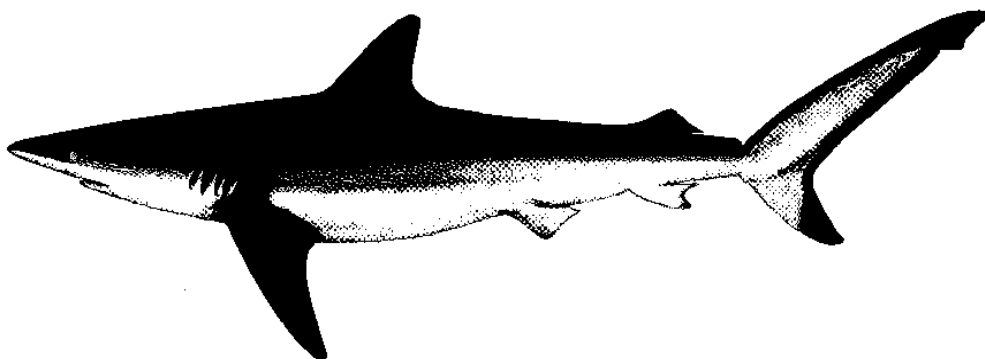


Status Report for the Southern and West Coast Demersal Gillnet and Demersal Longline Fisheries and Northern Shark Fisheries.

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The information provided in this report is the best available given the data and resources available at the time of production. As more data become available, new techniques developed, and historical data corrected, the outcomes of future assessments may vary from those currently reported.



EXECUTIVE SUMMARY

Fishing effort increased by 34% and 9% in Zones 1 and 2 of the JASDGLF, respectively, and by 43% in the WCDGLF between 2002/03 and 2003/04. Over the same period, northern shark fishing effort (*i.e.* WANCSF and JANSF combined) increased by 70% to 717,100 hook days. The temperate demersal gillnet and longline fisheries' total shark[‡] catch was 1,441 tonnes, 194 tonnes (16%) higher than in 2002/03. Total shark catches increased by 8% in Zone 1, 10% in Zone 2 and 31% in the WCDGLF. Total shark landings also increased by 21% in the northern shark fisheries. Dusky shark catches increased by 12% and 7% in Zones 1 and 2 of the JASDGLF, respectively, by 64% in the WCDGLF and by 17.7% in the northern shark fisheries. The substantial increase in the WCDGLF dusky shark catch, which follows a 55% increase in 2002/03, was a consequence of the nearly five-fold (465%) increase in demersal longline fishing effort. While there was no change in the whiskery shark catch in Zone 1, despite the increased level of effort, there was an overall increase of 14% in the temperate fishery's whiskery shark catch as a result of 21% and 31% increases in landings from Zone 2 and the WCDGLF, respectively. The fishery's total gummy shark catch increased for the fourth year in a row to 465 tonnes in 2003/04. The largest increase of 38 tonnes was in Zone 2, where 84% of the fishery's total gummy shark catch originated. However, the largest percentage increase of 108% (34 tonnes) occurred in Zone 1, where there was a noticeable increase in the amount of effort in the east of the region. Sandbar shark catches increased by 34% in the WCDGLF, decreased by a similar amount (35%) in the JASDGLF and increased by 138% in the northern shark fisheries, resulting in a combined catch of 413 tonnes, which was 60% higher than last year. Formal stock assessment of sandbar sharks, which was completed in April 2005, indicated that the combined levels of catch in 2001/02, 2002/03 and 2003/04 were unsustainable. Scalefish catches increased by 46% in Zone 1, 34% in Zone 2 and 18% in the WCDGLF, resulting in a 31% overall increase from the temperate demersal gillnet and longline fisheries. The northern shark fisheries' scalefish catch declined by 63% to 3.0 tonnes in 2003/04 due to the lack of pelagic gillnet fishing and associated grey mackerel catches. The following table summarises the catch and effort levels in the Western Australian target-shark fisheries during 2003/04.

	JASDGLF			WCDGLF	Total		% orig. Biomass (mean and 95% CI*)
	Zone 1	Zone 2	Total		Temperate	Northern	
Corrected Effort	52.4 (34%) [†]	132.6 (9%) [†]	184.8 (15%) [†]	84.7 (43%) [†]	271.8 (24%) [†]	717.1 (70%) ^{††}	
Catch (tonnes live weight)							
Total Shark	330.4 (8%)	628.6 (10%)	959.0 (9%)	482.0 (31%)	1,441.0 (16%)	590.8 (21%)	
Dusky	113.1 (12%)	89.0 (7%)	202.2 (10%)	137.0 (64%)	339.2 (26%)	17.2 (159%)	
Gummy	65.3 (108%)	390.2 (11%)	455.5 (19%)	9.0 (16%)	464.5 (19%)	n/a	42.7 (22.6–60.2)**
Whiskery	70.0 (0%)	80.2 (21%)	150.2 (10%)	34.1 (31%)	184.4 (14%)	n/a	35.1 (33.7–36.3)***
Sandbar	17.2 (-42%)	4.7 (12%)	22.0 (-35%)	182.2 (34%)	204.1 (20%)	208.9 (138%)	
Scalefish	94.7 (46%)	87.2 (34%)	181.9 (40%)	105.4 (18%)	287.3 (31%)	3.0 (-63%)	

*CI - confidence interval; ** based on the 1998 assessment; *** based on the 2004 assessment; [†] units of km gillnet hours x1000; ^{††} units of hook days x1000.

The status of the key target stocks are summarised as follows:

- the breeding stock of **dusky sharks** is overexploited and recruitment of neonate dusky sharks has decreased in recent years
- the total catch of **dusky sharks** by the JASDGLF and WCDGLF exceeded this species' trigger limit by 45%
- increased use of demersal longlines, particularly in the WCDGLF, has caused a rapid escalation in catches of **dusky sharks**. Due to the less size-selective nature of hooks and the areas in which longlines have been fished, a high proportion of this longline catch is thought to have been comprised of older juveniles, sub-adult and adult sharks

[‡] For the purposes of this report, the term 'shark' refers to all species of sharks and rays, unless specified otherwise

- larger hook-caught **dusky shark** may also have been contributing to reported gillnet catches over recent years, which might have caused an overly optimistic trend in gillnet catch rates
- continuing mortality of larger **dusky sharks** from capture by ‘wetline’ methods and other external sources, including entanglement in plastic packing straps, is likely to be further depleting the breeding stock
- total **whiskery shark** biomass was estimated to be stabilising at 5% below the target biomass level
- the biomass of mature female **whiskery sharks** has been increasing marginally for three consecutive years
- activation of latent effort in the temperate gillnet fisheries has reduced the probability of achieving the **whiskery shark** biomass target by 2010
- the total catch of **whiskery shark** by the JASDGDLF and WCDGDLF exceeded this species’ trigger limit by 8%
- the increasing trend in **gummy shark** Catch Per Unit Effort (CPUE) over the last eight years suggests that adult biomass has increased, however this trend could be confounded with increased targeting of this stock
- the total catch of **gummy shark** by the JASDGDLF and WCDGDLF exceeded this species’ trigger limit by 33%
- current levels of **sandbar shark** catches are unsustainable and the breeding stock has been depleted
- the total catch of **whiskery sharks** by the JASDGDLF and WCDGDLF exceeded this species’ trigger limit by 25%

BOUNDARIES AND ACCESS TO FISHERIES

Southern Demersal Gillnet and Demersal Longline Fishery

The Southern Demersal Gillnet and Demersal Longline Fishery (JASDGDLF), which covers waters between 33°S and the WA/SA border, was declared a limited entry fishery in 1988. The fishery is managed under a joint authority arrangement with the Commonwealth government, which gives day-to-day management responsibility to the WA State government. The fishery is comprised of two management zones:

- | | |
|---------------|---|
| Zone 1 | western zone, located south of 33° 00’S. to 116° 30’E and |
| Zone 2 | eastern zone, located east of 116° 30’E. to the SA border (129° 00’E) |

The fishery is currently managed using effort controls in the form of time/gear units, with each unit allowing the use of one net (or fixed number of hooks) for one month. When management was originally introduced a net was 600m, but a 10% effort reduction in 1992 brought it down to 540 metres. In June 1994 further effort reductions were put in place: there was a 30% net length reduction in zone 2, reducing each net to 378 metres while in Zone 1, units were reduced by 20%, allowing 432 metres of net per unit. In 1997/98, Zone 1 net lengths were further reduced (by 10% of their 1992 level), bringing them into line with Zone 2 units, which remained at 378 metres. Between 1999 and 2001, all JASDGDLF units were reduced to 270 metres, regardless of mesh specifications, or 90 longline hooks.

There are 57 JASDGDLF licenses (24 in Zone 1 and 33 in Zone 2), although only 8 Zone 1 vessels (the same as in 2002/03) and 19 Zone 2 vessels (5 less than in 2002/03) reported active fishing returns during 2003/04. Based on vessels’ reported net usage, it is estimated that 946 of the 1110.5 Zone 1 fishing units and 1190 of the 1404.5 Zone 2 units were active in 2003/04.

West Coast Demersal Gillnet and Demersal Longline Interim Managed Fishery

The West Coast Demersal Gillnet and Demersal Longline Fishery (WCDGDLF) is currently managed as a limited entry fishery, under an interim management plan introduced in 1997. Under this plan, the fishery is also managed using effort controls in the form of time/gear units, with each unit allowing a net length of 540 metres or 180 longline hooks. The interim plan was due to expire in June 2002, however due to appeals against the proposed unit allocation, introduction of the full management plan continues to be delayed. The

WCDGDLF extends from the northern boundary of the JASDGLF (33° 00'S) to a line drawn North from North West Cape (21° 78'S, 114° 06'E), although shark fishing between Steep Point (26° 30'S) and North West Cape has been prohibited since 1993, primarily to protect breeding stocks of dusky whaler sharks.

There were 26 licenses in the WCDGDLF in 2003/04, although only 16 (4 more than in 2002/03) reported active fishing returns during the year. Of the 667 fishing units in the WCDGDLF, 569 units were estimated to have been fished during 2003/04.

WA North Coast Shark Fishery and Joint Authority Northern Shark Fishery

New management arrangements for the WANCSF and JANSF were agreed at a meeting between northern shark fisheries licensees and the Department in May 2005 and the resulting package of measures are currently being drafted. These measures have been designed to address the unsustainable level of sandbar shark mortality, alleviate concerns about the sustainability of secondary target stocks and reduce the current level of shark fishing effort on the north coast.

WANCSF licenses permit 'shark' longlines (i.e. with metal snoods) to be used between NW Cape and the western border of the JANSF. Approved fishing methods in the JANSF are longlines to within 3 nautical miles of the coast (low water mark) and gillnets (pelagic or demersal) to within 12 nautical miles of the coast. The boundaries of the northern shark fisheries are:

WANCSF waters east of 114° 06'E to 123° 45'E

JANSF waters between: 123° 45'E and the WA/NT border (129° 00'E)

There are 15 licences in the northern shark fisheries, 10 allowing access to the WANCSF and 5 to the JANSF. Of these, 11 (the same as in 2002/03) were active during 2003/04, however not all fished full-time in the Western Australian northern shark fisheries.

Owing to the small number of operators in the northern shark fisheries, confidentiality arrangements do not permit the publication of catch and effort data from each fishery separately. Therefore, as the principal methods and some target species are common to both the JANSF and WANCSF, catch and effort data have been combined and the two regions are considered as a single northern shark fishery for reporting purposes.

PERFORMANCE TARGETS

Biomass targets for the fisheries' key stocks, as outlined in Table 2, were set by the Western Australian Demersal Net and Hook Fisheries Management Advisory Committee (WADNHFMAC; formerly the WA Demersal Gillnet and Demersal Longline MAC) in 1995. These targets are used by the WADNHFMAC and the Department of Fisheries to measure the outcomes of the management of the fisheries.

Table 1: Biomass targets for whiskery, gummy and dusky sharks

Species	Target biomass (% of initial biomass)	Date to be achieved
Whiskery	40	2010
Gummy	40	2010
Dusky	40	2040

Whilst these biomass target levels are considered to be appropriate for long-lived species, such as these, they were set before formal stock assessments were completed and therefore without reference to the actual biomass levels at the time. The specified timeframe for rebuilding the whiskery shark stock, which is now understood to have already been depleted to less than 40% of its unexploited biomass in 1995, is now considered to be probably insufficient to achieve the target level, even under negligible levels of exploitation. Given this, it is recommended that the MAC and the Department consider that a more appropriate performance target for this species is to achieve an increasing biomass trend by 2010.

In addition to the established biomass targets for the key stocks, in November 2004 the WADNHFMAC agreed to set target catch and effort levels (trigger points) for the temperate fisheries equal to the fisheries' 2001/02 levels. These are:

<i>Effort</i>	JASDGDLF, Zone 1	36,663 kilometre gillnet hours
	JASDGDLF, Zone 2	115,012 kilometre gillnet hours
	WCDGDLF	55,522 kilometre gillnet hours
<i>Total shark catch</i>	JASDGDLF, Zone 1	302 tonnes
	JASDGDLF, Zone 2	545 tonnes
	WCDGDLF	324 tonnes
<i>Dusky shark catch</i>	JASDGDLF, Zone 1	106 tonnes
	JASDGDLF, Zone 2	74 tonnes
	WCDGDLF	54 tonnes
<i>Gummy shark catch</i>	JASDGDLF, Zone 1	19 tonnes
	JASDGDLF, Zone 2	326 tonnes
	WCDGDLF	4 tonnes
<i>Whiskery shark catch</i>	JASDGDLF, Zone 1	76 tonnes
	JASDGDLF, Zone 2	68 tonnes
	WCDGDLF	28 tonnes
<i>Sandbar shark catch</i>	JASDGDLF, Zone 1	31 tonnes
	JASDGDLF, Zone 2	1 tonnes
	WCDGDLF	131 tonnes

METHODS

Catch and effort data for this report were derived from mandatory monthly fishing returns. Monthly returns data, which have been collected from the temperate gillnet and longline fisheries since 1975/76, are reported in 1° latitude by 1° longitude geographical blocks and are maintained by the Department's Catch and Effort Statistics (CAES) Section. Data have been verified and corrected as follows[§].

Definition of valid temperate 'shark' fishery data

As licensing information is only available from 1988 onwards, demersal gillnet and demersal longline fisheries catch and effort data have instead been defined according to fishing method and area of operation. Prior to 1993, the dataset includes all gillnet and longline fishing records, excluding data from the estuaries, between the South Australian border and North West Cape (22°S Latitude 114°E). From 1993 onwards, when the area between NW Cape and Steep Point was closed to commercial shark fishing, data have been taken only from records outside estuaries, between the South Australian border and 26°S latitude. Nets with a length of less than 100m have been excluded from the dataset to remove misreported non 'shark fishery' netting methods (eg. haul nets, beach seines and throw nets), which were present in early records.

Correction of catch data

[§] Because the procedures used to validate catch and effort data were revised in 2003, data presented in this report are not comparable to those given in status reports prior to 2003.

When formal stock assessment of WA's shark stocks began in 1993, the accuracy of catch records was examined and data from before 1989/90 were found to be incomplete. Problems were also found with some vessels' species identification and with returns where the shark catch was not properly split (eg. records where all shark was reported as 'shark' or 'bronze whaler'). To overcome these problems, a computer program was developed to adjust catch and effort data from years where records were missing and to reapportion the shark catch from returns that were judged to be inaccurate. After reexamination of this program, the criteria used to identify inaccurate catches were found to no longer be appropriate. A new program was therefore written in 2003, which reapportions incorrectly reported catches using modified criteria to account for improved species identification and reporting in recent years and to allow for regionally and temporally important differences in the fisheries' catch, eg. increased sandbar shark catches in the WCDGDLF and high school shark and dogfish catches in Zone 2 of the JASDGDLF in earlier years.

The program also adjusts catch data to account for missing and incomplete returns prior to 1990. Previously, catch and effort were increased by 25% in 1986, 35% in 1987, and by 5% in all other years up to 1989/90, after which records are thought to be complete. On re-examination of these data, there is a strong indication, which has been confirmed by industry, that there was considerable over-reporting in the years immediately prior to the implementation of the JASDGDLF management plan and the 25% and 35% corrections are no longer thought to be applicable. Therefore, all catch and effort data prior to 1990 have now been increased by a standard 5% per year, to account for missing data.

Correction of effort data

As with catch data, the data required for calculating fishing effort, ie net length, days fished per month, hours fished per day and number of shots per day, were found to be incomplete and in some cases incorrect, particularly prior to 1989/90. Where effort parameters were deemed to be invalid, they have been corrected using the vessel's annual average parameter value(s). Where average annual values were not available for an individual vessel, eg where the vessel only submitted one record for that year, the monthly fleet average was used.

Once data were corrected, each vessel's monthly gillnet effort in each block was calculated as the net length multiplied by the number of days fished multiplied by the average number of hours fished per day multiplied by the average number of shots per day. Total gillnet effort was then calculated as the sum of all vessels' monthly effort within each block of each management zone. Longline effort parameters, i.e. number of hooks, number of days fished, average number of hours fished per day and average number of shots per day were corrected and effort was calculated using the same procedures as for gillnet effort. Longline effort was standardised in terms of equivalent gillnet fishing effort by applying the gillnet catch rate of all sharks to the longline catch, in order to back-calculate the amount of gillnet effort that would have been necessary to have caught that quantity of sharks. Total fishing effort was calculated as the sum of the annual gillnet and (gillnet equivalent) longline effort and is expressed in units of "tonnes" (km.gn.hr).

As well as calculating the actual fishing effort in each management zone, the validation program also calculates the effort that was expended across the range of each of the target species within the fisheries and is referred to as '*effective area effort*'. Because longlining has been used to target species other than the key target shark species and has been more localised and sporadic than gillnet effort, longline CPUE data were judged to be an unreliable indicator of species abundance. Effective area effort, therefore, only considers gillnet fishing effort for the areas in which each target species commonly occurs in the catch. Specifically, these ranges are:

1. Dusky shark – South of 28°S to 120°E
2. Gummy shark – Between 116°E and 129°E
3. Whiskery shark – South of 28°S to 120°E
4. Sandbar shark – South of 26°S to 118°E

Effective area effort is also adjusted to account for increases in fishing efficiency arising from the introduction of new equipment (GPS, larger vessels, etc.) and improved fishing knowledge. Effort has been

adjusted by $+2\% \text{ yr}^{-1}$ for all years prior to 1994/95, after which increases in efficiency are assumed to have largely ceased and this adjustment has been capped for years after 1994/95.

Calculation of catch per unit effort

Previously, CPUE was calculated by averaging the average monthly catch rate in each block, across all blocks in each species range and throughout the year. Whilst this methodology was thought to remove some of the biases that are caused by targeting behaviour, it was found to consistently overestimate CPUE and showed a high degree of year-to-year variability. The CPUE for use in the models is now calculated as the total annual catch divided by the effective area effort for each of the ranges given above. Regional catch rates are calculated as the catch divided by the corrected effort without adjustment for efficiency increase.

Catch and effort in the Northern shark fisheries

CAES data from the northern shark fisheries are only available from 1994/95 and the accuracy of early records is uncertain. Since July 2000, catch identification and reporting in the northern fisheries has been validated by at-sea observation of catches and species identification of reported catches is now considered to be good. As longlining is the principal fishing method in the northern shark fisheries, effort is standardised in terms of longline hook days, *i.e.* the number of longline hooks multiplied by the number of fishing days. Prior to 2003, gillnet effort in the JANSF was converted to longline effort using a fixed conversion rate of 600m of net to 200 hooks, based on the gillnet to longline conversion ratio used in the temperate demersal gillnet and longline fisheries. However since 2001/02, comparative longline and gillnet catch and effort data from the JANSF have been available and gillnet effort from 1994/95 onwards, has instead been converted into longline equivalent effort using the gillnet catch and longline CPUE of all sharks caught in the same region. As there was no gillnet fishing in the northern shark fisheries during 2003/04, no such standardisation was necessary.

Biology and assessment

Dusky shark

The dusky shark (also known as bronze or dusky whaler shark), *Carcharhinus obscurus*, is common in temperate and tropical continental shelf and adjacent oceanic waters around the world. In Western Australia, the greatest abundance of dusky sharks appears to be in the region between the Pilbara and approximately 120° E on the south coast. Although dusky sharks tagged in Western Australia have been recaptured in South Australia, this species is apparently less common in Southern Australian waters, where a related and similar looking species of 'bronze whaler', the copper shark, *Carcharhinus brachyurus*, is more abundant. Dusky sharks produce litters of 6-19 pups, probably every second year. Young are born at 85-100cm, mature at approximately 280-310cm, and grow to over 365cm. Updated biological data and published age and growth estimates for Western Australian dusky sharks, indicate that females attain maturity at between 27 and 32 years (median=30 years), higher than previously estimated for this species overseas. It is not known exactly how long dusky sharks live but the best available estimates are that maximum age may be as high as 55 years. In Western Australia, dusky sharks mate during winter in the waters of the North West shelf and then migrate southwards, giving birth to their pups in the south-west of the State the following autumn.

Due to the selectivity of the mesh sizes used in the temperate demersal gillnet fishery and the size composition of the stock in the area, most of the state's dusky shark catch has historically been comprised of first year (neonate) and juvenile sharks. During the mid 1990s, approximately 45% (by weight) of dusky whalers caught in these fisheries were neonates. However, research data from the commercial gillnet fishery, indicate a statistically significant decline in the proportion of neonate dusky sharks in the catch over recent years, from 51% in 1994-96 to 38% in 2001-02.

Because the target fishery only exploits a small number of juvenile age-classes, there are no readily available indices of sub-adult or adult dusky shark abundance, which are necessary for stock assessment using traditional time-series models. To overcome this problem, a technique known as 'demographic analysis', which is widely considered to be the most appropriate approach to assessing long-lived shark species for which there are limited time-series of catch rate data, has been used to estimate the annual rate of population

growth (r). The demographic model used to assess the status of the Western Australian dusky shark stock was reassessed in 2005 using updated biological and tagging data and revised demographic modelling techniques that were developed during the recently completed FRDC-funded project. Although demographic analysis does not provide a biomass estimate with which to assess the stock's status, results provide a valuable reference point with which to assess recent catch rate trends.

Gummy shark

The gummy shark, *Mustelus antarcticus*, inhabits shallow southern continental shelf waters between Geraldton and northern New South Wales (possibly into southern Queensland). Reproduction is ovoviviparous and females produce litters of between 1 and 31 each year, with young being born at approximately 35cm. Males mature at about 4 years old and females at 5. Gummy sharks can live for up to 16 years, attaining a maximum size of 164cm. A study by the CSIRO Division of Fisheries has found that the gummy sharks caught on the south coast of WA are the same genetic population as those from south-eastern Australia. However, the results of microchemical analysis of jaw cartilage and differences in their reproductive biology suggest there is limited mixing between regions and both stocks need to be managed independently.

Fishing for gummy shark with longlines began in Western Australia in the early 1940s in the Leschenault Inlet, however, in WA they are currently only caught in significant numbers in Zone 2 of the JASDGLF. Gummy sharks are also the primary component of the shark catch in the Commonwealth-managed Gillnet, Hook and Trap sector of the Southern and Eastern Scalefish and Shark Fishery (previously the Southern Shark Fishery), which operates in Victorian, Tasmanian and South Australian waters. The selectivity of gillnets used in both the State (6.5"-7.0" stretched mesh), and Commonwealth fisheries (6.0"-6.5" stretched mesh), means that juveniles, and the largest females, are rarely caught.

An age structured population model, similar to the one described for whiskery sharks, was developed in 1998 to examine the status and future trends in gummy shark stock abundance. Although subsequent assessment of the status of gummy sharks has not been possible, gummy shark catch rates are monitored for any indications of changes in the status of this stock.

Whiskery shark

The whiskery shark, *Furgaleus macki*, is found in southern continental shelf waters between North West Cape in Western Australia and Bass Strait, although is most common in the southern half of WA. Recently, a small number of tagged whiskery sharks have been caught in South Australia, suggesting that there may be some migration in and out of the WA fishery across the Eastern border of the JASDGLF. Reproduction is ovoviviparous, meaning that embryos develop internally, attached via a placenta to an egg-sac and are born fully formed and free-swimming. Litter size is between 4 and 24. Young are born at 22-28 cm and grow rapidly until reaching sexual maturity after which there is little or no increase in length. Males reach maturity at an average of 4.5 years and females at 6.5 years. Both sexes are thought to live for between 10 and 15 years. The diet of whiskery sharks is comprised almost entirely of cephalopods (mainly octopus).

While the mesh selectivity of commercial gillnets largely excludes whiskery sharks less than 5 years old, adults are an important part of the gillnet catch in both zones of the southern fishery and on the west coast.

To investigate the status and future trends in whiskery shark stock abundance, an age structured population model was developed. This model incorporates biological information (reproduction, size, age and growth, etc.) and fisheries data (gillnet selectivity, catch and effort, etc.) in a simulation of the population since 1975. In order to analyse the level of uncertainty in the modelling procedure, a technique known as 'bootstrapping' is used to calculate 500, equally likely, new data sets. These bootstrapped data are refitted to the model, to provide 500 estimates of the biomass level. A risk assessment technique is then used to examine the impact of future harvest strategies on stock abundance and to determine the probability that the biomass of the stock will be above the target level (40%) by 2010 under different harvest regimes.

Sandbar shark

The sandbar shark (known locally as the thickskin shark), *Carcharhinus plumbeus*, is a medium sized whaler shark that is widespread around the world in temperate and tropical continental shelf and adjacent oceanic waters. Its range in Australia is similar to that of the dusky shark but they are not found in the more southern latitudes between Coffs harbour in New South Wales and Esperance in Western Australia. In WA, *C. plumbeus* is mainly found between Cape Leveque in the Kimberley and Albany on the south coast. The WA stock is segregated by size, with juveniles apparently more abundant in deeper continental shelf waters (>100m) south of Shark Bay but moving into shallower waters (50m-100m) between summer and early winter. Adults are more commonly found in depths greater than 40m between the Eighty Mile Beach in the Pilbara and the Abrolhos Islands, although they can also be found in deeper water (>100m) south of the Abrolhos Islands, particularly during summer and autumn. Adult sandbars are largely excluded from the gillnet catch in the JASDGDLF and WCDGDLF as most gillnet fishing is conducted in depths of less than 100m and because the commercially used mesh sizes select for older juvenile age classes (two to ten year olds).

Recently completed research into the biology of Western Australian sandbar sharks, has confirmed that this species takes a long time to reach sexual maturity (14 and 16 years for males and females, respectively), has long egg-development and gestation periods (ca. 12 months each) and produces an average of 6.5 offspring in each litter. In Western Australia, sandbar sharks are primarily born in waters south of the Abrolhos Islands at approximately 43cm Fork Length (FL), attain a maximum size of approximately 170cm FL and males and females reach sexual maturity at 127cm FL and 136cm, respectively. This combination of biological characteristics makes sandbar sharks susceptible to over-exploitation, as appears to have occurred on the east coast of the U.S.A., where the population was estimated to be declining by more than 7% per year during the mid 1990s and was predicted to eventually collapse.

Records of sandbar shark catches in Western Australia began in 1985/86, when the species was given its own CAESS database code. However, sandbar catches appear not to have been routinely separated until the mid 1990s, thus early records are considered to be underreported. As with dusky sharks, the available time-series of sandbar catch and effort data are insufficient for developing traditional fishery assessment models. Therefore, demographic analysis has been used to estimate the current rates of population growth (r), using age-specific fishing mortality rates determined from tag-recapture data. In addition to assessing how the stock is responding to current levels of exploitation, the model has also been used to predict how the stock might respond to a wide range of alternative harvest strategies.

STATUS OF THE FISHERIES

Southern Demersal Gillnet and Demersal Longline Fishery

In 2003/04, 959 tonnes of shark were caught in the southern fishery, 82 tonnes (9%) more than in 2002/03 (Figure 1). Total shark catches increased by 23 tonnes (8%) in Zone 1 and by 59 tonnes (10%) in Zone 2. JASDGDLF effort was 15% higher than in 2002/03 at 184,847 km gillnet hr, as a result of 34% and 9% increases in Zone 1 and Zone 2, respectively (Figure 2).

The southern fishery reported catching 202 tonnes of dusky shark, *Carcharhinus obscurus*, in 2003/04, 18 tonnes (10%) more than last year (Figure 3). The overall increase in dusky shark catches was comprised of 12 tonne (12%) and 6 tonne (7%) increases in Zones 1 and 2, respectively. At 456 tonnes, gummy sharks remained the largest component of the JASDGDLF catch. Landings increased by 34 tonnes (108%) and 38 tonnes (11%) in Zones 1 and 2, respectively (Figure 4). Catches of whiskery sharks, *Furgaleus macki*, were stable in Zone 1, 14 tonnes (21%) higher in Zone 2 and 14 tonnes (10%) higher overall (Figure 5). At 22 tonnes, sandbar shark catches remained a relatively small component of the overall JASDGDLF catch. Sandbar landings decreased by 12 tonnes (42%) in Zone 1 and increased by less than 1 tonne (12%) in Zone 2 (Figure 6). The composition of the 2003/04 JASDGDLF shark catch is given in Table 2.

Table 2: Species composition of the 2003/2004 JASDGDLF shark catch

Species	Catch (tonnes live weight; % of landings in parentheses)		
	Zone 1	Zone 2	Total
Gummy	65 (20%)	390 (62%)	456 (48%)

Dusky	113 (34%)	89 (14%)	202 (21%)
Whiskery	70 (21%)	80 (13%)	150 (16%)
Hammerhead	12 (4%)	29 (5%)	41 (4%)
Wobbegong	19 (6%)	7 (1%)	26 (3%)
Sandbar ('thickskin')	17 (5%)	5 (1%)	22 (2%)
School	0 (0%)	15 (2%)	15 (2%)
Longnose grey ('blacktip')	4 (1%)	0 (0%)	4 (0%)
Other skates and rays	0 (0%)	2 (0%)	2 (0%)
Other sharks	30 (9%)	12 (2%)	42 (4%)

After declining in 2002/03, JASDGDLF scalefish catches increased by 52 tonnes (40%) during 2003/04. This increase was comprised of a 30 tonne (46%) increase in Zone 1 and a 22 tonne (35%) increase in Zone 2 (Figure 7). Scalefish accounted for 22% of the total fishery catch in Zone 1, 12% of the total Zone 2 catch and 16% of the southern fishery's total catch. Queen snapper, *Nemadactylus valenciennesi*, was again the largest component of the fishery's scalefish catch at 40 tonnes (22%), followed by blue groper, *Achoerodus gouldii*, at 34 tonnes (19%) and pink snapper, *Pagrus auratus*, at 10 tonnes (6%). The composition of the 2003/04 JASDGDLF scalefish catch is given in Table 3.

Table 3. Species composition of the 2003/2004 JASDGDLF scalefish catch

Species	Catch (tonnes live weight; % of landings in parentheses)		
	Zone 1	Zone 2	Total
Queen snapper	10 (11%)	30 (34%)	40 (31%)
Blue Groper	12 (13%)	22 (25%)	34 (26%)
Pink snapper	2 (2%)	8 (9%)	10 (8%)
Salmon	9 (10%)	0 (0%)	9 (7%)
Dhufish	6 (6%)	2 (2%)	7 (6%)
Samson fish	2 (2%)	4 (5%)	6 (5%)
Leather jacket	1 (1%)	4 (5%)	5 (4%)
Boarfish	0 (0%)	3 (4%)	4 (3%)
Mulloway	0 (0%)	3 (3%)	3 (2%)
Other fish	51 (54%)	12 (13%)	11 (8%)

West Coast Demersal Gillnet and Demersal Longline Fishery

A total of 482 tonnes of shark were landed in the west coast fishery in 2003/04 (Figure 1), an annual increase of 113 tonnes (31%). Standardised fishing effort was 84,652 km gillnet hr, 43% more than in the previous year (Figure 2). However, while combining gillnet and longline effort into a single standardised measure of effort will continue, increased use of longlines in the WCDGDLF has altered the composition of the fisheries' overall effort. Gillnet fishing effort declined by 7% to 53,057 km gillnet hours in 2003/04, whilst longline effort increased by 465% to 309,050 hook days over the same period. Sandbar shark landings increased by 46 tonnes (34%) in the west coast fishery, where they remained the biggest single component of the catch (Figure 6). Dusky shark landings also increased noticeably in 2003/04 to 137 tonnes (Figure 3), an annual increase of 53 tonnes (64%). The WCDGDLF whiskery shark catch increased to 34.1 tonnes, an 8 tonne (31%) increase from the 2002/03 catch (Figure 5). The species composition of the 2003/04 WCDGDLF shark catch is given in Table 4.

Table 4: Species composition of the 2003/2004 WCDGDLF shark catch

Species	Catch (tonnes live weight; % of landings in parentheses)
Sandbar (thickskin)	182 (38%)
Bronze whaler	137 (28%)
Whiskery	34 (7%)
Shovelnose/fiddler rays	29 (6%)

Blacktip	25 (5%)
Wobbegong	23 (5%)
Hammerhead	17 (4%)
Gummy	9 (2%)
Tiger	4 (1%)
Other sharks	21 (4%)

WCDGDLF scalefish landings increased by 16 tonnes (18%) during 2003/04, accounting for 18% of the fishery's total catch (Figure 7). Dhufish, *Glaucosoma hebraicum*, remained the largest component of the fishery's scalefish catch (20 tonnes), followed by sweetlips, family Haemulidae (17 tonnes); pink snapper, *Pagrus auratus*, (13 tonnes) and samsonfish, *Seriola hippos*, (12 tonnes). The composition of the 203/04 WCDGDLF scalefish catch is given in Table 5.

Table 5: Species composition of the 2003/2004 WCDGDLF scalefish catch

Species	Catch (tonnes live weight; % of landings in parentheses)
Dhufish	20 (19%)
Sweetlip	17 (17%)
Pink snapper	13 (13%)
Samson fish	12 (12%)
Mulloway	10 (9%)
Baldchin groper	5 (4%)
Queen snapper	4 (4%)
Sweetlip emperor	4 (4%)
Parrotfish	3 (3%)
Other fish	16 (15%)

WA North Coast Shark Fishery and Joint Authority Northern Shark Fishery

The increasing trend in total shark landings by the State's two northern shark fisheries continued during 2003/04, with a 101 tonne (21%) annual increase to the fisheries' highest ever catch of 591 tonnes (Figure 8). Unlike in previous years, all of the 717,100 hook days of fishing effort (70% more than 2002/03) was expended by longlines. As in previous years, nearly three quarters (71%) of northern shark fishing effort was distributed in the area west of Cape Leveque. The shift of fishing effort away from pelagic gillnets in the JANSF area during 2003/04, caused a significant change in the composition of the northern shark fisheries catch (Table 6). Sandbar sharks reverted to the primary component of the fisheries' catch, with landings of 209 tonnes, 138% more than in 2002/03. Conversely, the catch of 'blacktip' sharks (a generic category, which in northern WA consists mainly of the Australian blacktip whaler, *Carcharhinus tilstoni*, the common blacktip whaler, *C. limbatus*, and the spottail shark, *C. sorrah*), declined by 138 tonnes (77%). The majority of the remaining catch was comprised of 51 tonnes of tiger sharks (*Galeocerdo cuvier*), 33 tonnes of hammerhead species (family Sphyrnidae), 24 tonnes of pignose sharks (*Carcharhinus amboinensis*) and 24 tonnes of lemon sharks (*Negaprion acutidens*).

Table 6: Species composition of the 2003/2004 WA northern shark fisheries shark catch

Species	Catch (tonnes, live weight and percentage in parentheses)
Sandbar ('thickskin')	209 (35%)
Tiger	51 (9%)
'Blacktip'	40 (7%)
Hammerhead	33 (6%)

Pigeye	24 (4%)
Lemon	24 (4%)
Bull	19 (3%)
'Bronze whaler'	17 (3%)
Grey reef	9 (2%)
Other sharks and rays	164 (28%)

The northern shark fisheries' scalefish catch declined by 63% in 2003/04 due to the absence of pelagic gillnet-caught mackerel, previously the largest component of the fisheries' scalefish catch. Catches of other scalefish species did not change appreciably from their 2002/03 levels. The species composition of the northern shark fisheries' scalefish catch is given in Table 7.

Table 7: Species composition of the 2003/2004 WA northern shark fisheries scalefish catch

Species	Catch (tonnes, live weight and percentage in parentheses)
Rankin cod	1 (34%)
Black kingfish (cobia)	>1 (20%)
red emperor	>1 (16%)
Goldband snapper	>1 (10%)
Spotted cod	>1 (7%)
Other cod	>1 (6%)
Spangled emperor	>1 (5%)
Sea catfish. (golden cobbler)	>1 (3%)
Red snapper, swallowtail	>1 (>1%)

STATUS OF THE STOCKS

Dusky shark

Dusky shark catches climbed steadily through the 1970's and early 1980's before beginning to decline in the early 1990's (Figure 3). Until the late 1980s, dusky sharks were the most important component of the catch, both in terms of weight and value, of the state's temperate demersal gillnet and longline fisheries. The combined catch of dusky sharks in the JASDGLF and WCDGDLF during 2003/04 was 339.2 tonnes, 71 tonnes (27%) higher than last year. The catch in Zone 1 of the southern fishery was 113 tonnes, an annual increase of 12 tonnes (12%) and in Zone 2 was 89 tonnes, 6 tonnes (7%) more than last year. The largest increase was in the WCDGDLF, where the catch of 137 tonnes was 53 tonnes (64%) more than in 2002/03. As most of the additional dusky shark catch in the west coast fishery was taken by longlines, which are less size-selective than gillnets, a high proportion of this catch is believed to have been comprised of larger juveniles, sub-adults and adult sharks. The dusky shark catch in the northern fisheries remained relatively small at 17 tonnes but this was 138% more than was landed last year.

Quantifying the true level of dusky shark catches outside the target fisheries is more problematic due to a generally poor level of species identification and probable underreporting of shark bycatch in non-target fisheries. In 2003/04, a reported 26 tonnes of 'bronze whaler' (believed to be primarily *Carcharhinus obscurus*) was reported from the State-managed non-target fishing sector, far less than the 62 tonnes that was reported last year. This catch included 1 tonne from other WA-managed fisheries and 25 tonnes from 'wetline' fishing methods. Additionally, an unknown portion of the 79 tonnes (29% less than 2002/03) of undescribed sharks that were landed by non-target vessels, could have been dusky shark. Dusky sharks are also a known component of the bycatch of the Commonwealth-managed Southern and Western Tuna and Billfish Fishery (SWTBF). Evidence for this includes the recovery of tuna hooks from dusky sharks taken in the State-managed shark fisheries, reported bycatch in AFMA logbooks, observed captures during a pilot SWTBF observer project and during surveys of Japanese longline vessels which previously operated in Australia's EEZ. Bycatch mortality of dusky sharks in the SWTBF is thought to have peaked during the mid to late 1990s as the fishery was developing in waters adjacent to the continental shelf and before wire traces were prohibited in the fishery. Although in recent years, SWTBF effort has declined substantially and much of the remaining effort has migrated further offshore in pursuit of economical catch rates of target species (i.e. swordfish and tuna), a significant proportion of this fishery's effort remains focussed along the edge of

the continental shelf. The Department is also concerned about other avoidable sources of adult dusky shark mortality, which include: the possibly high mortality rates of larger dusky sharks from entanglement in plastic packing straps ('bait bands'), reports of sharks being shot by fishers from boats and the shore and by recent targeted game-fishing for large 'bronze' whalers off Rottne Island.

Dusky shark catch rates decreased by 17% and 2% in Zones 1 and 2 of the JASDGLF, respectively, and increased by 14% in the WCDGLF during 2003/04 (Figure 9). The best available indicator of juvenile dusky shark abundance (effective area CPUE), also declined by 9% in 2003/04 (Figure 10). Whilst the declining trend in effective area CPUE since the mid 1990s suggests that recruitment of dusky sharks to the fishery has declined, analysis of CPUE data for this species has become complicated due to the apparent decline in the relative contribution of neonates to catches. As the increased contribution of older juveniles and larger hook-caught sharks to recent catches is believed to have resulted in an overly optimistic trend in catch rates, the actual level of the decline in neonate abundance is believed to be greater than is suggested by these CPUE trends. Declining recruitment is also supported by anecdotal advice from fishers that the abundance of neonate dusky sharks in traditional nursery grounds has decreased over recent years. Because the stock recruitment relationship in a viviparous species such as this is believed to be relatively direct, it can therefore be inferred from the declining catch rates that the breeding stock has been depleted.

Revised demographic analysis of the WA dusky shark stock suggests that although the fishing mortality rates of sharks born in 1994 and 1995 are likely to have been sustainable, this stock is less productive than previously thought. In the absence of fishing, the best estimate of the population growth rate was 2.5% per year (95% confidence intervals between -0.007 yr^{-1} and 0.052 yr^{-1}). Whilst the model indicates that during the mid to late 1990s this population had the capacity to offset the exploitation rates of primarily first year (neonate) and second year sharks ($r = 0.7$ and 1.3% per year for 1994 and 1995 'cohorts', respectively), it also indicated that additional mortality of as low as 1-2% per year in sharks older than 10 years of age, would cause the stock to decline. The model also re-estimated the generation time (*i.e.* the average time it takes for each mature female to be replaced) and population doubling time as 32 years and 35 years, respectively. Although the new estimate of generation time was only marginally higher than the 30 years determined by the previous assessment, the revised population doubling time twice that of the previous estimate of 17 years.

Given the results of the demographic analysis, the only feasible explanation for the apparent decline in neonate recruitment is that the combined mortality of older dusky sharks has exceeded the 1-2% per year threshold at some point since the mid 1990s. Although dusky shark catches during most of the 1980s and early 1990s were above the levels estimated to be sustainable since 1994, as this species does not attain maturity until about 30 years of age, the effects of these previously higher levels of exploitation could not yet be apparent in breeding stock. As the effects of these historic levels of catch are likely to eventually translate into a reduction in the numbers of mature sharks, it is predicted that recruitment will decline further as cohorts born in the 1980s and early 1990s reach breeding age. It is therefore imperative that ALL avoidable sources of adult and older juvenile dusky shark mortality cease immediately.

Whilst the agreed management measures of: commercial protection of dusky sharks above 1.5m Fork Length, restrictions on permitted longline configurations, prohibition on shark landings outside the recognised 'shark' fisheries and indefinite closure of the Pilbara area of the WANCSF, will afford significant protection to mature dusky sharks, the other previously described external sources of mortality still have the potential to contribute to further depletion of the dusky shark breeding stock.

In summary, although the exploitation of dusky sharks by the State's demersal gillnet fishery during the mid 1990s has been re-assessed as sustainable, the cumulative mortality of older sharks from a variety of sources has caused a depletion of the breeding stock to a level which has caused recruitment to fail. It is therefore imperative that ALL avoidable sources of older dusky shark mortality cease immediately.

Gummy shark

Gummy shark catches increased steadily through the 1970s and 1980s and peaked at 501 tonnes in 1991/92 (Figure 4). Subsequent effort reductions in Zone 2 of the JASDGLDF have resulted in generally lower levels of gummy shark catch through the rest of the 1990s, however catches began to escalate again in 2000/01. The total catch of gummy sharks in the JASDGLDF and WCDGLDF increased by 74 tonnes in 2003/04 to 465 tonnes, its highest level since 1991/92. Catches also increased in all management zones: by 108% to 65 tonnes in Zone 1, by 11% to 390 tonnes in Zone 2 and by 16% to 9 tonnes in the WCDGLDF. Gummy shark catches in the Commonwealth-managed Gillnet Hook and Trap sector peaked in 1987 at 4,228 tonnes but these have subsequently declined. The gummy shark quota for Commonwealth-managed fisheries is currently 1717 tonnes, of which 1578 tonnes were caught in 2004. Gummy sharks are not caught in either of the State's northern shark fisheries and catches in other Western Australian commercial fisheries are thought to be negligible.

Effective area CPUE was 2kg per km gillnet hour in 2003/04 (1% less than last year) and has been relatively stable at around this level since 2001/02 (Figure 11). Catch rates increased in both management zones of the JASDGLDF but declined by 19% in the WCDGLDF as a result of the high proportion of longline effort expended in the northern part of this fishery (Figure 12). As the best available index of (adult) gummy shark abundance, the increasing trend in effective area CPUE over the last ten years is thought to reflect a recovery of the Western Australian gummy shark stock following the steady reduction of catches in the Commonwealth-managed fishery and reductions in catch and effort in Zone 2 of the JASDGLDF throughout the 1990s. However, recent catch rate trends are also likely to be confounded with increased targeting of effort towards gummy sharks in Zone 2, as the abundance of other target species, particularly school shark (*Galeorhinus galeus*) and dogfish (family Squalidae), has declined.

The Western Australian gummy shark biomass in 1997/98 was estimated to be 42.7% of its original level, with 95% of biomass estimates between 22.6% and 60.2%. Risk assessment indicated that to have a high probability of achieving 40% of original biomass by 2010 the effort 'targeted at' gummy sharks needed to be between 50% and 70% of its 1993/94 level. According to the latest data, demersal gillnet effort expended within the gummy shark's range (effective area effort) has consistently been above 70% of the 1993/94 level and was 83% of that level in 2003/04 (Figure 11). However, because the previous assessment was based on CPUE data that were revised in 2003, a new model to incorporate the revised time series of catch and effort data, is required to re-estimate current biomass and to predict future biomass probabilities.

In summary, as the fishery primarily exploits adult gummy sharks, the increasing trend in effective area catch rates over the last ten years suggests that the breeding stock was not seriously depleted by the peak in Zone 2 effort in the early 1990s and that recruitment has continued at a reasonable level since the last assessment.

Whiskery shark

The exploitation of whiskery sharks was at its heaviest during the late 1970's and early 1980's with the catch peaking in 1981/82 at 524 tonnes (Figure 5). As whiskery shark catch rates declined during the early 1980s, targeting shifted to other more abundant species and by the early to mid 1990s, whiskery catches had stabilised at around 200 tonnes per year. The combined catch of whiskery sharks in the JASDGLDF and WCDGLDF during 2003/04 was 184 tonnes, a 14% increase from the previous year. Landings were stable in Zone 1 at 70 tonnes, increased by 21% to 80 tonnes in Zone 2 and by 31% to 34 tonnes in the WCDGLDF.

Whiskery shark catch rates declined by 25% in Zone 1 and by 8% in the WCDGLDF, while increasing by 11% in Zone 2 during 2003/04 (Figure 12). The effective area catch rate of whiskery sharks declined by 2% in 2003/04 but at 0.52 kg per km gillnet hr, was still around the level it has been since 1996/97 (Figure 13). As the mesh sizes used in the fishery are highly selective for adult-sized sharks, the stability in the effective area CPUE trend over the last eight years, suggests that the breeding stock biomass has stabilised and that recruitment has therefore been steady.

The 2004 stock assessment (based on catch and effort data from 2002/03) indicated that the whiskery shark biomass was 99% of its unexploited (virgin) level, with 95% confidence that the biomass was between 96% and 100% of virgin, in 1975 when catch and effort reporting began (Figure 14). Total biomass was estimated to have declined steadily between 1975/76 and 1993/94, after which the rate of decline slowed. The rate of biomass decline was estimated to have averaged 1.2% yr⁻¹ between 1996/97 and 2002/03 and was

almost stable at $0.9\% \text{ yr}^{-1}$ in 2002/03. The last assessment estimated that total whiskery shark biomass was higher than had been previously calculated, at 35.1% of its virgin level, with 95% confidence that it was between 33.7% and 36.3% of its unexploited size. Mature female biomass was also estimated to be higher than previously thought at 21.8% (with 95% confidence that it was between 20.6% and 22.8%) and was calculated to have increased by 1.6% since 2001/02, the second year running that mature female biomass had increased.

Based on the probability curves determined from the 2004 risk assessment and the current effective area effort for whiskery sharks, it is estimated that there was a 23.4% likelihood that the whiskery shark biomass would be at its 40% target level in 2010 (Figure 15). This probability is less than in recent years due to the higher level of effective area effort and due to the shorter timeframe for the target biomass level to be achieved. Using these same data, it was also estimated that the whiskery shark stock only had an 11.9% probability of increasing in size under the 2003/04 level of effective area effort. **Even though biomass was calculated to be higher than previously determined, these results demonstrate that latent effort activation is seriously undermining the chances of rebuilding the whiskery shark stock. Additional management measures are therefore required to ensure that the temperate demersal gillnet and longline fishery is harvesting this stock in a sustainable manner.**

The age-structure of the whiskery shark catch defined in the model, is based on data collected prior to 1999. More recent research data, however, suggests that the age structure of catches might have changed in recent years, as a 'pulse' of younger adult fish has apparently become more prevalent in observed catches. If these data are representative of catches across the entire fishery, then the reported catch (weight) is probably comprised of a greater number of fish than in previous years. Therefore, as the model uses the number of individuals in each age class, total biomass estimates based on the old age structure may be underestimating the current whiskery shark biomass. However, as recent research data were mainly collected from the northern half of the whiskery shark's range and in waters deeper than those from which the original age structure was derived, the observed size structure may be biased and may not accurately represent the size structure in other regions of the fishery.

Sandbar shark

Catches of *C. plumbeus* have increased in the WCDGDLF and, to a lesser degree, in the JASDGDLF since the mid 1990s (Figure 6). Sandbar shark catches in the northern shark fisheries, have also increased sharply since the late 1990s as full time shark-fishing vessels entered the fishery (Figure 8). However, comparison of voluntary logbook data with CAES records suggests that over the last four years, at least, sandbar catches in the northern shark fisheries have been under-reported by between 37% and 75%. The combined total reported catch of sandbar shark in the target shark fisheries (JASDGDLF, WCDGDLF and Northern Shark Fisheries) increased by 60% to 413 tonnes in 2003/04 (Figure 6). In 2003/04, the JASDGDLF sandbar catch decreased by 35% to 22 tonnes, the WCDGDLF catch was up by 34% to 182 tonnes and the Northern Shark Fisheries catch also increased by 138% to 209 tonnes. Declines of 44% and 7% in sandbar shark catch rates by the JASDGDLF and the WCDGDLF, respectively, caused a 20% decline in the species' effective area catch rate (Fig 16). Over the same period, sandbar shark CPUE increased by 40% in the northern fisheries (Figure 17). As the assessment model developed for *C. plumbeus* largely operates independently of reported catches, the potential under-reporting of catches will not have directly affected the assessment of this stock. However, if suspicions of under-reporting of catches are correct, the reliability of recent sandbar CPUE trends and those of the northern fisheries' secondary species will be undermined.

Results of the demographic analysis indicated that under zero fishing mortality the Western Australian *C. plumbeus* stock had the capacity to grow at $2.5\% \text{ yr}^{-1}$. This rate is at the lower end of the rates estimated for this species elsewhere and almost identical to the rate that was re-estimated for the closely related and co-occurring dusky shark (*Carcharhinus obscurus*). However, unlike the dusky shark, the Western Australian *C. plumbeus* stock is currently being exploited across almost all age-classes, a practice which is an unsuitable exploitation strategy for long-lived shark stocks, such as this.

Under the estimated age-specific fishing mortality rates during 2001/02, 2002/03 and 2003/04, the WA sandbar shark stock had negative capacity for population growth. The rate of population decline was calculated to have been greatest in 2003/04 when catches in both of the target fisheries, (*i.e.* the WA North

Coast Shark Fishery (WANCSF) and the temperate demersal gillnet and longline fishery), increased sharply. Given the empirically measured biological parameters and estimated mortality schedules, the stock's capacity for growth was estimated from the model to be $-4.9\% \text{ yr}^{-1}$ in 2003/04. As similar catches were reported from the target fisheries during 1999/00 and 2000/01, it is also assumed that the stock had similar levels of negative population growth capacity during these years.

To examine potential fishery management strategies, 65 hypothetical scenarios of fishing mortality in the various fishing sectors that catch *C. plumbeus* were tested in the model, 15 of which delivered neutral or positive population growth rates. However, as both of the target fisheries contribute to the exploitation of the stock, appropriate levels of exploitation in the WANCSF could not be determined independently of exploitation by the temperate demersal gillnet and longline fishery (mainly in the WCDGDLF) and *vice versa*. The demographic model indicated that to achieve the capacity for positive growth in the population and thus reverse the current declining trend in this stock, major reductions in fishing mortality were necessary in both the WANCSF and in the temperate demersal gillnet and demersal longline fishery, unless fishing mortality in one or other is reduced to zero.

FUTURE RESEARCH AND EVALUATION

While these are amongst the best researched and managed shark fisheries in the world, under the more rigorous standards of Ecologically Sustainable Development (ESD), the limitations of current assessment techniques are becoming increasingly apparent. In addition to ongoing monitoring of catch and effort data from the demersal gillnet/demersal longline and northern shark fisheries, the following areas of research should be considered as high priorities in the short to medium term.

Because it is no longer certain that the **dusky shark** stock can continue to sustain historical levels of catch, a new tagging project to calculate current exploitation rates is required. Despite the additional biological data that has been collected for *C. obscurus* during the recent FRDC-funded project, there are also still important gaps in our understanding of this species' life history. In particular, further research is required to determine the stock's reproductive frequency, its distribution and abundance outside the range of the temperate demersal gillnet fishery and the timing and duration of its migratory patterns. Until funding for such research can be obtained, the size composition of dusky shark catches in the target fisheries will continue to be monitored for indications of change, to the extent of available resources and other priority research constraints.

Whilst the results of the previous **gummy shark** assessment are becoming increasingly unreliable, analysis of CPUE data shows no cause for immediate concern. Nonetheless, a new gummy shark model is required to assess the stock against the stated management and ESD performance target of 40% of original biomass by 2010. The reliability of a new assessment for gummy sharks would also be greatly improved by incorporating an updated age-structure and development of a standardised fishery-independent index of abundance, such as a fixed-station monitoring regime. Although the latter has the potential to provide the necessary size-composition and abundance information and would ensure comparability of data collected between years, the amount of sampling that is likely to be required to account for the variability in catches, fixed station monitoring is currently beyond what can be achieved with available research resources.

Furthermore, as existing CPUE data provide only weights (not numbers) of catches and are heavily dependent on changes in fleet behaviour (eg. targeting of locally or temporally abundant stocks) and the size structure of the stock, the accuracy of the existing **whiskery shark** model would also be greatly improved by incorporating an updated age-structure and fishery-independent index of abundance.

Changes to the management arrangements for the north coast shark fisheries that have been agreed between the Department, northern shark fishery licensees, the Northern Shark Industry Association and the Minister for Fisheries, require that the fishery's catch of **sandbar sharks** be closely monitored to determine the effects of continued fishing in the area between Broome and Cape Leveque during the period between 1

October and 31 January. This monitoring will involve on-board 'observer' coverage of 10% of fishing effort in the Broome to Cape Leveque area, as well as additional observation of landings. Despite the detailed biological data that have been collected for *C. plumbeus* during the recent FRDC-funded project, some important aspects of this species' life history, still require further research. In particular, the stock's distribution and abundance outside the range of the State-managed shark fisheries and the timing and duration of its migratory patterns need to be resolved. As with dusky sharks, this information will enable a more quantitative assessment of the threats to the breeding stocks of these species outside of the target fisheries and more reliable assessments of the status of these stocks.

Other short to medium term priority research issues include:

- Stock assessment of '**blacktip**' shark species in northern Australia
- Further research into the biology and ecology of high conservation-value elasmobranch species, especially Sawfish (family Pristidae) and Grey Nurse Sharks, *Carcharias taurus*

ACKNOWLEDGMENTS

Production of this report would not have been possible without the considerable assistance of Western Australia's commercial shark fishers. Their provision of information in the form of catch and effort data, assistance with biological research, and reporting of tag recapture data, has made the ongoing assessment of these stocks possible. Thanks also to the staff at the Western Australian Marine and Fisheries Research Laboratories who have assisted with data analysis and reviewed this report, particularly Dan Gaughan, Rod Lenanton, Eva Lai, and Peter Stephenson.

Figures

Figure 1. Temperate demersal gillnet & longline fisheries total shark catch

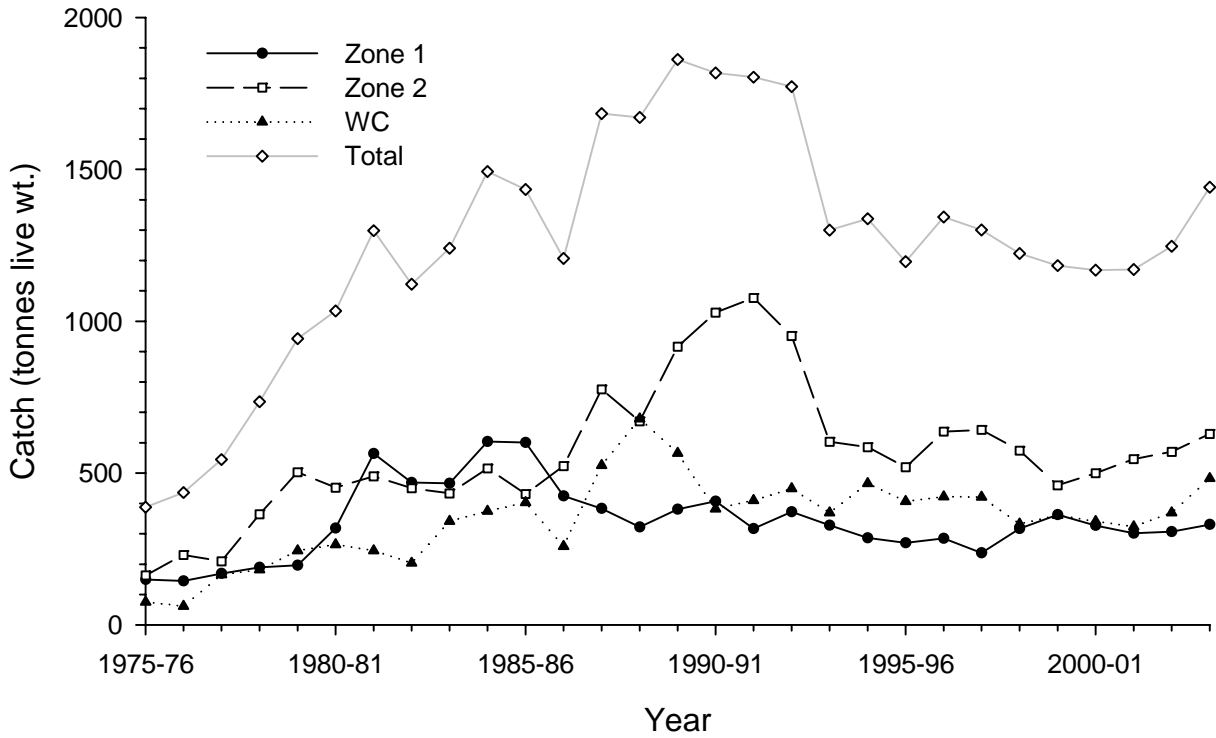


Figure 2. Temperate demersal gillnet & longline fisheries effort

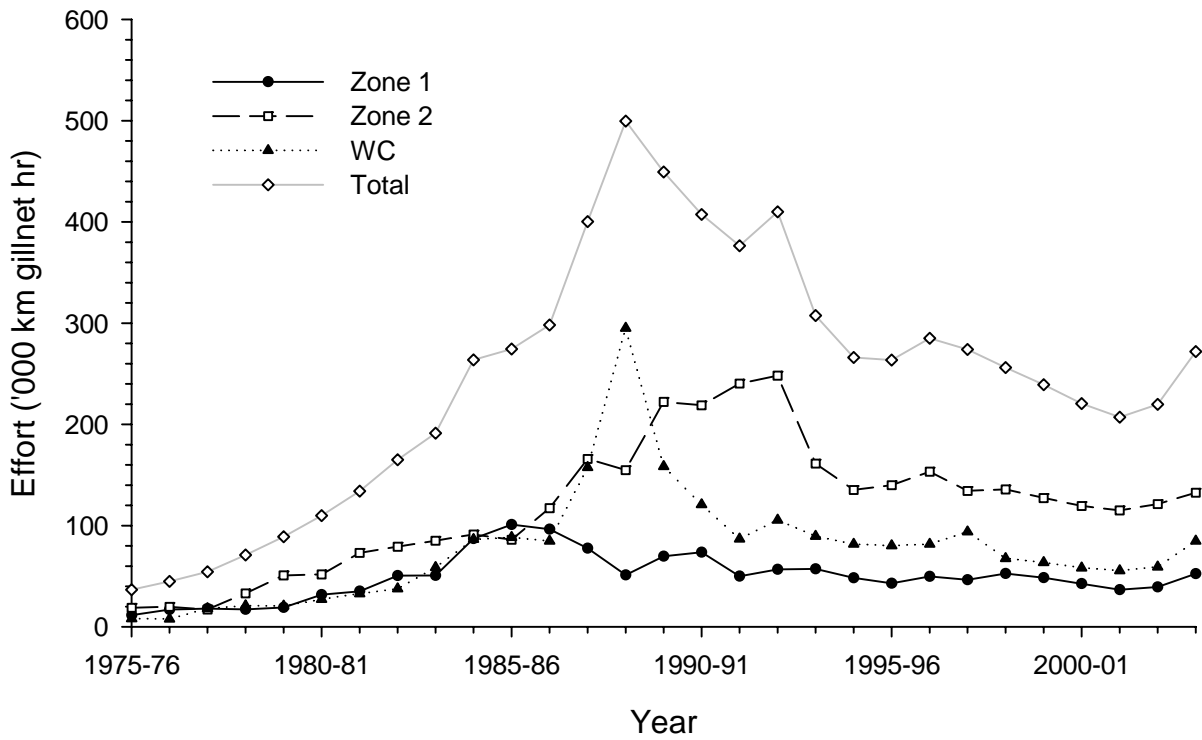


Figure 3. Temperate demersal gillnet & longline fisheries dusky whaler catch

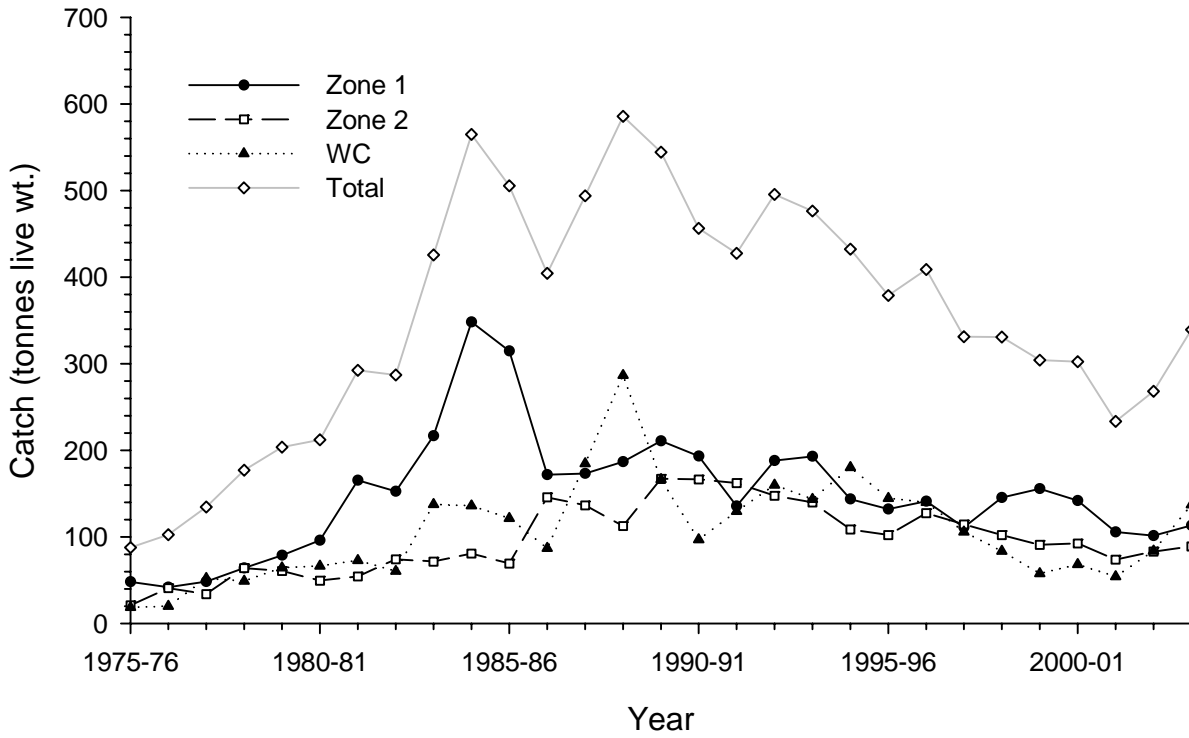


Figure 4. Temperate demersal gillnet & longline fisheries gummy shark catch

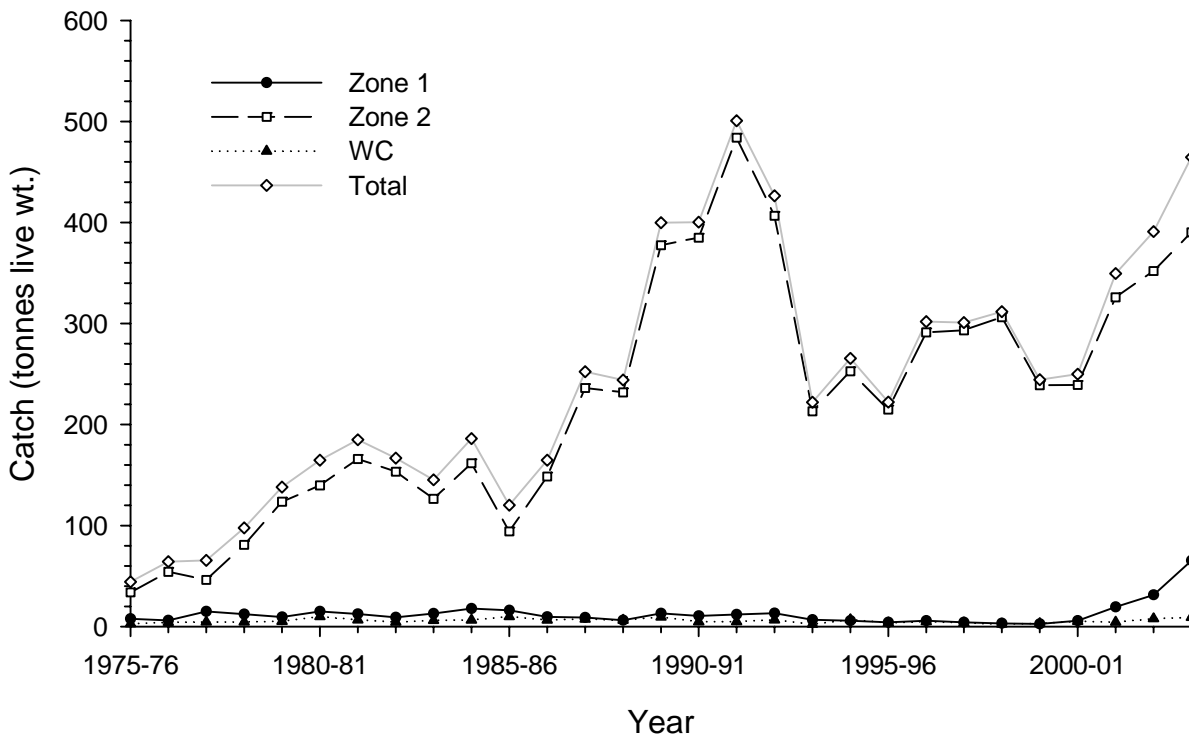


Figure 5. Temperate demersal gillnet & longline fisheries whiskery shark catch

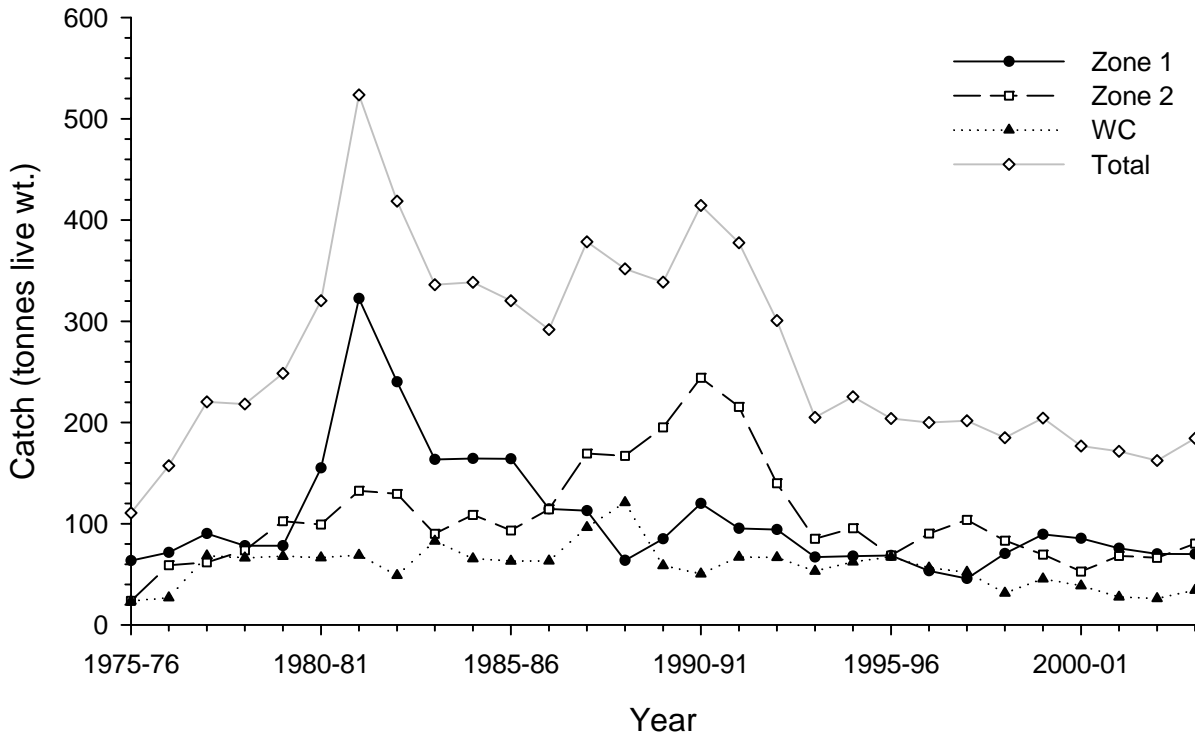


Figure 6. Temperate demersal gillnet & longline fisheries sandbar shark catch

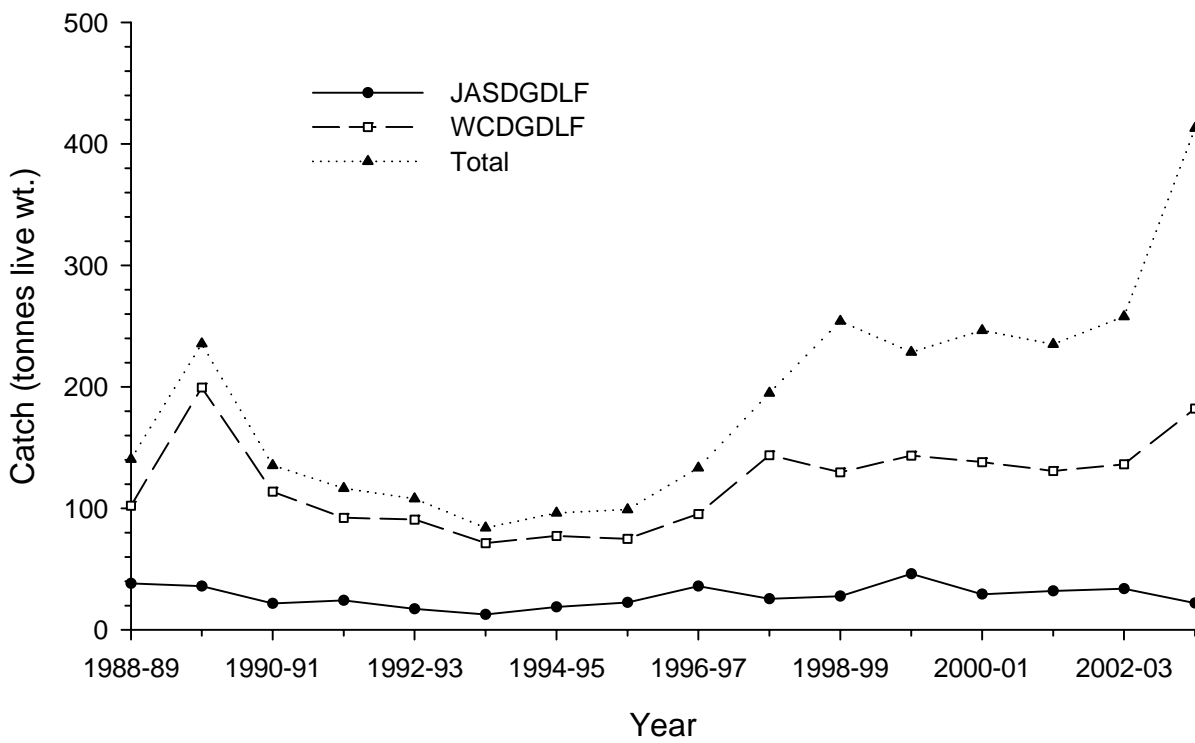


Figure 7. Temperate demersal gillnet & longline fisheries total scalefish catch

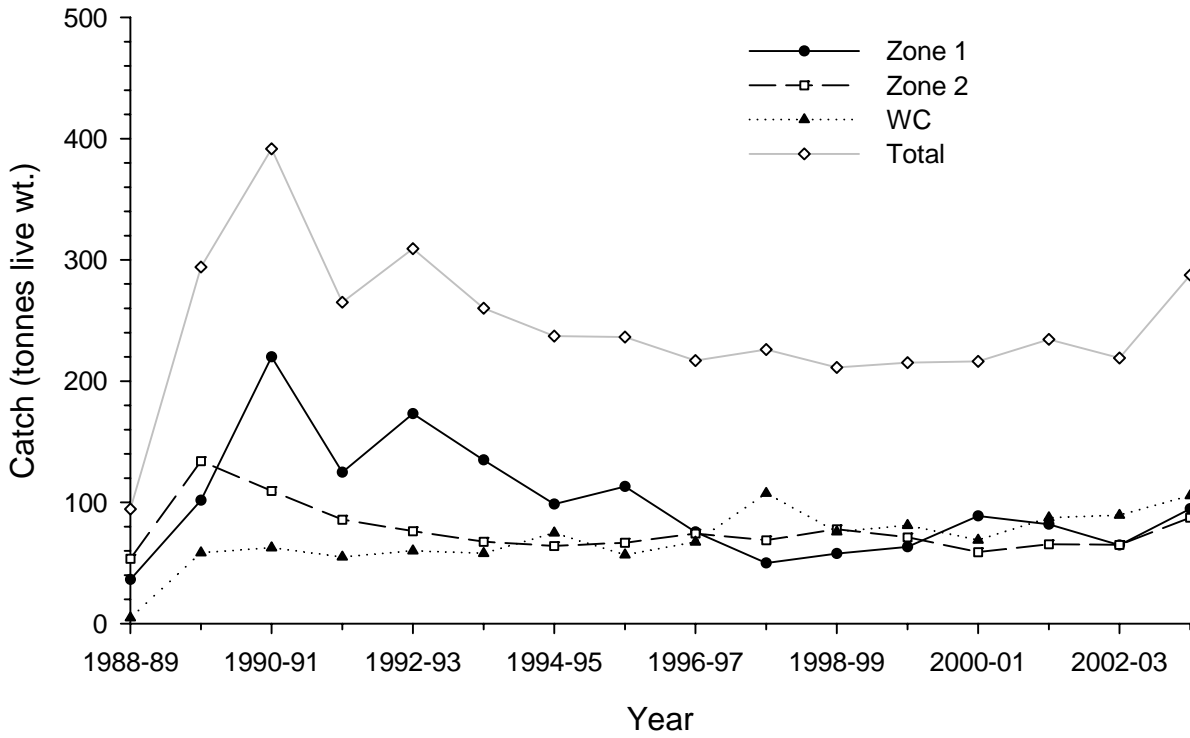


Figure 8. Northern shark fisheries catch by species and standardised effort

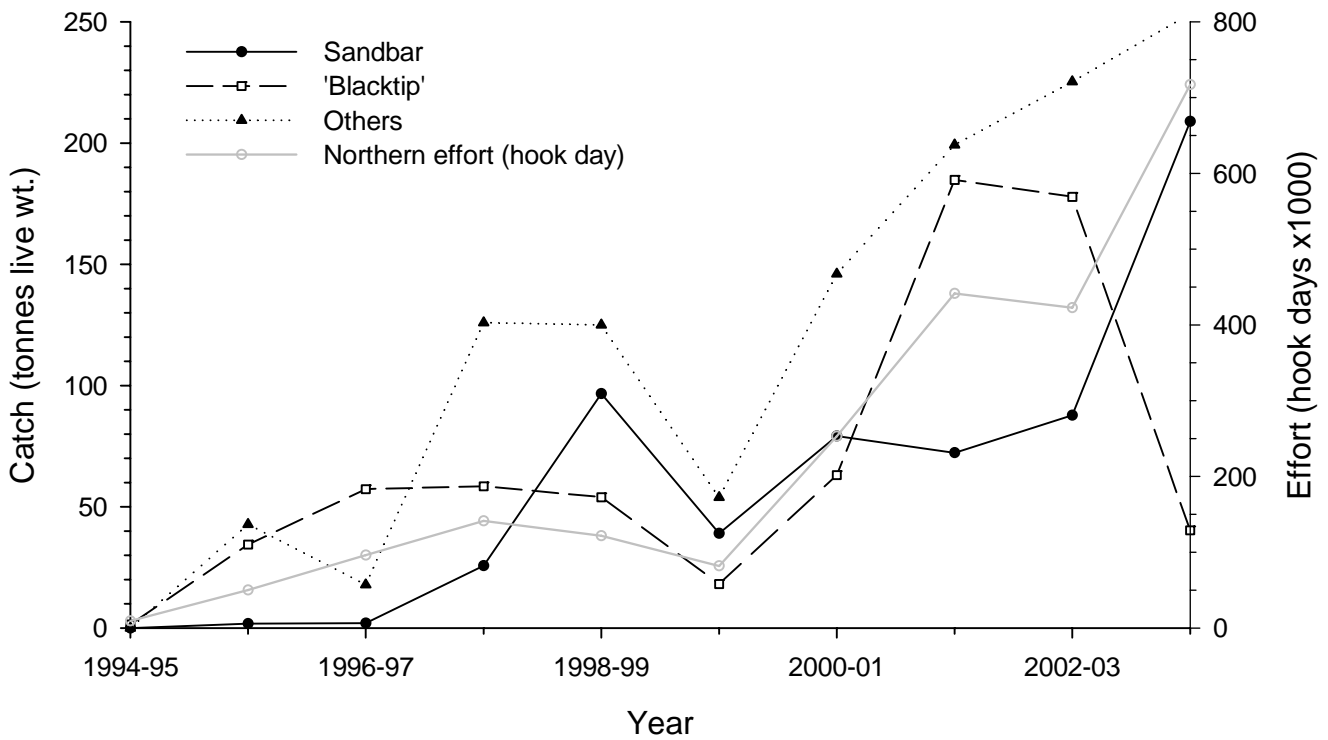
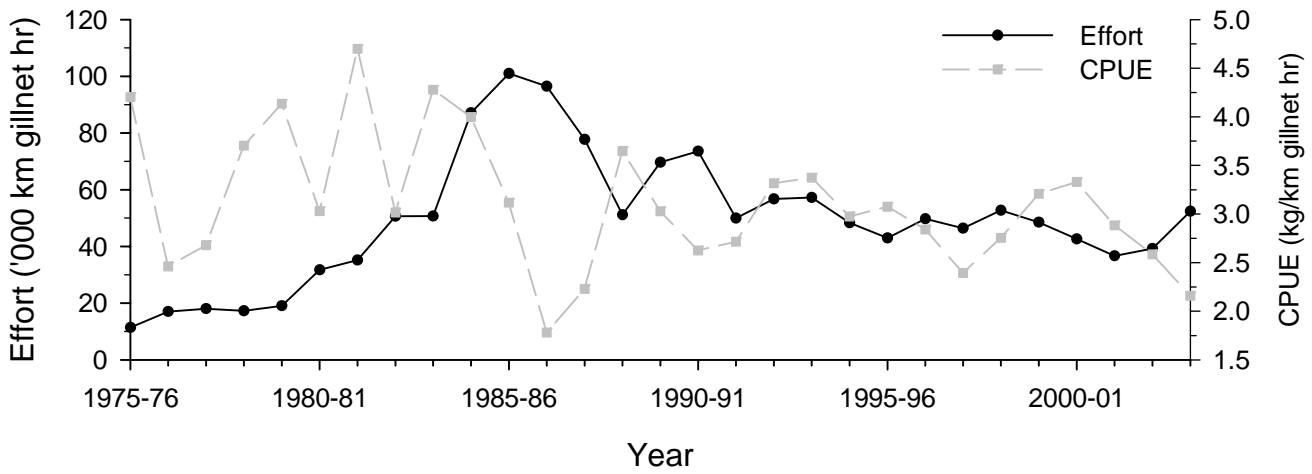
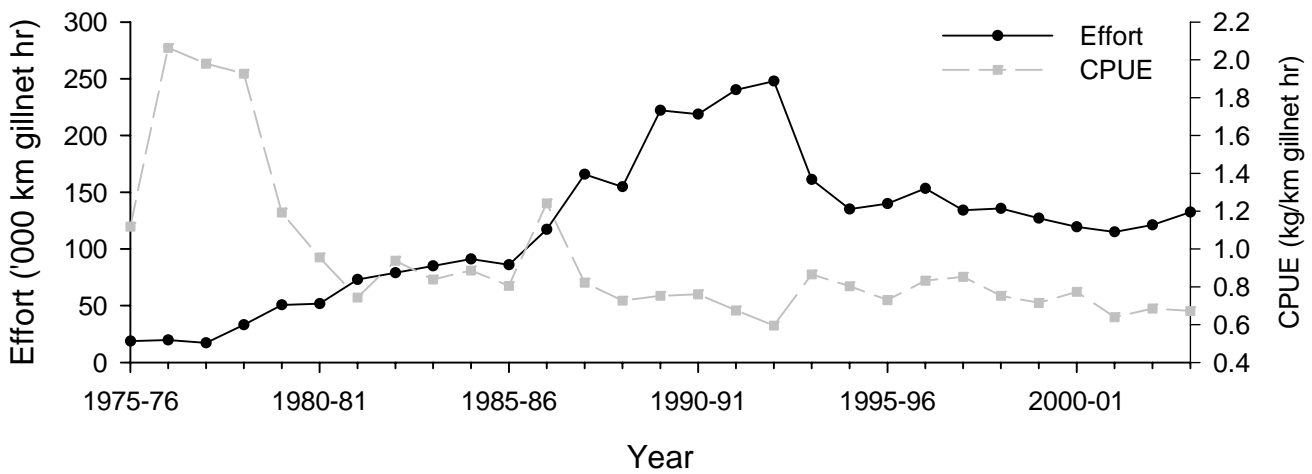


Figure 9. Temperate demersal gillnet & longline fisheries corrected effort and dusky whaler catch rates by zone

(i) JASDGLDF Zone 1



(ii) JASDGLDF Zone 2



(iii) WCDGLDF

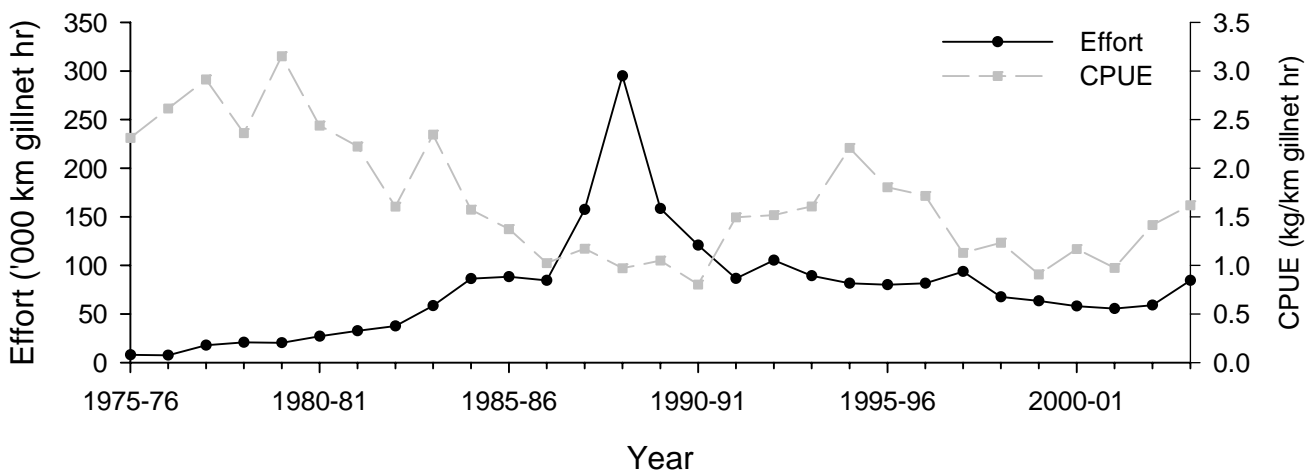


Figure 10. Dusky whaler effective area effort and catch rate

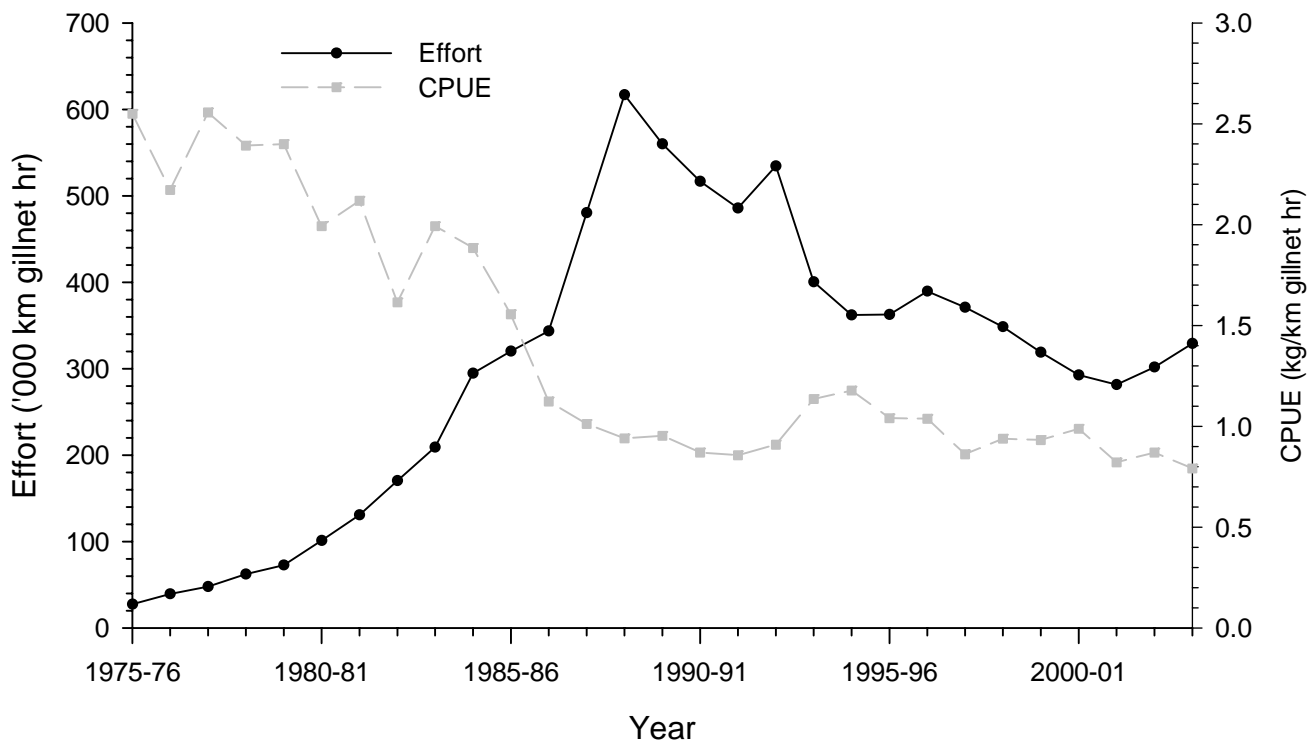


Figure 11. Gummy shark effective area effort and catch rate

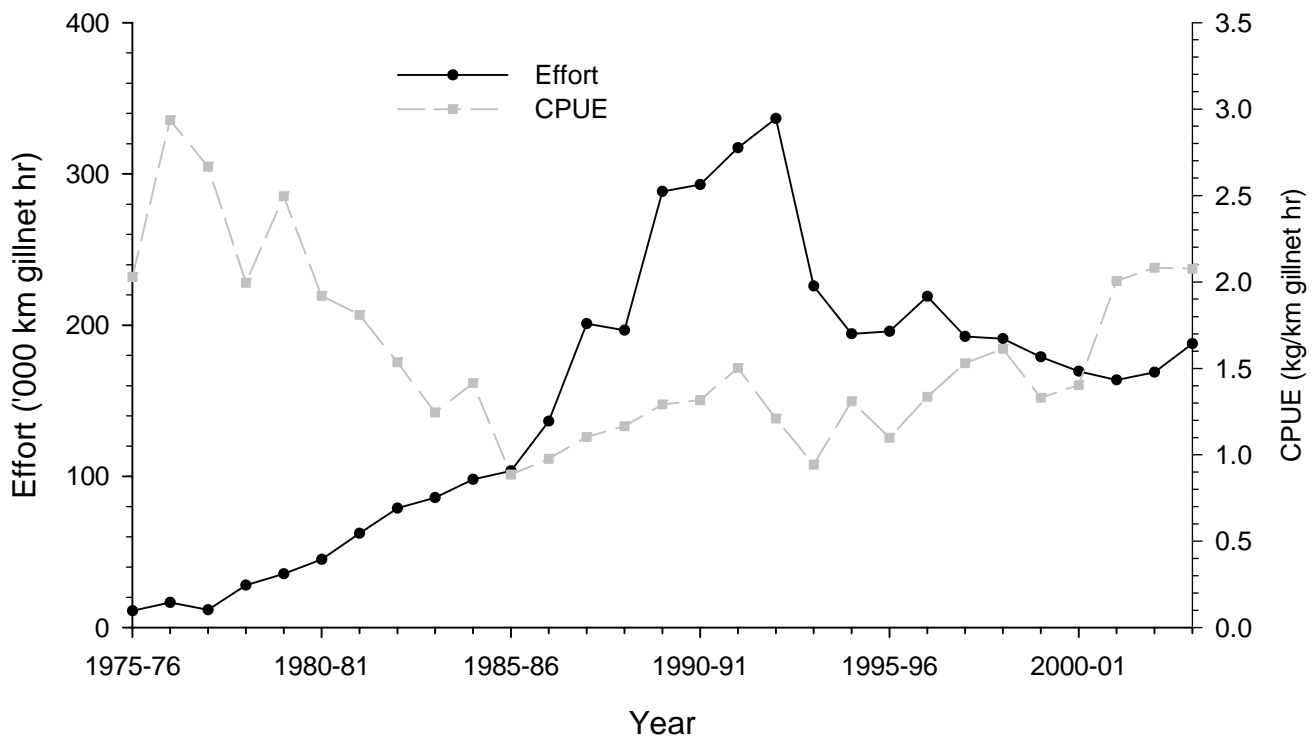
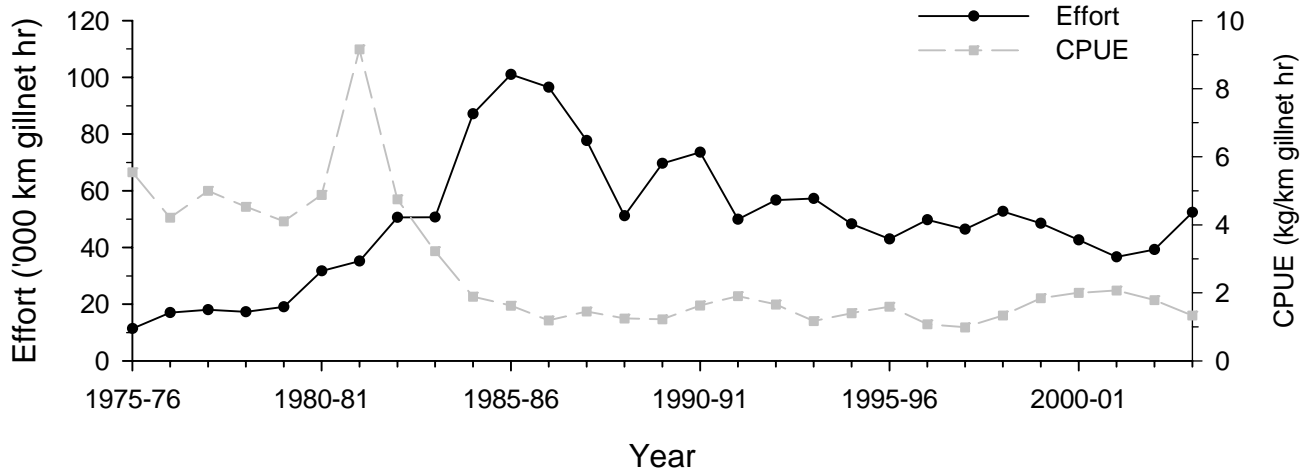
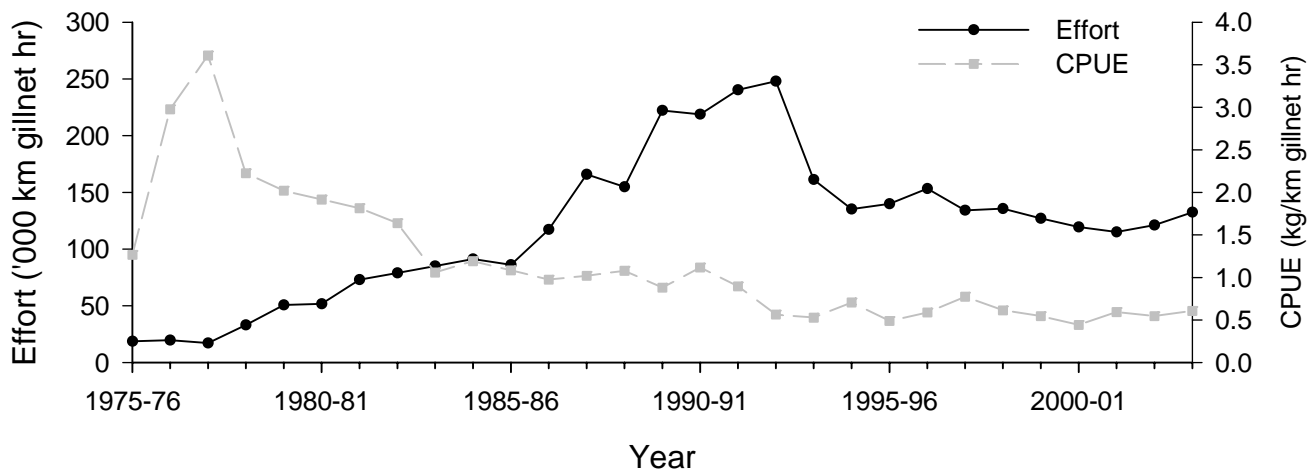


Figure 12. Temperate demersal gillnet & longline fisheries corrected effort and whiskery shark catch rates by zone

(i) JASDGDLF Zone 1



(ii) JASDGDLF Zone 2



(iii) WCDGDLF

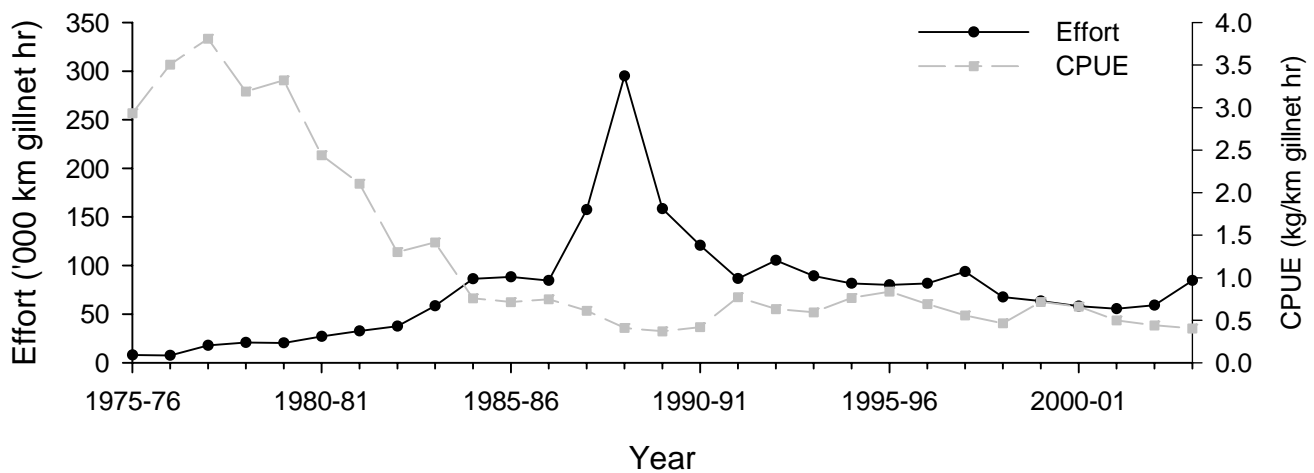


Figure 13. Whiskery shark effective area effort and catch rate

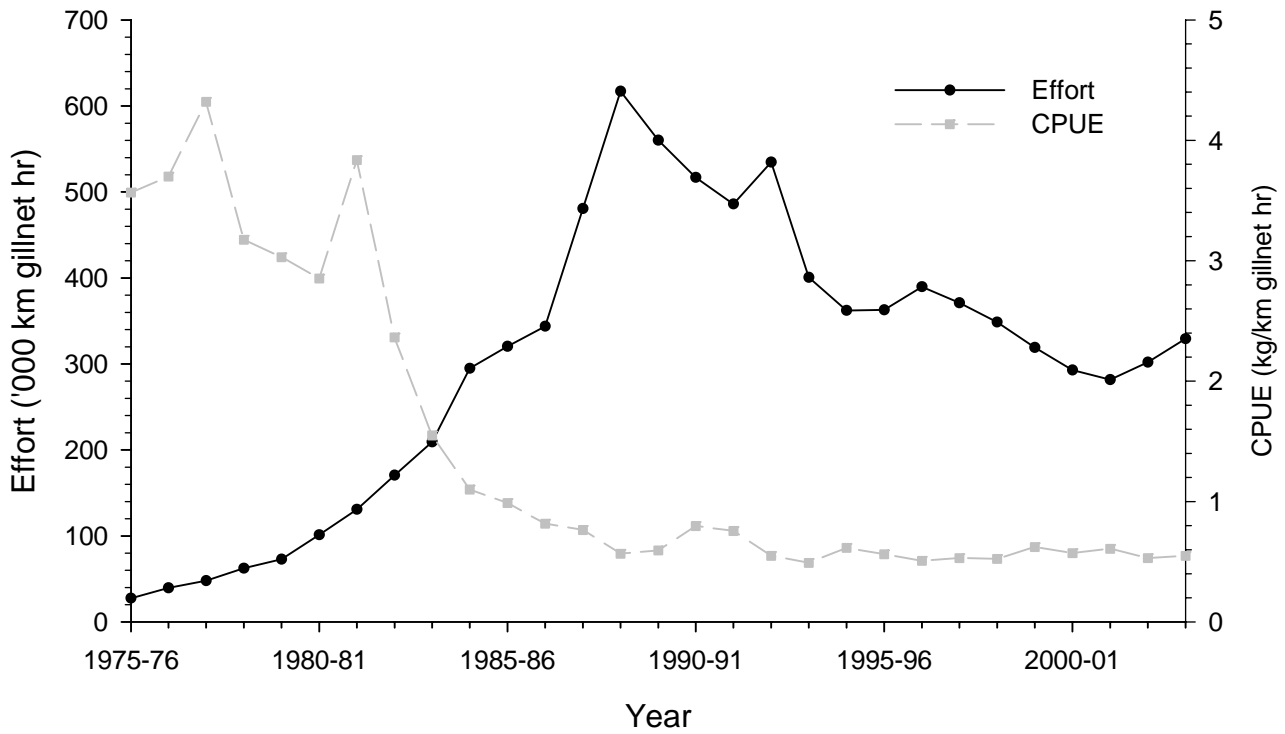


Figure 14. 2002/03 whiskery shark biomass estimates

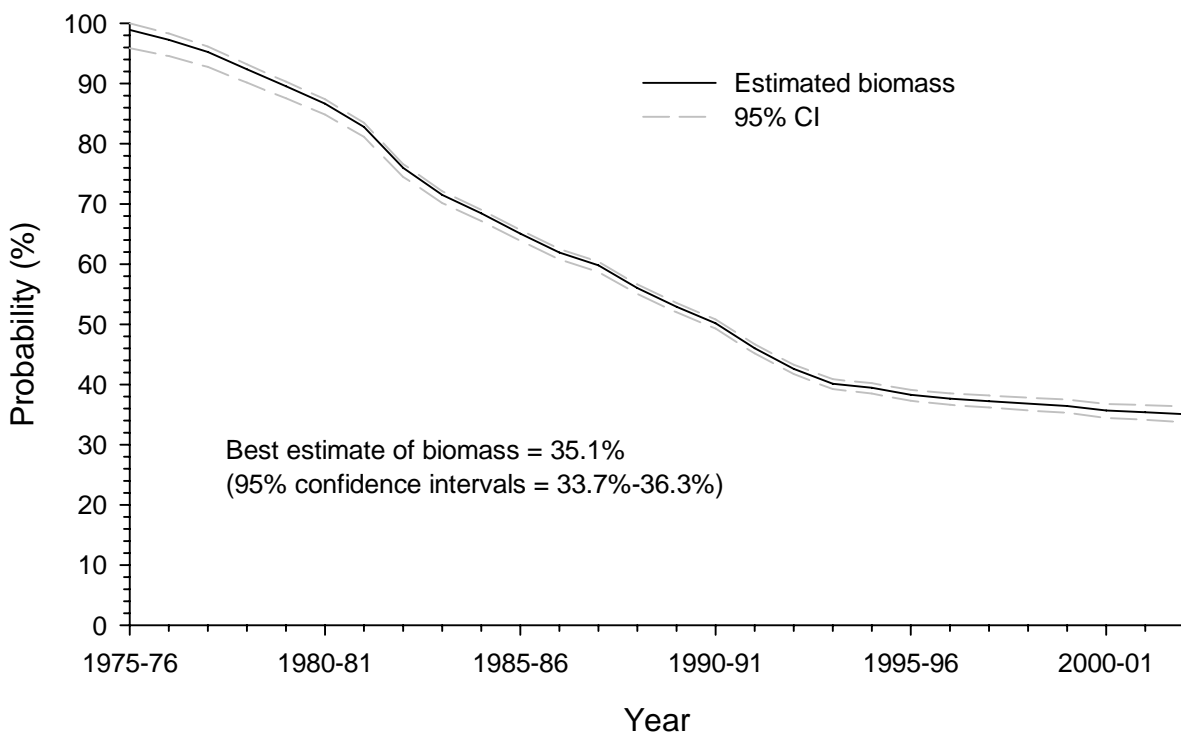


Figure 15. Whiskery shark biomass probabilities based on 2002/03 risk assessment

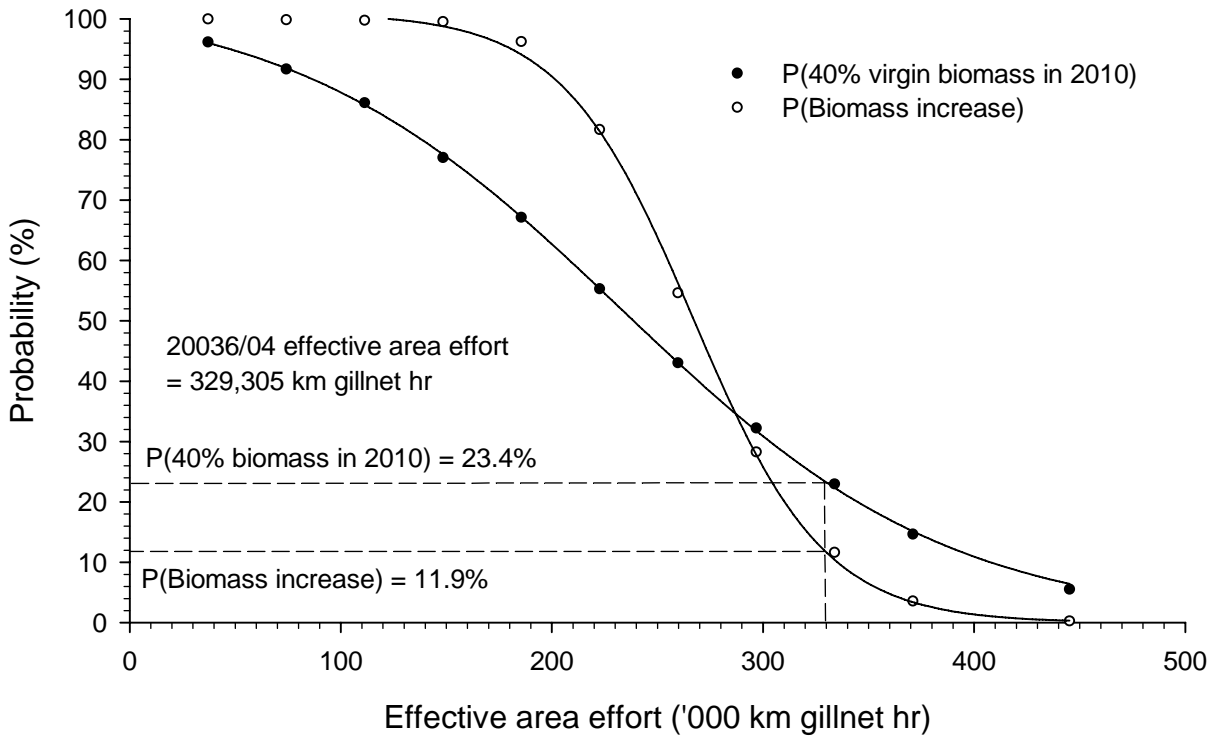


Figure 16. Sandbar shark effective area effort and catch rate

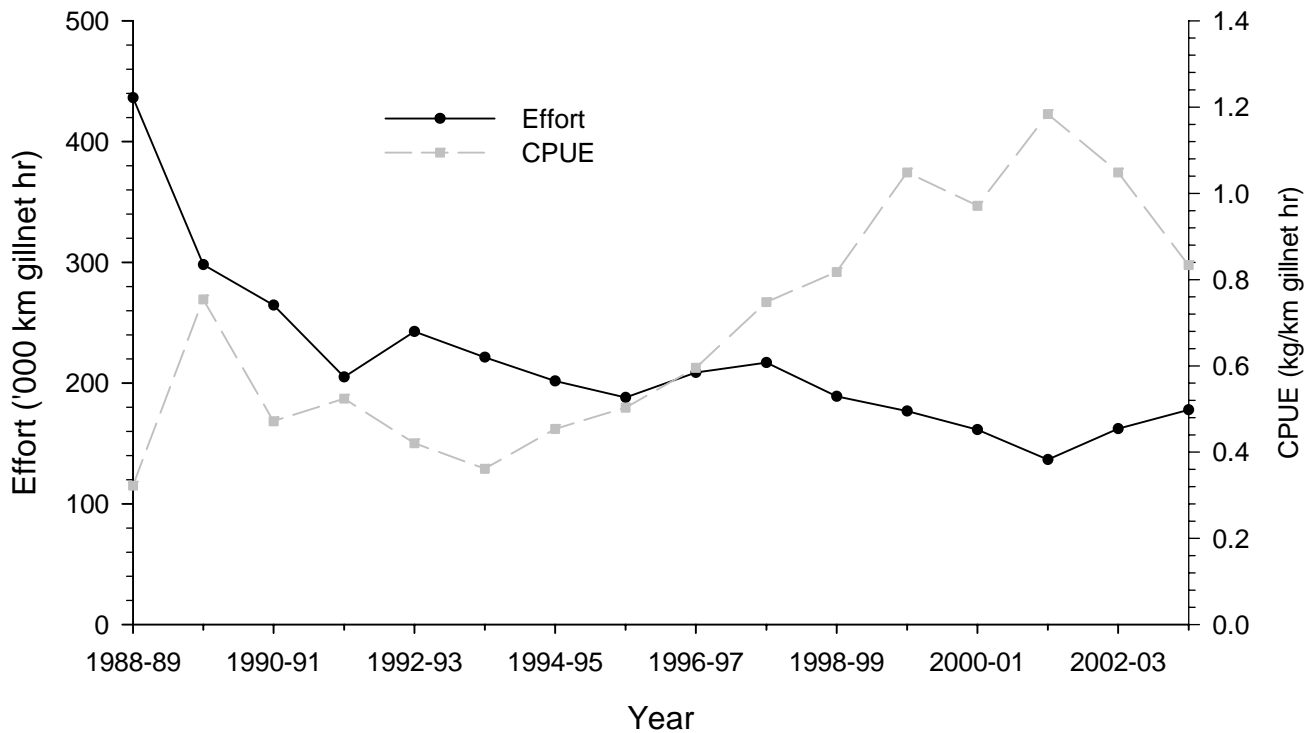


Figure 17. Northern shark fisheries target species catch rates

