UNIVERSITY of TASMANIA | IMAS INSTITUTE FOR MARINE & ANTARCTIC STUDIES

TASMANIAN BANDED MORWONG FISHERY ASSESSMENT 2016/17

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This assessment of the Tasmanian Banded Morwong Fishery is produced by the Institute for Marine and Antarctic Studies (IMAS), using data downloaded from the Department of Primary Industries, Parks, Water and Environment (DPIPWE) Tasmanian Scalefish Database. The information presented here includes all logbook returns for 2016/17 season that were entered prior to October 2017.

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Executive Summary

STOCK STATUS	TRANSITIONAL DEPLETING
Mature biomass of Banded Morwong in Tasmanian waters has declined steadily since the early 2000s. While the stock is not currently considered overfished (i.e. spawning stock biomass is above the limit reference point), modelling indicates that under the current management arrangements fishing pressure at 2016/17 levels will continue to deplete the stock resulting in it becoming recruitment overfished. Reductions in Total Allowable Catch have been progressively applied over time but positive increases in biomass have not yet been observed.	

This assessment of the Tasmanian Banded Morwong fishery covers the period from 1st March 2016 to 28th February 2017. The assessment examines trends in biological characteristics, catch, effort and standardised catch per unit effort (CPUE), and forecasts biomass levels under current and alternate management arrangements.

In Tasmania, Banded Morwong are commercially harvested by a small-scale coastal gillnet fishery. Prior to 1990, the species had little commercial value apart from use as bait by rock lobster fishers. However, in the early 1990s a targeted fishery for Banded Morwong started to supply domestic live fish markets. All holders of a Tasmanian Fishing Boat Licence were able to take Banded Morwong and, as a result, there was a dramatic increase in effort directed at the species, with reported catches peaking at 145 t in 1993/94. Catches fell dramatically in the late 1990s, with 34.6 t landed in 1999/2000. Since then, catches have stabilised around 30–40 t.

A quota management system with a Total Allowable Catch (TAC) was introduced in late 2008 to the east coast fishery. In the past few years the TAC has undergone a staged reduction, effectively declining from 38.8 t in 2012/13 to 32.2 t in 2016/17. In addition, a temporal closure is in place for 1st March to 30th April each year, encompassing the species' peak spawning period. The species is subject to keyhole size limits, which are currently set at a minimum legal size of 360 mm and a maximum legal size of 460 mm.

A sampling program commenced in 1995 to obtain biological information, in particular size and age compositions, to better inform assessments for Banded Morwong. Significant truncations in length and age structures have been observed over the course of this sampling program. Increases in mean length at age of individuals aged between 2–10 years, and declines in length at maturity, have also been observed.

State-wide catches in 2016/17 were estimated at 32.9 t. The total catch in the TAC area was 31.3 t (5.7 t in Area 1, 15.6 t in Area 2 and 10.1 t in Area 3), which represented 97% of the 2016/17 TAC (i.e. a TAC under-catch of 3%). Total catch in the non-TAC area was 1.6 t. In 2016/17, catches in Area 1 (northeast coast; NEC) declined by 2.6 t from the 2015/16 quota year. Catches in Area 2 (east coast; EC) were largely consistent with those for 2015/16, when 15.1 t were landed. Catches in Area 3 (southeast coast; SEC), declined slightly (by 1.3 t) relative to those for 2015/16.

In 2016/17 State-wide effort was largely consistent with the 2014/15 and 2015/16 quota years. Effort (in days fished) in TAC Areas 1 (NEC) and 3 (SEC) declined in 2016/17 relative to 2015/16, while effort in Area 2 has increased over the past two quota years.

Standardised catch rates in 2016/17 in the whole TAC area fell by approximately 4% relative to the 2015/16 quota year, equating to 69% of the 1995/96 level.

Modelling indicates that fishing pressure at 2016/17 levels under the current management arrangements will continue to deplete the stock resulting in it becoming recruitment overfished.

Model estimates suggest a phased reduction in catch to 22 kg / quota unit is required to meet the limit reference point of 30% spawning stock biomass in 5 years with 90% probability. Based on this evidence, the stock status for Banded Morwong in Tasmanian TAC area waters is classified as **transitional depleting**.

Acknowledgements

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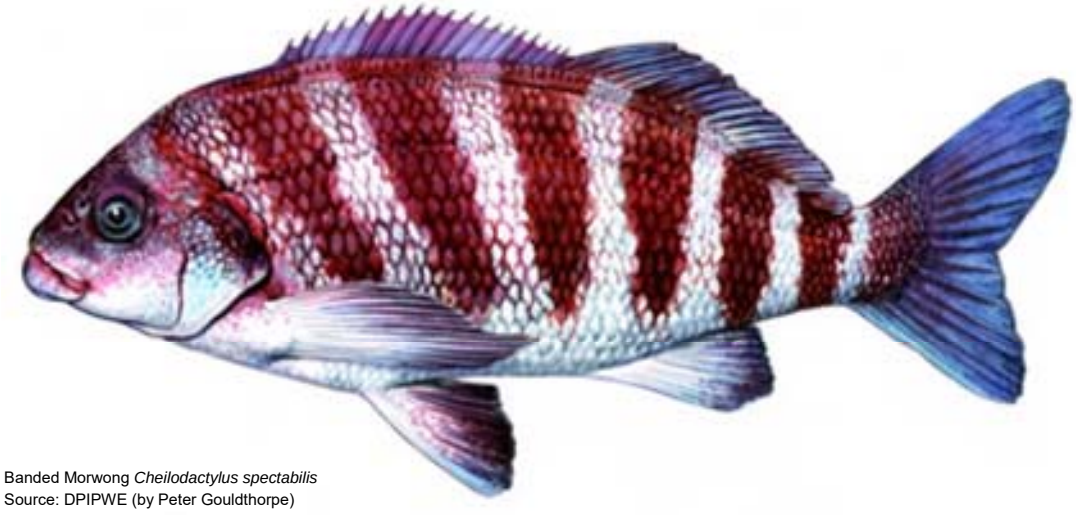
1. Introduction

Species biology

Banded Morwong (*Cheilodactylus spectabilis*; Figure 1) are large, sedentary fish that inhabit temperate reefs around south-eastern Australia and New Zealand (Gomon et al 1994). In Australia, the species distribution extends from Sydney, through Victorian and Tasmanian waters, to eastern South Australia. The species has occasionally been observed in Western Australia. Banded Morwong are long-lived, and can reach ages of at least 97 years (Ewing et al. 2007). While longevity is similar among sexes, the species displays strong sexual dimorphism in growth, with males growing substantially faster and reaching larger maximum sizes than females (Ziegler et al. 2007a).



Banded Morwong *Cheilodactylus spectabilis*
Source: DPIPWE (by Peter Gouldthorpe)

Figure 1. Banded Morwong, *Cheilodactylus spectabilis*.

The stock structure of Banded Morwong in Australian waters is presently undefined, however observations of a long pelagic larval stage (around 6 months; Wolf 1998) suggests that single genetic stocks may occur over large areas. After settlement, fish are relatively sedentary, with tagging studies indicating little exchange among reefs (Murphy and Lyle 1999) (see Table 1 for a summary of species biology).

Commercial fishery

In Tasmania, Banded Morwong are commercially harvested by a small-scale coastal gillnet fishery. Prior to 1990, the species had little commercial value apart from use as bait by rock lobster fishers (Ziegler et al. 2007a). In the early 1990s a targeted fishery for Banded Morwong started to supply domestic live fish markets, primarily in Sydney and Melbourne. All holders of a Tasmanian Fishing Boat Licence were able to take this species and, as a result, there was a dramatic increase in effort directed at the species, with reported catches peaking at 145 t in 1993/94. Catches fell dramatically in the late 1990s, with 34.6 t landed in 1999/00. Since then, catches have stabilised around 30–40 t.

Table 1. Biology of Banded Morwong, *Cheilodactylus spectabilis*.

<table>
<tr><th>Parameters</th><th>Estimates</th><th>Source</th></tr>
<tr><td>Habitat</td><td>• Rocky reefs down to 50 m depth. Females and juveniles inhabit the shallow section of the reef while males dominate in the deeper section of the reef.</td><td>McCormick (1989a, b)</td></tr>
<tr><td>Distribution</td><td>• South Sydney (New South Wales) through Victoria and Tasmania to eastern South Australia, also in New Zealand.</td><td>Gomon et al. (1994)</td></tr>
<tr><td>Diet</td><td>• Invertebrates, algae, crabs.</td><td>McCormick (1998)</td></tr>
<tr><td>Movement and stock structure</td><td>• Limited movement of juveniles and adults, generally restricted to within 5 km of the release site.
• No information on the stock structure.</td><td>Murphy and Lyle (1999)
Ziegler et al. (2006)
Buxton et al. (2010)</td></tr>
<tr><td>Natural mortality</td><td>• Low. Estimated at M=0.05.</td><td>Murphy and Lyle (1999)</td></tr>
<tr><td>Maximum age</td><td>• Females: 94 years
• Males: 97 years</td><td>Ewing et al. (2007)</td></tr>
<tr><td>Growth</td><td>• Males grow to larger sizes than females
• Growth described by the Schnute and Richards (1990 growth function:
$L = L_{\infty}(1 + \alpha^{(-at^{c})})^{-\frac{1}{b}}$
where L is the length (mm), t is the age (years), L_{∞} is the average maximum length for the species and α, a, b and c are (year-specific) constants.
• Parameters estimates (for 2007) are:
<table>
<tr><th>Sex</th><th>L_{∞}</th><th>a</th><th>b</th><th>c</th><th>α</th></tr>
<tr><td>Female</td><td>442</td><td>18.8</td><td>$3.3e^{-7}$</td><td>0.05</td><td>51.4</td></tr>
<tr><td>Males</td><td>516</td><td>2.3</td><td>0.0088</td><td>0.33</td><td>0.1</td></tr>
</table>
• Length-weight relationship for 2007 was estimated at $W = 3.563E^{-5}L^{2.875}$ for females and $W = 3.729E^{-5}L^{2.852}$ for males, where W is weight (g) and L is the fork length (cm).</td><td>Schnute and Richards (1990)
Ziegler et al. (2007a)</td></tr>
<tr><td>Maturity</td><td>• Size-at-50% maturity estimated at 320 mm for females (~2.5 years of age).</td><td>Ziegler et al. (2007a)</td></tr>
<tr><td>Spawning</td><td>• Spawning occurs between mid-February to late May.
• Species is a serial spawner.</td><td>Murphy and Lyle (1999)</td></tr>
<tr><td>Early life history</td><td>• Eggs and larvae are concentrated on the surface.
• Banded Morwong has a pelagic stage distributed offshore, as suggested by the large amounts of larvae caught off the shelf break of eastern Tasmania.
• Juveniles appear in shallow water on rocky reefs and tide-pools between September and December, after a pelagic phase of 4-6 months.</td><td>B. Bruce, Pers. Com.

Wolf (1998)</td></tr>
<tr><td>Gillnet post release survival</td><td>• High: 97% irrespective of gillnet soak duration</td><td>Lyle et al. (2014a)</td></tr>
</table>

Banded Morwong are currently targeted almost exclusively for the live fish market with large mesh gillnets, primarily of 130–140 mm stretched mesh. 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 have been taken along the south coast and around Flinders Island. While Banded Morwong inhabit depths down to at least 50 m (May and Maxwell 1986), fishing operations are conducted over inshore reefs, with gear set primarily in the 5–20 m depth range, in order to minimise effects of barotrauma and maximise survival for the live fish trade.

The Banded Morwong fishery in Tasmanian waters is based on a range of input and output controls (Table 2). The fishery has undergone numerous management changes over time (summarised in Table 3). The commercial fishery in Tasmania is currently managed as two areas: an area in which individual transferable quotas are used to limit the total allowable catch (TAC; the TAC area), and an area in which it does not (the non-TAC area) (Figure 2). In order to fish for Banded Morwong within the TAC area a person must hold a fishing licence (Banded Morwong) which has uncaught quota units authorised on it. There is no quota management outside the TAC area and any holders of a fishing licence (Banded Morwong) can fish in this region with or without quota authorised to their licence. A temporal closure is in place for 1st March to 30th April each year, encompassing the species' peak spawning period. The species is subject to keyhole size limits, which are currently set at a minimum legal size of 360 mm fork length (FL) and a maximum legal size of 460 mm FL. A bag limit of two fish and a possession limit of four fish is in place for recreational fishers. For management and assessment purposes, a limit reference point has been implemented whereby a spawning stock biomass (SSB) of 30% must be exceeded in five years (2022) with a 90% probability.

Table 2. Summary of management controls for Banded Morwong in Tasmanian waters.

FISHING METHODS	Mainly gillnet
MANAGEMENT METHODS	**Input control:** • Gear licence (Scalefish fishing licence) • Species licence (Banded Morwong licence) • Temporal closure (March-April) **Output control:** • Possession limit of 4 and bag limit of 2 individuals for recreational fishers • Minimum and maximum size (360–460 mm fork length) • TAC of 32.2 t for the 2016/17 quota year
MAIN MARKET	Interstate

The quota management system with a TAC was introduced in late 2008. Up to and including the 2015/16 quota year a given number of fish were allocated to each quota unit and the tonnage associated with the TAC was inferred based on an assumed average weight of 1.3 kg per fish. From 2016/17 onwards quota has been set in weight. Over the past few years the TAC has undergone a staged reduction (Table 4).

Post-release survival of Banded Morwong under current maximum permitted gillnet soak durations is very high (Lyle et al. 2014a). Using a semi-quantitative approach, gillnetting was considered a medium risk activity to Banded Morwong populations in the Ecological Risk Assessment (ERA) of Bell et al. (2016), with the authors recognising that current management arrangements (namely the TAC and individual catch quotas) have the objective of gradually rebuilding biomass.

Table 3. Management changes in the Tasmanian Banded Morwong Fishery over time (from DPIPWE 2017).

Date	Management changes
Pre 1987	Unrestricted access to Tasmanian Fishing Boat Licences (TFBL); unlimited access to scalefish and shark using all gear types; no restrictions on the amount of gillnet net that could be used; and unrestricted access to all other gear types (i.e., beach seine, purse seine, dipnet, squid jig, fish traps, small mesh gillnets, mullet nets, longlines, droplines and spears).
1987	Tasmanian Fishing Boat Licences were capped at 850.
1990	Restricted gillnetting in Shark Nursery Areas (SNAs). Commercial access to SNAs is limited to holders of non-transferable endorsements (38 endorsees).
31 May 1994	Ministerial warning issued explaining that any catches of Banded Morwong and wrasse taken after that date would not be used towards catch history, should previous catches be used to determine future access to the live fishery.
1994	Minimum size limit of 33 cm fork length and maximum size limit of 43 cm fork length introduced for Banded Morwong.
1995	An annual closed season in March and April was introduced to coincide with the peak spawning period of Banded Morwong.
1996	An interim non-transferable 'live fish' endorsement to take Banded Morwong and wrasse was introduced. Eligibility was based on a demonstrated history of taking one or both species (at least 50 kg between 1 January 1993 to 31 May 1994), and around 90 endorsements were issued.
November 1998	Introduction of a species specific licence for the Banded Morwong fishery (live or dead) in State waters. There were 29 licences issued. The minimum size limit was increased to 36 cm fork length and the maximum size limit increased to 46 cm fork length.
November 2001	A daily bag limit of two fish was introduced for recreational fishers.
November 2004	The recreational bag limit of two fish was changed to a personal possession limit of two fish.
October 2008	Introduction of a quota management system for east coast waters from Low Head to Whale Head (excluding the Furneaux Group). A total of 1,169 Banded Morwong quota units were issued.
July 2009	An additional 24 Banded Morwong quota units were issued following a review of a quota allocation, bringing the total number of units to 1,193.
November 2009	Introduction of a 6 hour soak time for commercial gillnets
March 2011	Introduction of the Commercial Banded Morwong Quota Docket for all Banded Morwong fishers.
November 2015	New gillnet free areas for the protection of seabirds such as little penguins (applies to both commercial and recreational gillnets). New quota management arrangements for the Banded Morwong fishery as it moves from a numbers to a weight based quota management system for the 2016/17 quota year.
May 2017	New Commercial Banded Morwong Quota Docket and new Commercial Catch, Effort and Disposal Logbook for all Banded Morwong fishers.

Table 4. Reductions in Total Allowable Catch (TAC) in the Tasmanian Banded Morwong Fishery since the 2012/13 quota year.

Quota year	TAC (in t)	TAC (in no. fish)	No. of Fish/Quota Unit	Kg / Quota Unit
2012/13	38.8	29,825	25	-
2013/14	37.2	28,632	24	-
2014/15	35.7	27,439	23	-
2015/16	35.7	27,439	23	-
2016/17	32.2	N/A	-	27

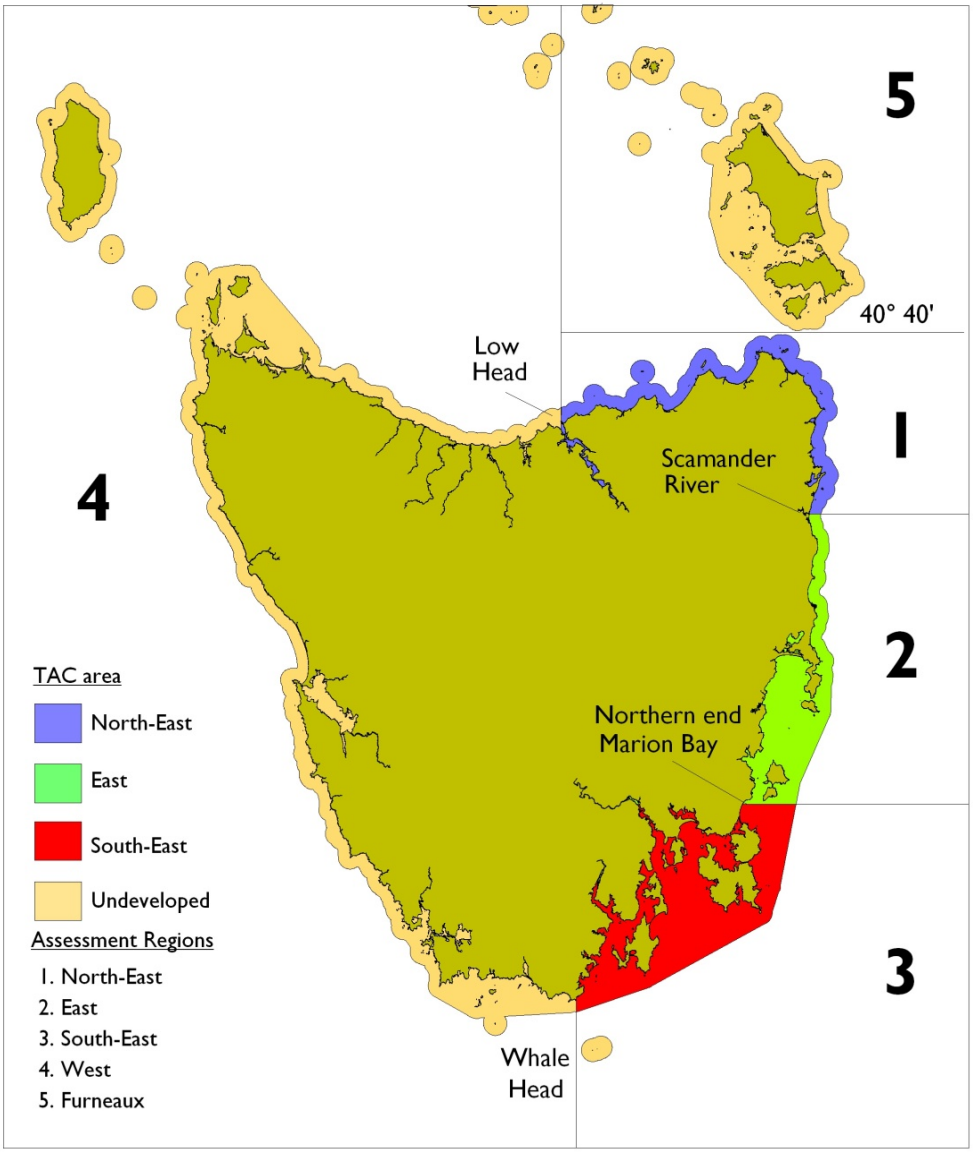


Figure 2. Designated TAC areas and assessment regions for Banded Morwong (Areas 1, 2 and 3) from Low Head on the north coast to Whale Head in the south. Assessment regions 4 and 5 are currently undeveloped.

Recreational fishery

Banded Morwong are a relatively minor component of the recreational fishery. A total of 298 individuals were reported as retained in the 2012/13 recreational fishing survey of Lyle et al. (2014b), equating to a total estimated harvest of 0.5 tonnes, or around 1% of the total Banded Morwong landings (commercial + recreational) for that year. A total of 1,082 Banded Morwong were reportedly retained in the 2010 recreational gillnet survey of Lyle and Tracey (2012), representing 3.6% of total Banded Morwong landings for 2010. No species-specific catch estimates for Banded Morwong were available in the 2000/01 or 2007/08 recreational fishing survey reports of Lyle (2005) or Lyle et al (2009). A new survey for 2017/18 is currently underway and should be available for inclusion in the 2018/19 assessment.

2. Methods

Data sources

Biological characteristics

A sampling program commenced in 1995 to obtain biological information, in particular size and age composition, to inform assessments for Banded Morwong. Sampling was conducted annually in 1996, 1997 and between 2001–2005, then every second year from 2007 onwards. In this sampling program fish are collected during the spawning closure by commercial fishers working under permit and contracted to the Institute for Marine and Antarctic Studies. Sampling sites and general fishing practices (including the use of standard commercial 'Banded Morwong nets') have been standardised as much as possible. Approximately 400 fish were collected in each sampling year. For each fish collected, the fork length (to the nearest 1 mm) and weight (to the nearest 1 g) were measured and the pair of sagittal otoliths (hereafter otoliths) were removed, cleaned, and stored dry in plastic vials. Gonads were dissected, weighed (to the nearest 0.1 g), sexed and staged macroscopically according to West (1990).

Commercial fishery data

Commercial catch and effort data are collected through compulsory Tasmanian Commercial Catch, Effort and Disposal Returns. The catch and effort logbooks have been amended several times (1995, 1999, 2007, 2010 and 2013) in an effort to report at finer spatial scales and provide greater operational detail. While the offshore fishing blocks are still at the 30 nm (1/2 degree) spatial resolution, the logbooks introduced in 2010 have redefined the scale of the coastal blocks (Figure 3). In analysing catch and effort information data quality control has been undertaken, details of which are explained the data analysis section below.

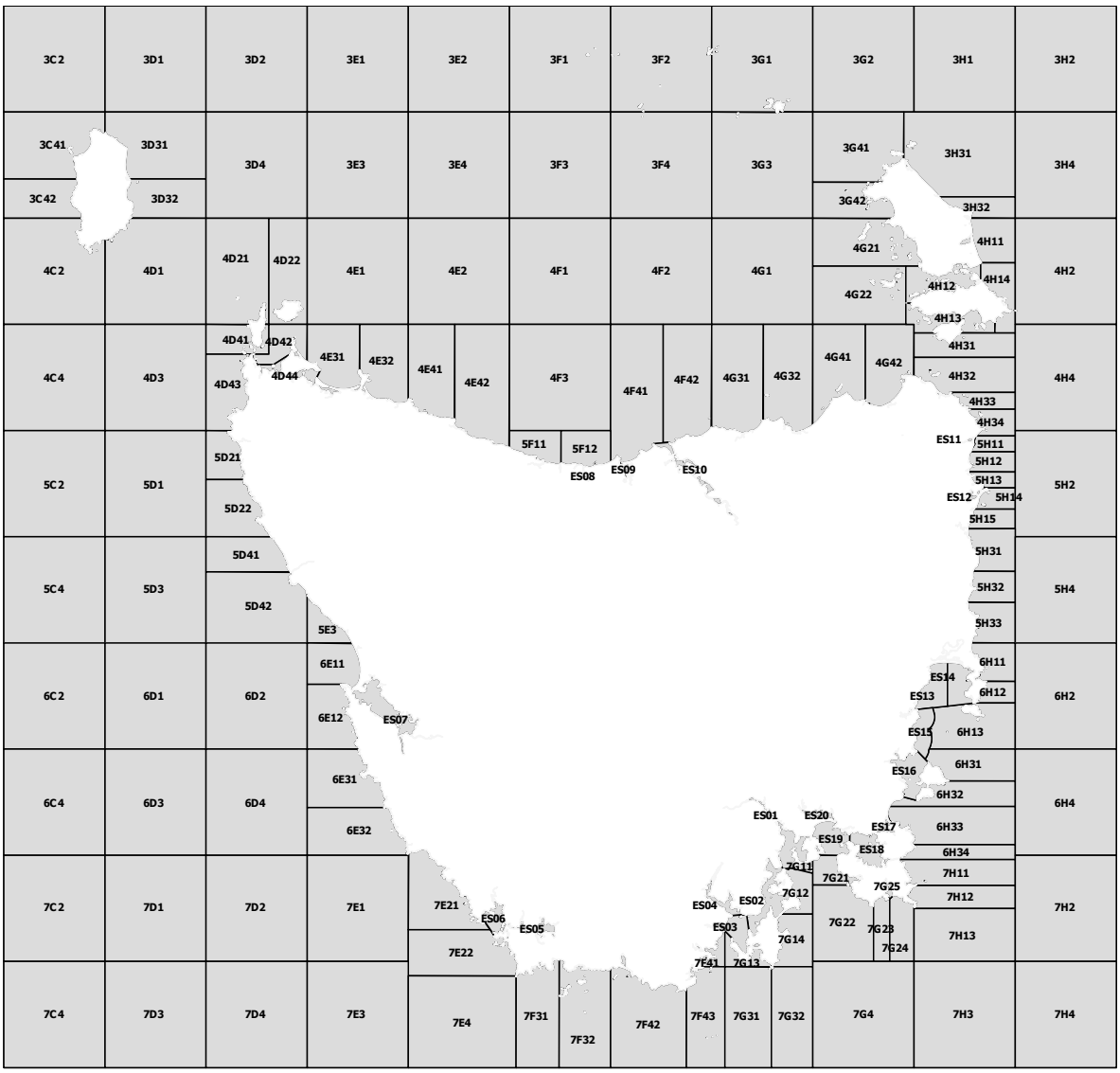


Figure 3. Map of Tasmania displaying the fishing blocks.

Data analysis

Biological characteristics

Length and age frequency plots were developed for each sampling year. Sex and sampling-year specific patterns in growth of Banded Morwong were modelled using a modified version of the Schnute and Richards (1990) growth function fitted by nonlinear least-squares regression of *FL* on age. A sample of six recently settled juveniles collected from Bicheno in 1996, estimated to be around 6 months old, were used to anchor the growth functions for all years and sexes.

Generalised linear mixed-effect models (GLMMs) were used to model the length at maturity of female Banded Morwong. Maturity state (immature or mature) was treated as a binomial response variable with logit link function and modelled as a function of *FL*. Area (i.e. TAC Areas 1, 2 and 3; Figure 2) was modelled as a random effect term in all models to eliminate potential bias or pseudoreplication resulting from the non-independence of samples collected within the same area. Due to low numbers of immature females, sampling years were combined as follows: 1996-1997, 2001, 2002-2003, 2004-2005, 2011 & 2013, and 2015 & 2017. Samples collected in 2007 and 2009 were excluded due to small numbers of immature females.

Catch and Effort

For the purposes of this assessment, catch, effort and catch per unit effort (CPUE) analyses are restricted to commercial data provided for the period March 1995 to February 2017. The assessment year for Banded Morwong is based on the quota year (1st March to the last day of February the following year) rather than the financial year (July to June) as for other scalefish species. The current Banded Morwong assessment includes data up to and including the 2016/17 quota year (which ended 28 February 2017).

Under the quota management system, commercial catches prior to 2016/17 were reported as numbers of fish rather than weight. These numbers were converted to weight based on a conversion ratio of 1.3 kg per fish. In addition, and particularly prior to the introduction of the quota management system, fish were landed in a variety of forms, including gilled and gutted, trunked, and filleted. In these instances, the equivalent whole weight was estimated by applying a standard conversion factor[1].

Two measures of effort have been examined in this and past assessments: (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 (effort gear units). For gillnets (the main fishing method for Banded Morwong), effort gear units are measured in 100 m net hours.

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. Only a small number of fishing records for 2016/17 needed to be excluded in this manner. All records were, however, included for reporting catch, days fished and catch per day.

Catch per unit effort

In the Banded Morwong fishery, the amount of gear set and the fishing duration is recorded by fishers, however these data have been inconsistently reported over time and among fishers. Accordingly, for the purposes of this assessment, CPUE is calculated using days fished as a measure of effort. Previous work has shown that this is highly correlated with CPUE derived from using gear and soak time where that data is reliably available (IMAS unpublished data).

Following Ziegler et al. (2007b), CPUE for Banded Morwong was standardised in order to remove the influence of confounding effects such as area, depth, season of vessel on relative trends in abundance. CPUE was standardised using generalised linear models (GLMs). Standardisation of CPUE was conducted for an annual time scale, and at four spatial scales (whole of TAC area, and individual north-east, east and south-east areas within the TAC area). Data were restricted to skippers who had reported catches for at least two years.

The GLMs were fitted to different combinations of factors for which information were available, namely skipper, vessel, fishing block, depth zone fished (0–10 m, 11–20 m, 21–30 m, > 30 m), bimonthly period and seal interactions. A bimonthly period rather than month was included as a temporal factor to ensure there were sufficient records in each period to give reliable results. Due to the annual spawning season closure in March and April, only five bimonthly categories were investigated. Interaction terms between some of the factors were also considered, but these were limited to combinations for which sensible interpretations could be ascribed.

Standardised CPUE were fitted to natural log-transformed (Ln) catch rate data (assuming a lognormal distribution), using a normal distribution family with an identity link. All GLMs were fitted using a forward approach by manual stepwise addition of each factor starting with the time-step. The best-fitting model was chosen by minimising the Akaike's Information Criterion (AIC; Burnham and Anderson 1998). Adding new data from 2016/17 at times resulted in alternative model selection to that used in previous assessments (Table 4).

[1] Conversion factors to whole weights are 2.50 for fillet; 1.50 for trunk; and 1.18 for gilled and gutted.

Table 4. Generalised Linear Models (GLMs) used to standardise catch per unit effort of Banded Morwong across the whole TAC area, and in the North-East, East and South-East TAC areas as defined in Figure 2.. Ln = natural log.

TAC Area	Model
Whole TAC area	Ln CPUE = Lnweight ~ BMWyear + Vessel + seals+ bimonth+ Block + skipper + depth + Vessel:Block
North-East	Ln CPUE = Lnweight ~ BMWyear + Vessel + bimonth + seals + Block + depth + bimonth:Vessel
East	Ln CPUE = Lnweight ~ BMWyear + Vessel + bimonth + seals + Block + skipper + depth + bimonth:Vessel
South-East	Ln CPUE = Lnweight ~ BMWyear + Vessel + bimonth + Block + ClientID + seals + Vessel:seals

Stock modelling

Model structure

The 2016/17 assessment was conducted using the Banded Morwong population model implemented in CASAL v 2.30 (Bull et al. 2012). The CASAL framework is a widely used for fisheries assessments, including a number of New Zealand's fish stocks. The implementation of the Banded Morwong model in CASAL is mathematically equivalent to the previous model used to assess Banded Morwong stocks developed by Ziegler et al. (2007b). As previous assessments of Banded Morwong have stressed that a greater emphasis should be placed on the whole of fishery model for TAC setting purposes, models were run using data for the entire TAC area. Because the distribution of Banded Morwong extends beyond the depth of the fishery, there is potential for an unfished component of each 'stock' to be located in a depth refuge. The model accounted for this by specifying a fished population inshore and an unfished population offshore.

Model inputs

Biological components: Length-at-age was modelled by a Schnute and Richards (1990) growth function. Age-at-maturity was modelled using a logistic function. Single growth and maturity functions were used across all fishery areas in any given year. Growth was modelled until 2007. Because patterns of growth have changed over time, periods with specific growth were identified and modelled. For the periods 1990–1998, 1999–2001, 2002–2003, 2004–2006 and 2007 and above all available data from 1996–1997, 2001, 2002–2003, 2004–2006 and 2007, respectively, were pooled by sex across all model areas. Natural mortality was assumed to be constant at $M = 0.05$.

The selectivity-at-age function was determined from the length-at-age function in conjunction with growth variation, gear selectivity and keyhole size limits. Gear (mesh) selectivity and vulnerability were assumed to be constant between sexes, assuming similar body shape and behaviour of males and females. For the 2016/17 assessment, a single keyhole size limit was assumed for the entire history of the fishery.

Fishery (harvest) components: Annual total catches within the quota area for the period 1990/91–2016/17 and standardised CPUE (described above) for the period 1990/91–2015/16 were used in each model run. Catchability was estimated in the model from the relationship between observed CPUE and exploitable biomass. The catchability coefficient q was assumed to be constant over time, with random annual variations around the overall q.

Recruitment: Recruitment was modelled to occur at the start of each year and was assumed to be equal between males and females, and occur uniformly along the entire coastline of the modelled area. All recruitment in the models was assumed to occur to onshore populations,

consistent with observations of juvenile Banded Morwong in inshore shallow waters and a gradual outward migration with increasing size (Leum and Choat 1980; McCormick 1989b).

Model outputs

The model was used to estimate SSB trajectories within the quota area at present and into the future under various catch scenarios. A number of different catch scenarios, with decreasing weight per quota unit values, were examined. For purposes of brevity, only the current management scenario (i.e. a total allowable catch of 32.2 at a unit value of 27 kg / quota unit) and management scenarios that meet or exceed the 30% SSB limit reference point are presented here.

Assessment of stock status

Stock status definitions

In order to assess the Banded Morwong fishery in a manner consistent with the national approach (and other jurisdictions) we have adopted the national stock status categories (Table 5; Flood et al. 2012). These categories define the assessed state of the stock in terms of recruitment overfishing, which is often treated as a limit reference point. Recruitment overfished stocks are not collapsed but they do have reduced productivity. Fisheries are ideally also managed towards targets that maximise benefits from the harvesting, such as economic yield or provision of food. The scheme used here does not attempt to assess the fishery against any target outcomes.

Performance indicators and reference points

The determination of stock status is based on the consideration of model outputs and the commercial catch and effort data, which are assessed by calculating fishery performance indicators and comparing them with the limit reference point (SSB of 30% must be exceeded in five years (i.e. 2022 for the current assessment) with a 90% probability).

Other measures are also taken into consideration in the determination of stock status such as changes in biological characteristics of the stock, indicators of stock stress and significant external factors related to fishing activity.

Table 5. The stock status classifications of Flood et al. (2012) that were adopted for this assessment.

Stock status	Description	Potential implications for management of the stock
SUSTAINABLE	Stock for which biomass (or biomass proxy) is at a level sufficient to ensure that, on average, future levels of recruitment are adequate (i.e. not recruitment overfished) and for which fishing pressure is adequately controlled to avoid the stock becoming recruitment overfished.	Appropriate management is in place.
TRANSITIONAL-RECOVERING ↑	Recovering stock—biomass is recruitment overfished, but management measures are in place to promote stock recovery, and recovery is occurring.	Appropriate management is in place, and the stock biomass is recovering.
TRANSITIONAL-DEPLETING ↓	Deteriorating stock—biomass is not yet recruitment overfished, but fishing pressure is too high and moving the stock in the direction of becoming recruitment overfished.	Management is needed to reduce fishing pressure and ensure that the biomass does not deplete to an overfished state.
OVERFISHED	Stock is recruitment overfished, and current management is not adequate to recover the stock; or adequate management measures have been put in place but have not yet resulted in measurable improvements.	Management is needed to recover this stock; if adequate management measures are already in place, more time may be required for them to take effect.
UNDEFINED	Not enough information exists to determine stock status.	Data required to assess stock status are needed.

3. Results

Biological characteristics

Length frequency composition

Significant changes in the length frequency composition between the late 1990s and the early 2000s raised concerns about the Banded Morwong stock (Figure 4 and Ziegler et al. 2007a). Length frequency composition appears to have stabilised since, with average length of Banded Morwong around 36–40 cm with fewer large, legal sized fish being present in landings (Figure 4).

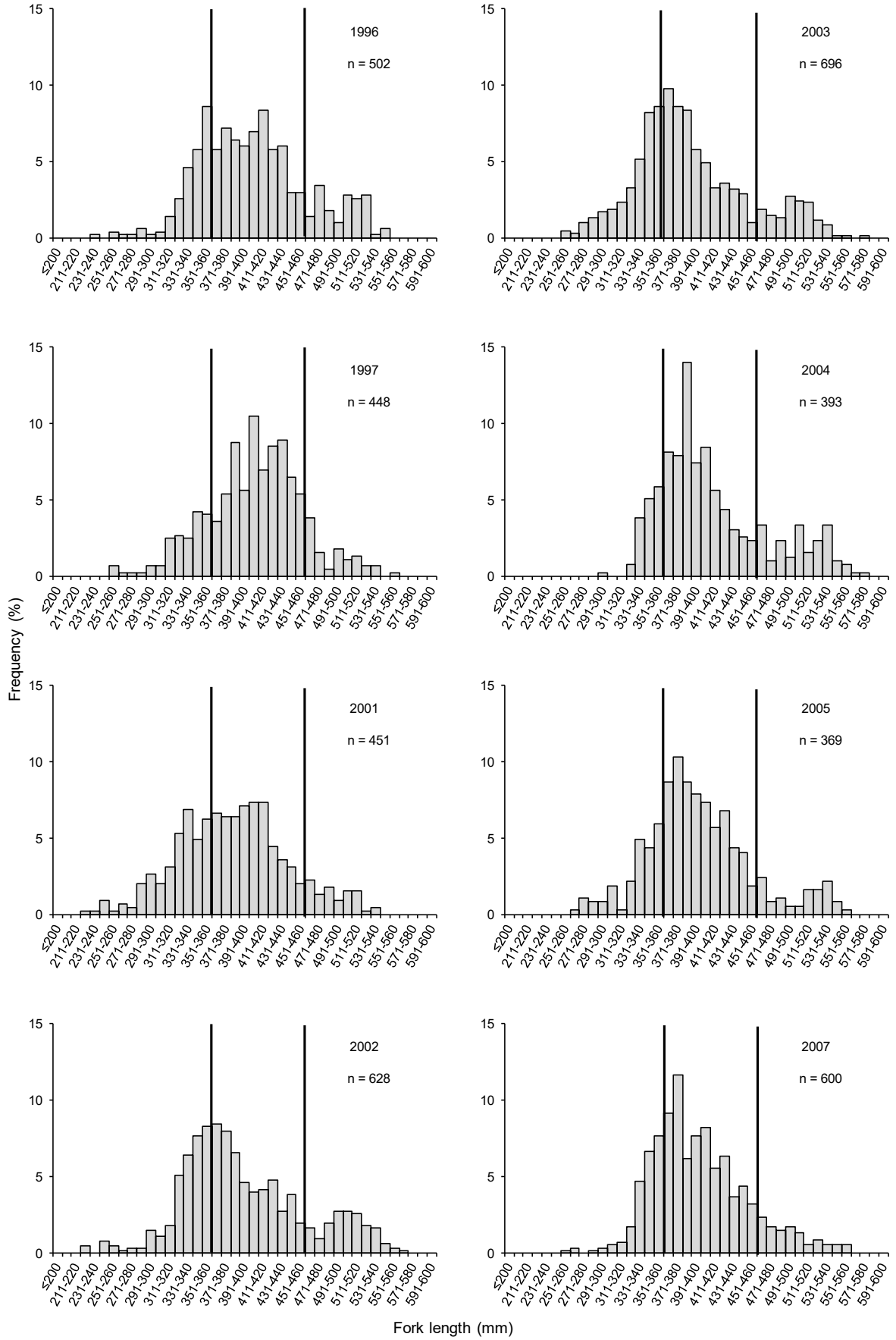


Figure 4 Length composition of sampled Banded Morwong by year. 'n' is the sample size. The solid lines represent minimum and maximum size limits. Year is the year in which sampling was conducted.

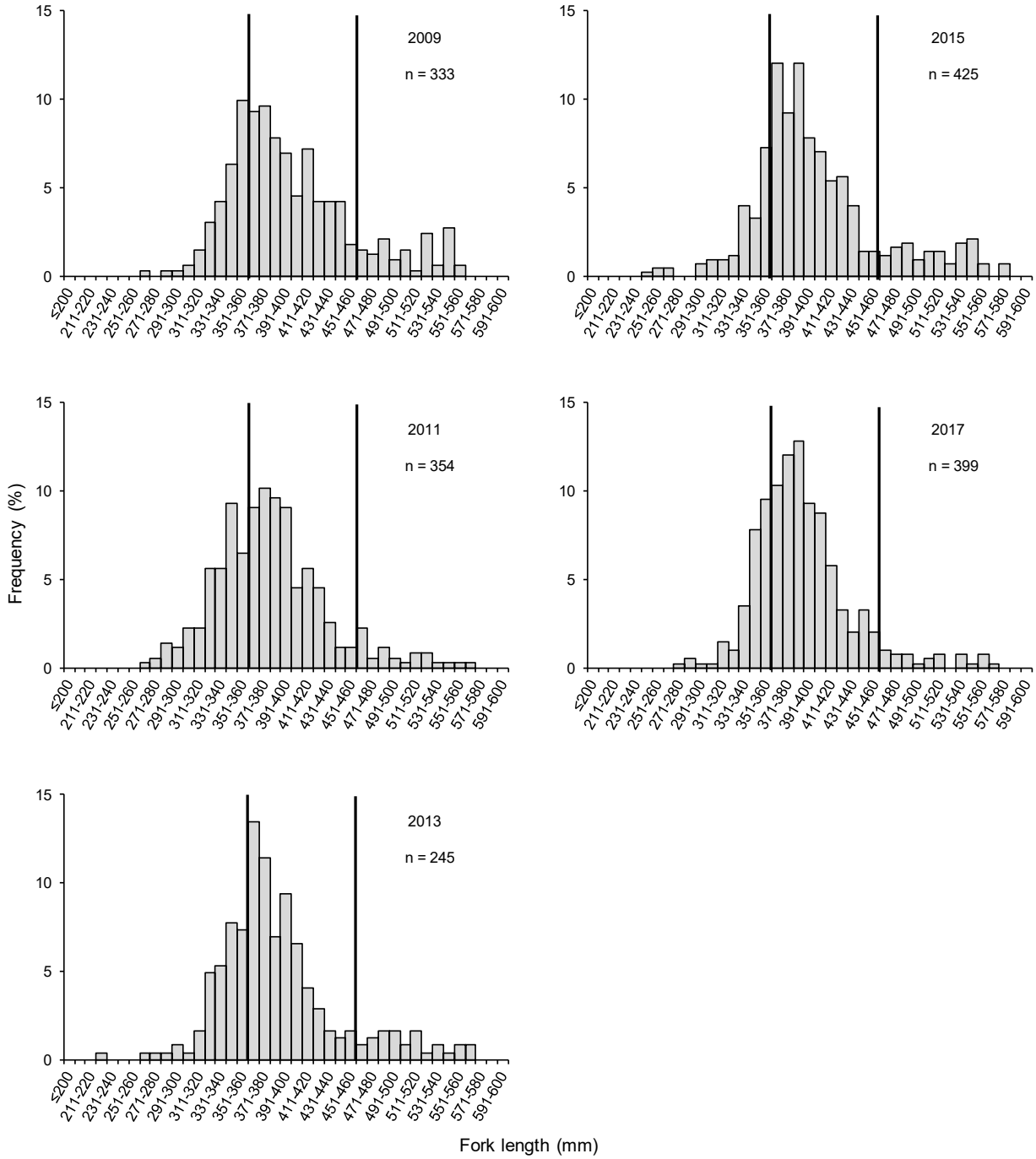


Figure 4 - continued.

Age frequency composition

Age frequency composition also showed signs of change from the late 1990s (Figure 5 and Ziegler et al. 2007a). The age structure is now dominated by young fish around 4–5 years old (Figure 5), with relatively very few individuals older than 15 years old in current population samples compared to the late 1990s, while no fish older than 80 years have been observed in the sampling program since 2007 (Figure 5).

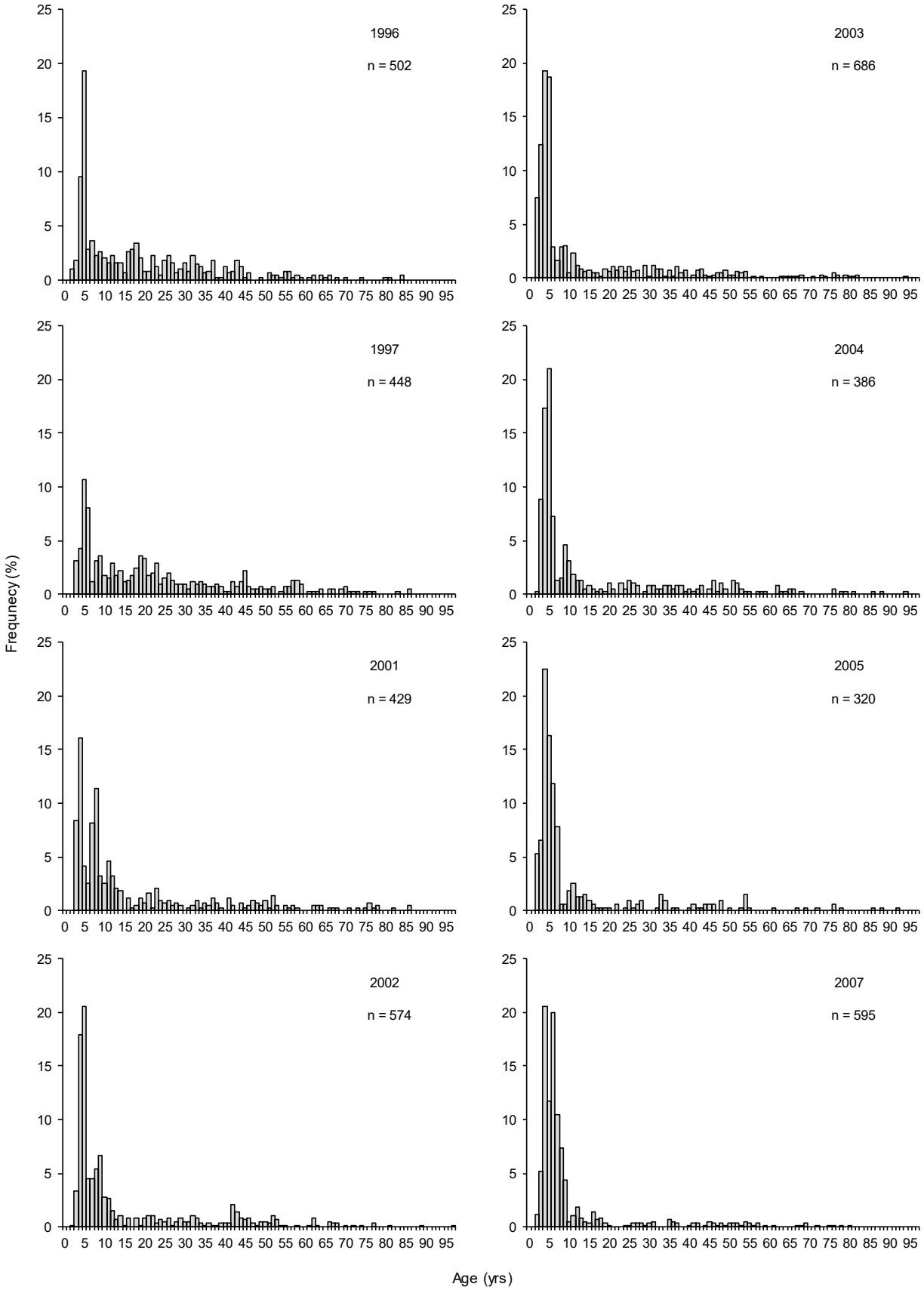


Figure 5 Age composition of sampled Banded Morwong by year. 'n' is the sample size. Year is the year in which the sampling was conducted.

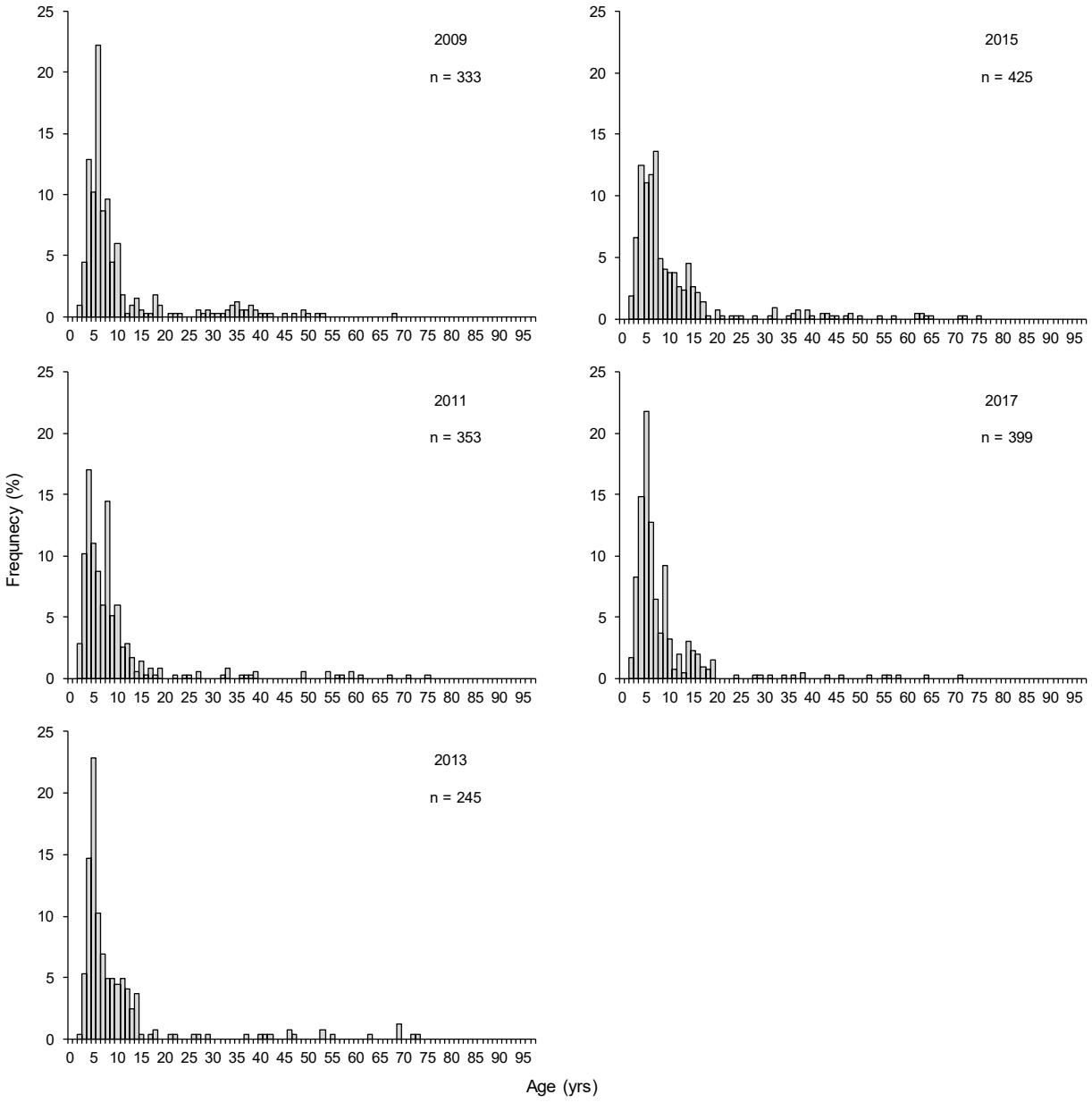


Figure 5 – continued.

Growth rates

Growth functions fitted to the length at age data provided evidence for a general acceleration of growth in the younger age classes over the sampling period (Figure 6). This was particularly evident in fish sampled in the early to mid-2000s (exemplified by fish sampled in 2005 and 2007 in Figure 6), with consistent increases in length at age observed among years and age classes relative to 1996 for age classes 2–10. In 2013 and 2015 growth of fish aged 2–10 years generally appeared similar that of fish sampled in 1996 (exemplified by fish sampled in 2013 in Figure 6). In 2017, sampled fish again had accelerated growth, with lengths at age generally comparable to those sampled in the mid-2000s (Figure 6).

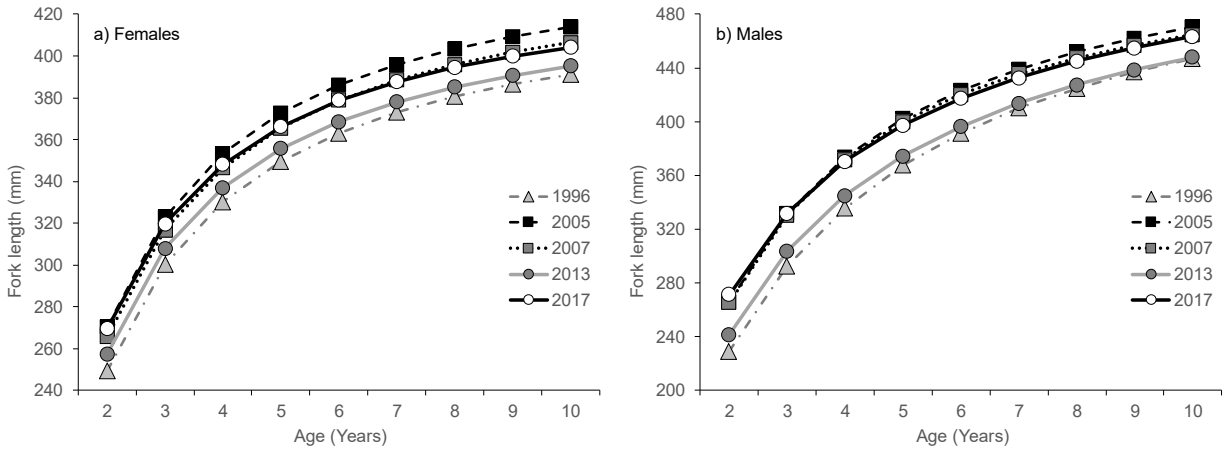


Figure 6. Predicted lengths for female (left) and male (right) Banded Morwong aged 2–10 years from the Schnute and Richards (1990) growth model for samples collected in 1996, 2005, 2007, 2013 and 2017.

Length at female maturity

Declines in the length at which female Banded Morwong mature are evident among sampling years. Length at 50% maturity declined from around 325 mm in 1996–1997 to around 315 mm in 2001, and to below 305 mm in 2002–2003 (Figure 7; Ziegler et al. 2007a). In 2004–2005 length at maturity returned to a similar level to that observed in 1996–1997, a result Ziegler et al. (2007a) attributed to increased length at age by 2004–2005. Since then, length at maturity has subsequently decreased, with 50% of females maturing at around 315 mm in both 2011–2013 and 2015–2017 (Figure 7).

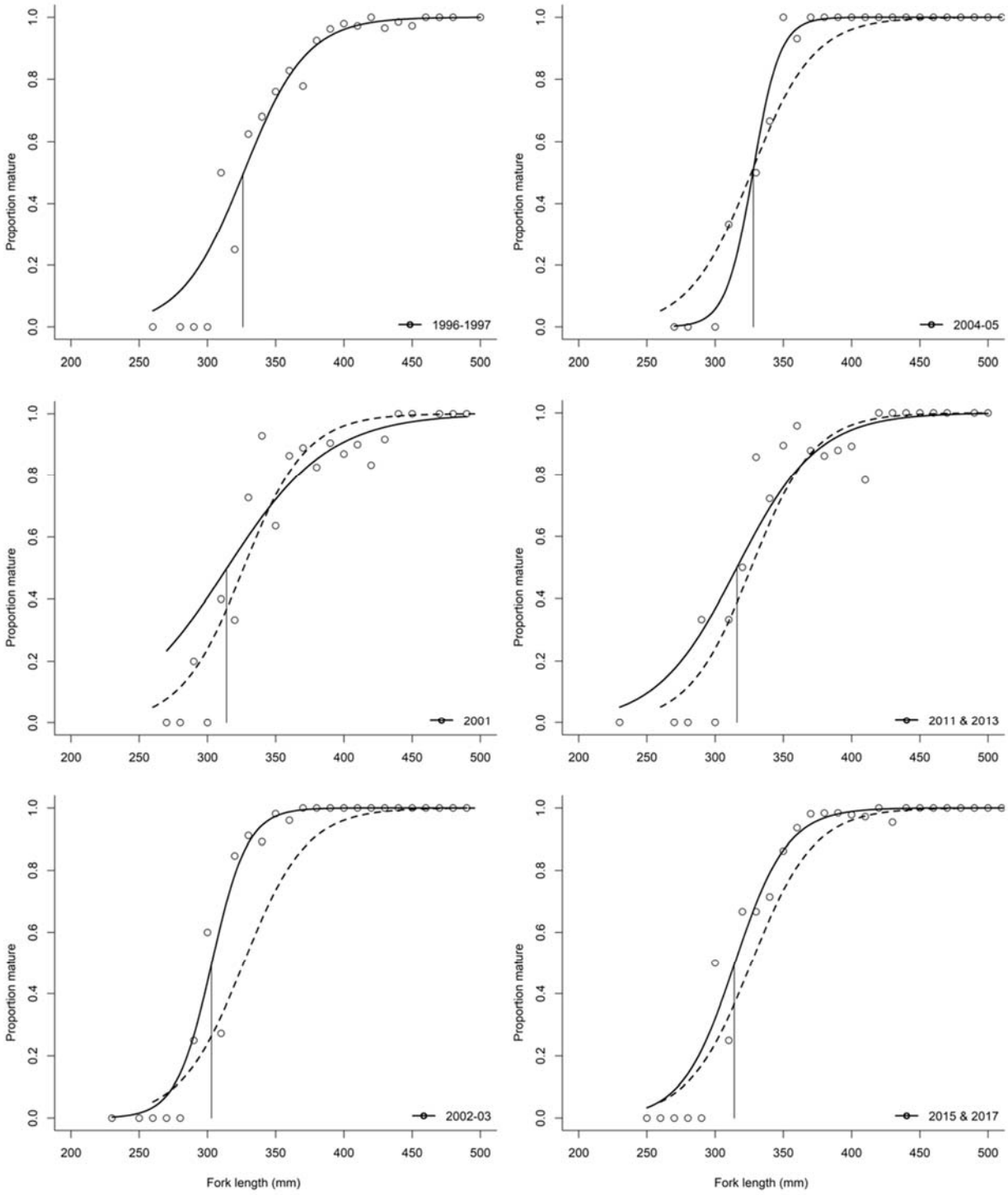


Figure 7. Predicted proportion of mature female Banded Morwong from generalised linear mixed-effects models examining the effect of fork length and sampling period on maturity. Circles represent the proportion of mature females in each 10 cm length class. Data were pooled into the period 1996–1997, 2001, 2002–2003, 2004–2005, 2011 & 2013 and 2015 & 2017. The model fitted to the 1996–1997 data is shown in plots for subsequent sampling years as a dashed line as a reference. The solid vertical line represents the length at 50% maturity. Note data collected in 2007 and 2009 were excluded due to small numbers of immature individuals.

Catch, effort and catch rates

Catch and effort

State-wide commercial catches have been relatively stable since the introduction of the quota system in 2008/09, and in 2016/17 were estimated at 32.9 t (Figure 8). The total catch in the TAC area (Areas 1–3 in Figure 2) in 2016/17 was 31.3 t (5.7 t in Area 1, 15.6 t in Area 2 and 10.1 t in Area 3), which represented 97% of the 2016/17 TAC (i.e. a TAC under-catch of 3%). The total catch in the non-TAC area (Areas 4 and 5 in Figure 2) was 1.6 t.

In 2016/17, catches in Area 1 (NEC) declined by 2.6 t from the 2015/16 quota year and 5.1 t from 2014/15, when 10.8 t was landed from this area. Catches in Area 2 (EC) were largely consistent with those for 2015/16, when 15.1 t were landed. Catches in Area 3 (SEC), declined slightly (by 1.3 t) relative to those for 2015/16 (Figure 8).

In 2016/17 State-wide effort in both days fished and gear units (100 m net hour) was largely consistent with the 2014/15 and 2015/16 quota years (Figure 9). Effort (in days fished) in Areas 1 (NEC) and 3 (SEC) declined in 2016/17 relative to 2015/16, potentially as a response to increasing levels of seal interactions over time driving affected fishers to fish with less gear or doing fewer sets each day to reduce losses to seals (Ziegler et al. 2006). Effort (in days fished) increased in Area 2 over the past two quota years (Figure 9, Figure 10).

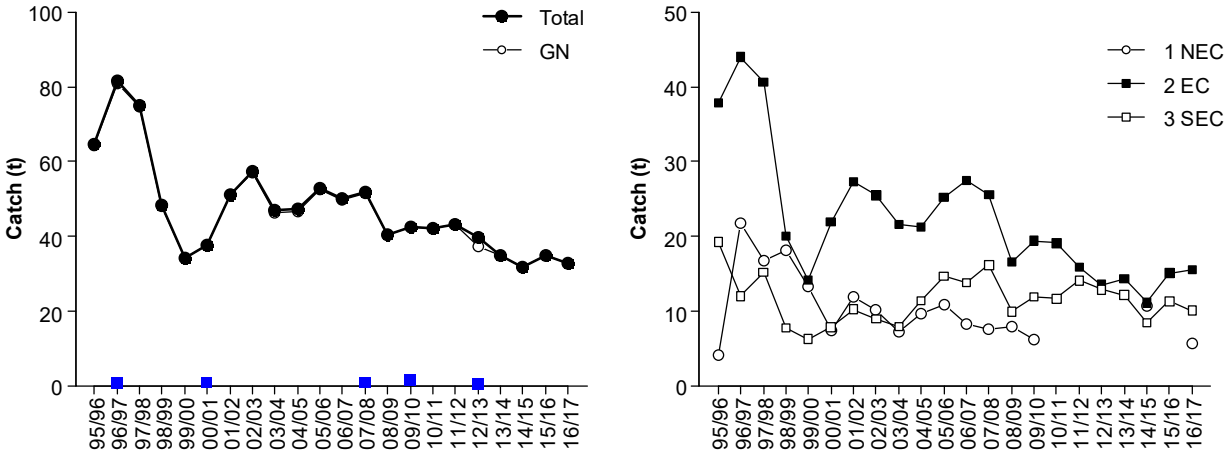


Figure 8 Banded Morwong commercial catches (t). Left: Total state-wide (Total) and gillnet (GN) catches, and best estimates of recreational catches (blue squares); Right: regional gillnet catches in the TAC areas 1 NEC, 2 EC and 3 SEC. Note: catches in the NEC for years in which five vessel or less were active are not displayed (2010/11, 2011/12, 2012/13, 2013/14 and 2015/16).

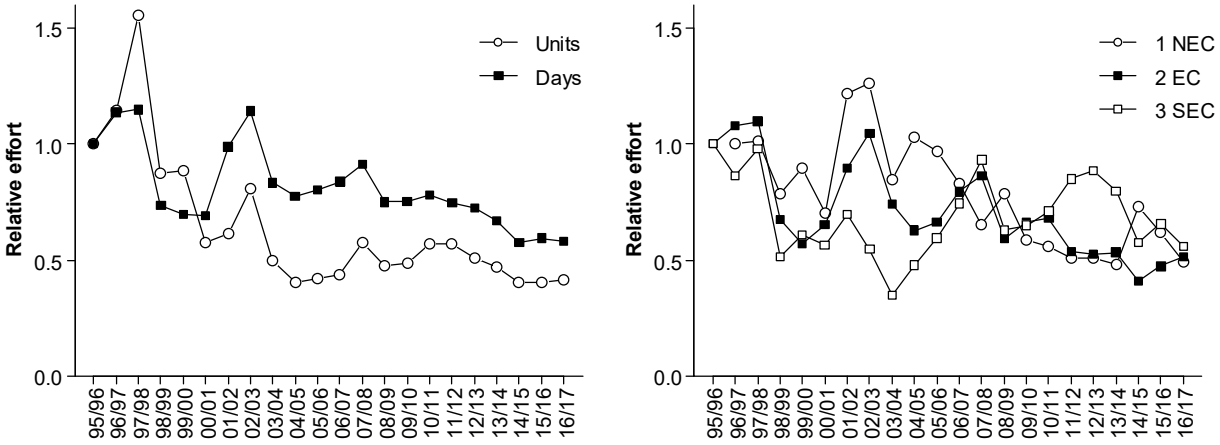


Figure 9 Left: State-wide commercial effort based on gear units and days fished relative to 1995/96. Right: Commercial effort in days fished in the TAC areas 1 NEC, 2 EC and 3 SEC relative to 1995/96.

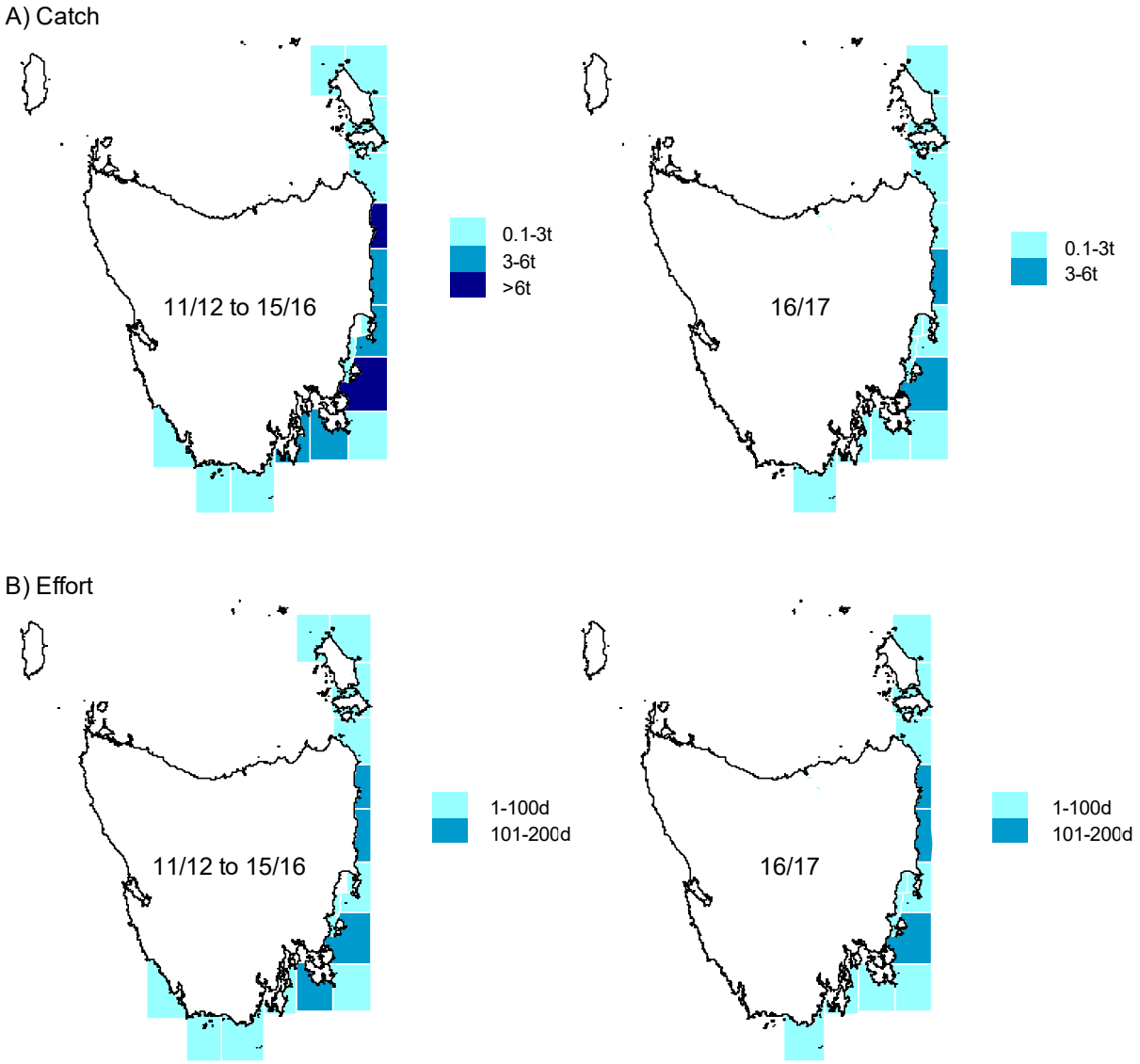


Figure 10 (A) Banded Morwong total catches (tonnes per year) and (B) effort (days per year) by fishing blocks. The left-hand column displays spatial patterns in total catch (top) and effort (below) by block averaged from 2011/12 to 2015/16, while the right-hand column displays spatial patterns in total catch (top) and effort (below) observed by block during 2016/17.

Standardised catch per unit effort

In 2016/17, standardised CPUE in the whole TAC area fell by approximately 4% relative to the 2015/16 quota year, equating to 69% of the 1995/96 level (Figure 11). On a regional basis, standardised CPUE declined by 17% in Area 1, were relatively steady in Area 2, and increased by 11% in Area 3 relative to 2015/16 levels (Figure 11).

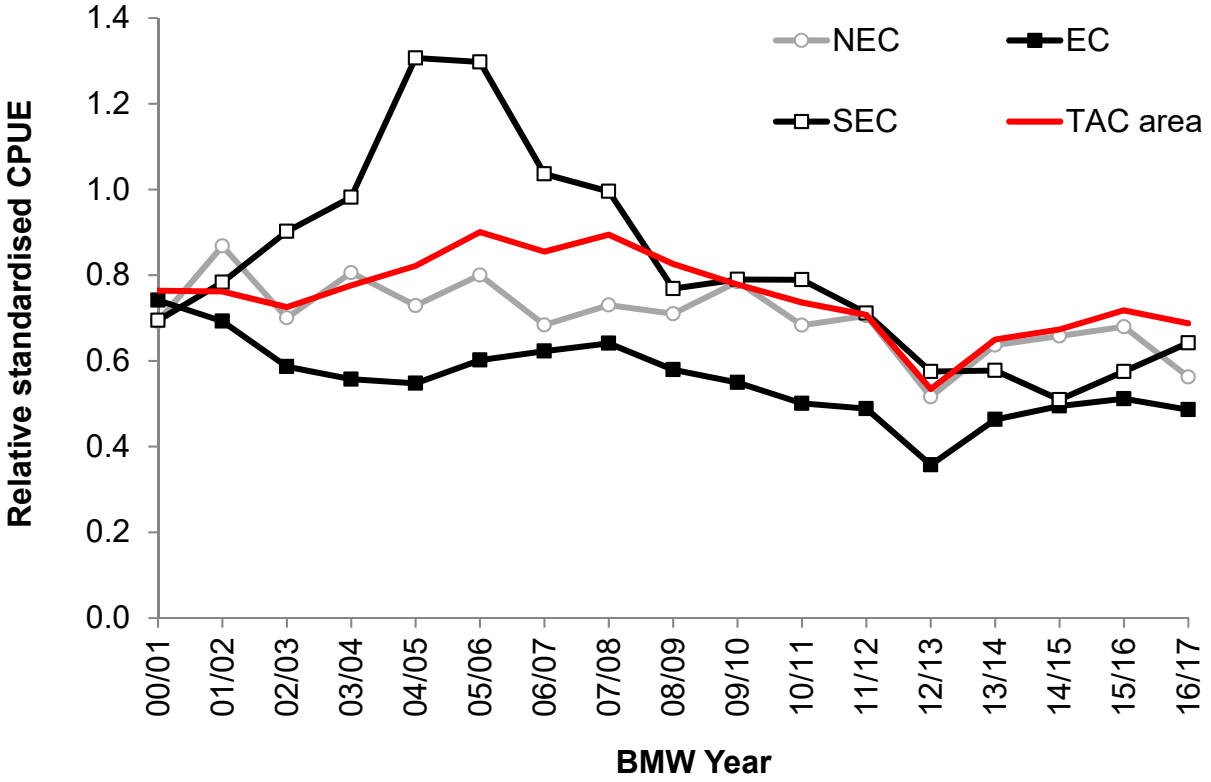


Figure 11 Banded Morwong standardised gillnet catch per unit effort (CPUE by days fished) relative to 1995/96, in the TAC areas North-East Coast (NEC), East Coast (EC) and South-East Coast (SEC), and from the whole TAC area (red line).

Selected stock modelling results

Modelling showed that the current harvest strategy (i.e. 27 kg / quota unit and a TAC of 32.2) is unable to meet the limit reference point of 30% spawning stock biomass (SSB) within a 5-year period. Under the current catch scenario, SSB is projected to continue to decline to levels below the limit reference point (Figure 12).

Figure 13 shows the probability of exceeding the 30% SSB limit reference point under each of two additional scenarios – annual reductions of one kg / quota unit to 23 kg / quota unit and 22 kg / quota unit. A 22 kg / quota unit catch scenario achieves this limit reference point with the required 90% probability in five years (2022) whilst a 23 kg / quota unit catch scenario nearly achieves this (Figure 13).

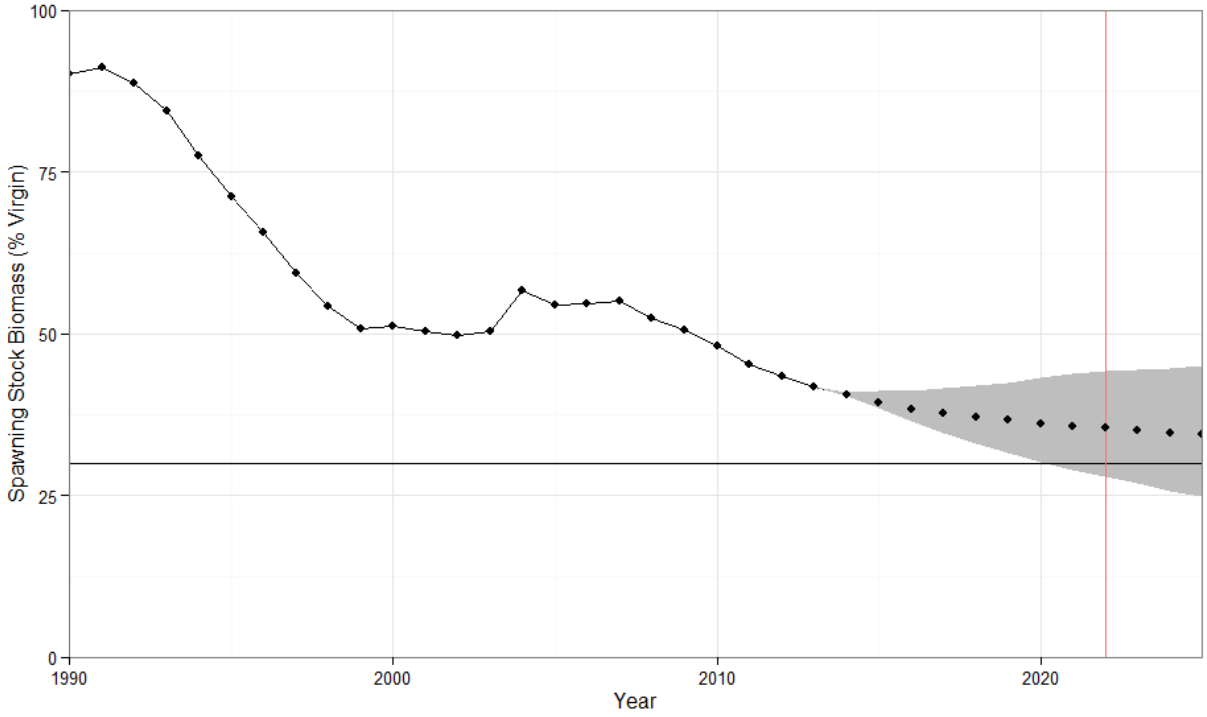


Figure 12 Forward projections (to 2025) of Banded Morwong spawning stock biomass (SSB) expressed as a percentage of the unfished SSB, based on the 2016/17 harvest strategy of 27 kg / quota unit. The red vertical line indicates the 5-year period in which SSB is required to meet the limit reference point of 30% SSB (indicated by the grey horizontal line) with a 90% probability (as shown by the dark shaded area).

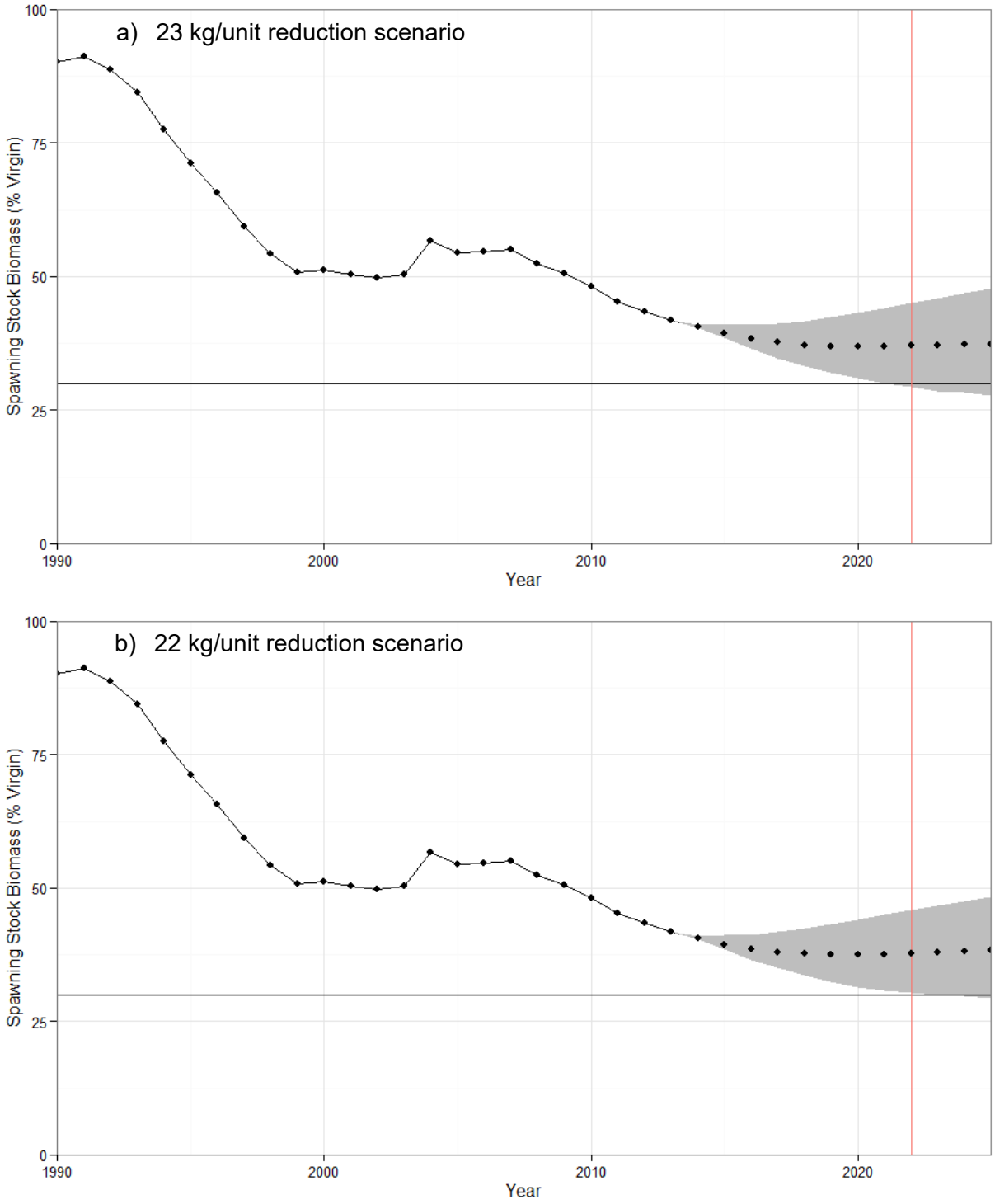


Figure 13 The probability of exceeding the 30% spawning stock biomass (SSB) limit reference point under two different catch scenarios for the entire quota area. The scenarios are: (a) a one kg / quota unit reduction annually to 23 kg / quota unit, and (b) a one kg / quota unit annual reduction to 22 kg / quota unit. The limit reference point (SSB of 30%) must be exceeded in five years (2022) with a 90% probability (as shown by the dark shaded areas); this is achieved by the 22 kg / quota unit reduction scenario. Note both scenarios assume a 5 % undercatch.

5. Stock status

Although the Banded Morwong stock is not yet considered to be recruitment overfished; modelling indicates that fishing pressure at 2016/17 levels and current catch scenarios will continue to deplete the stock resulting in it becoming recruitment overfished. Accordingly, the species is therefore classified as transitional depleting in Tasmanian quota area waters (Figure 14). Significant truncations in age structures and alterations in biological process, including growth and maturity, suggest this species has historically been negatively impacted by fishing. Reductions in catch quotas have been progressively applied to rebuild populations, however a positive increase in biomass has not yet been observed. Due to the biological characteristics of Banded Morwong, stock recovery is expected to be a slow process.

STOCK STATUS	TRANSITIONAL DEPLETING

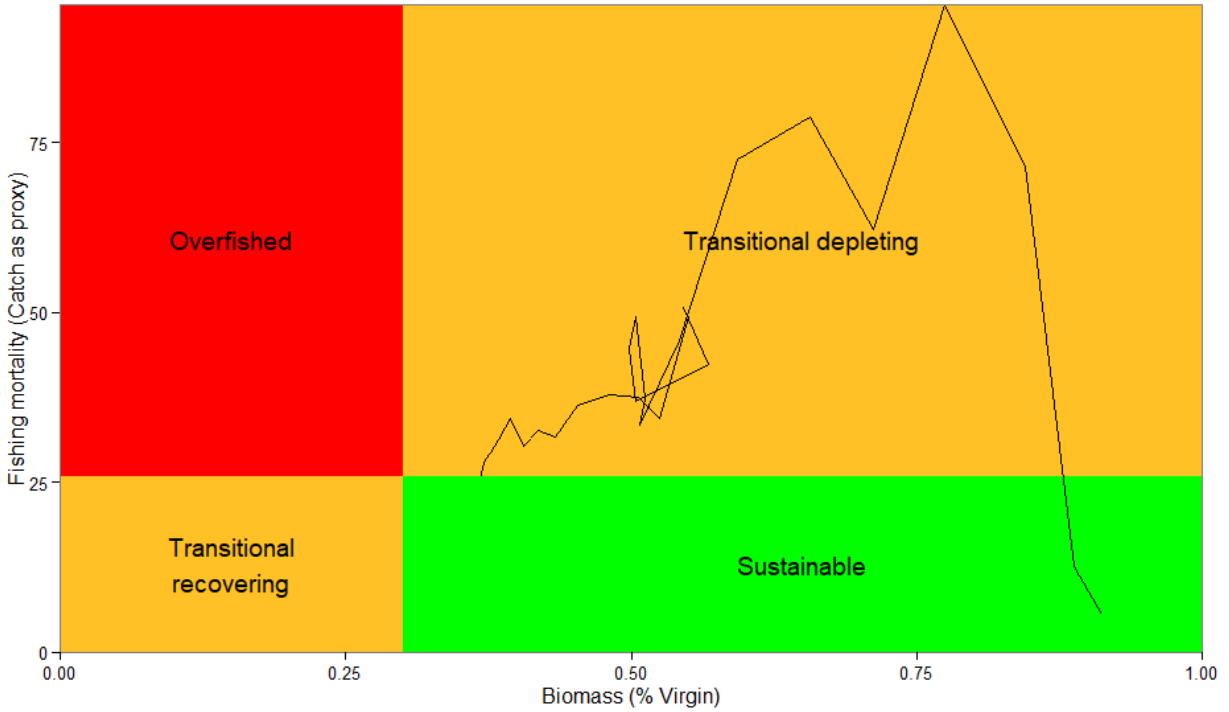


Figure 14 Diagrammatic representation of the stock status classification system, with biomass (% virgin) on the x-axis and fishing mortality (catch as proxy) on the y-axis. The black solid line is the performance of the Banded Morwong fishery over time.

6. By-product and protected species interactions

By-product in the Banded Morwong fishery is relatively low, due in part to the large mesh sizes used for Banded Morwong fishing (~140 mm mesh size). In the ERA of Bell et al. (2016), no species achieved a ranking of high vulnerability within the Banded Morwong fishery, due to the minimal gillnet effort on the west coast, the shallow nature of fishing operations relative to depths inhabited by bycatch species, low selectivity of smaller by-product and bycatch species given the large mesh sizes imposed in the fishery, and high post-release survival of many of the key by-product and bycatch species.

During the 2016/17 quota year, Banded Morwong comprised 87% of all fish caught during targeted Banded Morwong fishing trips, with Bastard Trumpeter and Bluethroat Wrasse constituting the most commonly caught by-product species (4.1% and 2.4% of the total catch for 2016/17, respectively) (Figure 15).

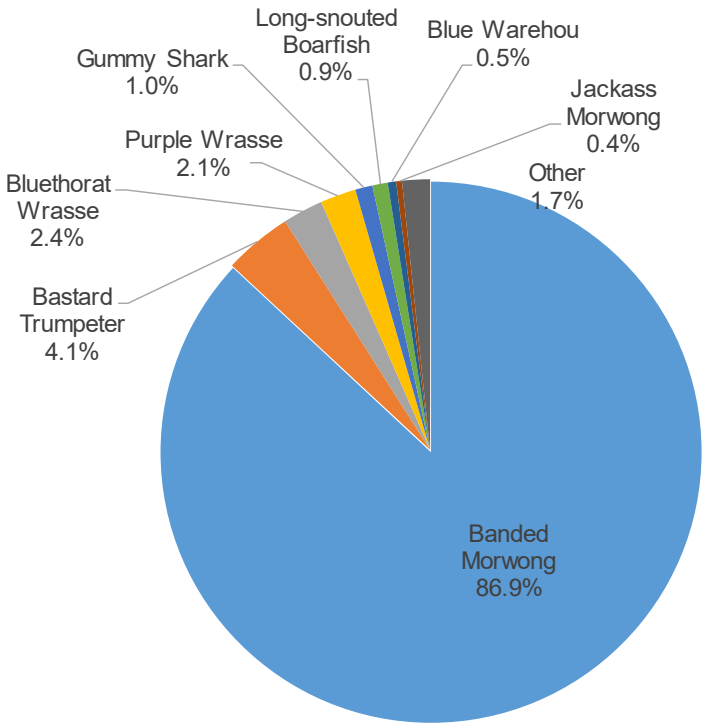


Figure 15 Catch composition (including discards) of targeted Banded Morwong fishing trips. A targeted Banded Morwong fishing trip was defined as a trip on a given day by a given fisher where Banded Morwong were retained.

Fish mortality due to predation and fishery interactions with Australian and New Zealand fur seals is largely unknown but represents another source of uncertainty in the assessment. Seals can cause substantial mortality to Banded Morwong as well as causing gear damage and influencing fishers' behaviour, factors that impact upon catches and catch rates. This is believed to be caused predominantly by individual 'rogue' seals which learn to target Banded Morwong gillnet fishing. The proportion of shots in which fishers reported a seal interaction decreased slightly in 2016/17 relative to 2015/16, with seal interactions being reported in around 15% of all shots (Figure 16). However, from the current data collection program it is unclear how fishers interpret

a seal interaction, or the effect of seal predation on catches (i.e. how many fish are lost). Additionally, effects on fisher behaviour are poorly understood. A number of fishers have indicated that they are setting a proportion of their nets as a decoy to reduce catch losses through seal interactions, and setting the remainder of their gear elsewhere, however the effect of these additional nets on seal interactions, or on fisher catch metrics (e.g. effort), is poorly understood.

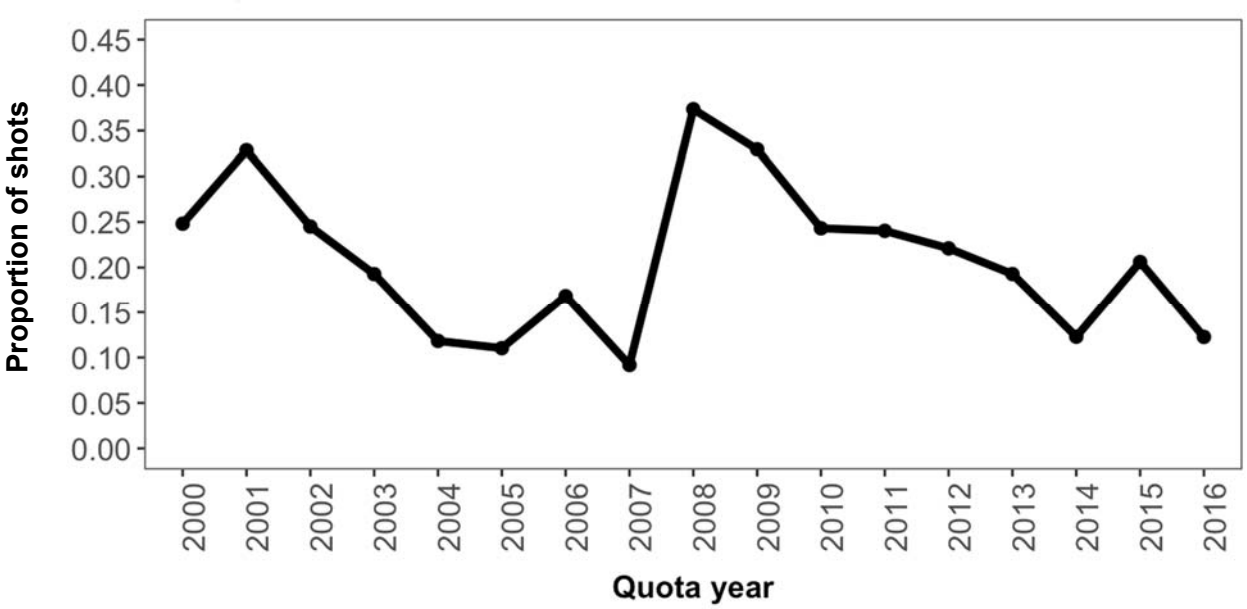


Figure 16 The proportion of shots in which fishers reported an interaction with a seal or seals.

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