Northern Fisheries Centre Cairns QI

Fishery assessment update 1988-2003: Queensland East Coast shark

Dr N. Gribble[+^], O. Whybird[+], L. Williams*, and R. Garrett[+^]

DPI&F Animal Science[+]
Queensland Fisheries Service*
CRC Reef [^]

FISHERIES RESEARCH & DEVELOPMENT CORPORATION

CRC Reef Research Centre

Queensland Government Department of Primary Industries and Fisheries

Information Series QI04070

Fishery assessment update 1988-2003: Queensland East Coast shark

Dr N. Gribble, O. Whybird, L. Williams, and R. Garrett

Jan 2005

DPI&F Animal Science

Queensland Government
Department of Primary Industries and Fisheries

QI04070

ISSN 0727-6273

AGDEX

Disclaimer

Information contained in this publication is provided as general advice only. For application to specific circumstances, professional advice should be sought.

The Department of Primary Industries and Fisheries have taken all reasonable steps to ensure the information contained in this publication is accurate at the time of the survey. Readers should ensure that they make appropriate enquires to determine whether new information is available on the particular subject matter.

The correct citation of this document is N. Gribble *et al.* (2004) Fishery assessment update 1988-2003: Queensland East Coast shark. Department of Primary Industries and Fisheries, Queensland QI 04070

Coordinated by the Tropical Resource Assessment Program, Queensland Department of Primary Industries and Fisheries,
Northern Fisheries Centre, Cairns, 2005.

Enquires should be directed to:

Dr Neil Gribble
Northern Fisheries Centre,
PO Box 5396
Cairns QLD 4870

Acknowledgements

Thanks to Dr Ilona Stobutzki for the use of her data and analysis (currently in prep), which allowed the assessment of the relative sustainability of the Gulf of Carpentaria caught species.

We wish to thank the East Coast fisheries observers Jason Stapley, Stirling Peverell, and Stuart Hyland for the data on shark species composition for the East Coast Fishery.

Special thanks to those skippers and fishing vessel crews that participated in the pilot shark observer programs by allowing the observers to come onboard and access their shark catches. Without this co-operation the gathering of valuable information would not have been possible.

Acronyms

CFISH	Commercial Fishery catch and effort logbook database
CHRIS	Coastal Habitat Resources Information System
CPUE	Catch per Unit Effort
CRC	Co-operative Research Centre
DPI&F	Department of Primary Industries and Fisheries
FRDC	Fisheries Research and Development Corporation
GBR	Great Barrier Reef
NPF	Commonwealth Northern Prawn Fishery
QBF	Queensland Barramundi Fishery
QLF	Queensland Line Fishery
QSMF	Queensland Shark and Mackerel Fishery
WHA	World Heritage Area
WTBF	Commonwealth Western Tuna and Billfish Fishery

....

TABLE OF CONTENTS

List of Figures and Tables

Queensland East Coast Shark Catch: 1988 - 2003

1 Introduction

This document updates an assessment of the Queensland East Coast Shark catch, undertaken in 2003 (Rose *et al.* 2003). The assessment extends previous baseline information on commercial shark catches for fishery managers, industry and others with an interest in the shark fisheries of Queensland waters. We also provide a preliminary sustainability assessment of the shark species caught on the Queensland East Coast, based on the approach of Stobutzki *et al.* (in prep.).

Analysis of the data from CFISH commercial fishery catch and effort logbook database has a number of limitations. There is no differentiation made between different shark species caught, and the records that are available originate from a number of fisheries because there is no specific shark fishing endorsement on the East Coast. These limitations can only be addressed at some future date with improved logbooks. In the current analysis, the generic category of "shark" was used in the absence of more detailed identification. Therefore this report must be viewed as a general summary only.

2 Commercial Logbook Data Summary

2.1 Methods

There are two main zones for net-caught shark harvest in Queensland: the Gulf of Carpentaria and the East Coast of Queensland. Only the East Coast statistics are considered in this report. A complementary assessment of the Queensland Gulf of Carpentaria Coastal Shark fishery is given in Gribble *et al*. (2004).

The logbook data was extracted from CFISH in late April 2004, however records from 2004 were incomplete and therefore excluded. The co-ordinates of the statistical regions used for this summary are shown in Table 1.

The shark products are reported in the form of shark trunks or fillets, and is back-calculated to whole weight in the CFISH logbook database. Since the time of the 2003 assessment of the Queensland East Coast shark fishery (Rose *et al*. 2003), major changes have been made to this method. The conversion factors used to calculate whole shark weight from processed products have been changed to 3.3 for fillet and 1.659 for trunk. Also additional data, from logbooks submitted after March 2003 has been included in the analysis, leading to revised catch totals.

Selection of Data

- Data was selected by Month and Year from the East Coast of Queensland
- Records were divided into The Great Barrier Reef and Southern Areas
- Area record were further categorized into regions (see Table 1)
- Only net and line fishing methods were analysed
- New conversion rate from fillet or trunk to whole weight have been applied

Table 1 - Queensland East Coast Fisheries Regions analysed from commercial logbook records of shark catch and effort.

Location	Feature	Min Latitude	Max Latitude	Min Longitude	Max Longitude
Remote	Cape York to Cape Flattery	10^{o} 30'	15^{o} 00'	142^{o} 30'	155^{o} 00'
Northern Wet	Cape Flattery to Paluma R	15^{o} 00'	18^{o} 30'	142^{o} 30'	155^{o} 00'
Northern Dry	Paluma River to Cape Conway	18^{o} 30'	20^{o} 30'	142^{o} 30'	155^{o} 00'
Swains	Cape Conway to Cape Manifold	20^{o} 30'	22^{o} 00'	142^{o} 30'	155^{o} 00'
Capricorn	Cape Manifold to Baffle Creek	22^{o} 00'	24^{o} 30'	142^{o} 30'	155^{o} 00'
GBR Area	**Cape York to Baffle Creek**	**10^{o} 30'**	**24^{o} 30'**	**142^{o} 30'**	**155^{o} 00'**
Fraser Burnett	Baffle Creek to Rainbow Beach	24^{o} 30'	26^{o} 00'	142^{o} 30'	155^{o} 00'
Moreton	Rainbow Beach to NSW Border	26^{o} 00'	28^{o} 30'	142^{o} 30'	155^{o} 00'
Southern Area	**Baffle Creek to NSW border**	**24^{o} 30'**	**28^{o} 30'**	**142^{o} 30'**	**155^{o} 00'**
East Coast		**10^{o} 30'**	**28^{o} 30'**	**142^{o} 30'**	**155^{o} 00'**

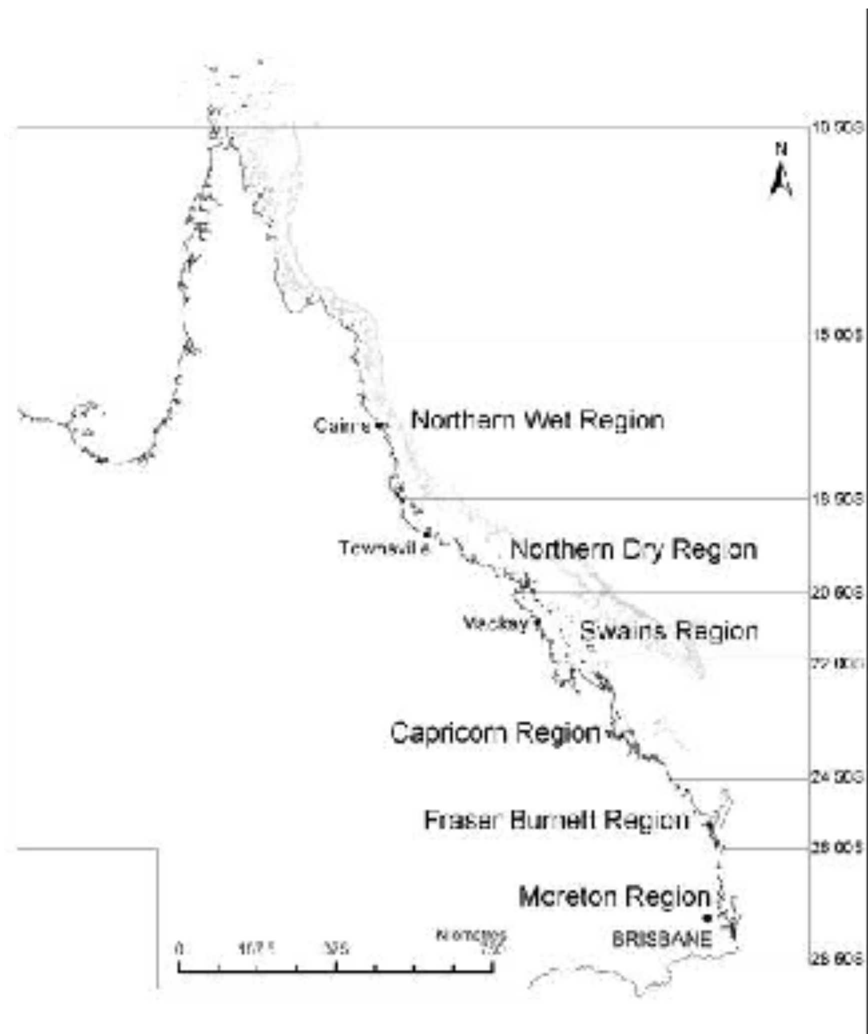

Figure 1 – Map of Queensland East Coast Fisheries Regions analysed from commercial logbook records of shark catch and effort
Note: - Latitude in decimal degrees

2.2 Overview of Commercial Logbook Shark Data 1988-2003

Substantial landings of shark are reported every year in Queensland's net and line fisheries. This is especially so along the East Coast, and in the Great Barrier Reef region in particular. According to the latest fishery logbook records, the statewide harvest of shark increased from approximately 460t in 1989 to approximately 1900t in 2003. In this context the total annual East Coast shark catch grew, by 36% from approximately 1100 tonnes in 2000 to 1500 tonnes in 2003 (see Figure 2). The observed increase in shark harvest has been accompanied by an expanding fishery effort, especially amongst those fishers who deliberately target shark product.

In 2003, most of the East Coast shark harvest (approximately 94%) can be attributed to commercial net fishing operations with the remainder taken predominantly by line fishing (6%). CFISH Shark harvest records in the past have included very small quantities of harvest from trawl, pot, and beam trawling. Because of a change in the entry of logbook data, the majority of these records are now attributed to their method of harvest, rather than the type of vessel. The East Coast Trawl Fishery reported harvests of between 5 and 45 t of shark each year, until the 2003 harvest where only 34 kg (0.002% of East Coast shark landings for the year) was caught. This is probably an example of the change in logbook reporting. Anecdotal information suggests much of this shark is line-caught from the trawler, therefore would be no longer reported in trawl logbooks. Other fishing methods for which very small catches were reported in 2003 include beam trawling (0.01%) and pot (0.001%). The Moreton region recorded shark catches by trawl and beam trawl in 2003, Fraser Burnett recorded sharks from beam trawling and Northern Wet recorded pot caught sharks. Because of the small quantities of shark caught incidentally in these operations, and their rarity in term of the effort expended, the analysis in this report considers only the net and line fishery (Figure 2 and 3).

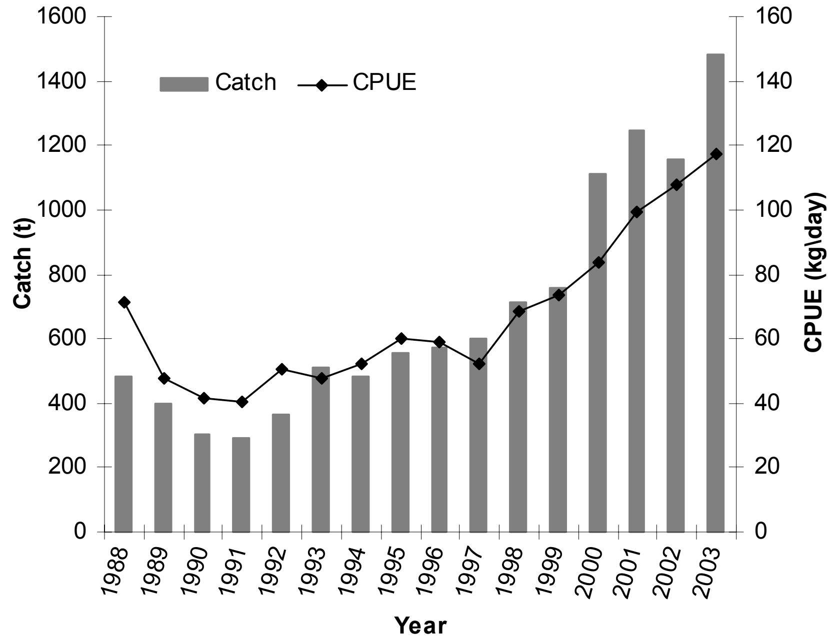

Figure 2 - Annual shark harvest and catch per unit effort on the East Coast All Fisheries combined 1988 to 2003 (data from CFISH database). Catch includes fillets and trunks that have been converted to whole weight.

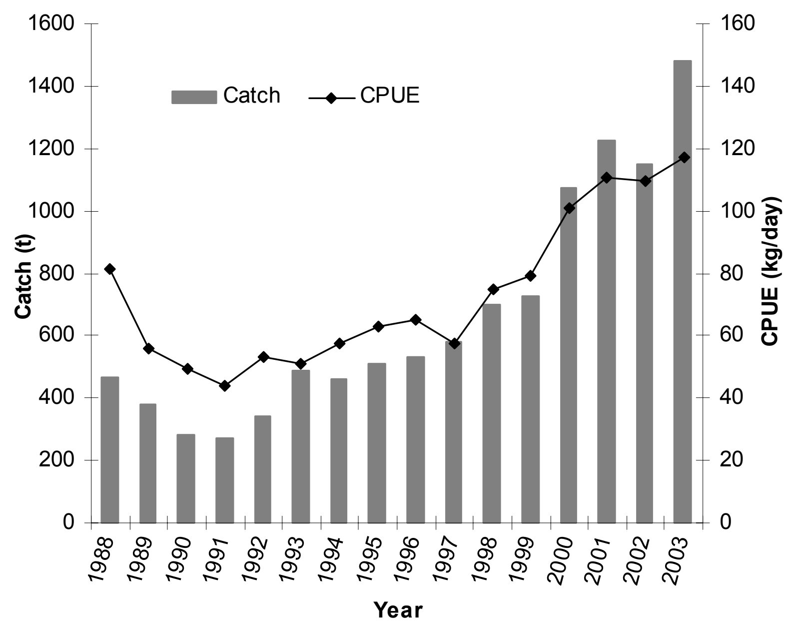

Figure 3 - Annual shark harvest and catch per unit effort in the East Coast Net and Line fisheries only 1988 to 2003 (data from CFISH database). Catch includes fillets and trunks that have been converted to whole weight.

Annual harvests from the inshore net fishery on the East Coast of Queensland have been variable, although they steadily increased from 1989 to 2003. The East Coast harvest decreased from 439t in 1988 to 243t in 1991, then steadily increased to about 1390t in 2000. Effort in the East Coast net fishery, measured as the number of fishing days when shark were caught, was variable, although there was a rise from 5200 to 11000 fishing days between 1988 and 2003. The line fishery catch of shark on the East Coast also increased until 2003, when the catch declined 20% from 113t in 2002 to 90t (see Figure 4). Over all, the trend for the shark catch for the East Coast net and line fisheries is of a steady increase, especially since 2000 (Figure 5).

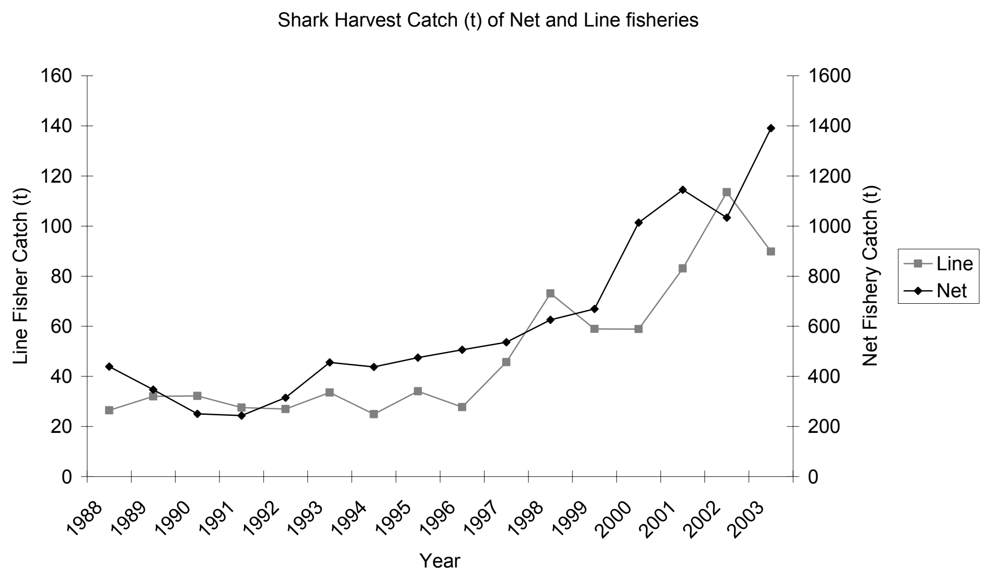

Figure 4 - Queensland East Coast shark Net Fishery versus Line Fishery yearly catch, plotted on different y-axis 1988 to 2003 (data from CFISH database).

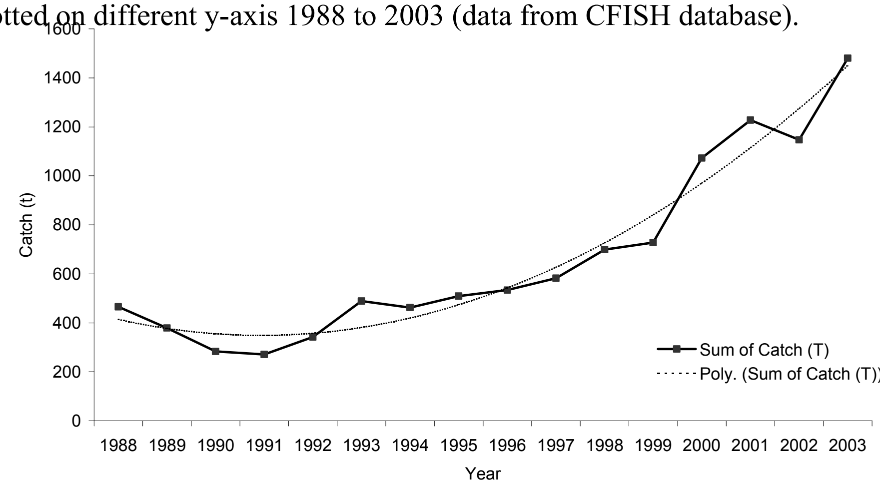

Figure 5 – Queensland East Coast Net and Line Shark Fishery yearly catch and trend line (second order polynomial) 1988 to 2003 (data from CFISH database).

CPUE (kg per day) of sharks in the East Coast net and line fishery has also increased over the last decade, rising 49% from around 57 kg/day in 1994 to 117 kg/day in 2003 (Figure 3). Mean daily shark harvest per vessel increased from 40kg in 1994 to 92 kg in 2003, and varied from a high of 190 kg per vessel per day in the Remote region to a low of 41 kg per vessel per day in the Moreton region (Table 4).

The largest proportion of Queensland's shark harvest is taken in the Great Barrier Reef (GBR) area with 66% of the 2003 catch. The Gulf of Carpentaria accounted for 22% and the remaining 12% came from the Southern area of the East Coast. Growth in shark fishing operations within the Great Barrier Reef region has been particularly marked, with the harvest in 2003 almost four times larger than in 1994. The fishing effort, in fishing days, in this region, increased by 82% over the same period.

2.3 Regional summaries

Tables 2, 3 and 4 summarise catch, effort and catch per day for net and line fisheries for shark in the different regions along the Queensland East Coast.

The **Northern Dry** region (18° 30'S to 20° 30'S) has dominated the reported East Coast shark catch, especially from 1998, with harvests over 300t each year since 1998. Some 424 tonnes (calculated whole weight) were landed in 2003, from a total of 2907 fishing days. This performance equates to 34% of the total shark catch in the GBR region (29% of the East Coast catch), and 32% of the GBR shark fishery effort. Mean annual daily boat harvest has fluctuated in this region from a high (of over 130 kg/day) in 1998 - 2000 to only 105 kg/day in 2003.

The **Capricorn** region is currently the second most productive fishery area for sharks on the East Coast, with 19.1 % of the catch.

The **Northern Wet** region's harvest of shark dramatically increased in 2000, peaked in 2001, then fell again in 2002 and 2003. This may correspond with the commissioning of new, more efficient boats into this fishery, and the movement of this component of the fleet from the northern wet to the remote region over this period.

The greatest percentage increase in shark catch has been reported in the **Remote** region, from 17t in 1994 to 214t in 2003. This 12.8 fold increase in harvest has been achieved by an only 2.9 fold increase in effort (Table 4). The reason for this is not clear but may indicate a change in fish targeting by the fishers, rather than huge increase in fishing efficiency.

The **Fraser-Burnett** region (24° 30'S to 26° 00'S) was the East Coast's top shark producing area in 1996 with 142t (27% of the East Coast catch). Catches have remained fairly stable since, with 136t caught in 2003 (9%). Over the last 4 years the majority of areas further north have overtaken the Fraser-Burnett region as prime shark producing fisheries.

Table 2 - Shark harvest (t) by Queensland East Coast region, from net and line fisheries (data from CFISH database).

Location	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Remote	16.7	41.5	20.0	37.3	16.7	14.5	91.9	154.8	158.5	214.1
Northern Wet	29.8	31.3	33.1	83.9	21.9	51.6	197.8	287.4	142.8	155.1
Northern Dry	123.2	92.7	96.9	141.1	329.6	322.1	323.6	303.4	390.8	423.9
Swains	60.7	82.1	106.2	75.7	62.5	71.2	119.0	159.7	74.2	176.3
Capricorn	88.7	107.8	86.3	97.4	76.4	86.2	96.5	117.2	161.3	283.3
GBR Area	**319.2**	**355.4**	**342.4**	**435.5**	**507.0**	**545.6**	**828.8**	**1022.5**	**927.6**	**1252.7**
Fraser Burnett	104.4	114.5	141.7	87.4	131.0	123.1	165.4	142.1	141.8	135.9
Moreton	38.4	37.1	48.4	54.5	59.0	55.2	76.9	62.7	77.8	91.6
Southern Area	**142.7**	**151.6**	**190.1**	**142.0**	**190.1**	**178.3**	**242.3**	**204.8**	**219.6**	**227.5**
East coast	**461.9**	**507.0**	**532.5**	**577.5**	**697.1**	**723.9**	**1071.1**	**1227.3**	**1147.2**	**1480.1**

Table 3 – Effort (number of days when was shark harvested) by Queensland East Coast region, from net and line fisheries (data from CFISH database).

Location	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Remote	294	282	247	218	371	409	671	790	772	840
Northern Wet	522	615	603	1095	704	1021	1507	1643	1327	1448
Northern Dry	1250	1552	1101	1745	1679	1396	1634	2256	2346	2907
Swains	1028	756	939	1252	937	1027	903	1030	965	1139
Capricorn	1956	2133	2255	2627	2173	2167	2295	2184	1894	2819
GBR Area	**5050**	**5338**	**5145**	**6937**	**5864**	**6020**	**7010**	**7903**	**7302**	**9153**
Fraser Burnett	1785	1643	1949	1721	2096	1826	2099	1942	1799	1798
Moreton	1216	1089	1081	1445	1342	1326	1501	1223	1373	1669
Southern Area	**3001**	**2732**	**3030**	**3166**	**3438**	**3152**	**3600**	**3165**	**3172**	**3467**
East coast	**8051**	**8070**	**8175**	**10103**	**9302**	**9172**	**10610**	**11068**	**10474**	**12620**

Table 4 - Mean daily boat harvest (kg/day) by Queensland East Coast region, from net and line fisheries (data from CFISH database).

Location	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Remote	55.1	143.9	89.8	119.6	37.3	29.6	85.4	163.8	127.4	190.2
Northern Wet	76.5	58.5	51.5	50.3	29.2	36.6	95.3	139.1	94.7	76.9
Northern Dry	79.7	57.1	73.8	69.5	134.4	131.8	137.1	99.5	117.5	105.4
Swains	47.3	77.5	76.0	49.0	52.0	53.8	102.5	105.3	59.1	122.0
Capricorn	35.7	42.1	29.6	35.2	27.8	30.8	35.9	47.0	78.3	87.8
GBR Area	**46.9**	**58.0**	**45.8**	**48.0**	**60.0**	**54.9**	**80.5**	**96.1**	**99.4**	**104.0**
Fraser Burnett	55.0	49.2	42.4	36.1	44.2	41.1	60.8	71.1	112.9	95.5
Moreton	23.7	27.1	38.2	26.6	25.9	24.5	35.1	46.7	60.9	41.0
Southern Area	**36.8**	**37.3**	**40.3**	**31.3**	**29.8**	**29.3**	**43.1**	**64.1**	**81.7**	**68.5**
East coast	**40.4**	**46.3**	**38.6**	**39.9**	**47.0**	**45.4**	**59.7**	**81.4**	**91.6**	**91.7**

Overall, the exploitation of the shark resources in the Great Barrier Reef area is increasing, with more specialist shark fishers entering the fishery and/or the existing fishers becoming more efficient in their operations.

At this stage no comment has been made on shark fin reported in the logbooks. Difficulties in the logbook format, and fisher's reticence, meant these data were under-reported.

3 Recreational Catch

Recreational fishers also harvest sharks. The 2000-2001 National Recreational and Indigenous Survey (Henry and Lyle, 2003) estimated 35,899 +/- 8,095 sharks and rays were harvested in the whole of Queensland. This was 16% of the total recreation harvest of shark and rays nationally. On a national scale the recreational shark and ray harvest consisted of:

- 50% caught coastally, 40% in estuary, 10% offshore and 0.01% in rivers;
- 74% boat based fishers; and
- 98% line caught, other methods include dive, nets and pots/traps.

It is assumed that these trends would be reflected in Queensland.

Queensland Indigenous fishers harvest 3,819 sharks, 21% of the number harvested nationally (Henry and Lyle, 2003).

- 53% caught inshore, 30% coastally, 14% in rivers and 2% offshore
- 49% line caught, 40% by spear, 11% by net and 0.3% by pots/traps.

Due to a lack of size and species information these numbers of animals cannot be converted into comparable weight with any accuracy.

4 Shark Relative Sustainability Index for Queensland East Coast fishery

4.1 Introduction

The logbook catch rates are for all shark species combined, and do not provide information on individual species. The only species composition information is from the limited fishery observer program data, however this is neither for the full time series nor across the full geographic range of the East Coast fishery. It is possible however to infer the sustainability of species by assessing their biological characteristics and how these impact on their productivity and their vulnerability to capture.

We have applied a risk assessment method developed by Stobutzki *et al.* (in prep.) for Northern Australia to examine the impacts of fishing on shark species fished on the Queensland East Coast. The method provides an initial assessment to guide management, as traditional stock assessment methods are not feasible due to lack of comprehensive species composition data. The Stobutzki *et al.* (in prep.) method assumes the species sustainability depends on a balance between its productivity and fishing mortality attributes.

In this preliminary report we are using the species identifications available from the limited observer program and treating the East Coast shark population as separate to the stocks from Western Australia, Northern Territory or Indonesia. It is planned to complete a more comprehensive sustainability risk assessment of East Coast shark as part of the current FRDC funded "Sustainability of Northern Sharks and Rays: Phase II"

4.2 Data source

In the CFISH logbook "shark" catch is a generic category for all shark species, the highest proportion of which has been assumed to be the black tip whaler sharks *Carcharhinus tilstoni* and *C. sorrah* (Williams, 2002). Rose *et al*. (2003) suggest that while the largest proportion may be comprised of these species, the commercial catch has a much wider species composition (see Table 5).

Table 5 - Queensland East Coast shark catch composition (% of sharks caught) for all species caught across 4 observer trips (Rose *et al*. 2003).

Shark species	**% of sharks**
Carcharhinus tilstoni	32.0
Sphyrna lewini	18.0
Carcharhinus sorrah	7.7
Carcharhinus dussumieri	7.5
Rhizoprionodon acutus	6.8
Carcharhinus amblyrhynchos	6.6
Carcharhinus amboinensis	4.8
Carcharhinus brevipinna	3.1
Carcharhinus fitzroyensis	2.9
Sphyrna mokarran	2.9
Carcharhinus macloti	2.2
Carcharhinus melanopterus	1.3
Rhizoprionodon taylori	1.3
Rhinoptera neglecta	1.1
Triaenodon obesus	0.4
Aetobatus narinari	0.4
Rhynchobatus djiddensis	0.4
Hemipritis elongatus	0.2
Galeocerdo cuvier	0.2
Carcharhinus falciformis	0.2

4.3 Methods

Risk Assessment Analysis *[extracted from Stobutzki et al. (in prep.)].*

(i) Index of Productivity

As direct estimates of longevity, reproductive rate and natural mortality rate were not available for most species, alternative attributes were used to provide an index of productivity (Appendix 1). These included size at maturity, maximum size, age at maturity, lifespan, litter size, reproductive period. These were the basis for ranking the species with respect to their productivity, modified from Stobutzki *et al*. (2002).

Each species was ranked from 1 to 3 for each attribute, a rank of 1 reflecting high productivity, a rank of 3 reflecting low productivity (Appendix 1). For each attribute the range of values (natural log transformed) was divided into three levels or categories to determine the ranks. This transformation reduced the influence of outliers (heteroscedasticity).

A range of methods was used to estimate attributes of age and size at maturity, taken from the literature, e.g. age at first maturity, age at 50% maturity. Due to the scarcity of information Stobutski *et al*. (in prep.) did not standardize the method used. Information from Australian studies was given preference. In cases where several values were available for a single species, due to differences between the sexes, the value for males was used. This value was available for more species, but if not available then the value for females was used. Where one or more value was available for the Lifespan of a species the maximum value was taken.

If species-specific information was unavailable for size at maturity, reproductive period or litter size, estimates were made from closely related species. The estimates of size at maturity were based on the ratio between size at maturity and maximum size for co-familiar or co-genera species. The estimates of litter size and reproductive period are the mean for co-familiar or co-genera species. If there were insufficient data available at the family level a species was given a rank of 3, on a precautionary basis.

The total productivity ranking for each species was calculated as the mean of the rankings for the individual attributes. Shark species that have a higher ranking have a lower productivity (see Table 6) and therefore may be more vulnerable to the impact of harvesting.

Table 6 - The rankings of East Coast caught shark species on attributes that contribute to their total productivity rank (taken from Stobutzki *et al.* in prep.).
Attributes and ranking system in Appendix 1; Species List from fishery observers.
(1 = high productivity 3 = low productivity)

Species	Longevity	Age at Maturity	Year Fecundity	Maximum size	Size at Maturity	Depth Range	Ranking
Carcharhinus amblyrhynchos	2	2	3#	2	2	1	**2.00**
Carcharhinus amboinensis	3*	3*	2	2	3	1	**2.33**
Carcharhinus brevipinna	2	3	2	2	3	1	**2.17**
Carcharhinus dussumieri	3*	3*	3	2	2	1	**2.33**
Carcharhinus falciformis	2	2	2	3	3	1	**2.17**
Carcharhinus fitzroyensis	3*	3*	2#	2	2	1	**2.17**
Carcharhinus macloti	1	3*	3#	2	2	1	**2.00**
Carcharhinus melanopterus	3*	3*	2	2	2	1	**2.17**
Carcharhinus sorrah	1	1	3	2	2	1	**1.67**
Carcharhinus tilstoni	2	2	3	2	2	1	**2.00**
Galeocerdo cuvier	2	2	2	3	3	1	**2.17**
Rhizoprionodon acutus	3*	3*	3	2	2	1	**2.33**
Rhizoprionodon taylori	1	1	2	1	2	1	**1.33**
Triaenodon obesus	2	3	3	2	2	1	**2.17**
Hemipristis elongata	3*	3*	3	2	2	1	**2.33**
Aetobatus narinari	3*	2	3*	3	3*	1	**2.50**
Rhinoptera neglecta	3*	3*	3*	2	3*	1	**2.50**
Rhynchobatus djiddensis	3*	3*	3*	2	2	1	**2.33**
Sphyrna lewini	2	2	2	3	3	1	**2.17**
Sphyrna mokarran	3*	3*	2	3	3	1	**2.50**

species-specific data was not available for attribute estimate; was made based on co-genera or co-familiar species
* species-specific data was not available for attribute; rank of 3 was used

(ii) Index of Fishing Mortality

The total fishing mortality of a particular species is dependent on (i) its susceptibility to capture and mortality within each East Coast fishery and (ii) the level of effort in all East Coast fisheries.

Within each East Coast shark fishery, attributes of the species were used to provide an index of their susceptibility to capture and mortality, modified from Stobutzki *et al.* (2002). The susceptibility to capture and mortality is a function of (i) the availability of a species to the fishery, (ii) their catchability and (iii) their survival. The fishery specific attributes used to provide an index of these factors are shown in Appendix 2.

Each species was ranked from 1 to 3 for each attribute, in each fishery where the species was known or predicted to be captured. A rank of 1 reflects low susceptibility to capture and mortality, a rank of 3 reflects high susceptibility to capture and mortality (Appendix 2). The susceptibility ranking for a species in a fishery was calculated as the mean rank of all attributes for that fishery.

We assumed the susceptibility attributes calculated by Stobutzki *et al*. (in prep.) (Appendix 2) would apply equally well for each species vulnerable to East Coast fisheries using similar gear to that used in Northern Australia. The indices for mortality were then estimated from the susceptibility indices weighted by effort in the relevant East Coast Fisheries (average annual effort over the last 4 years); Table 7. Average effort was derived from the data provided in the CHRIS database for the major East Coast Fisheries and estimated from the average number of days multiplied by the number of boats in the East Coast Tuna Fishery.

We modified the ranked index of total fishing mortality for the Queensland East Coast by first reducing the number of fisheries that were used by Stobutzki *et al*. (in prep.) in the calculation of sustainability of northern sharks. WA and NT fisheries and Commonwealth managed fisheries were removed from the calculation. Accordingly fisheries that are likely to impact on the East Coast Shark populations were East Coast trawl (NPF as surrogate), Tuna (WTBF as surrogate), Reef Line (QLF), Shark and Mackerel (QSMF) and Barramundi (QBF); see Table 7.

The average fishery effort (over the most recently available three years of data) was used as the weighting factor, reflecting the fact that the amount of effort in a fishery will influence its impact on a species. The index of total fishing mortality for a species was then calculated as the sum of the weighted ranking for each fishery in which the species was predicted to be caught.

The higher the ranking of fishing mortality, the higher the predicted fishing pressure on the species (see Table 7), which translates into a higher risk to sustainability if there is a corresponding low productivity for this species.

Table 7 - Queensland East Coast Shark Catch Species Fishing Mortality Susceptibility rank (from Stobutzki *et al.* in prep.) for each species recorded by fisheries observers in the East Coast fishery for each fishery, weighted by effort to produce an overall Mortality Index rank.

Fishery	Trawl		Tuna		Reef Line		Barramundi		Shark /Mackerel		East Coast Fishing
Species	Suscept-ibility	Weighted Mortality	Suscept-ibility	Weighted Mortality	Suscept-ibility	Weighted Mortality	Suscept-ibility	Weighted Mortality	Suscept-ibility	Weighted Mortality	Mortality Index
Carcharhinus amblyrhynchos		0		0	2.50	0.37	2.33	1.21	1.67	0.13	**1.71**
Carcharhinus amboinensis	2.00	0.20		0	2.50	0.37	2.33	1.21	2.33	0.17	**1.96**
Carcharhinus brevipinna	1.50	0.15	2.50	0.39	2.50	0.37	1.67	0.87	1.67	0.13	**1.91**
Carcharhinus dussumieri	1.83	0.18		0	2.50	0.37	2.33	1.21	2.33	0.17	**1.94**
Carcharhinus falciformis		0	2.00	0.31	2.50	0.37	1.67	0.87	1.67	0.13	**1.68**
Carcharhinus fitzroyensis	2.33	0.23		0	2.50	0.37	2.67	1.39	3.00	0.22	**2.22**
Carcharhinus macloti	2.00	0.20		0	2.50	0.37	1.67	0.87	2.33	0.17	**1.61**
Carcharhinus melanopterus	2.17	0.22		0	2.50	0.37		0	2.00	0.15	**0.74**
Carcharhinus sorrah	1.67	0.17	2.75	0.43	2.50	0.37	2.33	1.21	2.00	0.15	**2.33**
Carcharhinus tilstoni	1.50	0.15	2.50	0.39	2.50	0.37	2.33	1.21	1.67	0.13	**2.25**
Galeocerdo cuvier	1.33	0.13	2.50	0.39	2.50	0.37	2.33	1.21	1.67	0.13	**2.23**
Rhizoprionodon acutus	2.00	0.20		0	1.50	0.22	1.67	0.87	1.33	0.10	**1.39**
Rhizoprionodon taylori	2.17	0.22		0	1.50	0.22	1.67	0.87	1.00	0.07	**1.38**
Triaenodon obesus	2.00	0.20		0	2.50	0.37	2.33	1.21	2.67	0.20	**1.98**
Hemipristis elongata	1.83	0.18		0	1.50	0.22	1.00	0.52	1.67	0.13	**1.05**
Aetobatus narinari	2.00	0.20		0		0	2.00	1.04	2.00	0.15	**1.39**
Rhinoptera neglecta		0		0		0		0	1.00	0.07	**0.07**
Rhynchobatus djiddensis	2.33	0.23		0	2.50	0.37	2.33	1.21	2.67	0.20	**2.01**
Sphyrna lewini	1.50	0.15	2.50	0.39	2.50	0.37	2.67	1.39	2.00	0.15	**2.45**
Sphyrna mokarran	1.50	0.15	2.25	0.35	2.50	0.37	2.33	1.21	1.67	0.13	**2.21**

Note: Effort in average boat days Trawl 1398, Tuna 2200, Reef Line 2075, Barramundi 7268, Shark/Mackerel 1048

(iii) Relative Sustainability Plot

The rankings for each species in terms of productivity and fishing mortality were then plotted to determine the relative vulnerability of the species to fishing. Because neither productivity nor fishing mortality alone provide a complete index to the sustainability of species, the index is a combination of these two factors. A symmetrical relationship was assumed between the two axis, i.e. there is a one-to-one correspondence between the categorical scales of the productivity and mortality.

The ranking of the species both in terms of productivity and fishing mortality (Tables 6 and 7) is shown in Figure 6.

4.4 Results

Using the Gulf WTBF as a surrogate for the East Coast Tuna fishery we predicted (based on Stobutzki *et al*. in prep.) that this fishery would have lowest species diversity of shark catch (see Table 7). This has not been verified due to the absence of observer validation in this fishery. Low species diversity would be because it is a hook and line fishery (long-line) that is targeted by depth and temperature profile to catch Tuna. Some shark species also target Tuna and are therefore vulnerable to the long-lines. This suite of sharks however is a reduced subset of the East Coast Shark species complex (see Table 5).

The mortality index was plotted against the productivity index to obtain estimates of the relative sustainability of each shark species identified by fisheries observers as caught on the Queensland East Coast (Figure 6).

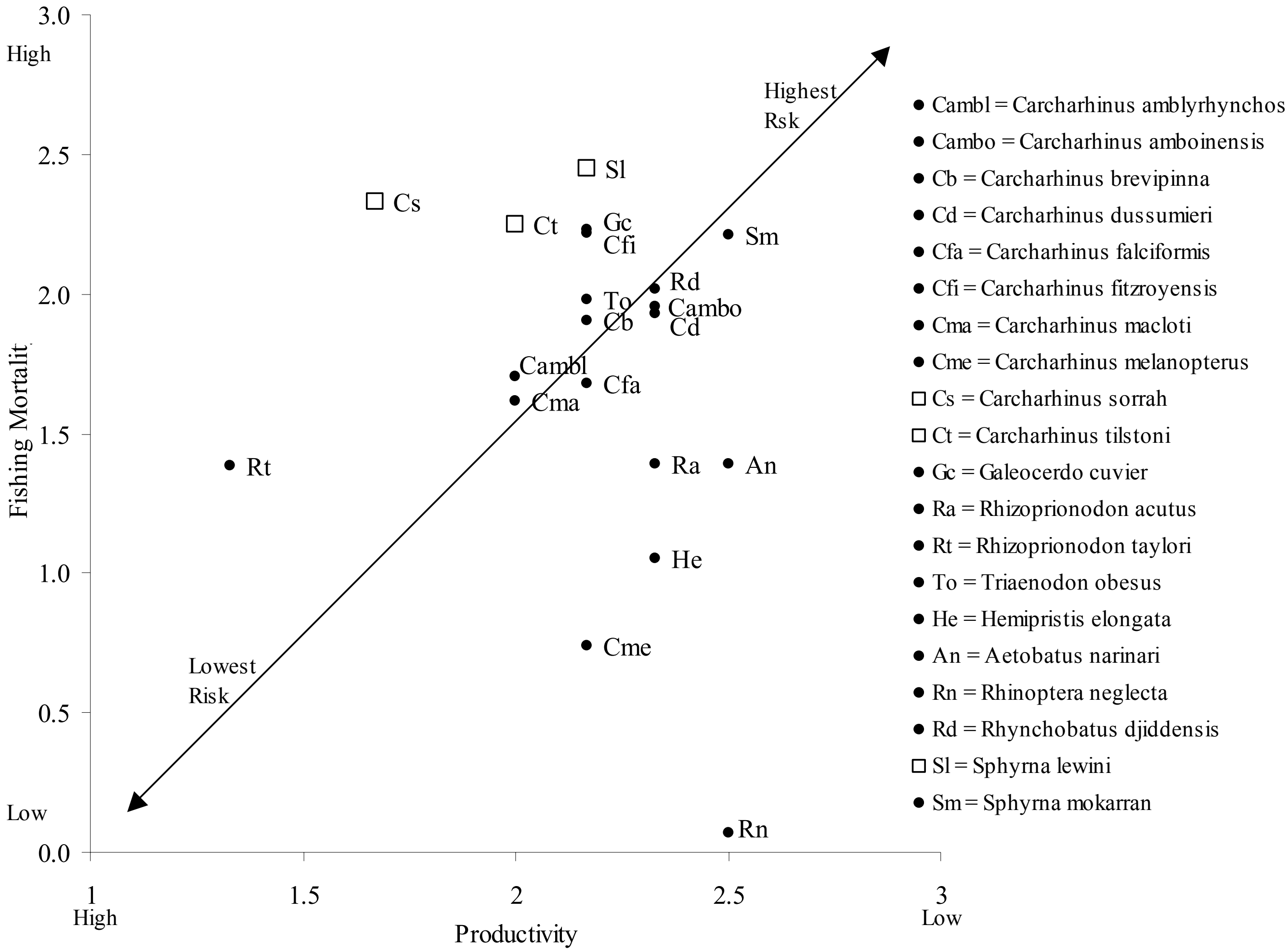

Figure 6 - *Relative Sustainability Plot.* The rankings of shark species caught in the Queensland East Coast in terms of their relative risk due to the impacts of commercial fishing in the study region (based on Tables 6 and 7). Open square markers are used for species (*Carcharhinus sorrah, Carcharhinus tilstoni* and *Sphyma lewini*) that dominate catch in this fishery, see Table 5.

4.5 Discussion

The relative sustainability index, as noted by Stobutzki *et al*. (in prep.), "provides an initial assessment to guide management, when traditional stock assessment methods are not feasible, due to lack of data and the large number of species". Given the paucity of information on shark biology across the species likely to be taken in the various East Coast fisheries, this index can be a guide only.

Figure 6 shows very few East Coast harvested species in the lowest sustainability risk region. This could be due to two reasons:

- There has been limited observer presence in the East Coast fisheries, particularly the offshore component and for species that will be caught rarely; hence the species list may not be complete.
- It should be recognized that all species that fall in the two categories (ranking of 2.50 and 2.33) of lowest productivity (see Table 6), have two or more unknown life history attributes used to calculate this ranking. In these cases a high rank for unknown attributes is assumed under the precautionary principle, which can also lead to an apparently high sustainability risk.

Rhinoptera neglecta (Australian cownose ray) is a case in point. On current information this species occurs very infrequently due to its very restricted geographic distribution (Stobutzki *et al.* in prep.). Its mortality ranking (Table 7) suggests that it has an inherently low mortality due to fishing. Table 6 shows this species with a low productivity rank, mainly because of its unknown life history attributes. If the fishing mortality were greater, then the apparent sustainability risk would be higher due to the precautionary principle.

Capture of *R. neglecta* was recorded as approximately 1% of the catch on the East Coast (Table 5), through the observer program during four trips in the shark/mackerel fishery. As predicted by Strobutzki *et al.* (in prep.), the fishing mortality is very low and as a consequence so is the sustainability risk.

Sphyma lewini (Scalloped hammerhead shark), by contrast, constituted a large proportion (18%) of the observed catch (Table 5) and also has a relatively low productivity (Table 6) but in this case the life history attributes are known. Therefore this species has a genuinely high-risk sustainability because of a combination of low productivity and relatively high mortality.

5 Summary

Update of Fisheries Assessment

- The basic trends in the data are unchanged from the report of Rose *et al*. 2003, in that there has been a steady increase in catch and effort over the last 10 years and this trend in continuing.
- The absolute values for catch are dependent on the conversion ratios from reported fillet and trunk weight to the whole weight, which is output by the CFISH database. The apparent increases in catches across all years are due mainly to the change in conversion ratio used in CFISH.

Sustainability estimates

- The relative sustainability risk index is by its very nature an approximation of a combination of mortality due to fishing balanced by productivity of a particular shark species.
- The major commercially exploited species in the Queensland East Coast shark fishery as reported by fisheries observers were *Carcharhinus tilstoni*, *Carcharhinus sorrah* and *Sphyrna lewini*. *C. tilstoni* (Australian blacktip shark) and *C. sorrah* (Spot-tail shark). The majority of these species were towards the middle to lower end of the sustainability risk estimates. However, *S. lewini* (Scalloped hammerhead shark) is towards the higher risk to sustainability.
- Species at highest relative sustainability risk according to this assessment were *Sphyrna mokarran* (Great hammerhead shark) and *Rhynchobatus djiddensis* (White-spotted guitarfish). This is consistent with the conclusions drawn by Stobutzki *et al*. (in prep.), that sawfish, guitarfish, shovelnoses ray and some whalers are particularly susceptible to fishing mortality. *S lewini* (Scalloped hammerhead shark) has a low productivity, hence is particularly vulnerable to even small levels of fishing mortality.
- At the other end of the spectrum are *Rhizoprionodon taylori* (Graceful shark) and *Carcharhinus melanopterus* (Blacktip reef shark), which appear to have the lowest risk to their sustainability. In the case of *R. taylori* they are moderately fished but have a very high productivity. *C. melanopterus* in contrast has a relatively low productivity but is not heavily fished. It should be noted that in the case of the Blacktip reef shark if fishing pressure increased there would be a dramatic increase in its sustainability risk.

6 Conclusions

- Information is urgently required on the species composition, stock structure, biology and optimal harvesting of Queensland East Coast shark.
- The second priority would be to develop a method of standardisation of effort between the net and line fisheries, and within these fisheries for fishing power throughout the CFISH time series.
- The consideration of management interventions for species identified as at risk by this preliminary analysis, particularly for some hammerheads and guitarfish.
- A review in 2 years is recommended.

7 References

Gribble, N., Stapley, J., Peverell, S., Williams, L., and Garrett, R. (2004) *Fishery assessment: Queensland Gulf of Carpentaria Coastal shark catch.* Queensland Department of Primary Industries. QI 04038

Henry, G.W and Lyle, J.M (2003) *The National Recreational and Indigenous Fishing Survey*, Tasmanian Aquaculture and Fisheries Institute, Hobart 188pp.

Rose, C., Williams, L., Gribble, N., Garrett, R. and Stapley, J. (2003) *Queensland East Coast shark catch*. Queensland Department of Primary Industries. QI 03020.

Stobutzki, I, M. Miller, D.S. Heales and D. Brewer. 2002. Sustainability of elasmobranchs caught as bycatch in a tropical prawn (shrimp) trawl fishery. *Fishery Bulletin* 100:800-821.

Stobutzki, I., Stevens, J., Miller, M., Deng, R., Salini, J., McAuley, R.,Buckworth, R., Gribble, N., McPherson, G., and McLoughlin, K. (in prep.) Assessing the regional impact of fishing on chondricthyans in northern Australia: 148 species, 28 fisheries and limited data. *In prep.*

Williams, L. (2002) *Queensland's fisheries resources. Current conditions and recent trends 1988-2000*. Department of Primary Industries. Information Series Q102012.

8 Appendices

Appendix 1 - The attributes used to provide an index of the productivity of species, the rationale for each attribute, the process followed when the species-specific information was unknown and the levels of the ranks (from Stobutzki *et al.* in prep.).

Productivity Attribute	**Rationale**	**Unknowns**	**Rank** **High productivity** **1**	 **2**	 **Low productivity** **3**
Longevity	Longer-lived species tend to have lower natural mortality and populations with lower productivity (Roberts and Hawkins 1999).	Rank of 3	< 8 y	8 - 20 y	> 20 y
Age at Maturity	Species that mature at a later age have a longer generation time and lower productivity.	Rank of 3	< 3 y	3 - 8 y	> 8 y
Yearly fecundity (litter size/ reproductive period)	The higher the fecundity of a species, the higher the productivity.	Litter size was estimated as the average of co-genera or co-familiar species. If reproductive period was unknown, gestation period was used and if this was unknown the average for co-genera or co-familiar species was used	> 36 young or eggs per year	4 - 36 young or eggs per year	< 4 young or eggs per year
Maximum Size	Larger species tend to be longer lived and slower growing, they also tend to show a greater decrease in abundance with fishing (e.g. Jennings *et al.* 1998, Walker and Hislop 1998, Dulvy *et al.* 2000)	Rank of 3	*< 77 cm TL* < 64 cm DW	77 – 391 cm TL 64 - 241 cm DW	> 391 cm TL > 241 cm DW
Size at Maturity	Species with a large size at maturity tend to be have a longer generation time and are more vulnerable to over-exploitation (Roberts and Hawkins, 1999, Jennings *et al.* 1998)	The ratio between size at maturity and maximum size was calculated for co-genera or co-familiar species and used to estimate size at maturity	*< 46 cm TL* < 50 cm DW	46 –143 cm TL 50 - 146 cm DW	> 143 cm TL > 146 cm DW
Depth range	Species that live in deeper water are generally less productive (Wilson and Seki 1994, Stevens *et al.*, 2000).		Pelagic and benthopelagic species, or demersal species with <50 % of depth range >200 m	n/a	Bathypelagic and bathydemersal species, or demersal species with >50 % of depth range >200 m

y = years   TL = Total Length   DW = disc width

Appendix 2 - Attributes used to provide an index of the susceptibility of species to capture and mortality from a fishery; grouped with respect to whether they influence the availability, catchability or survival of a species. The rational is shown, as well as the ranking for the levels of the attribute (from Stobutzki *et al.* in prep.).

				Ranking		
				Low susceptibility		**High susceptibility**
Factor	**Attribute**	**Rational**	**Fisheries**	**1**	**2**	**3**
Availability	Depth range	Extent of overlap between depths fished and depth range of species will influence the amount of the species population that is available to the fishery	All	% of species' depth distribution covered by the fishery < 33.3 %	33.3 % ≤ % of species' depth distribution covered by the fishery < 66.6 %	66.6 % ≤ % of species' depth distribution covered by the fishery
	Preferred habitat	A fishery may fish particular habitats (e.g. soft sediments or reefs). The extent to which a species uses these habitats (e.g. whether it is the species preferred habitat or just used occasionally) will influence the amount of the population of the species that is available to the fishery.	NPF	Primary habitat in non-prawn trawl grounds (e.g. reefs)	Habitat includes areas other than soft sediments and prawn trawl grounds	Primary habitat is soft, muddy or sandy sediments or prawn trawl grounds.
			QSMF	Predominantly offshore species	Use both close inshore and offshore habitats	Close inshore, estuarine, coastal flats
			QBF	Predominantly offshore species	Use both close inshore and offshore habitats	Close inshore, estuarine, coastal & mud flats,, freshwaters, open rivers
			QLF (WTBF)	Primary habitat not reef	Use reefs & other habitats	Reef associated species
Catchability	Water column position	Fishing gear often fishes a particular section of the water column; species that live in this section of the water column will be more likely to be caught by the fishery.	NPF,QBF, QSMF	Pelagic	Benthopelagic	Demersal or benthic or bathydemersal
			WTBF, QLF	Demersal or benthic	Benthopelagic	Pelagic
	Diet	The diet of a species may influence its catchability, by attracting the species to the area being fished, or the section of the water column.	NPF, QBF	Pelagic feeders	Benthopelagic feeders	Benthic feeders or known to feed on prawns
			WTMF, QLF	Benthic feeders	Benthopelagic feeders	Pelagic feeders
	Day vs night catchrate	Fisheries may operate at particular times. The species catchability may vary with time of day or night.	NPF	highest during the day	not known to differ between night and day	highest during the night
Survival	Survival records	Direct records of survival rates of species caught in the fishery (Stobutzki *et al.* 2002).	NPF	Recorded survival of species >66.7%	33.3%< recorded survival of species ≤66.7%	Recorded survival of species <33.3%
	Retention	Species targeted or byproduct for fisheries, used to determine if it is likely to be retained. Information on species sold for flesh or fins (Rose and McLoughlin 2000) also used to estimate fate of species. Management arranges that prevent or limit retention of species was also taken into account.	All	Species that are known to be discarded or likely to be discarded on the basis the lack of value for flesh or fins	Species that are known target or byproduct species in fisheries, or likely to be retained on the basis of the value of the flesh	Species that are known to sometimes be retained or may be retained on the basis of the value of the fins

Note: We have used East Coast Fisheries that are the closest approximates to generalised north Australian fisheries; following *Stobutzki et al*. (in prep.)