A SCIENTIFIC BASIS FOR A COMPREHENSIVE APPROACH TO MANAGING SEA TURTLE BY-CATCH: THE QUEENSLAND EAST COAST AS A CASE STUDY

by

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Julie Belinda Robins  Date: 10th May 2003

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PUBLICATIONS ASSOCIATED WITH THIS THESIS

This thesis has been undertaken over an extended period. Information presented in this thesis has been published in a variety of forums, including peer-reviewed articles, funding agency reports, and reports to various Government committees.

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

Robins, J., Yeomans, K. and Mayer, D. (1997). Monitoring the impact of trawling on sea turtle populations of the Queensland east coast. Supplementary report to the Queensland Department of Environment. 26 pps.

Robins, J.B., and Mayer, D.C. (1998). Monitoring the impact of trawling on sea turtle populations of the Queensland East Coast. *FRDC Final Report Project No T93/229*, 56 pps.

Slater, J., Limpus, C., **Robins, J**., Pantus, F., and Chaloupka, M. (1998). Risk assessment of sea turtle capture in the Queensland East Coast otter trawl fishery. Inter-agency report to TrawlMAC, 31 pps.

Estimates of the size and composition of sea turtle by-catch presented in this thesis were incorporated in the Queensland Trawl Management Plan (2000), as a legally binding reference point from which reduction targets for sea turtle by-catch were calculated.

Estimates of the relative spatial distribution of sea turtles presented in this thesis are being used by the Great Barrier Reef Marine Park Authority in the selection of Representative Areas to enhance protection of the biodiversity within the Great Barrier Reef World Heritage Area at the time of writing.

Advice on critical areas for sea turtle by-catch is being provided to the Queensland Fisheries Service, to assist in the development of a strategy to monitor the effectiveness of TEDs in the Queensland East Coast Trawl Fishery as at the time of writing.

RELATED PUBLICATIONS

Armstrong, M., **Robins, J**. and Maguire, K. (2000). Recovery planning for marine turtles in Australia: Benefits of a co-ordinated approach. In: *Sea turtles of the*

Indo-Pacific: Research, management and conservation. Proceedings of the Second ASEAN Symposium and Workshop on Sea Turtle biology and Conservation. Eds. Pilcher, N. and Ismail, G., University of Malaysia. ASEAN Academic Press, London. pp 261-276.

Burridge, C.Y. and **Robins, J.B**. (2000). Benefits of statistical blocking techniques in the design of gear evaluation trials: introducing the Latin Square design. *Fisheries Research* 47: 69-79.

Robins, J.B. and Dredge, M.C.L. (2000). Strategies used to achieve the industry adoption of by-catch reduction devices in prawn trawl fisheries of northern Australian trawl fisheries. In: *Management for Sustainable Ecosystems*, Eds. P. Hale, A. Petrie, D. Maloney and P. Sattler. Centre for Conservation Biology, the University of Queensland, Brisbane. pp. 147-153.

Robins, J.B. and Courtney, A.J. (1999). Status report on by-catch within the Queensland Trawl Fishery. In: *Proceedings of the Australian Society for Fish Biology Workshop on Establishing Meaningful Targets for By-catch Reduction in Australian Fisheries.* Hobart, 24-25th September 1998. Eds. Buxton, C. and Eayrs, S., Australian Society for Fish Biology, Sydney. Pp 24-45.

Robins, J.B., Campbell, M.C. and McGilvray, J.G. (1999). Reducing prawn trawl fishery by-catch in Australia: An overview and an example from Queensland. *Marine Fisheries Review* 61(3): 46-55.

Robins, J.B. and McGilvray, J.G. (1998). The AusTED II, an improved trawl efficiency device 2. Commercial performance. *Fisheries Research* 42: 1-13.

Tucker, A.D., **Robins, J.B**. and McPhee, D.P. (1997). Adopting TEDs in Australia and the USA: what reasons promote successful technology transfer? *Coastal Management* 25(4): 405-421.

Robins-Troeger, J.B., Buckworth, R.C. and Dredge, M.C.L. (1995) Development of a trawl efficiency device (TED) for Australian prawn fisheries II: field evaluations of the AusTED. *Fisheries Research* 22: 107-117.

Robins-Troeger, J.B. (1994). Evaluation of the Morrison soft TED: prawn and by-catch variation in Moreton Bay Queensland. *Fisheries Research* 19: 205-217.

ABSTRACT

Key words: sea turtles, by-catch, trawling, TEDs, compliance strategy

The Australian continental shelf is one of the few remaining areas of the world where sea turtle populations have been subject to relatively small levels of direct harvest and where nesting- and feeding-ground habitats remain essentially intact. The area supports six of the world's seven sea turtle species (i.e., *Chelonia mydas*, *Caretta caretta*, *Eretmochelys imbricata*, *Natator depressus*, *Lepidochelys olivacea* and *Dermochelys coriacea*), contains significant nesting populations of three species (i.e., *Chelonia mydas*, *Caretta caretta*, *Eretmochelys imbricata*), the world's only nesting populations of *N. depressus* and is the main feeding-grounds area of *Natator depressus*. The incidental capture of sea turtles in the trawl fisheries of northern Australia was a significant threat to sea turtle populations of Australia. Trawl by-catch mortality of *Caretta caretta* is considered to have contributed to the 80% decline in numbers of nesting sea turtles in eastern Australia, but this speculation is based on limited or unpublished data relating to mortality associated with trawl fisheries. There is limited information on the potential impact of trawl fisheries on other sea turtle species that occur in Australian waters. Turtle Excluder Devices (TEDs) were legislated for use in trawl fisheries of northern Australia in 1999. TEDs allow sea turtles to escape from trawl nets whilst enabling the trawl fishery to continue to operate and catch prawns. TEDs can be an effective solution to sea turtle by-catch, but the adoption and use of TEDs in a fishery needs to be monitored to ensure that the devices are having the desired outcome i.e., sea turtle exclusion. The scale and geographic extent of Australian trawl fisheries have the potential to result in a poor capacity to monitor the effective use of TEDs by fishers. TED compliance strategies (i.e., monitoring and enforcement) should be focused in areas where the effective use of TEDs would have the greatest benefit to sea turtle conservation i.e., areas where sea turtle by-catch or mortality is greatest.

The present study adopted a comprehensive approach to understanding the interaction between trawling and endangered sea turtle species in waters adjacent to the Queensland east coast, by collecting and utilising baseline data on the size and distribution of sea turtle by-catch. Aspects of compliance strategies for TEDs that would contribute to the

sustainable management of sea turtle by-catch in trawl fisheries are also considered. In this context, the following objectives are addressed in this thesis:

(i) To estimate the number and species composition of sea turtles caught and killed in a multiple sector trawl fishery using spatial stratification;

(ii) To examine the behavioural responses of sea turtles to trawl capture in order to investigate the potential for post-trawl mortality;

(iii) To investigate the factors that influence the distribution pattern of sea turtles, and from this analysis, predict the relative in-water densities of sea turtles at broad spatial scales; and

(iv) To develop a spatially explicit strategy for TED compliance (i.e., monitoring and enforcement), based on an assessment of the interaction between sea turtles and fishing effort.

The thesis concentrates on sea turtle by-catch in the Queensland East Coast Trawl Fishery, but has broader implications for the management of sea turtles in their feeding-grounds.

Baseline information on sea turtle by-catch was collected from select commercial fishers who voluntarily reported information on sea turtles caught in the Queensland East Coast Trawl Fishery. About 1,500 sea turtles were reported caught during ~24,000 days of trawling by 105 fishers who participated in a voluntary program to monitor sea turtle by-catch between 1991 and 1996. Stratified, weighted analysis of the data resulted in an annual estimated sea turtle catch of about 5,900 for the Queensland East Coast Trawl Fishery, given a mean annual total fleet effort of about 85,000 days fished per year. The catch was comprised of *Caretta caretta* (~50%), *Chelonia mydas* (27%), *Natator depressus* (16%) and *Lepidochelys olivacea* (6)%. The fishery had minimal catches of *Eretmochelys imbricata* and *Dermochelys coriacea*. Sea turtle by-catch was dominated by immature individuals, with between 60 and 80% of individuals caught being immature, based on approximate size-at-maturity for each species. Estimates of total mortality were based on observed rates as well as published mortality rates from USA shrimp trawl fisheries. In general, mortality rates of sea turtles caught in the Queensland East Coast Trawl Fishery were lower than mortality rates reported for other trawl fisheries in northern Australia and the USA. Lower mortality rates were probably a function of the tow duration associated with various sectors of the Queensland East

Coast Trawl Fishery. However, the combined by-catch of sea turtles in the three major trawl fisheries of northern Australia (i.e., the Queensland East Coast Trawl Fishery, the Northern Prawn Fishery and Torres Strait Prawn Fishery) was estimated to be of sufficient magnitude to have contributed to the observed declines in nesting numbers of east Australian *Caretta caretta*. Estimates of the mortality of sea turtles in the trawl fisheries of northern Australia raise concerns about the likely impacts of these fisheries on other species of sea turtle, particularly Australian sub-populations of *Natator depressus* and *Lepidochelys olivacea*. These species frequent feeding-ground habitats typical of trawl grounds and are poorly monitored through nesting-ground surveys. The scale of impact estimated in this thesis indicates that the use of TEDs in the trawl fisheries of northern Australia is warranted.

Mortality rates of trawl-caught sea turtles could be higher than currently estimated if sea turtles die after release as a consequence of the delayed effects of capture or secondary mortality resulting from changes in diving behaviour. Six trawl-caught sea turtles were monitored post-release using ultrasonic transmitters and Temperature Depth Recorders in order to assess their diving patterns for signs of modified behaviour. Two rodeo-caught sea turtles were monitored post-release as controls to the trawl-caught individuals. All sea turtles swam rapidly away from the point of release and displayed a period of frequent surfacing behaviour that was speculated to represent swimming and hyperventilation. The sea turtles then settled into a steady pattern where dive intervals were long and regular. This was speculated to represent recovery behaviour. 'Normal' activity patterns, as documented in the literature, were not apparent in the dive profiles of the trawl-caught sea turtles within the post-release monitoring period (i.e., 66 hours). Rodeo-caught sea turtles displayed 'normal' activity patterns at about 85 and 111 hours post-release. There was no evidence of delayed post-release mortality in the limited number of individuals monitored. However, the trawl-caught sea turtles displayed modified diving patterns that potentially made them more susceptible to secondary mortality such as boat strike or predation. Recovering sea turtles did not appear to undertake normal feeding activities, suggesting that sea turtles exposed to non-lethal interactions with human activities on a frequent basis may have lower growth rates. The results suggest that sea turtles are affected by interactions with humans to a much greater extent than previously thought and that the recovery period of such interactions can take several days.

The relative spatial distribution of sea turtles is poorly known and is insufficient for developing management plans, such as monitoring and enforcement strategies for TEDs. Sea turtle catch per unit effort from trawl captures and sea turtle sightings from aerial surveys were used to estimate the relative density of sea turtles in the waters adjacent to the Queensland east coast. As expected, sea turtles were not evenly distributed, with several areas having exceptionally high relative densities. In trawled areas, the relative density of sea turtles was significantly correlated with the benthic species trawled (e.g., species of prawn) as well as water-depth. *Natator depressus* and *Lepidochelys olivacea* had high relative densities in inshore, tropical waters less than 40 m deep, where tiger prawns (*Penaeus esculentus*, *P. semisulcatus*) and endeavour prawns (*Metapenaeus endeavouri*, *M. ensis*) were caught most commonly. *Caretta caretta* had high relative densities in inshore, sub-tropical waters less than 30 m deep, where banana prawns (*Fenneropenaeus merguiensis*) or bay prawns (*Metapenaeus bennettae* i.e., Moreton Bay) were caught most commonly. The relative density of sea turtles was predicted for the majority of waters adjacent to the Queensland east coast based on the mean sea turtle CPUE and information on target species caught most commonly and mean-depth trawled. The relative distribution of sea turtle density developed in this thesis provides the first broad scale maps that quantitatively identify areas that appear to be important as sea turtle habitat. This information could be used to assist the conservation management of sea turtles populations of eastern Australia.

Sea turtle by-catch in northern Australia has been addressed through the mandatory use of Turtle Excluder Devices (TEDs) in otter trawl fisheries. However, the use of TEDs in a fishery needs to be supported by monitoring or enforcement to ensure that TEDs are used effectively, but this is difficult in fishery that operates over a large geographic scale. A pragmatic solution would be to target the monitoring and enforcement of TEDs in critical areas where reductions in sea turtle by-catch will make the greatest contribution to recovery of impacted populations of sea turtles. The spatial distribution of effort for the Queensland East Coast Trawl Fishery in the year 2001 was integrated with the relative density of sea turtles to identify critical areas for sea turtle by-catch. Critical areas for sea turtle by-catch were similar despite the use of qualitative or quantitative methods. The results suggest that effective TED use is most critical in the inshore waters of the Queensland east coast. Monitoring and enforcing TEDs in these critical areas would enable fisheries managers to measure progress towards the stated

target of the 95% reduction in sea turtle by-catch and contribute to the sustainable management of the fishery. The use of TEDs in non-critical areas should also be monitored, but because of the lower contribution of these areas to sea turtle by-catch, monitoring and enforcement could take place with less intensity. Critical areas for monitoring the effective use of TEDs may change if the intensity of fishing effort changes and may become unnecessary should it be demonstrated that most fishers comply fully with TED regulations.

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GLOSSARY OF ABBREVIATIONS

AFMA	Australian Fisheries Management Authority
BRD	By-catch Reduction Device
BRS	Bureau of Resource Sciences
CITES	Conference on International Trade in Endangered Species
CCL	Curved Carapace Length
CFWG	Commonwealth Fisheries Working Group
CPUE	Catch Per Unit of Effort
CSIRO	Commonwealth Scientific and Industrial Research Organisation
EA	Environment Australia
ESD	Ecologically Sustainable Development
FRDC	Fisheries Research and Development Corporation
GBRMPA	Great Barrier Reef Marine Park Authority
GBRWHA	Great Barrier Reef World Heritage Area
QDPI	Queensland Department of Primary Industries
QECTF	Queensland East Coast Trawl Fishery
QEPA	Queensland Environmental Protection Agency
QFS	Queensland Fisheries Service
QPWS	Queensland Park and Wildlife Service
QTRG	Queensland Turtle Research Group
IUCN	World Conservation Union (WCU)
	(formerly the International Union for the Conservation of Nature)
MPA	Marine Protected Area
NMFS	National Marine Fisheries Service (USA)
NPF	Northern Prawn Fishery
TED	Turtle Excluder Device
TDR	Temperature Depth Recorder
TSPF	Torres Strait Prawn Fishery

DEFINITIONS

The following terms are defined to establish their meaning as used in this thesis.

By-catch terms

(the) Capture	All that is taken in the gear (Hall *et al*. 2000).
Target catch	The catch of a species or species assemblage that is primarily sought in a fishery (McCaughran, 1992; Hall 1999), and with particular reference to the Queensland East Coast, it is the dominant species (by weight, number or value) that the fishing operation is aiming to catch.
Non-target catch	Species other than the target catch caught incidentally but retained for economic reasons (Hall *et al.* 2000).
By-catch	That portion of the capture that is discarded at sea for economic, legal or personal reasons (Hall *et al*. 2000).
CFISH grid	A 1,668 km^2 area (=30^2 nautical miles = 90 nm^2) for the recording of fishery catch and effort in the Queensland East Coast Trawl Fishery. A CFISH grid is comprised of 25 CFISH sites.
CFISH site	A 66.7 km^2 area (=6^2 nautical miles = 36 nm^2) for the recording of fishery catch and effort in the Queensland East Coast Trawl Fishery.
Fishing sector	A portion of the Queensland East Coast Trawl Fishery subdivided on the basis of target catch (i.e., dominant by weight).

Sea turtle terms

Hatchling	Sea turtles that are recently hatched and have not commenced feeding, including those at-sea using the internalised yolk sac (Musick and Limpus 1996).
Juvenile	Sea turtles that have commenced feeding but are not sexually mature, including immature and sub-adult individuals in the epipelagic phase (i.e., oceanic) and demersal phase (i.e., continental) of the generalised life history (Musick and Limpus 1996).
Adult	Sea turtles that are as large as the minimum breeding size, including adult-sized individuals that may be sexually immature (Musick and Limpus 1996).
Sub-population	A nesting assemblage (IUCN 2000), encompassing those individuals of a genetic stock (which can be monitored at a nesting beach) whilst they are dispersed throughout feeding grounds.