

Report to:
Recfish Australia

**Review of Issues Related to Research on Grey Nurse
Sharks (*Carcharias taurus*) in New South Wales**

May 2007

The Ecology Lab Pty Ltd

Marine and Freshwater Studies



Review of Issues Related to Research on Grey Nurse Sharks (*Carcharias taurus*) in New South Wales

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Report Number – 14/0405a

Report Status – Final 31 May 2007

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TABLE OF CONTENTS

1.0 Summary of Key Points.....	1
2.0 Introduction.....	4
3.0 Background of the Author.....	4
4.0 Recent Research on Grey Nurse Sharks in NSW by DPI.....	6
4.1 General Comments.....	7
4.2 Specific Comments Focusing on the Otway and Burke (2004) Report.....	8
5.0 Preliminary Research by Lincoln Smith.....	15
5.1 Background and Methods.....	15
5.2 Results.....	16
6.0 Conclusions.....	17
7.0 References.....	18
Appendix 1 – <i>Curriculum Vitae</i> of Marcus Lincoln Smith.....	19
Appendix 2 – Data supplied to me by Recfish Australia on August 2003 Survey.....	29

1.0 SUMMARY OF KEY POINTS

- I was asked by Recfish Australia to provide advice in relation to Administrative Appeals Tribunal Proceedings N2006/1443. This is an action being brought by the Nature Conservation Council of NSW (NCC) against the Commonwealth Minister for the Environment and Heritage in regard to the NSW Ocean Trap and Line Fishery and its effects on the grey nurse shark (*Carcharias taurus*).
- An affidavit prepared by Dr Victor Peddemors on behalf of the NCC relies greatly on research on grey nurse sharks undertaken by the NSW Department of Primary Industries (DPI). Among other things, the affidavit calls for a complete ban on fishing (including commercial fishing and recreational angling and spearfishing) at certain areas along the NSW coast that have been designated as “critical habitat” for grey nurse sharks.
- I have read the Guidelines for Expert Witnesses in the Proceedings in the Federal Court of Australia and will, to the best of my ability, comply with them.
- I have been asked to evaluate the suitability of sampling methods used to estimate the population size of grey nurse sharks on the east coast of Australia and the interpretation of survey data obtained by and on behalf of DPI. The main documents reviewed were Otway and Parker (2000), Otway *et al.* (2003) and Otway and Burke (2004) and referred to hereafter as the DPI reports or studies). Other references, including statements of evidence are always referenced individually. In addition, reference is made herein to a survey done by and on behalf of DPI in August 2003, but was not, as far as I am aware, included in the DPI reports. The August 2003 data are annexed to my report.
- A tagging study done by DPI allows us to greatly broaden the known geographical and depth distributions of grey nurse sharks on the east coast of Australia. I conclude that, before greater restrictions are imposed on fishers, it would be highly prudent to evaluate the population size within this larger area.
- The methods used to survey grey nurse sharks are unsuitable for many of the sites surveyed and hence likely to underestimate the population size of grey nurse sharks because:
 - Survey areas are comparatively large and there is likelihood that volunteer divers would be unable to adequately search all areas where grey nurse sharks may be present.
 - The time allowed (15 minutes) to do a survey is probably also too short to enable adequate site coverage in many places.
 - Grey nurse sharks have been demonstrated to occur in water much shallower than 15 m. Sharks have been recorded in depths < 10 m in rocky gutters that are very turbulent and (understandably) are unlikely to be inspected by scuba divers for safety reasons. They also occur in water depths too great to be accessed safely by scuba.
 - There is an urgent need to re-assess the survey methodology, which could be done relatively quickly (say, over 6 to 9 months) at a subset of sites. There is also a need to implement a proper and transparent training and auditing

program for all divers used in the surveys – This measure is increasingly expected as part of QA/QC procedures in environmental research.

- Attributes of aquatic habitat identified by DPI as being crucial for grey nurse sharks (e.g. caves, overhangs, sandy and boulder-filled gutters) that are documented to occur at known aggregation sites for grey nurse sharks also occur in numerous other areas of reef along the east coast of Australia from SE Qld to the Victoria border. Sites where habitats suitable for grey nurse sharks occur that I know of personally include: Unnamed reefs between Mermaid Reef and Crowdy Head, Grassy Head, sites to the north of Coffs Harbour, The Banks (NE of Jervis Bay), Charlotte Head and White Top Rock (Seal Rocks).
- These sites are not as readily identifiable as the aggregation sites recognised by DPI, which are generally easy to locate because they often occur adjacent to prominent landmarks, such as offshore islands, the coastline or shallow, breaking reefs. The less well-known sites are nevertheless known to some fishers as being utilized by grey nurse sharks and hence the sharks occurring there may not have been incorporated into the surveys undertaken by DPI. This would therefore tend to lead to underestimates of the east coast population of grey nurse sharks and warrants further investigation to assess whether there is a need for more restrictive management to be imposed on current stakeholders.
- The data on abundance of grey nurse sharks recorded per site has shown an increase over time since 1999. This appears, in part, to be due to recruitment of juvenile grey nurse sharks to north coast sites in 2003. There is, however, a large proportion of sharks of unknown size (and sex) in the counts at this time, limiting further interpretation. Moreover, the DPI reports do not provide enough raw data to enable confidence limits to be placed on their estimates.
- Otway and Burke (2004) reported on a mark-recapture (i.e. resighting) experiment for grey nurse sharks done from 2002 (initial tagging) to 2003 (resighting). The experiment was originally planned to cover two resighting surveys (i.e. following tagging of the sharks): the one reported in Otway and Burke (2004), which was done in June 2003; and the one undertaken in August 2003 (Appendix 2), which was not reported in Otway and Burke (2004). The June survey yielded sightings of 19 tagged grey nurse sharks from 313 sharks observed in total, which equates to approximately six tagged sharks in every 100 sharks observed. The August survey yielded no tagged sharks from 162 sharks surveyed, with 27 sites inspected. In addition, research conducted by me in September/October 2004 yielded 103 sharks with one tagged shark being sighted.

The surveys done in August 2003 and September/October 2004 provide indicative but not conclusive evidence that the grey nurse population on the east coast of Australia is larger than estimated by Otway and Burke (2003) for the following reason. The 19 resighted sharks from 313 observed sharks in total suggest a resighting rate of about six tagged sharks for every 100 observed. If, as a conservative measure in favour of the experiment, we consider that the population could be as large as the upper confidence limit of any of the mark-recapture analyses done by Otway and Burke (2004), which was 766 sharks, we would expect a resighting rate in the order of about 2.5 tagged sharks per 100 sharks recorded, if there are 19 tagged sharks dispersed through the population (in fact, there may be 24 tagged sharks within the population, as this was the total number tagged). On the

basis of 19 sharks being available to be observed, a sighting of 162 sharks, as at August 2003, should yield a resighting rate of between 10 tagged sharks (if the population were only 313) or 4 tagged sharks (if it were 766, which is the maximum estimate derived by Otway and Burke 2004). The fact that no tagged sharks were sighted at that time suggests a population in excess of DPIs greatest estimate. Similarly, a sighting of 103 sharks in September/October 2004 would imply sightings of between three and six tagged sharks, whereas only one was sighted.

Given that so few tagged sharks were sighted in the latter two studies, a valid mark-recapture analysis would not be possible using these data, suggesting that many more sharks should be tagged if an accurate estimate of population size is to be obtained.

- In addition to the above, several of the assumptions of a mark-recapture experiment undertaken by DPI are questionable and there is at least one other assumption inherent in these procedures that was not identified (i.e. that tagged sharks are double-counted). This casts further doubt on the outcomes of the experiment.
- The most recent DPI report available to me (dated June 2004) has a number of errors in tables and at least one figure – these are discussed in the main part of my report. The errors were identified by cross-reference to various parts of the report. There is clearly a concern that there may be other errors that cannot be identified by the reader without access to the survey data. Therefore, these data should be made available for review and independent analysis.
- In conclusion, based on (1) the occurrence outside of recognised aggregation sites of habitat characteristics considered to be of importance to the ecology of grey nurse sharks; (2) a trend to increased numbers of grey nurse sharks observed per site from 1999 to 2003; (3) the finding that grey nurse sharks occur well to the north of Flat Rock, SE Qld, the most northerly site unambiguously reported in the DPI Reports; (4) the finding that grey nurse sharks occur in water depths well in excess of 50 m and hence much deeper than would be safely accessible by divers involved in surveys of grey nurse sharks; (5) the lower than expected number of tags observed in some surveys of grey nurse sharks; and (6) my observations of grey nurse sharks at sites not surveyed by DPI leads me to conclude that there are likely to be many more grey nurse sharks in the population than is presently accepted by the NCC.
- Thus, the review of the relevant literature casts significant doubt on the estimates of population size of grey nurse sharks on the east coast of Australia and there are compelling reasons to suspect that the size of the grey nurse shark population is greater than the estimates being used to manage this species. These conclusions indicate that, at the very least, some testing of the methodology used to sample the populations is required urgently. The existing management regime for grey nurse sharks (which is in itself a major precautionary measure) and the likelihood of increasing numbers of grey nurse sharks observed per site in NSW and SE Qld indicate that there is less urgency to implement severe restrictions and that a more measured approach is warranted.

2.0 INTRODUCTION

There is currently an appeal being heard in the NSW Administrative Appeals Tribunal which challenges the issuing of a Wildlife Trade Operation licence to the Ocean Trap and Line Fishery (OTLF) under the *Environment Protection and Biodiversity Act* (EPBC, 1999) by the Commonwealth. The basis of the appeal by the Nature Conservation Council (NCC) is that the Fishery Management Strategy (FMS) prepared for the OTLF by the NSW Department of Primary Industries (DPI) is inadequate to protect the grey nurse shark (*Carcharias taurus*). Specifically, the population of grey nurse sharks on the east coast of Australia is classified as being critically endangered. This threatened species status confers responsibilities on the Commonwealth in terms of ensuring that this species is protected. Recfish Australia represents recreational fishers and there is concern by them, along with several other fishing interest groups that increased restrictions will be imposed on fishers as a result of the arbitration, even though they are not directly part of the current appeal. Moreover, Recfish Australia believes that the current levels of protection are more than adequate to protect grey nurse sharks.

The current appeal is based, at least in part, on research on grey nurse sharks done on behalf of and by DPI over the past decade or so. Recfish Australia is concerned that the estimates of population size of grey nurse sharks grossly underestimate the true population on the Australian east coast and that, although grey nurse sharks should be protected, further measures now being proposed by the NCC are both unwarranted and unnecessarily restrictive of recreational fishing activities.

Recfish Australia has engaged me provide advice on the veracity of the population estimates used as a basis for the current appeal. It is understood that neither the Commonwealth nor the NCC dispute DPI's population estimates for grey nurse sharks. Furthermore, an affidavit by Dr Victor Peddimors (2007) relies heavily on the data obtained by DPI. Because the population estimates are at the core of management of grey nurse sharks, they warrant a detailed review.

3.0 BACKGROUND OF THE AUTHOR

I am the Director of The Ecology Lab Pty Ltd. The Ecology Lab is a Sydney-based firm specialising in providing advice on the effects of human activities on the aquatic environment. The company was founded in 1985 and during our period of operation we have undertaken numerous studies on behalf of individuals, companies and local, state and federal government departments. My *Curriculum vitae* is annexed to this report as Appendix 1 and areas of expertise and experience are summarised as follows:

- Qualifications:
 - BA and BSc (Hons) from the University of Sydney (1978). My Honours thesis was based on the construction and survey of artificial reefs, including use of artificial and natural reefs by fish and their habitat value.
 - MSc from the University of Sydney (1985). This degree was obtained by thesis and involved research on the development and application of underwater visual census for fishes on rocky reefs in temperate marine waters. As a result of this project, I gained a broad understanding of survey techniques required to estimate populations of fish using underwater visual methods. I also studied methods of assessing fish habitat. I published two

articles in scientific, peer-reviewed journals directly on this work. The expertise I obtained also led to a number of projects done on behalf of government (e.g. marine reserves, impacts of spoil disposal on habitat and fishes, etc – see CV).

- PhD from the University of Sydney (1998). My thesis topic investigated the application of principles and methods of aquatic ecology in Environmental Impact Assessment (EIA). Key outcomes were analysis of environmental documentation in terms of aquatic ecology and development of ways in which aquatic ecology can be adapted to (EIA).
- Commercial Diver and Dive Supervisor. I hold accreditation in scientific diving and dive regularly for work projects. I have undertaken thousands of dives on rocky reefs in NSW and southern Queensland since 1978, spanning the entire NSW coastline.
- Experience: grey nurse sharks
 - In 1991 I was engaged by the (then) NSW Fisheries Department to undertake surveys of grey nurse sharks at Seal Rocks. I developed a survey procedure suitable for the sites selected and undertook surveys at each of four sites and comparing counts between the morning and afternoon.
 - In 1995 I was engaged by NSW Fisheries to repeat the 1991 survey.
 - In 1996 I co-authored a scientific paper with Dr David Pollard and Dr Adam Smith (both co-authors from NSW Fisheries at that time) on the biology and conservation of grey nurse sharks (see CV).
 - In 1998 I was engaged by NSW Fisheries to assist in training for broadscale surveys of grey nurse sharks on the NSW coast. For this engagement, surveys were done at sites at South West Rocks and Seal Rocks.
 - From 2000 – 2002 I was a member of the NSW Advisory Council on Conservation providing advice to NSW Fisheries on conservation issues, including grey nurse sharks.
 - In 2001 I was engaged by the (then) Department of Urban Affairs & Planning to prepare guidelines for the environmental assessment of the beach meshing program in NSW. A significant component of this work involved development of guidelines for assessing effects of beach meshing on grey nurse sharks.
 - In June 2004 I applied for a grant from the NSW Recreational Fishing Trust to undertake research on the veracity of methods for surveying grey nurse sharks. This was based on representations from fishers to me who believed that grey nurse sharks populations were being underestimated and from concerns that I had regarding the survey methodology, which I had assisted in developing. The grant application was not successful, but was considered by the Trust to have merit. I therefore sought to collect additional data that might provide a firmer basis for a later application.
 - In September/October 2004 I undertook independent research, including a field program over approximately two weeks on grey nurse sharks to evaluate if the methodology could be improved. Fishers, divers and other researchers were interviewed and diver surveys were conducted along the

east coast extending from Crowdy Head to Moreton Island. Some of the findings of this research are presented and discussed in this report.

- Experience: EIA and Reef Ecology.
 - Peer review of ecological studies and environmental data for Port of Melbourne 2006 and Port of Gladstone 2003.
 - Peer reviewer for several national and international scientific journals, including *Marine and Freshwater Research*, *Austral Ecology*, *Marine Ecology Progress Series*, *Marine Pollution*, *Marine Biology*, *Journal of Experimental Biology and Ecology*, *Aquaculture*.
 - Review of EISs and FMSs for the Estuary General, Estuary Prawn and Ocean Hauling Fisheries in NSW. Done on behalf of NSW DPI.
 - Review of data and reports on a proposed sewerage upgrade at Christchurch New Zealand. Done on behalf of Christchurch City Council.
 - Surveys of spoil disposal on reef habitats and fish at the Five Islands Nature Reserve and in Sydney. Done whilst employed as a technical officer at NSW Fisheries.
 - Surveys of reef habitats and reef fish at Twofold Bay as part of environmental management for the construction and operation of the multi-purpose berth in East Boyd Bay.
 - Surveys of the ecological effects on rocky reef habitats and biota of various ocean outfalls in NSW, including locations at Forster, Central Coast, Sydney, Wollongong/Illawarra, Jervis Bay and Ulladulla. These studies were done over the past two decades for a variety of water authorities.
 - Project leader for assessment of the effectiveness of various marine reserves including studies in the Solitary Islands Marine Reserve, Solomon Islands and around Sydney.

4.0 RECENT RESEARCH ON GREY NURSE SHARKS IN NSW BY DPI

The study of large, mobile animals in the ocean is very difficult and the researchers at DPI and their volunteers have done an enormous amount of very difficult work over the past decade. Prior to that, in 1984 NSW Fisheries were successful in having grey nurse sharks fully protected in NSW waters. NSW Fisheries also commissioned studies beginning in the early 1990's. Prior to that time, the gamefishers in 1977 removed the grey nurse shark from their lists of game species to be taken. Thus, it is important to recognise that the issue of conserving grey nurse sharks is not new, but has been a concern in this State for three decades.

Notwithstanding the efforts by DPI and volunteers in their research since 1998, it is very important to all stakeholders that there is a high degree of confidence in the findings of the research and confidence that the appropriate management actions are taken. On this basis, I have considered primarily three reports prepared by NSW DPI (formerly NSW Fisheries) as part of this review, including Otway and Parker (February 2000), Otway *et al.* (June 2003) and Otway and Burke (2004). The broad aim was to evaluate the level of confidence that we can place in the research findings to date, particularly estimates of population size. Recfish Australia also provided me with information on a survey of grey nurse sharks done by and

on behalf of DPI in August 2003, and this is annexed to my report. The above reports and the August 2003 data are referred to generally as the DPI studies (or "DPI reports"), whilst particular reports and other literature are cited as appropriate.

The main focus of the review is the most recent report (Otway and Burke June 2004), which presents results of tagging experiments, counts of grey nurse sharks and estimates of population size using mark-recapture procedures. Reference to earlier reports is made as appropriate.

4.1 General Comments

1. All three reports are extremely difficult to read and require very detailed cross-checking of the data provided to understand the conclusions drawn by the authors.

The consequence of this is that it is difficult to review the documentation in detail.

2. There are no tables or appendices in any of the reports that present the most basic details such as exactly which sites were surveyed during each survey period, the actual dates of sampling, environmental conditions at the time, such as water visibility (which can have a huge bearing on underwater visual counts) or the numbers of sharks recorded at those sites. Thus, after numerous surveys we cannot determine from the reports how many times a particular site was surveyed, the date it was visited or the number of grey nurse sharks counted. This type of information should be provided to allow stakeholders to assess the veracity of data analysis and conclusions and would be expected in the most basic of scientific reports. Such information also allows reviewers to calculate confidence limits around the counts - for example, at the same sites surveyed through time or between sites surveyed during the same time period.

The consequence of this is that independent checks of the data analyses (or the application of other types of analyses) are difficult if not impossible based on the information provided.

3. The maps of survey sites presented in Otway and Parker (2000) and Otway *et al.* (2003) are not to scale and not informative regarding the actual route that survey divers are supposed to take. For example, at Mermaid Reef (Otway and Parker 2000, Figure 3.10), it would be virtually impossible for a diving team to survey all sites on the two reefs identified in a single 15 minute period. It takes at least 15 minutes of strong swimming to travel between the reefs, let alone to do surveys at those reefs. I am a relatively strong swimmer and have snorkelled around both reefs at Mermaid Reef during the same dive on several occasions. Each time it has taken at least 30 minutes to cover all possible sites where grey nurse sharks can occur. If the methodology for sites such as Mermaid Reef differs from other sites, then this should be reported.

The consequence of this is that divers, particularly unskilled volunteers, have a large chance of underestimating the occurrence of grey nurse sharks at more extensive sites.

4. As discussed by Otway and Parker (2000) and Otway *et al.* (2003) the use of volunteer divers enabled a large section of the east coast to be surveyed in a relatively short time period and was also cost-effective. There are, however, significant risks

associated with this approach and the volunteers may not have an appreciation of the requirements of objective scientific sampling. Whilst Otway and Parker (2000) and Otway *et al.* (2003) state that some cross-comparisons of diver groups were done as a quality control measure, no presentation of QC results is given, nor are there any details of how volunteer divers were trained or subsequently supervised.

The consequence of this is that it reduces any confidence that the counts at any time or place are accurate.

5. There are numerous sites north of Flat Rock (North Stradbroke Island) SE Qld where grey nurse sharks are known to occur (e.g. Henderson Reef off Moreton Island and Wolf Rock just south of Fraser Island – Queensland Department of Primary Industries, QDPI, 2007). Any estimate of total population, especially using surveys from winter when grey nurse sharks would be expected to occur in the northern part of their range, should explicitly factor-in these sites.

The consequence of this is that the surveys done in winter almost certainly underestimate the total population of grey nurse sharks by omitting sharks occurring north of Flat Rock.

6. The great majority of aggregation sites identified by DPI were selected based on anecdotal information from the 1960's and 1970's. With few exceptions, these sites are adjacent to the coastline, offshore islands or very prominent reefs, some of which having breaking waves under some conditions. Otway and Parker (2000) state that the sites have common topographical features including caves, sandy-bottomed and boulder-filled gutters and large overhangs which provide crucial habitat. The features are found in many areas of reef along the NSW coast. The sites surveyed by and on behalf of DPI represent a tiny (but unquantified) proportion of the reef habitat available in NSW and southern Qld.

The consequence of this is that there may be very many areas of reef that provide topographic features utilised by grey nurse sharks. If these areas are not near to easily-locatable features (e.g. offshore islands) then they may remain undiscovered. Thus, there may be many more grey nurse sharks present than are counted at the specific sites identified by anecdotal information in the 1960's and 1970's.

4.2 Specific Comments Focusing on the Otway and Burke (2004) Report

Executive Summary

- Page vi, dot point 1. The first sentence of the report (Executive Summary) is wrong – it is stated that grey nurse sharks are inshore, coastal dwelling species in reefs of 15 – 50 water depth and cites Otway *et al.* 2003 in terms of distribution. The 2003 reference states that grey nurse sharks occur south of Mooloolaba on the east coast of Australia. In fact, the 2004 report presents the finding that one tagged grey nurse shark was recaptured at Yeppoon on the mid-Qld coast in 70 m water depth. This finding expands the distribution of and habitat available to grey nurse sharks further north and further offshore by hundreds of square kilometres – this has never been surveyed or, as far as I am aware, considered. The implications of this recapture are not fully explored in the report.

- Comments in relation to the other summary points are considered in response to the main report.

Section 1. General Introduction

- Page 1, para 2, line 4. The text states that grey nurse sharks in previous surveys were totally absent from 63% of sites sampled. This statement cannot be justified on the basis of the sampling methodology – sharks present at these sites may simply not have been observed.

Section 2. Tagging and movements of grey nurse sharks

- Page 13 – Table 2.2 and accompanying text.
 - Information that would be crucial to the reader is not presented, including the length, sex and all dates of resighting (not simply the minimum and maximum times). In addition, the report should state where each of the re-sighted sharks was recorded during the mark-resighting survey of winter 2003. This latter information would assist stakeholders to evaluate key assumptions of the population estimate based on the mark-resighting calculations.
 - Table 2.2 identifies three grey nurse sharks tagged at Flat Rock, SE Qld in August 1999. This tagging operation does not appear to be related directly to the experiment described in Otway and Burke (2004), but I cannot find anywhere in the text that explains why they were included or how they were dealt with in the data analysis.
 - Table 2.2 identifies shark number B216 as being re-sighted at Yeppoon. Mooloolaba is cited (Otway *et al.* 2003) as the northern limit of grey nurse sharks on the east coast of Australia and this sighting extends the distribution north by some 500 km. Its capture in 70 m also extends its reported depth distribution from 50 m to 70 m, an increase of 40%. This potentially expands the available habitat for grey nurse sharks on the east coast of Australia by hundreds of square kilometres. The minimum time at liberty for this shark is miss-reported in Table 2.2. It was actually 45 days, which means it travelled the 681 km at a rate of over 15 km/day.

Section 3. Mark-resighting survey

- Page 21, para 2 states that sea conditions constrained the sampling to only 44 sites, which is 12 and 6 fewer sites than in surveys done in 2000 and 1999, respectively. Conclusions drawn later in Otway and Burke (2004) do not consider the reduced sampling effort.
- Table 3.1 has errors in the summation of sites for the north and south coast sections in 2003. That is, the total number of sites where grey nurse sharks were present or absent (i.e. north coast: 14 & 7; south coast: 10 & 13) does not add up to the total number of sites surveyed (i.e. north coast: 21 not 23 as presented; south coast: 23 and not 21 as presented). These data are probably transposed, but they mean that we cannot do independent analyses without making assumptions.
- Figure 3.1b is wrong – it does not depict the number of grey nurse sharks per site as specified in the figure caption. This figure is re-drawn as Figure 1, below and assumes that 21 and 23 sites were surveyed on the north and south coasts,

respectively. It shows a far greater number of grey nurse sharks per site in the northern section during winter 2003 than in the south, which would be expected for that season on the basis of a winter, northern migration.

- Table 3.2 is wrong: for 1999, the total of all individuals $134 + 70 = 204$, not 207 as in the text on page 22. For 2000, it appears that the numbers for all individuals have been repeated (i.e. $134 + 70$) whereas the total count reported for that survey was 292 grey nurse sharks (see p. 22) and hence the two numbers presented for the north and south regions should sum to 292 (not 204). These mistakes make it extremely difficult to follow the arguments being developed in the report, or to check the veracity of such arguments.
- Section 3.3.2 and 3.3.3 are rendered almost uninterpretable due to the extremely large proportion of grey nurse sharks that were of unknown size and/or sex (see Table 3.2 and Figures 3.2 and 3.3). Figure 3.3 shows the number of grey nurse sharks of different sexes and size classes. Sharks of unknown sex are distributed between 3 size classes, rather than the two discussed previously. In addition, this figure is not consistent with Table 3.2 because it does not provide a breakdown of grey nurse sharks of unknown sex into size classes.

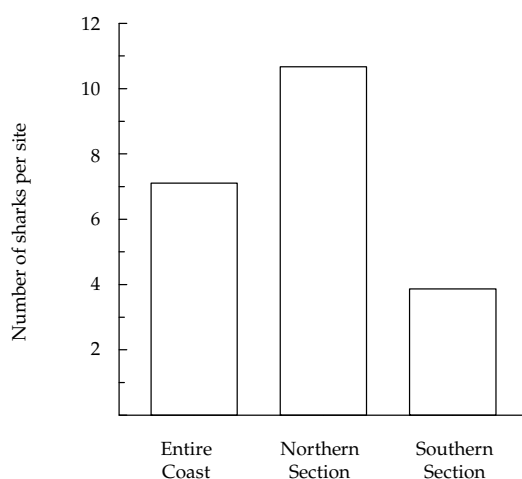


Figure 1. Number of sharks recorded per site in June 2003 (Data derived from Otway and Burke 2004)

- Section 3.4, incidence of hooking. I am not sure of the significance of this section. Clearly, those tagged sharks with hooks had appeared to survive being hooked and released (or were able to break free), suggesting that fishing methods and attitudes of fishers to releasing grey nurse sharks are changing. I also wonder if the fact the DPI (Otway and Burke 2004) actually used hook and line to capture the NSW specimens for tagging might not suggest that those sharks that took the bait were either pre-disposed to bait presented to them, or took hooks at a higher rate because they had already been hooked. Finally, the authors do not state if any of the sharks captured for tagging already had hooks in their mouths at the time of tagging.
- Section 3.4, page 29 Discussion. The discussion states that the larger number of sharks recorded in winter 2003 was only a small increase since 2000. This potentially

represents an increase of 6.7% over three years (i.e. from 2000 to 2003), but numbers were 50% greater in 2003 than in the 1999 survey. Of more relevance, however, is the number of sharks recorded per site, as substantially fewer sites were sampled in 2003 (see Figure 2, below). Examining the data in this way corrects, at least partially, for the reduced sampling effort in 2003. Furthermore, had the report appended the number of sharks recorded at each site, we would be able to calculate confidence limits associated with relative abundance among sites. Notwithstanding this, over the entire coastal area surveyed, the number of sharks per site increased by 50% from 2000 to 2003; and by 72% from 1999 to 2003.

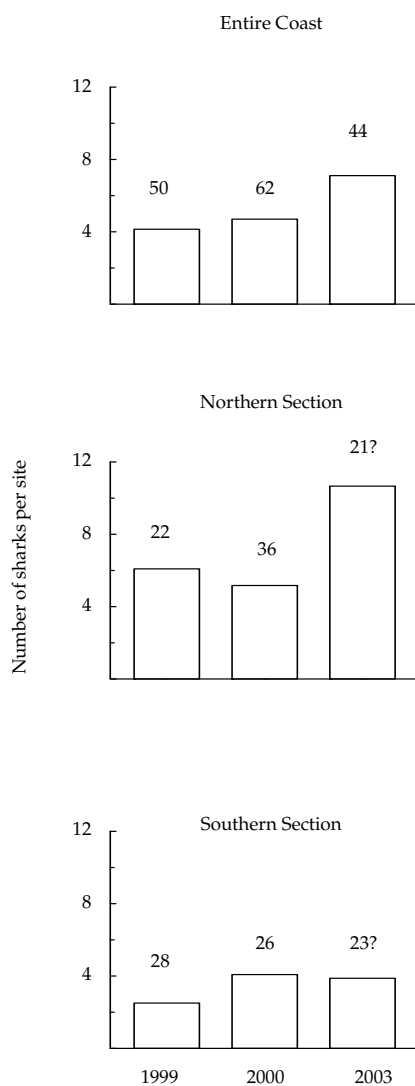


Figure 2. Number of sharks recorded per site at all sites surveyed in winter 1999, 2000 and 2003. Numbers above each bar are the total number of sites surveyed, those with “?” are unclear due to an error in the data source (Data derived from Otway and Burke 2004).

It is noteworthy that the data obtained from the survey done in August 2003 yielded 162 sharks from 27 sites along the NSW coast to SE Qld, of which 10 sites had no sharks present (Appendix 2). Over all the sites, this equates to six sharks per site. This value is

slightly less than the number per site in June, but is still consistent with a relatively large increase in the number of grey nurse sharks per site since 1999.

- Of some concern regarding the data on the August survey is that the summary sheet states that surveys were done as far north as Bundaberg, which contrasts with the methods as described in all the DPI reports. It is important that it be established if the surveys were extended northwards and if so, how many sites were included and what sightings were obtained.
- For the entire coast, there was a steady increase in the number of grey nurse sharks recorded per site over the period 1999 to 2003. This represents an increase of 50% in the number of sharks per site from 2000 to 2003 and a 70% increase from 1999 to 2003. In the north coast section the trend is even more pronounced, with 75% more grey nurse sharks recorded per site in 2003 compared to 1999, although there was also a slight dip in numbers per site in 2000 (Figure 2). On the south coast, numbers per site were generally smaller than on the north coast, but there was a relatively large increase between 1999 and 2000 (95% increase), with a slight dip in 2003 (but still 54% greater than in 1999 – Figure 2). These trends provide good evidence of an increase in abundance of grey nurse sharks, particularly on the north coast of NSW and SE coast of Qld.
- Page 29, para 1, 2nd sentence. This sentence is wrong given the record of a tagged shark dispersing as far north as Yeppoon, some 500 km further north than stated as the northern-most limit by Otway *et al.* (2003).
- Section 3.4.3, Page 29, 1st sentence. The hooking of sharks by DPI in order to tag them hardly provides an independent measure of hooking rates by other fishers.

Section 4. Mark-resighting population estimate

I am not qualified as an expert in mark-recapture studies, although I am familiar with the basic principles and application of the methodology. I am therefore not in a position to evaluate the suitability of the various mathematical formulae used by Otway and Burke (2004). Comments here are confined to a general review of Section 4 of Otway and Burke (2004) and the assumptions upon which the application of the method is based. In addition, I have also considered the results of the August 2003 survey (Appendix 2) and of research that I did in September/October 2004 (which is discussed more generally in Section 5 of this report).

It is understood that the mark-resighting experiment was originally planned to cover two resighting surveys (i.e. following tagging of the sharks): the one reported in Otway and Burke (2004), which was done in June 2003; and the one undertaken in August 2003, which was not reported in Otway and Burke (2004). The June survey yielded sightings of 19 tagged grey nurse sharks from 313 sharks observed in total, which equates to approximately six tagged sharks in every 100 sharks observed. The August survey yielded no tagged sharks from 162 sharks surveyed, with 27 sites inspected. In addition, research conducted by me in September/October 2004 yielded 103 sharks with one tagged shark being sighted (see Section 5, below).

The surveys done in August 2003 and September/October 2004 provide indicative but not conclusive evidence that the grey nurse population on the east coast of Australia is larger than estimated by Otway and Burke (2003) for the following reason. The 19 resighted sharks from 313 observed sharks in total suggest a resighting rate of about six tagged sharks for

every 100 observed. If, as a conservative measure in favour of the experiment, we consider that the population could be as large as the upper confidence limit of any of the mark-recapture analyses done by Otway and Burke (2004), which was 766 sharks (Table 4.1 in Otway and Burke 2004), we would expect a resighting rate in the order of about 2.5 tagged sharks per 100 sharks recorded, if there were 19 tagged sharks dispersed through the population. In fact, there may have been up to 24 tagged sharks within the population, as this was the total number tagged.

However, on the basis of just 19 sharks being available to be observed, a sighting of 162 sharks, as at August 2003, should yield a resighting rate of between 10 tagged sharks (if the population were only 313) or 4 tagged sharks (if it were 766, which is the maximum estimate derived by Otway and Burke 2004). The fact that no tagged sharks were sighted at that time suggests a population potentially well in excess of DPIs largest estimate. Similarly, a sighting of 103 sharks in September/October 2004 would imply sightings of between three and six tagged sharks, whereas only one was sighted.

Given that so few tagged sharks were sighted in the latter two studies, a valid mark-recapture analysis would not be possible using these data, suggesting that many more sharks should be tagged if an accurate estimate of population size is to be obtained. As noted above, however, these results suggest, at least tentatively, a population larger than the range proposed in Otway and Burke (2004).

Otway and Burke (2004) list seven assumptions that must be upheld to ensure a valid population estimate using mark-recapture procedures. These are discussed below, but it is also important to recognise that there is an eighth assumption that must be satisfied. This assumption is that tagged grey nurse sharks are counted only once during the re-sighting period. Tagged sharks that are counted more than once will lead to an underestimate of the population size. My comments on the eight assumptions are as follow:

- *Assumption 1: Tagged individuals are unaffected by the tagging process and behave in the same manner as untagged animals.* Use of a fish hook and hauling grey nurse sharks to the surface is likely to be a traumatic event for the sharks. There are unconfirmed reports of one shark dying immediately following tagging, but I have been unable to confirm this. There are also reports that tags cause infection and rotting in grey nurse sharks, which could impair basic activities (Otway and Burke 2004).

The use of baited hooks may also make tagged sharks more or less susceptible to fishing due to the experience. As grey nurse sharks often feed at night, visual observations would not assist in evaluating whether tagged individuals are affected by the tagging process in terms of feeding. On balance, however, this assumption should probably be accepted pending more research.

- *Assumption 2: Tagged animals disperse throughout the untagged population.* The argument presented by Otway and Burke (2004) that tagged grey nurse sharks disperse over long distances along the east coast gives little indication that they also disperse throughout the population. There is insufficient knowledge of the social behaviour of grey nurse sharks to be confident that they intermingle during their migrations. This assumption is highly questionable based on current knowledge and therefore cannot be upheld.
- *Assumption 3: All animals have the same probability of being tagged initially.* This assumption is violated given that 92% of tagged fish were adults whilst their

proportional representation in 2002 was likely to be somewhere between 56% (from 2000 survey) and 79% (2003 survey). Therefore, there is a large bias against tagged juvenile grey nurse sharks in the mark-resighting experiment.

The consequences or even direction of bias associated with this violation are difficult to predict. The population estimates based on the total population and the adult population (Tables 4.1 and 4.3) use the same R-value (i.e. the number of tagged grey nurse sharks recorded in the re-sighting survey – June 2003) indicating that no juvenile sharks were resighted. As noted above, Table 2.2 does not present data on the sizes of tagged sharks, so it is not possible to determine where the juveniles were tagged. Therefore, the mark-resighting experiment does not appear to be relevant for smaller grey nurse sharks.

- *Assumption 4: Tags are not lost in the time between samples.* The use of two tags was a precautionary measure in seeking to retain tags. Whilst there are reports of rotting fins associated with the tags, it is reasonable to expect that this assumption would have been upheld over the year between tagging and the re-sighting experiment.
- *Assumption 5. The second sample is a random sample.* Two issues emerge here. First, on page 43, para 2 it is stated that the sharks counted were observed at 44 sites; this statement was incorrect because grey nurse sharks occurred at only 24 of the sites (Table 3.1) and therefore could be observed and counted only at those 24 sites. Thus, while the pool of sites visited was 44 (albeit still less than on previous winter surveys), only a little over half the sites were available for counting sharks that were potentially tagged.

Second, I could not find anywhere in the report where it is stated whether sites where sharks were tagged (i.e. Flat Rock, South Solitary Island, Fish Rock, Little Broughton or the Tollgates) were also sites where re-sighting surveys were done and tagged sharks resighted. If so, then the second sample is unlikely to be a random sample in violation of the assumption. The consequence of this is that if these sharks showed any homing ability at all, then re-sampling of sites where sharks were tagged is likely to increase the chance that they would be recorded during the second phase of the resighting experiment (i.e. in June 2003).

- *Assumption 6: The effects of emigration, immigration mortality and recruitment are negligible.* The first sentence under this section on page 43 is incorrect: it states that the sampling covered almost the entire range of the population whereas there was a resighting of a tagged grey nurse shark at Yeppoon. Moreover, grey nurse sharks are also known to occur at reefs north of Flat Rock (e.g. Henderson's Reef and Wolf Rock – QDPI 2007) and as far as is known, aggregations occurring at these northern sites were not included in the population estimate. The Yeppoon resighting means that either the experiment did not encompass the range of the species or that this individual migrated away from the population being estimated. It may also have been accompanied by other grey nurse sharks hence we cannot say whether the effects of migration were negligible, but it seems there is a significant chance that this assumption was violated.
- *Assumption 7: All tagged animals in the second sample are reported.* There is little reason to suspect under-reporting of grey nurse sharks during the June 2003 survey, unless some volunteers simply failed to place sightings on their report sheets. This assumption is probably valid.

- *Assumption 8: None of the resighted tagged animals were counted twice.* There is potential for some of the tagged sharks to have been reported more than once. This could happen where tags cannot be read and divers see the same shark more than once on a dive, but consider it to be a different tagged shark. Two situations where tag numbers could not be accurately read are for tags which are obscured by algal growth or the shark is observed at a distance (or under poor visibility) and the tags cannot be seen clearly.

Multiple reporting of the same tagged sharks would lead to an underestimate of the population size. We have no way of assessing the validity of this assumption, but given that some tags were reported by Otway and Burke (2004) to be obscured by algal growth and that volunteers were used, violation of this assumption is highly plausible.

In my opinion, there is sufficient doubt regarding the mark-recapture experiment that it should be largely discounted unless more informative data on specific details can be provided.

5.0 PRELIMINARY RESEARCH BY LINCOLN SMITH

During the course of my environmental research along the NSW coast, I have had opportunity to visit sites where grey nurse sharks are likely to occur. For example, I have visited the Banks, near Jervis Bay and recorded approximately ten grey nurse sharks there on one of three visits to that location. I have undertaken ecological monitoring on behalf of Midcoast Water in the Seal Rocks and Forster areas and have observed grey nurse sharks on three occasions at Charlotte Head and White Top Rock, as well as at recognised aggregation sites. The text below summarises some preliminary work I did on assessing the presence of habitat considered important to grey nurse sharks, but occurring outside recognised aggregation sites, on the extent of tags in grey nurse sharks from a series of sites visited, and on the suitability of the survey methods reported in the DPI studies.

5.1 Background and Methods

As noted in Section 2, I undertook research on grey nurse sharks on the north NSW coast and SE Qld in September/October 2004. The aims of the research were to determine if different methods could have a better chance of detecting grey nurse sharks and to assess the likelihood that grey nurse sharks and habitats that they appear to prefer occur at sites other than the aggregation sites recognised by the DPI studies. It was not intended that this research would seek to derive an estimate of population size of grey nurse sharks on the east coast, or to provide an analysis of size or sex structure.

The study extended from 18 September to 6 October 2004. Conditions were generally suitable for diving during this time, with a few days of bad weather with poor water clarity that prevented visits to some sites. Prior to leaving for the field trip, several fishers and divers were contacted at different localities and they agreed to meet with me to discuss grey nurse sharks in their area. Several agreed to take me to sites that were not included in the DPI surveys but on a confidential basis.

At each site visited the following were recorded on waterproof paper:

- Environmental conditions at the time of the visit, including sea state and water clarity.

- Features of the habitat in terms of presence of topographic features identified by Otway and Parker (2000), Otway *et al.* (2003) and Otway and Burke (2004) as being crucial for grey nurse sharks.
- All grey nurse sharks seen were recorded in terms of size class, sex, any distinctive features of individuals and presence/absence of tags or fishing tackle.
- Diversity and relative abundance of other fishes at the site, with particular emphasis on potential prey for grey nurse sharks.

Dives were done using scuba and snorkel. Scuba enabled divers to thoroughly search deeper areas and specific features such as caves and overhangs that might be missed by snorkelling. Depths covered by scuba ranged from approximately 12 m to 30 m, although at one or two sites we ventured into depths of about 8 m. The snorkelling enabled divers to inspect shallow areas which can be turbulent and hence unsafe for scuba. It also enabled a far greater areal coverage of a site than would normally be practical for scuba divers. Depths covered by snorkelling ranged from about 5 m to 20 m. At each site, divers initially inspected the part of the site assumed to have grey nurse sharks, based on previous research and on maps in Otway and Parker (2000). The search was then broadened to extend the area as far as practicable during the time available. No time limit was set on the inspection of a site and we were present in the water at most sites for at least an hour. For this study, no attempt was made to standardise the area covered or the time spent – the emphasis was on achieving the most thorough search possible, given conditions at the time.

5.2 Results

Broadly, we found that use of scuba alone or snorkelling alone is likely to lead to the conclusion that grey nurses were not present or less abundant in some areas when in fact they were. In other words, there was a reasonable chance of recording a “false-negative” conclusion at some sites. This seems to be due to two factors. First, some grey nurse sharks are widely dispersed at sites (in one case, individuals were 500 m apart). A 15-min scuba swim would seem to be most unlikely to encounter sharks this far apart. Second, grey nurse sharks were encountered in parts of a site where they might not normally be counted by scuba.

In particular, there were three sites where sharks were found by snorkelling in quite shallow water under “white-water”. Snorkellers were able to swim into the turbulent water with little risk of being swept onto or against rocks. Examples of such sites include Mermaid Reef, Green Island and South Solitary Island. On the other hand, at some sites, it appeared that snorkel diving was less suited for surveys – this was most obvious in deep areas and where water clarity was poor. These findings suggest that a combination of methods is needed to compile an accurate count of population size.

We visited several alternative sites (at Crowdy Head, Grassy Head near South West Rocks and Coffs Harbour) that are not currently recognised as “critical habitat”. We also intended to dive at headlands to the south of Crescent Head, but were unable to due to rough seas. At each of the sites we did dive (including the recognised sites) we recorded major features of the habitat that have been considered favourable for grey nurse sharks, including presence of caves, gutters, overhangs, etc; and abundance of prey species, including baitfish. All the non-recognised sites contained habitat that appeared very favourable for grey nurse sharks. These sites are also places where grey nurse sharks are reported by locals. During

our investigations, we did not record grey nurse sharks at these sites, in some cases possibly due to very poor water clarity.

During the field survey, we received a report that local divers had seen eight grey nurse sharks on headlands south of Crescent Head and 20 at the Cod Grounds (we were unable to directly confirm these sightings due to subsequent bad weather). One of these sharks at Crescent Head was reported to have two fin tags. This location is not recognised as critical habitat.

In total, there were 103 grey nurse sharks that were either counted directly or were reliably present on reefs we could not visit due to poor weather conditions. Only one shark had a mark-recapture tag, although two sharks with an acoustic tag on each were recorded. We were able to find grey nurse sharks at every site popularly reported to be utilised by grey nurse sharks, with one exception, Cherub's Cave, off Moreton Island (SE Qld).

Our observations suggest that the term "critical habitat" is not very useful and is simply called "critical" because that is where grey nurse sharks have been seen.

6.0 CONCLUSIONS

Grey nurse sharks have been fully protected in NSW since 1984 and, given the extensive media attention given to this species over many years, it is likely that the majority of fishers on the NSW coast are aware of the ban. The statement by Dr Peddimors on behalf of the NCC relies greatly on population estimates obtained by NSW DPI. A review of the available information indicates that these estimates may underestimate the true population, and there is evidence in these studies that the population of grey nurse sharks is increasing in the areas that are being studied, particularly on the north coast of NSW extending into SE Qld.

Based on (1) the occurrence outside of recognised aggregation sites of habitat characteristics considered to be of importance to the ecology of grey nurse sharks; (2) a trend to increased numbers of grey nurse sharks observed per site from 1999 to 2003; (3) the finding that grey nurse sharks occur well to the north of Flat Rock, SE Qld, the most northerly site unambiguously reported in the DPI Reports; (4) the finding that grey nurse sharks occur in water depths well in excess of 50 m and hence much deeper than would be safely accessible by divers involved in surveys of grey nurse sharks; (5) the lower than expected number of tags observed in some surveys of grey nurse sharks; and (6) my observations of grey nurse sharks at sites not surveyed during the DPI studies leads me to conclude that there are likely to be many more grey nurse sharks in the population than is presently accepted by the NCC.

Thus, the review of the relevant literature casts significant doubt on the estimates of population size of grey nurse sharks on the east coast of Australia and there are compelling reasons to suspect that the size of the grey nurse shark population is greater than the estimates being used to manage this species. These conclusions indicate that, at the very least, some testing of the methodology used to sample the populations is required urgently. Thus, in my opinion, increasing restrictions on fishing activities for recreational fishers or beyond the recommendations of the FMS for the OTLF is unwarranted at this time.

I have made all the inquiries that I believe are desirable and appropriate and that no matters of significance that I regard as relevant have, to my knowledge, been withheld from the court.

7.0 REFERENCES

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APPENDIX 1 – *CURRICULUM VITAE* OF MARCUS LINCOLN SMITH

DR MARCUS PAUL LINCOLN-SMITH - *CURRICULUM VITAE*

PERSONAL DETAILS:

Date of Birth: 21/10/1954.

Nationality: Australian

Marital status: Married with three children

Contact Address: The Ecology Lab Pty Ltd, 4 Green Street, Brookvale, New South Wales (NSW), 2100, Australia.

Contact Numbers: Work: 61 2 9907 4440; Fax: 61 2 9907 4446; mobile: 0413 622 086

E-mail: mls@theecologylab.com.au

QUALIFICATIONS/AWARDS/SKILLS:

- Ph.D., University of Sydney, 1998. Title of thesis: *Aquatic Ecology and Environmental Impact Assessment: A Critical Evaluation*. Winner of the 1998 Jabez King Heydon Memorial Prize for the most meritorious PhD awarded within the School of Biological Sciences in the 12 months preceding the award.
- MSc, University of Sydney, 1985. Title of thesis: *The Development and Application of Visual Survey Procedures for Fish Communities on Shallow Rocky Reefs*.
- BSc (Honours), University of Sydney, 1978. Title of thesis: *Aspects of the Ecology of Artificial Reefs*.
- BA, University of Sydney, 1978.
- MapInfo Professional Training Course, January 2002.
- PADI advanced open water SCUBA diver (1978).
- Commonwealth Commercial SCUBA Diver (AS 2815.1)
- Accredited Commercial Diving Supervisor (AS 2815.1)
- NSW boat operators licence (NSW).
- Class 1 drivers licence (NSW).
- St John Ambulance Australia, Senior First Aid Certificate (valid to 12/5/09)
- Oxygen First Aid Provider's Certificate

EMPLOYMENT HISTORY:

General. I have over 30 years experience in the field of aquatic ecology, with extensive tertiary training and a wide practical knowledge of the flora and fauna, occurring in numerous coastal, estuarine and freshwater habitats. In addition, I have also acquired extensive training and have a good practical knowledge of sampling designs and the use of statistics in ecology.

Throughout my career I have placed a strong emphasis on being able to communicate my research results and have sought to promote the importance of expanding our general understanding of aquatic ecosystems. To this end, I have attended and presented papers at numerous conferences and symposia and have given tutorials at several universities, including the University of Sydney and Newcastle University. Topics include environmental impact assessment, fish ecology, experimental design, seagrasses, bioaccumulation and marine reserves. The following sections outline my career path and list some of the major outputs of my work.

1985-present. Founder and Director of The Ecology Lab Pty Limited. Major achievements during this period:

- Prepared a major set of guidelines on assessment of aquatic ecology and EIA for the NSW Department of Infrastructure, Planning and Natural Resources. A key component of these guidelines was the development of methods for determining the optimal level of sampling required for specific development proposals.
- Prepared and/or presented submissions for 6 Commissions of Inquiry 1 Federal Court hearing and 10 Land & Environment Court hearings. Several of these hearings required expert input regarding seagrasses. Recent examples of expert testimony include the following:
 - Expert witness on effects of construction of fender piles, Dolans Bay, Port Hacking. Expert on seagrass ecology for the appellant. NSW Land & Environment Court, July 2006.
 - Court-appointed expert for proposed development at Arrawarra, near Coffs Harbour in relation to proposed development within a Caravan Park, 2006. My brief was to advise on the effects of the development on the Solitary Islands Marine Park, which fronts onto the development site. NSW Land & Environment Court, May 2006.
 - Expert witness on effects of an oil spill at HMAS Waterhen, Sydney Harbour, by the *Seahorse Horizon*. Issues relate to potential damage to local natural and artificial habitat. Witness for the NSW EPA. NSW Land & Environment Court, May 2006.
 - Expert witness on effects of an oil spill at Brotherson Dock, Botany Bay by the *Magnavia*. Key issues were potential damage to natural and artificial habitat and potential impacts to nearby seagrass beds. Witness for the NSW EPA. NSW Land & Environment Court, March 2006.
 - Expert witness on the potential effects of a ship grounding (*La Pampa*) at Port Curtis, Gladstone, Queensland. Key issues were potential impacts to seagrasses, mangroves and crab and prawn fisheries. Witness for the salvors. Australian Federal Court, March 2006.
 - Expert witness on effects of an oil spill at White Bay, Sydney Harbour by the *Tavake Oma*. Issues related to impacts to natural and artificial habitats. Witness for the ship's owners and captain. NSW Land & Environment Court, July 2005.
 - Specialist consultant on aquatic ecology, including seagrasses, on behalf of the Sydney Port Corporation in regard to a Commission of Inquiry for the proposed expansion of the facilities at Port Botany. NSW Commissions of Inquiry, 2004/5.
- Author of over 100 major reports, published articles & seminar presentations.
- Designed, researched and submitted PhD thesis.
- Technical reviewer for EISs prepared by NSW Fisheries on fishing in the state. Reviews include Estuary General EIS; Ocean Hauling EIS and Estuary Prawn Trawling EIS. Also assisted Planning NSW in the preparation of guidelines for preparing Fisheries EISs. Completed preparation of the EIS for the commercial Abalone Fishery in NSW.
- Peer reviewer for numerous environmental projects, conference proceedings & journals (national & international).
- Participated – often as team leader & principal investigator - in over 200 ecological studies, including state, national & international projects. Examples of recent major studies include the following:

- Team member of study evaluating potential for farming of gold lip pearl oysters (*Pinctada maxima*) in the Solomon Islands (2007). Studies include design and implementation of surveys of pearl oysters at selected locations, analysis of data, reporting and application of findings to other potential locations within the South Pacific. Study done on behalf of WorldFish with grant provided by the European Union.
- Ecological investigator for studies of sediment ecology in Port Phillip Bay, Victoria, in relation to proposed and previous dredging for shipping (2006-). Studies include analysis of previous data with use of confidence limits and power analysis to optimise sampling methods; and design and implementation of surveys of benthic macroinvertebrates.
- Team leader for study environmental assessment of impacts related to a proposed desalination plant located at Kurnell, Sydney, 2005 – 2007. Studies included evaluation of the effects of laying a water distribution pipeline across Botany Bay, including effects on seagrasses; and evaluation of the effects of intake and discharge pipelines for the plant. Our client is the Sydney Water Corporation.
- Team leader for environmental impact assessment of the proposed expansion of Port Botany, on the northern side of Botany Bay, 2002. Work involved habitat surveys (especially seagrass mapping), analysis of existing information and assessment of issues associated with antifouling treatment, introduced species (ballast water and ships' hulls) and shipping activities. Our client is the Sydney Port Corporation.
- Team member (advisor on ecological issues) for the Hastings National Demonstration, 2002. This study was done in collaboration with Meyrick and Associates on behalf of the Victorian EPA. It involves auditing the Ballast Water Decision Support System in relation to vessels entering the Port of Hastings, Victoria. The ultimate aim is to assist in the development of risk assessment strategies related to ballast water issues for domestic shipping.
- Team Leader on ecological studies for the Dendrobium Coal Mine, Illawarra, NSW. The Ecology Lab has been involved with this project, done on behalf of BHP Billiton, since 1999, with contributions to the EIS, Commission of Inquiry and development of a monitoring program.
- Project Director for contributions on aquatic ecology for Estuary Process Studies in NSW, including Hastings River, Wallis Lake, Smiths Lake, Port Stephens and Myall Lakes, Berowra (Hawkesbury River), Brooklyn (Hawkesbury River), Salt ash Creek (Georges River), Tuross and Coila Lakes and Lake Curalo.
- Member of Expert Review Panel for Christchurch City Council, New Zealand, June-August, 2002. I was engaged by Council as part of a team of three experts to:
 - Review documentation on a proposed outfall upgrade, including background studies, EIS and technical documents and tribunal evidence, on a proposed upgrade of the Christchurch sewerage scheme. This involved upgrade of an existing shoreline discharge (within the Avon-Heathcote Estuary) and an option for offshore discharge, approximately 1.5 to 3 km offshore in a habitat including soft sediments.

- Attend and assist with facilitation of a forum (“ecoforum”) to acquire and discuss information from local ecologists, hydrologists, engineers and selected stakeholders
- Provide a report summarising our recommendations for future management of the system, based on ecological matters.
- Project Director, bioaccumulation and ecological studies on the effects of the Newcastle Steelworks, South Arm of the Hunter River, New South Wales (NSW) 1993 – 2004. Several studies were commissioned on behalf of BHP and BHP Billiton to investigate the effects of the former steelworks. This led to input regarding the implications of sediment remediation; results of which were provided in reports, conference presentations and a scientific paper in *Marine Pollution Bulletin*.
- Principle investigator – review of studies done by the Queensland EPA on the effects of dredging Gladstone Harbour on bioaccumulation in oysters, mud crabs (including physiological studies) and seagrasses, 2003. Study undertaken on behalf of Gladstone Port Authority. The study involved reviewing reports and providing independent statistical analysis and interpretation of data.
- Team leader for ecological investigation of Twofold Bay, NSW in relation to proposed naval installations, 1999 – 2002; and 2006 - 2007. Designed and implemented a range of studies to assess the impacts and establish a baseline for understanding the effects of dredging, jetty construction and colonisation of artificial surfaces, and shipping activities (e.g. ballast water issues) on aquatic ecosystems, including whales, fisheries and aquaculture activities (mussel farming). Studies included surveys of fish, invertebrates, seagrass beds and rocky reefs, and analysis of data on whales entering the bay.
- Project leader for Baseline Monitoring of flora and fauna in relation to the upgrade of the Illawarra Waste Water Treatment Scheme, on behalf of Sydney Water, 2001. Surveys were planned, implemented and reported in relation to photoquadrat surveys of reef habitat in shallow (2–4 m) and deep (21-24 m) habitats; surveys of soft-bottom benthos, rocky intertidal surveys and a study on the distribution and abundance of weedy seadragons (*Phyllopteryx taeniolatus*) on reef habitat.
- Surveys of freshwater fish and invertebrates in the Clarence River system, NSW, as part of an investigation of the effects of diverting water, 1998 – 2001. I was engaged as team leader by the NSW Department of Public Works & Services and the Lower Clarence County Council to design and implement a series of investigations on aquatic habitats and flora and fauna. Outcomes included the establishment of a monitoring baseline.
- Team leader for a major study of a marine reserve at the Arnavon islands, Solomon Islands (Pacific Ocean), 1996 - 2001. This study has involved development of methods during a pilot study and subsequent participation in annual surveys of a marine reserve and three reference areas from 1994 to 1999. The main species of interest are commercially exploited invertebrates, including trochus, beche-de-mer, clams and pearl oysters. In addition, my role has included training of staff from the Ministry of Fisheries to undertake surveys of invertebrates and periodic meetings with local communities to explain the study and provide an indication of the success of the reserve. Outcomes include:
 - Submission of a major report on pilot investigations,

- Annual progress reports and presentation of a final report including a complete analysis and interpretation of the data.
- Senior authorship of a paper presented at the International Coral Reefs Symposium in 1996 and co-authorship on a paper being prepared for *NAGA* (the journal of ICLARM) on management issues. An abstract has been submitted for presentation at the 2000 ICRS. Senior author on paper published in the Canadian Journal of Fisheries and Aquatic Sciences on the use of environmental impact assessment in evaluating marine reserves (Lincoln Smith *et al.* 2006 – see below). The paper presents detailed BACI and delta ratios as assessment tools, supported by power analysis.
- Establishment of a mentor program whereby an officer from the Ministry of Fisheries, Solomon Is, visited my office for 1 month to enter and check data from the project, do preliminary statistical analysis, review literature and draft a paper for scientific publication.
- Team partner for a major international study on the effects of logging on tropical aquatic ecosystems, 1999 - 2001. This was done in collaboration with ICLARM (now WorldFish), the New Zealand Government and Solomon Islands Government and involved close collaboration with local communities. Investigations focused on freshwater fish and decapods (i.e. giant freshwater prawns), corals and coral reef fish near logged and unlogged catchments. The study area included Kolombangara Island and Islands around Marovo Lagoon.
- Project leader for study of reef benthos at Burwood Beach deepwater outfall 1995 – 1997, on behalf of the Hunter Water Corporation, NSW. Surveys involved the collection of photoquadrats at the outfall location (3 sites) and at 3 reference locations (3 sites per location).
- Participant in surveys of grey nurse sharks (*Carcharias taurus*) along the NSW coast, 1993 – 1999. The Ecology Lab was engaged by NSW Fisheries to undertake surveys of this endangered species of shark and wobbegong sharks (*Orectolobus* spp.), using underwater survey techniques.
- Participated (as facilitator and presenter) in training workshop on underwater visual census (UVC) procedures for coral reefs involving Australia, New Guinea, Solomon Islands and Fiji, 1998. Two major outcomes of the study were a report on the finding of UVC surveys on Pacific Islands and a manual for design and implementation of UVC surveys. I assisted in the preparation of the report and co-authored two of the chapters in the manual.
- Undertook a major study on beds of tropical *Sargassum* and associated epifauna at the Montebello Islands, on the North West Shelf of Western Australia, 1997 (Client: Apache Energy). The study involved design and implementation of field studies, laboratory sorting and identification, and power analyses to determine optimal sampling strategies for long term work. The outcome of the study included a major report detailing the development of sampling procedures, including quadrat and transect surveys, laboratory procedures for epifauna and mapping of *Sargassum* beds from aerial photography. This report now forms the basis for future monitoring of the effects of oil spills on *Sargassum* beds around the islands.
- Team member for marine reserves proposals at Christmas Island and Cocos Keeling Islands (Indian Ocean), 1993 -4. The investigation was done in

collaboration with the University of Sydney under contract to the Commonwealth Government. The studies involved design and implementation of surveys of marine resources in and outside marine reserves; creel and questionnaire surveys of local fishers and liaison with community groups on traditional fishing methods, target species and preferred fishing areas. Outcomes of the study included three reports and a publication that was presented at the PACON conference, in Townsville, 1994.

- Team leader/project manager for major ecological investigation into the effects of sand extraction off the NSW coast, 1989 – 1993. Work involved coastal sampling of fish and invertebrates living in sedimentary habitats using trawling, grab sampling and trapping; review of the impacts of dredging and plume dispersal on marine ecosystems and fisheries. The work was subject to intensive peer review both locally and internationally and the standard of work was judged to be exceptionally high. The project also involved interaction with a range of other specialists in engineering, dredging technology, water and sediment quality, coastal geomorphology and hydrology.

1980-1985. Completed part time Masters degree, also worked at the 'Homes Pictorial' publishing firm and undertook part time environmental consulting.

1978-1980. Technical assistant/Technical officer, New South Wales State Fisheries Department, 1978 to 1980. Project involvement:

- 2 year ecological study of fish populations in Botany Bay, including seagrasses, mangrove, mud/sand, and rocky reef habitats).
- Marine Reserves Program, assessing the value of rocky reef and estuaries in NSW, including surveys of rocky reef fishes at the Five Islands, Pt Kembla.
- Artificial Reefs Program, evaluating the benefits of estuarine and coastal artificial reefs; rock breakwaters and revetments; and floating fish attractors.

1973-1980. Full time university studies. Other activities done during that time include work as a courier, marina employee in Sydney (November 1972 – January, 1973; jackeroo on a sheep and wheat station, western NSW in January 1973/February 1974; work as an assistant to a geologist at Kalgoorlie, WA, from December 1974 to February 1975; and study leave to undertake student research with Jean Michel Cousteau in New Guinea, August/September 1975.

PROFESSIONAL ASSOCIATIONS:

Member of Environment Institute of Australia Inc.

Member of the Australian Marine Sciences Association.

Member of the Australian Society for Fish Biology.

Member of Coast and Wetlands Society.

Member of the Ecological Society of Australia.

Member of PACON (Pacific Congress)

Associate of the Centre for Ecological Impacts of Coastal Cities, University of Sydney, 2004-2006.

ADVISORY POSITIONS:

Member, Advisory Council on Fisheries Conservation. Established by NSW Fisheries to advise the State Minister on issues related to conservation on aquatic species, 1999-2002.

Member, Bicentennial Park scientific committee, 1999 – 2001.

Member, Course Advisory Committee, Faculty of Science, UTS Sydney, 2004 - .

Member of Working Group on Accreditation of Consultants for Ecological Investigations in Environmental Impact Assessment in NSW. Co-ordinated by the Department of Heritage and Environment, 2005.

ACADEMIC CONTRIBUTIONS

Peer Reviewer, scientific journals including *Marine Ecology Progress Series*, *Journal of Experimental Marine Biology and Ecology*, *Marine Pollution Bulletin*, *Aquaculture*, *Applied Ecology*, *Austral Ecology*, *Marine and Freshwater Research* and several conference proceedings.

Guest lecturer in aquatic ecology and environmental impact assessment at the University of Sydney, University of NSW, Newcastle University, UTS and Great Barrier Reef Marine Park Authority.

Co-supervisor of two PhD candidates – Dr Adam Smith, University of NSW and Ms Brianna Clynick, University of Sydney.

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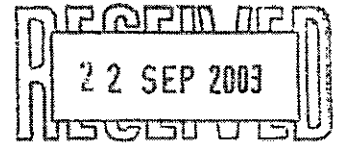
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**APPENDIX 2 – DATA SUPPLIED TO ME BY RECFISH AUSTRALIA
ON AUGUST 2003 SURVEY**



NSW Fisheries

Mr M. Brown
NSW Spearfishing & Freediving Association
9 Narelle Crescent
Woonona NSW 2517

September 17th, 2003

Dear Mel,

The second of the two grey nurse shark distribution and abundance surveys for 2003 has recently finished, please find attached a summary of the results. I would like to thank you and your divers for your assistance with these, everyone has put in a great effort and the information you have provided has been invaluable. The number of sharks counted and the re-sightings of the tagged sharks has provided us with a greater understanding of movements of grey nurses along the east coast of Australia and a more accurate population estimate.

I would also like to remind you that if you see any sharks with tags to please contact me or call the tagging hotline. Many of the tagged sharks have algae on the tags covering the numbers and making them difficult to read. However, it is still extremely important that the shark (its size, sex, and location of sighting) is reported to us as we can still use this information to identify that shark. The simple fact that it is tagged, and not its number, is the most important piece of information that is critical to our ongoing research.

We are currently in the process of producing a report documenting the information from the tagging. If you are interested in obtaining a copy please let me know and I will send one out to you when it is finalised.

Kind regards,


Adrienne Burke

Phone: (02) 4916 3829

Facsimile: (02) 4982 2265

Email: Adrienne.Burke@fisheries.nsw.gov.au

Tagging Hotline: (02) 4916 3888

PORT STEPHENS FISHERIES CENTRE

Taylor's Beach Road, Taylor's Beach 2316 - Private Bag 1 Nelson Bay 2315

Telephone: 4982 1232 Facsimile: 4982 1107

Website: www.fisheries.nsw.gov.au

ABN 56 287 047 871

Grey Nurse Shark Survey August 2003

- This is a summary of the second and final of this years New South Wales coast-wide surveys of the population and movements of Grey Nurse Sharks undertaken by NSW Fisheries (Dr Nick Otway and Adrienne Burke). The survey was carried out with the assistance of the scuba diving and spearfishing communities and funded by NSW Fisheries and Environment Australia.
- The survey covered the whole of the NSW coast from Eden in the far south to Tweed Heads in the north and extending up the Queensland coast to Bundaberg. It was carried out over the last 2 weeks in August.
- A total of 162 Grey Nurse Sharks were sighted over 27 sites.
- No sharks were sighted at 10 of the sites sampled (37% of all sites).
- Of the 24 tagged sharks none were sighted along the coast in this survey period.
- The following table summarises, according to size and gender, the numbers (and percentages) of the sharks that were sighted during the survey.

Sex	Size			Unknown	Total
	< 2 m	2 – 3 m	> 3 m		
Male	18 (11.1%)	21 (12.9%)	0	0	39
Female	29 (17.9%)	44 (27.2%)	11 (6.8%)	0	84
Unknown	13 (8%)	4 (2.47%)	0	22 (13.6%)	39
Total	60 (37%)	69 (42.6%)	11 (6.8%)	22 (13.6%)	162

- Of the 162 Grey Nurse Sharks sighted, 80 (49.4%) were of a reproductively mature size. For individuals of known sex, 21 (12.9%) of males were of reproductively mature size, and 55 (34%) of females were of reproductively mature size with a 1: 2.2 sex ratio.