled various handling and release tools to determine which styles were the most appropriate for their fishing operations. The recommended tools were the ARC 16" Bite-Blocked Dehooker for on-deck dehooking, the ARC 12' Pole Big-Game

Dehooker for in-water dehooking and the NOAA 12’ La Force Line-cutter. These tools are approved by the United States for use in pelagic longline fisheries and must be carried by all of their licensed pelagic longliners.

2. Analysis of the impacts of making circle hooks compulsory in the ATBLF

Ward *et al*. (2009) assessed the performance of circle hooks in the ETBF by comparing the difference between circle hooks (size 14/0) and Japanese tuna hooks. The results indicated that the financial benefits of increased target catches as a result of using circle hooks outweighed the cost of converting to circle hooks. The study didn’t consider any changes in turtle encounters due to the rarity of turtle catches in the ETBF.

An increase in catch rates of some shark species was noted as possibly a concern in the adoption of circle hooks. However, the shark mortality rate may decrease due to the reduction of bite-offs and the possibility of sharks being brought on deck and dehooked before release.

3. Investigate the variance in bycatch composition between ‘deep-set’ and ‘shallow-set’ longline operations

AFFA (2009b) contains an analysis of observed marine turtle interaction rates using shallow-set shots in the ETBF (defined as less than or equal to 10 hooks per basket). It was reported that prior to 2007 all turtles were caught using shallow-set gear; in 2007 and 2008 it was approximately 80% and 40%, respectively. It should be noted, however that the data does not agree with those reported in the Resource Advisory Group Analysis of Observer Data (Dambacher 2005 and 2006). These investigations should continue.

4. Provision of a weather proof bycatch recording device to all ATBLF vessels to provide a convenient facility to record bycatch during hauling operations

It has been decided that the provision of weatherproof bycatch reporting devices would not impact on the bycatch reporting rate so this objective has been cancelled.

5. Develop and implement an education strategy for crew to be made aware of bycatch and discarding obligations

From 2005 to 2007, a FRDC-funded project provided voluntary turtle training to the fishers of the ETBF and WTBF (FRDC 2003/013). In 2009, a seabird education campaign was conducted but marine turtles were not considered. In 2010, some turtle training was provided by AFMA personal and observers (Trent Timmis AFMA, personal communication 2011).

Important components of a successful education campaign are:

- Speakers should have experience in the area of marine turtle mitigation and marine turtle handling and release so correct and up-to-date information can be provided and fishers are installed with a degree of confidence in the information provided.
- The information covered must include turtle biology and conservation status so fishers understand the reasons behind the workshops and the background and also the sensitivity of losing even a small number of individuals from a declining population.
- To maximize attendance workshops should be made compulsory to ensure every vessel has at least one fisher with the correct training and they should be conducted at a venue and time that allows fishers to attend. An issue that would

need to be resolved is that AFMA does not currently accredit or authorise skippers in fisheries.

Ecological Risk Management Report (AFMA 2009c)

This report aligns itself with the Bycatch and Discarding Workplan so comments are as for that document.

The Ecological Risk Management Report for the Eastern Tuna and Billfish Fishery May 2009 (AFMA, 2009c) lists the leatherback turtle (*Dermochelys coriacea*) with a risk score of 'HIGH'. The associated proposed action is that 'all boats in the ETBF were supplied with dehookers and line-cutters in 2005 and as part of the Bycatch and Discarding Workplan these will be made compulsory on boats during 2010 (AFMA, 2009c p 11).

Sea Turtle Mitigation Plan (AFFA 2009 a and b)

The Sea Turtle Mitigation Plan (STMP) was approved by the WCPFC at the Sixth Regular Session (AFFA 2009b). It is currently in operation and data will be examined in 2012 (Trent Timmis AFMA, personal communication 2011).

279. Australia requested WCPFC6's approval of its sea turtle mitigation plan (WCPFC6-2009/IP16) as required under CMM 2008-03, noting that both Scientific Committee and Technical and Compliance Committee had recommended Commission approval of the plan.

280. WCPFC6 approved Australia's sea turtle mitigation plan (WCPFC6-2009/IP16).

The Eastern Tuna and Billfish Sea Turtle Mitigation Plan (AFFA 2009a) and the Revised Draft Eastern Tuna and Billfish Sea Turtle Mitigation Plan (AFFA 2009b) were designed 'to fulfil Australia's obligations under the Western and Central Pacific Fisheries Commission (WCPFC) Conservation and Management Measure (CMM) CMM-2008-03 with regards to the need to implement a plan designed to reduce the interaction rate of turtles in pelagic longline fisheries which target broadbill swordfish' (AFFA 2009a p 1).

The suggested strategy is for the certain actions to take place if trigger limit interaction rates for sea turtle (by species) are reached. The suggested trigger limit for green turtles is 0.0048 interactions per 1000 observed hooks and for leatherback turtles, loggerhead turtles and other species the suggested trigger limit is 0.0040 interactions per 1000 observed hooks. The report notes that these interaction rates were based on historical interaction rates and will be redefined to sustainable levels when information becomes available.

The suggested actions are:

1. If any trigger limit is reached in a year then AFMA will establish a Sea Turtle Mitigation Working Group to determine the measures to be adopted with the intention that the fishery can produce an interaction rate less than the trigger rates; and encouraging industry to adopt best practice to minimize interaction rates; and providing guidance through consultative mechanisms.

2. If the trigger limit is reached the following year, then AFMA will require vessels using the shallow-set pelagic longline fishing method targeting broadbill swordfish to use only whole fish bait and large circle hooks.

3. Finally, if the trigger limit is reached the subsequent year, then AFMA will require all operators to comply with a swordfish limit of 20 unless they are granted an exemption for using whole fish bait and large circle hooks.

The Revised Draft Plan (AFFA 2009b) was only marginally changed from the original TMP (AFFA 2009a). Corrections were made to tables and shallow-setting versus deep-setting was defined. Shallow setting was defined as 'any shot set to target fish at a depth of less than 100m; generally this could be defined as a set with less than or equal to 10 hooks per basket' (AFFA 2009b Appendix A p 4).

Review of the STMP

The observed interaction rates 2003 - 2008 (AFFA 2009b Table 2) noted in the Plan do not agree with available observer data to 2007 or with data reported in the data summaries to 2006/2007. These data should be checked before determining trigger limits and also to ascertain when the trigger has been reached by the fishery.

The 2009 trigger point for each group (leatherback turtles, green turtles, loggerhead turtles, and other species) would have been three turtles from either group if trigger limits are rounded up. These trigger limits are not correct given the reasoning documented in the STMP.

AFMA reports that the observer database has been reviewed and verified and so inconsistencies can be corrected (Trent Timmis AFMA, personal communication 2011).

Additional comments on this plan are:

First year

While these three actions are appropriate, all should be put into place now and not wait until the trigger point is reached.

- A Sea Turtle Mitigation Working Group (STMWG) should be established. To begin to establish a group, conducting meetings and deciding on a strategy after a trigger limit is reached, will leave the fishery in limbo for a length of time. Membership of this group has not been defined in the report, but should consist of scientists working in areas of turtle mitigation, fishers and observers with a specific interest in turtles, and management officers.
- Industry should be made aware of best practice to minimize interactions and to minimize mortality through correct handling and release procedures. Workshops were conducted from 2005 to 2007 and a DVD was produced through a FRDC-funded project (Robins *et al*. 2007). Each season the crews change significantly, so it is now appropriate that handling and release workshops are conducted regularly. Robins *et al*. 2007 demonstrated that if these workshops are to be well attended they should be made compulsory and conducted by bycatch mitigation experts with experience in turtle handling and release techniques, as it is with endangered species interactions and pelagic longline fisheries in the United States.

- The information needs to get to the actual fisher who is dealing with the animals. If guidance is to be provided through consultative mechanisms, then there must be certainty that information is actually getting to the fishers themselves.

Second and third years

It may be appropriate for these comments be considered by the STMWG.

- There is no information on how management officers will ensure compliance in monitoring the number of hooks being set per basket as a proxy for the depth the gear is fishing.
- The suggested methodology that less than or equal to 10 hooks per basket will result in all hooks fishing above 100m can be considered debatable. Other factors such as length of the float rope, environmental conditions (currents, wind and sea state) and the weight on the mainline may also impact on fishing depth.
- The impact of the manadatory use of 'whole finfish' baits needs to be examined. Squid remains one of the most popular baits of choice and many fishers believe that the routine adoption of whole finfish bait may have a significant negative impact on their target fish catch and subsequently their profitability (Steve Hall AFMA, personal communication 2010). A further issue may be increasing the risk to other bycatch species, such as seabirds, when using whole finfish bait. Sandmar, a whole finfish bait, and live-bait may potentially pose an increased risk to seabirds as a result of the bait possibly sinking slower. Another possible issue is the commercial availability of whole fish bait if many, or most, ETBF operations are using these baits and also the possible increase in resource conflicts if the harvesting of live-bait increases.
- The definition of what constitutes a 'large' circle hook needs to be determined. By 2010, a very high proportion of the fleet has already adopted circle hooks, but the large circle hooks adopted by the United States (16/0 and 18/0) is not common in the ETBF. Some research results from Central America imply that smaller circle hooks may also effective in reducing marine turtle bycatch.
- If trigger points are to be by species it is vital for photographs to be taken of every turtle that interacts with the gear. Even a blurry head shot in the water may be enough for a qualified person to use to determine the species of the animal.
- The listed trigger rates of 0.0048 interactions per 1000 observed hooks for green turtles, 0.0040 interactions per 1000 observed hooks for leatherback turtles, loggerhead turtles, and other species – equates to (using 2009 statistics of 8.82 million hooks and an observer coverage of 6.4% of 564,408 hooks) an observed catch rate of three turtles per group. The appropriateness of a trigger point as low as this needs to be carefully assessed considering the error rates surrounding the low observer coverage. These trigger rates are based on possibly incorrect observer data and will change if different observer data is applied to the formula.
- It is possible that a situation may occur where the trigger limit is reached but a majority are caught using what has been defined as 'deep-set' gear. For example – if the trigger is met and all turtles caught in that year are caught using deep-setting – what is the management reaction and are the shallow-set fishers (who didn't catch the turtles) still penalised? AFMA (2009b) documents that in 2008 approximately 60% of turtles (5 out of 8 turtles) were caught in what has been defined as deep-setting.

Western Tuna and Billfish Fishery

Management Arrangements Booklet 2010

The WTBF Management Arrangements Booklet 2010 mentions that marine turtles are one of the species monitored during the WTBF observer program (which has an objective of 5% coverage) and that turtles are one of the most common protected species encountered in the WTBF.

Western Tuna and Billfish Fishery Management Plan 2005 (Appendix 4)

The Management Plan does not deal with marine turtles specifically, but does cover legislation on bycatch and specific ecosystem requirements. These include the preparation and implementation of a bycatch action plan to be reviewed every second year.

Bycatch and Discarding Workplan (both ETBF and WTBF)

This workplan has already been assessed in the ETBF section (page 42).

Ecological Risk Management March 2010

The Ecological Risk Assessment (ERA) was designed to assess and rate the ecological effects of fishing in Commonwealth waters. All six species of marine turtles were assessed as 'medium risk score' and so all reasonable steps will be taken to minimize interactions with these species.

IOTC obligations

Australia has been a member of the Indian Ocean Tuna Commission (IOTC) since 1996 and is obliged to work by the management measures defined by the IOTC, under resolutions adopted by the IOTC. The data requirements on Sea Turtles (source: IOTC 2010a) are:

Sea turtles IOTC Resolution 09/06: On Marine Turtles (Full Resolution in Appendix 4) IOTC Resolution 10/02: Mandatory statistical requirements for IOTC Members and Cooperating Non-Contracting Parties (CPCs)	Paragraph 2: CPCs shall collect (including through logbooks and observer programs) and provide to the Scientific Committee all data on their vessel's interactions with marine turtles in fisheries targeting the species covered by the IOTC Agreement. CPCs shall also furnish available information to the Scientific Committee on successful mitigation measures and other impacts on marine turtles in the IOTC Area, such as the deterioration of nesting sites and swallowing of marine debris. Paragraph 3: The provisions, applicable to tuna and tuna-like species, shall also be applicable to the most commonly caught shark species and, where possible, to the less common shark species. CPCs are also encouraged to record and provide data on species other than sharks and tuna taken as bycatch.

3 Mortality estimates, global distribution and movement patterns

Estimates of mortality

Northern Prawn Fishery

An early study on marine turtles in the NPF (Poiner *et al*. 1990), using data from various research surveys (1979 - 1988), estimated that 344±125 of the captured turtles may have died as a result of interactions.

Poiner and Harris (1996) estimated that between 5000 and 6000 marine turtles were incidentally caught from August to November each year (i.e. during the tiger prawn season) and of these 39% (approximately 2000) may have died as a result. That percentage was comprised of 14% death by drowning and 25% with injuries or predicted to die from being returned to the water in a comatose state.

The later study by Robins *et al*. (2002b) estimated mortality pre-TEDs to be around 22%. This lower mortality rate is assumed to be as a result of improved handling techniques, primarily keeping comatose turtles on deck in a recovery position until responsive. Compared with earlier notions that to get them back into the water as quickly as possible would improve their survival chances.

The mortality rate could not be estimated from the post-TED part of this study due to the small number of turtles reported as being caught in nets fitted with TEDs. These would be small turtles that can fit through the grid of the TED or animals that were caught as the trawl net was being winched on-board and so had little chance of mortality due to the short time they would be in the gear.

East Coast Trawl Fishery

Pre-TED levels of marine turtle bycatch, as estimated from the entire 1991 to 1996 STBMP, were approximately 5900 encounters annually with from 1.3% (around 60 turtles) to 5.7% (around 320 turtles) for observed direct mortality and observed potential mortality (comatose animals), respectively. In total (direct and comatose), an estimated 150 loggerhead turtles, 100 green turtles, 40 flatback turtles, 10 olive ridley turtles and 10 hawksbill turtles potentially died as a result of an interaction during ECTF operations. The low mortality rates, compared to the NPF, were predicted to be due to the short trawl times in the fishery of less than 80 minutes (Robins 2002).

An extensive study of the impact of bycatch reduction devices in the ECTF began in 2000 (Courtney *et al.* 2007). Such a small number of turtles were caught during the project that estimates were not made for turtle catch or mortality rates.

In 2009, there were three interactions with marine turtles reported in ECTF logbooks, all were released alive (Queensland Government 2010a).

Eastern Tuna and Billfish Fishery and Western Tuna and Billfish Fishery

Mortality rates in the ETBF and WTBF are predicted to be very low (Robins *et al.* 2002a). Both fishers in their logbooks and observers in their reports note few deaths as a result of the interaction event. A high proportion of leatherback turtles are released alive and healthy following entanglement (the way this species is usually caught) and few shelled turtles are landed dead or with serious injuries. Observer records from the ETBF from 2001 to 2007 show that one turtle died, eight were sluggish and 53 were returned to the water alive and vigorous (AFMA Observer Program). Additionally, the use of line-cutters and dehookers would have resulted in fewer animals leaving the vessel injured and/or carrying hooks or line.

Generalised global distributions

The global distribution for each species of marine turtle is in Figures 19 to 25. These distribution maps were sourced from www.wikipedia.org and although useful in a general sense, cannot be assumed to be accurate to a fine scale including location or importance of nesting grounds.

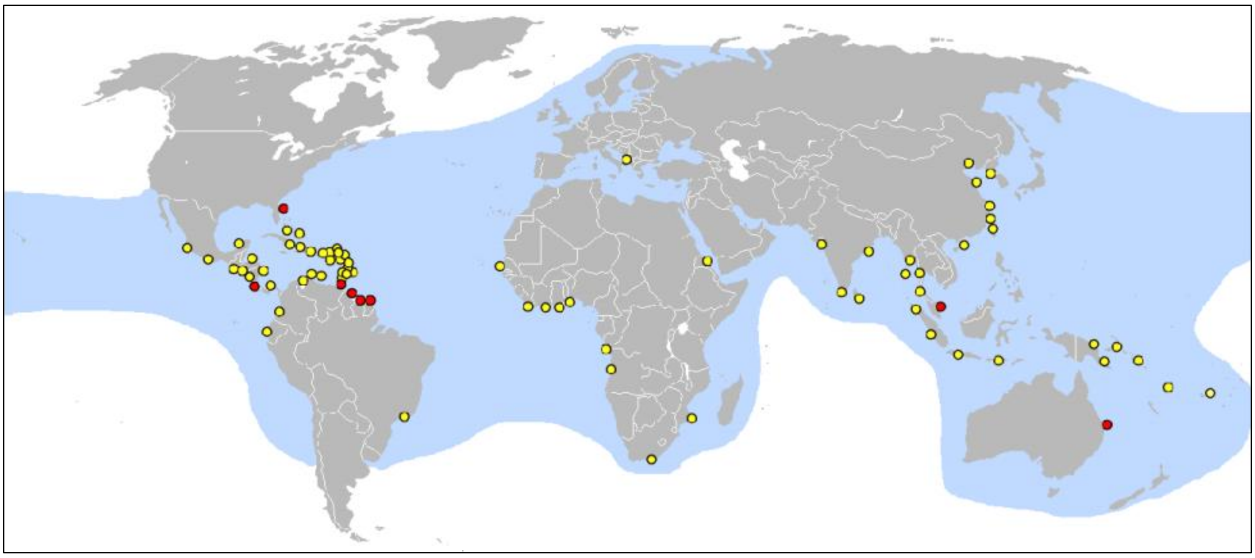

Figure 19 ***General global distribution of the leatherback turtle*** *(major nesting grounds in red, minor nesting grounds in yellow)*

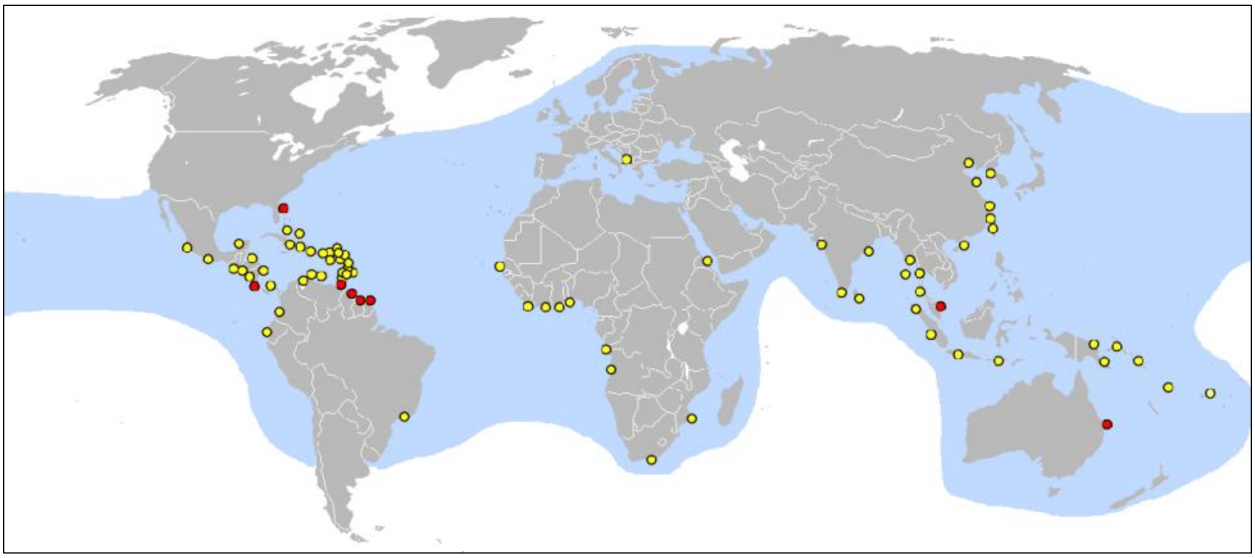

Figure 20 ***General global distribution of the hawksbill turtle*** *(major nesting grounds in red, minor nesting grounds in yellow)*

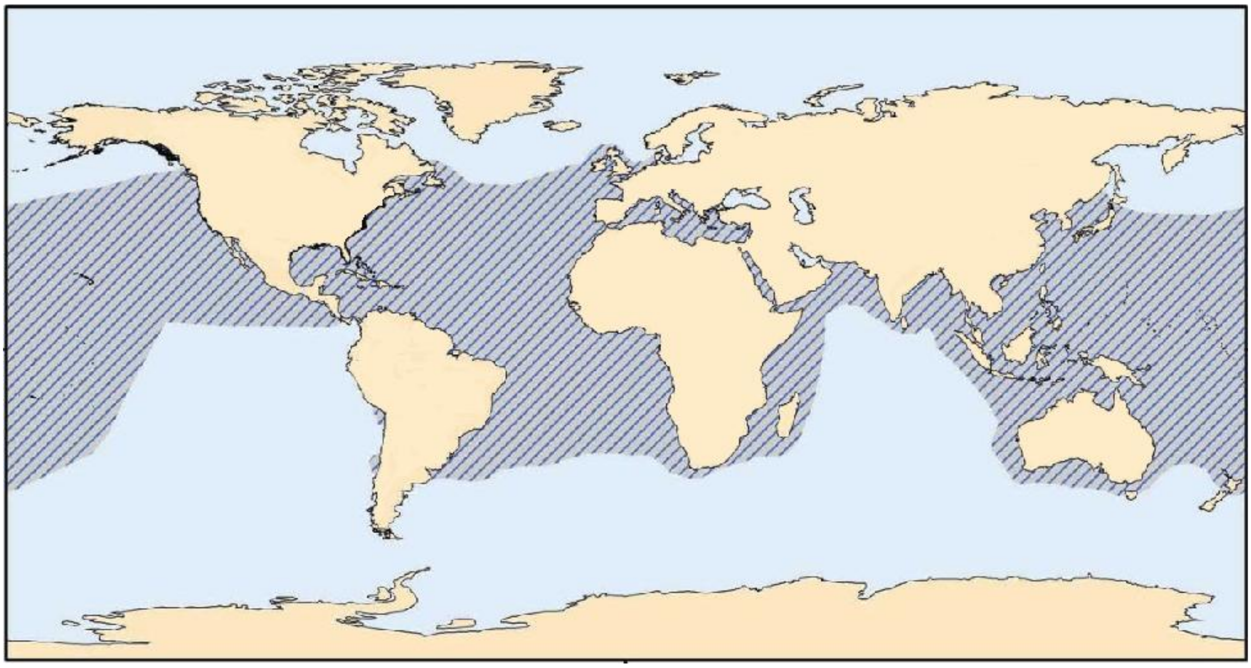

Figure 21 General global distribution of the loggerhead turtle

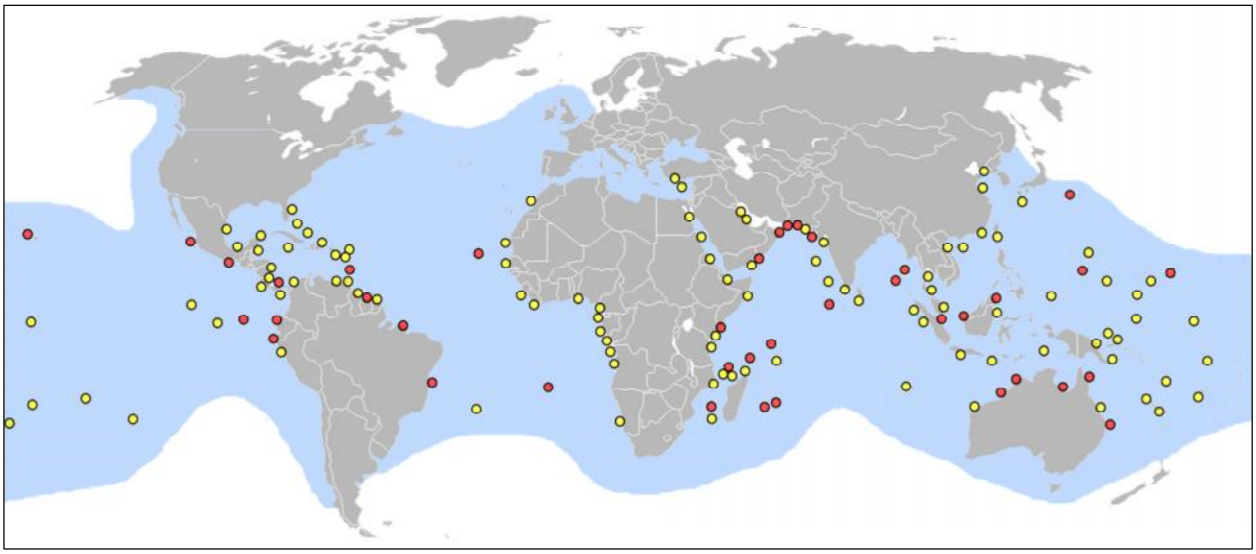

Figure 22 General global distribution of the green turtle *(major nesting grounds in red, minor nesting grounds in yellow)*

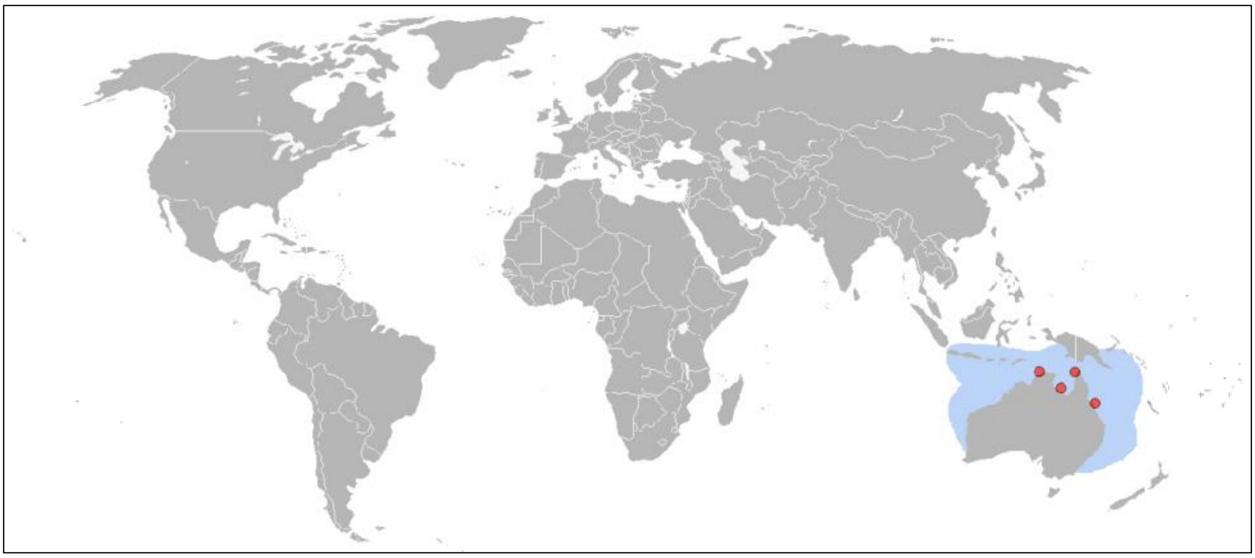

Figure 23 ***General global distribution of the flatback turtle*** *(major nesting grounds in red)*

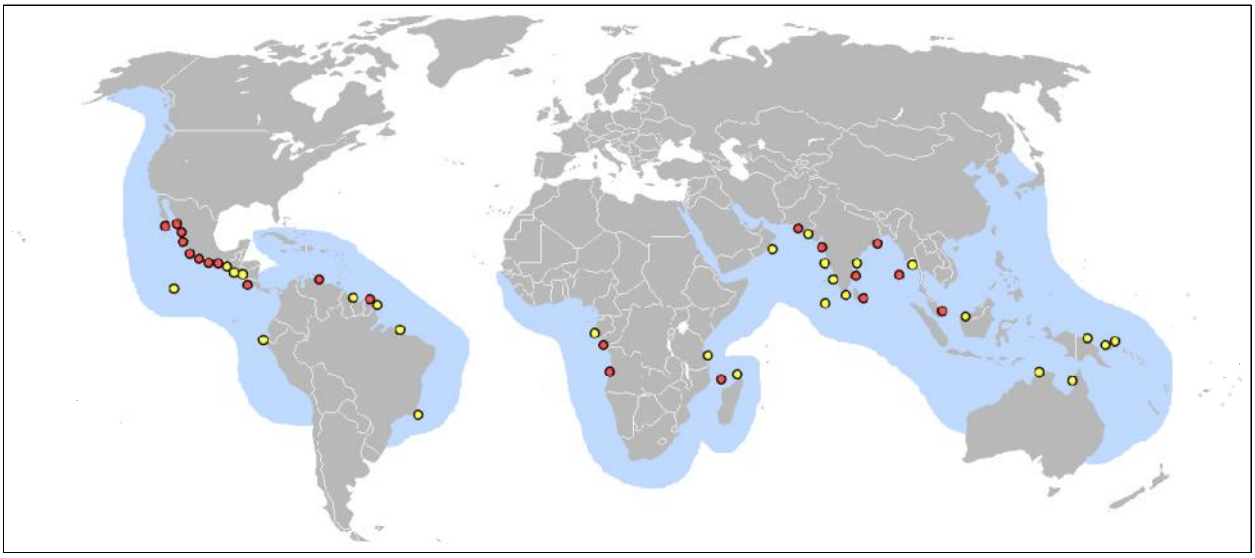

Figure 24 ***General global distribution of the olive ridley turtle*** *(major nesting grounds in red, minor nesting grounds in yellow)*

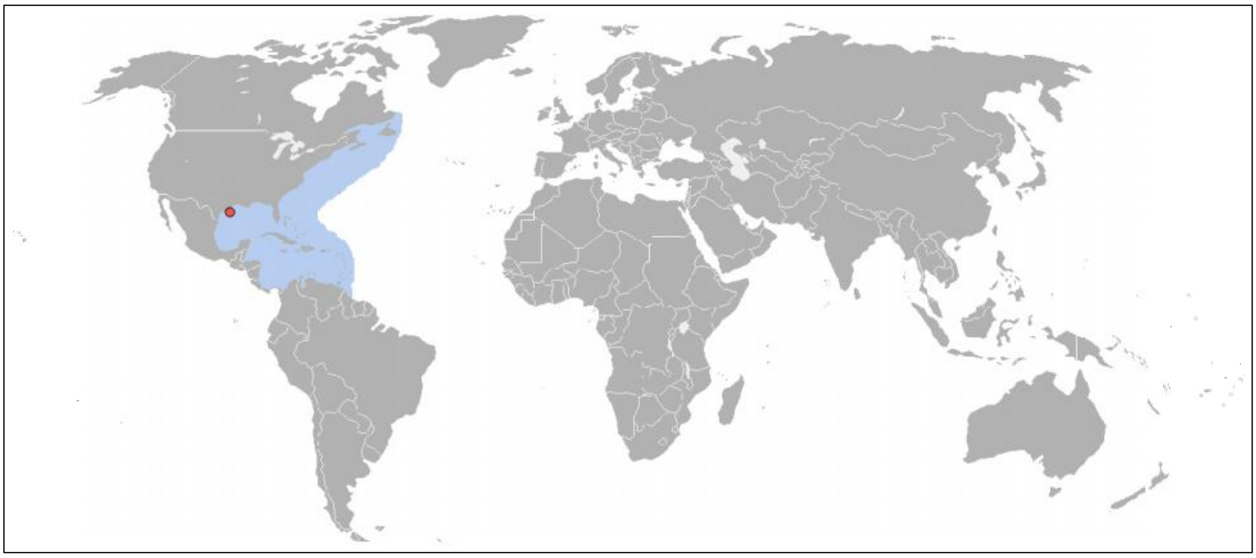

Figure 25 General global distribution of the Kemp's ridley *(major nesting grounds red)*

Australian distribution and movement patterns

Leatherback turtle

Leatherback turtles are distributed in tropical and temperate waters worldwide. They forage in the waters around Australia, across the Top End, down the western and eastern coastlines, and across the southern areas (Figure 26). There have been unverified sightings by fishers as far south as the Antarctic Confluence (David Kreutz, personal communication 15 November 2010). A small amount of nesting activity has been confirmed on Australian beaches, but it is assumed that most of the animals migrating through Australian waters would have come from beaches in neighbouring countries to the north or from further a field in the Americas or India (Limpus 2009).

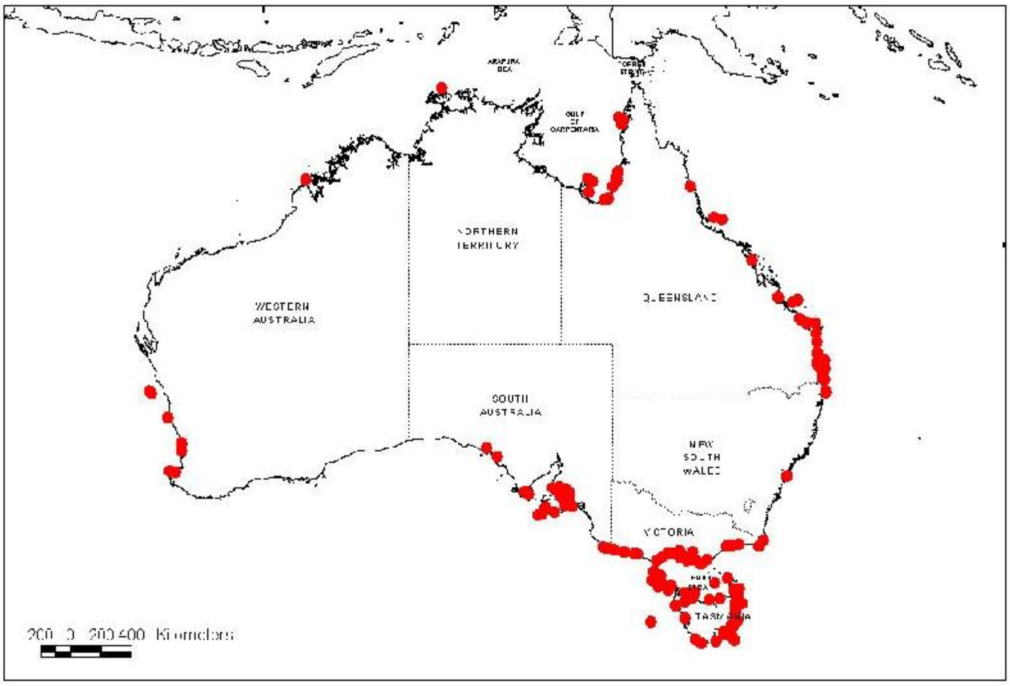

Figure 26 Distribution of non-nesting records of leatherback turtles in Australian waters *(Limpus 2009)*

Hawksbill turtle

Hawksbill turtles have a worldwide circumtropical and subtropical distribution (Figure 27). There is evidence of limited interbreeding between the populations that breed in northeastern and Western Australia and also that the Australian populations are genetically separate from populations further north. Within the Indian Ocean – Western Pacific Ocean region, Australia supports the largest remaining stocks of breeding hawksbill turtles (Limpus 2009).

Significant numbers of hawksbill turtles nest on rookeries in the Torres Strait and far northern Queensland beaches (Cape York and the Great Barrier Reef) with the Queensland population possibly being one of the largest nesting populations of hawksbill turtles in the world. There are numerous rookeries in northeastern Arnhem Land including around the Groote Island area (Limpus 2009).

Hawksbill turtles are highly migratory, often undertaking long breeding migrations. Animals from northern Australian rookeries, for example, have been shown to scatter widely into foraging grounds, possibly into Indonesian waters where they contribute to the high number of harvested hawksbill turtles (Limpus 2009).

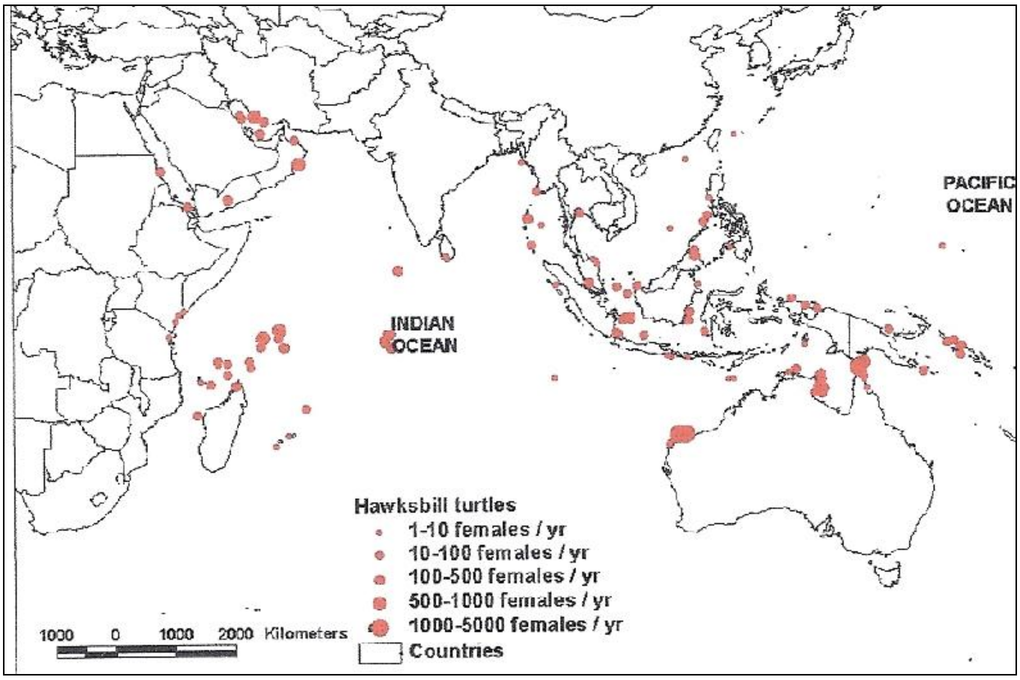

Figure 27. Distribution of hawksbill turtle nesting beaches in the Indian Ocean and Western Pacific Ocean *(Limpus 2009).*

Loggerhead turtle

Loggerhead turtles have a worldwide distribution in tropical to sub-tropical waters (Figure 28). The major breeding aggregations in the South Pacific Ocean are found in the southern Great Barrier Reef mainland (Mon Repos and neighbouring beaches of the Woongarra Coast and Wreck Rock Beach). Also on the 13 islands of the Capricorn-Bunker Groups of the southern Great Barrier Reef. Less significant nesting beaches occur from Bustard Head to the Sunshine Coast and on Fraser, Moreton and North Stradbroke Islands and on the islands of the Swain Reefs and at Bushy Island off Mackay. Isolated nesting occurs as far south as the beaches of New South Wales (Limpus 2009).

Nesting occurs in Western Australia at Muiro Islands, Ningaloo Coast south to about Carnarvon and islands near Shark Bay, including Dirk Hartog Island. Sporadic nesting also occurs over a wider area (Limpus 2009).

Loggerhead turtles show a high degree of faithfulness between their feeding and breeding grounds, returning to the same general area for each breeding migration. Turtles nesting at a rookery come from many feeding grounds, and turtles at a feeding ground will disperse to many different rookeries. The distance travelled during the breeding migration has been recorded to be as far as 2600km but most are less than 1000km (Limpus 2009).

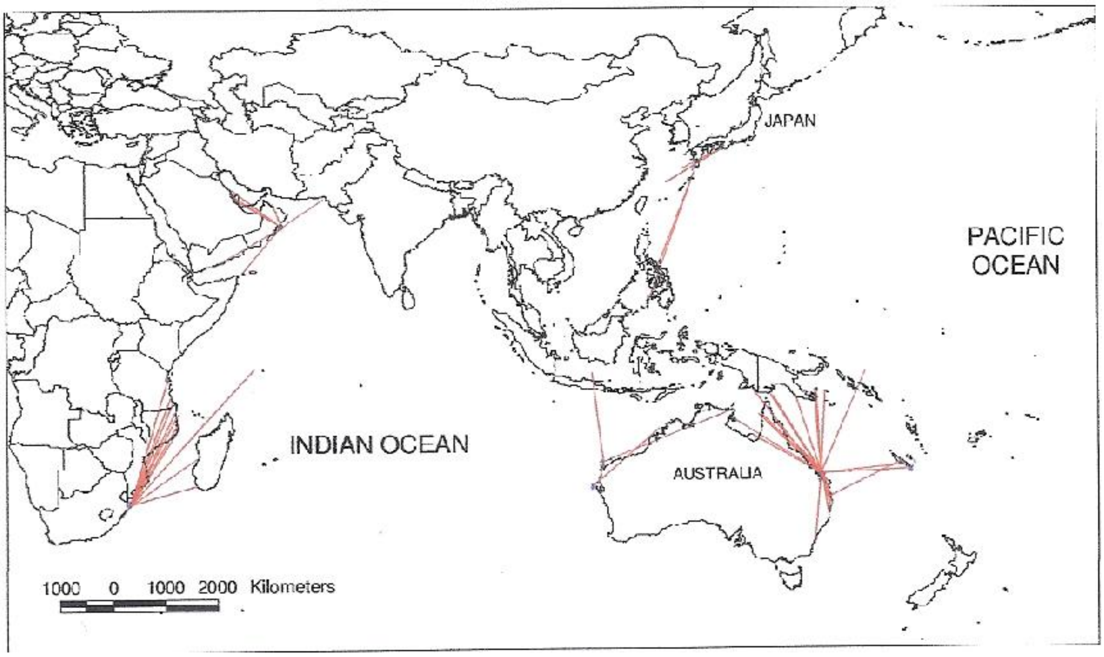

Figure 28 ***Post-nesting dispersal of loggerhead turtles from Indian Ocean - Western Pacific Ocean rookeries to their respective foraging areas.*** *Lines have been used to denote end points, not migration pathways (Limpus 2009)*

Green turtle

Green turtles have a worldwide tropical and subtropical distribution. Several Australian stocks have been shown to be genetically diverse, but although they have different breeding distributions, turtles from the various Australian stocks can occupy the same feeding grounds. These feeding grounds can also contain green turtles from other breeding units with their rookeries possibly in neighbouring countries (Limpus 2009).

In Queensland, major breeding aggregations occur on the islands of the Capricorn Bunker Groups of the southern GBR: Northwest, Wreck, Hoskyn, Tryon, Heron, Lady Musgrave, Masthead, Erskine, Fairfax, North Reef, and Wilson Islands. Minor breeding aggregations occur at Bushy Island, the Percy Islands, Bell Cay, Lady Elliott Island, the mainland coast from Bustard Head to Bundaberg and the northern part of Fraser Island (Figure 29). Some turtles also nest on other beaches within this general area (Limpus 2009).

The green turtles of the Gulf of Carpentaria represent a geologically very recent colonisation with breeding having been established in only the last few thousand years. The population aggregates for breeding at rookeries across the southern and western

Gulf. A small number of green turtles nest in northern and western Arnhem Land and the adjacent islands (Limpus 2009).

Western Australia green turtles nest on beaches from the Ningaloo Coast to the Lacepede Islands. This is one of the largest green turtle populations remaining in the world and appears to be the largest for the Indian Ocean. The principal rookeries include Lacepede Islands, Monte Bello Islands, Barrow Island, North West Cape and Browse Island. Many smaller rookeries also occur in Western Australia (Limpus 2009).

Post-hatchlings are believed to live a long pelagic lifestyle feeding on macro zooplankton before migrating to their feeding habitat in coastal waters from the age of five to ten years. When adult they will begin their breeding migration. The adult green turtles migrate vast distances from their foraging grounds to their traditional breeding areas but follow no set route. While the average distance traveled for the breeding migration is less than 1000km, green turtles have been tracked as far as 2600km. Animals nesting at a rookery can come from different feeding areas and animals living on a feeding ground come from many different rookeries (Limpus 2009).

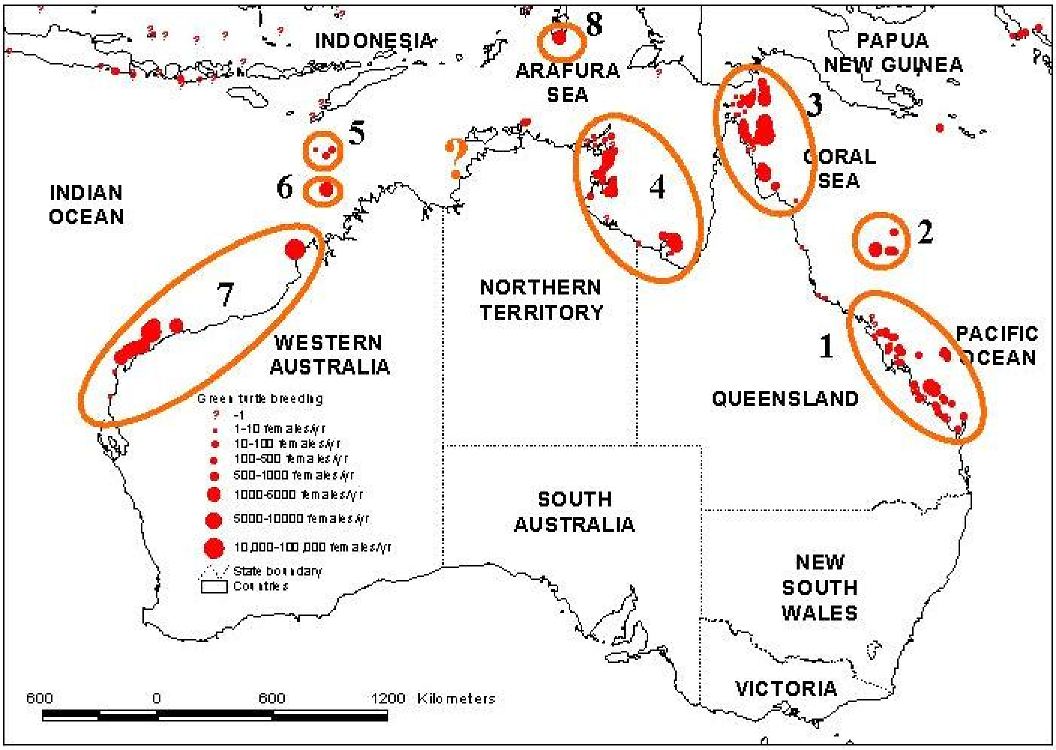

Figure 29 ***Genetically identifiable Australian breeding green turtle stocks****. 1=southern GBR; 2=Coral Sea; 3=northern GBR; 4=Gulf of Carpentaria; 5=Ashmore Reefs; 6=Scott Reef;7=Northwest Shelf. The Indonesian breeding stock at Aru Islands (8) is another stock in the region. ? denotes where nesting populations have yet to be assessed for genetic stock (Limpus 2009).*

Flatback turtle

The flatback turtle is endemic to the Australian continental shelf, but forages as far north as the Gulf of Papua and the coastal waters of Papua. All known rookeries are on Australian beaches including in Queensland, Northern Territory and Western Australia (Figure 30). Major eastern Australian breeding aggregations occur on the continental islands in inshore areas of the southern Great Barrier Reef at Peak, Wild Duck, Avoid and Curtis Islands. Some nesting occurs on the mainland coast and adjacent continental islands north from Mon Repos to Herald Island near Townsville (Limpus 2009).

Significant flatback turtle nesting occurs in the north-eastern Gulf of Carpentaria and western Torres Strait where the major rookeries include Crab Island, Deliverance Island and Kerr Island. There are other smaller breeding aggregations along the mainland coast south of the Jardine River mouth along western Cape York Peninsula to south of Weipa (Limpus 2009).

Nesting beaches in Western Australia are on the Coburg Peninsula and adjacent islands including the McCluer group of islands, Field Island, Green Turtlehill Island, Quail and Bare Sand Islands (Limpus 2009).

It is believed that flatback turtles do not follow a common migration route between foraging grounds and rookeries with each adult migrating to the same rookery each breeding cycle over distances in excess of 1300km. There is no evidence that flatback turtles have a post-hatchling pelagic oceanographic phase, as for other shelled turtles. They have been regularly seen in waters inside the Great Barrier Reef, throughout the Gulf of Carpentaria and southern Arafura Sea, and coastal waters of Western Australia (Limpus 2009).

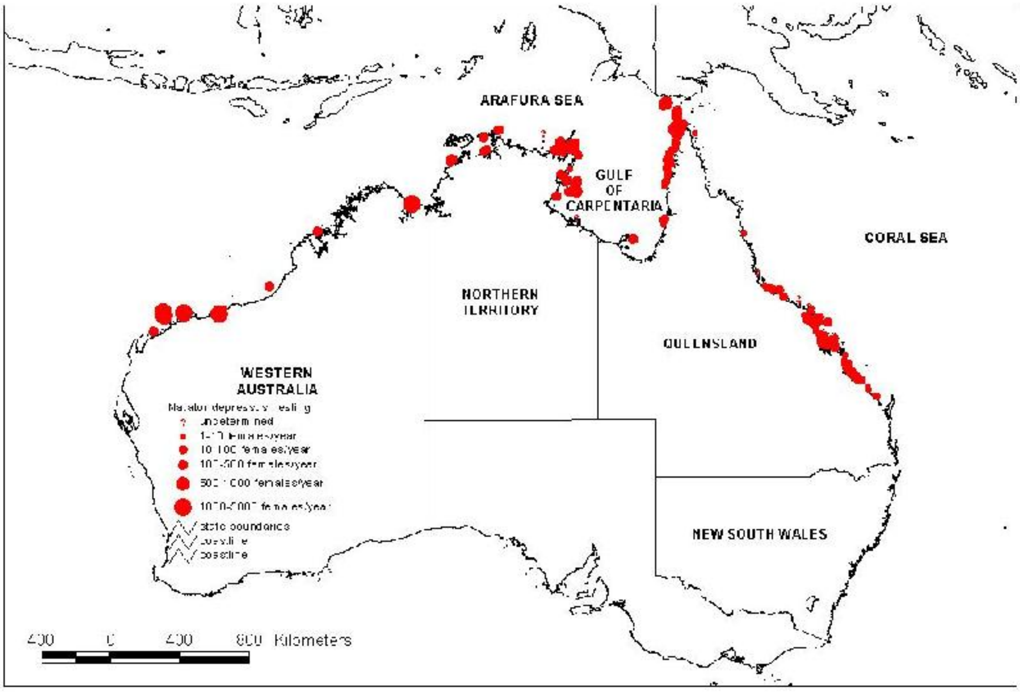

Figure 30 ***Distribution of flatback turtle nesting beaches****. The data are incomplete for the western part of Arnhem Land and Western Australia (Limpus 2009)*

Olive ridley turtle

There are two species within the genus Lepidochelys: Olive ridley turtles are distributed worldwide and Kemps ridley turtles occur in the Gulf of Mexico and north Atlantic basin. In the past, Olive ridley turtles nested in huge numbers, but the only remaining large nesting populations with over 100,000 nesting females annually are in Orissa, India and the eastern Pacific coast of Central America in Mexico and Costa Rica. This species is well known for their high density synchronised breeding aggregations, called arribadas (Limpus 2009).

The Australian Olive ridley turtle nesting distribution and population size remains unknown but it is believed to be the largest breeding population remaining in the Southeast Asia – Western Pacific region (Figure 31).There is no evidence that arribadas ever occurred in Australia. Rookeries in the Northern Territory include islands along the Arnhem coast, in the west and in eastern Arnhem Land. There is also low-density nesting along the northwestern coast of Cape York Peninsula, but there are no records of olive ridley turtles nesting on the east or west coasts of Australia (Limpus 2009).

In other parts of the world olive ridley turtles are known to make long distance breeding migrations and there is some evidence that the same applies in Australian waters.

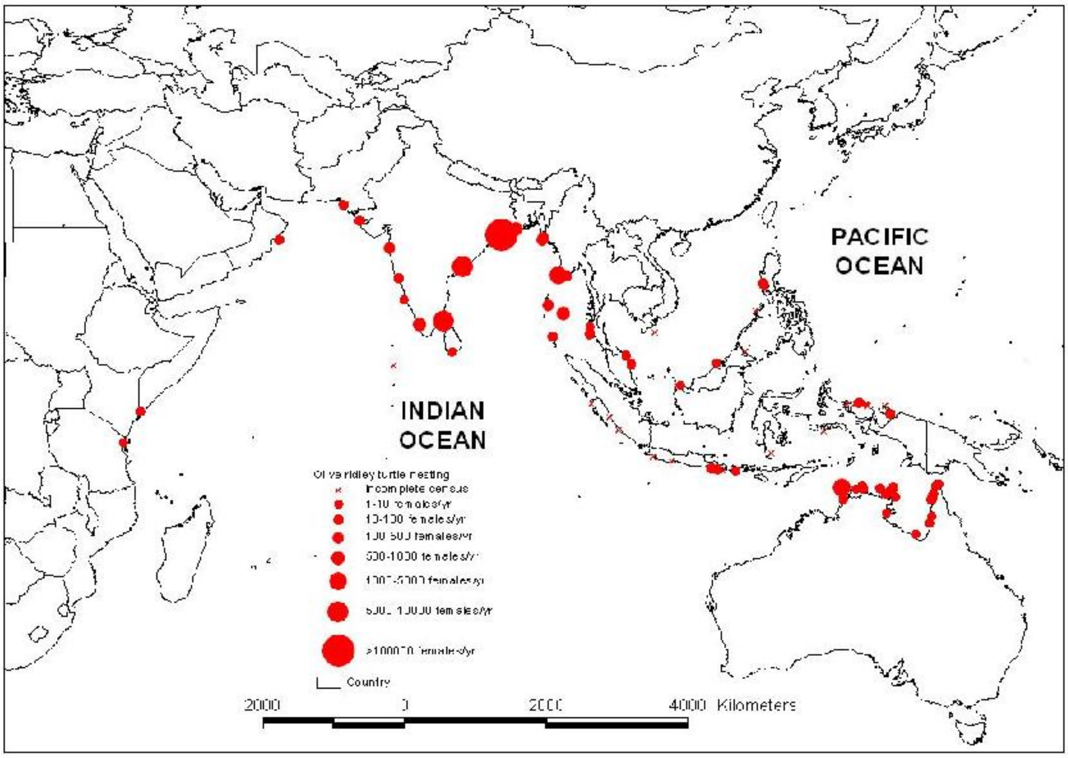

Figure 31** **Distribution of olive ridley turtle breeding sites in the Indian Ocean – Western Pacific *(Limpus 2009).*

4 Turtle stock assessments and anthropogenic impacts

Turtle stock assessments

Leatherback turtles

There is no data that can be used to determine or predict the health of the population of leatherback turtles in Australian waters, but the outlook for this species is considered to be grave. There is substantial evidence that leatherback turtle nesting numbers are in serious decline on rookeries in Southeast Asia and in the Pacific basin, so if leatherback turtles seen in Australian waters are from these rookeries then we must assume that these numbers are also in decline (Limpus 2009). For example, the last sighting of a nesting leatherback turtle on Terengganu Peninsular in Malaysia was in 1993. This was once a 2000 or 3000-strong annual population (Limpus 2009).

If the animals seen in Australian waters originated on Australian beaches then their future seems just as bleak, given the low nesting numbers and poor incubation success. In the late 1970s and early 1980s, there were up to three females reported annually nesting on beaches from Bundaberg to Roundhill (Agnes Waters). A leatherback turtle nesting on these beaches is now considered very rare, with the last seen in February 1996. Seven clutches on these beaches were studied and the average incubation success was just 15.3% (range from 0 to 39 hatchlings). In the 1992/93 breeding season three or maybe four, leatherback turtle clutches were laid near Ballina, New South Wales, and in 1995 one clutch was laid at Bootie Bootie National Park, south of Forster. There were also five nesting attempts in the Northern Territory and two unconfirmed reports in Western Australia. Incubation success of two of the Ballina nests was 60.5% (43 and 78 hatchlings) and the Forster nest failed to complete embryonic development (Limpus 2009).

With a population in such severe decline, even the death of one adult may contribute significantly to the extinction of the species (Limpus 2009).

Hawksbill turtle

The outlook for the Australian nesting sub-populations of hawksbill turtles, some of the largest remaining breeding populations in the world, does not look promising. These stocks continue to be subject to considerable threats that are predicted to be unsustainable (Limpus 2009).

A tagging census shows that the Queensland nesting sub-population of hawksbill turtles has been declining at 3% to 4% annually from at least 1990. While harvesting for tortoiseshell stopped many years ago, there remains an unquantified harvest of eggs on Torres Strait beaches and unquantified death in ghost nets. This decline equates to over 80% decline in the number of breeding females in less than one generation, making the future for the Queensland hawksbill turtle grim (Limpus 2009).

While there are no long-term census data on the Northern Territory sub-population of hawksbills, it is considered to be in danger. Threats to this stock include death in ghost nets, substantial amounts of harvest in neighbouring countries and unquantified egg collection from rookeries (Limpus 2009).

The status of the Western Australian sub-population is also unknown due to lack of data, but the stock is still considered to be threatened. Most rookeries are on islands so exempt from feral animal predation and egg collection, but are subject to disturbance due to oil and gas industry infrastructure. These activities have changed the light horizons in the surrounds, thus impacting on hatchling survival and nesting numbers on adjacent beaches (Limpus 2009).

Loggerhead turtle

Since 1968, the eastern Australian loggerhead turtle sub-population of nesting females has been monitored at various rookeries. In the 1976 and 1977 breeding seasons the total nesting population was estimated at about 3500 females. This fell to just 500 females for the 1999/2000 season, a decline of 86% with dire predictions that the stock was doomed (Limpus 2004). Another warning was that for at least 15 years there was evidence of a decline in recruitment of new immature loggerhead turtles into coastal waters. It was believed that earlier fox predation, trawl and longline bycatch and ingestion of synthetic marine debris had contributed to the decline (Limpus 2008).

In 2001, positive signs were noted. The numbers of nesting females started to increase with each breeding season. During the 2009/2010 breeding season the number of nesting females seen was the highest since 1985. The rebuilding of the depleted stock has been attributed to the mandatory adoption of TEDs in the ECTF and NPF. Other threats that have also been addressed, and that are predicted to further assist the recovery of the eastern Australian loggerhead turtle sub-population, is the reduction in fox predation that has been occurring since the late 1980s and the rescuing of doomed nests in the 2000s. The impact of the fox predation and doomed eggs measures are not expected to be evident until around 2020, given the expected age at first breeding of the hatchlings that were able to survive as a result of the management measures (Limpus 2008).

The status of the Western Australian loggerhead turtle stock is unknown due to lack of data on the breeding population and on the impact of the anthropogenic threats. There are concerns that the stock cannot withstand the high mortality rates. Threats include egg loss to foxes, vehicle traffic on nesting beaches, bycatch, boat strike and lighting disorientation near coastal development (Limpus 2009).

Green turtle

The largest remaining nesting population of green turtles in the world occurs in Australia. The population, however, is believed to be in crisis and at risk with even modest levels of mortality (Limpus 2009).

The southern Great Barrier Reef stock is comprehensively studied, but the actual status of the stock remains unclear. There should have been recovery following the cessation of an extensive and intensive commercial harvest of green turtles in 1950, but there is no evidence this has occurred. Nesting numbers are considered to be relatively stable but there are warning signs within the breeding population that there may be a loss of adult nesting animals from the population. Indigenous harvest remains the greatest source of mortality, with boat strike also a significant threat (Limpus 2009).

The northern Great Barrier Reef stock of green turtles is believed to be in grave danger. Harvest for meat, primarily the death of adult or near-adult animals, throughout much of their foraging range is the most significant threat. A further critical issue is the Raine Island rookery which has been subject to beach changes including loss of sand and a rising water table that has caused egg loss due to flooding. This has been occurring since 1970 and it is predicted that if this continues the population will crash irrespective of other management measures taken with the stock (Limpus 2009).

There is no data on the status of the Gulf of Carpentaria stock although it is believed that the significant harvest for meat and eggs by indigenous communities across the green turtle's foraging and nesting grounds is unsustainable (Limpus 2009).

The Western Australian stock of green turtles should be in recovery following the nuclear testing in the 1950s and the widespread commercial harvest up until the 1970s. However, other activities continue, causing significant mortalities including harvest of eggs, harvest of adults or sub-adults for meat, animal predation on mainland rookeries, and the impact of the oil and gas industry infrastructure and associated altered light horizons (Limpus 2009).

The status of the Coral Sea, Ashmore Reef and Scott Reef Stocks are unclear due to lack of data (Limpus 2009).

Flatback turtle

The eastern Australian stock of flatback turtles are considered to be currently secure but conservation dependent. The reason for this assumption is that the number of nesting females are believed to be stable, as most of their foraging grounds are protected within the GBRMP and a significant proportion of nesting occurs inside National Parks (Limpus 2009).

The Gulf of Carpentaria and Torres Strait stocks are considered to be in decline. It is believed that the current level of mortality is not sustainable in the long-term. Sources of mortality include egg collection and harvest for meat, ghost nets, dog and pig predation on eggs and hatchlings, and unquantified deaths in trawl and gill nets in neighbouring countries (Limpus 2009).

Although little data exists, there is a reasonable probability that the western Northern Territory and North-West Shelf stocks will not withstand their current threats. These include possible fisheries bycatch in Indonesian waters and gill net bycatch in Australian waters, predation on eggs (fox, dog, monitor lizard and pig), ghost nets, harvest of eggs and meat, oil and gas industry infrastructure light impacts and the impact of past Defense Force nuclear testing and bombing (Limpus 2009).

Olive ridley turtle

The status of the olive ridley turtle is uncertain with very little research being conducted on the species in Australia. There is a belief, however, that there is a distinct possibility that the Australian population, which has been shown to be unique, is in decline and unable to sustain current mortality. Threats are bycatch, ghost net entanglement, egg harvest and feral animal predation on eggs (Limpus 2009).

Anthropogenic impacts

Commercial fishing is only one of a varied range of anthropogenic mortality events marine turtles are subject to throughout their geographical range and throughout their life-times. Entanglement and ingestion of plastic debris is considered to be one of the greatest threats all species of marine turtles currently face. The impact of future climate change is a potentially significant threat that may surpass all others.

Limpus (2009) conducted a detailed review of each species of marine turtle found in Australian waters, including anthropogenic sources of mortality. Information provided in Limpus (2009) is summarized below and tabled in Appendix 4.

Leatherback turtle

The magnitude of mortality of leatherback turtles from anthropogenic sources in Australian waters is difficult to quantify due to lack of data. Mortality from gillnet and lobster pot fisheries within Australian waters warrants further investigation and needs to be addressed, as do some commercial fisheries in other countries (gillnets, longlines and driftnets). There has been no commercial harvest of this species or its eggs in Australia, and currently, commercial harvest is not permitted. Harvest of eggs and nesting females continues in other countries.

Hawksbill turtle

Hawksbill turtles are killed for eggs, meat and leather and its shell is made into tortoiseshell jewellery, combs, spectacle frames and ornaments. Whole turtles are also stuffed and polished to make wall ornaments. In the past they have been actively harvested in almost all of the countries in which they occur, including Australia. Large scale commercial harvest for tortoiseshell has not occurred in Australia since the 1950s, but there are still many human activities that continue to impact on the species, both in Australia and further afield. These include killing for meat and egg collection for food, entanglement in ghost nets, harvest in other countries and unquantified impact to hatchlings, nesting females, habitat and nesting beaches through development of gas, oil and mining industries.

Loggerhead turtle

Loggerhead turtles are being impacted through a wide range of anthropogenic activities throughout Australia, but this mortality is largely undetermined. This species was believed to be rarely targeted for commercial or indigenous harvest in Australia for either meat or leather. Concerns are held for Australian loggerhead turtles as a result of mortality from oil and gas industry infrastructure developments.

Green turtle

Green turtles are harvested for their meat and leather, their oils are used for manufacturing cosmetics, their scutes are turned into jewellery and offal makes fertilizer. In the past, they were particularly renowned for being turned into turtle soup and vast numbers of adults, primarily females, were slaughtered. Commercial harvest ceased in Australia in 1959, but indigenous harvest continues both in Australia and neighbouring countries. A more recent significant threat is disorientation of hatchlings and repelling of nesting females as a result of unnatural light horizons emitted from oil and gas industry infrastructure.

Flatback turtle

Flatback turtle populations are being negatively impacted through a wide range of anthropogenic activities throughout northern Australia. These impacts have been, for the most part, poorly quantified in recent years and usually ignored in the past.

Olive ridley turtle

Due to lack of data it is not possible to quantify the present magnitude of cumulative mortality from the wide array of anthropogenic sources impacting olive ridley turtles within Australia. Fisheries outside of Australian waters are expected to negatively impact on olive ridley turtles due to their migratory nature.

5 Alternative management options

Currently available mitigation measures for trawl and pelagic longline fisheries, summarised below, has been sourced from FAO Fisheries Department (2009), except where referenced otherwise. It should not be assumed that all of these options will be applicable to Australian fisheries.

Trawl fisheries

- TEDs are the most successful mitigation measure adopted in trawl fisheries around the world. Factors influencing the efficiency of TEDs include bar spacing, escape opening, escape covers, backwash funnels, grid angle, flotation, grid orientation, grid material, bent bars, guiding panel or funnel, grid size and grid shape.
- Area or seasonal closures may be effective for fisheries when there is adequate knowledge on seasonal turtle distribution. An example is a seasonal closure near nesting beaches during nesting season or where turtles are known to be in abundance (hot spots).

Pelagic longline fisheries

- Area or seasonal closures may be effective for longline fisheries when there is adequate knowledge on seasonal turtle distribution. This is not believed to be the case in the ETBF or WTBF (Robins *et al*. 2007).
- In some cases, vessels can be directed away from turtle 'hot spots' so fishing can continue while avoiding marine turtle interactions (Howell *et al*. 2008). Effective fleet communication can alert fishers to move away from areas of high turtle catches as they occur.
- Large circle hooks, as an alternative to tuna hooks or J-hooks, have been shown in various fisheries around the world to reduce marine turtle interaction rate and reduce marine turtle injury as a result of the interaction (Gilman *et al*. 2006, Piovano *et al*. 2008, Sales *et al.* 2010). Catch rates of target species, possibly resulting in financial concerns, and shark bycatch may be impacted, so fishery-specific testing is important.

  Turtle interaction rate is reduced because:

    - The circle hook is wider than the relative sized tuna hook or J-hook, so turtles with a mouth gape smaller than the width of the hook will not be hooked (Boggs and Swimmer 2007).
    - The circle hook tends to have a narrower distance between shank and barb compared with relative sized tuna hooks or J-hooks, so is less likely to foul-hook a turtle, especially a leatherback turtle for example, with wide flippers and neck (Boggs and Swimmer 2007).

  Turtle injury is reduced because:

    - If swallowed by an animal, the circle hook will have less chance of internally hooking an animal as the barb is somewhat guarded by the shank. There is a greater chance of an animal being mouth hooked, usually a minor injury rather than the more severe and more likely to result in death, throat or stomach hooking (Boggs and Swimmer 2007).

    - Gear removal is easier, and more likely to be successful, if the hook can be seen within the mouth cavity, rather than unable to be seen, down the throat or in the stomach.

- The use of fish, rather than squid, has been shown in some fisheries to reduce the catch of turtles. This is believed to be due to the rubbery nature of squid versus fish. Squid, and its associated hook, will tend to be sucked down whole and swallowed. Fish tends to be eaten progressively in small chunks until the fish is completely removed and the hook remains. The switching of bait type may impact on target catch, and consequently the economic viability of the fishery (Gilman *et al.* 2006, Boggs and Swimmer 2007, Echwikhi *et al.* 2010).
- The use of large circle hooks and fish bait has been successfully used in fisheries around the world (Boggs *et al*. 2009).
- Setting the hooks deeper (i.e. below the upper water column) where turtles tend to be less abundant may result in fewer interactions. The 'general' depth generally considered to be deep is below 100m. The impact on target catch is fishery specific, so research on the economic implications of this gear change is important. While the catch rate of turtles may be reduced with deep-setting, the mortality rate of those caught may be higher due to the inability of a hooked turtle to make it to the surface to breath.
- Using small circle hooks rather than J-hooks or tuna hooks have been shown to still give an advantage in reducing the impact of the fishery on turtles (Gilman *et al.* 2006, Boggs and Swimmer 2007).
- Single threading bait, rather than multiple threading, may result in a decrease in turtle catch due to the turtle being able to chew the bait off and not just swallow it whole (Gilman *et al.* 2006)
- Reducing the time the gear is in the water (soak time) may reduce the catch of turtles (Gilman *et al*. 2006).
- Hooks that have been offset 10 degrees show no difference to non-offset hooks (Swimmer *et al.* 2010).
- Blue-dyed bait has been shown in some cases to be effective in reducing the catch of turtles but unless competitively priced dyed bait becomes available the measure is considered financially impractical.
- Another gear strategy is to determine the water temperature where more turtles occur and where the target species occur. If these are different, fishing operations can be modified to catch less turtles and possibly more target species.
- Fishing without lightsticks may reduce turtle bycatch. Lightsticks have been shown to be an attractant to some turtle species, primarily leatherback turtles.
- Stealth fishing gear is designed to be less detectable to turtles. Examples of ideas that have been tested with varying success include shaded lightsticks, lightsticks with modified light frequencies, counter shaded floats, dark grey lines and dulled hardware. More research would be required before any stealth mitigation measures be adopted in a fishery.
- Research has been conducted on float lines made from alternative materials so that entanglement is reduced (Boggs and Swimmer 2007).

- Research has also been conducted on making the bait less attractive through odours and acoustic deterrents. Results are inconclusive.
- Various modifications have been done to hooks to physically protect them from turtles (Boggs and Swimmer 2007). For example, the 'weedless' hook is a device that covers the hook until a fish bites it, the 'whisker' hook is a device making hooks wider and more difficult to swallow, and the 'smart' hook is a device fitted over the hook that releases at a certain depth.

  A wire appendage on hooks has been successfully trailed in a number of studies in New Zealand in the New Zealand commercial longline fishery for snapper (*Pagrus auratus: Sparidae*). The aim was to reduce the bycatch of undersized fish and minimize the rate of gut-hooking – thereby improving the value of the landed catch (Willis and Millar 2001; Barnes et al. 2004 from Boggs and Swimmer 2007).

  Subsequently trials in the Costa Rican mahi mahi and shark longline fishery (Hall 2006) have also been successful in reducing the catch rate of marine turtles using a similar wire appendage on hooks. The objective is to effectively increase the perceived width of the hook while still using a relatively small hook.

6 Research gaps

Northern Prawn Fishery

- Recent estimates of turtle catch from the current CMOP are much higher than previous years. The reason for these differences must be determined and the CMOP modified if catch estimates are found to be biased. Before any assumption should be made concerning adjusted catch numbers, the data needs to be examined in detail to determine if it is viable to do a simple adjustment up to total effort.
- The modification of TEDs to make them more effective with respect to target catch and the release of other bycatch is on-going.

East Coast Trawl Fishery

- Research is on-going in the ECTF on improving TED design in the prawn trawl fishery.
- Research should continue into the development and uptake of TEDs and BRDs in all sectors of the ECTF. Fishery independent trawl surveys (i.e. research surveys) and commercial fisher trials have been conducted testing modified mesh cod ends in both the scallop and shallow water prawn sectors, and the deep water prawn sectors for the later method.
- Management, research and industry groups should foster research and endeavours into improving public perception through activities such as rescue efforts (for example, releasing rehabilitated turtles), participation in environmentally-friendly ventures (for example, clean-ups) and research.

Eastern Tuna and Billfish Fisheries and Western Tuna and Billfish Fisheries

- A fundamental research gap for longline fisheries is the average rate of turtle mortality following each type of interaction event. The assumption that every interaction results in a turtle death is obviously incorrect considering there have been numerous satellite tagged animals, including in Australian waters, which were shown to have survived following a longline interaction. To date, satellite tagging and tracking interacting turtles has been the most common way to determine mortality rates. While this method is expensive due to the cost of the tag and the satellite time plus the number of animals required before reasonable conclusions can be drawn, it does achieve other objectives. This includes participating fishers becoming more turtle-aware and can give them the drive to help solve their turtle bycatch problem and also advance our knowledge of the species. This is especially important as so little is known about marine turtles during the pelagic phase of their lives
- While not technically a research gap, the training of fishers in marine turtle handling and release techniques is a knowledge gap that needs to be recognised and addressed within the ETBF and WTBF. It is important that industry be made aware of best practice to minimize interactions and to minimize mortality through correct handling and release procedures. If workshops are to be well attended they preferably need to be made compulsory and conducted by bycatch mitigation experts with experience in turtle handling and release techniques.

- There is a considerable lack of knowledge of marine turtles while in the pelagic phase of their life cycle which is why these years are referred to as 'the lost years'. An on-going program to fill these knowledge gaps will not only assist scientists and mitigation experts to develop suitable mitigation measures with a high chance of success, but also inspire fishers to improve their understanding of marine turtle biology, ecology and conservation. This may prompt fishers to work towards becoming more turtle-friendly in their fishing activities and encourage other fishers to become involved. Types of research activities are: flipper tagging and morphological measurements; satellite tagging for migration studies; spatial distribution including links to environmental variables such as sea surface temperature; providing dead turtles to scientists for necropsies which can offer information on food sources, general health, morphological measurements and specimens for museums or for training purposes.
- A research gap which has become apparent during the writing of this report is the discrepancies in historical turtle catch statistics including both logbooks and observer data. On many occasions different turtle catch statistics have been documented. AFMA reports that this issue has been resolved (Trent Timmis AFMA, personal communications 2011).
- Management, research and industry groups should foster research and endeavours into improving public perception through activities such as rescue efforts (for example, releasing rehabilitated turtles), participation in environmentally-friendly ventures (for example, clean-ups) and research.

Innovative bycatch strategies

Compensatory mitigation strategies

A relatively new concept in bycatch mitigation is Compensatory Mitigation Strategies for Marine Bycatch (CMMB). This management approach aims to reduce mandatory restrictions on commercial fisheries in exchange for funding compensatory activities that result in improved protection of certain marine species. An example is for fishers' levies to fund a reduction in feral predators impacting a stock of seabirds that are also impacted by the fishery. It is based on the premise that damage caused by one activity may be offset by compensating with beneficial activities elsewhere (Finkelstein *et al.* 2008, Wilcox and Donlan 2007). Before considering this approach it should be demonstrated that the effectiveness of any potential conservation strategy will outweigh the fishery threat.

Gear invention competitions

Gear invention programs are proving to be a valuable incentive to those involved in bycatch mitigation to share their developments and further refine their mitigation technologies. A prime example is the international WWF Smartgear Competition which began in 2005 (www.smartgear.org). This competition brings together the fishing industry, research institutes, universities, and government, to inspire and reward practical, innovative fishing gear designs that reduce bycatch and related deaths of turtles, birds, marine mammals, cetaceans and non-target fish species.

In the first year of the competition, over 90 submissions were received from around the world, and in 2009, Australian entries took out the grand and first runner-up prizes. Judged by a panel of gear technologists, fisheries experts, researchers and conservationists, winners were chosen for originality, the potential to reduce bycatch, and the potential for future development. Most importantly, the ease of use and cost-effectiveness were important considerations, as these factors greatly influence the level of adaptability and adoption within other fisheries around the world, particularly those in developing countries, where bycatch is often high and funding for mitigation is low.

Mentoring programs

Mentoring programs are proving to be a practical and effective method to improve the development and adoption of mitigation measures within and between countries. Recently, Southern Seabird Solutions in New Zealand (www.southernseabirds.org) implemented a mentoring program to support fishers with their ideas for reducing seabird capture in commercial and recreational fisheries. Working with a reference group, the mentor will provide feedback and advice to fishers and other inventors. The scope of advice will include feedback on design, guidance on development and testing, and advice on potential collaborators or funding bodies. An important part of the role will be to provide a co-ordinating hub and put people in touch with each other.

A further mentoring approach which has proven successful both in Australia and overseas is that in which 'fishers train fishers'. For example, In Sabah, Malaysia, the Marine Research Foundation is introducing fishers to TEDs. In 2009, NOAA's National Marine Fisheries Service (NMFS), through their Harvesting Systems Branch, hosted five Malaysians (fishers and fishery officers) to learn about TEDs, how they work, changes needed to vessels and legal processes. The trip was a resounding success, with the NMFS sharing a great deal of knowledge. The main difference during this trip was that every boat was TED-compliant, whereas when trainers came to Sabah in 2007, the backdrop was a fishery with no TEDs. As a result of this visit, the Malaysian visitors were inspired and enthusiastic about the introduction of TEDs into their fishery, having seen the benefits of their use, both to bycatch species and their fishing operations.

Discussion

Review of fisheries

The available evidence from the two trawl fisheries considered, the NPF and the ECTF, gives a clear indication that the marine turtle mitigation plans for these fisheries have been successful. The fishers who provided their opinions agree with this conclusion.

Prior to TEDs, the NPF was estimated to catch around 5000 turtles annually (1998 - 1999). After TEDs were introduced, less than 200 turtles per year (2000 - 2001) were estimated to have been caught. Prior to TEDs, the ECTF was estimated to catch around 5900 turtles annually (1991 - 1996), post TED estimates using logbooks report an average of 10 turtles per year (2001 - 2009).

The mitigation strategy for both fisheries listed a management and conservation target of 95% reduction in marine turtle catches following the adoption of TEDs. This converts to a maximum target of 286 turtles per year for the NPF and 295 for the ECTF (NORMAC 1998, QFMA 1998). These targets were shown to have been met in the years following the introduction of TEDs in both fisheries.

All available data demonstrates that mortality rates have also substantially decreased. This is expected as most turtles caught are those that enter the net as it is being winched up, and so hadn't reached the TED before the gear was retrieved onto the deck. These animals would have little chance of drowning due to the short time they are in the net (Robins *et al*. 2002b, Robins 2002).

Indirect evidence that this mitigation measure implemented in the NPF and ECTF has been successful in reducing the trawl-related mortality of marine turtles is the noticeable, and very welcomed, upward trend in the eastern Australian sub-population of loggerhead turtles. The stock has switched from long-term decline in the pre-TED years to resurgence in the post-TED years. Since 2000, the number of nesting females' at all eastern Australian loggerhead turtle index beaches has increased each year. As the fisheries were interacting with adult and large-immature animals, the impact of a reduction in mortality was expected to be evident within a few years of the threat easing. The prediction came true – it was evident by the increasing number of nesting loggerhead turtles (Limpus 2008).

Further good news for the eastern Australian loggerhead stock is that other mitigation efforts will also assist the recovery process in the near future. As a result of two initiatives of the Queensland DERM, addressing the issue of fox predation and saving vulnerable (or doomed) eggs, there has been an increase in hatchling production, thereby enabling more hatchlings to reach the water. These changes are predicted to be evident in the next generation of nesting turtles (i.e. when the extra hatchlings return to breed in 25 to 30 years) (Limpus 2008).

Throughout the 1970s and 1980s, foxes were estimated to take approximately 90% of turtle eggs off mainland beaches; baiting schemes have reduced this predation to less than 5% since the late 1980s. Additionally, volunteers throughout the Sunshine Coast and south east Queensland islands have been protecting nests using fox excluder devices (mesh). Volunteers and DERM staff also have a program of rescuing doomed eggs that has resulted in an estimated 40 to 50 thousand extra hatchlings being produced from the Woongarra Coast annually. These eggs would have otherwise been destroyed as a result of being laid below the high-water mark or been flooded during storm events (Limpus 2008).

Both fisheries have an on-going assessment of the effectiveness of the TEDs. The ECTF includes comparisons between pre-TED estimated catches and post-TED logbook reported catches and also a limit performance measure based on percentage of the fleet found to have non-compliant TEDs. If the limit performance indicator is met a management response is triggered. Every year since the introduction of TEDs, the catch assessments have been positive and the limit performance measure has not been trigged.

Marine turtle catch rates in the NPF are estimated from the routine monitoring program (CMOP), but there has been a problem in recent years. The catch rate determined from crew-member observers has risen, with the 2009 estimate of 0.068 turtles/day. Using 2009 effort this can be raised up to around 500 turtles per year. These estimates are derived from smaller sample sizes than used previously, so error rates around the estimates will be larger. Before any assumption should be made concerning adjusted catch numbers, the data needs to be examined in detail to determine if it is viable to perform a simple adjustment up to total effort. If the data is non-random for either vessels or days, then an estimate of this type may cause incorrect, and possibly inflated or deflated, estimates. Although catch rates estimated in the routine monitoring programs are higher than earlier estimates, they remain substantially lower than in the years before TEDs were introduced.

Another obvious similarity between these fisheries is the close involvement industry has had with the research, development and trialling of the devices. From the very early days of TEDs and continuing today, the fishing industry has worked in collaboration with scientists and managers. Various fisher education programs have been conducted in these fisheries to keep the fishers informed of research results and up-to-date with their knowledge; allow them to provide ideas, opinions and suggestions; and enable them to be part of the team working to solve the problem. The importance of collaboration has been internationally applauded (Cox *et al.* 2007).

While the reduction in marine turtle bycatch is the primary benefit of adopting these measures, the sociological benefits are also of great value. With the success of the various strategies, fishers are confident in the knowledge that they are on the right track, that they are ‘making a difference’ and confident that their livelihoods are more secure as a result. Knowledge empowers fishers to make a difference.

The two longline fisheries reviewed, the ETBF and the WTBF, are different from the trawl fisheries in more ways than the obvious differences in gear type. The ETBF has a plan in operation, while it is considered the WTBF does not currently require a plan due to very low fishing effort.

In developing a plan, one of the first steps is determining the scale of the issue. Two sources of information were used to estimate total turtle interactions in the ETBF - fisher interviews and observer reports. Both estimate turtle interactions of between 200 and 300 interactions per year using data from the mid-2000. Total turtle interactions in the WTBF for 2001 were estimated to be around 140 turtles. This estimate was calculated from the 2001 effort of over six million hooks set, while in 2009 only half a million hooks were set.

Marine turtle interaction rates in recent years are expected to be substantially lower due to effort reductions and operational changes, such as deep-setting and the use of circle hooks. Both fishers in their logbooks and observers in their reports note very few deaths as a result of the interaction event. The use of line-cutters and dehookers will result in fewer animals leaving the vessel injured and/or carrying hooks or line, actual rates are not able to be estimated due to lack of adequate data. The adoption of circle hooks is also expected to improve survivability in hooked turtles due to the chance of deep (stomach) hooking being substantially reduced.

It is not possible to calculate more accurate marine turtle interaction rates for the ETBF and WTBF due to low observer coverage and rarity of marine turtle interactions. Solving the dilemma of having adequate data by increasing the observer coverage however, may not be considered reasonable taking into account the scarcity of interaction events and the substantial increase in observer coverage required to collect adequate data.

The Marine Turtle Mitigation Plan approved in the ETBF was placed in operation in 2011 and the annual review of observer data will occur in 2012. There are uncertainties of a practical nature, however, that should be resolved. For the proposed measures to be successful they must be biologically appropriate for the turtle species and practically appropriate for the fishers.

Although interaction events are rare, fishers need to know how to react when a turtle is either landed or entangled and additionally they need tools to allow the turtles to be released with the best possible chance of survival. Fisher opinions in general, mirror this recommendation. Fishers asked for more marine turtle information to be provided to them personally and not just sent to the permit holders. All fishers acknowledged the usefulness of dehookers and line-cutters.

At this stage, along with enacting the mitigation plan, the most logical course of action would be to continue to reduce the impact of the fishing operations on marine turtles through: fisher education on ways to reduce interactions; fisher cooperative research keeping the fishers motivated in changing their practices to reduce catches and improve survivorship; improved education in turtle handling and release techniques and ability to source the necessary tools.

One aspect compelling these fisheries to develop and adopt mitigation plans is international pressure on all pelagic longline fisheries to reduce their impact on turtle stocks. Leatherback turtles and loggerhead turtles seen in the South Pacific will traverse the fishery grounds of many countries during their migratory activities. A reduction in mortality events combined due to all longline fisheries operating in all oceans in which they travel may be fundamental to the survival of the species.

Lessons apparent during the review of the history of the NPF and ECTF with regard to marine turtle mitigation include the importance of bearing in mind technologies from other fisheries but amending them to suit the fishery; of having fisher, gear builder and industry involvement in research and development; of maintaining appropriate monitoring and review procedures; and the fishers having the ability to further improve the mitigation technology. The importance of underpinning mitigation measures on available knowledge is apparent. This includes considering other anthropogenic threats and marine turtle biology and conservation; reviewing the success and failures of alternative measures during research trials and when fishing occurs; and prioritising research gaps so the eventual mitigation measure or measures adopted have a high chance of success.

Marine turtle knowledge

One aspect of marine turtle ecology to consider is the life-stages of marine turtles and their susceptibility at each phase. The life cycle of marine turtles can be generalised into five stages (eggs, hatchlings, juveniles, sub-adults, adults) and each life stage is subjected to particular threats, both anthropogenic and natural.

The death of a female adult turtle may have a far greater impact on the population, than the death of a hatchling. However, the death of many hatchlings, as often occurs during uncontrolled egg harvests, can still significantly impact on the population. If conservation efforts focus only on protecting eggs and hatchlings, and adult mortality is ignored, then there is little chance of population recovery. Using the reverse premise, if nesting adults are protected through mitigation efforts, but all eggs are harvested and no hatchlings make it to the water, then this population will also have little chance of recovery (Lewison and Crowder 2007).

The level of susceptibility to capture depends on the distribution of individuals at that stage and the length of exposure to the threat. Factors related to fishing that influence the level of susceptibility are the gear and how it is being used, the mitigation measure being considered or used, and the distribution of the fishing effort. If a turtle spends a considerable amount of its life at a life stage that is vulnerable to the fishing activity, then logically there is a relatively high chance of an interaction. This is as opposed to an individual either spending a short time in the vulnerable stage, or being exposed to the threat for a short time. Information on the impact of the fishing operations on the life stage is important in developing appropriate mitigation strategies for commercial fisheries, and also to ensure target monitoring, research and enforcement on areas of critical concern.

In the NPF all life stages are caught. There have been verified reports of hatchlings in the past, but they are very rarely encountered. Robins *et al.* (2002b) determined that for all species encountered in the NPF the most common body length would have been adult sized animals, but with significant numbers of sub-adults. While animals from all life stages were also occasionally encountered in the ECTF, immature animals were the most commonly caught (60% – 80%), as determined by a size-based maturity classification. The leatherback turtles encountered in the ETBF and WTBF are almost all described as very large animals from 1.5 to two metres in length and are assumed to be adults or sub-adults. Most green turtles and loggerhead turtles scientifically examined in the ETBF are juveniles and sub-adults. This is evident by their size, sharp edges around their carapace and signs of residing in the pelagic zone including blackened mouth.

Along with juveniles in the pelagic stage of their lives, satellite tagging migration maps demonstrate that adult turtles can also enter the longline fishing grounds in their migration from feeding to breeding grounds and also when sub-adults cross from the pelagic stage of their lives to feeding habitats. There are also various reports of small hatchling and larger turtles being seen around floats or swimming past vessels.

Marine turtles occupy broad geographic ranges, with specific habitat ranges depending on the species. Every commercial fishery in Australia (except maybe those fishing Antarctic waters) using oceanic or coastal waters will be fishing where turtles are living or migrating through. The important factor to consider is whether the fishing gear type utilised means that an interaction can occur and whether these interactions negatively impact on the turtles.

Anthropogenic threats

Marine turtles are subject to an assortment of threats (natural and anthropogenic) due to their long life span, their various life stages that require different habitats and their extensive migrations that take them across bays, oceans and through various environments. Each phase of their life is confronted with a different array of threats and each threat may need an array of solutions if it is to be addressed (Wallace *et al.* 2008).

The impact of each source of mortality, and indeed, some of the sources of mortality, is somewhat unclear at times. Equally unclear in many populations and sub-populations of marine turtles is their conservation status. This is primarily due to a lack of adequate data, one example being anthropogenic mortality rates, but also for more fundamental population dynamics factors such as abundance levels and natural mortality.

The impact of each anthropogenic event causing mortality (or injury resulting in mortality) to the turtle population or sub-population will depend on many factors. These include the species and the geographical area, but also the life stage in which the mortality event occurred and other threats the turtle population faces. The death of a hundred individuals may not be significant for a healthy population of turtles, but the death of one individual may be detrimental in a declining population.

While it may be highly preferable in endangered species conservation to be able to manage all anthropogenic sources of mortality over the entire range of the animal, this is not practical, or in most cases, possible. In the situation of a migrating species that crosses international boundaries, in some cases many times during their lives, it is virtually impossible to even attempt to manage or control all of the commercial fisheries with which they interact. In many cases, the best that can be achieved is to be aware of all known sources of mortality and take these factors into account when developing management plans for activities under your control.

Currently, a recognized, but largely unquantified, threat to marine turtles throughout the world’s oceans is entanglement in, and ingestion of, plastic debris. One potential threat that may supersede all others is man-induced climate change. Marine turtles did survive past shifts in climate, and so must have adapted to those changes. Present day climate changes however, are predicted to be much more rapid with the implications of rising temperature and increased storm intensity as yet unknown. The consequences of each individual component of climate change are expected to be complex and confounded, with some predicted changes appearing to benefit turtle populations and others not (Hawkes *et al.* 2009, Poloczanska *et al.* 2009). This potentially significant anthropogenic threat is currently not able to be quantified due to the many uncertainties involved.

Mitigation strategies

Bycatch of marine turtles in commercial fisheries is recognised as a major threat to all species of marine turtles (Wallace *et al.* 2010). There are various strategies that could be applied when dealing with bycatch issues of rarely caught, and often charismatic species, and/or threatened endangered or protected species in commercial fisheries. In some situations the bycatch of a particular species can be managed using the concept of allowing a sustainable kill or allowable mortality rate to occur. For this strategy to be appropriate there must be a sufficient knowledge-base of the species of concern to enable mortality rates which do not threaten the population to be estimated. This strategy may not be appropriate for species with depleted populations (Robins 2002).

The alternative strategy is to reduce the impact of fishing operations on the species of concern. This can be achieved via:

- Closing or restricting fishing access to areas where the interactions occur;
- Closing or restricting fishing access in times when the interactions occur;
- Modifying fishing practices to reduce the number of interactions;
- Modifying fishing practices to reduce the severity of interaction events.

The first two measures, spatial and temporal avoidance, seem the most obvious and in some cases, the most effective, but they may be problematic. In some situations there is inadequate information available regarding the interaction events and where they occur, to devise a management plan with a high chance of success. In addition, if the mortality events are relatively rare, as is often the case with a depleted population or a large fishing ground or simply a fishing method with a low rate of interaction, a lack of accurate data on which to base decisions may be an issue. Also the same areas where turtles are caught may be the most productive fishing areas and to close these areas would financially destroy the fishery.

The last two measures, mitigation through changes in fishing practices to reduce the number and severity of interactions have been used in many parts of the world and for many gear types. Research into innovative mitigation techniques with the intention of reducing the impact of commercial fisheries on marine turtles has been focused and on-going since bycatch was recognised as an important issue for commercial fisheries. The success or failure of mitigation measures has been regularly shown to be fishery-specific, so research specificity to each fishery is imperative. In many cases, direct fishing industry involvement in projects has been credited as the main ingredient for success. It is necessary and beneficial to have industry involvement in mitigation projects because fishers can offer technical and commercial knowledge, supply a means for measures to be trialled in a commercial situation and involvement in projects encourages a feeling of ownership which can lead to better uptake of the technology.

Impact of fishing mortality relative to other threats

In the past, the NPF and ECTF could be considered as having a significant impact on marine turtles, and possibly being a substantial contributor to the decline of some of the turtle species in Australian waters. Since the adoption of turtle mitigation plans centred on TEDs, area closures and effort reductions, their impact on marine turtles has moved towards insignificance in comparison to other anthropogenic impacts. The adoption of mitigation plans and changes to fishing practices, in conjunction with an increased knowledge-base across the industry has proven that these fisheries can be maintained alongside marine turtle populations.

The ETBF and WTBF alone are not considered to have a significant impact on marine turtles compared to the scale of other anthropogenic threats endured by each species of marine turtle. However, these fisheries cannot be considered in isolation as the combined risk to marine turtles across their entire range from pelagic longline fisheries is considered to be significant. While one fishing vessel may encounter only a few turtles with the fishers perceiving they have no effect on the whole population, this impact must be multiplied for all vessels in the fleet, and multiplied again for all fleets that interact with the marine turtles (Lewison and Crowder 2007). There is a need for this issue to be addressed within all longline fisheries, and indeed all commercial fisheries across the Pacific and the Atlantic Oceans. The mitigation measures adopted must not only be effective but also commercially viable (Gilman *et al*. 2006).

Over its lifetime, a single turtle may cross the jurisdictional boundaries of many countries and pass through the fishing grounds of many fisheries. All fishers have the responsibility to ensure this turtle is protected while in their fishing grounds, and assist other fishers in ensuring the turtle's survival.

Benefits and Adoption

The NPF and ECTF adopted marine turtle mitigation plans approximately ten years ago and the fishers and managers of these fisheries benefit from the knowledge that their efforts on mitigating marine turtle catch has been successful. This success story should be disseminated to a wider audience.

The fishers and managers of the ETBF and WTBF will benefit from the extensive information provided on relevant aspects of marine turtle conservation and scale of other anthropogenic threats. Many valuable lessons can be learnt by studying the journey undertaken by the NPF and the ECTF since research into suitable turtle mitigation measures commenced over 20 years ago. Important factors that contributed to their success should be considered in the development and actioning of plans for other fisheries.

Through the review of all four fisheries and the documentation of relevant turtle information and knowledge, research gaps have been identified for each fishery. Additionally, recommendations have been made for the ETBF and WTBF on how to advance the mitigation plans.

Further Development

There is a pressing need for every Australian commercial fishery that is suspected to interact with marine turtles, but do not have turtle mitigation plans in place, to be recognised, reviewed and, if considered necessary, to develop an appropriate mitigation strategy. If there is no way for the interactions to stop completely these plans should include fisher training in handling and release techniques to minimise mortality and injury to turtles.

Suggested further developments in the NPF, ECTF, ETBF and WTBF, include:

- On-going and regular review of changes to bycatch levels, and the continual improvement of gear and operational procedures.
- The continuations of fisher education to ensure new crew members are educated in the importance and application of mitigation measures.
- Public education regarding the reality of marine turtle bycatch in these fisheries, including the extent to which fishers are taking on board the importance of reducing interactions, the lengths to which they have gone to adopt the necessary strategies and how fishers are assisting marine turtle conservation activities.

The ETBF has a turtle mitigation plan being actioned and the WTBF has been assessed as not requiring a plan. A summary of additional research gaps that have been identified include:

- Reliable estimation of rate of turtle mortality following each type of interaction event.
- The considerable lack of knowledge of marine turtles while in the pelagic phase of their life cycle and the possibility that longline fishers can enhance this knowledge.
- Access to accurate catch statistics on which to base decisions.
- Ensuring the Sea Turtle Mitigation Plan is adequately descriptive, but remains flexible, in order for it to achieve the desired outcomes of reducing the impact of the fishery on marine turtle stocks, while maintaining fishing capability and financial feasibility.

Planned Outcomes

This report documents currently available knowledge on aspects of marine turtle conservation that is vital for fishers, managers and scientists to consider when developing, monitoring or modifying mitigation plans for fisheries. This includes:

- Information on the conservation status of populations and sub-populations of each species of turtle found in Australian waters.
- The scale of other anthropogenic threats these animals face in comparison to fishery-related interactions.
- Species-specific distribution and migratory behaviours.

The review of the history of fisheries with successful mitigation plans in place, the NPF and the ECTF, highlights the importance of:

- Conducting fishery specific research to adopt current technologies to the specific fishery.
- Industry involvement (fishers, permit holders, gear builders) in research and development.
- Introduce a mechanism to ensure devices and technologies can be further developed/modified to improve their efficiency with respect to turtle mitigation and/or fishery improvement.

The ETBF currently has a plan in operation. These aspects, plus the list of research gaps and alternative management options provided, are essential in furthering the process towards implementing a mitigation plan that will be effective in reducing the threat of the fishery to marine turtles, without compromising financial viability of the fleet.

Conclusion

The conservation status of all species of marine turtles in Australian waters is of grave concern. In the past, marine turtle stocks (sub-populations or populations) were subject to intense pressures from activities such as commercial and indigenous harvesting, habitat destruction, unsustainable fishery bycatch and appalling numbers of turtle deaths through events such as the nuclear testing in the 1950s on Trimouille Island, Western Australia. These severely depleted stocks continue to endure anthropogenic threats (such as indigenous take of adults for meat and egg harvesting; fishery bycatch in Australia and elsewhere; the negative effects of pollution such as plastic ingestion and contamination sourced from the land and from vessels; coastal development; oil, gas and mining industry infrastructure and port development impacting on foraging areas and rookeries; and altering light horizons resulting in increases of hatchling mortality and driving nesting females off beaches). Many of these threats are largely unquantified and remain a significant risk to the survival of marine turtles.

Climate change processes may further complicate the whole process of assessing threats and assigning risk to marine turtle populations. The possible impacts of climate change to marine turtles are being extensively debated, but probable impacts remain essentially undetermined due to the complex nature of the processes. Predicted turtle responses to each single component of climatic change may never occur, because the climate change processes will occur simultaneously, so effects may be cumulative. Also, some predicted impacts and responses may be negated by other impacts and responses. An undeniable recommendation is that if marine turtle populations become more resilient and management is flexible and adaptive to current threats, then marine turtle populations have a better chance of surviving the impact of possible climate change. One way to improve resilience is to reduce other anthropogenic threats already faced by marine turtles (Hawkes *et al.* 2009, Poloczanska *et al.* 2009).

Commercial fisheries bycatch cannot be considered in isolation as all other threats impacting turtles must be taken into account. Additionally, while the impact of one fishery may seem to be irrelevant when compared to other current threats, the collective risk to the species from all commercial fisheries turtles encounter is recognised as a major threat. These animals migrate extensively throughout their lives, traversing international boundaries, and encountering various types of fisheries and also multiple fisheries of the one gear-type. If the total mortalities from all commercial fisheries are considered, the risk to the species as a result of fishery bycatch will inflate.

Each fisher, in every fishery that encounters marine turtles has the responsibility to ensure the animals are not injured to such an extent as to influence their breeding success or cause death. For a severely depleted stock, every death is one death too many, and the loss of a single breeding female in certain populations could tip the balance against the future success of the species.

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Appendix 1 Intellectual Property

There are no recognised intellectual property issues arising from this research.

Appendix 2 Staff

Principal Investigator	Carolyn Robins, Belldi Consultancy
Investigator and editor	Emma Bradshaw

Appendix 3 List of Tables and Figures

Tables

Figures

Appendix 4 Relevant Legislation

Northern Prawn Fishery

NPF Directives No 133

“Turtle Excluder Device” means a device fitted to a net, and modification made to a net, that allows turtles to escape immediately after being taken in the net, and which has:

a rigid or semi-rigid inclined barrier grid comprised of bars extending from the foot to the head of the net that is attached to the circumference of the net which must guide turtles towards an escape hole immediately forward of the grid. The minimum dimensions of this grid to be at least 81cm by 81cm. This structure is to be set at a minimum angle of between 30 and 55 degrees in relation to the horizontal plane of water through the net; and

an escape opening which must be:

a double flap rectangular net opening where the cut immediately forward of the TED must be a minimum of 61cm and the two forward cuts of the escape opening must not be less than 51cm long from the points of the cut immediately forward of the TED frame. The resultant length of the leading edge of the escape opening cut must be no less than 142cm stretched, or a double flap net triangular opening where the cut immediately forward of the TED must be a minimum of 102cm with minimum forward cuts of 101cm.The flaps must be composed of two equal size rectangular panels of mesh. Each panel must be a minimum of 147cm wide and may overlap each other no more than 38cm. The panels may only be sewn together along the leading edge of the cut. The trailing edge of each panel must not extend more than 61cm past the posterior edge of the TED frame. Each panel may be sewn down the entire length of the outside edge of each panel, or;

a single flap rectangular net opening where the cut immediately forward of the TED must be a minimum of 61cm and the two forward cuts of the escape opening must not be less than 66cm long from the points of the cut immediately forward of the TED frame. The resultant length of the leading edge of the escape opening cut must be no less than 181cm stretched, or a single flap triangular net opening where the cut immediately forward of the TED must be a minimum of 102cm with minimum forward cuts of 136cm. The flap must be a minimum of 338cm by 132cm piece of mesh. The 132cm edge of the flap is attached to the forward edge of the opening 180cm edge. The flap may extend no more than 61cm behind the posterior edge of the TED frame; and

a maximum bar spacing of 120mm.

In addition:

floats must be attached to the top one-half of all TEDs with bottom escape openings. The floats may be attached either outside or inside the net, but not to a flap. Floats of any size and in any combination must be attached such that the combined buoyancy of the floats, as marked on the floats, equals or exceeds the weight of the TED; and

it is not permitted to attach any weights, meshing or other materials which may inhibit the opening of this escape flap.

2.1.3 Compulsory use of Turtle Excluder Devices (TEDs) and Bycatch Reduction Devices (BRDs)

It is compulsory that all nets rigged for fishing in the NPF are fitted with BRDs and TEDs or (modified TEDs) for the entire fishing year. A description of the approved specifications for both BRDs and TEDs is included over the page and in Direction No NPFD 133.

Fishers are encouraged to improve the effectiveness of BRD's. If you want to test a TED and/or BRD that does not meet the current prescribed specifications you can apply to AFMA for a Scientific Permit.

This provision of BRD's is limited to testing new designs and will not be granted to accommodate the general use of devices that don't meet the specifications. If you would like to obtain a scientific permit please contact the NPF Senior Management Officer on (02) 6225 5456.

Permitted BRDs and Modified TED

Modified TED Specifications

"Modified Turtle Excluder Device" means a device that:

(i) is a Turtle Excluder Device with the escape opening in the top of the codend; and

(ii) a bar spacing no more than 60mm; and

(iii) may have an escape flap over the escape opening (but no part of the escape flap may be closer than 150mm to any part of the grid, when the Turtle Excluder Device is fitted to a codend hung vertically); and

(iv) may have a guiding funnel or flap inside the codend ahead of the grid (but no part of the guiding funnel or flap may be closer than 150mm to any part of the grid, when the TED is fitted to a codend hung vertically).

2.7 WILDLIFE INTERACTIONS

2.7.1 Interactions with protected species under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)

The then Minister for the Environment and Heritage accredited the Northern Prawn Fishery Management Plan 1995 (NPF Plan 1995), on 19 August 2003. Therefore, any operator that interacts with a protected species as listed in Part 13 of the EPBC Act 1999, and is acting in accordance with the NPF Plan 1995, will not commit an offence if their operations are consistent with the NPF Plan 1995. However, fishers are required to report all interactions with protected species. Failure to report an interaction with a protected species is an offence under the EPBC Act 1999.

Protected Species Identification Guide

To help operators accurately report their protected species interactions, AFMA has produced a protected species identification guide. This guide covers the range of protected species that AFMA managed fisheries do, or have the potential to, interact with during their normal fishing operations. The guide provides pictures of these species along with an indicative distribution and key biological information. All NPF boats have been provided with a copy of this identification guide – if you would like a copy, please contact the AFMA Environment Section, AFMA on 1300 723 621.

What is an interaction with a protected species?

"Interaction" means any physical contact an individual (person, boat or gear) has with a protected species that causes death, injury or stress to the individual directly resulting from fishing activities. This includes any collisions, catching hooking, and netting, entangling, or trapping of a protected species.

2.7.2 Reporting of interactions with protected species

There are currently two options for reporting interactions with protected species either to directly to the Department of Environment, Water, Heritage and the Arts (DEWHA) or to AFMA.

To DEWHA

Under the EPBC Act 1999, operators are required to report all physical interactions with protected species to DEWHA within seven (7) days of an interaction with a protected species by calling (free-call) 1800 641 806, or email protectedspecies@environment.gov.au. This reporting to DEWHA is required unless operators are participating in the reporting initiative as outlined below.

In the AFMA logbook

A Memorandum of Understanding (MoU) enabling operators to fulfil their reporting obligations under the EPBC Act 1999 by reporting through AFMA logbooks was established in 2005. Under the MoU AFMA provides a summary protected species interaction report to DEWHA on a quarterly basis on behalf of fishers. All concession holders were notified of this reporting arrangement and are reporting interactions to DEWHA via the AFMA logbooks.

Through participating in this reporting arrangement, operators only need to report protected species interactions once, to AFMA, through the Wildlife and Other Protected Species form in their logbook.

NPF operators are required to report interactions with protected species in logbook NP16 or the e-log. Operators who interact with a protected species are required to circle Yes in the box at the bottom of the logsheet and then fill out the Listed Marine and Threatened Species form. These forms are located at the back of the NP16 logbook and, once filled out, should be returned to AFMA within the specified timeframe.

Any operator who does not participate in the new reporting arrangements needs to continue to report protected species interactions separately to both AFMA via their logbooks and to DEWHA on the phone number listed above.

All interaction reports provided to DEWHA since 1 April 2006 to date are available on the AFMA website at: http://www.afma.gov.au/environment/eco_based/reporting.htm

2.7.3 Interactions with tagged wildlife

Researchers investigating some wildlife species will periodically tag animals or, in the case of seabirds, use bands to help better understand aspects of their biology and population status. In the case of protected wildlife, most of the follow-up sightings of the marked animals are made at haul out sites, rookeries or at breeding colonies. Researchers are therefore very interested in recoveries or observations of marked animals made by fishers, as they tend to be well away from colonies.

Operators who capture a tagged animal should record the details in the listed marine and threatened species form. The band or tag number should be inserted in the appropriate section of the form and the following details recorded in the Comments section:

- tag or band number and colour
- species identification or description (photos are very useful)
- size
- sex
- time, date and position of capture.

If the tagged animal is captured alive, operators should record as many details as possible about that animal then release it as carefully as possible, noting the condition in which it was released. AFMA will arrange to notify the appropriate researchers. Researchers are often prepared to provide people with feedback on tagged animals.

East Coast Trawl Fishery

Fisheries Act 1994

Fisheries (East Coast Trawl) Management Plan 1999

Part 4 Use of TEDs

Division 1 Preliminary

51 Application and purpose of pt 4

This part—

(a) applies if, under chapter 4, a TED must be used with a net used under a provision of that chapter; and

(b) prescribes an additional condition to which the licence under which the net is used is subject.

52 Purpose of TED

The purpose of a TED is to allow turtles to escape immediately after being taken in the net.

Division 2 TED use condition

53 Requirement to achieve purpose

(1) The licence under which the net is used is subject to a condition (the TED use condition) that the use of the net must achieve the purpose of a TED.

(2) The TED use condition also applies to anyone acting under the licence.

Division 3 Compliance with TED use condition

54 Compliance with TED use condition

The TED use condition is taken to have been complied with if a device that complies with section 55 (a recognised TED) is used with the net.

55 Requirements for a recognised TED

(1) A recognised TED for a net must consist of each of the following—

(a) a grid complying with subsection (2);

(b) an opening in the net (the escape hole) that—

(i) allows turtles to escape immediately after they are taken in the net; and

(ii) otherwise complies with subsection (3);

(c) either of the following covering the escape hole—

(i) a single flap complying with subsection (4);

(ii) a double flap complying with subsection (5);

(d) if the escape hole is in the bottom of the net, there must be attached to the grid—

(i) floats that are of a type, and are attached in a way, that comply with subsection (6); and

(ii) the number of floats required under subsection (7).

(2) The grid must—

(a) be at least 81cm wide and 81cm high; and

(b) have vertical bars, spaced no more than 12cm apart, extending from the top to the bottom of the net; and

(c) be constructed of rigid material; and

(d) be constructed as a single solid unit without any hinged or collapsible components; and

(e) be attached to the entire circumference of the net; and

(f) be installed and kept at an angle of between 30º and 55º in the net so that it is inclined towards the escape hole.

(3) The escape hole must consist of either—

(a) the following cuts—

(i) a horizontal cut that is—

(A) at the trailing edge of the escape hole and immediately in front of and parallel to the trailing edge of the grid; and

(B) no less than 61cm wide; and

(C) no narrower than the grid, other than for 10cm at either side of the grid;

(ii) 2 cuts each of which is—

(A) in front of and perpendicular to the trailing edge of the grid; and

(B) of equal length; and

(C) no less than 66cm long if the escape hole is covered with a single flap, or no less than 51cm long if the escape hole is covered with a double flap;

(iii) a leading edge cut that, when the net is stretched, is no less than—

(A) 181cm, if the escape hole is covered with a single flap; or

(B) 142cm, if the escape hole is covered with a double flap; or

(b) the following cuts—

(i) a horizontal cut that is—

(A) at the trailing edge of the escape hole and immediately in front of and parallel to the trailing edge of the grid; and

(B) no less than than 102cm wide;

(ii) 2 all bar cuts that—

(A) are each of equal length and no less than 136cm long; and

(B) taper from each end of the horizontal cut mentioned in subparagraph (i) to where they meet.

(4) A single flap—

(a) must—

(i) be on the outside of the net; and

(ii) have a mesh size of no more than 50mm; and

(b) must consist of 1 rectangular panel—

(i) that is no less than 338cm by 132cm; and

(ii) the longer edge of which is attached to the net in front of the leading edge of the escape hole; and

(iii) that does not overlap the escape hole by more than 13cm on either side; and

(iv) that is not sewn down the outside edges more than 15cm past the trailing edge of the grid; and

(v) the trailing edge of which does not extend more than 61cm behind the trailing edge of the grid.

(5) A double flap—

(a) must—

(i) be on the outside of the net; and

(ii) have a mesh size of no more than 50mm; and

(b) must consist of 2 rectangular panels—

(i) that are of equal size; and

(ii) that are each no less than 147cm wide; and

(iii) that do not overlap by more than 38cm; and

(iv) that are sewn together only along the leading edges of the panels; and

(v) that are attached to the net in front of the leading edge of the escape hole; and

(vi) the trailing edges of which do not extend more than 61cm behind the trailing edge of the grid.

(6) A float must—

(a) be attached—

(i) to the top half of the grid; and

(ii) inside or outside the net but not to a flap; and

(b) if it is attached inside the net, be attached behind the grid; and

(c) be made of—

(i) aluminium; or

(ii) ethylene vinyl acetate (EVA); or

(iii) hard plastic; or

(iv) polyvinyl chloride (PVC); and

(d) if it is made of EVA or PVC—

(i) be at least 22cm long; and

(ii) have a diameter of at least 17.2cm; and

(e) if it is made of aluminium or hard plastic, have a diameter of at least 25cm.

(7) There must be attached to the grid—

(a) if the grid has a circumference of no more than 305cm—at least 1 float; or

(b) if the grid has a circumference of more than 305cm, either—

(i) at least 2 floats made of EVA or PVC; or

(ii) at least 1 float made of aluminium or hard plastic.

(8) In this section— all bar cut means a cut through parallel opposing bars in a row of meshes.

behind, in relation to a part of a net, means away from the front opening of the net.

front opening, of the net, means the opening through which fish enter the net.

in front of, in relation to a part of a net, means towards the front opening of the net.

leading edge means the edge nearest to the front opening of the net.

trailing edge means the edge furthest from the front opening of the net.

Western Tuna and Billfish Fishery

Western Tuna and Billfish Fishery Management Plan 2005

Part 2 Specific ecosystem requirements
9 By-catch (Act s 17 (6D))
(1) AFMA must prepare and implement a by-catch action plan, or by-catch action plans, for the fishery.
(2) AFMA must review each by-catch action plan at least once every second year, while it is in force.
(3) A by-catch action plan must require action to ensure that:
(a) information is gathered about the impact of the fishery on by-catch species; and
(b) all reasonable steps are taken to minimise interactions with seabirds, marine reptiles, marine mammals and fish of a kind mentioned in sections 15 and 15A of the Act; and
(c) the ecological impacts of fishing operations on habitats in the area of the fishery are minimised and kept at an acceptable level; and
(d) by-catch is reduced to, or kept at, a minimum, and below a level that might threaten by-catch species.
(4) In developing a by-catch action plan, AFMA must take into account:
(a) the protection given to whales and other cetaceans under Division 3 of Part 13 of the EPBC Act; and
(b) the requirements under the EPBC Act for the protection of:
(i) listed threatened species; and
(ii) listed threatened ecological communities; and
(iii) listed migratory species; and
(iv) listed marine species; within the meanings given in that Act.
(5) If information gathered under a by-catch action plan shows it is necessary to do so, AFMA must consider making appropriate amendments to this Management Plan or changes to the conditions imposed on the holders of fishing concessions.

Resolution 09/06 on marine turtles (IOTC 2010b)

RESOLUTION 09/06 ON MARINE TURTLES
The Indian Ocean Tuna Commission (IOTC),
RECALLING Recommendation 05/08 On Sea Turtles;
AWARE that the populations of the six species of marine turtles under 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) are listed as vulnerable, endangered or critically endangered on the IUCN - The World

Conservation Union Red List of Threatened Species;

RECOGNISING that the 26th FAO-COFI Session in March 2005 adopted the Guidelines to Reduce Sea Turtle Mortality in Fishing Operation (hereinafter referred to as “the FAO Guidelines”) and recommended their implementation by regional fisheries bodies and management organizations;

RECOGNISING that some fishing operations carried out in the Indian Ocean can adversely impact marine turtles and the need to implement measures to manage the adverse effects of fishing in the Indian Ocean on marine turtles;

ACKNOWLEDGING the activities undertaken to conserve marine turtles and the habitats on which they depend within the framework of the IOSEA MoU in particular its Resolution to Promote the Use of Marine Turtle Bycatch Reduction Measures by IOSEA Signatory States adopted by the Fifth Meeting of the Signatory States.

NOTING the Scientific Committee‟s concern that the expansion of gillnet fishing from traditional fishing grounds into high seas might increase the interaction with marine turtles and lead to increased mortality;

FURTHER NOTING the Scientific Committee‟s adoption of a status report on marine turtles at its eleventh session and its finding that there is an urgent need to quantify the effects of Indian Ocean fisheries on non-target (bycatch) species and to develop mitigation measures to reduce adverse effects on these species;

ADOPTS in accordance with paragraph 1 of Article IX of the IOTC Agreement, that:

1. Contracting Parties and Cooperating non-Contracting Parties (hereinafter referred to as “CPCs”) will implement, as appropriate, the FAO Guidelines.

2. CPCs shall collect (including through logbooks and observer programs) and provide to the Scientific Committee all data on their vessels‟ interactions with marine turtles in fisheries targeting the species covered by the IOTC Agreement. CPC shall also furnish available information to the Scientific Committee on successful mitigation measures and other impacts on marine turtles in the IOTC Area, such as the deterioration of nesting sites and swallowing of marine debris.

3. CPCs shall report to the Commission, in accordance with Article X of the IOTC Agreement, their progress of implementation of the FAO Guidelines and this Resolution.

4. CPCs shall require fishermen on vessels targeting species covered by the IOTC Agreement to bring aboard, if practicable, any captured hard shelled turtle that is comatose or inactive as soon as possible and foster its recovery, including aiding in its resuscitation, before safely returning it to the water. CPCs shall ensure that fishermen are aware of and use proper mitigation and handling techniques and keep on board all necessary equipment for the release of turtles, in accordance with guidelines to be adopted by the IOTC.

5. CPCs with gillnet vessels that fish for species covered by the IOTC Agreement shall:
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(a) Require that operators of such vessels record all incidents involving marine turtles during fishing operations in their logbooks1 and report such incidents to the appropriate authorities of the CPC;

1 This information should include, where possible, details on species, location of capture, conditions, actions taken on board and location of release

2 This information should include, where possible, details on species, location of capture, conditions, actions taken on board and location of release

3 This information should include, where possible, details on species, location of capture, conditions, actions taken on board and location of release

(b) Provide the results of the reporting under paragraph 5(a) to the Commission as part of the reporting requirement of paragraph 2.

6. CPCs with longline vessels that fish for species covered by the IOTC Agreement shall:

(a) Ensure that the operators of all longline vessels carry line-cutters and dehookers in order to facilitate the appropriate handling and prompt release of marine turtles caught or entangled, and that they do so in accordance with IOTC Guidelines to be developed. CPCs shall also ensure that operators of such vessels are required to carry and use, where appropriate, dip-nets, in accordance with guidelines to be adopted by the IOTC;

(b) Encourage the use of whole finfish bait where appropriate;

(c) Require that operators of such vessels record all incidents involving marine turtles during fishing operations in their logbooks2 and report such incidents to the appropriate authorities of the CPC;

(d) Provide the results of the reporting under paragraph 6(c) to the Commission as part of the reporting requirement of paragraph 2.

7. CPCs with purse seine vessels that fish for species covered by the IOTC Agreement shall:

(a) Ensure that operators of such vessels, while fishing in the IOTC Area:

(i) To the extent practicable, avoid encirclement of marine turtles, and if a marine turtle is encircled or entangled, take practicable measures to safely release the turtle.

(ii) To the extent practicable, release all marine turtles observed entangled in fish aggregating devices (FADs) or other fishing gear.

(iii) If a marine turtle is entangled in the net, stop net roll as soon as the turtle comes out of the water; disentangle the turtle without injuring it before resuming the net roll; and to the extent practicable, assist the recovery of the turtle before returning it to the water.

(iv) Carry and employ dip nets, when appropriate, to handle turtles.

(b) Encourage such vessel to adopt FAD designs which reduce the incidence of entanglement of turtles;

(c) Require that operators of such vessels record all incidents involving marine turtles during fishing operations in their logbooks3 and report such incidents to the appropriate authorities of the CPC;

(d) Provide the results of the reporting under paragraph 7(c) to the Commission as part of the reporting requirement of paragraph 2.

8. All CPCs are requested to:

(a) Where appropriate undertake research trials of circle hooks, use of whole finfish for bait, alternative FAD designs, alternative handling techniques, gillnet design and fishing practices and other mitigation methods which may improve the mitigation of adverse effects on turtles; Collection of Resolutions and Recommendations

Appendix 5 Anthropogenic Impacts

Leatherback turtle

Known, predicted or estimated leatherback turtle mortality from anthropogenic activities. Sourced, unless otherwise referenced, from Limpus (2009). Detailed information in Limpus (2009) (* depicts an activity that may no longer occur)

Activity	Location	Known, predicted or estimated mortality	Information
Australian commercial harvest (now illegal)			
No evidence			
Australian indigenous harvest			
Meat	Qld	Estimate 1 every 10 years	
Eggs/hatchlings	Qld	Probably none	Probably none in last decade
NPF	WA/NT/Qld	Probably none	Reports of one in 1972 and one in 1997 – both alive 1 in 2000
Torres Strait Prawn Trawl Fishery (pre and post-TED)	Qld	Probably none	None reported from 1991 - 1996
ECTF	Qld	Probably none	1 reported caught from 1991 - 1996
WA Trawl	WA	Unquantified. 1 reported death.	
ETBF	Qld	Very few deaths or probably none	Estimate 156 caught (07/04 – 06/05) Estimate 94 caught (07/05 – 06/06)
WTBF	WA	Probably none	Few interactions due to low effort
Barramundi Gillnet Fishery	SE Gulf of Carpentaria	Probably few deaths	Regular catches but unquantified (data from early 1990s)
*Taiwanese Gillnet Fisheries (Same type of fishery continues in Indonesian waters)	Arnhem Land coast	Probably some deaths (56% mortality pooled for all species)	1 leatherback turtle out of 16 turtles captured over 4 months (1985 - 1986)
WA Herring Net Fishery	WA	Unquantified	Reported bycatch but unquantified
*Drifting gillnets	TAS	Unquantified	Estimate 800 interactions from 1936 - 1986
Crab Fisheries	Qld	Unquantified. Report of 2 deaths in 14 years (1990 - 2003).	Unquantified buoy line entanglement

Rock Lobster Fishery	WA	Unquantified	Unquantified buoy line entanglement
Rock Lobster Fishery	Tas, SA and Vic	Unquantified. Est. 25% death rate	Unquantified buoy line entanglement
Various other international fisheries			
Other activities			
Boat strike		Unquantified. Report of 1 death in QLD in 14 years (1990 - 2003). Some deaths in WA	Unquantified number of interactions
Shark Control Program	Qld	Est. 1 death every 4 years Drum-line hooks - no mortality	Report of 3 caught in 8 years, 6 on drum-line hooks – alive (1996 - 2004)
Shark Control Program	Qld and NSW	Estimate 1 death every 3 years	Data from late 80s to early 90s
Pollution and disease			
Marine debris	Qld	1 known death (1990 - 2003) in Qld.	Unquantified
Marine debris		Unquantified but considered significant	Ingested marine rubbish, entanglement, plastic bags, balloons, unspecified plastic Ceccarelli (2009)
Diseases		Unquantified	
Harvesting in neighbouring countries			
*Egg harvesting and bycatch (rare nesting occurs)	Terengganu Peninsular, Malaysia. From the late 1950s		Were over 3000 nesters/year in late 60s. Less than 20 nesters/year by 1993. Only two or three nesters to 2001. (Liew 2006) Now none.
Egg harvesting and nest predation by pigs	Indonesia Northwestern West Papua	In decline	Were over 1000 nesting females/year
Egg harvesting	Java and Sumatra	Near total egg harvest	
Traditional fishery for adults	Kai and Aru Islands, E Indonesia	Estimate 100's per year	Adult harvest
Harvesting of eggs and adults	Papua New Guinea, Solomon Islands	Fewer nesting females in the early 1980s than before, adult take rare	Intense traditional and commercial egg harvest

Hawksbill turtle

Known, predicted of estimated hawksbill turtle mortality from anthropogenic activities. Sourced, unless otherwise referenced, from Limpus (2009). Detailed information in Limpus (2009) (* depicts an activity that no longer occurs).

Activity	Location	Known, predicted or estimated mortality	Information
Australian commercial harvest (now illegal)			
*Malay trade in tortoiseshell	Arnhem Land	Estimate over 1000 adults annually	Estimate over a ton of tortoiseshell exported annually from 17th and 18th centuries
*European trade in tortoiseshell	Torres Strait	Estimate over 1000 adults annually	Estimate over a ton of tortoiseshell exported annually from late 1700s to 1930s
*Tortoiseshell trade with visiting ship	Cocos (Keeling) Islands in the Atlantic Ocean	Unquantified but there was a significant depletion of stocks	Unquantified (19th and early 20th centuries)
*Tortoiseshell trade	WA	Unquantified	Unquantified (but surprising if it didn't occur)
Australian indigenous harvest			
Tortoiseshell, meat and eggs	Traditionally hunted for centuries. Meat can be toxic (fatal)	Unquantified	Widespread but unquantified
Meat	Northern Australia	Unquantified	Unquantified
Meat	Torres Strait (TS)	Estimate 50 per year	Estimate 50 per year (data from 1991 - 1992)
Meat	Qld (incl. TS)	Estimate 50 to 100 per year	Estimate 50 to 100 per year
Eggs	Qld	Probably hundreds of clutches	Substantial but unquantified egg harvesting
Eggs	Arnhem Land	Expected to be comparable to QLD egg harvest	Unquantified
Eggs	WA	Unknown	Not featured prominently in any reports of indigenous harvest of turtles and/or eggs
Bycatch in commercial fisheries			
Gillnet Fisheries	Northern Australia	Not quantified	Not quantified but evidence exists that interactions occur
*Taiwanese Gillnet Fisheries (Same type of fishery continues in	Arnhem Land coast	Prob. some deaths (56% mortality pooled for all species)	6 hawksbill turtles out of 16 turtles captured over 4 months (1985 - 1986)

Indonesian waters)			
Individual Fisher - Inshore N3 Gillnet Fishery	SE Gulf of Carpentaria	Expect low mortality	2 hawksbill turtles from 47 turtles caught and tagged in 1993
*Shark Gillnet Fishery (bottom set gillnet)	Fog Bay NT	Unquantified. Report. 3 drowned	Estimate 300 turtles drowned (1% hawksbill turtle*)* over 15 days in 1991
Net Fisheries	VIC	Unquantified	Unconfirmed reports of interactions with immature hawksbill turtles
*NPF (pre-TED)	WA/NT/Qld	Estimate 22 per year	2% hawksbill turtles of 5000 turtles caught annually (est. 100)
NPF (post-TED)	WA/NT/Qld	Probably none	Less than 200 turtles (all species)
*ECTF (pre-TED)	Qld	Estimate 10 per year	1.5% hawksbill turtles of 5900 turtles caught annually (est. 80) (data from 1991 - 1996)
ECTF (post-TED)	Qld	Probably none	Over 95% reduction
*Torres Strait Prawn Fishery (pre-TED)	Qld	Estimate less than 1 per year	1.3% of 151 turtles caught (data from 1991 - 1996)
ETBF and WTBF	Qld/WA	Few deaths, Probably none	Small number caught
Pacific longline fisheries		Data poor, Expect some deaths	Data poor, Expect some catches
Various other international fisheries			
Other activities			
Boatstrike		Unquantified	Boat strike /propeller cuts
Shark Control Program	Qld	Report of 5 deaths in 11 years (1993 - 2004)	Immature turtles captured -rare
Recreational fishing and sporting activities	Qld	Estimate few 10's of mostly immature hawksbill turtle	Ingested hooks and line (4), trapped inside wide-opening, collapsible crab traps (2) (1995 - 2003)
Seismic Surveys		Unquantified	Expected to impact on turtle breeding and nesting
Nuclear testing on nesting habitat	Trimouille Island, Montebello Group WA	Unquantified – 'dead turtles piled 3 or 4 deep across the width and length of two 500m beaches' (sailor)	In 1952 and twice in 1956 nuclear testing probably caused the largest localised kill of marine turtles from human activities in Australia's history. The impact would have continued for many years with radiation poisoning to breeding adults and hatchlings (green turtles, flatback turtles and hawksbill turtles)
Oil and gas industry infrastructure	Especially Northwest shelf WA	Unquantified	Impact of burn-off flares, loading facilities, exploration and production platforms unknown
Port development and dredging			Foraging ground disturbance, boat strike, pollution
Disorientation from altered light horizons (coastal development)		Unquantified	Hatchlings killed after heading towards light source and away from the ocean

Disorientation from altered light horizons (light from anchored boats infrastructure)		Unquantified	Traps hatchlings in light and predation increases
Disorientation from altered light horizons (oil and gas industry)		Unqualifies	Impacts hatchlings and repeals nesters
Feral animal predation on eggs and hatchlings		Unquantified	Dogs, foxes and pigs
Coastal development and tourism			Vehicles on beaches, disturbance of nesting females by people and domestic dogs, beach activities, boat strike, sewage, run-off, pollution
Pollution and disease			
Marine debris	Qld	Estimate few 10's per year. Of the 115 turtles (all species) necropsied in Moreton Bay, Qld (2006 – 2011) around 30% were considered to have died as a result of rubbish in gestion and 6% as a result of entanglement (UQ data).	Fishing line entanglement (3), frayed sack entanglement (1); Ingested synthetic material (3); Tyre entrapment (1) (1995 - 2000)
Marine debris		Unquantified but considered significant	Ingested marine rubbish, entanglement, plastic bags, balloons, unspecified plastic Ceccarelli (2009)
Ghost nets		Unquantified	Entanglement (primarily foreign nets) Ceccarelli (2009)
Disease		Unquantified	Limited studies
Fluke infection	SE Qld and Fog Bay NT	Unquantified	A high frequency of fluke infection has been associated with debilitated but uninjured hawksbill turtle
Fibropapilloma	Qld Moreton Bay	Unquantified	Low frequency of fibropapilloma disease tumours on foraging hawksbill turtles (9% of 34 turtles examined)
Harvesting in neighbouring countries			
Tortoiseshell	Papua New Guinea	Unquantified	Low intensity but wide spread harvest
Tortoiseshell	Daru area of Western Province	Estimate 20 - 100 deaths per year	Data from mid-1980s
Tortoiseshell	Solomon Islands/Fiji	Estimate many 1000's	Annual harvest
Tortoiseshell	Fiji	Estimate 2000 per year	Annual harvest in 1994
Tortoiseshell	Indonesia	Estimate 20 000 per year	Annual harvest in the mid-1980s

Loggerhead turtle

Known, predicted or estimated loggerhead turtle mortality from anthropogenic activities. Sourced, unless otherwise referenced, from Limpus (2009). Detailed information in Limpus (2009) (* depicts an activity that no longer occurs).

Activity	Location	Known, predicted or estimated mortality	Information
Australian commercial harvest (now illegal)			
*No harvesting since 1970s			
Australian indigenous harvest			
Meat	WA		Insignificant
Meat	Qld	Unquantified	Occasional. 1 per year from tagged animals (data 1968 - 1993)
*Eggs/hatchlings	Qld	Unquantified	Low level harvest to 1970s
Bycatch in commercial fisheries			
Tunnel nets	Qld Moreton Bay	No mortality	Interact with 1000's
*Individual Shark Fisher (bottom set gillnet)	Fog Bay NT, 1991	Unquantified. Report. 3 drowned in 1991	Est 300 turtles drowned annually (1% hawksbill turtle)
*NPF (pre-TEDs)	WA/NT/Qld	Estimate 66 per year	6% loggerhead turtles of 5000 turtles caught annually(est. 300)
NPF (post-TED)	WA/NT/Qld	Probably none or very few	Less than 200 turtles annually (all species)
*ECTF (pre-TED)	Qld	Estimate 150 per year	50% loggerhead turtles of 5900 turtles caught annually (est. 2950) (data from 1991 - 1996)
ECTF (post-TED)	Qld	Probably none or very few	Over 95% reduction
ETBF	Qld	Few deaths	Small number caught
WTBF	WA	Few deaths. Probably none	Few interactions due to low effort
*Shark Gillnet Fishery (bottom set gillnet)	Fog Bay NT	Unquantified.	Est. 300 turtles drowned (15 loggerhead turtles) over 15 days in 1991
Trawl fisheries	WA and Torres Strait	Unquantified	Unquantified but much less since TEDs used
Trawl fisheries	NSW	Unquantified	Unquantified
Oceanic fisheries	South Pacific and Indian Ocean	Unquantified but predicted substantial	Unquantified
*Crab fisheries deliberate	Qld	Unquantified	Circumstantially linked to fishery in 1980s and early 1990s

killing			
Crab fisheries	Qld	Estimate 2.5 adult and large immature loggerhead turtles/year	Entanglement in buoy lines and dillies (data from 1998 - 2002)
Cray Pot Fishery	Sth WA	Unquantified but predict few deaths	Small numbers killed by entanglement in float lines
Various other international fisheries			
Other activities			
Boat Strike		Unquantified. Minimum 8 killed per year (1998 - 2002) in Qld	13% - 50% of loggerhead turtles have evidence of fractures to shell (1998 - 2002)
*Shark Control Program	Qld	Estimate 14 deaths per year	586 captured (all species) (data from 1986 - 1992)
*Shark Control Program	Qld	90% released alive	Estimate 3/year (data from 1992/3 – 1995)
Shark Control Program	Qld	Mortality rate 0.6/year	232 captured (data from 1998 - 2002)
Shark Control Program	NSW	Probably none	0 - 5 turtles (all species) per year
Seismic Surveys		Unquantified	Unknown but expected to impact on turtle breeding and nesting
Oil and gas industry infrastructure		Unquantified but significant	Significant impact of operations – light horizon disorientation, nesting beach disturbance, foraging ground disturbance, boat strike, pollution impact
Port development and dredging		Unquantified. Ave. 1.7 loggerhead turtles reported as killed/year in Qld	Foraging ground disturbance, boat strike, pollution. Unquantified interactions (data from 1999 - 2002)
Disorientation from altered light horizons (coastal development)		Unquantified	Disoriented hatchlings have been regularly found in Qld. Hatchlings killed after heading towards light source and away from the ocean
Disorientation from altered light horizons (light from anchored boats infrastructure)		Unquantified	Traps hatchlings in light and predation increases
Disorientation from altered light horizons (oil and gas industry)		Unquantified but considered significant	Impacts hatchings and repeals nesters
Feral animal predation on eggs and hatchlings			Dogs, foxes and pigs
Coastal development and tourism		Unquantified	Vehicles on beaches, disturbance of nesting females by people and domestic dogs, beach activities, boat strike, sewage, run-off, pollution

Pollution and disease			
Marine debris	Qld	Estimate 6.5/year killed in Qld. Of the 115 turtles (all species) necropsied in Moreton Bay, Qld (2006 – 2011) around 30% were considered to have died as a result of rubbish in gestion and 6% as a result of entanglement (UQ data).	Ave. 5/year, rope, fishing line, bag entanglement. Ave.1.5/year ingestion of synthetic material, usually fishing line (data from 1999 - 2002)
Marine debris		Unquantified but considered significant	Ingested marine rubbish, entanglement, plastic bags, balloons, unspecified plastic Ceccarelli (2009)
Ghost nets		Unquantified	Entanglement (primarily foreign nets) Ceccarelli (2009)
Disease		Unquantified	No reports of diseases causing significant mortality
Harvesting in neighbouring countries			
Meat	In Australian and overseas	Estimate 40/year	From modelling using tagging data
Meat	South Pacific	Probably very low	Uncommon

Green turtle

Known, predicted or estimated green turtle mortality from anthropogenic activities. Sourced, unless otherwise referenced, from Limpus (2009). Detailed information in Limpus (2009) (* depicts an activity that no longer occurs).

Activity	**Location**	**Known, predicted or estimated mortality**	**Information**
Australian commercial harvest (now illegal)			
*Turtle soup cannery and meat for domestic and export to England. Maybe 1863 -1968	Qld (Factories in Brisbane, Heron Island, North West Island)	Many thousands annually	Commercial harvest from 1863 to 1959. For example, 8472 Southern GBR females were harvested from 1924 - 1930
*Turtle soup manufacture	Sydney	Unquantified	2 months in 1959, app.1200 nesting females were harvested from the Northern GBR
*Turtle farming for meat and soup (1970 - 1980)	Torres Strait	Unquantified number of turtles and eggs sourced from the wild	Reported 2000 turtles and 7000 hatchings in farm – some eggs from doomed nests and some turtles released after closing
*Live turtles harvest for meat	WA	Extensive harvesting live meat trade	Unquantified. For example, in August 1840, there were 70 adult turtles taken from Barrow Island
*Turtle soup cannery and meat (domestic and export to England)	WA (Factories in Perth and Cossack)	Many thousands annually	Commercial harvest ceased in 1973. For example, one cannery took 2 500 large green turtles annually. Government figures quote 4431 turtles taken in 1964
*Turtle skin leather for European and Japanese trade	WA	Byproduct of meat trade	Operated during 1960s and 1970s
*Turtle farming (Early 1970s- mid 1970s)	WA	Unquantified number of turtles and eggs sourced from the wild	Unquantified
Australian indigenous harvest			
Eggs	Qld Torres Strait	Unquantified	Known to occur
Eggs	NT	Unquantified	Known to occur
Meat	Qld South of Cape Melville	Estimate 500 - 1000 per year	Target adult females
Meat	Qld Lockhart River	Estimate 100 per year	Target adult females
Meat	Qld Torres Strait	Estimate 4000 per year	Target adult females

Meat	Qld West Cape York and Gulf of Carpentaria	Unquantified	Known to occur
Meat	NT	Estimate 480 per year	Target adult and large immature females
Meat	WA	Estimate several thousand per year	Target adult and large immature females
Adults for meat and females killed for eggs by Indonesian fishers	Northern Australian waters	Unquantified	Sometimes eggs are removed from females with meat not utilised
Bycatch in commercial fisheries			
Tunnel Nets	Qld Moreton Bay	No mortality	Interact with 1000’s
*NPF (pre-TEDs)	WA/NT/Qld	Estimate 33 per year	3% green turtles of 5000 turtles caught annually (est. 150)
NPF (post-TED)	WA/NT/Qld	Probably none or very few	Less than 200 turtles annually (all species)
*ECTF (pre-TED)	Qld	Estimate 100 per year	27% green turtles of 5900 turtles caught annually (est. 1600) (data from 1991 - 1996)
ECTF (post-TED)	Qld	Probably none or very few	Over 95% reduction
ETBF	Qld	Few deaths	Small number caught
WTBF	WA	Few deaths. Probably none	Low numbers due to low effort
Trawl Fishery	NSW	Unquantified	
Gillnet Fisheries	Qld/NT	Unquantified	Known impact
Crab Fisheries (incl recreational)	Qld	Unquantified	Entanglement in pot lines and drowning in collapsible crab pots
Various other international fisheries			
Other activities			
Shark Control Program	Qld	Estimate 2.7 per year	91% released alive from drum lines and 52% released alive from nets
Shark Control Program	NSW	0 - 5 per year for all species	Considered negligible
Seismic surveys		Unquantified	Unknown but expected to impact on turtle breeding and nesting
Nuclear testing on nesting habitat	Trimouille Island, Montebello Group WA	Unquantified – ‘dead turtles piled 3 or 4 deep across the width and length of two 500m beaches’ (sailor)	In 1952 and twice in 1956 nuclear testing probably caused the largest localised kill of marine turtles from human activities in Australia’s history. The impact would have continued for many years with radiation poisoning to breeding adults and hatchlings (green turtles, flatback turtles and hawksbill turtles)

Oil and gas industry infrastructure		Unquantified but significant	Significant impact of operations – light horizon disorientation, nesting beach disturbance, foraging ground disturbance, boat strike, pollution impact
Port development and dredging		Unquantified	Foraging ground disturbance, boat strike, pollution disturbance
Boat Strike		Many 10's per year in Qld	60% adult-sized in Qld
Disorientation from altered light horizons (coastal development)		Unquantified	Disoriented hatchlings have been regularly found in Qld. Hatchlings killed after heading towards light source and away from the ocean
Disorientation from altered light horizons (light from anchored boats infrastructure)		Unquantified	Traps hatchlings in light and predation increases
Disorientation from altered light horizons (oil and gas industry)		Unquantified but considered significant	Production areas are coincident with one of the world's largest green turtle nesting populations. Impacts hatchlings and repeals nesters
Feral animal predation on eggs and hatchlings		Unquantified	Dogs, foxes and pigs
Coastal development and tourism		Unquantified	Vehicles on beaches, disturbance of nesting females by people and domestic dogs, beach activities, boat strike, sewage, run-off, pollution
Pollution and disease			
Ghost nets		Unquantified	Entanglement (primarily foreign nets) Ceccarelli (2009)
Marine debris		Estimate 10's of turtles annually in Qld, Unquantified. Of the 115 turtles (all species) necropsied in Moreton Bay, Qld (2006 – 2011) around 30% were considered to have died as a result of rubbish in gestion and 6% as a result of entanglement (UQ data).	Ingested marine rubbish, entanglement, plastic bags, balloons, unspecified plastic Ceccarelli (2009)
Coccidiosis	SE Qld	Over 70 turtles died in 1991. Deaths continue	Possibly as a result of environmental contamination
Fibropapilloma-Associated Turtle Herpes Virus		Unquantified	Beach-washed, dead or moribund, infected individuals often encountered

Parasitic worms (Blood Fluke)			Heavily infected beach-washed, dead or moribund individuals often encountered (may not be anthropogenic related)
Harvesting in neighbouring countries			
Meat	New Caledonia, Fiji, Vanuatu	Estimate 500 - 1000 per year of southern GBR stock. Few from northern GBR stock	
Meat	Papua New Guinea – Torres Strait (NE Torres Strait Protected Zone)	Estimate 953 – 1363 per year. Estimate 2000 - 2600 per year	Kiwai people: data from 1985 - 1987 show lower harvest. Later study estimate is doubled
Meat	Papua New Guinea (all other regions)	Unquantified	Turtles are sold in most coastal markets
Meat	Indonesia	50 000+/year harvested in the 1980s	Decreased significantly as green turtles were listed as protected in 2001

Flatback turtles

Known, predicted or estimated flatback turtle mortality from anthropogenic activities. Sourced, unless otherwise referenced, from Limpus (2009). Detailed information in Limpus (2009) (* depicts an activity that no longer occurs).

Activity	**Location/**	**Known, predicted or estimated mortality**	**Information**
Australian commercial harvest (now illegal)			
No evidence			
Australian indigenous harvest			
Meat	Qld and NT	Unquantified	Occasional adult harvest
Eggs	Qld and NT	Unquantified	Known to occur
Meat and eggs	WA	Unquantified	Harvesting not identified as significant
Bycatch in commercial fisheries			
*NPF (pre-TEDs)	WA/NT/Qld	Est. 660 per year	60% flatback turtles of 5000 turtles caught annually (est. 3000)
NPF (post-TED)	WA/NT/Qld	Probably none or very few	Less than 200 turtles annually (all species)
*ECTF (pre-TED)	Qld	Est. 40 per year	16% flatback turtles of 5900 turtles caught annually (est. 94) (data from 1991 - 1996)
ECTF (post-TED)	Qld	Probably none or very few	Over 95% reduction
*Shark Gillnet Fishery (bottom set gillnet)	Fog Bay NT	Unquantified	Estimate 300 turtles drowned (24 flatback turtles*)* over 15 days in 1991
Gill Net fisheries	Qld and NT	Unquantified	Known to occur
*Torres Strait Trawl Fishery (pre-TED)	Qld	Estimate 4 mortalities per year	Est. interaction with 400 flatback turtles per year (data from 1991 - 1996)
Torres Strait Trawl Fishery (post-TED)	Qld	Probably none	Unquantified

*Taiwanese Gillnet Fisheries (Same type of fishery continues in Indonesian waters)	Arnhem Land coast	Probably some deaths (56% mortality pooled for all species)	4 flatback turtles out of 16 turtles captured over 4 months (1985 - 1986)
Other activities			
Shark Control Program	Qld	Estimated less than one annually. Report of one mortality.	Rarely captured. 4 flatback turtles captured from 1996/97 o 2002/03.
Shark Control Program	NSW	No evidence	No captures recorded
Seismic surveys		Unquantified	Unknown but expected to impact on turtle breeding and nesting
Nuclear testing on nesting habitat	Trimouille Island, Montebello Group WA	Unquantified – 'dead turtles piled 3 or 4 deep across the width and length of two 500m beaches' (sailor)	In 1952 and twice in 1956 nuclear testing probably caused the largest localised kill of marine turtles from human activities in Australia's history. The impact would have continued for many years with radiation poisoning to breeding adults and hatchlings (green turtles, flatback turtles and hawksbill turtles)
Oil and gas industry infrastructure		Unquantified but significant	Significant impact of operations build on rookeries – light horizon disorientation, nesting beach disturbance, foraging ground disturbance, boat strike, pollution impact
Port development and dredging		Unquantified	Foraging ground disturbance, boat strike, pollution disturbance
Boat strike		Unquantified. Three reported dead (1995 - 2003) in Qld	Unquantified injury and death
Disorientation from altered light horizons (coastal development)		Unquantified	Hatchlings killed after heading towards light sources and away from the ocean
Disorientation from altered light horizons (light from anchored boats infrastructure)		Unquantified	Traps hatchlings in light and predation increases
Disorientation from altered light horizons (oil and gas industry)		Unquantified but considered significant	Impacts hatchlings and repeals nesters

Feral animal predation on eggs and hatchlings		Unquantified	Dogs, foxes and pigs
Coastal development and tourism		Unquantified	Vehicles on beaches, disturbance of nesting females by people and domestic dogs, beach activities, boat strike, sewage, run-off, pollution
Pollution and disease			
Marine debris		Unquantified but considered significant. Of the 115 turtles (all species) necropsied in Moreton Bay, Qld (2006 – 2011) around 30% were considered to have died as a result of rubbish in gestion and 6% as a result of entanglement (UQ data).	Ingested marine rubbish, entanglement, plastic bags, balloons, unspecified plastic Ceccarelli (2009)
Marine debris	NT	Unquantified. One reported dead.	Plastic ingestion
Ghost Nets		Unquantified	Entanglement (primarily foreign nets) Ceccarelli (2009)
Diseases		Unquantified	No reports of mortality from anthropogenic origins, but very limited pathology studies
Harvesting in neighbouring countries			
Meat	Southeast Papua coastal villages	Unquantified	Evidence that it exists

Olive ridley turtle

Known, predicted or estimated olive ridley turtle mortality from anthropogenic activities. Sourced, unless otherwise referenced, from Limpus (2009). Detailed information in Limpus (2009) (* depicts an activity that no longer occurs).

Activity	**Location**	**Known, predicted or estimated mortality**	**Information**
Australian commercial harvest (now illegal)			
No evidence			
Australian indigenous harvest			
Meat	Qld and NT	Unquantified	Known to occur
Eggs	Qld and NT	Unquantified	Known to occur
Bycatch in commercial fisheries			
*NPF (pre-TEDs)	WA/NT/Qld	Est. 350 per year	30% olive ridley turtles of 5000 turtles caught annually (est. 1500) (data from 1998 - 1999)
NPF (post-TED)	WA/NT/Qld	Probably none	Less than 200 turtles annually (all species)
*ECTF (pre-TED)	Qld	Estimate 10 per year	6% olive ridley turtles of 5900 turtles caught annually (est. 350) (data from 1991 - 1996)
ECTF (post-TED)	Qld	Probably none	Over 95% reduction
*Shark Gillnet Fishery (bottom set gillnet)	Fog Bay NT	Unquantified	Est. 300 turtles drowned (250 olive ridley turtles) over 15 days in 1991
*Torres Strait Trawl Fishery (pre-TED)	Qld	Unquantified	Est. interaction with 18 olive ridley turtles per year (data from 1991 - 1996)
Torres Strait Trawl Fishery (post-TED)	Qld	Probably none	Unquantified
Various other international fisheries			
Other activities			
Shark control program	Qld	Unquantified.	Report 3 olive ridley turtles caught in mesh nets between 1996/97 and 2002/03.

Seismic surveys		Unquantified	Unknown but expected to impact on turtle breeding and nesting
Oil and gas industry infrastructure		Unquantified	Nesting beach disturbance, foraging ground disturbance, boat strike, pollution impact
Port development and dredging		Unquantified	Foraging ground disturbance, boat strike, pollution disturbance
Boat strike		Unquantified. Five reported dead in Qld (1996 - 2003)	Unquantified injury and death
Disorientation from altered light horizons (coastal development)		Unquantified	Hatchlings killed after heading towards light sources and away from ocean
Disorientation from altered light horizons (light from anchored boats infrastructure)		Unquantified	Traps hatchlings in light and predation increases
Disorientation from altered light horizons (oil and gas industry)		Unquantified	Impacts hatchlings and repeals nesters
Feral animal predation on eggs and hatchlings		Unquantified	Dogs, foxes and pigs
Coastal development and tourist		Unquantified	Vehicles on beaches, disturbance of nesting females by people and domestic dogs, beach activities, boat strike, sewage, run-off, pollution
Pollution and disease			
Marine debris		Unquantified but considered significant	Ingested marine rubbish, entanglement, plastic bags, balloons, unspecified plastic Ceccarelli (2009)
Ghost Nets		Unquantified	Entanglement (primarily foreign nets) Ceccarelli (2009)
Diseases		Unquantified	Many sources