FISHERY ASSESSMENT REPORT

TASMANIAN SCALEFISH FISHERY – 2004

J.M. Lyle, M. Haddon, P.E. Ziegler, and S.R. Tracey

June 2005

This assessment of the scalefish fishery is the seventh to be produced by the Tasmanian Aquaculture and Fisheries Institute (TAFI).

TAFI Marine Research Laboratories, Private Bag 49, Hobart, TAS 7001, Australia. E-mail: Jeremy.Lyle@utas.edu.au. Ph. (03) 6227 7277, Fax (03) 6227 8035

Tasmanian Scalefish Fishery – 2004

Executive Summary

The Tasmanian scalefish fishery is a multi-species fishery operating in State Fishing Waters and encompassing a wide variety of capture methods. The Scalefish Management Plan, introduced in 1998. reviewed in 2001 and again in 2004, provides the management framework for the fishery. An important element of the management plan is the explicit identification of performance indicators that have two primary functions:

- to monitor performance of the fishery in relation to catch and effort, and
- to provide reference points against which the status of fish stocks can be assessed.

Fishery Assessment

In this assessment the scalefish fishery is described in terms of species composition, catch and effort. Commercial catch history for the period 1990/91 to 2003/04 is presented, with more detailed analyses of catch and effort by method for the period 1995/96 to 2003/04. In addition to information provided in the General Fishing Returns (Tasmanian commercial catch and effort data), data from Commonwealth logbooks for dual endorsed operators fishing in Tasmanian waters and for species managed under Tasmanian jurisdiction (i.e. striped and bastard trumpeter) have been incorporated in the analyses. Catch estimates for the recreational fishery in 2000/01 are available for a number of key species.

Commercial catch and effort information is available for a nine year period, the first three years of which were used to define reference effort and catch rate levels against which subsequent performance is evaluated. In this regard there are six years of data against which the fishery performance is assessed.

The most important development in the fishery since the introduction of the management plan has been the expansion of dipnet, dropline and squid jig effort to historically high levels. However, apart from squid jigs and days fished with droplines, effort levels for these methods had fallen to within or below reference levels in the 2003/04 period (July 1 to June 30; Table 1). The dramatic increase in squid jig effort has occurred primarily in response to the expansion of fishery for southern calamary.

Notwithstanding the fact that effort performance indicators were not triggered for the other methods, there are continuing concerns regarding the level of latent effort within the fishery from licence-holders who are currently either not active or participating only at low levels.

Table 1. Effort performance indicator assessment by major fishing methods for 2003/04
Y triggered, N not triggered.

	Effort >10% peak 1995-97 levels	
Method	*Gear units*	*Days fished*
Beach seine	N	N
Purse seine	N	N
Graball net	N	N
Small mesh	N	N
Dropline (<200m)	N	Y
Handline	N	N
Troll	N	N
Fish trap	N	N
Spear	N	N
Dip net	N	N
Squid jig	Y	Y

Species assessments

Detailed assessments are provided for several species (banded morwong, southern calamary and striped trumpeter) while other key species (sea garfish, wrasse, blue warehou, bastard trumpeter, Australian salmon and flounder) are considered more briefly. Descriptions of the various fisheries, including fishing methods, seasonality and spatial distribution of catches have been provided in previous assessment reports and are updated here.

Species assessments evaluate fishery-dependent information (catch, effort and catch rate trends) against performance criteria detailed in the Scalefish Management Plan. Specifically, these criteria relate to levels of catch, effort and catch rates. The management plan also provides for biological indicators to be used as reference points against which stock status can be evaluated and where such data are available they have been updated in this assessment.

Banded morwong

Performance indicators

- Banded morwong catch indicators were triggered state-wide as well as in the main fishing regions during 2003/04, with catches remaining below reference levels. Expansion of the fishery into the north east meant that catches in that region were again above reference levels and indicative of spatial extension in the fishery.
- Increased effort in the north east coast exceeded the effort indicator for that region for the second year running.
- The State-wide catch rate indicator was not triggered, however, standardised catch rates for Bicheno and St Helens triggered the indicator, as did the unstandardised catch rate for Bicheno.
- Significant changes in size and age composition, and sex ratios indicate that the fishery has impacted on stock structure.

Resource status

- Evidence suggests that current exploitation rates are high and may not be sustainable.

Management advice

- Management action is required to ensure that fishing mortality in this fishery does not increase. Maintaining *status quo* in the management of this fishery represents a high risk strategy and, given the limited mobility of this species, any management action should explicitly include reference to the spatial distribution of effort.

The fishery for banded morwong expanded in the early 1990s with the development of live fish markets for the species. Between 1994/95 and 1999/00 annual production declined steadily with catches generally tracking changes in effort. The 2003/04 catch of 45 tonnes represented a slight drop compared with 2002/03. Recent increases in catches from the north east coast offset declines in the more traditional east coast fishing areas (apart from the Maria region in which catches also increased).

State-wide effort fell slightly in 2003/04 and remained low compared with the reference period. There has, however, been a sharp increase in effort over the past two years in the north east. Other regions were within or below reference levels. State-wide catch rates were generally higher than 2002/03 and within or slightly above reference levels. Regionally, St Helens and Bicheno catch rates have trended downward since the late 1990s to less than 80% of the lowest reference level. By contrast, catch rates for the Maria, Tasman and north east coast regions have increased recently.

Catch and catch rate indicators suggest that, initially at least, the fishery impacted on banded morwong populations. There has, however, been improvement in both measures over the last few years; observations that are consistent with industry perceptions. However, this improvement does not necessarily indicate the sustainability of current levels of exploitation. There are at least four limitations related to the use of fishery dependent data. These include the masking of localised changes in abundance arising from the expansion of the fishery within and outside of traditional fishing grounds; the limited insights that catch rates provide into stock status for a species such as banded morwong; fleet dynamics with a general move towards a core group of experienced (effective) fishers after a period of considerable turnover; and issues of data quality of commercial catch returns. Seal interactions also continue to represent a significant factor in this fishery, in terms of incidental mortality and impacts on catch rates and fisher activity.

A range of biological measures that relate to fishery performance, including size structure, age structure, and sex ratios of the catch were updated. Each of these measures indicate that the character of the stock has changed, some of these changes being dramatic, for example the decrease of median age for females from around 20 to 7 years and the shift in sex ratio from a strong dominance of females to slight dominance of males. Changes in the character of the stock are to be expected with exploitation, however, at sustainable levels of exploitation it would be expected that the biological indicators would attain some form of dynamic equilibrium and there is little evidence to support this at this stage.

Therefore, despite uncertainty in the significance of the biological changes in relation to stock status, the general downward trend in the biological indicators suggest that current fishing pressure is high and may not be sustainable in the long-term. Management action is required to ensure that fishing mortality in this fishery does not increase, maintaining *status quo* in the management of this fishery represents a high risk strategy. Given the limited mobility of this species, any management action should explicitly include reference to the spatial distribution of effort.

Southern calamary

Performance indicators

- Catch and jig effort performance indicators for southern calamary were triggered for the sixth consecutive year.
- Preliminary modelling suggested that despite a slight fall, current exploitation rates in the main area of the fishery remained high and are unlikely to be sustainable.

Resource status

- There is a high degree of uncertainty with the assessment model but key indicators do suggest the need for management action to reduce exploitation rates in the main region of the fishery.

Management advice

- Maintaining the *status quo* for the Tasmanian southern calamary fishery is a high risk strategy. For the fishery to be sustainable a more precautionary approach is required including consideration of options that will effectively reduce harvest rates in the main area of the fishery.

The fishery for southern calamary expanded markedly in 1998/99 and, reflecting the development of this as a target fishery, subsequent catches have exceeded those for the reference period. The 2003/04 catch of 86 tonnes was 20% lower than in the previous year, being influenced by a three-month closure of the major fishing grounds during the peak

catching period. Despite the closure, jig effort was still very high and, in terms of days fished, was virtually unchanged compared with the peak of 2002/03. State-wide and regional catch rates declined during 2003/04 but remained within reference levels.

Preliminary analysis of catch and effort data for the major fishing areas (Great Oyster Bay and Mercury Passage) was investigated using non-equilibrium surplus production modelling. The analysis suggested that the unfished, mid-season exploitable biomass was in the order of 200-245 tonnes but had been reduced to below 40% of this level, implying that the current harvest rate was very high despite a relatively large reduction in catch (a consequence of the seasonal closure). Although considerable uncertainty is associated with this analysis, the trend in the implied harvest rate was consistent with declining observed catch rates and declining levels of estimated egg-production.

Since the calamary fishery effectively developed after the management plan was introduced the application of the generic catch and effort performance indicators have little relevance. In fact, it would be of greater concern if catches fell to within historic levels (suggesting the collapse of the fishery) than remain above reference levels.

Although there is a high degree of uncertainty with the present assessment, key indicators do suggest that maintaining the *status quo* for the Tasmanian southern calamary fishery is a high risk strategy. For the fishery to remain sustainable a more precautionary approach is required including consideration of options that will effectively reduce harvest rates in the main area of the fishery.

Striped trumpeter

Performance indicators

- Striped trumpeter catches remained low and were virtually unchanged compared with 2002/03, resulting in the catch performance indicator again being triggered.
- Handline and graball effort was below reference levels and catch rates within or above reference levels. By contrast, dropline effort (days fished) remained high and the daily catch rate was low such that both effort and catch rate performance indicators were triggered.

Resource status

- Resource status is uncertain though potentially depleted due the effects of fishing coupled with apparent poor recruitment in recent years.

Management Advice

- Although a more rigorous assessment is required to assess the sustainability of the fishery, the expectation is that the stocks are declining and will continue to do so without management action or a period of sustained good recruitment. It would be prudent to act to reduce fishing mortality, both commercial and recreational, and to review the minimum size limit.

During 2003/04 only 36 tonnes of striped trumpeter was taken commercially, virtually unchanged from 2002/03 and effectively the second lowest catch recorded since the late 1980s. Handline and graball effort was well below levels experienced during the latter half of the 1990s, dropline effort (days fished), however, remained high and above the peak reference value. Graball and handline catch rates increased steadily over time whereas daily dropline catches declined and have remained well below levels experienced during the mid-1990s. It is unclear why the two hook methods exhibit such different trends in catch rates.

Resource status is uncertain. Falling graball net catches (primarily juvenile fish) over the past four years and reductions in offshore hook catches (mainly adult fish) over the past three years suggest that the biomass of new recruits and adults may have declined significantly. While fishing will have acted to reduce biomass, noting that commercial catches in 1998/99 and 1999/00 were historically very high, striped trumpeter do exhibit strong recruitment variability that will produce inter-annual variability in fishable biomass.

Recent size composition data imply that there has been no substantial recent recruitment and, if this is the case, the average size of hook-caught fish is likely to continue to increase and the spawner biomass to decline.

The introduction of a 250 kg trip limit may have contributed to the downturn in catches. There was evidence that the quantities of gear fished each day had declined (presumably to limit catches) and there are reports that some operators have simply decided not to bother targeting the species because of the low catch limit.

Based on per-recruit analysis and new information about size at maturity it would appear that the recently introduced minimum size limit, while a positive step, was sub-optimal and still presents a risk of recruit overfishing.

Although a more rigorous assessment is required to assess the sustainability of the fishery, the expectation is that the stocks are declining and will continue to do so without management action or a period of sustained good recruitment. It would be prudent to act to reduce fishing mortality, both commercial and recreational, and to review the minimum size limit.

Sea garfish

Performance indicators

- No performance indicators were triggered for sea garfish in 2002/03.

Resource status

- Fishery dependent indicators provide no basis for concern over resource status.

Management advice

- While it is not known whether present catch levels are sustainable the potential for increased catches is great so it would be prudent to consider management options that limit further expansion in this fishery.

The 2003/04 garfish catch of 66 tonnes was about 28% lower than in 2002/03 but within the reference range for the species. Beach seine and dipnet effort fell slightly as did beach seine catch rates. Dipnet catch rates have remained stable since the late 1990s. Sea garfish are a schooling species and thus catch rate trends may not be reliable nor sensitive indicators of abundance.

There is little evidence for concern over the status of the garfish stocks based on the fishery dependent indicators but there is potential for targeted effort to expand, especially in the dipnet sector. While it is not known whether present catch levels are sustainable it would be prudent to consider management options that limit further expansion in this fishery.

Wrasse

Performance indicators

- Wrasse catches remained below reference levels for the second consecutive year.
- Effort and catch rate indicators were not triggered.

Resource status

- Resource status is unknown though the species are vulnerable to localised depletion of legal-size biomass. However, minimum size limits provide considerable protection to female spawner biomass of both of the key wrasse species.

Management advice

- The *status quo* would appear to be acceptable in terms of sustainability. If improvements in the collection of spatial information and species based reporting can be developed this would reduce the risk of serial depletion failing to be detected.

The development of live fish markets for wrasse the early 1990s resulted in increased catches. Two species are involved, purple wrasse and blue-throat wrasse, though catches of these species are not generally distinguished in catch returns. The 2003/04 catch of 73 tonnes was slightly higher 2002/03 but remained below the reference catch level.

General stability in catch rates for both of the major fishing methods imply that stocks have not been impacted significantly by the fishery. However, broad-scale analyses may be relatively insensitive to changes in abundance at the level of individual reefs at which the fishery impacts on the fish populations. Marked regional shifts that have occurred in the fishery may also mask localised depletions, with fishers moving to new or lightly fished areas to maintain catches. As a consequence, caution needs to be exercised when making inferences about the status of the wrasse stocks even though key fishery indicators do not indicate significant fishery impacts.

There are concerns that blue-throat males may not be adequately protected by the current minimum size limit. This is because blue-throat wrasse change sex, with males derived from mature females generally after they have entered the fishery. This coupled with the fact that they are strongly site attached and have higher catchability (being more aggressive than females) suggests that they are vulnerable to over-fishing. In extreme situations localised heavy fishing pressure could result in 'sperm shortage' that would affect spawning success even though there may be a robust population of mature (sub-legal size) females present. The removal of the maximum size limit has exacerbated this situation.

Blue warehou

Performance indicators

- Blue warehou catches fell sharply in 2003/04 to a historically low level, triggering both catch performance indicators.
- Effort and catch rate indicators were not triggered.

Resource status

- Stocks are over-fished and availability of warehou in Tasmanian waters continues to be low.

Management advice

- Management action to reduce catches has been implemented in the Commonwealth fishery.

Recent studies have indicated that there are two stocks of blue warehou in Australian waters, one to the west and one to the east of Bass Strait. The fishery for blue warehou in Tasmanian inshore waters is centred off the southeast coast and thus probably targets the eastern stock. Catches are also taken off the northeast and northwest coasts, the latter potentially involving the western stock.

The blue warehou catch of 27 tonnes in 2003/04 represented a drop of 55% compared with 2002/03 to be the lowest reported since the mid-1980s. Graball effort remained low and catch rates were either within or above reference values.

A range of environmental factors, as well as stock size, influences the availability of blue warehou in Tasmanian waters. Recent depressed catches are almost certainly linked to reduced biomass, the result of overfishing by Commonwealth and State fisheries during the 1990s and in the absence of significant rebuilding, catches are likely to remain low.

Bastard trumpeter

Performance indicators

- Current catches of bastard trumpeter were below reference levels, triggering the catch performance indicator for the third year.
- Effort and catch rate indicators were not triggered.

Resource status

- Resource status is uncertain though potentially depleted, due to the effects of fishing coupled with poor recruitment.

Management advice

- Management options that reduce the total fishing mortality on this species should be explored.

Bastard trumpeter catches have declined steadily since the mid 1990s and the current catch of 22 tonnes was the second lowest reported since the late 1980s, and only a slight improvement over 2002/03.

Catch rates are probably a poor indicator of stock status for bastard trumpeter since the species is largely taken as by-product and total catch may be a better indicator of abundance and/or availability. As such, trends in commercial production suggest that current inshore populations are at low levels. Strong recruitment variability is a feature of this species, with limited evidence of good recruitment in recent years.

The commercial and recreational fishery is almost entirely based on juveniles, giving rise to the possibility of growth overfishing. Consideration of increasing the minimum size limit to above the size at maturity would be beneficial to the stock, but would effectively close down inshore fisheries for the species.

Australian salmon

Performance indicators

- Australian salmon catches fell sharply in 2003/04, triggering catch performance indicators for the first time.
- Effort was at the lowest level since the mid-1990s and the beach seine catch rates had fallen to below reference levels, triggering the catch rate indicator.

Resource status

- Resource status is unknown but fishers do not report an inability to catch the species.

Management advice

- The *status quo* would appear to be acceptable but the possibility of significant expansion in this fishery if a suitable market occurs means it should be watched.

The total catch of Australian salmon in 2003/04 of 167 tonnes was less than half that in 2002/03, reflecting a marked fall in the beach seine catch. Beach seine catch rates were also low, at just over half the minimum for the reference period. It is, however, recognised that catch rate estimation is influenced by the extremely skewed nature of the data, i.e. the majority of catches are small but the total catch is influenced by a very small number of extremely large catches. In this respect catch rates are not a sensitive indicator for a schooling species such as Australian salmon.

Commercial catches of Australian salmon are to a large extent linked to market demand (specifically the bait market) and are thus probably not a good indicator of stock status. There is capacity within industry to significantly expand production should new markets be found and under such circumstances management may need to be proactive moderating such expansion.

Flounder

Performance indicators

- Flounder catches in 2003/04 were almost 50% higher than in 2002/03 but remained below reference levels and thus triggered both catch performance indicators.
- Spear and graball effort for flounder has remained low and did not exceed indicators.
- The catch rate measure influenced trends with daily graball catches and catch per hour for spears being below reference levels and triggering the performance indicators. By contrast, graball catches based on kg per 100-m net hour and daily catches for spears were either within or higher than reference levels.

Resource status

- Resource status is unknown.

Management advice

- *Status quo* appears to be acceptable until more evidence, industry reports, or recreational reports are forthcoming.

Flounder catches increased to 15 tonnes in 2003/04 but still remained well below the minimum reference level. Fishing effort for the major methods, spear and graball, has also remained low and stable over the past 4-5 years. Catch rate trends were variable between methods and depending on the rate measure considered (daily or gear units of effort). Catch per hour for spears declined slowly over time whereas catch per day fished remained relatively stable. By

contrast, graball catch rates (kg per 100-m net hour) increased while daily graball catches have declined since the mid-1990s. These apparently contradictory trends imply some changes in fishery dynamics, with more time fished per day on average with spears and less graball net effort expended on each day fished for flounder.

The degree of interest by the commercial sector in flounder appears to quite low at present. It is unclear whether this is market or resource driven. The current status of flounder stocks is therefore unknown.

2003/04 performance indicator summary

Performance indicator analysis for key species is summarised in Table 2.

Table 2 Summary performance indicator assessment for key species with assessment of risk if no management action (i.e. *status quo*) is taken.

Y triggered; N not triggered; arrows indicate direction of change; na not assessed; # applies only to particular methods or regions; Catch history period is *1994/95 to 1997/98 & ** 1995/96 to 1997/98; H high risk, M medium risk; ˣ management action being taken in Commonwealth fishery.

	Catch		*Effort*	*Catch rate*	*Biological*	
Species	*Outside 90-97 range*	*Decline/ increase by >30%*	*Increase by >10% from highest 95-97 level*	*< 80% min. 95-97 range*	*Indicators of stock stress*	*Risk of no management action*
Banded morwong*	Y ↓	Y↑↓ #	Y #	Y #	Y	H
Southern calamary	Y ↑	N	Y	N	Y	H
Striped trumpeter	Y ↓	N	Y #	Y #	na	M
Garfish	N	N	N	N	na	
Wrasse**	Y ↓	N	N	N	na	
Blue warehou	Y ↓	Y ↓	N	Y	na	Hˣ
Bastard trumpeter	Y ↓	N	N	N	na	
Australian salmon	Y ↓	Y ↓	N	Y	na	
Flounder	Y ↓	Y ↑	N	Y #	na	

Table of Contents

1 Management Objectives and Strategies

The Scalefish Management Plan was first introduced in 1998 (DPIF 1998) and was reviewed in 2001 and again in 2004. The primary issues tackled in the latest review related to latent effort in the fishery (addressed by introducing non-transferability for class-C and inactive licences), wastage in gillnets (addressed by a prohibition on night netting for recreational fishers and the requirement for commercial operators to be in attendance whilst night netting[1]), a review of recreational possession and size limits and the closing of further selected waters to gillnetting.

The management plan provides the regulatory framework for the fishery, which covers commercial and recreational components. The plan contains the following objectives, strategies and performance indicators.

1.1 Major objectives

- To maintain fish stocks at sustainable levels by restricting the level of fishing effort directed at scalefish, including the amount and types of gear that can be used;
- To optimise yield and/or value per recruit;
- To mitigate any adverse interactions that result from competition between different fishing methods or sectors for access to shared fish stocks and/or fishing grounds;
- To maintain or provide reasonable access to fish stocks for recreational fishers;
- To minimise the environmental impact of scalefish fishing methods generally, and particularly in areas of special ecological significance;
- To reduce by-catch of juveniles and non-target species; and
- To implement effective and efficient management.

1.2 Primary Strategies

- Limit total fishing capacity by restricting the number of licences available to operate in the fishery;
- Define allowable fishing methods and amounts of gear that can be used in the scalefish fishery;
- Monitor the performance of the fishery over time, including identification and use of biological reference points (or limits) for key scalefish species;
- Protect fish nursery areas in recognised inshore and estuarine habitats by prohibiting or restricting fishing in these areas;
- Employ measures to reduce the catch and mortality of non-target or undersized fish; and
- Manage developing fisheries under permit conditions.

1.3 Performance Indicators

In the absence of more quantitatively rigorous stock assessments, the Scalefish Fishery Management Plan includes a number of performance indicators that are applied

[1] Note: some exclusions exist iPn relation to the gillnet usage changes.

generically to the fishery and specifically at the species level. Analysis of fishery performance under this (initial) strategy is measured by reference to:

- variations in the total catch from year to year, or between seasons, regions and sectors;
- trends in effort;
- trends in catch rates;
- changes in biological characteristics, such as a changes in size or age structure; and
- other indicators of fish stock stress, for example disease outbreaks.

As part of this strategy, trigger points have been defined as levels of, or rates of change, that are considered to be outside the normal variation of the stock(s) and the fishery. The trigger points provide a framework against which the performance of the fishery can be assessed and (if necessary) flag the need for management action. Trigger points are reached when one or more of the following criteria are met:

- total catch of a key target species is outside of the 1990 to 1997 range; or when total catch of a key target species declines or increases in one year more than 30% from the previous year;
- fishing effort for any gear type, or effort targeted towards a species or species group, increases by 10% from the highest of the 1995 to 1997 levels;
- catch rates for a key target species is less than 80% of the lowest annual value for the period 1995 to 1997;
- a significant change in the size composition of commercial catches for key target species; or when monitoring of the size/age structure of a species indicates a significant change in the abundance of a year class (or year classes), with particular importance on pre-recruit year classes;
- a change in the catch of non-commercial fish relative to 1990 to 1997 records; or when incidental mortality of non-commercial species or undersized commercial fish is unacceptably high;
- significant numbers of fish are landed in a diseased or clearly unhealthy condition; or when a pollution event occurs that may produce risks to fish stocks, the health of fish habitats or to human health; or when,
- any other indication of fish stock stress is observed.

2 Fishery Assessment

2.1 The Fishery

The scalefish fishery is a multi-gear and multi-species fishery. Jurisdictional issues complicate its management, with several key species harvested across a number of jurisdictions (Lyle and Jordan 1999).

A wide range of fishing gears, the most important being gillnet, hooks and seine nets, are used to harvest a diverse range of scalefish, shark and cephalopod species. Other fishing gears in use include traps, Danish seine, dip nets and spears. A listing of common and scientific names of species reported in catches is presented in Appendix 1.

In many respects the fishery is dynamic, with fishers readily adapting and changing their operations in response to changes in fish availability and in response to market requirements. As a consequence, only a small proportion of the fleet has specialised in a single activity or on targeting a primary species. For many operators, scalefish represent an adjunct to other activities, for instance rock lobster fishing.

This report represents the seventh in a series of annual assessments of the scalefish fishery and incorporates catch and effort information available up to and including June 2004. Copies of previous assessment reports (Lyle and Jordan 1999, Jordan and Lyle 2000, Lyle and Hodgson 2001, 2002, Lyle 2003, Lyle et al. 2004) are available on the TAFI web page - http://www.utas.edu.au/docs/tafi/TAFI_Download.htm.

2.2 Data sources

Commercial catch and effort data are based on Tasmanian General Fishing Returns and Commonwealth non-trawl (GN01 and GN01A) and Southern Squid Jig Fishery (SSFJ) logbook returns. Unless noted otherwise, catch and effort data reported in this assessment relate to the commercial sector.

2.2.1 General Fishing Returns

General Fishing Returns prior to 1995 only provided monthly summaries of catches (landings) but were often incomplete or very limited in terms of providing effort information. Lennon (1998) discussed in some detail the limitations of these catch returns and, in summary, noted that they provided only basic information about production levels and were of little value for effort and catch rate analyses.

During 1995, a revised General Fishing Return was introduced, replacing the monthly return with catch and effort information reported on a daily basis for each fishing method used. The revised returns provided greater detail about fishing operations, including more explicit specification of fishing method, greater spatial resolution (½ degree rather than 1 degree blocks), plus details about effort and depths fished. Recent amendments (1999) to the catch return have included provision to nominate target species and indicate interference to fishing operations from marine mammals (e.g. seals or killer whales).

In the analysis of General Fishing Returns some data manipulation has been undertaken, details of which are provided in Appendix 2.

2.2.2 Commonwealth catch returns

Following the introduction of the Commonwealth non-trawl logbook (GN01 and subsequent versions) in late 1997, dual endorsed Tasmanian and Commonwealth (South East Non-Trawl and Southern Shark) operators generally commenced recording all of their catch and effort data, including fishing in State waters, in the Commonwealth logbooks. In addition, several dual endorsed squid operators reported some or all of their state waters fishing activity in the Southern Squid Jig Fishery (SSJF) logbook. As most of these operators did not explicitly indicate whether fishing occurred in State or Commonwealth waters, it has been necessary to incorporate all activity reported from coastal fishing blocks in the analyses. For details of data restrictions and manipulations involving Commonwealth logbook data refer to Appendix 2.

During 2001, dual endorsed fishers were instructed to report all fishing activities under State jurisdiction in the Tasmanian General Fishing Returns. This has to some extent removed the necessity to include subsequent Commonwealth catch and effort data into analyses. However, it has become apparent that there may be some confusion amongst fishers about reporting requirements and there are concerns that catches of species, such as striped trumpeter taken by Commonwealth operators, have not been routinely reported in the Tasmania catch returns as instructed.

2.2.3 Data analysis

For the purposes of this assessment, effort and catch rate analyses are restricted to commercial data provided for the period July 1995 to June 2004. All catch returns from within this period and available as at February 2005 have been incorporated in the analyses.

A fishing year from 1st July to 30th June in the following year has been adopted for annual reporting. The primary justification being that this period better reflects the seasonality of the fisheries for most species, with catches (and effort) generally concentrated between late spring and early autumn. In addition, it better encompasses the biological processes of recruitment and growth for most species.

Two measures of effort have been examined: (i) days fished (i.e. number of days on which a method/gear type was reported); and (ii) quantities of gear/time fished using the method. Since a diverse range of gear types are utilised in the fishery, appropriate measures of effort differ with gear type. For instance, gillnet effort has been calculated as a function of the quantity of net set and fishing duration, for dropline and longline, effort is expressed as number of hooks set, while handline fishing as the product of the number of lines fished and fishing time. A table of effort measures is provided in Table 2.3.

Catch returns for which effort information was incomplete or unrealistically high or low (either due to data entry error or misinterpretation of information requirements by fishers) were flagged and excluded when calculating effort levels based on gear units or catch rates based on catch per unit of gear. Less than 2% of all fishing records during

2003/04 were excluded in this manner. All records were, however, included when reporting catches, days fished and catch per day.

In generating catch rate statistics, the arithmetic mean of catch rates does not accurately describe the data. Instead, the geometric mean of all valid individual daily catch records has been calculated, since catch rate data are typically log-normally distributed. The geometric mean is calculated as the *n*th root of the product of the individual rates (y_i)

$$GM_{\bar{y}} = \sqrt[n]{\prod y_i}$$

This is equivalent to computing the arithmetic mean of the logarithm of each number, and then taking the exponent:

$$GM_{\bar{y}} = \exp\left[\frac{1}{n}\left(\sum \ln\left(y_n\right)\right)\right]$$

It should be noted that catch rates calculated in this manner may differ slightly from the more simplistic approach of dividing total catch by total effort or using an arithmetic average of all catch records. The advantage is that they are less affected by the few observations that are skewed very high, as often happens with log-normally distributed data.

2.2.4 Recreational fishery

A detailed analysis of the Tasmanian recreational fishery, based on the 2000/01 National Survey dataset, has been recently completed (Lyle 2005). Apart from recreational net licence numbers, there is no additional data relevant to the recreational finfish fishery in Tasmania.

2.3 Commercial catch trends

2.3.1 Overview

Annual commercial catches since 1990/91 are presented in Table 2.1 and catch trends for the major species are summarised in Fig. 2.1. Overall, scalefish catches declined from over 2000 tonnes in the early 1990s to between 1000-1500 tonnes in recent years. The 2003/04 catch of 760 tonnes represented a fall of 255 tonnes compared to the previous year, largely due to a sharp fall (almost 240 tonnes) in Australian salmon landings. Catches of most other scalefish species were within ± 10 tonnes of 2002/03 levels. Exceptions included jack mackerel and whiting, which increased by around 20 tonnes, and were offset by decreases of similar magnitude for garfish and blue warehou.

In assessing trends within the scalefish fishery it is important to recognise that some species, such as blue warehou, barracouta and arrow squid, occur seasonally within Tasmanian waters and that availability can vary markedly between years. It is generally recognised that such variability does not necessarily reflect changes in stock condition and as such these species represent ‘bonus’ or opportunistic fisheries when

available. By contrast, species such as banded morwong, garfish, wrasse, the trumpeters and calamary are resident coastal species and variability in catches may reflect a combination of factors including market forces, management intervention, stock status, and intrinsic variability in life history.

2.3.2 Key species

Australian salmon have consistently dominated the scalefish catch, with catches in excess of 650 tonnes p.a. prior to 1995/96 (Fig. 2.1). More recent landings of this species have remained lower, fluctuating between about 300-480 tonnes. The 2003/04 catch of 167 tonnes represented a decline of over 50% compared with 2002/03 and was outside the catch range for the reference period (1990/91 to 1997/98). Industry reports suggest that the generally lower landings since the mid 1990s have been largely in response to reduced bait-market demand rather than reduced stock abundance.

In the early 1990s, barracouta catches declined sharply from around 350 tonnes to around 60 tonnes by 1993/94. Up until 2001/02, landings remained at low levels reflecting, in part at least, low market demand coupled with reduced availability. The most recent catch of 80 tonnes was slightly higher than in the preceding year and was within reference catch levels (Fig. 2.1).

Flathead catches declined from over 150 tonnes p.a. in the early 1990s to around 50 tonnes by the mid-1990s (Fig. 2.1), largely due to reductions in inshore trawl (demersal trawl and Danish seine) activity (Lyle and Jordan 1999). Flathead catches have generally declined since 2000/01 and in the current year landings were below the reference range at just 30 tonnes. Demersal trawling was banned in State Fishing Waters in 2001 and there are currently very few active Danish seine operators, factors that have contributed to the fall in catches.

Catches of flounder typically ranged between 30-40 tonnes, but over the past five years have fallen to below 20 tonnes, with 15 tonnes reported in 2003/04 (Fig. 2.1). It is unclear whether this is a reflection of reduced abundance or changed market demand, but recent catches remain well below reference catch levels.

Apart from the mid 1990s, sea garfish production has remained relatively stable at between 80-100 tonnes p.a (Fig. 2.1). Current landings of 66 tonnes represented a 27% decrease compared with 2002/03 but remained within reference levels.

The development of live fish markets for banded morwong during the early 1990s resulted in a marked increase in reported landings to 145 tonnes (1993/94), though it is generally accepted that this figure is unreliable and represents a significant overstatement of the real catch. Catches after 1995/96 declined from almost 90 tonnes to less than 35 tonnes by 1999/00 (Fig. 2.1). Over the past four years catches have averaged about 50 tonnes, the current catch of 45 tonnes representing a slight decline compared with 2002/03.

Corresponding to the reduction in inshore trawl activity in the early 1990s, jackass morwong landings declined from over 100 tonnes p.a. to between 15-30 tonnes in more recent years (Fig. 2.1). The current catch was slightly higher than in 2002/03 but still below the reference level.

Landings of mullet were around 30 tonnes in the early 1990s but have generally declined to below 10 tonnes (Fig. 2.1). The catch in the most recent year was virtually unchanged from 2002/03 and remained below the lower reference catch level for the second year running.

Prior to the mid 1990s, bastard trumpeter catches fluctuated between 35-65 tonnes p.a. but have since declined to the lowest levels reported since the late 1980s, around 20 tonnes p.a. (Fig. 2.1). By contrast, striped trumpeter production expanded to over 100 tonnes by 1999/00 and fell sharply afterwards and has remained stable at between 36 – 40 tonnes over the past three years, showing no signs of recovery (Fig. 2.1). The reasons for recent declines in trumpeter catches may lie to some extent in reduced availability due to a period of apparently poor recruitment rather than changes in market demand (which remains high).

Blue warehou production has fluctuated widely, between around 100-300 tonnes p.a. since the early 1990s (Fig. 2.1). The most recent catch of 27 tonnes represented a 45% decline compared with the previous year and was, for the fourth year running, well below the minimum reference catch level.

Whiting catches experienced a marked decline during the early 1990s, largely in response to reduced inshore trawl activity (Lyle and Jordan 1999), but have stabilised since 1996/97 with annual landings of between 30-55 tonnes (Fig. 2.1). Landings increased in 2003/04 but remained within reference levels.

The marked increase in wrasse landings that occurred in the early 1990s was due to the expansion of live fish markets. Subsequent to 1995/96, however, wrasse production generally stabilised at around 85-100 tonnes p.a. (Fig. 2.1). In the past two years there has been a slight decline in production to just over 70 tonnes, which is just outside the lower reference catch level.

Cephalopod production, at 159 tonnes, was slightly down on 2002/03, due mainly to a fall in the quantities of calamary caught. During the latter half of the 1990s there was a marked expansion in the fishery for calamary in Tasmania, with catches rising from less than about 20 tonnes p.a. prior to 1995/96 to about 90 tonnes in 1998/99 (Fig. 2.1). Subsequent catches have remained high and peaked in 2002/03 at 108 tonnes, before falling to 86 tonnes in 2003/04 (Fig. 2.1). Octopus production increased gradually from around 30 to 75 tonnes p.a. by the mid 1990s and despite some variability since, appears to have stabilised at between 60-70 tonnes p.a. (Fig. 2.1). After increasing sharply in 1999/00 to 480 tonnes, arrow squid catches fell to 40 tonnes in 2000/01. Subsequent catches have remained in the order of 2 tonnes p.a., reflecting a series of poor seasons in terms of arrow squid abundances in inshore waters (Fig. 2.1).

Table 2.1. Annual 'Tasmanian' scalefish and cephalopod production (whole weight) between 1990/91 to 2003/04 by species

Based on General Fishing Returns and Commonwealth (GN01, GN01A and SSJF) logbook returns.

	Catch (tonnes)													
Species	**90/91**	**91/92**	**92/93**	**93/94**	**94/95**	**95/96**	**96/97**	**97/98**	**98/99**	**99/00**	**00/01**	**01/02**	**02/03**	**03/04**
Scalefish														
Australian salmon	815.9	651.9	867.0	878.8	682.1	412.7	287.3	476.0	384.7	363.7	485.0	462.1	406.8	167.1
Barracouta	351.5	268.3	205.4	59.6	25.2	19.9	53.8	65.2	27.6	25.0	15.1	132.1	65.4	79.9
Boarfish	7.2	9.4	7.6	10.1	9.1	7.3	10.4	9.4	7.0	7.3	8.0	5.5	3.3	4.0
Bream	5.7	3.5	1.4	7.4	7.2	2.5	9.9	1.0	0	0.1	0	0.1	0.4	0
Cod	10.0	11.3	11.6	14.5	12.7	22.4	15.3	10.2	9.8	9.0	4.0	3.0	2.2	2.1
Dory	2.8	1.3	6.0	1.1	1.0	0.4	1.0	1.3	0.2	0.2	0.2	0.1	0.1	0.2
Eel	0.2	0.5	0.9	2.2	3.1	2.1	1.4	1.7	2	1.2	0.8	0.4	0.4	0.2
Flathead	165.3	118.1	98.8	121.4	91.1	57.8	51.8	62.9	50.6	60.3	63.4	52.1	40.5	30.6
Flounder	44.0	36.8	31.8	27.3	27.1	33.3	29.3	26.7	22.8	15.4	10.5	11.6	10.1	14.7
Garfish	80.9	80.1	82.3	82.9	69.3	56.0	91.6	83	101.7	91.2	81.4	87.8	91.8	66.5
Gurnard	20.5	19	19.3	19.3	14.0	14.2	12.4	9.9	7.1	9.9	7.8	5.4	9.7	6.6
Latchet	13.9	10.0	6.5	12.4	11.9	6.1	3.3	1.9	1.1	2.3	1.5	0.8	0.8	0.6
Leatherjacket	12.2	14.0	13.1	23.3	27.7	14.5	12.6	13.3	12.9	16.5	16.7	16.6	13.7	14.8
Ling	5.1	13.6	30.0	41.6	33.2	21.7	23.8	11.8	5.0	2.2	5.2	1.1	0.4	0.8
Mackerel, blue	3.0	2.1	0.3	8.5	5.7	2.0	1.3	1.0	0.5	2.1	0.1	0	0.1	0
Mackerel, jack	6.1	11.1	32.8	48.4	39.7	26.2	19.3	19.7	59.8	13.7	8.6	19.4	19.4	41.1
Marblefish	0.2	0.9	0.3	1.0	1.8	3.5	5.6	3.0	2.6	4.2	4.0	4.4	3.1	0.6
Morwong, banded	7.0	6.9	39.2	145.5	105.8	86.7	79.0	72.6	42.4	33.8	39.2	53.7	54.1	45.4
Morwong, jackass	136.9	111.9	83.2	117.6	63.1	27.2	19.2	34.1	18.2	16.7	13.7	14.8	14.4	16.3
Morwong, other	3.8	5.6	5.2	13.9	8.1	5.4	7.5	7.5	6.3	1.5	0.6	1.4	1.8	1.1
Mullet	31.2	22.2	26.2	19.5	23.8	10.4	11.2	16.0	14.5	21.0	13.7	12.1	7.3	7.5
Other	106.8	92.1	77.6	60.0	25.2	21.1	23.8	21.2	19.4	10.6	9.7	10.9	33.3	23.3
Pike, long-finned	0.1	0	0.1	0.3	0.2	0.3	3.1	3.9	9.5	10.0	6.6	12.2	10.7	14.2
Pike, short-finned	10.4	9.5	11.0	12.4	18.6	13.7	15.2	17.7	3.2	4.1	5.9	6.6	6.6	3.7
Pilchard/anchovy	0.1	0	3.8	14.6	12.1	6.2	4.3	15.4	2.8	1.7	3.2	0.7	0	0.6
Stargazer	10.7	3.0	1.2	4.3	1.5	0.2	0	0.3	0.1	0.2	0.1	0.1	0.1	0.1
Trevally, silver	15.0	12.2	2.5	5.9	15.5	5.9	4.5	7.8	8.0	3.2	1.6	4.6	5.4	3.4
Trevally, unspec.	5.6	1.4	9.5	2.4	6.1	0	0	0	0	0	0	0	0	0
Trumpeter, bastard	63.3	37.2	34	54.8	50.8	60.1	51.8	40.7	47.7	36.4	26.2	23.9	20.4	22.2
Trumpeter, striped	74.5	58.2	52.7	56.5	72.4	60.3	80.4	81.1	107.4	100.9	49.6	40.0	35.9	36.0
Trumpeter, unspec.	0.7	0	0	0.4	0.1	0.2	0.1	0.6	3.5	0	0	0	0	0
Warehou, blue	257.6	317.6	187.7	250.1	205.4	82.2	128.9	189.5	274.3	187.6	36.3	66.4	48.9	27.0
Warehou, spotted	0.7	0.4	4.2	8.8	3.4	14.6	15.6	4.8	0	0	0	0	0.2	0.1
Whiting	124.2	152.3	84.3	97.9	81.4	25.3	39.3	48.1	30.4	31.4	42.5	39.9	35.9	55.5
Wrasse	57.2	71.7	97.3	142.4	178.0	83.4	110.1	100.0	90.7	85.4	88.4	92.0	71.6	73.1
Total scalefish	**2450**	**2154**	**2135**	**2367**	**1933**	**1206**	**1224**	**1459**	**1374**	**1169**	**1050**	**1182**	**1015**	**760**
Cephalopod														
Calamary	8.2	7.5	5.8	9.7	12.6	33.0	19.0	26.6	90.6	84.6	76.6	104.8	108.4	86.3
Cuttlefish	0.5	0.7	0	1.1	0.8	0.2	0.3	0.2	0	0	0	0.7	2.4	1.0
Octopus	32.2	35.2	47.4	58.2	55.3	76.9	40.8	43.4	85.5	61.5	62.0	63.1	67.6	69.4
Squid, arrow	35.1	7.2	7.0	7.7	8.6	5.7	7.8	12.9	79.7	480.5	39.7	2.4	1.9	2.0
Total cephalopod	**76.0**	**50.6**	**60.2**	**76.7**	**77.3**	**115.8**	**67.9**	**83.0**	**255.8**	**626.7**	**178.3**	**170.9**	**180.3**	**158.6**

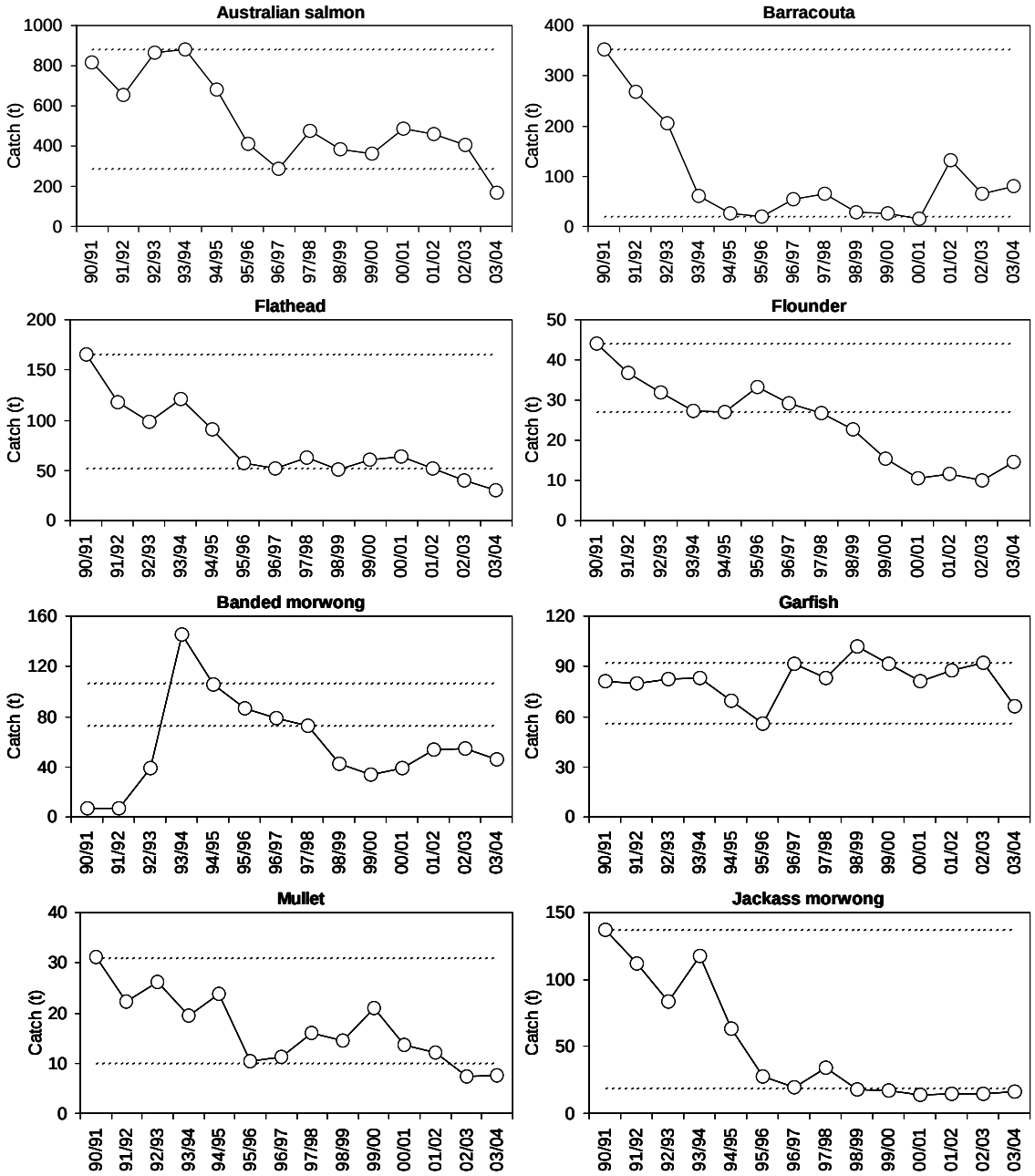


Fig. 2.1. Annual catches for key scalefish species 1990/91 to 2003/04. Dotted lines indicate upper and lower catch levels for the catch reference period (1990/91-1997/98 for all species except banded morwong [1994/95-1997/98] and wrasse [1995/96-1997/98]).

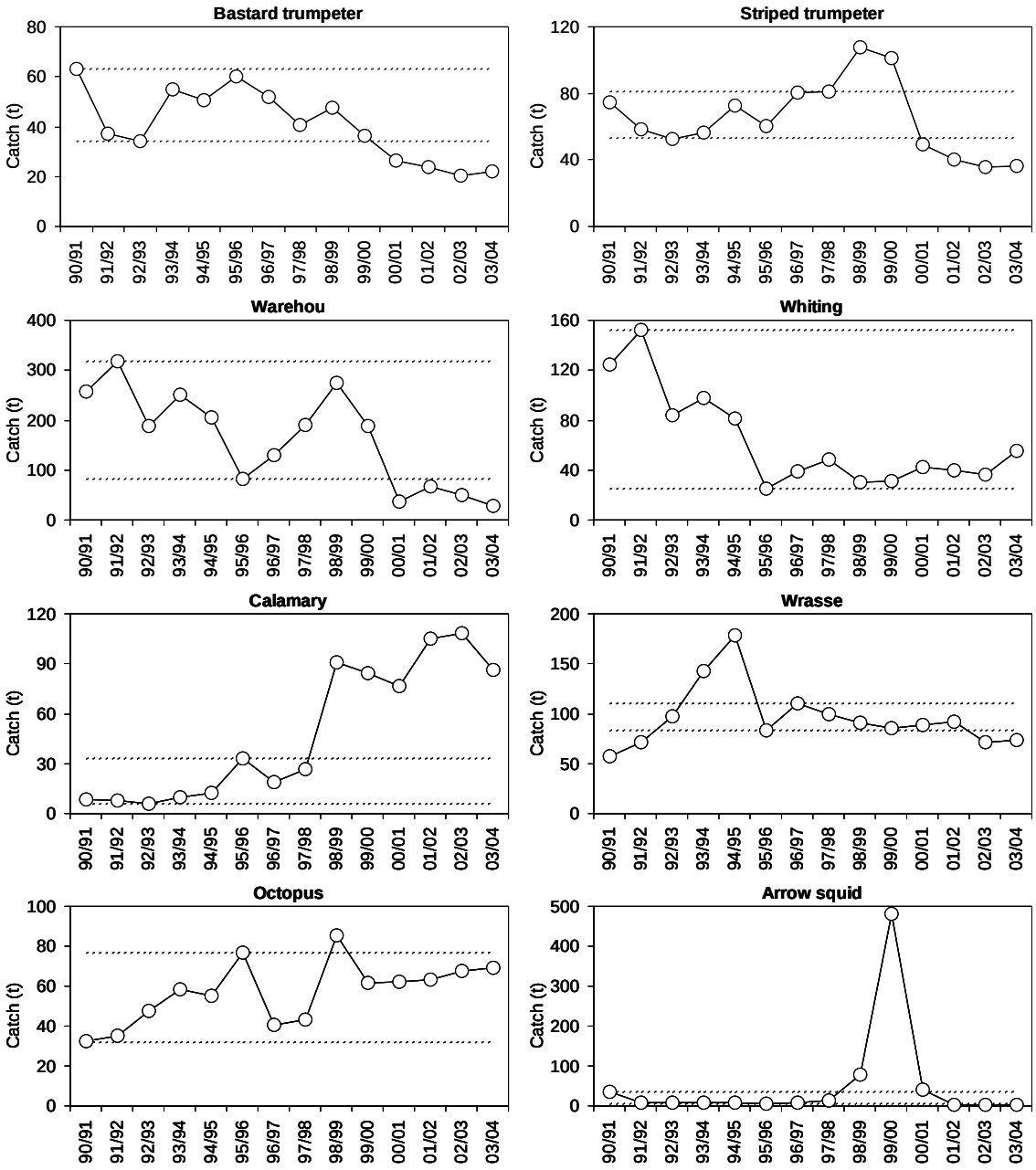


Fig. 2.1. Continued.

2.4 Commercial effort trends

The Scalefish Management Plan contains two trigger points that pertain to fishing effort, one based on effort relating to a particular gear type and the other based on effort directed towards a species or species group. A trigger point is reached when effort exceeds the peak level for the period 1995-1997 by at least 10% (for the present analysis the reference period is taken as 1995/96 to 1997/98).

Catch and effort by the main fishing gear types are presented in Table 2.2. Since a variety of gear types are represented, it has been necessary to express effort in units appropriate to each specific fishing method (Table 2.3). Effort has also been expressed in terms of number of days fished using the specified gear type, irrespective of the

amount of gear utilised each day. Although days fished is a less sensitive measure of effort, it has become apparent that some fishers have misinterpreted reporting requirements for effort. Days fished overcomes any uncertainty about the accuracy of reporting effort units.

For the purpose of analysis, dropline catch and effort has been limited to depths of less than 200 m. This restriction effectively excludes fishing for blue-eye trevalla (now managed by the Commonwealth) and, as less than 1% of the striped trumpeter catch is reported from depths greater than about 200 m, effectively encompasses the target dropline fishery for that species. Catch and effort for shark net and bottom longline methods has been excluded from this analysis since these methods relate specifically to the shark fishery, now managed by the Commonwealth.

Since the mid-1990s effort trends for the major gear types have either declined (purse seine and graball), increased initially or remained stable but undergone recent declines (dipnet, dropline and fish trap), remained relatively stable (spear and handline) or exhibited an increase over time (squid jig) (Table 2.2 and Fig. 2.2). Following the introduction of the new management arrangements in November 1998, beach seine, purse seine, graball and handline effort fell whereas dropline, squid jig and dipnet effort increased sharply. While a range of factors, including availability of target species and market developments have had an impact, there is little doubt that the management changes have had a direct impact on effort levels. Specifically, methods for which gear allocations or access became more regulated (beach seine, purse seine and gillnets) demonstrated declines in effort whereas there was a shift to and increase in effort for less regulated[2] methods (hooks, jigs and dipnets).

Effort levels during 2003/04 were generally similar or lower than in 2002/03 for most gear types, exceptions being spear, dropline (gear fished) and fish traps (days fished) which were higher. By comparison with reference levels, however, effort was either lower (beach seine, purse seine, graball, small mesh, fish traps and handline) or within (dipnet and spear methods) the range from the reference period (Table 2.2). The amount of gear set during 2003/04 for droplines (number of hook lifts) was lower than during the reference period despite more fishing days reported and more operators (number of vessels) participating in the fishery. The introduction of trip limits in late 2000 for striped trumpeter, the primary dropline target species, may have resulted in fishers using fewer hooks/lines per day in an effort to restrict catches to within the trip limit. Squid jig effort, by contrast, continued to be significantly higher than during the reference period, a direct consequence of the development of the calamary fishery.

Considering effort by gear type alone, however, can mask important dynamics within the fishery itself, such as shifts in species targeting. This is particularly pertinent where individual species may be targeted using a variety of gear types and where a given gear type can be used to target a number of different species. For instance, beach seines are used primarily to target Australian salmon or garfish. While effort for Australian salmon has remained relatively stable since 1995/96, fluctuations in effort for garfish have had the greatest influence on overall beach seine effort (Fig. 2.2). The decline in purse seine effort (Table 2.2) has been driven largely by falls in effort directed at calamary, whereas there has been only minor variation in effort for garfish in recent years (not shown).

[2] That is, the gear is equally available to all licence-holders.

Lyle (1998) noted that within the graball fishery there are effectively three main sub-fisheries, i.e. targeted at blue warehou, banded morwong and flounder, with a variety of other species commonly taken as by-product of these sub-fisheries. If graball effort is analysed based on the occurrence of these target species, an initial increase in effort for blue warehou was evident, peaking in 1997/98 (gear units) and 1998/99 (days fished), followed by a rapid decline especially between 1999/00 and 2000/01. Subsequent effort has remained low. By comparison, effort directed at banded morwong and at flounder declined steadily over time although the decline for banded morwong appears to have been arrested in the recent years.

Striped trumpeter and wrasse are the two main species targeted by handlines and these fisheries demonstrate different trends in effort. Handline effort for striped trumpeter increased up until 1999/00 but has gradually fallen since that time. This contrasts the pattern for wrasse, where effort rose to an initial peak in 1996/97, declined to 1998/99, before climbing steadily once again to levels similar to the mid 1990s.

The significant expansion in jig effort (particularly evident in days fished) commenced in 1998/99 and was initially directed at calamary, but in 1999/00 there was also a dramatic increase in effort targeted at arrow squid (not shown). Effort for calamary has continued to rise to the present year, whereas effort directed at arrow squid fell sharply after the 1999/00 peak and has remained very low especially during the last three years.

The remaining key methods are used primarily to target single species and as such effort trends tend to reflect the dynamics of the fishery for the target species, i.e. dipnets for garfish, droplines for striped trumpeter, spears for flounder and fish traps for wrasse. Species-based effort trends are also considered in more detail in Chapters 3-6.

In terms of the effort-based performance criterion, squid jig and dropline (days fished) were more than 10% higher than the peak for the reference period (see Table 2.2). Effort limits were not exceeded for the remaining methods. Notwithstanding these observations, there are continuing concerns, regarding the level of latent effort from licence-holders who are currently either not active in the fishery or participating at low levels but with access to gear such as gillnets, hooks, dipnets and jigs. The recent management plan review has attempted to address this issue through several strategies including making C-class licences non-transferable.

Table 2.2. Total annual catch, effort and number of vessels by fishing methods - 1995/96-2003/04
Effort units are defined in Table 2.3. * Catch data not shown where five or fewer vessels involved.

Gear	Year	Catch (tonnes)	Effort#	Days fished	No. vessels
Beach seine	95/96	467.3	1024	524	54
	96/97	364.1	1351	681	50
	97/98	520.7	1184	573	44
	98/99	440.4	869	397	41
	99/00	422.7	970	428	33
	00/01	528.1	1130	372	32
	01/02	570.9	1497	494	30
	02/03	489.6	1371	508	35
	03/04	234.6	1085	480	32
Purse seine	95/96	35.2	418	185	11
	96/97	30.4	337	153	10
	97/98	41.8	319	154	7
	98/99	73.0	228	142	9
	99/00	33.7	268	123	10
	00/01	*	275	104	4
	01/02	*	274	91	5
	02/03	*	182	76	4
	03/04	*	68	45	3
Graball	95/96	347.9	223679	5439	261
	96/97	378.7	231305	5182	233
	97/98	446.3	232088	5249	217
	98/99	494.1	167664	4706	210
	99/00	360.1	205131	4174	206
	00/01	173.6	104511	3192	187
	01/02	196.0	100240	3303	180
	02/03	227.3	117756	3340	168
	03/04	169.8	64447	2840	161
Small mesh net	95/96	38.7	11019	286	20
	96/97	27.0	7964	260	14
	97/98	21.8	7875	246	17
	98/99	31.0	7767	272	14
	99/00	22.4	6840	202	15
	00/01	20.3	10406	238	14
	01/02	24.6	13047	259	12
	02/03	22.7	11972	274	11
	03/04	21.5	6005	219	11
Dropline	95/96	19.9	438	158	31
	96/97	30.0	433	203	27
	97/98	24.7	540	222	42
	98/99	31.8	669	309	38
	99/00	30.5	424	288	47
	00/01	15.8	604	248	36
	01/02	12.7	313	257	35
	02/03	18.2	338	345	43
	03/04	17.7	364	269	50

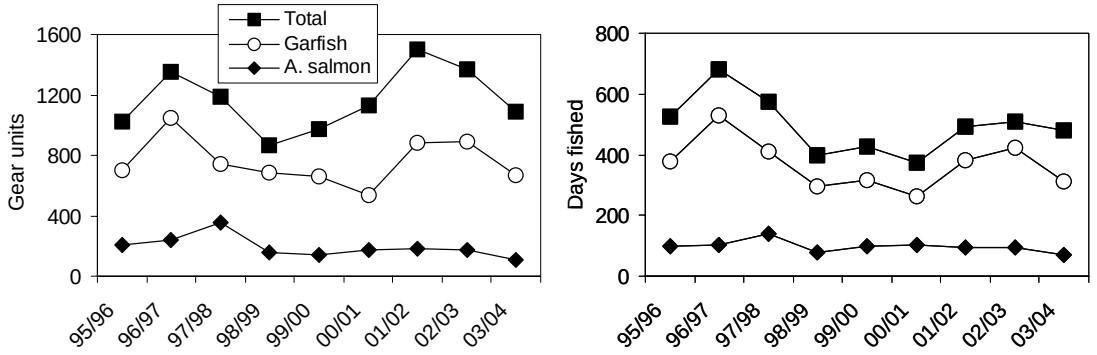
Table 2.2. Continued

Gear	Year	Catch (tonnes)	Effort#	Days fished	No. vessels
Handline	95/96	76.0	17188	1627	147
	96/97	94.5	21583	1895	135
	97/98	97.7	21131	1703	145
	98/99	87.9	17884	1271	131
	99/00	90.9	19197	1464	134
	00/01	81.7	15657	1588	131
	01/02	98.5	20277	1661	137
	02/03	80.3	18841	1584	122
	03/04	77.2	16278	1455	126
Fish trap	95/96	41.8	8265	1401	67
	96/97	57.2	10710	1796	66
	97/98	49.9	9880	1875	71
	98/99	53.7	10893	1558	56
	99/00	56.1	11292	1637	63
	00/01	54.3	10581	1548	68
	01/02	49.0	6600	1278	62
	02/03	38.2	6950	1239	58
	03/04	47.6	6345	1424	57
Squid jig	95/96	8.7	8022	94	17
	96/97	6.5	10491	71	16
	97/98	15.0	4133	186	17
	98/99	89.6	10014	591	45
	99/00	173.7	173309	1000	60
	00/01	59.2	16120	730	48
	01/02	74.6	21622	807	62
	02/03	82.2	25261	1115	65
	03/04	62.3	17052	1130	65
Dipnet	95/96	*	317	78	5
	96/97	24.1	1511	361	11
	97/98	33.4	1711	409	22
	98/99	42.4	2708	557	29
	99/00	29.3	2390	500	35
	00/01	22.8	1822	371	27
	01/02	23.9	1896	372	26
	02/03	18.5	1364	335	19
	03/04	16.0	1052	299	18
Spear	95/96	14.0	1383	361	21
	96/97	19.2	1845	462	28
	97/98	13.8	1554	437	41
	98/99	17.2	1377	390	41
	99/00	16.0	1500	375	25
	00/01	12.6	1192	289	22
	01/02	11.7	1463	279	20
	02/03	9.5	1416	242	22
	03/04	10.5	1462	306	23

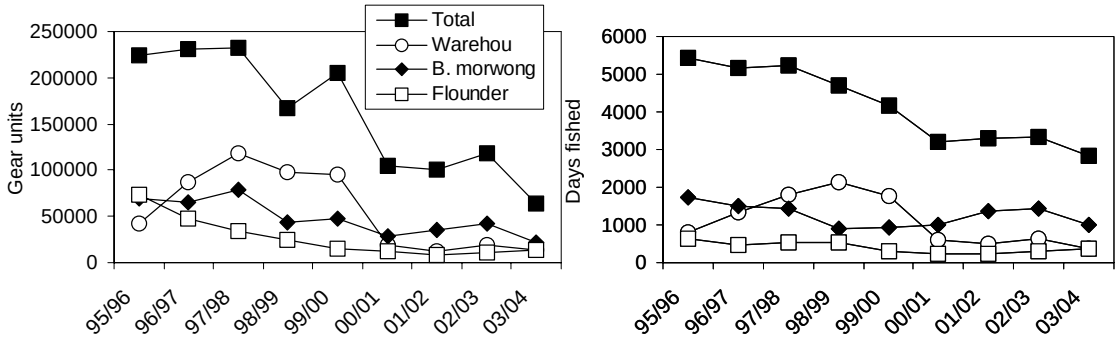
Table 2.3. Table of effort gear units by fishing method

Method(s)	*Effort gear units*
Beach seine/purse seine	No. of shots
Graball/small mesh net	100 m net hours
Dropline	100 hook lifts
Handline	Line hours
Fish trap	No. trap or pot lifts
Squid jig	Jig hours
Spear	Fisher hours
Dip net	Dip net hours

A) Beach seine



B) Graball



C) Handline

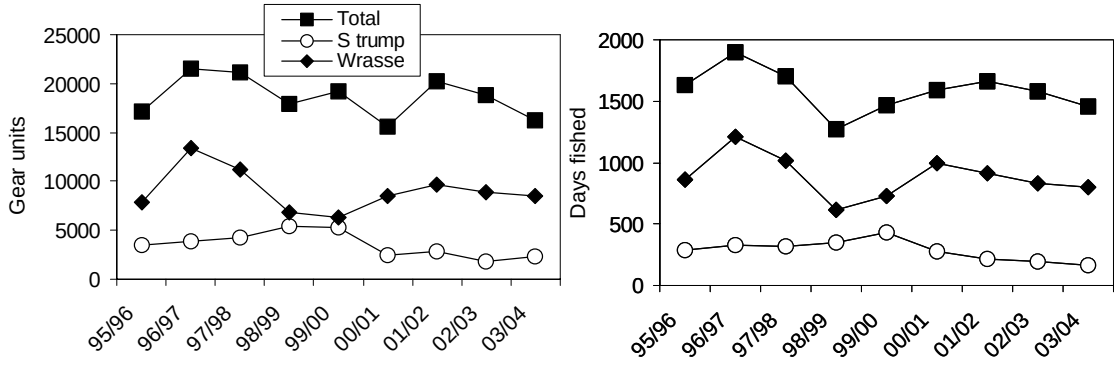


Fig 2.2. Annual effort by selected methods for key species, expressed as gear units (refer Table 2.3) and days fished.

2.5 Catch rates

Catch rate or catch per unit effort (CPUE) is often used in fisheries assessment as a relative index of stock abundance. In the context of the scalefish management plan, a catch rate performance indicator is triggered when catch rates fall below 80% of the lowest value for the reference period (i.e. 1995/96 to 1997/98 unless otherwise specified). Catch rate trends for key species and species groups are considered in some detail in Chapters 3-6.

2.6 Recreational fishery

2.6.1 Catch and effort

Catch and effort information are not routinely available for the recreational fishery. However, a recreational fishing survey conducted between May 2000 and April 2001 does provide the first comprehensive snapshot of the Tasmanian recreational fishery (Henry and Lyle 2003, Lyle 2005). There have been no subsequent surveys to date though there are plans to repeat a state-wide assessment in the near future.

The 2000/01 survey demonstrated that the recreational catch represented a significant component of the total harvest for many of species, either as a proportion of the total harvest or in absolute quantities taken. For instance, the recreational sector accounted for over half of the total catch of flathead, barracouta, jackass morwong, bastard trumpeter, cod, flounder and silver trevally (Lyle 2005). By contrast, the commercial sector dominated the catches of Australian salmon, southern calamary, arrow squid, wrasse, garfish, whiting and banded morwong. The striped trumpeter catch was shared more or less equally between the two sectors.

In the absence of more recent data few inferences can be made in relation to the relative impacts of recreational catches on the finfish stocks.

2.6.2 Recreational net licences

Since 1995, the use of recreational nets in Tasmania has been subject to licensing, with fishers able to licence up to two graball nets prior to 2002/03, one mullet net and a beach seine. From November 2002 the number of graball nets was reduced to one per person.

Following the introduction of recreational net licences in 1995 the number of net licences issued rose rapidly from around 8,900 to a peak of over 11,000 in 1999/00, but has subsequently declined to about 8,000 in 2003/04 (Table 2.5). However, as indicated by the number of Graball Net 1 licences issued, the actual number of gillnet licence-holders peaked in 2002/03 but declined slightly in 2003/04. Although not a direct index of recreational net fishing effort (not all licence holders fish each year and in any case the level of individual fishing effort is highly variable), licence numbers suggest that netting effort increased towards the end of the 1990s but has fallen over the past couple of years. With the exception of surveys conducted between 1996-98 (Lyle 2000) and the national survey in 2000/01 (Lyle 2005) there have been no recent assessments of recreational net catch or effort in Tasmania.

Table 2.5. Number of recreational gillnet licences issued by licensing year since 1995/96

na not applicable

Licence type	*95/96*	*96/97*	*97/98*	*98/99*	*99/00*	*00/01*	*01/02*	*02/03*	*03/04*
Graball Net 1	5615	6290	6685	6709	7477	7401	6960	7695	7313
Graball Net 2	2612	2678	2683	2426	2652	2515	1841	na	na
Mullet Net	656	684	738	739	879	845	608	754	753
Total licences	**8883**	**9652**	**10106**	**9874**	**11008**	**10761**	**9409**	**8449**	**8066**

2.7 Uncertainties

While considerable attention has been directed at ensuring comparability of commercial data over time (refer Appendix 2), it is acknowledged that some recent administrative changes relating to the reporting of catches may have, nonetheless, exerted some influence on observed catch and effort trends.

Other uncertainties in this assessment relate to limitations in catch and effort data, both in terms of the limited time series available and the level of detail provided. In addition, since the General Fishing Return was designed to accommodate a diverse range of fishing activities, compromises have been necessary, with data collection on a daily rather than operational (set or shot) basis.

It has also become apparent that some fishers have experienced problems in correctly interpreting or complying with reporting requirements, especially in terms of how effort information is reported. There continues to be an urgent need to educate fishers in this regard. Further, the lack of catch verification remains a major issue in relation to data quality. Anecdotal reports suggest that some catch and effort data may be unreliable, particularly prior to the implementation of the management plan. Recent industry and management workshops have identified the need to improve the quality of catch reporting, including provision for catch verification. The logbook design is currently under review and this may go some way to addressing these problems.

Catch and effort are influenced by a combination of factors which include fishers matching their fishing operations to changing market requirements and/or resource availability, as well as responses to changing management arrangements. The latter adds further uncertainty regarding the underlying causes of any observed trends in catch and effort. There is, therefore, a need to take account of industry perceptions and information when interpreting fishery dependent information.

Limited information about the recreational fishery remains a major uncertainty, although the recent national survey represents an important baseline about this sector. There is a need to consider on-going monitoring of the recreational fishery. Without such information, attempts to assess the status of those species with significant recreational catches will be flawed.

2.8 Implications for Management

A major issue confronting the commercial sector at present is that of latent effort. There is general consensus that excess capacity exists in the scalefish fishery, and that options to remove this capacity need to be pursued as a matter of urgency.

In the short to medium term, uncertainty will continue to be associated with this fishery because of the short time series available coupled with uncertain data quality (lack of verification). Related to this is the need to review the present 'generic' performance indicators to ensure that they are appropriate for each species and that the fishery is managed in accordance with the principles of ecologically sustainable development.

3 Banded Morwong (*Cheilodactylus spectabilis*)

3.1 The Fishery

The 'live fish' fishery for banded morwong began in the early 1990s. All holders of a fishing licence (vessel) were able to take this species and, as a result, there was a dramatic increase in effort directed at the species. Reported landings increased from 7 tonnes in 1991/92 to over 145 tonnes in 1993/94 (though the latter figure is considered to be highly unreliable). Between 1994/95 and 1999/00, catches declined steadily from over 100 tonnes to just 34 tonnes, before increasing to over 50 tonnes in 2001/02.

Banded morwong are targeted almost exclusively with large mesh gillnets (primarily 130-140 mm stretched mesh) for the live fish market. The fishery is centred mainly along the east coast of Tasmania, between St. Helens in the north and the Tasman Peninsula in the south, with the largest catches traditionally coming from around Bicheno. Smaller catches are taken along the south coast and around Flinders Island. Fishing operations are conducted over inshore reefs, with gear set primarily in the 10-20 m depth range. In addition to targeted fishing, the species occurs as a by-product of netting operations primarily targeted at blue warehou.

3.2 Management Background

On 31 May 1994, a Ministerial warning was issued explaining that any catches of banded morwong and wrasse taken after that date would not be used toward catch history, should previous catches be used to determine future access to the live fishery. In the same year, minimum and maximum size limits (33 and 43 cm fork length) were introduced for banded morwong in an attempt to maintain adequate egg production by protecting large adults and to reflect market requirements by restricting the size range to that of highest value. Subsequent research indicated that these size limits offered minimal protection to mature females; few actually exceeded the upper size limit and the lower size limit was set close to the size at 50% maturity (Murphy and Lyle 1999). For these reasons, the size limits were revised in 1998 and minimum and maximum sizes were both increased by 3 cm.

During 1995, a closed season (March and April inclusive) was introduced to coincide with the peak spawning period. The primary objectives of the closure were to protect spawning fish and to minimise wastage of fish at a time when they are most vulnerable to mortality in captivity. Spawning closures have been implemented each year since that time.

In addition to the closed season, an interim live fish endorsement to take banded morwong and wrasse was introduced in 1996. Eligibility was based on a demonstrated history of taking one or both of these species (at least 50 kg between 1 January 1993 to 31 May 1994) and around 90 endorsements were issued. These arrangements continued until the scalefish fishery management plan was implemented in late 1998. Under the plan, a specific licence was introduced for the banded morwong fishery (live or dead) in State waters. To qualify for a banded morwong fishing licence, a more stringent catch history requirement was applied (minimum of two tonnes of banded morwong during the period 1 January 1993 to 31 May 1994). There are currently 29 fishing licences for banded morwong.

In November 2001, largely as a result of concerns about stock status, a daily bag limit of two fish was introduced for recreational fishers.

3.3 Stock Structure and Life-history

Banded morwong is a rocky reef species distributed from around Sydney, south to eastern Victoria and around Tasmania (Gomon *et al*. 1994). They also occur in New Zealand waters where they are found down to about 50 m, with females and juveniles inhabiting the relatively shallow sections of the reef and males tending to dominate deeper reef regions (McCormick 1989a). On many southern Tasmanian reefs large changes in depth occur over short distances, suggesting depth stratification of the population may be less pronounced than that described from New Zealand. There is no information on the stock structure of banded morwong and thus the relationships of populations throughout the range are unknown. With the long pelagic larval stage, however, it seems possible that there is a single stock on the East coast of Australia.

In Tasmanian waters, banded morwong are present in a spawning condition between mid to late February and early May, with the size distribution of oocytes in the ovaries indicating they are serial spawners. Sexual maturity in females commences at about 30 cm FL, equivalent to 4-5 years of age, and length at 50% maturity is 32 cm (Murphy and Lyle 1999). Individuals have been found to be highly territorial, spawning on the same reef over several years (McCormick 1989b). The eggs and larvae are concentrated on the surface. Considerable numbers of *Cheilodactylus spp.* larvae have been caught some distance off the shelf break of eastern Tasmania, suggesting that banded morwong have a pelagic stage that is distributed in offshore waters (B. Bruce pers. comm.). Juveniles appear in shallow water on rocky reefs and tide-pools between September and December after a pelagic phase of around 4-6 months (Wolf 1998).

Tagging studies have indicated that movement of juvenile and adult banded morwong is limited, generally restricted to within 5 km of the release site (Murphy and Lyle 1999).

In Tasmania, growth in female banded morwong is relatively rapid for the first 5-6 years, to a size of about 35 cm, after which it slows dramatically (Murphy and Lyle 1999). By contrast, males grow relatively rapidly for the first 10-12 years, to about 45 cm, before slowing. Maximum recorded ages for female and male banded morwong are 93 and 96 years, respectively. The age structure of banded morwong populations from some east coast sites provides some evidence of year class (recruitment) variability (Murphy and Lyle 1999).

3.4 Previous Assessments

Up until 2001/02, assessments were limited to an examination of trends in catch, effort and catch rates, with analyses conducted at State-wide as well as regional scales. In 2002/03 a series of biological indicators were examined, including size and age composition, sex ratios, catch curves and yield and spawner biomass-per-recruit analyses. These analyses indicated that the fishery had impacted on the stocks. While changes in the character of the stock are expected with exploitation, there was little evidence of a dynamic equilibrium being attained in biological indicators over the time series of available data. Recognising the high levels of uncertainty in the 2002/03

assessment it was concluded that, on the weight of evidence, fishing pressure was most likely too high and not sustainable.

3.5 Current Assessment

Since juvenile and adult banded morwong are largely site attached, populations on individual reefs will remain relatively discrete and therefore catch and catch rate trends should ideally be evaluated at this spatial scale. However, for practical reasons, primarily the spatial resolution of the data (½ degree fishing blocks), analyses have been undertaken at the regional or block level for the main fishing areas. Regions have been defined as north east coast, including Flinders Island (3F2, 3F4, 3G1, 3G2, 3G3, 3G4, 3H3, 4G2, 4G4, 4H1, 4H2, 4H3, 4H4), St Helens (block 5H1), Bicheno (5H3 & 6H1), Maria (6H3 & 6G4) and Tasman (7G2 & 7H1). Collectively, catches from these regions have averaged over 90% of the total banded morwong production each year since the mid-1990s.

Similar to previous years, trends in graball catch and effort were examined. Catch rate standardisation using generalised linear modelling was also undertaken with the statistical model taking account of year, season, vessel, skipper, fishing block, depth and seal interference.

In addition to catch and effort analysis, biological indicators have been investigated and updated with information collected during 2004. These indicators include trends in size and age composition and sex ratios. Data for these analyses were derived from fishery dependent and independent sampling in the Tasman, Bicheno and St. Helens regions.

Data presented for this assessment have been evaluated against performance indicators specified in the scalefish management plan and detailed in Section 1.3.

3.5.1 Catch

State-wide reported catches declined sharply from over 100 tonnes to just 33 tonnes between 1993/94 and 1999/2000 before recovering to between 45-55 tonnes p.a. (Table 2.1, Fig. 3.1A). The 2003/04 catch of 45 tonnes represented a drop of about 16% compared with the previous year. Industry reports suggest that a generally tighter domestic market has played a role in the reduction of catches.

At the regional scale, catches generally declined in most areas between the mid to late 1990s with the exception of St. Helens where catches expanded up until 1997/98 before declining (Fig. 3.1B&C). Since 1999/2000, catches from most regions recovered slightly and either have remained relatively stable (Tasman), declined (St Helens and Bicheno) or increased (north east coast and Maria). Expansion of the fishery into the north east coast in 2002/03 (particularly around Flinders Island) suggest that state-wide production has been maintained to some extent by increased effort in areas that have been lightly exploited in the past.

Results of the National Survey indicated that the recreational catch of banded morwong in 2000/01 was low at around one tonne (Henry and Lyle 2003). This is consistent with estimated recreational gillnet catch levels from the latter part of the 1990s (Lyle 2000) and confirms that the recreational take relative to the commercial fishery is small.

Evaluation of 2003/04 catches against performance indicators

- The State-wide catch was below the 1994/95 to 1997/98 range and therefore triggered the performance indicator.
- Catches in the Tasman, Bicheno and St. Helens fishing regions were below the reference range and therefore triggered the performance indicator.
- The catch in the north east coast was above the reference range, triggering the performance indicator.
- The Bicheno catch declined by more than 30% while the Maria region increased by more than 30% compared to 2002/03 and therefore the rate of change performance indicator was triggered in both instances.

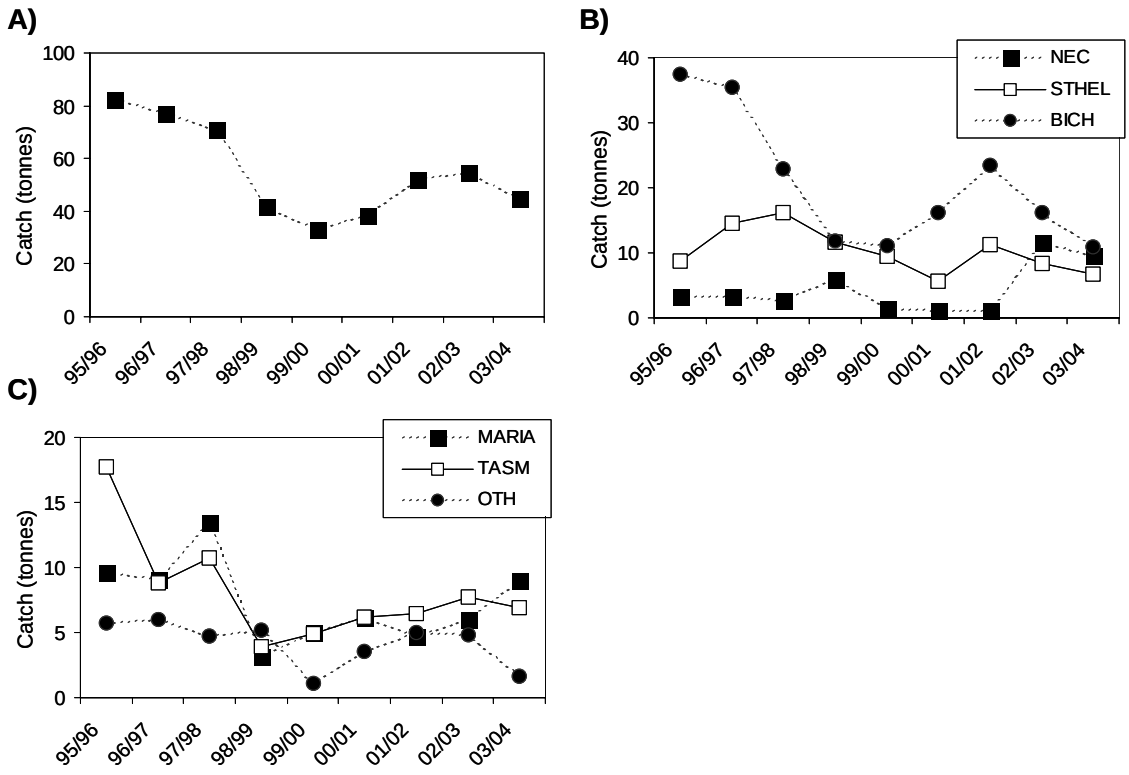


Fig 3.1. Banded morwong graball catches (tonnes) since 1995/96: A) state-wide catches; C) north east coast, St Helens and Bicheno catches; and C) Maria, Tasman and remaining regions. NEC is north east coast ; STHEL is St Helens, BICH is Bicheno; MARIA is Maria; TASM is Tasman; and OTH is all remaining areas (refer to text for definitions).

3.5.2 Fishing effort

Total effort expressed as days fished declined initially to about half the mid-1990s level by 1999/2000, then increased steadily to 2002/03 but fell in 2003/04 to a level equivalent to 63% of that expended in the mid-1990s (Fig. 3.2A). By contrast, gear

usage (100m net hours), increased prior to the introduction of the management plan in late 1998 but has since declined to less than 40% of mid-1990s level. This implies that early in the fishery fishers progressively deployed more gear on average for each day fished (prior to gear restrictions introduced as part of the management plan), and that since about 2000 they appear to be setting less gear on average for each day fished. There are numerous industry reports of increasing levels of seal interference over time that have meant that affected fishers have often resorted to fishing with less gear or doing fewer sets each day to reduce losses to seals.

Regionally, the most conspicuous trends in effort (days fished) have been general declines in effort in the Maria and Tasman regions, an initial decline then build up of effort in Bicheno (note in the current year effort declined to about 55% of the mid-1990s level), a recent fall preceded by a general build up of effort in St Helens region and a sharp increase in effort over the past two years in the north east coast region.

Evaluation of 2003/04 effort against performance indicators

- State-wide graball effort has not triggered the performance indicator.
- Fishing effort in the north east coast was greater than 10% of the highest of the 1995-97 levels and therefore triggered the performance indicator.

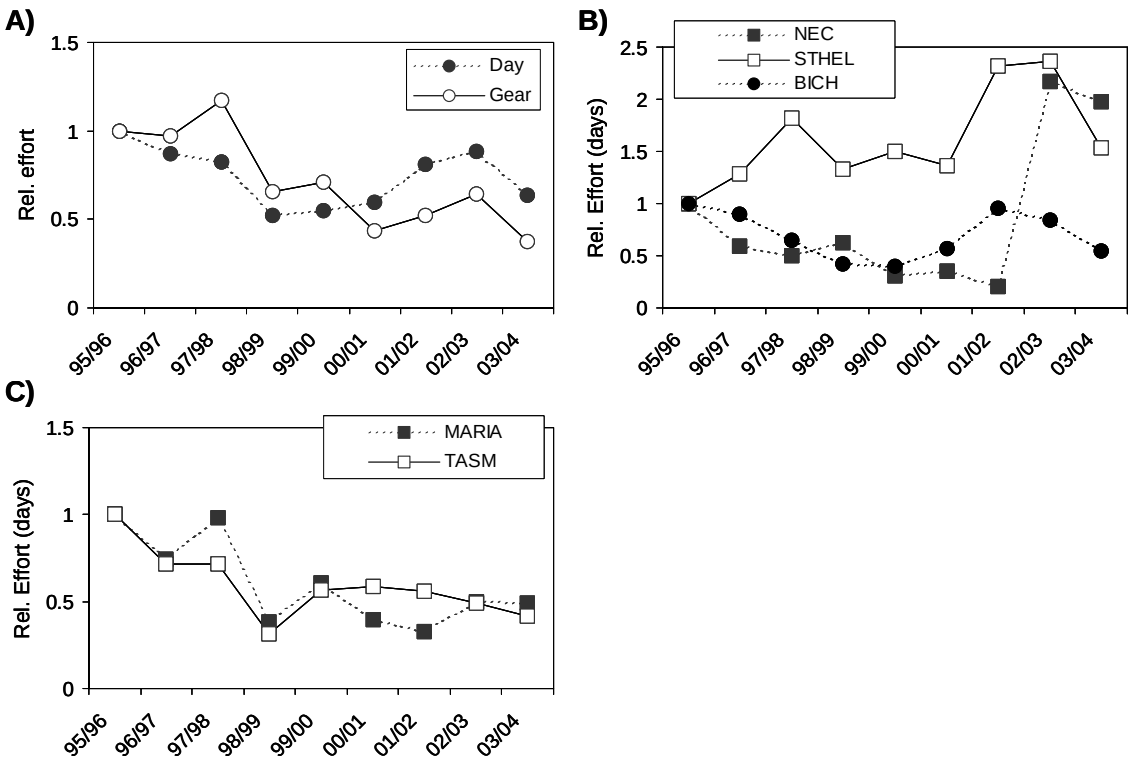


Fig. 3.2. Banded morwong graball effort relative to 1995/96 levels: A) state-wide relative effort based on gear units (Gear – refer Table 2.3) and days fished (Day); B) relative effort (days fished) in the north east coast, St. Helens and Bicheno regions; and C) relative effort (days fished) in the Maria and Tasman regions. NEC is north east coast; STHEL is St Helens; BICH is Bicheno, MARIA is Maria; TASM is Tasman (refer to text for regional definitions).

3.5.3 Catch rates

Declines in catch and effort between 1995/96 and 1999/2000 were accompanied by a steady fall in the State-wide catch rates (Fig. 3.3A). Catch rate performance indicators were triggered in 1999/2000 giving rise to serious concerns about the sustainability of the fishery. Since then catch rates have risen to above 1995/96 levels, with a stronger increase evident for catch per gear unit than catch per day.

Regional catch rates indicate that after initial falls, there have been recent increases in the north east coast, Maria and Tasman regions, to levels comparable to or higher than during the reference period (Fig. 3.3B & C). By contrast, catch rates for the St. Helens and Bicheno regions have remained comparatively low (< 70% of the minimum reference levels).

As an alternative to using the geometric mean of catch rates as a stock indicator, catch rates have been standardised to reduce the impact of obscuring effects such as region, depth, season or skipper. Standardisation suggested a greater degree of stability by comparison with unstandardised catch rates, with State-wide, St Helens and Tasman catch rates remaining just above the trigger levels (Fig. 3.3D). By contrast, in the Bicheno region standardized catch rates have remained below reference levels over the past two years.

Evaluation of 2003/04 catch rates against performance indicators

- State-wide catch rates (standardised and unstandardised) have not triggered the performance indicator.
- Standardised and unstandardised catch rates in the Bicheno region were less than 80% of the lowest value for the 1995-97 period and therefore triggered the performance indicator.
- Unstandardised catch rates in the St. Helens region were less than 80% of the lowest value for the 1995-97 period and therefore triggered the performance indicator.

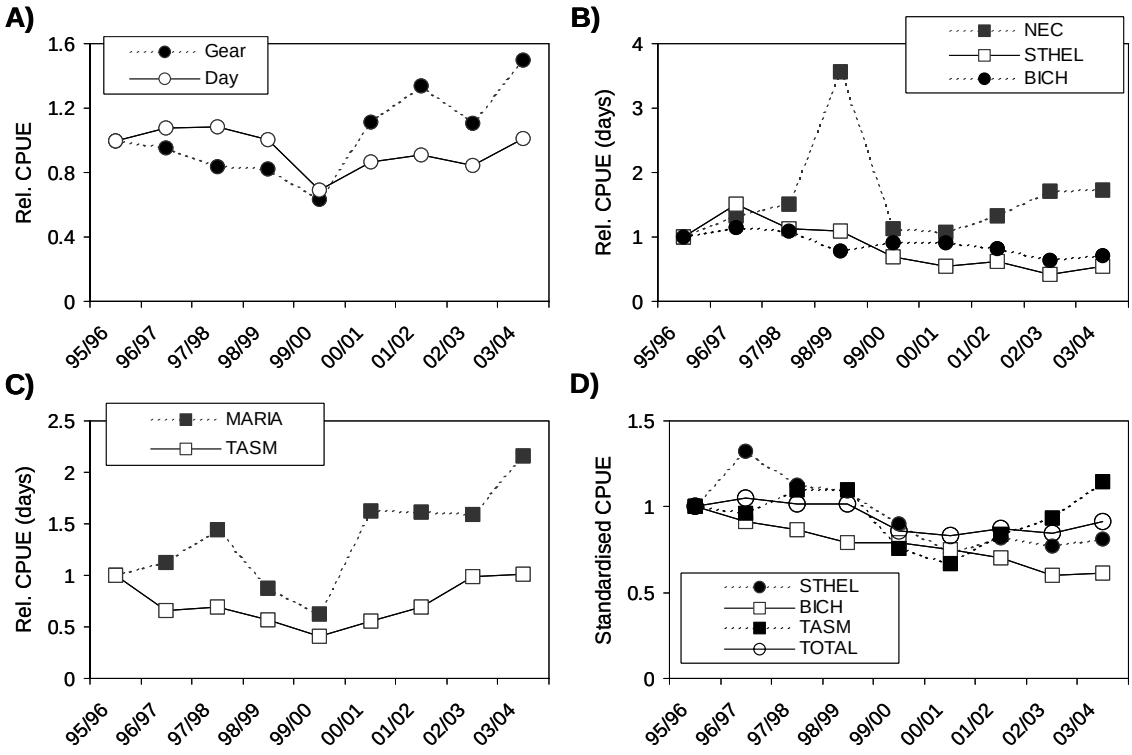


Fig. 3.3. Banded morwong graball catch per unit effort (CPUE) relative to 1995/96 levels: A) state-wide CPUE based on gear units (Gear – refer Table 2.3) and days fished (Day); B) relative CPUE (days fished) in the north east coast, St. Helens and Bicheno regions; C) relative CPUE (days fished) in the Maria and Tasman regions,; and D) standardised CPUE for Tasmania and the St Helens, Bicheno and Tasman regions. NEC is north east coast; STHEL is St Helens; BICH is Bicheno, MARIA is Maria; TASM is Tasman; TOTAL is state-wide (refer to text for regional definitions).

3.5.4 Size composition

The only new data available for this assessment relate to the Bicheno region and indicate that, apart from a shift in modal lengths to the right (possibly the result of growth), size compositions are very similar to those for the previous year (Fig. 3.4).

Male size compositions are typically bimodal, however, the relative sizes of the modes have altered over time. In the Bicheno region, the dominant size class dropped from around 51 cm in the samples from the mid 1990s to around 37 cm in the most recent samples. Female size compositions are generally unimodal, but the position of the mode has moved from 41 cm to around 39 cm and distributions have become skewed towards a greater representation of smaller size classes in recent years.

These changes are reflected in changes in median size (a more appropriate measure than average size) (Fig. 3.5). While median sizes varied considerably during the 1990s

for males, they have generally declined to around 38.5 cm in recent years in all regions. For females, the downward trend from around 40.5 to 37.5 cm has been more consistent over time and was most pronounced in the Bicheno region. Interestingly, median lengths for both males and females increased by 18 mm in 2003/04.

In practice, changes in mesh sizes may have masked even stronger changes in the size composition over time. In the mid 1990s most gillnets used by fishers had mesh sizes of 133 mm whereas in the latter part of the 1990s most fishers had switched to mesh sizes of around 140 mm, which are more selective for larger fish.

While decreases in fish size are consistent with expected impacts of fishing on the stocks, the biological significance of these observations is not clear. Firstly, levels of change that are considered either tolerable or significantly severe have not been defined. Secondly, relative size compositions are not useful for distinguishing between the effects of the removal of larger fish and/or increases in the numbers of smaller fish through recruitment. And thirdly, beside fishing mortality which includes handling mortality and seal-induced mortality, seasonal changes in availability of fish may have also contributed to the observed changes.

Evaluation against size composition performance indicator

- There have been substantial changes in the size structure of banded morwong catches since the mid 1990s, with changes consistent with the impacts of fishing on the stocks. However, the full implications of these changes for the stock status are uncertain.

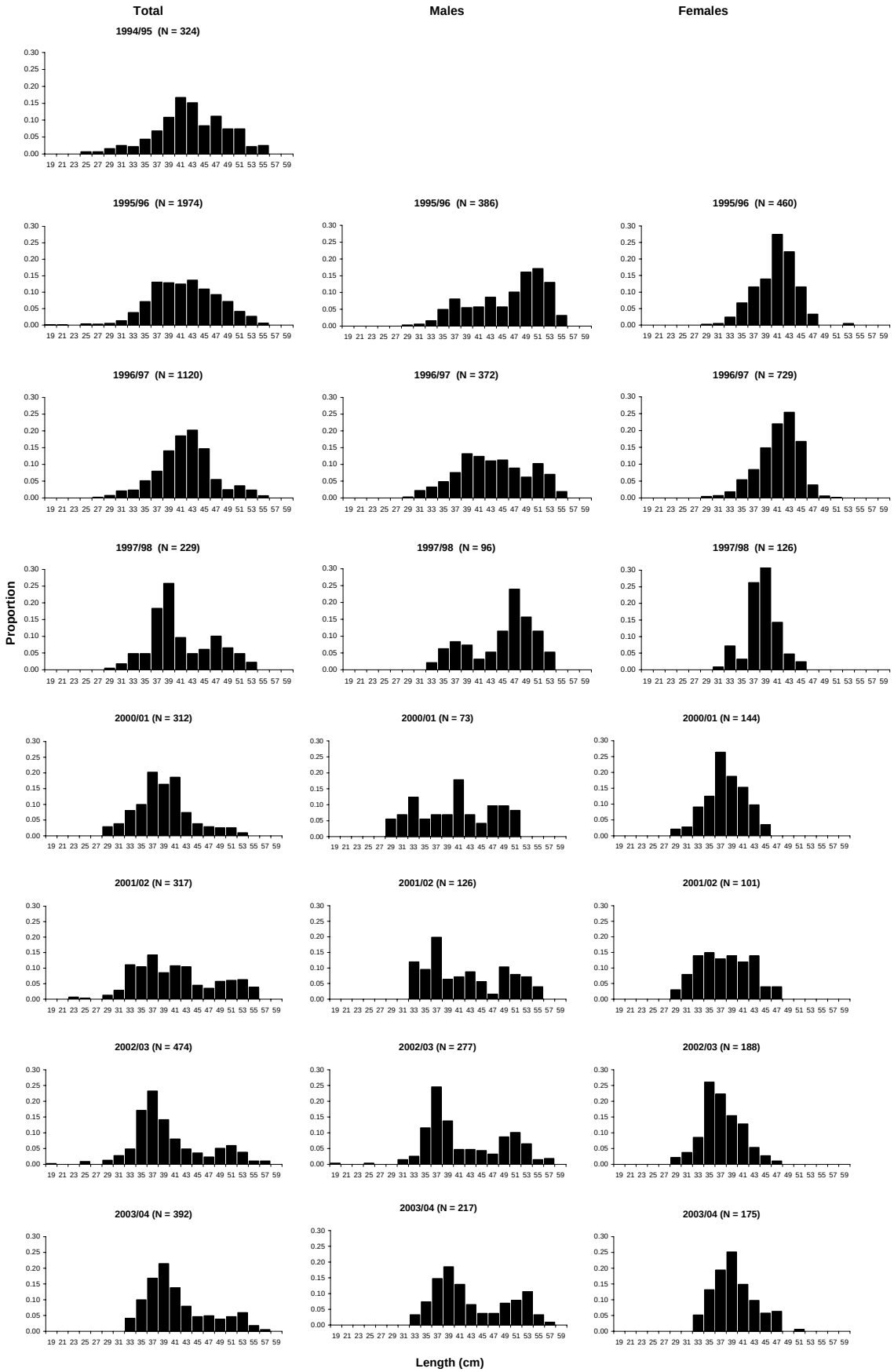


Fig. 3.4. Annual size composition of total sample, male and female banded morwong in catches of the Bicheno fishing region between 1994/95 and 2003/04. Relative frequencies in 2 cm bins (values given denote mid-point).

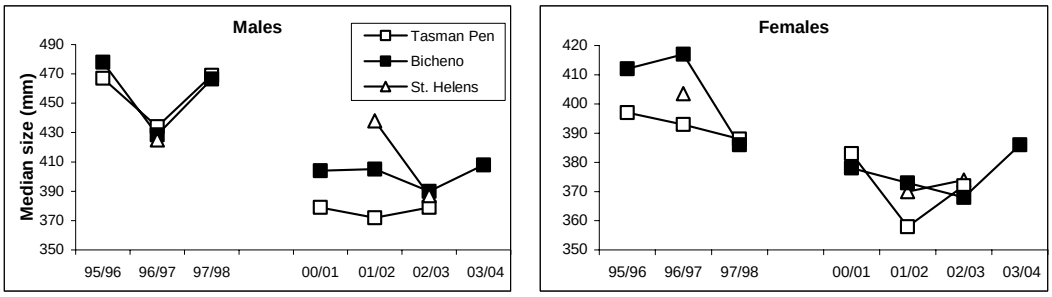


Fig. 3.5. Median size of male and female banded morwong in catches of the Tasman, Bicheno and St. Helens regions.

3.5.5 Age composition

Banded morwong have been sampled during the spawning season in the Bicheno region between 1995/96 and 2003/04, in the Tasman regions between 1995/96 and 2002/03 and in the St. Helens region between 2001/02 and 2002/03. Age has been determined and validated by analysis of otolith structure (Murphy and Lyle 1999). Age composition information is currently available for about 3000 individuals.

Fishing has impacted on the age composition of male and female banded morwong. Over time, individuals up to 6 years have become increasingly dominant in samples of males in all regions, representing 59% of the 2003/04 sample (Fig. 3.6). Because males grow rapidly through the legal-size keyhole, most males are susceptible to fishing between the ages of 4-10 years.

Since 2000/01 in the Bicheno region, males older than 10 years have been proportionally less abundant compared to the samples taken during the mid 1990s. Reductions are particularly evident for males aged 10-20 years, age classes that would have been exposed to fishing pressure for some years. The same trend is apparent in the Tasman region, however, males older than 10 years have been generally scarce throughout all years sampled.

In contrast to males, females recruit to the fishery at around 4-5 years of age and typically remain vulnerable for the remainder of their lives (Fig. 3.7). Fishing has had a marked impact on age structure in the Tasman and Bicheno regions. While there are still old females present, their relative contribution has decreased significantly in recent years compared to the mid 1990s, such that females up to 6 years, now dominate catches (Fig. 3.7). These data suggest that the fishery is becoming increasingly dependent on new recruits.

Changes in age composition are reflected in the trends based on median ages (Fig. 3.8). While the median age of males has decreased only slightly (with the exception of St. Helens), the median age of females has fallen dramatically from around 20 to 7 years since the mid-1990s, a trend that is reflected in both Bicheno and Tasman regions.

Evaluation against age composition performance indicator

- There has been a significant change in the age composition of commercial catches since the mid 1990s that is consistent with a significant fishery impact on the populations.

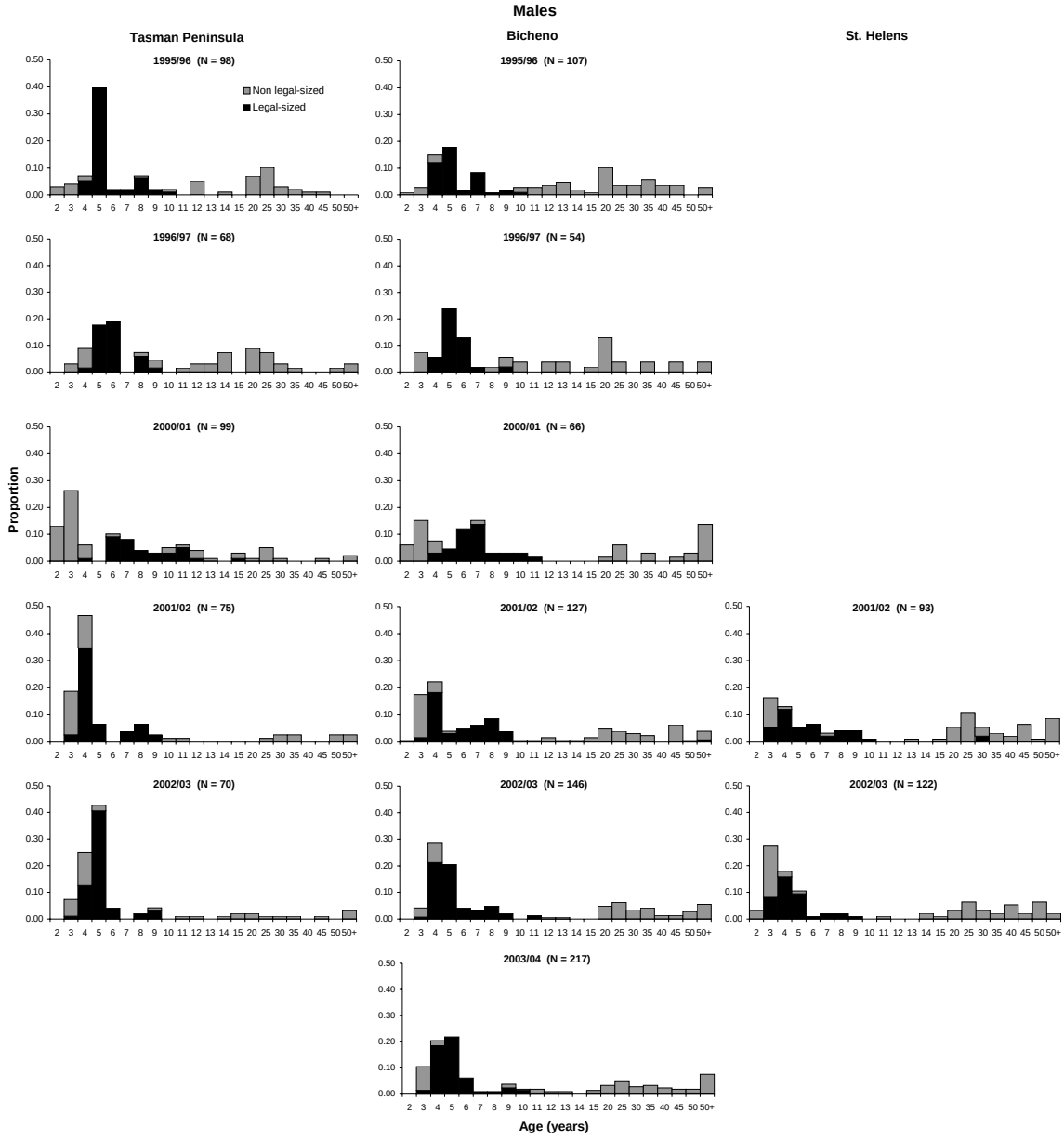


Fig. 3.6. Relative age composition of male banded morwong in research catches from the Tasman, Bicheno and St. Helens fishing regions between 1995/96 and 2003/04. Black bars refer to legal-sized fish, grey bars to non-legal-sized (undersized and oversized) fish. Relative frequencies in 5-year classes.

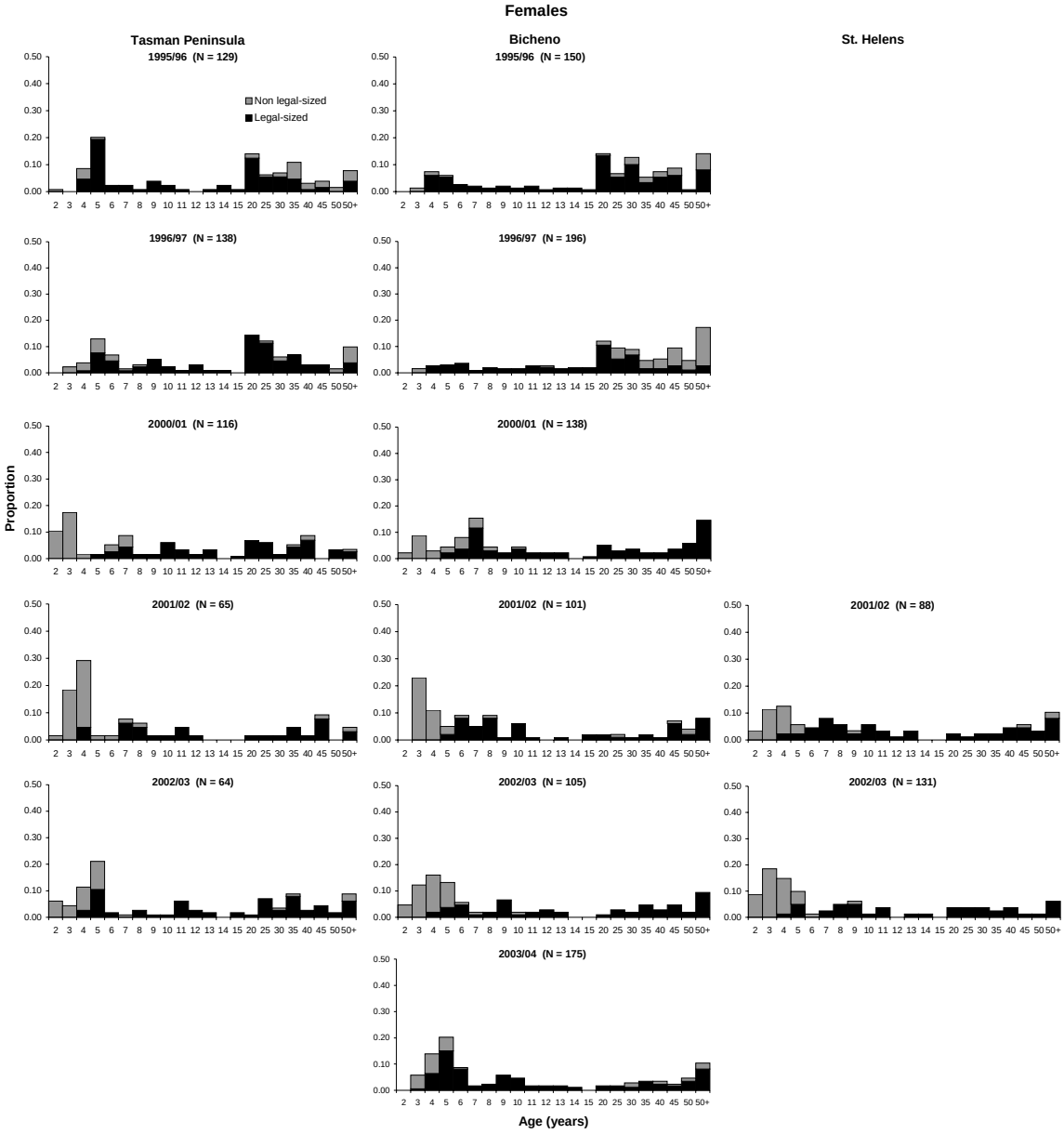


Fig. 3.7. Relative age composition of female banded morwong in research catches of the Tasman, Bicheno and St. Helens fishing regions between 1995/96 and 2003/04. Black bars refer to legal-sized fish, grey bars to non-legal-sized (undersized and oversized) fish. Relative frequencies in 5-year classes.

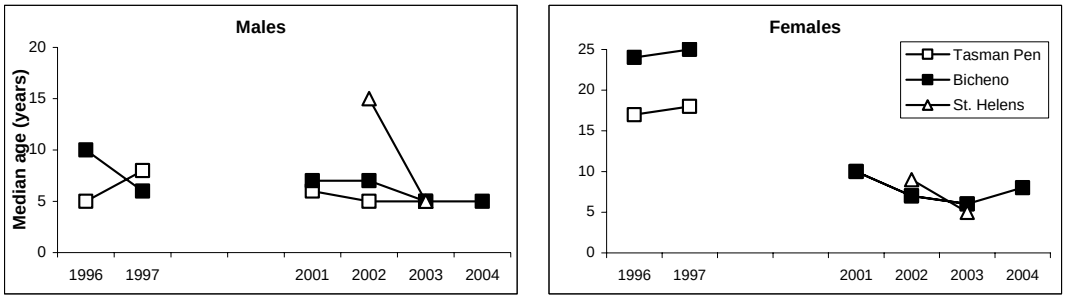


Fig. 3.8. Median age of male and female banded morwong in research catches of the Tasman, Bicheno and St. Helens regions.

3.5.6 Sex ratio

Sex ratios based on spawning season surveys in the Bicheno and Tasman fishing regions have shifted from female dominated (up until 2001) to roughly equal numbers of males and females in the more recent samples (Fig. 3.9). The proportion of females in the legal-sized catch dropped consistently in both regions, which would be at least partly caused by the greater selective fishing pressure on females. The sudden shift in sex ratios between 2000/01 and 2001/02 in both Bicheno and Tasman regions is difficult to explain but may be due to sampling issues, mediated through some behavioural mechanism on behalf of the fish (for instance, activity patterns and hence vulnerability may change at different times within a spawning season). Consistency in ratios since 2001/02, however, lends support for a real change in population sex ratios.

Change in sex ratios were also apparent in the total sample but, reflecting the influence of the substantial numbers of undersized recruits of both sexes, were less extreme when compared with the legal sized catch.

Evaluation of sex ratio performance indicator

- There have been substantial changes in sex ratio that are linked to differential fishing pressure on males and females (due to growth rate differences), providing further evidence for an impact of fishing on population structure.

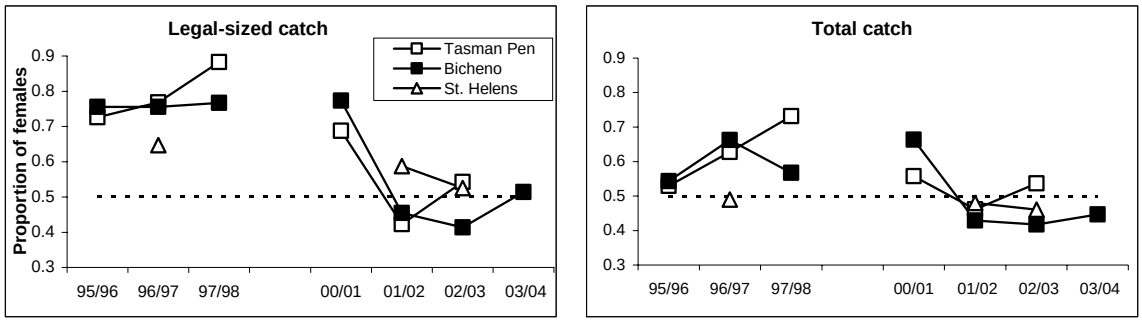


Fig. 3.9. Proportion of female banded morwong in the legal-sized and total catch in the Tasman, Bicheno and St. Helens fishing regions. Dotted lines represent a sex ratio of 1:1.

3.5.7 Other indicators

Catch curve and yield-per-recruit and spawner biomass-per-recruit analyses have not been up-dated and reference should be made to the 2003 assessment for details (Lyle et al. 2004).

3.6 Implications for Management

Catch and catch rate indicators suggest that, initially at least, the fishery impacted on banded morwong populations. However, there has been stability in both measures in the last few years, an observation that is consistent with industry perceptions. Unfortunately, this stability does not necessarily indicate the sustainability of current levels of exploitation and is not reflected in stability of selected biological indicators. There are several limitations related to the use of fishery dependent data. These include the masking effects on localised changes in abundance arising from the expansion of the fishery within and outside of original fishing grounds, the limited insights that catch rates provide into stock status for a species such as banded morwong, and issues of data quality of commercial catch returns. More specifically:

- State-wide catches have been maintained to some extent by an expansion of fishing effort from traditional fishing grounds on the east coast to new areas, with a significant increase in catches off the north east coast since 2002/03.
- Due to the limited movement of banded morwong, their populations are spatially structured and may even differ from one reef to the next. At the same time, fishers operate over relatively wide areas of coast to maintain catches. Because a fishing block, the spatial scale for reporting, is likely to encompass catches from many, potentially independent, populations of banded morwong, localized or serial depletions may not be detected.
- Catches and catch rates ignore the fact that banded morwong can grow very old (over 95 years) and catches do not distinguish between production due to new recruits entering the fishery from the fish-down of accumulated biomass by successively removing the older fish.
- Industry members affirm the view that both the frequency of seal interactions and the quantities of fish lost to seals have increased over the history of the fishery, and that seal interactions are considered to be a more significant factor influencing the downturn in catch and effort than variation in stock abundance.
- Industry representatives also noted that new participants had entered the fishery (and some experienced operators had exited the fishery) during the late 1990s and early 2000s and this was likely to have depressed catch rates. Over the past few years there has been some stability in terms of participants in the fishery, with experienced operators now accounting for the bulk of the catch. Their experience in the fishery will undoubtedly result in higher catch rates than those achieved by inexperienced operators.
- Over the past few years the domestic market for banded morwong has remained flat, partly due to competition from other live product (including banded morwong from Victoria). As a result, processors influence the level of effort and catch as they seek to match market requirements. To this end, fishers often operate under what are effectively weekly catch quotas and this undoubtedly impacts on effort.
- Fishers emphasized that the reliability of the commercial catch and effort data was probably poor up until about 2000. In addition, a number of issues were identified

in relation to catch and effort reporting, which affect any interpretation of fishery-dependent information, they include:

(i) there is considerable confusion about how gear units should be recorded;
(ii) fishers tend to report only the portion of the catch that was sold live and do not include mortalities; and
(iii) most operators do not consistently report activity on days of heavy seal impacts.

All biological measures investigated indicate that the fishery has impacted on the stocks. Some of these changes, such as the decrease of median age for females from around 20 to 7 years, appear dramatic. Changes in the character of the stock are to be expected with exploitation, however, at sustainable levels of exploitation it would be expected that the biological measures would attain some form of dynamic equilibrium. Although not presented here, recent evidence has come to light that growth rates of the younger cohorts have increased over the past decade and, significantly, there appears to have been a change in the age at maturity, with females currently attaining maturity at an earlier age than they did during the mid-1990s. Such changes may be driven by environmental factors, such as increased average water temperatures, but may also be density-dependent responses to reduced population size. If these differences do in fact prove to be density-dependent, they would suggest a significant reduction in stock size and as such a precautionary approach to future management is required.

The role of external factors such as climate change, and recovery in seal numbers around Tasmania with consequent increased predation on banded morwong, are potentially confounding factors that may have also impacted on banded morwong stocks. There is little doubt that increased incidence of seal interactions over the history of the fishery have resulted in substantial incidental mortality of banded morwong and impacted on fisher behaviour and catch rates.

Despite uncertainty in the significance of the biological changes in relation to stock status, the general downward trend in all biological indicators suggest that current fishing pressure is high and may not be sustainable in the long-term. Management action is required to ensure that fishing mortality in this fishery does not increase. Maintaining *status quo* in the management of this fishery represents a high risk strategy, and given the limited mobility of this species any management action should explicitly include reference to the spatial distribution of effort.

3.7 Research Needs

The Scalefish Fishery Research Advisory Group has accorded stock assessment of banded morwong a high priority. Reliable but simple estimators of stock status together with management reference points that take into account the sedentary character and the specific life-history characteristics of the species are urgently needed as an integral component of the stock assessment. A Fisheries Research and Development Corporation project is being finalised and will enable a more robust stock assessment for banded morwong in 2005.

Spawning season surveys continued in 2005 and should provide further insights into the impact of fishing on the size, age and sex structure. However, given the level of spatial

structuring, sampling needs to be focussed regionally, even at the scale of discrete reef areas. This degree of sampling intensity is in practice difficult to achieve and justify in a fishery of this size. As an alternative, commercial catch and effort data needs to be reported at a much finer scale, an issue that is being addressed as part of a current review of the logbook design.

Information about the character or relative abundance of populations in the deeper reef areas or potential mixing rates with the shallower areas is also missing. Fishing surveys of such areas and an understanding of the size and distribution of suitable deep reef habitat relative to the shallow fished reef areas could prove informative in evaluating the potential importance of depth refuges.

4 Southern calamary (*Sepioteuthis australis*)

4.1 The Fishery

During the latter half of the 1990s there was a marked expansion in the fishery for calamary in Tasmania, with catches rising from less than about 20 tonnes p.a. prior to 1995/96 to about 90 tonnes in 1998/99, accompanied by a trebling of effort. Southern calamary are taken by a variety of methods including purse seine, beach seine, squid jig, spear and dipnet, with squid jigs the primary method in recent years. Although some night fishing occurs, fishing is generally conducted during the day over shallow areas of seagrass and macro-algae where squid aggregate to spawn.

4.2 Management Background

The dramatic rise in southern calamary catches prompted a ministerial warning in August 1999 that management arrangements were under review and restrictions on catch, effort and numbers of operators accessing the resource may be introduced in the future. In addition, as a precautionary measure to protect egg production, two, 2-week-long closures of Great Oyster Bay to fishing for southern calamary were implemented during the peak spawning season between October and December 1999. Short-term closures were implemented again in 2000 and 2001, while in 2002 closures were extended to include adjacent fishing grounds in Mercury Passage. During 2003 and again in 2004 the commercial fishery in Great Oyster Bay and Mercury Passage was closed for a three month period (September to November, inclusive) to reduce catches from the spawning population. Recreational fishers were permitted to fish for calamary during this period but with a reduced daily bag limit of five calamary and there was some limited research fishing by commercial fishers, operating under permit.

Growing markets for the species coupled with increasing use of squid jigs (a method available to all holders of scalefish and rock lobster licences) to target the species have contributed to the recent expansion of the fishery. Under the reviewed management plan implemented in November 2001, a combined possession limit of 30 calamary and arrow squid was introduced for all holders of scalefish C licences (but excluding those also holding beach seine or purse seine licences) in an effort to limit further expansion of the fishery. Also in November 2001, a daily bag limit of 20 ‘squid’ (southern calamary and/or arrow squid) and a possession limit of 30 squid were introduced for recreational fishers. Bag limits for squid were replaced in 2004 with a possession limit of 15 calamary (and 15 arrow squid).

4.3 Stock Structure and Life-history

Southern calamary are a shallow water species endemic to southern Australian and northern New Zealand waters. It is one of the most common cephalopods in the coastal waters of southern Australia and is an important component of the coastal ecosystem being a primary consumer of crustaceans and fishes, and as a significant food source for numerous marine animals.

The species is short-lived, probably living for less than one year, and growth is extremely variable (Pecl *et al.* 2004). Maximum recorded ages of female and male

southern calamary are 263 and 275 days respectively, with males appearing to live slightly longer on average than females. Males also attain a greater size at age than females. The maximum recorded size of males and females and are 3.6 kg and 538 mm dorsal mantle length (ML) and 2 kg and 398 mm ML, respectively. The rate of growth is rapid, at 7-8% body weight per day (BW day $^{-1}$) in individuals less than 100 days old, decreasing to 4-5% BW day $^{-1}$ in squid older than 200 days. At 200 days of age individual males may vary in size by as much as 1.5 kg and females by as much as 0.9 kg. Some of this variability in growth may be explained by temperature or food availability at hatching, with those individuals hatched in warmer seasons or years generally growing faster (Pecl *et al.* 2004).

On the east coast of Tasmania, males account for around 60% of the commercial catch. In summer and winter, the vast majority of males taken by the fishery are mature. Over 90% of females caught in summer are mature, whereas in winter over 50% of the females are either immature or in early stages of maturity. Minimum recorded age and size at maturity for females is approximately 117 days, 0.12 kg and 147 mm ML. However, immature females as old as 196 days and up 0.62 kg and 237 mm ML have been recorded. Males are mature as young as 92 days and as small as 0.06 kg and 104 mm ML.

Although spring/summer appears to be a major spawning period in Tasmania, there is evidence that low levels of spawning occur all year round (Moltschaniwskyj *et al*. 2003). The majority of summer caught squid are hatched in winter and vice versa. Southern calamary are multiple spawners although the duration of individual maturity and the frequency of batch deposition are unknown. Summer spawners appear to have the potential to lay larger batches of eggs than winter spawners (Pecl 2001). Several females deposit eggs together in collective egg masses, attaching the finger-like capsules to the substrate by small stalks. Eggs appear to be most commonly attached to *Amphibolis* seagrass although they are also found attached to other seagrasses, macro-algae and also embedded directly into sand (Moltschaniwskyj *et al*. 2003). Individual egg capsules contain 4-7 eggs, with 50 to several hundred egg strands joined together to form larger egg mops. Development takes between 4-8 weeks, depending on water temperature (Steer *et al*. 2002).

Newly hatched calamary are 2.4-7 mm ML and immediately swim to the surface following hatching. Hatchlings can be found near the spawning grounds for 20-30 days. The habitat and ecology of individuals between about 20-80 days of age is unknown, however at 80-150 days, juveniles have been found in deeper water adjacent to the spawning grounds. Individuals become available to the fishery at approximately 90-120 days of age.

4.4 Previous Assessments

Previous assessments have been largely restricted to analyses of catch, effort and catch rate trends. Rising effort and declining catch rates in the main fishing regions were noted and flagged as potential indicators that the fishery had impacted on the calamary stocks. Preliminary modelling of catch and effort data for the major fishing areas (Great Oyster Bay and Mercury Passage) was investigated for the 2003 assessment using surplus production modelling. The analysis suggested that the unfished, mid-season exploitable biomass was in the order of 200-245 tonnes but had been reduced to

below 50% of this level, implying that harvest rates were very high and not sustainable. Management responded to this advice and closed the fishing grounds to commercial fishing for three months 2004 in an attempt to reduce catches (and harvest rate).

4.5 Current Assessment

Southern calamary are taken by a variety of methods including purse seine, beach seine, squid jig, spear and dipnet. Squid jigs are the primary method and accounted for around 70% (60 tonnes) of the catch in 2003/04 (Fig. 4.1A). A further 8% was attributed to handline fishing which, in this instance, was almost certainly squid jigging. Although some night fishing occurs, jig fishing is generally conducted during the day over shallow areas of seagrass and macro-algae to target fish concentrated on these beds.

The non-equilibrium surplus production model applied in the previous assessment has been updated and refined for the present assessment. Data presented for this assessment have been evaluated against performance indicators specified in the scalefish management plan and detailed in Section 1.3.

4.5.1 Catch

Over the past six years a significant fishery for southern calamary has developed in Tasmania, with catches expanding rapidly from less than about 30 tonnes p.a. prior to 1998/99, to over 100 tonnes (Fig. 4.1A). The expansion in the fishery was almost exclusively due to increased squid jig catch. The most recent catch of 86 tonnes represented a 20% decline compared with 2002/03 but was close to the average annual production since 1998/99.

The fishery developed initially in Great Oyster Bay (blocks 6H1, ES13 & ES14), but has subsequently expanded in Mercury Passage (6H3, 6G4 & ES16) (Fig. 41B) and elsewhere around Tasmania. The impact of seasonal closures, first introduced in Great Oyster Bay during 1999/2000 and then in Mercury Passage in 2002/03, on production is clearly evident in Fig. 4.1B. Reduced catches from both regions in 2003/04 are a direct result of the three-month closure of both regions during the peak catching period (September – November). In addition to reducing pressure on the main spawning grounds, a secondary objective of the closures was to encourage industry to spread the effort into other regions. There is some evidence of this being achieved, with a slight increase in catches from Norfolk-Frederick Henry Bay region (ES17, ES18, ES19), general stability in catches from the Tasman Peninsula (7G2) but a general increase in catches from the north coast such that the total catch from remaining areas in 2003/04 was comparable to that for Great Oyster Bay.

A recent estimate of the recreational catch of calamary (18 tonnes in 2000/01) indicates that this sector has the potential to contribute significantly to the overall fishing pressure on the species.

Evaluation of 2003/04 catches against performance indicators

- Current State-wide catch was lower than 2002/03 but remained above the reference catch range; the catch performance indicator was therefore triggered.
- Regionally, jig catches from Great Oyster Bay and Mercury Passage were higher than reference levels and thus triggered the performance indicator.

4.5.2 Fishing effort

State-wide jig effort based on days fished was effectively unchanged compared to 2002/03, remaining at the highest level on record and almost ten times higher than during the reference period (1995/96-1997/89) (refer Table 2.2). Effort based on gear units (refer Table 2.3) experienced a 14% decline compared to 2002/03 but was still almost twenty times higher than reference values.

Jig effort in Great Oyster Bay rose dramatically in 1998/99 but more or less stabilised since then, the seasonal closures have presumably played an important role in this stability (Fig. 4.1C&D). By contrast, there has been an underlying increase in effort in Mercury Passage over time, although in 2003/04 effort levels were slightly down compared with 2002/03, almost certainly affected by the three month closure of this region.

Although not shown, purse seine effort has continued to decline and was well below reference levels in 2003/04.

Evaluation of 2003/04 effort against performance indicators

- State-wide, jig effort has remained at historically high levels and substantially greater than reference levels, the effort performance indicator was thus triggered.
- Regionally, jig effort in the major fishing regions (Great Oyster Bay and Mercury Passage) remained well above trigger levels despite the imposition of three month closures.

4.5.3 Catch rates

State-wide, catch rates (gear and daily based) have generally declined since the initial expansion of the fishery in 1998/99 with further declines evident in 2003/04 (Fig. 4.1E&F). This trend was evident in both of the main fishing areas (Great Oyster Bay and Mercury Passage), although catch per day for Great Oyster Bay at least did rise for a couple of years. Since purse seine effort has been very low in recent years, catch rates for this method are not considered to be very informative of stock condition.

Evaluation of 2003/04 catch rate against performance indicator

- Although catch rates in 2003/04 had fallen compared with 2002/03 they were within reference levels and thus had not triggered the catch rate performance indicator.

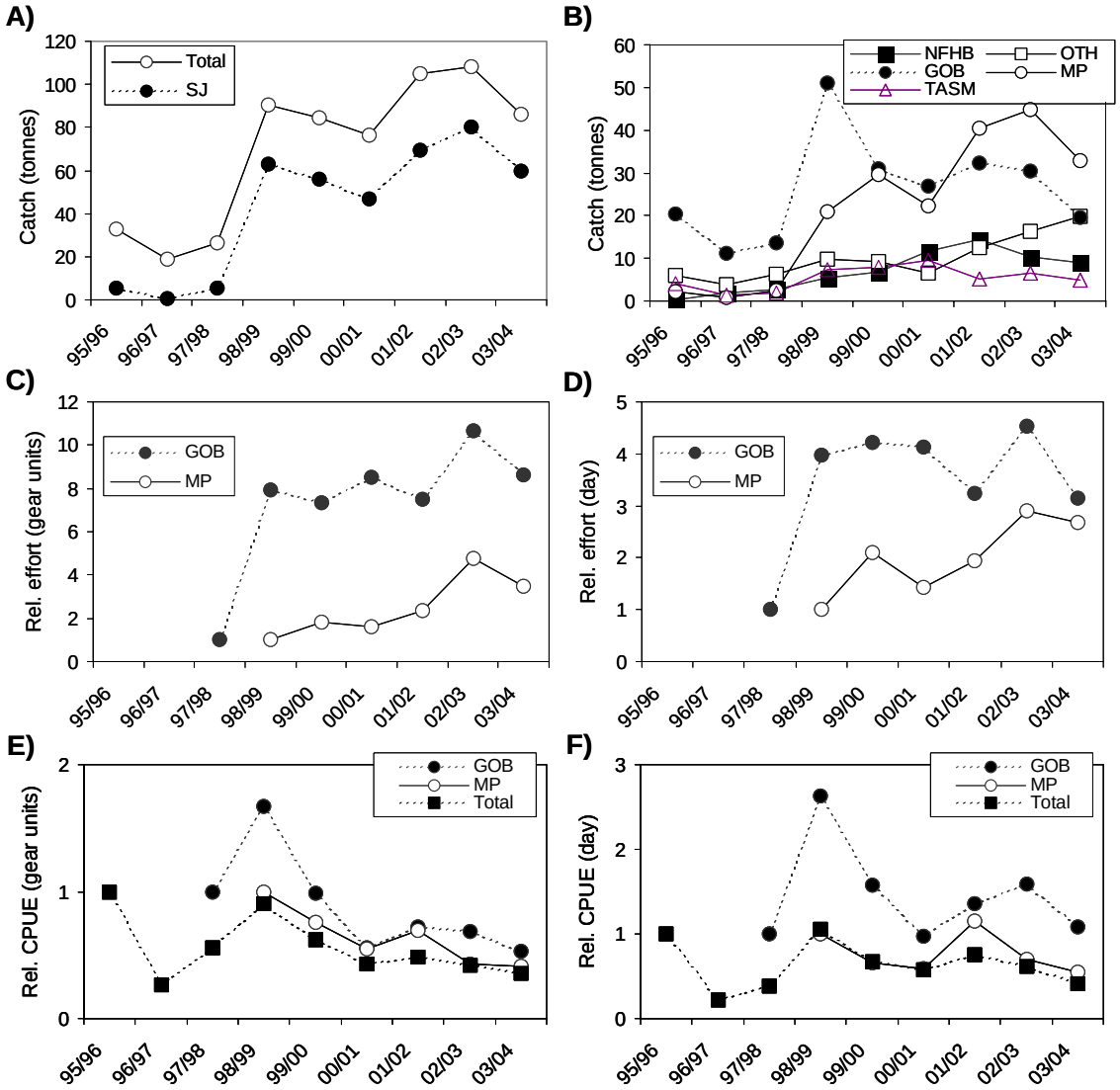


Fig. 4.1 A) Annual catch (tonnes) of calamary by method since 1995/96; B) annual catch (tonnes) of calamary by region since 1995/96; C) squid jig effort based on gear units (refer Table 2.3) and expressed relative to 1997/98 for GOB and 1998/99 for MP; D) squid jig effort based on days fished and expressed relative to 1997/98 for GOB and 1998/99 for MP; E) squid jig catch per unit effort based on weight per gear unit (refer to Table 2.3) and expressed relative to 1995/96 for Tasmania (Total), 1997/98 for GOB and 1998/99 for MP; and F) squid jig catch per unit effort by region based on weight per day fished and expressed relative to 1995/96 for Tasmania (Total), 1997/98 for GOB and 1998/99 for MP. GOB is Great Oyster Bay, MP is Mercury Passage, TASM is Tasman, NFHB is Norfolk – Frederick Henry Bay and OTH is all remaining areas (refer to text for definitions) (note: only years where >5 operators are represented are shown)

4.5.4 Surplus Production Model

The surplus production model developed for the 2003 assessment has been updated with 2003/04 data and applied to describe the catch through time in terms of implied spawning biomass available and harvest rates. For the purposes of the model, fishery data for Great Oyster Bay and Mercury Passage have been combined (Table 4.1; Fig 4.2). Catch rate trend is used as the index of relative abundance needed to relate the catches to stock spawning biomass. Because there are only seven years of catch rate data (1997/98 to 2003/04), it would be best to use only the simplest of models with a minimum number of parameters. A non-equilibrium version of the simplest model available (Schaefer, 1954, 1957; Haddon, 2001) can be described by the following equations with only two parameters. The basic stock dynamics are described by the delay-difference version of the standard logistic production model:

$$B_0 = K$$

$$B_{t+1} = rB_t\left(1 - \frac{B_t}{K}\right) - C_t$$

where K represents the unfished equilibrium population size B_0, r is a parameter representing the population growth rate, B_t represents exploitable spawning stock biomass in year t and C_t the catch in year t. Although catch data are available from 1995/96, the model can only be fitted to catch rate data from 1997/98. The model is fitted to the available catch rate data with the following:

$$\hat{I} = \frac{\hat{C}}{E} = qB_t$$

$$SSQ = (Ln(I) - Ln(\hat{I}))^2$$

where $\hat{I}$ is the expected catch rates (catch per effort), q is the catchability coefficient, and SSQ is the sum of squared residuals between the natural logs (Ln) of observed and expected catch rates. This implies that residual errors are log-normally distributed, as demonstrated in the 2003 assessment (Lyle et al. 2004).

Table 4.1 Total catch, relative geometric mean catch rate (jig) and number of jig days of effort by fishing season for Great Oyster Bay and Mercury Passage combined.

.

Fishing Season	Catch (tonnes)	Catch rate (relative to 97/98)	Effort (jig days)
1995/96	22.5		
1996/97	11.9		
1997/98	15.8	1.000	40
1998/99	69.1	1.006	323
1999/00	60.7	0.729	438
2000/01	49.0	0.518	422
2001/02	76.0	0.570	431
2002/03	75.7	0.387	618
2003/04	48.3	0.400	379

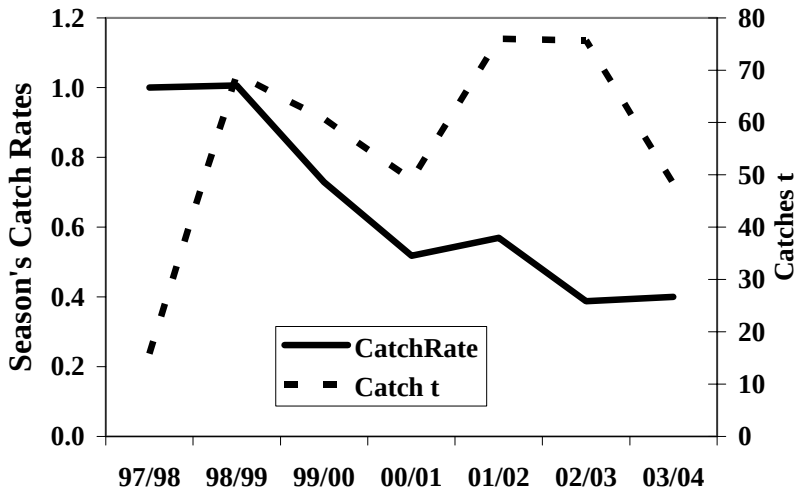


Fig. 4.2. Total catches by all methods (dotted line) and jig catch rates (solid line; relative to 1997/98) from the combined Great Oyster Bay and Mercury Passage region.

An alternative model fitting criterion, the maximum likelihood approach, results in identical solutions with log-normal errors which would entail minimizing the following negative log-likelihood (Haddon, 2001):

$$-LL = \frac{n}{2}\left(Ln\left(2\pi\right) + 2Ln\left(\hat{\sigma}\right) + 1\right)$$

where the standard deviation $\hat{\sigma}$ is:

$$\hat{\sigma} = \sqrt{\frac{\sum\left(Ln\left(I_t\right) - Ln\left(\hat{I}_t\right)\right)^2}{n}}$$

where I_t and $\hat{I}_t$ are again the respective observed and expected catch rates, and n is the number of years of observations. The estimation of the catchability coefficient can be made using a closed form version of the equation:

$$\hat{q} = e^{\frac{\sum Ln\left(\frac{I_t}{B_t}\right)}{n}}$$

While the model may only be fitted to the final seven years of data, it is apparent from the count of records that not all estimates of seasonal catch rate are estimated with equal precision or confidence (e.g. 1997/98 has only 40 data points). One solution to this heterogeneity is to use a weighted least squares approach which applies a weight equal to the square root of the number of observations contributing to that data point:

$$SSQ = \sqrt{N}\left(Ln(I_t) - Ln(\hat{I}_t)\right)^2$$

where N is the number of observations that contribute to the estimate of I_t. With this weighting the optimum solution provides a reasonable match of observed and predicted catch rates with the exception of the earliest data point, which is not weighted greatly in the analysis (Fig. 4.3).

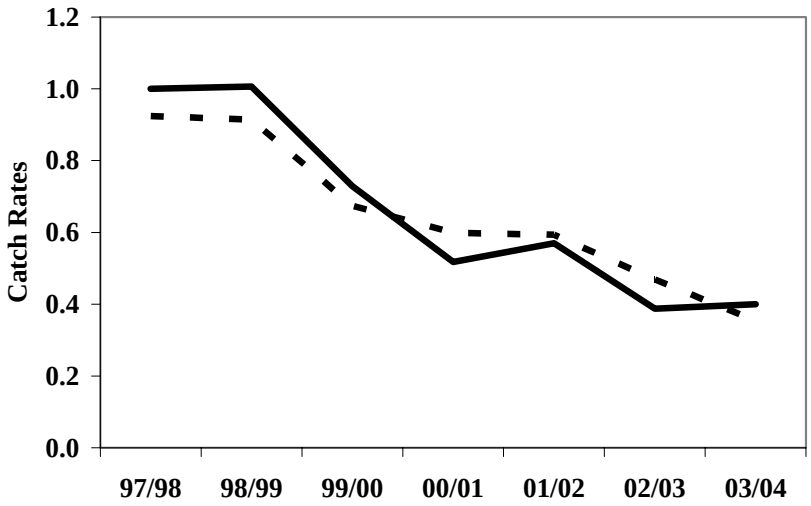


Fig. 4.3. A comparison of catch rates from the observed (solid line) and the predicted (dotted line) catch rates; with zero recreational catch.

Model Fit

The surplus-production model has been fitted under three different scenarios of recreational catch with recreational catches added as a proportion (0%, 10% and 20%) of the commercial catch. The effect of including recreational catch is to imply that the stock is more productive than if recreational catches are ignored.

The optimum model fit continues to imply a declining series of spawning stock biomass levels, even though the harvest rate in the last year of data has declined somewhat (Table 4.2; Fig. 4.4). The most recent year exhibits relatively stable catch rates with respect to 2002/03 but the continued decline in the inferred spawning stock biomass suggests that the catches remain unsustainable. The optimum solution is robust in that it is not possible to force the model to accept alternative scenarios of productivity and biomass i.e. there are no false minima even close to the optimum solution.

Table 4.2. Output from the surplus production model fitted to data for combined Great Oyster Bay and Mercury Passage region

a) Model parameters under three scenarios of recreational catch contribution: productivity (*r*) and unfished population size (*K*) are parameters of the model; *q* is the catchability; *SSQ* is the sum of weighted squared residuals; σ is the standard deviation from the negative log-likelihood *–LL* function. Recreational catches are added as a proportion of the commercial catch. Note the decline in *r* and increase in *K* as recreational proportion increases. b) Model outputs assuming 0% recreational catch: Observed catch and catch rates, number of records, predicted exploitable stock biomass in the middle of the fishing season, predicted catch rate (Pred CE); and catch/exploitable biomass or harvest rate (H).

a) Recreational %	0.0	10.0	20.0
r	0.889	0.876	0.865
K	224.25	249.29	274.341
q	0.00445	0.00399	0.00361
SSQ	2.006	1.986	1.971
σ	0.5782		
-LL	8.0152		

b) Season	Catch (t)	Catch Rate	Records	Biomass	Pred CE	H
1995/96	22.48			224.3		
1996/97	11.94			201.8		
1997/98	15.80	1.000	40	207.8	0.92	0.076
1998/99	69.15	1.006	323	205.6	0.91	0.336
1999/00	60.70	0.729	438	151.6	0.67	0.400
2000/01	49.04	0.518	422	134.6	0.60	0.364
2001/02	76.00	0.570	431	133.4	0.59	0.570
2002/03	75.69	0.387	618	105.5	0.47	0.718
2003/04	48.30	0.400	379	79.4	0.35	0.608

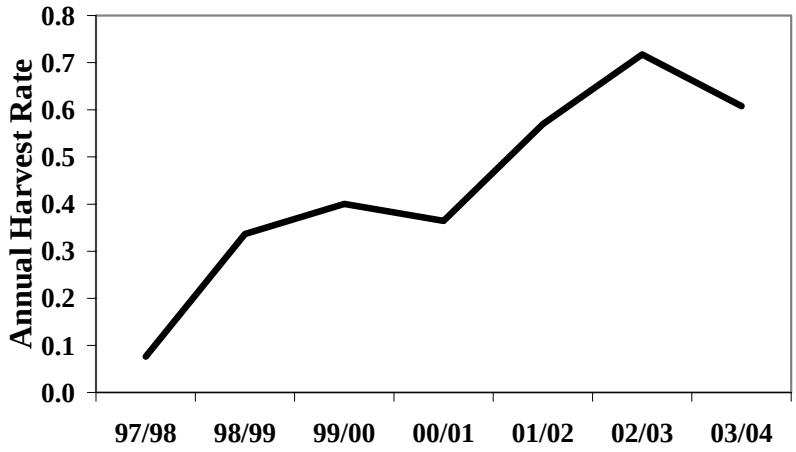


Fig. 4.4. The predicted annual harvest rate (as Catch/Exploitable Biomass) through the seven seasons of the fishery being modelled (H from Table 4.2).

Uncertainty

Unfortunately, the precision of the assessment using the simplistic representation of a surplus production model is low. The uncertainty can be estimated by using a bootstrap procedure that generates a sample of the log-normal residuals which are combined with the optimal fitting line to generate new samples of catch rate time series, each of which are refitted providing new estimates of parameters and model outputs (Haddon, 2001). Bootstrap 95% confidence intervals can thus be placed around the various model outputs. While the predicted catch rates appear relatively precise, the predicted harvest rate has a poor precision (Figs 4.5 & 4.6). For instance, in 2002/03 the upper 95% confidence limit on harvest rate reached 1.0 (total harvest of all available biomass – clearly false) whereas the lower limit was around 40%. While the median predicted harvest rate declined in 2003/04, the confidence intervals around this value were so wide such that there was no significant difference between 2002/03 and 2003/04.

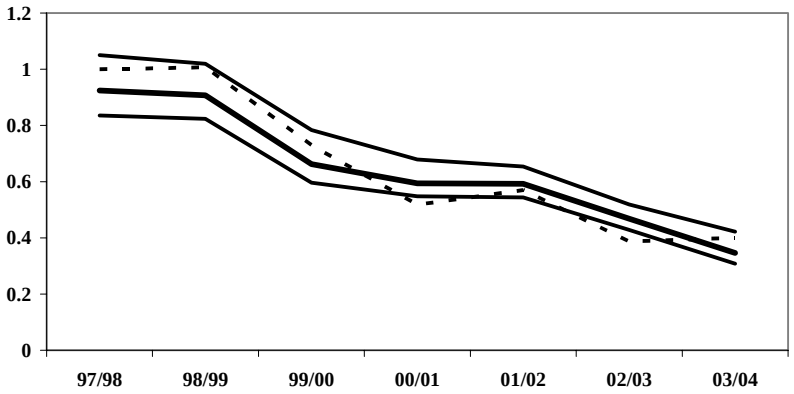


Fig. 4.5. Predicted catch rates from the optimal fit (thick line) with 95% confidence intervals (thin lines). Observed catch rates are denoted by the dotted line.

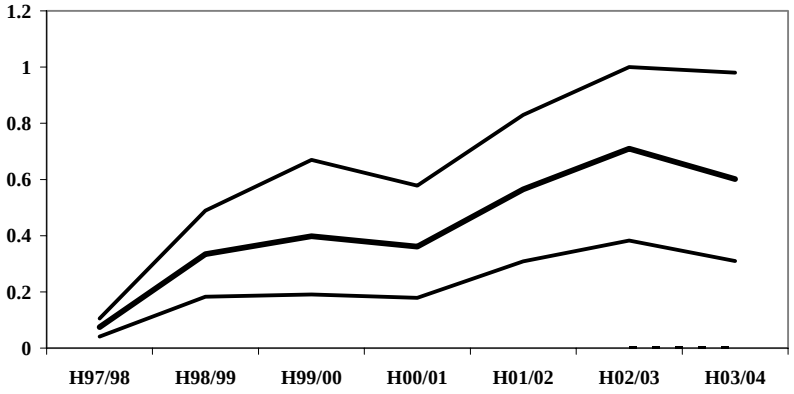


Fig. 4.6. Predicted harvest rate from the optimal fit (solid line) when recreational catches are set at 10% of commercial catches. Thin lines represent the 95% confidence intervals.

Performance Indicators

The analysis suggests that the unfished, mid-season exploitable biomass in the regions considered was in the order of 225-275 tonnes, but has been reduced to only about 80-100 t depending on recreational catch proportion. Commercial catches in the order of 50-70 t with zero recreational take imply that the harvest rate is very high. When recreational catches are included the predicted harvest rate reduces only slightly. If the recreational take is assumed to be 10% of the total commercial catch, the harvest rate in the final year reduces slightly to 0.6 and a recreational take of 20% takes the harvest rate down to 0.59[3]. The reducing effect on harvest rates brought about by accounting for recreational catches is in effect very small, because the increased catches imply that the stock has a higher starting biomass but is less productive than when there are no recreational catches. Irrespective of the level of recreational catch, the total harvest rate continues to appear to be too high to be sustainable. The slight drop in harvest rate in the most recent year is heartening but the continued decline in implied spawning biomass is a negative sign that needs to be reversed.

The current performance indicator relating to catch rates is not as sensitive as one based on harvest rate. Harvest rate provides an indication of the escapement (the proportion of the available biomass not harvested) and could be used as an effective performance indicator, although a target level of escapement would need to be agreed upon. Typical escapement values used are approximately 40%, which is an arbitrary figure derived from experience with other squid fisheries (Agnew *et al*. 1998). It should be noted, however, that while this was the target in the Falkland squid fishery, that fishery still experienced collapse. This implies is that harvest rates probably should not exceed about 60%.

High levels of uncertainty about this analysis mean that care must be taken if the results of this assessment are to be used in the management of the Tasmanian stock. However, the increasing trend in the implied harvest rate is consistent with declining observed catch rates, declining levels of estimated egg-production (Moltschaniwskyj *et al*. 2003), and increasing effort being imposed on this species. A further source of uncertainty in the most recent assessment is the change in the fleet dynamics brought about by the three-month closure. This in fact led to a huge surge of catch and effort in December. The surplus production model operates at a yearly time-step that is an acceptable approximation only as long as the fleet dynamics through the year does not alter drastically. The change introduced by the three-month closure has led to significant changes and this must be treated as an extra source of uncertainty in the assessment modelling.

4.6 Management Implications

Evaluation of performance indicators based on catch and effort for calamary is compromised because the fishery effectively developed after the management plan was introduced. As such, comparisons are based between a fishery in under-developed (pre-1998/99) and in developed states and thus will always result in catch and effort

[3] Note, recreational catch estimates for 2001/02 for Great Oyster Bay and Mercury Passage are equivalent to about 8% of the commercial catch.

indicators being triggered. In fact, at this stage it would be of greater concern if catches were to fall to within historic levels.

The sustainability of current catch levels is uncertain but preliminary modelling suggests that, within the main area of the fishery, harvest rates are very high, implying that the fishery has impacted significantly on stocks. This observation is set against the fact that there continues to be a high level interest in the fishery and that there is substantial capacity within the Tasmanian scalefish industry to increase effort levels. Furthermore, there is growing awareness of calamary amongst recreational fishers and effort directed at the species is likely to increase. Areas such as the D'Entrecasteaux Channel, Norfolk and Frederick Henry Bay and Great Oyster Bay are recognised as hotspots.

Currently there is limited information available on the stock structure of southern calamary in Tasmania. Such information is required to assess the validity of current spatial management and regional analyses reported here. In particular, the relationships between populations fished in Great Oyster Bay and Mercury Passage and other regions need to be further investigated.

Calamary have a life span of generally less than one year, with no accumulation of recruitment across a number of years. This suggests considerable potential for inter-annual variability in abundance coupled with vulnerability to recruitment over-fishing, especially since the species can be targeted whilst aggregating to spawn. In addition, since growth and reproductive characteristics of 'micro-cohorts' differ substantially, depending upon the timing of hatching and subsequent environmental conditions, environmental factors may prove as important as fishing mortality in driving the population dynamics and determining spatial patterns of abundance.

Although there is a high degree of uncertainty with the present assessment, key indicators do suggest that maintaining the *status quo* for the Tasmanian southern calamary fishery is a high risk strategy. For the fishery to remain sustainable, a more precautionary approach is required including consideration of options that will effectively reduce harvest rates.

4.7 Research Needs

The Scalefish Fishery Research Advisory Group has recognised stock assessment, evaluation of critical habitat requirements, impact of management arrangements and gear interactions on calamary populations as high priority research areas.

Information on the stock structure and level of fishing pressure that can be sustained on southern calamary is required. Integral to this is the need to analyse statoliths for age in order to determine spawning times and growth rates of seasonal cohorts. Our understanding of the variability and plasticity in the life cycle, and the subsequent application of population modelling techniques, would benefit from more detailed research into determining links between environmental factors and growth, reproductive and survival characteristics. Given the vulnerability to recruitment failure, the impact of fishing activities on the spawning behaviour of the aggregations needs to be addressed. There may be benefits in quantifying the relationships between reproductive output, spawning stock size and subsequent recruitment.

5 Striped Trumpeter (*Latris lineata*)

5.1 The Fishery

Striped trumpeter have had a long history of commercial exploitation in Tasmania, being highly esteemed for its eating qualities. There is also a high level of interest in the species from recreational fishers and charter boat operators.

The species is taken by a variety of fishing methods, with hooks and gillnets being the primary methods. Juvenile striped trumpeter are taken predominantly by graball net in inshore waters (within 3 nautical miles) and usually in depths <20 m whereas adult fish are taken in deeper offshore waters by hook methods (dropline, handline, bottom longline, trotline) and as by-product in large mesh gillnets (shark nets). Catches are concentrated off the east coast, including Flinders Island, as well as off the south and southwest coasts of Tasmania. Limited catches are taken off the west coast.

5.2 Management Background

Responsibility for the management of striped trumpeter was passed to Tasmania in 1996 through an Offshore Constitutional Settlement (OCS) arrangement with the Commonwealth. A memorandum of understanding accompanied the OCS, specifying trip limits for Commonwealth only fishers of 100 kg for South East Non-Trawl (SENT) permit holders and 20 kg for all other permit holders.

When the Tasmanian scalefish fishery management plan was implemented in 1998, gear restrictions were introduced for all commercial scalefish fishers operating in State waters. However, after the introduction of the management plan, those fishers who held a Tasmanian licence and a Commonwealth permit to fish in the southern shark or SENT fisheries were effectively allowed to target unrestricted quantities of striped trumpeter in offshore waters using their Commonwealth gear allocations (this was a significant change to their original 20 kg or 100 kg restrictions). In addition, Tasmanian rock lobster fishers were also allowed to target unrestricted quantities of striped trumpeter in offshore waters using their State scalefish gear allocations.

In August 2000, the State Government introduced a combined 250 kg trip limit for striped trumpeter, yellowtail kingfish and red snapper for all fishers (Commonwealth and State) in inshore and offshore waters relevant to Tasmania. This measure was introduced to limit the potential for expansion of effort directed at these species. A bag and possession limit of five striped trumpeter was also introduced for recreational fishers.

The legal minimum size limit for striped trumpeter was raised from 35 to 45 cm total length (TL) in November 2004 in recognition that the smaller size limit was substantially below the size at maturity. The recreational bag limit was also replaced with a possession limit of 8 fish.

5.3 Stock Structure and Life-history

Striped trumpeter are distributed throughout southern Australia, from Sydney around to Kangaroo Island in South Australia and including Tasmania. The species is also found in New Zealand, the St. Paul and Amsterdam Islands in the southern Indian Ocean, and

the Tristan da Cunha Group and Gough Island in the southern Atlantic Ocean. In 2001, a striped trumpeter tagged off the Tasman Peninsula in 1996 was recaptured off St. Paul Island in the Indian Ocean. Such large-scale movements suggest the potential for mixing between widely separated populations (Lyle and Murphy 2001).

Striped trumpeter occur mainly on the continental shelf over rocky bottom to depths of about 300 m, with juveniles associated with shallow inshore reefs. Since nothing is known of the stock structure in Australian waters and they are such a mobile species, a common stock throughout its range is assumed for management purposes.

Striped trumpeter are reported to grow to 1.2 m in length and 25 kg in weight (Gomon *et al*. 1994). Growth in juveniles is rapid, reaching a mean length of around 28 cm after two years and 42 cm after four years, with most growth occurring during summer and autumn (Murphy and Lyle 1999, Tracey and Lyle 2005). Older fish grow significantly more slowly, with a large range in size-at-age for fish over about 50 cm. Maximum age is currently estimated to be 43 years (Tracey and Lyle 2005) and, while this has yet to be fully validated, the incremental structure in sectioned otoliths is clear and unambiguous.

There is limited knowledge about the life history of striped trumpeter. Spawning occurs from July to early October, depending on geographical location (Ruwald *et al.* 1991), with spawning commencing and finishing earlier at lower latitudes. Hutchinson (1994) reported that females reach maturity at a smaller size and age (44 cm and 5 years) than males (53 cm and 8 years). However, more recent data suggest that size at 50% maturity in females is in fact somewhat larger, around 54 cm (S. Tracey, TAFI pers. comm.). Striped trumpeter are multiple spawners, highly fecund (100,000 to 400,000 eggs for females weighing 3.2 and 5.2 kg, respectively) and produce small pelagic eggs (1.3 mm diameter) with a single oil droplet (Ruwald *et al.* 1991, Ruwald 1992, Hutchinson 1994). Larval rearing trials indicate a complex and extended larval phase, with a post-larval 'paperfish' stage of up to nine months prior to settlement. The distribution of larvae and recruitment processes have not been studied.

While no information is available on the size and timing of settlement, juveniles of around 18 cm fork length (FL) have been caught on shallow reefs off the southeast coast in January (Murphy and Lyle 1999). Tagging studies suggest that juveniles tend to remain around shallow reefs for several years, with only limited movement, before moving into deeper offshore reefs. This pattern is supported by data from the commercial fishery that shows fish do not recruit to the offshore hook fishery until about 45 cm (Lyle and Jordan 1999).

Recruitment is highly variable, with evidence of a particularly strong year class spawned in 1993 (Murphy and Lyle 1998) and indications of good recruitment from the 1994 and 1996 cohorts. Recruitment in intervening years has apparently been poor (based on anecdotal reports of low numbers or absence of juvenile fish observed associated with inshore reefs).

5.4 Previous Assessments

Previous assessments have been largely limited to the examination of catch, effort and catch rate trends, and reporting against performance indicators (trigger points). Catch performance indicators were triggered in 2001/02 and 2002/03, with catches below

reference levels. Dropline effort exceeded the reference trigger in 2002/03 and dropline catch rates have been below trigger levels since 2001/02. Yield per recruit analysis was undertaken for the 2003 assessment and indicated that the minimum size limit of 35 cm (TL) was sub-optimal and by raising the size limit potential yield would be increased. The minimum size limit was raised to 45 cm TL in November 2004.

5.5 Current Assessment

The current assessment examines trends in catch, effort and catch rate for the primary fishing methods, namely dropline, handline and graball net.

Limited research sampling (handline) was undertaken during 2004 and size composition data are compared with similar commercial data collected since 1999. In addition, yield and spawner biomass per-recruit analyses have been undertaken.

Data presented for this assessment have been evaluated against performance indicators specified in the scalefish management plan and detailed in Section 1.3.

5.5.1 Catch

The recent catch history in waters south of latitude 39° 12'S (i.e. waters incorporated within the OCS agreement for striped trumpeter), including catches reported in Victorian and Commonwealth logbooks, is presented in Table 5.1. In the early 1990s catches by Victorian vessels were significant, peaking at around 37 tonnes. Since the mid 1990s, data from this sector have been unavailable; though it is assumed that subsequent catches have been reported in Commonwealth logbooks. Apart from 1999/00 when over 14 tonnes was taken, Commonwealth catches have been relatively low. Data for Commonwealth vessels has been unavailable since 2001/02, though dual endorsed operators are now required to report trumpeter catches in the Tasmanian logbook.

Annual production was high at the beginning of the 1990s (due partly to relatively high catches taken by Victorian vessels) at over 110 tonnes but then fluctuated generally between 70-80 tonnes through the early to mid-1990s before increasing to over 100 tonnes by the late 1990s (Table 5.1). Between 1999/00 and 2000/01 catches almost halved, to less than 50 tonnes, and have remained low since that time. The reported catch of 36 tonnes for 2003/04 was virtually unchanged compared with the previous year and represented the second lowest catch reported since the late 1980s.

Catches by the primary fishing methods are presented in Fig. 5.1A. The most conspicuous trend was the initial increase in production for all methods up until 1999/00, followed by general declines in catches for graball and handline methods. Dropline catches also followed this trend although have increased slightly over the past two years.

Strong 1993 and 1994 year-classes entered the fishery between 1995/96 and 1997/98 and influenced subsequent catches (and catch rates). There is circumstantial evidence to suggest that the 1996 year-class was also relatively strong and would have recruited to the inshore gillnet fishery in 1998/99. The subsequent decline in graball catches

since 1998/99 presumably reflects the movement of the strong year-classes offshore but also suggests that there has been limited recruitment in recent years. The 250 kg trip limit for commercial operators is likely to have contributed to the fall in dropline and handline catches since 2000/01. Industry representatives suggest that the trip limit has represented a strong disincentive for some operators to fish for the species.

A recent estimate of the recreational take of striped trumpeter (48 tonnes in 2000/01) indicates that the recreational catch may well be comparable to the commercial catch and, therefore, a significant component of the overall fishery. The introduction of a voluntary logbook for the charter boat sector during 2003 should provide on-going catch information and may have some potential as an indicator of trends in the broader recreational fishery.

Table 5.1. Annual catches of striped trumpeter (tonnes) south of latitude 39° 12'S.
Based on Tasmanian (General Fishing Return), Victorian and Commonwealth catch returns.

	Catch (tonnes)			
Year	*Tasmanian*	*Victoria*	*Commonwealth*	*Combined*
1990/91	74.5	37.1		111.6
1991/92	58.2	36.8		95.0
1992/93	52.7	19.8		72.5
1993/94	56.5	16.0		72.5
1994/95	72.4	14.6		87.0
1995/96	60.3			60.3
1996/97	79.7		0.7	80.4
1997/98	75.4		5.7	81.1
1998/99	98.4		8.9	107.4
1999/00	86.3		14.5	101.8
2000/01	41.2		7.5	49.6
2001/02	40.0			40.0
2002/03	35.9			35.9
2003/04	36.0			36.0

Evaluation of 2003/04 catches against performance indicator

- State-wide catch was essentially unchanged compared with 2002/03 and well below the reference catch range; the catch performance indicator was therefore triggered.

5.5.2 Fishing effort

During the latter part of the 1990s, effort for the major fishing methods increased, presumably linked to the increased availability of striped trumpeter (Fig. 5.1B&C). Since then effort has generally declined (gear units and days fished) for graball and

handline and hook lifts for dropline. Despite less gear being used the relative number of days fished by dropliners has remained high, suggesting that fishers have tended to use less gear for each day fished in the later years, possibly in response to the trip limit. However, an examination of catch records suggests some inconsistency between fishers in how effort based on gear units has been reported and thus the situation may be more complex than suggested by the data.

Evaluation of 2003/04 effort against performance indicator

- Handline and graball effort were below reference levels. Despite being lower than during 2002/03, dropline effort (days fished) was still effectively 10% higher than the peak level during the reference period and therefore the effort performance measure was triggered for the second year.

5.5.3 Catch rates

Graball catch rates have increased steadily since 1990/91, despite declining catches during the latter half of the period (Fig. 5.1D&E). Catch rates (based on gear units) for the hook methods have also increased slightly since the late 1990s. This trend was evident for daily catch rates for handline fishing but was reversed for droplines, with daily catch rates declining to less than half reference levels by 2001/02 and then stabilising at this low level. It is unclear why the two hook methods exhibit such different trends but given the general decline in catches even in the face of high market demand, increases in catch rates for some methods at least, seem counterintuitive. The influence of the trip limit on catch rates (daily catches) is unclear, although logbook data suggest that few operators would have been affected by the trip limit, at least on the basis of trips of a single day's duration (i.e. daily catch rates rarely exceeded 250 kg).

Evaluation of 2003/04 catch rate against performance indicator

- Catch rates for handline and graball net effort were above reference values. By contrast, dropline catch rates were below 80% of the lowest reference level and triggered the catch rate performance indicators for the fifth year in a row.

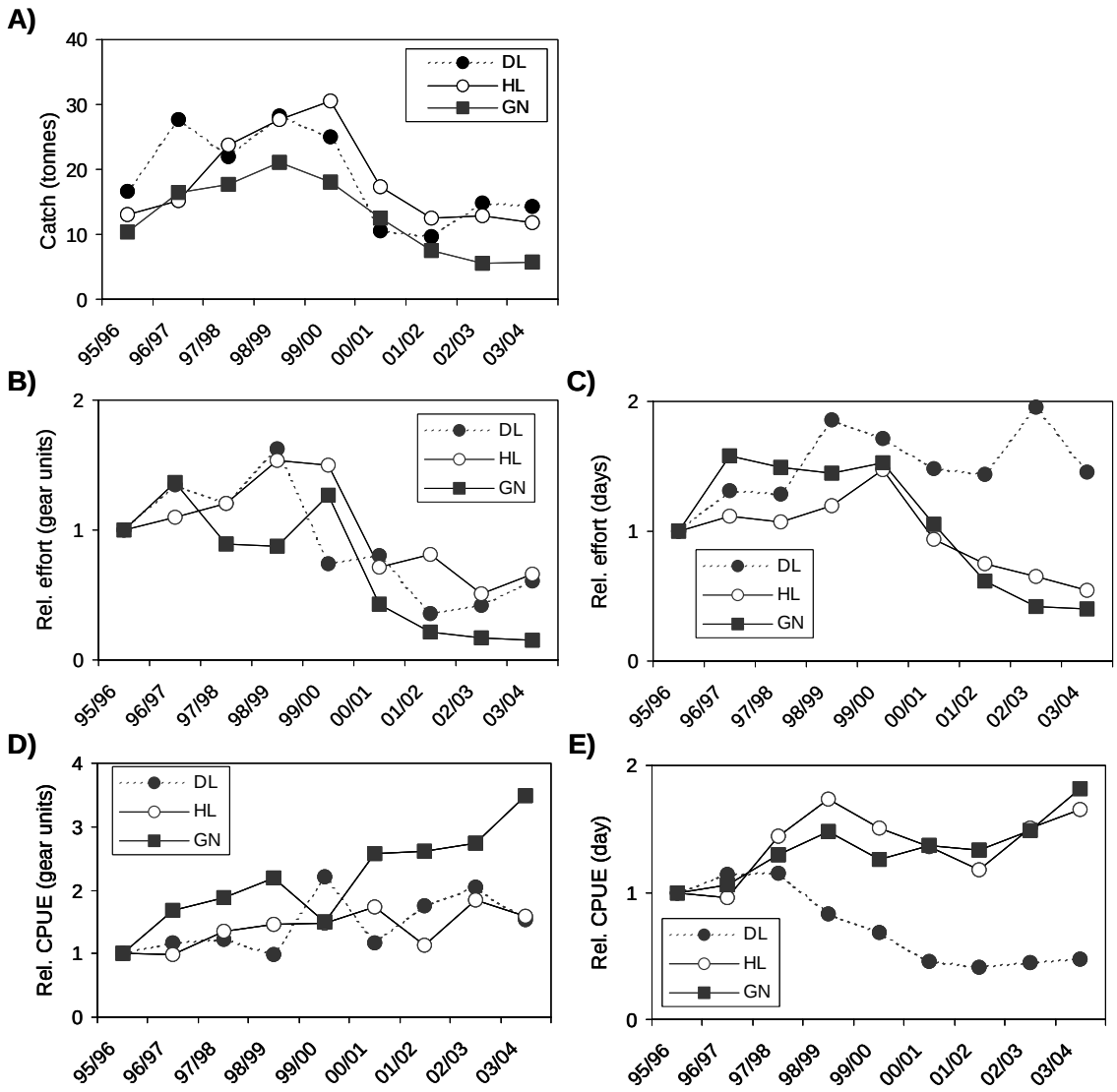


Fig. 5.1. A) Annual catch (tonnes) of striped trumpeter by method since 1995/96; B) effort by method based on gear units (refer Table 2.3) and expressed relative to 1995/96; C) effort based on days fished and expressed relative to 1995/96; D) catch per unit effort based on weight per gear unit (refer to Table 2.3) and expressed relative to 1995/96; and E) catch per unit effort based on weight per day fished and expressed relative to 1995/96. DL is dropline, HL is handline and GN is graball.

5.5.4 Size composition

Size composition information obtained from research fishing and commercial catch sampling (hook catches) for 1999, 2002 and 2004 are presented in Fig. 5.2. In 1999, the sample was clearly dominated by fish in the 450-550 mm size range, 5 and 6 year olds (i.e. the strong 1993 and 1994 cohorts). The shift in the size structure towards larger fish in 2002 and 2004 is consistent with the growth of these cohorts over time. In 2002, the mode of fish measuring 500-520 mm is within the expected size range of the 1996 cohort (6 year olds), which was also thought to be relatively strong.

Of concern, however, is the lack of fish smaller than 500 mm in the 2004 sample, implying that recruitment has been poor over several years (noting that fish generally

recruit to the offshore hook fishery at around 450 mm (5 years of age). If in fact this is the case, adult biomass is expected to continue to decline and average size of hook-caught fish will increase in the short-term, at least until such time as there is a period of sustained good recruitment.

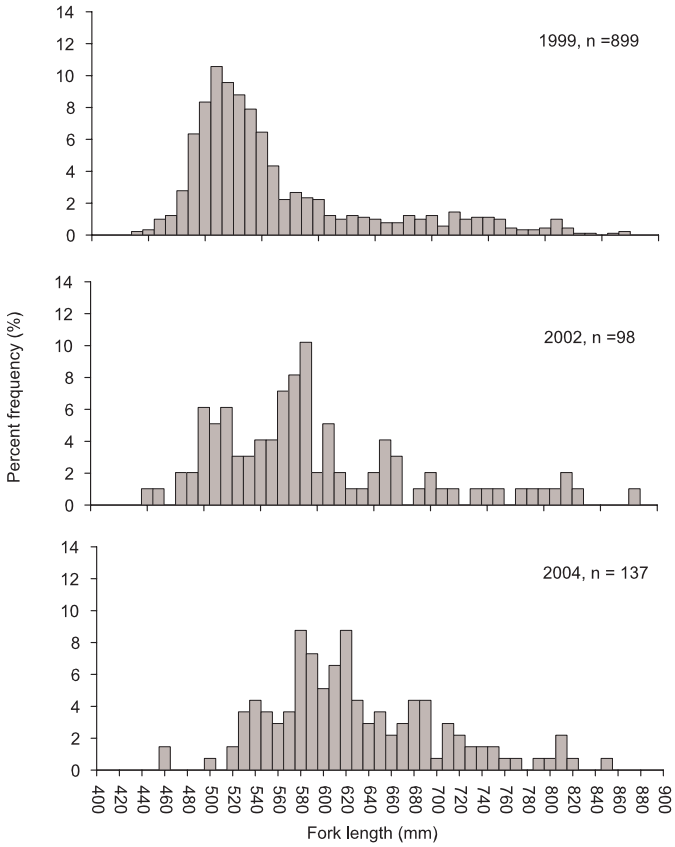


Fig. 5.2. Length frequency distributions of hook caught striped trumpeter collected in 1999, 2002, and 2004. Note the different sample sizes.

5.5.5 Spawner biomass and yield-per-recruit

Yield-per-recruit (YPR) analysis reported in the 2003 assessment indicated that maximum yield could be achieved if the size at first capture (minimum legal size) was above 450 mm (FL). This analysis did not, however, take account of the relationship between size at first capture and fishing mortality on potential mature spawner biomass. More recent information about size at maturity and fecundity in striped trumpeter (S. Tracey, unpublished data) has enabled spawner biomass per-recruit (SPR) analysis to be undertaken (using an estimate of natural mortality, M = 0.1) (Fig. 5.3). Based on fishing mortality (*F*) estimate of 0.15 (best estimate from Tracey and Lyle 2005) this analysis indicated that with the current minimum size limit of 450 mm TL (425 mm

FL) SPR was less than 20% of the unfished level. At a size at first capture of 550 mm FL (equivalent to the size at 50% maturity), SPR was just over 35% whereas at 600 mm FL this increased almost 50%. Under each of these scenarios, however, YPR was optimized at an *F* of approximately 0.15 (Fig. 5.3).

Internationally, *F* that results in 40% SPR has been adopted as a target reference point whereas *F* that reduces SPR to 30% or below is considered a recruitment overfishing limit. Based on these criteria and the assumptions about mortality rates, the current size limit would appear to be sub-optimal and there is still a risk of recruit overfishing in striped trumpeter.

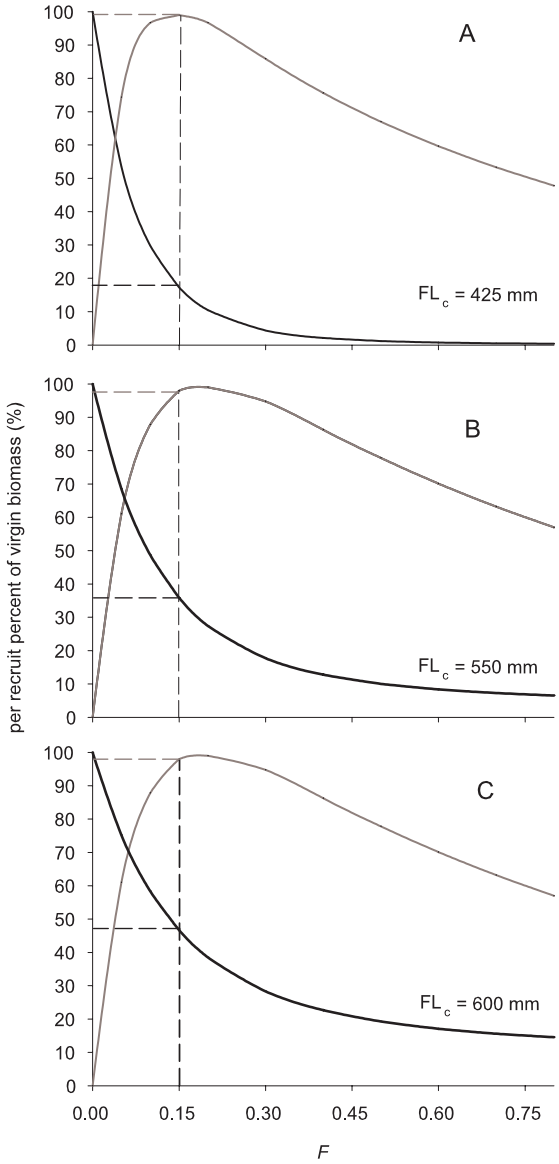


Fig. 5.3. Spawner biomass-per-recruit (dark line) and yield-per-recruit (grey line) for female striped trumpeter estimated with length at first capture of A) 425 mm FL (current size limit); B) 550 mm FL; and C) 600 mm FL. Dashed vertical lines represent best estimate of current fishing mortality (F =0.15) and horizontal lines represent corresponding estimates of percent spawner biomass and yield per recruit from the predictive curves.

5.6 Implications for Management

The sharp decline in catches since 2000/01 gives rise to concern about the current status of striped trumpeter stocks. As suggested in previous assessments, strong recruitment variability could result in marked variations in population size, especially if there is a prolonged period of poor recruitment, with the fishery becoming dependent upon relatively few year classes. If there has been poor recruitment as implied by the most recent catch and biological data, and the abundance of the mature stock has declined significantly, then catches are likely to remain depressed until there is a period of sustained good recruitment. Furthermore, if the decline in catches does represent a decline in abundance, then it is likely that fishing mortality is too high and may lead to recruitment over-fishing, a situation exacerbated by the minimum size limit still being set smaller than the size at maturity.

The impact of recent management changes, however, cannot be discounted as a contributing factor to the downturn in catches. Reduced incentives for fishers to target striped trumpeter due to the 250 kg trip limit appear to have been reflected in reduced handline effort over the past three years, though the recent increase in dropline effort goes against this trend. There is also concern that the decline in commercial catches may be due, in part at least, to changes in reporting requirements for Commonwealth operators. Although these operators have been requested to provide catch information in Tasmanian catch returns for species under Tasmanian jurisdiction (including striped trumpeter) and for fishing within state waters, this may not have routinely occurred. In fact industry reports suggest that some Commonwealth operators may have not even been reporting catches in their Commonwealth catch returns. There is an urgent need to resolve this matter with the Commonwealth and ensure that catch and effort information are comprehensive.

As commercial catches decline, it is likely that interest by the recreational sector will grow and there is evidence that this sector may already account for a significant component of the total mortality. There are anecdotal reports to support this trend and, in addition, the National Survey has demonstrated that the recreational take is at least comparable to the commercial catch (Lyle 2005).

The impacts of the recent increase in minimum size limit are yet to be felt in the fishery data but because of size structuring within the population (immature inshore/mature offshore), it is likely that few if any fish captured in the inshore gillnet catch will be of legal size and therefore a sharp decline in the graball catch can be expected in the near future.

Spawner biomass-per-recruit analyses imply that either fishing mortality needs to be reduced or that the minimum size limit should be increased further, noting that the current limit of 45 cm is still below the size at maturity at about 53-54 cm.

Although a more rigorous assessment is required to assess the sustainability of the fishery, the apparent lack of recent recruitment means the expectation is that this fishery is declining and will continue to do so without action.

5.7 Research Needs

The Scalefish Fishery Research Advisory Group has identified the need for research into stock assessment, recruitment variability and gear interactions as areas of high research priority for striped trumpeter.

There is an urgent need to characterize the commercial and recreational fisheries for this species in terms of size composition and age-structure. There is a need to refine life history and population parameters for striped trumpeter (including growth and mortality, reproductive biology, movements, etc) and examine the impacts of present and alternative harvest strategies.

Fishery independent gillnet surveys have the potential to assess the relative abundance/presence of pre-recruits which could be valuable in predicting and interpreting future catch trends.

6 Other key scalefish

6.1 Sea Garfish (*Hyporhamphus melanochir*)

6.1.1 Catch

The garfish catch has remained relatively stable since the early 1990s, at between 80-90 tonnes in most years (Table 2.1). The 2003/04 catch of 66 tonnes represented a fall of almost 28% compared with the previous year, being largely due to a reduction in the catch taken by beach seine rather than variability in dipnet catches (Fig. 6.1A). Beach seines represent the primary capture method and catch levels have varied only slightly since the mid 1990s with the exception of the current year. Following an initial expansion in dipnet catches to 1998/99 (34 tonnes), catches have declined slowly to 13 tonnes in the current year.

Regionally, the north east coast, including Flinders Island (blocks 3G4, 4G2, 4G4, 4H1, 4H3), has dominated catches with the south east coast (blocks 7G1, 7G2, ES17, ES18, ES19) of secondary importance in recent years (Fig. 6.1B). Declines in catches from both regions were the primary contributors to the overall fall in catches observed in 2003/04. There has been only limited variability in catches for the east coast (blocks 6G4, 6H1, ES13, ES14, ES15, ES16) and other regions.

Evaluation of 2003/04 catches against performance indicators

- Current catches were lower than in 2002/03 but remained within the reference catch range, indicating that the catch performance indicators were not triggered.

6.1.2 Fishing effort

Dipnet effort increased initially to a peak during 1998/99 but has subsequently declined (Fig. 6.1C & D). On the other hand, beach seine effort has fluctuated without obvious trend over time, with effort in the current year being similar to levels that persisted during the late 1990s.

Evaluation of 2003/04 effort against performance indicators

- Beach seine and dipnet effort were within or below the range for the reference period, indicating that effort performance indicators were not triggered.

6.1.3 Catch rates

Beach seine and dipnet catch rates have been relatively stable over the past 4-5 years, the former being slightly higher than during the mid-1990s (Fig. 6.1E & F). However,

for schooling species such as garfish, catch rates may be relatively insensitive to changes in abundance.

Some industry members have expressed concerns about the effects of dipnets on the schooling behaviour of garfish. Specifically, it has been suggested that intensive dipnet activity tends to cause schools to break up, which could reduce opportunities to use beach seines to target the species and even impact on beach seine catch rates. In regard to the latter, there was no evidence of a decline in beach seine catch rates as dipnet effort increased, though such impacts may have been localised and masked in this broad-scale analysis.

Evaluation of 2003/04 catch rates against performance indicator

- Beach seine and dipnet catch rates have not triggered performance indicators.

6.1.4 Implications for management

The reason for the decline in production is uncertain but it can be linked to reduced effort levels. The fishery data provide no evidence to support concern over garfish stock status. There remains, however, potential for effort to expand, particularly within the dipnet sector.

While it is not known whether present catch levels are sustainable, it would be prudent to consider management options that limit further expansion in this fishery.

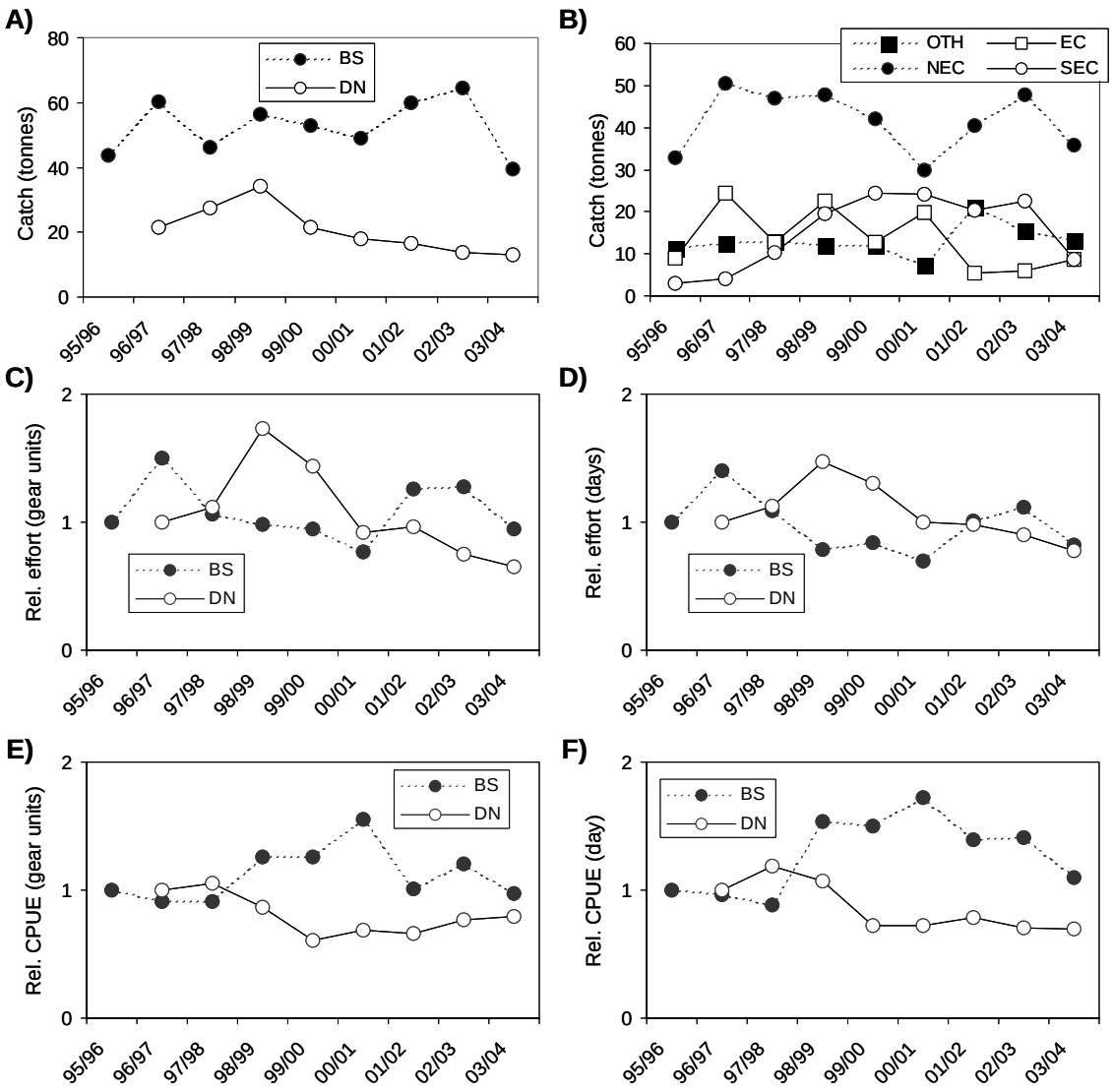


Fig. 6.1 A) Annual catch (tonnes) of garfish by method since 1995/96; B) annual catch (tonnes) of garfish by region since 1995/96; C) effort based on gear units (refer Table 2.3) and expressed relative to 1995/96 for BS and 1996/97 for DN; D) effort based on days fished and expressed relative to 1995/96 for BS and 1996/97 for DN; E) catch per unit effort based on weight per gear unit (refer to Table 2.3) and expressed relative to 1995/96 for BS and 1996/97 for DN; and F) catch per unit effort based on weight per day fished and expressed relative to 1995/96 for BS and 1996/97 for DN. BS is beach seine and DN is dip net; NEC is north east coast, EC is east coast, SEC is south east coast, OTH is all remaining areas (refer to text for definitions).

6.2 Wrasse (Fam. Labridae)

6.2.1 Catch

Several species of wrasse occur in Tasmanian waters with purple wrasse (*Notolabrus fucicola*) and blue-throat wrasse (*N. tetricus*) the main species taken commercially. Wrasse are targeted for the live fish markets as well as being sold as dead product and utilised as bait for rock lobster (bait usage is possibly under-reported). Fish marketed live are distinguished in the logbooks. Over the past four years 'live' wrasse have accounted for between 66-76% of the total catch, and thus trends in the live-fish fishery will ultimately be reflected in overall production levels. The two species of wrasse are not routinely distinguished in catch returns.

Between 1997/98 and 2001/02, wrasse catches were relatively stable at between 85-100 tonnes; over the past two years catches have declined to just over 70 tonnes and as such are just below the lower reference level (Table 2.1 and Fig. 2.1). Live-fish markets have apparently contracted slightly, due in part to competition from other live fish species and this may have impacted on the magnitude of the live fish catch (53 tonnes of wrasse in 2003/04).

Handline and fish trap represent the primary capture methods for wrasse (Fig. 6.2A), with blue-throat wrasse more susceptible to line methods and purple wrasse more vulnerable to trap capture. On this basis it would appear that purple and blue throat wrasse have been taken in roughly equal quantities in the live fishery over the past few years. Gillnets account for the bulk of the remaining catch but because survival in nets is poor, graball caught wrasse are rarely marketed live. Handline catches fell in 2002/03 and remained at similar levels in the current year, a factor that appears to be the primary cause of the relatively low overall catch during 2003/04. The trap catch increased slightly in 2003/04 while there was little change in the graball catch.

Since the mid 1990s the focus of the fishery has shifted from the southeast (blocks 7F3, 7F4, 7G1, 7G2, 7G3, 7H1) to the east coast (blocks 5H1, 5H3, 6G4, 6H1, 6H3, ES13, ES14, ES15, ES16) (Fig. 6.2B). Catches from the north east coast, including Flinders Island (blocks 3F1, 3F2, 3G1, 3G2, 3G3, 3G4, 3H3, 4G2, 4G4, 4H1, 4H3), increased up to 2001/02 but have fallen over the past two years. There was comparative stability in catches from the north west coast (4E1, 4E3, 4E4, 4D1, 4D2, 4D4, 5D2) along with a sharp increase in catches from remaining areas (OTH in Fig. 6.2B) during 2003/04, particularly influenced by catches from around King Island. The underlying drivers for the regional shifts in the fishery have not been investigated but may relate to fishers entering and exiting the fishery and/or species availability and market influence, noting that while there is an apparent market preference for blue-throat wrasse, purple wrasse are more robust for live handling.

Evaluation of 2003/04 catches against performance indicators

- Current State-wide catch was similar to the previous year but outside (below) the reference catch range; therefore the catch performance indicator was triggered for the second year running.

6.2.2 Fishing effort

Fish trap and handline effort increased initially but stabilised since 2000/01 at levels comparable to or below that reported in the mid-1990s (Fig. 6.2C&D). Gillnet effort generally declined from the mid-1990s, to about half of the 1995/96 level by 2003/04.

Evaluation of 2003/04 effort against performance indicator

- Trap and handline effort were either within or slightly below reference levels, and therefore did not trigger the effort performance indicators.

6.2.3 Catch rates

Since the mid 1990s, catch rates based on gear units for handline (kg per line hour) have remained stable whereas trap catch rates (kg per trap lift) have increased, particularly over the past three years (Fig. 6.2E &F). Daily catch rates for handline and trap generally increased over the same period, implying that handline fishers tended to exert greater effort for each day fished. Daily catch rates, however, fell to mid-1990s levels in 2003/04 for both methods. Graball catch rates have exhibited very little variation over time, presumably reflecting the fact that wrasse tend to be taken incidentally rather than targeted by this method.

Catch rate trends imply that stocks of both wrasse species have not been impacted significantly by the fishery. However, these broad-scale analyses are insensitive to changes in abundance at the level of individual reefs at which the fishery impacts on the fish populations. In fact, there is evidence on some east coast reefs that exploitation rates of legal sized purple wrasse are extremely high (Ewing 2004). The marked regional shifts that have occurred in the fishery may also mask localised depletions, with fishers moving to new or lightly fished areas to maintain catches. As a consequence, caution needs to be exercised when making inferences about the status of the wrasse stocks though key fishery indicators do not suggest significant fishery impacts.

Evaluation of 2003/04 catch rates against performance indicator

- Catch rate performance indicators were not triggered.

6.2.4 Implications for management

While input controls (limited entry) have capped participation in the live wrasse fishery, it is unknown whether current effort levels are sustainable. Under present arrangements, there is potential for localised depletions, especially if effort becomes concentrated in particular regions. There is already evidence for a concentration of catch and effort off the east coast.

The minimum size limit provides good protection (several years post size at maturity) for purple wrasse and for female blue-throat wrasse. The limit does not, however, provide the same level of protection for male blue-throat wrasse because males are

derived from mature females, typically at sizes after they have entered the fishery. This coupled with the fact that males are strongly site attached and have higher catchability (being more aggressive than females) suggests that they are vulnerable to over-fishing. In extreme situations it is possible that localised heavy fishing pressure could result in 'sperm shortage' that would affect spawning success even though there may be a robust population of mature (sub-legal size) females present. The removal of the maximum size limit may have exacerbated this potential problem.

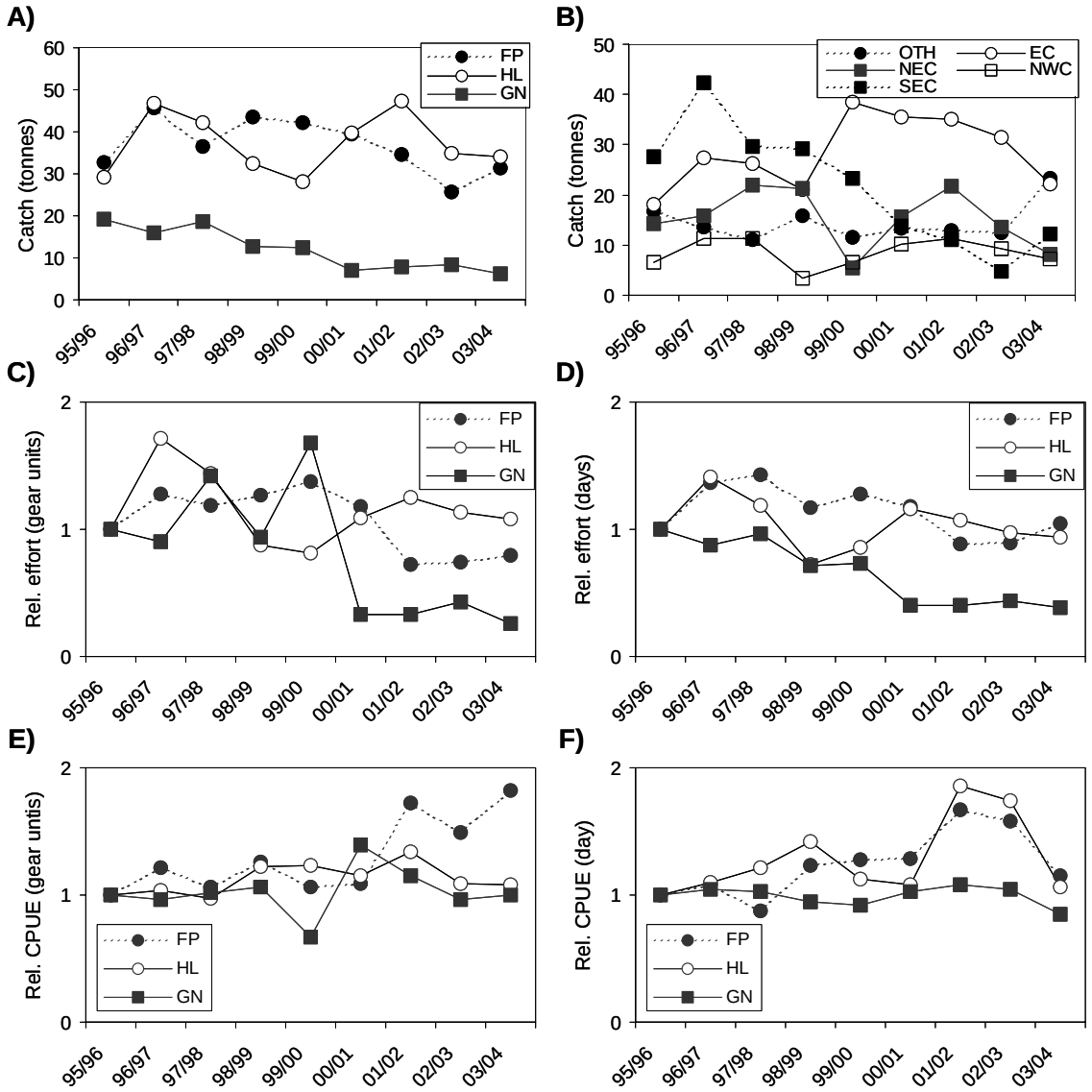


Fig. 6.2 A) Annual catch (tonnes) of wrasse by method since 1995/96; B) annual catch (tonnes) of garfish by region since 1995/96; C) effort based on gear units (refer Table 2.3) and expressed relative to 1995/96; D) effort based on days fished and expressed relative to 1995/96; E) catch per unit effort based on weight per gear unit (refer to Table 2.3) and expressed relative to 1995/96; and F) catch per unit effort based on weight per day fished and expressed relative to 1995/96. FP is fish trap. HL is handline and GN is graball net; NEC is north east coast, EC is east coast, SEC is south east coast, NWC is north west coast and OTH is all remaining areas (refer to text for definitions).

6.3 Blue warehou (*Seriolella brama*)

6.3.1 Catch

Recent studies have indicated that there are two stocks of blue warehou in Australian waters, east and west of Bass Strait. The fishery for blue warehou in Tasmanian waters is centred off the southeast coast and thus probably targets the eastern stock. Catches are also taken off the northeast and northwest coasts, the latter potentially involving the western stock.

Blue warehou occur seasonally in Tasmanian inshore waters, the region representing the southern-most extent of the species' distribution. Traditionally, the availability of blue warehou in coastal waters has assumed to be influenced by prevailing oceanographic conditions and availability of prey species. These factors combine to produce marked inter-annual variability in abundance and hence catches taken from state waters, as demonstrated in Fig. 2.1. The current catch of 27 tonnes represented a 55% reduction compared to the previous year, and was the lowest catch reported since the mid-1980s. The species is taken primarily in graball nets, with a range of other capture methods used, including other gillnet categories (small mesh and shark net) and seine nets (Fig. 6.3A). Significantly, in 2001/02 about half the catch was taken by beach seine off the northeast coast and in many respects this was unusual, with fishers reporting the presence of large schools of fish off some beaches.

Recreational fishers also target the species using gillnets and to a lesser extent line fishing. The estimated recreational harvest in 2000/01 was just 16 tonnes (Lyle and Henry 2003), substantially lower than recreational catches taken in 1997 and 1998 (Lyle 2000) but consistent with the depressed state of the commercial catches.

Evaluation of 2003/04 catches against performance indicator

- Current state-wide catch was reduced by 55% compared to the previous year and was outside (below) the reference catch range; therefore both catch performance indicators were triggered.

6.3.2 Fishing effort

Graball effort increased sharply between 1995/96 and 1998/99, resulting in increased catches over this period, but has since fallen and stabilised at a low level, largely in response to the reduced availability of the target species.

Evaluation of 2003/04 effort against performance indicator

- Graball effort exhibited a modest increase in the current year but remained at a low level, indicating that the effort performance indicator was not triggered.

6.3.3 Catch rates

Since blue warehou are taken as a target species as well as by-product of gillnetting, catch rates have been estimated for the total fishery as well as the target fishery. In order to distinguish targeted catches, fishing on a given day was assumed to be targeted if:

- the catch of blue warehou was greater than 10 kg and accounted for at least half of the total weight of all species retained; or
- the catch of blue warehou was greater than or equal to 50 kg.

Total and targeted catch rates increased markedly between 1995/96 and 1998/99 in response to the increased availability of warehou around Tasmania (evidenced by increased catches) (Fig. 6.3C&D). However, since then catch rates have declined to levels similar to the mid-1990s (total), or to below the previous minimum value (targeted).

Evaluation of 2003/04 catch rates against performance indicators

- During 2003/04 the targeted catch rate was less than 80% of the minimum reference level and therefore activated the catch rate trigger.

6.3.4 Implications for management

Blue warehou are a Commonwealth managed species and an MOU exists to cover catches from Tasmanian State Fishing Waters. Within the context of this MOU, State catches of blue warehou are to be managed within historic levels.

The 2002 South East Fishery stock assessment for blue warehou concluded that the blue warehou stocks have experienced a serious decline since the early 1990s and that a stock rebuilding strategy is required (Smith and Wayte 2002). In the absence of significant rebuilding through recruitment, catches of blue warehou are expected to be poor for the foreseeable future. The total allowable catch (TAC) for the Commonwealth fishery has been set at 300 tonnes per year since 2003, down from over 2,000 tonnes in late 1990s, reflecting concerns over stock status.

A range of environmental factors, as well as stock size, influences the availability of blue warehou in Tasmanian inshore waters. Recent depressed catches are almost certainly linked to reduced biomass, the result of overfishing by Commonwealth and state fisheries during the 1990s and in the absence of significant rebuilding catches are likely to remain low.

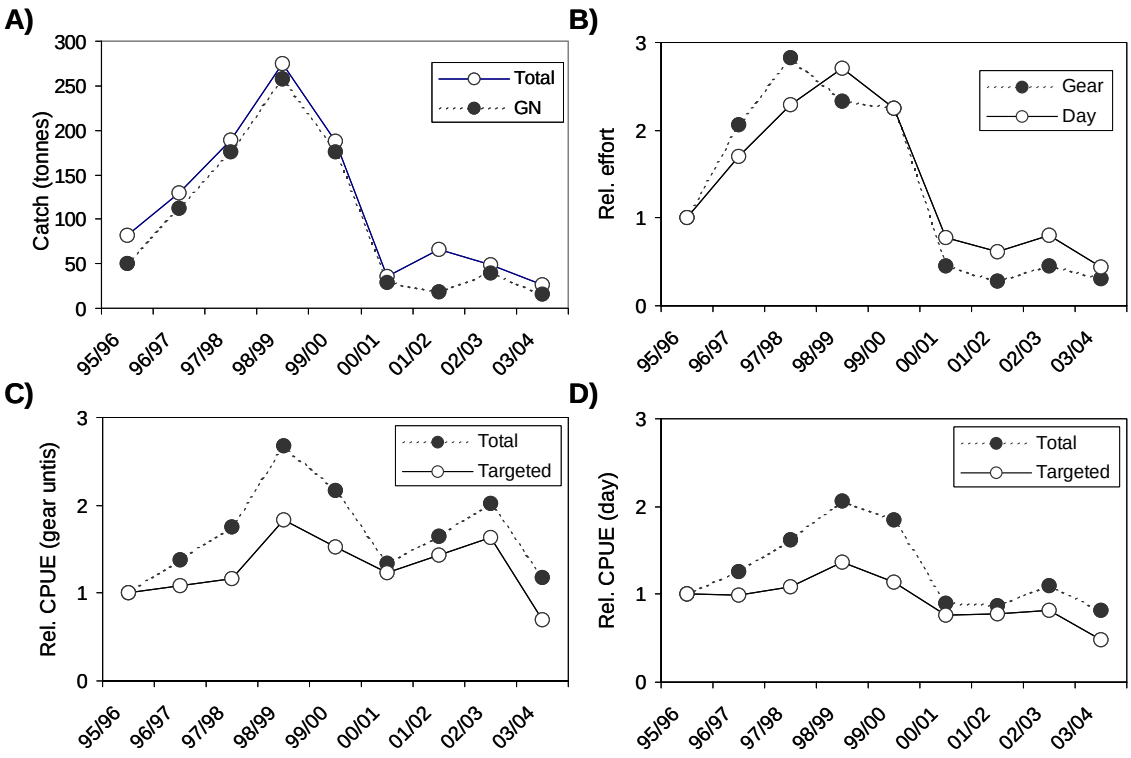


Fig. 6.3 A) Annual catch (tonnes) of blue warehou by method since 1995/96; B) graball effort based on gear units (Gear - refer Table 2.3) and days fished (Day) and expressed relative to 1995/96; C) graball catch per unit effort based on weight per gear unit (refer to Table 2.3) for total and targeted catches and expressed relative to 1995/96; and D) graball catch per unit effort based on weight per day fished for total and targeted catches and expressed relative to 1995/96. In A) total is all methods combined and GN is graball net.

6.4 Bastard trumpeter (*Latridopsis forsteri*)

6.4.1 Catch

Bastard trumpeter catches have declined steadily since the mid 1990s (Table 2.1, Fig. 6.4A), the 2003/04 catch of 22 tonnes being only slightly higher than the lowest catch (2002/03) since the late 1980s. Bastard trumpeter are taken almost exclusively by graball (Fig. 6.4A).

The species has significance to recreational fishers, with an estimated 43 tonnes taken in 2000/01, almost double the size of the commercial catch for the corresponding period. Industry and recreational representatives have expressed concerns about the scarcity of the species in recent years.

Evaluation of 2003/04 catches against performance indicators

- The current year's catch represented only a minor improvement over the previous year and was outside (below) the reference catch range; therefore the catch performance indicator was triggered for the fourth year running.

6.4.2 Fishing effort

Graball effort for bastard trumpeter has declined steadily since the mid 1990s and was slightly lower during 2003/04 than the previous year (Fig. 6.4B).

Evaluation of 2003/04 effort against performance indicators

- Graball effort was at its lowest level since 1995/96 and did not trigger the effort performance indicator.

6.4.3 Catch rates

Gear and daily based catch rates have varied little over time although they did exhibit an increase compared with 2002/03 (Fig. 6.4C). The lack of an obvious trend, despite the sharp decrease in catches over time, presumably reflects the fact that bastard trumpeter are taken primarily as by-product rather than as a target species.

Evaluation of 2003/04 catch rates against performance indicator

- Catch rates were within or above reference values and therefore the catch rate performance indicator was not triggered.

6.4.4 Implications for management

Catch rates are probably a poor indicator of stock status for bastard trumpeter since the species is largely taken as a by-product and total catch may be a better indicator of abundance/availability. As such, trends in commercial production suggest that current inshore populations are at historically low levels.

Two aspects of bastard trumpeter life history have bearing on the fishery. Firstly, the fishery is based almost entirely on juveniles. As the fish grow they appear to move offshore and are rarely caught. Secondly, the species exhibits strong variability in recruitment that can result in short-term variability in catches and such variability has been a feature of the fishery over the past century (Harries and Croome 1989). Anecdotal reports suggest that recruitment levels have not been high in recent years. Whilst juvenile biomass may vary widely due to recruitment variability and fishing pressure, we have no information regarding adult biomass because fish that evade the inshore fishery are subject to very low levels of fishing pressure. However, the fact that the commercial and recreational fishery is based on juveniles gives rise to the possibility of recruitment overfishing as well as growth overfishing. Increasing the minimum size limit to above the size at maturity, which appears to be greater than 50 cm FL, would be beneficial to the stock but would also effectively close down the current commercial and recreational fisheries for the species.

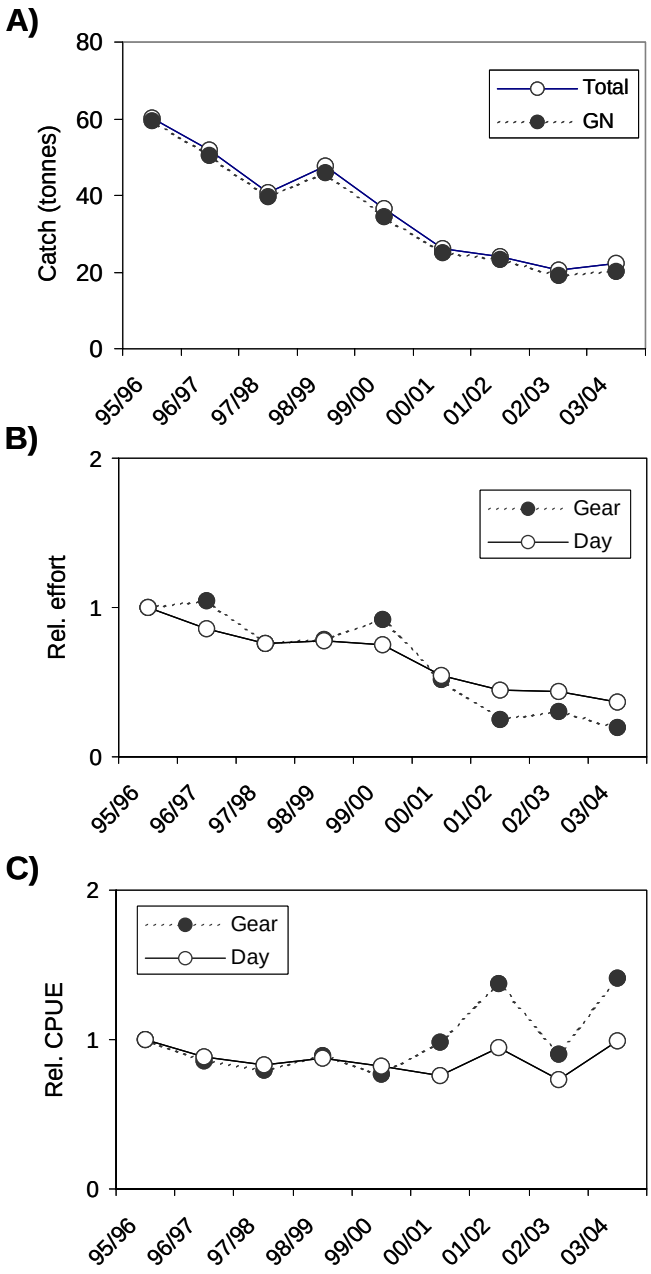


Fig. 6.4 A) Annual catch (tonnes) of bastard trumpeter by method since 1995/96; B) graball effort based on gear units (Gear - refer Table 2.3) and days fished (Day) and expressed relative to 1995/96; C) graball catch per unit effort based on weight per gear unit (Gear) and weight per day fished (Day) and expressed relative to 1995/96. Total is all methods combined and GN is graball net.

6.5 Australian salmon (*Arripis* spp.)

6.5.1 Catch

The commercial catch of Australian salmon of 167 tonnes in 2003/04 was 58% lower than in the previous year (Table 2.1) and the lowest reported since the 1980s. Beach seines account for the bulk of the catch (Fig. 6.5A).

Australian salmon represent the second most commonly caught species in the recreational fishery, with an estimated harvest of 111 tonnes in 2000/01 (Henry and Lyle 2003).

Evaluation of 2003/04 catches against performance indicator

- Current State-wide catch declined by greater than 30% compared with 2002/03 and was outside (below) the reference catch range; indicating that both catch performance indicators were triggered.

6.5.2 Fishing effort

There has been a recent decline in beach seine effort that presumably contributed to the marked fall in the catch (Fig. 6.5B).

Evaluation of 2003/04 effort against performance indicator

- Beach seine effort had fallen to the lowest level since the mid-1990s and therefore the effort performance indicator was not triggered.

6.5.3 Catch rates

Beach sine catch rates during 2003/04 were about 84% (gear based) and 74% (daily catch rate) of the minimum levels reported the reference period and only slightly higher than 2002/03 (Fig. 6.5C). It should be noted, however, that catch rate estimation is influenced by the extremely skewed nature of the data, i.e. the majority of catches are small but the total catch is influenced by a relatively small number of extremely large catches. In this respect, the geometric mean approach to calculating catch rates may provide biased estimates and, in any case catch rates are not a particularly sensitive indicator for a schooling species such as Australian salmon.

Evaluation of 2003/04 catch rates against performance indicator

- Daily beach seine catch rates were less than 80% of the lowest level reported during the reference period and thus the catch rate performance indicator was triggered.

6.5.4 Implications for management

Australian salmon catches are, to a large extent, linked to market demand, specifically the bait market, and are thus not a good indicator of stock status. The recent drop in catches is believed to be due to reduced market demand and not evidence for a fishery collapse. There is, however, capacity for industry to significantly expand production should new markets be found (there is interest in developing export markets) and under such circumstances management may need to be proactive in moderating such expansion.

Australian salmon have commercial and recreational significance across several other southern states and thus a coordinated approach to management of stocks across jurisdictions would have the advantage to minimising potential conflicts, especially if there is a change in the market situation.

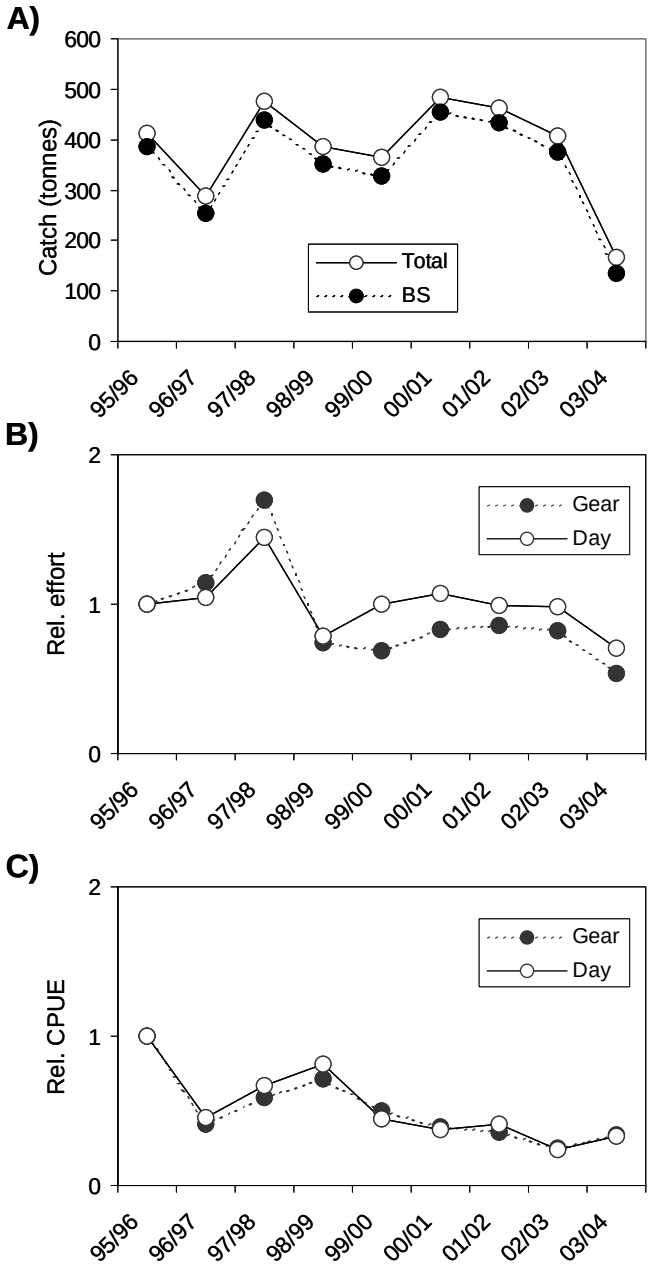


Fig. 6.5 A) Annual catch (tonnes) of Australian salmon by method since 1995/96; B) beach seine effort based on gear units (Gear - refer Table 2.3) and days fished (Day) and expressed relative to 1995/96; C) beach seine catch per unit effort based on weight per gear unit (Gear) and weight per day fished (Day) and expressed relative to 1995/96. Total is all methods combined and BS is beach seine.

6.6 Flounder (Fam. Pleuronectidae)

6.6.1 Catch

Several species of flounder occur in Tasmanian waters, but catches are dominated by greenback flounder (*Rhombosolea tapirina*) and to a lesser extent long-snouted flounder (*Ammotretis rostratus*).

Flounder catches declined steadily from over 40 tonnes p.a. during the mid 1990s to around 10 tonnes in 2000/01 and have remained low ever since (Table 2.1). The current catch of 15 tonnes represented almost a 50% increase over 2002/03 but was still well below reference catches. Graball ('flounder') nets and spears represent the primary fishing methods for flounder and declines in catches were evident for both methods (Fig. 6.6A).

The estimated recreational catch of flounder in 2000/01 of 21 tonnes was double the size of commercial catch for the corresponding period, indicating the importance of the recreational component of this fishery (Lyle 2005).

Evaluation of 2003/04 catches against performance indicator

- Current State-wide catch represented an increase compared to 2002/03 but was still outside (below) the reference range; triggering the catch performance indicator for the sixth year running.

6.6.2 Fishing effort

Graball effort for flounder has declined steadily since 1995/96 whereas spear effort increased initially, fell over a period of several years up to 2000/01 and then tended to increase (Fig. 6.6B&C). During 2003/04, spear effort based on gear units was comparable to levels during the reference period whereas days fished remained well below reference levels, implying that fishers exerted more effort (spear hours) for each day fished.

Evaluation of 2003/04 effort against performance indicator

- Graball and spear effort remained at or below reference levels and did not trigger the effort performance indicator.

6.6.3 Catch rates

The measure of catch rate used influences the underlying trends exhibited (Fig. 6.6D&E). Graball catch rates based on gear units have tended to increase over time whereas daily catches have declined to about 65% of the minimum level during the reference period. In effect this suggests that fishers are deploying less gear on average for each day fished. Spear catch rates on the other hand have declined based on spear

hours, with 2003/04 representing the lowest rates reported since the mid-1990s (about 68% of the lowest reference value). Daily catches, on the other hand, varied little over time and infer that fishers are having to fish for longer periods each day to maintain catch levels.

Evaluation of 2003/04 catch rates against performance indicator

- Spear catch rates based on hours fished and daily catches for graball nets were less than 80% of the lowest reference levels and therefore triggered the performance indicator. Graball catch rates based on catch per 100-m net hour and daily catches for spear were, however, either higher or within reference levels and therefore imply some uncertainty as to how effectiveness of catch rates as an indicator of stock status.

6.6.4 Implications for management

Industry members have commented that while there have been declines in flounder stocks, there have also been changes in the markets for the species that have impacted on the amount of effort directed at flounder.

The current status of the flounder stocks is unknown, but it appears that they have declined in recent years. Recreational catches of flounder clearly represent a significant component of the harvest and trends in that fishery may be more informative of stock condition.

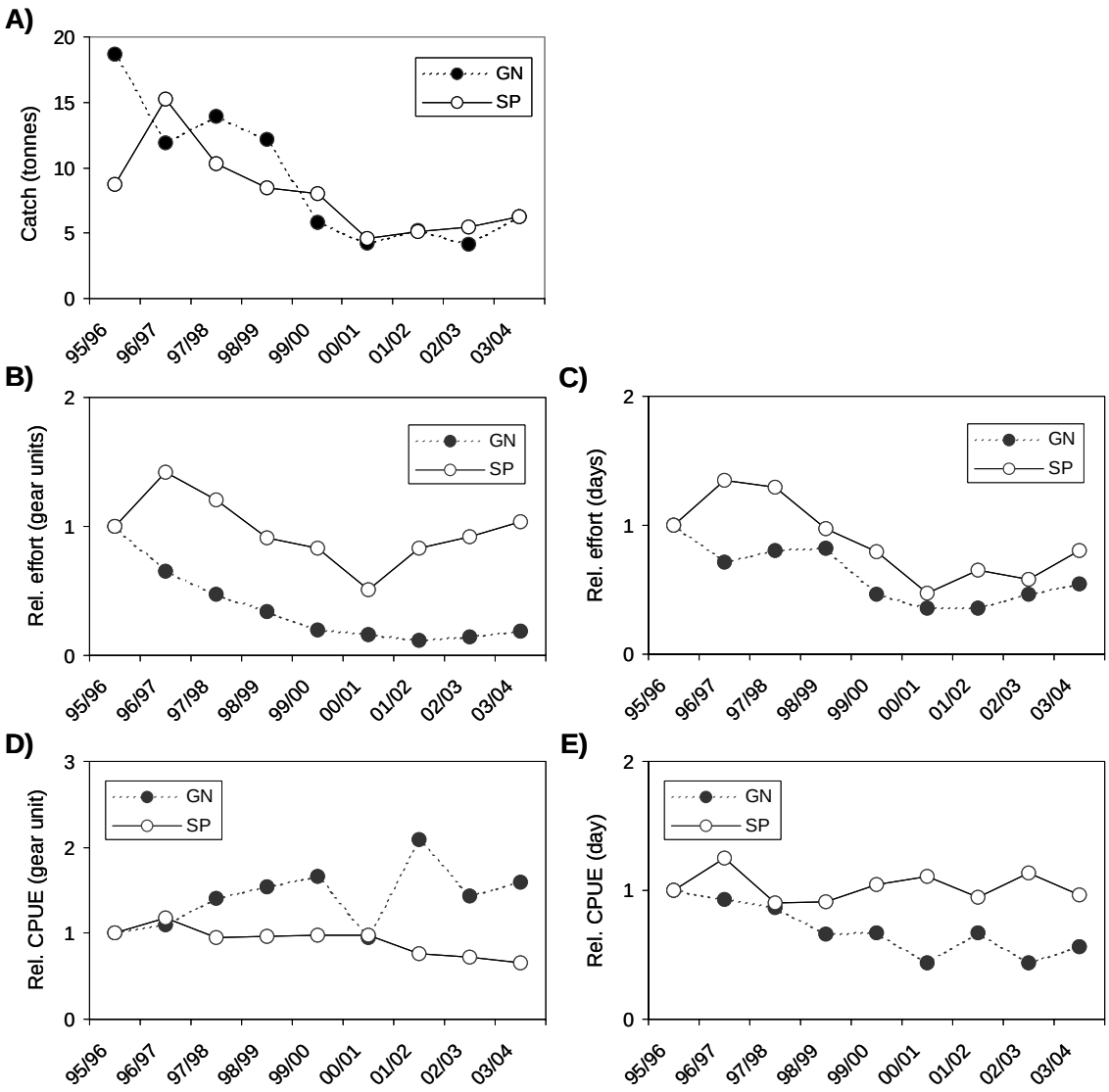


Fig. 6.6 A) Annual catch (tonnes) of flounder by method since 1995/96; B) effort by method based on gear units (refer Table 2.3) and expressed relative to 1995/96; C) effort by method based on days fished and expressed relative to 1995/96; D) catch per unit effort by method based on weight per gear unit (refer to Table 2.3) and expressed relative to 1995/96; and E) catch per unit effort by method based on weight per day fished and expressed relative to 1995/96. GN is graball and SP is spear.

Acknowledgements

In addition to the contributions of SFAWG members, Graeme Ewing, Gretta Pecl, Natalie Moltschaniwskyj and Dirk Welsford provided valuable inputs into this report.

References

Agnew, D.J., Baranowski, R., Beddington, J.R., des Clers, S., and C.P. Nolan (1998) Approaches to assessing stocks of *Loligo gahi* around the Falkland Islands. *Fisheries Research* **35**, 155-169.

DPIF (1998) Scalefish fishery: Policy Document. Department of Primary Industry and Fisheries.

Ewing, G.P. (2004) Spatial and temporal variation in growth and age composition of the temperate wrasse *Notolabrus fucicola* in Tasmanian waters. MSc Thesis, University of Tasmania.

Gomon, M.F., Glover, J.C.M. and R.H. Kuiter (1994) The fishes of Australia's south coast. State Print, Adelaide.

Haddon, M. (2001) *Modelling and Quantitative Methods in Fisheries.* Chapman & Hall/CRC Boca Raton. 406p.

Harries, D.N. and Croome, R.L. (1989) A review of past and present inshore gill netting in Tasmania with particular reference to the bastard trumpeter, *Latridopsis forsteri* Castelnau. *Papers and Proceedings of the Royal Society of Tasmania* **123**:97-110.

Henry, G.W. and J.M. Lyle (2003) National recreational and indigenous fishing survey. Final Report to FRDC Project 99/158, 188p.

Hutchinson, W. (1993) The reproductive biology and induced spawning of striped trumpeter, *Latris lineata.* M.Sc. thesis, University of Tasmania.

Jordan, A.R. and J.M Lyle (2000) Tasmanian scalefish fishery assessment – 1999. *TAFI Fishery Assessment Report*, 51p.

Lennon, S.M. (1998) General fishing returns and Tasmanian scalefish fishery catch data for the period 1990-96. *Stock Assessment Background Report 98/01*.

Lyle, J.M. (1998) Overview of the Tasmanian scalefish fishery based on 1995-1997 catch returns. *Stock Assessment Background Report 98/02*.

Lyle, J.M. (2000) Assessment of the licensed recreational fishery of Tasmania (Phase 2). Final Report to FRDC, Project No. 96/161, 102p.

Lyle, J.M. (2003) Tasmanian scalefish fishery assessment – 2002. *TAFI Fishery Assessment Report*, 70p.

Lyle, J.M (2005) 2000/01 survey of recreational fishing in Tasmania. *TAFI Technical Report* **24**, 97p.

Lyle, J.M. and K. Hodgson (2001) Tasmanian scalefish fishery assessment – 2000. *TAFI Technical Report No.* **19**, 70p.

Lyle, J.M. and K. Hodgson (2002) Tasmanian scalefish fishery assessment – 2001. *TAFI Fishery Assessment Report*, 88p

Lyle, J.M. and A.R Jordan (1999) Tasmanian scalefish fishery assessment – 1998. *TAFI Fishery Assessment Report*, 88p.

Lyle, J.M., Ziegler, P.E., Haddon, M., Tracey, S.R. and P. Burch (2004) Tasmanian scalefish fishery assessment – 2003. *TAFI Fishery Assessment Report*, 88p.

Lyle, J. and R. Murphy (2001) Long distance migration of striped trumpeter. *Fishing Today* **14**(6): 6.

McCormick, M.I. (1989a) Spatio-temporal patterns in the abundance and population structure of a large temperate reef fish. *Marine Ecology Progress Series* **53:** 215-25.

McCormick, M.I. (1989b) Reproductive ecology of the temperate reef fish *Cheilodactylus spectabilis* (Pisces: Cheilodactylidae). *Marine Ecology Progress Series* **55:** 113-120.

Moltschaniwskyj N.A., Pecl G.T. and J. Lyle (2002) An assessment of the use of short-term closures to protect spawning southern calamary aggregations from fishing pressure in Tasmania. *Bulletin of Marine Science* **70**: 501-514.

Moltschaniwskyj N.A., Pecl G.T., Lyle. J.M., Haddon, M. and M.A. Steer (2003) Population dynamics and reproductive ecology of the southern calamary (*Sepioteuthis australis*) in Tasmania. Final Report to FRDC Project 2000/121.

Murphy, R. and J.M. Lyle (1999) Impact of gillnet fishing on inshore temperate reef fishes, with particular reference to banded morwong. Final report to FRDC, Project No. 95/145, 135p.

Pecl, G.T. (2001) Flexible reproductive strategies in tropical and temperate *Sepioteuthis* squids. *Marine Biology* **138**: 93-101.

Pecl, G.T. (2004). The in situ relationships between season of hatching, growth and condition in the southern calamary, Sepioteuthis australis. *Marine and Freshwater Research*, **55**. In press

Pecl, G., Moltschaniwskyj, N. A., Tracey, SR and A. Jordan (2004). Inter-annual plasticity of squid life history and population structure: ecological and management implications. *Oecologia*, **139**: 515-524.

Steer, M., N.A. Moltschaniwskyj, and F.C. Gowland (2002) Temporal variability in embryonic development and mortality in the southern calamary *Sepioteuthis australis*: a field assessment. *Marine Ecology Progress Series* **243**: 143-150.

Ruwald, F.P. (1992) Larval feeding trials with striped trumpeter, *Latris lineata*. In *Larval biology. Australian Society for Fish Biology Workshop, Hobart, 20 August 1991.* Ed by Hancock, D.A. *Bureau of Rural Resources Proceedings No. 15*, AGPS, Canberra.

Ruwald, F.P., Searle, L.D. and L.A. Oates (1991) A preliminary investigation into the spawning and larval rearing of striped trumpeter, *Latris lineata*. *Department of Primary Industry, Sea Fisheries Division Technical Report* **44.**

Schaefer, M.B. (1954) Some aspects of the dynamics of populations important to the management of the commercial marine fisheries. *Bulletin, Inter-American Tropical Tuna Commission* **1**: 27-56.

Schaefer, M.B. (1957) A study of the dynamics of the fishery for yellowfin tuna in the eastern tropical Pacific Ocean. *Bulletin, Inter-American Tropical Tuna Commission* **2**: 247-285.

Smith, A.D.M. and S.E. Wayte (eds) (2002) The South East Fishery 2002. Fishery Assessment Report compiled by the South East Fishery Assessment Group. AFMA, Canberra.

Tracey, S.R. and J.M. Lyle (2005) Age validation, growth modeling and mortality estimates for striped trumpeter (*Latris lineata*) from southeastern Australia: making the most of patchy data. *Fishery Bulletin* **103**: 169-182.

Trianifillos, L. (1998) Southern Calamary. South Australia Fisheries Assessment series No 98/08 SARDI Aquatic Sciences, Adelaide

Wolf, B. (1998) Update on juvenile banded morwong in Tasmania. *Fishing Today* **11**(4): 30.

Appendix 1. Common and scientific names for species reported in catch returns.

Common name	*Scientific name*	*Common name*	*Scientific name*
Alfonsino	*Beryx* spp.	Pilchard	Fam. Clupeidae
Anchovy	Fam. Engraulidae	Rays bream	Fam. Bramidae
Atlantic salmon	*Salmo salar*	Redbait	*Emmelichthys nitidus*
Australian salmon	*Arripis* spp.	Red fish	Fam. Berycidae
Barracouta	*Thyrsites atun*	Red mullet	*Upeneichthys* spp.
Boarfish	Fam. Pentacerotidae	Silverfish	Fam. Atherinidae
Bream	*Acanthopagrus butcheri*	Snapper	*Pagrus auratus*
Butterfish	Spp unknown	Stargazer	Fam. Uranoscopidae
Cardinal fish	Fam Apogonidae	Sweep	*Scorpis* spp
Cod deep sea	*Mora moro*	Tailor	*Pomatomus saltatrix*
Cod, bearded rock	*Pseudophycis barbata*	Thetis fish	*Neosebastes thetidis*
Cod, red	*Pseudophycis bachus*	Trevalla, white	*Seriolella caerulea*
Cod, unspec.	Fam. Moridae	Trevally, silver	*Pseudocaranx dentax*
Dory, john	*Zeus faber*	Trout, rainbow	*Oncorhynchus mykiss*
Dory, king	*Cyttus traversi*	Trumpeter, bastard	*Latridopsis forsteri*
Dory, mirror	*Zenopsis nebulosus*	Trumpeter, striped	*Latris lineata*
Dory, silver	*Cyttus australis*	Trumpeter, unspec.	Fam. Latridae
Dory, unspec.	Fam. Zeidae	Warehou, blue	*Seriolella brama*
Eel	*Conger* spp.	Warehou, spotted	*Seriolella punctata*
Flathead	Fam Plactycephalidae	Whiptail	Fam. Macrouridae
Flounder	Fam. Pleuronectidae	Whiting	Fam. Sillaginidae
Garfish	*Hyporhamphus melanochir*	Whiting, King George	*Sillaginoides punctata*
Gurnard	Fam. Triglidae & Fam. Scorpaenidae	Wrasse	*Notolabrus* spp.
Gurnard perch	*Neosebastes scorpaenoides*	**'Commonwealth' spp**	
Gurnard, red	*Chelidonichthys kumu*	Blue grenadier	*Macruronus novaezelandiae*
Hardyheads	Fam. Atherinidae	Gemfish	*Rexea solandri*
Herring cale	*Odax cyanomelas*	Hapuka	*Polyprion oxygeneios*
Kingfish, yellowtail	*Seriola lalandi*	Oreo	Fam. Oreosomatidae
Knifejaw	*Oplegnathus woodwardi*	Trevalla, blue eye	*Hyperoglyphe antartica*
Latchet	*Pterygotrigla polyommata*	**Tunas**	
Leatherjacket	Fam. Monocanthidae	Albacore	*Thunnus alalunga*
Ling	*Genypterus* spp.	Skipjack	*Katsuwonus pelamis*
Luderick	*Girella tricuspidata*	Southern bluefin	*Thunnus maccoyii*
Mackerel, blue	*Scomber australasicus*	Tuna, unspec.	Fam. Scombridae
Mackerel, jack	*Trachurus declivis*	**Sharks**	
Marblefish	*Aplodactylus arctidens*	Shark, angel	*Squatina australis*
Morwong, banded	*Cheilodactylus spectabilis*	Shark, blue whaler	*Prionace glauca*
Morwong, blue	*Nemadactylus valenciennesi*	Shark, bronze whaler	*Carcharhinus brachyurus*
Morwong, dusky	Fam. Cheilodactylidae	Shark, elephant	*Callorhynchus milii*
Morwong, grey	*Nemadactylus douglasii*	Shark, gummy	*Mustelus antarcticus*
Morwong, jackass	*Nemadactylus macropterus*	Shark, saw	*Pristophorus spp.*
Morwong, red	Fam. Cheilodactylidae	Shark, school	*Galeorhinus galeus*
Morwong, unspec.	Fam. Cheilodactylidae	Shark, seven-gilled	*Notorynchus cepedianus*
Mullet	Fam. Mugilidae	Shark, spurdog	Fam. Squalidae
Nannygai	*Centroberyx affinis*	**Cephalopods**	
Perch, magpie	*Cheilodactylus nigripes*	Calamary	*Sepioteuthis australis*
Perch, ocean	*Helicolenus* spp.	Cuttlefish	*Sepia* spp.
Pike, long-finned	*Dinolestes lewini*	Octopus	*Octopus* spp.
Pike, short-finned	*Sphyraena novaehollandiae*	Squid, arrow	*Nototodarus gouldi*

Appendix 2. Data restrictions and adjustments

There have been a number of administrative changes that have affected the collection of catch and effort data from the fishery. The following restrictions and adjustments have been applied when analysing the data as an attempt to ensure comparability between years, especially when examining trends over time.

Tasmanian logbook data

i) Correction of old logbook landed catch weights

Prior to 1995, catch returns were reported as monthly summaries of landings. With the introduction of a revised logbook in 1995, catch and effort was recorded on a daily basis for each method used. Since catch data reported in the old general fishing return represent landed catch, it has been assumed to represent processed weights. For example, where a fish is gilled and gutted, the reported landed weight will be the gilled and gutted and not whole weight. By contrast, in the revised logbook all catches are reported in terms of weight and product form (whole, gilled and gutted, trunk, fillet, bait or live). If a catch of a species is reported as gilled and gutted then the equivalent whole weight can be estimated by applying a standard *conversion factor*[4].

Without correcting for product form, old logbook and revised logbook catch weights are not strictly compatible. In an attempt to correct for this and provide a 'best estimate', a *correction factor* was calculated using catch data from the revised logbook and applied to catches reported in the old logbook. A species based ratio of the sum of estimated whole weights (adjusted for product form) to the sum of reported catch weights was used as the correction factor (Lennon 1998).

ii) Effort Problems

Records where effort (based on gear units, refer to Table 2.3) was zero or null, or appeared to be recorded incorrectly (implausible), were flagged. The catch was included in catch summaries but the records were not included in gear unit effort and catch rate calculations. These records were, however, used in calculating days fished and daily catches.

iii) Vessel restrictions

In all analyses of catch and effort, catches from six vessels (four Victorian based and two Tasmanian based) have been excluded. These vessels were known to have fished consistently in Commonwealth waters and their catches of species such as blue warehou and ling tended to significantly distort catch trends. In fact, all four Victorian vessels and one of the Tasmanian vessels ceased reporting on the General Fishing Returns in 1994. With the introduction of the South East Fishery Non-Trawl logbook (GN01) in 1997, the remaining Tasmanian vessel ceased reporting fishing activity in the Tasmanian logbook.

Commonwealth logbook data:

[4] Conversion factors to whole weights are 1.00 for whole, live or bait; 2.50 for fillet; 1.50 for trunk; and 1.18 for gilled and gutted.

Commonwealth logbook data from Australian Fisheries Management Authority was included in the analyses so that the assessment reflected all catches from Tasmanian waters

Area restrictions
Commonwealth logbook records were only included if the catch was taken in fishing blocks adjacent to Tasmania *and* the maximum depth of the fishing operation was less than 200 m. These conditions were applied to all records *except* where striped or bastard trumpeter were caught. All records that included catches of these species were included for analysis, because these species are managed under Tasmanian jurisdiction in all waters adjacent to Tasmania.

Fishing blocks adjacent to land and used in the analyses (refer Fig. A1) include: 3C2, 3D1, 3F1, 3F2, 3G1, 3G2, 3C4, 3D3, 3F4, 3G3, 3G4, 3H3, 3H4, 4C2, 4D1, 4D2, 4E1, 4G2, 4H1, 4H2, 4D4, 4E3, 4E4, 4F4, 4G3, 4G4, 4H3, 4H4, 5D2, 5E2, 5F1, 5F2, 5H1, 5D4, 5E3, 5H3, 6E1, 6H1, 6E3, 6G4, 6H3, 7E1, 7E2, 7G1, 7G2, 7H1, 7E4, 7F3, 7F4, 7G3.

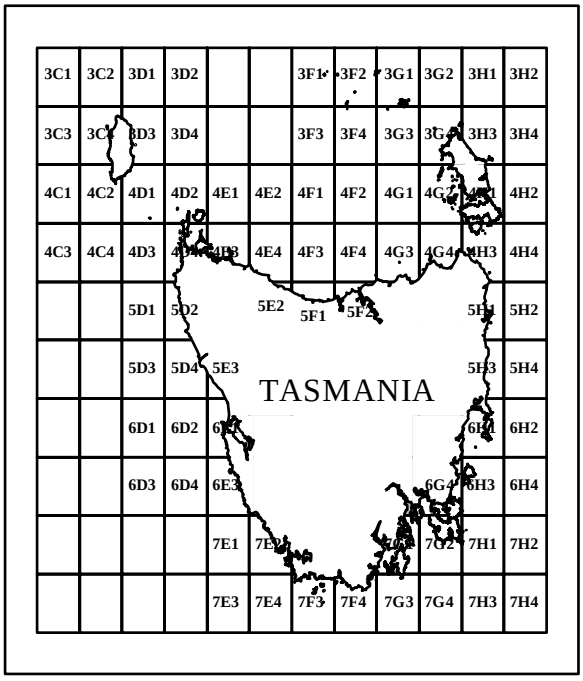


Fig. A1. Numbers for fishing blocks used in calculation of catch figures.

Duplicate records
A number of records in Commonwealth logbooks had matching records (fisher, date, gear type) in the Tasmanian database. Such records were examined individually and decisions made as to whether it was more appropriate to keep the Tasmanian record, the Commonwealth record or both. In most situations the Tasmanian logbook entry was kept and the Commonwealth record excluded. The only exceptions were records with extra information in the Commonwealth record, e.g. catch of a Commonwealth species that was not recorded in the Tasmanian logbook.