Southern Sand Flathead Assessment 2023

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This assessment of the Southern Sand Flathead Fishery is produced by the Institute for Marine and Antarctic Studies (IMAS) using a combination of data generated from fishery-independent surveys between 2012 and 2023 as well as commercial fishery data downloaded from the Department of Natural Resources and Environment, Tasmania (NRE Tas) Fisheries Integrated Licensing and Management System (FILMS) database. The commercial fishery data presented here includes all logbook returns up until the 2021/22 season.

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2 Executive summary

Stock status: **DEPLETED**

This report provides an assessment of the status of Southern Sand Flathead (*Platycephalus bassensis*) in Tasmania, including a summary of key biological characteristics, management arrangements, trends in commercial catch and effort, and an analysis of data from fishery-independent surveys of age and length composition across the state.

Fishery impacts on Southern Sand Flathead in Tasmania are primarily driven by the recreational sector, with commercial catches most recently estimated to represent only 2% of the combined total catch. A fishery-independent survey of Southern Sand Flathead populations commenced in 2012 to support the assessment of this species. Initial results from the survey revealed a low relative abundance of legal-sized fish at survey sites in the D'Entrecasteaux Channel, Frederick Henry-Norfolk Bay, and Great Oyster Bay, suggesting that local populations of Southern Sand Flathead in these main fishing areas along the south and east coasts of Tasmania are heavily fished. In late 2015, management changes were introduced to reduce fishing mortality, including: (1) an increase in the minimum size limit from 300 mm to 320 mm, and (2) a reduction of the daily bag limit from 30 to 20 fish per fisher. Initial subsequent analyses of fishery-independent data and associated estimates of fishing mortality suggested that these management measures might have supported stock recovery. However, more in-depth analyses based on increasingly comprehensive survey data (six sampling locations around the state were added from 2021) indicate the persistence of highly unsustainable levels of fishing mortality, specifically for female Southern Sand Flathead. Importantly, first estimates of the biomass and spawning potential of females presented in this and last year's assessment reports further indicate that Southern Sand Flathead have been depleted below critical levels. Although additional regulations have been implemented in 2023 to support stock recovery, the most recent estimates of fishing mortality presented in this report indicate continued biomass depletion where surveys have been conducted (except for Flinders Island). Thus, Southern Sand Flathead remains classified as Depleted.

3 Introduction

Southern Sand Flathead (*Platycephalus bassensis*; hereafter Sand Flathead) is a bottom-dwelling species, inhabiting inlets, estuaries and coastal waters at generally shallow depths (< 50 m), but can be found to around 100 m. Sand Flathead are endemic to southern Australia, including New South Wales, Victoria, Tasmania and the southern part of Western Australia (Edgar 2008; Gomon, Bray, and Kuiter 2008). The population structure of Sand Flathead is uncertain, which is why stocks are generally assessed at the state level (except for Port Phillip Bay in Victoria; see SAFS 2020). However, studies of movement, growth, and reproductive biology show regional variability that indicates population differentiation at finer scales is likely to be more prevalent (Bani and Moltschaniwskyj 2008). A more detailed summary of key biological characteristics of Sand Flathead can be accessed here.

Sand Flathead is the dominant recreational fishery species in Tasmania, with approximately 300 t of catch per year in the early 2000s and almost 200 t estimated for the 2017/18 fishing season (Lyle et al. 2019). In contrast, less than 5 t of Sand Flathead have been caught annually over recent years by the commercial sector (Fraser et al. 2022).

Handline is the main gear used for both fisheries. Additionally, some Sand Flathead bycatch is landed by commercial gillnet fishers and Danish seine operators. The first stock assessment for the 2014/15 fishing season classified Sand Flathead as Depleting. This first classification reflected estimates of fishing mortality that were considered too high for long-term sustainability. Based on spatially extended survey data up until 2022 (six regions across the state were added in 2021), Sand Flathead was firstly classified as Depleted in the 2020/21 scalefish assessment report. This last assessment report estimated that fishing mortality remains highly unsustainable and has already resulted in the depletion of spawning biomass below critical levels in most regions (Fraser et al. 2022).

Catches of Southern Sand Flathead are regulated through input controls for commercial fishers and output controls for recreational fishers. Until November 2023, when commercial fishing of Sand Flathead was banned, commercial fishers required Scalefish and Danish seine licences which were restricted by gear regulations. Updated output controls for the recreational sector include a statewide possession limit of 10 fish, a maximum bag limit of 10 fish (reduced to 5 fish in the “Eastern Zone”, and 2 fish in Zone- Dentrecasteaux Channel, Derwent River, Frederick Henry and Norfolk Bays), a minimum legal size of 35 cm and a maximum legal size of 40 cm (except for King Island and Flinders Island). The Department of Natural Resources and Environment (NRE) Tasmania plans to review these output controls from November 2025 against stock recovery targets that are to be developed as part of a rebuilding plan for Sand Flathead. More detailed information on current management controls for Sand Flathead is available from the NRE Tasmania website: click here.

4 Data analyses

This report provides a stock assessment for Sand Flathead in Tasmania. Stock status classification follows the national reporting scheme used in the Status of Australian Fish Stocks (SAFS) reports (https://www.fish.gov.au/). SAFS reports include four stock status classification categories: “Sustainable”, “Depleting”, “Depleted”, or “Recovering”. These four categories define the status of the stock exclusively in terms of likely recruitment impairment. Recruitment impairment occurs when the mature adult population (spawning biomass) is depleted to a level where it might no longer ensure the reproductive capacity for stock rebuilding. Stock status compared to potential target reference points (e.g., the biomass supporting maximum sustainable ecological or economic yield) is also considered but not included in the stock status classification scheme. For more detailed information on the framework for stock status classification, please refer to the TasFisheriesResearch webpage: stock classification. Historical stock status classifications for Sand Flathead are available in Appendix 2 of this report.

4.1 Analyses of fishery-dependent data

Commercial catches of Sand Flathead are managed under the Tasmanian Scalefish Fishery Trends in commercial catch and effort were analysed using data collected through compulsory logbook returns administered by NRE Tasmania. Detailed fishery information including management objectives, assessment criteria, and analyses of catch and effort time series as presented below can be accessed online through the TasFisheriesResearch webpage. Periodic catch and effort information for the recreational sector is estimated from statewide surveys conducted every 5 years and published on the IMAS webpage.

Routine assessments of commercial scalefish fishery data are based on time series of catch, effort, and catch-per-unit-effort (CPUE). For San Flathead, effort and CPUE analyses are restricted to commercial data from 1 July 2007 to 30 June 2022. A ‘fishing year’, running from 1 July to 30 June of the following year, is used for our annual commercial catch reporting. This decision is based on the understanding that reporting aligned with the financial year, as opposed to the calendar year, provides a more accurate representation of the seasonality of fisheries for most species, which are characterized by a concentration of catch (and effort) between late spring and early autumn. Moreover, the financial year reporting schedule better accommodates the biological processes of recruitment and growth for most species, including Sand Flathead.

Commercial catch and effort data have generally been analysed at the state level. However, more recent analyses include a regional breakdown encompassing five fishing regions: the southeast coast (SEC), east coast (EC), northeast coast (NEC), northwest coast (NWC), and west coast (WC) (see Figure 1).

Commercial effort is expressed in numbers of days fished per gear type (almost exclusively handline). Examining effort in terms of days fished overcomes uncertainty about the reporting of effort units and provides consistency through time, assuming that there have been no major changes to fishing practices during that time (2007-2022).

Since CPUE data are typically log-normally distributed, the geometric mean (*GM*) rather than arithmetic mean of daily catch records has traditionally been calculated to generate CPUE statistics. The geometric mean is the n^{th} root of the product of individual CPUE values, which is equivalent to computing the arithmetic mean of the natural logarithm of each number, and then taking the exponent:

CPUE calculated using this method may differ slightly from the more simplistic approach of dividing total catch by total effort or using the arithmetic mean. The advantage of calculating the geometric mean is that results are less affected by relatively few, unusually high data points, which are characteristic of log-normally distributed data.

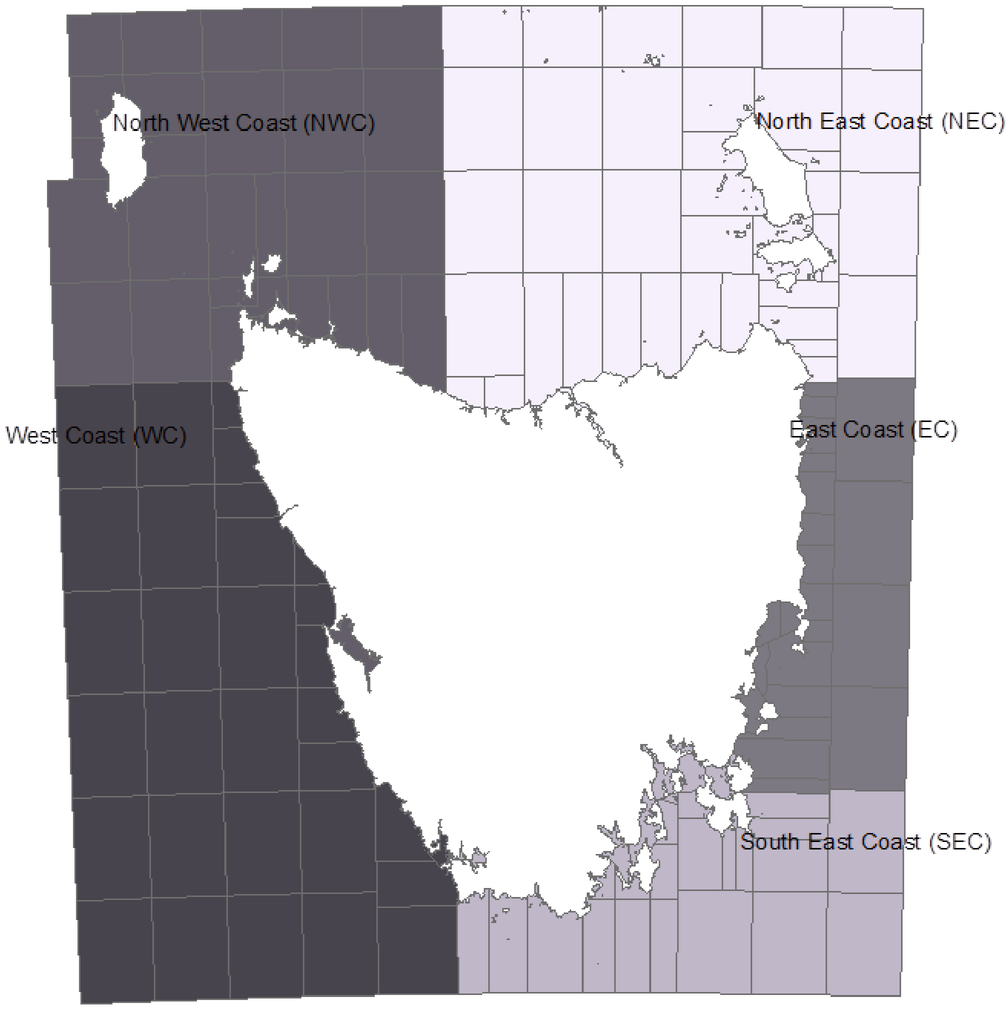


Figure 1: NRE fishing blocks and management regions (in grey) for the Tasmanian Scalefish Fishery.

State-wide CPUE based on the geometric mean has traditionally been reported by normalising data based on the first representative values of the catch and effort time series (i.e., the reference year), which allows for the simultaneous comparison of multiple CPUE trends for different gear types. However, in this report we also report nominal CPUE trends (i.e., raw CPUE in kg/day) for each gear type and region.

4.2 Analyses of fishery-independent data

Concerns surrounding the abundance of legal-sized Sand Flathead led to the establishment of an annual fishery-independent survey in 2012 (Ewing, Lyle, and Mapleston 2014). The initial survey, using fishing gear and targeting practices typical of recreational fishers, covered three regions off the south and east coasts, but was extended in 2021 by adding five additional regions off the east and north coasts of Tasmania (Figure 2). Surveys are conducted annually from January to March, generally over three (not necessarily consecutive) days per region with 19-21 standard sites fished in each region (see maps here). These sampling sites represent a range of suitable habitats and depths for Sand Flathead, providing comprehensive coverage in each region. In addition to these routine sampling sites, Flinders Island was added as a survey region in 2023, with first samples collected in February 2023.

Sex-specific length and age frequencies from survey data inform Sand Flathead stock status assessments. Assessment approaches require estimates of key life history parameters for meaningful parameterization, including the infinite or asymptotic length (*Linf*), the von Bertalanffy growth rate (*k*), the lengths at 50% and 95% maturity (*L50* and *L95*), the length at 50% and 95% gear selectivity (*SL50* and *SL95*), and the instantaneous rate of natural annual mortality (*M*). Most parameters have been estimated and presented in previous assessment reports (Krueck, Hartmann, and Lyle 2020; Fraser, Hartmann, and Krueck 2021; Fraser et al. 2022). However, all parameters were re-estimated as needed for the current assessment using the latest available survey data.

Following a widely applied approach parameterized according to a recent meta-analysis, the sex-specific instantaneous rate of natural mortality (*M*) was estimated by assuming 1.5% adult survival until the maximum observed age available from the flathead survey data (Dureuil and Froese 2021). *Linf*, *L50*, *L95*, *SL50*, and *SL95* were estimated using established methods as implemented in the "TropFishR" package in R (Mildenberger, Taylor, and Wolff 2017). *Linf* and *k* were also estimated using the "nls2" function in R to fit the standard von Bertalanffy growth function (VBGF) to survey data:

$$L = L_{inf}\left(1 - e^{-k_{(a-t_0)}}\right),$$

where *L* is length (reported in cm), *Linf* is the mean length of fully grown individuals, *k* is the growth coefficient, *a* is age, and *t0* is the theoretical age when length is equal to zero. The parameter space for VGBF fitting of *k* was determined by assuming credible *M*/*k* ranges between values of 1 and 2. The parameter space for *Linf* was determined based on prior *Linf* estimates using the "Powell-Wetherall" (PW) regression as implemented for example in the TropFishR package. Length thresholds for inclusion of data points in PW regressions were specified according to prior estimates of *SL95* (i.e., full gear selectivity). An *Linf* range between 0.5 and 2 times the PW estimate of *Linf* was then used for VGBF fitting. However, the survey data for most species was collected from key fishing grounds of the assessed species, which made VGBF estimates of *Linf* more sensitive to size and age-truncation than PW regressions. Thus, in case of notable underestimation of *Linf* values due to evident size and age truncation, the VGBF function was fitted by constraining *Linf* to the PW estimate. The parameter space for *t0* was restricted to values between 0 and -10% of *tmax*. If gear selectivity (*SL50*) indicated an introduction of bias in the length at age of young fishes available from the survey data, *t0* was fixed to 0.

TropFishR was further used to estimate the instantaneous rate of total annual mortality (*Z*) from catch curves, including 95% confidence intervals. Values of *Z* were then used to infer fishing mortality *F* (*F* = *Z* – *M*), and relative fishing mortality (*F*/*M*). A relative fishing mortality *F*/*M* value of 1, where fishing mortality equals natural mortality, is commonly used as a threshold for overfishing. However, lower *F*/*M* values of 0.87 and 0.5 have been recommended for teleosts to ensure that *F*/*M* does not exceed the fishing mortality supporting maximum sustainable yield and does not undermine the precautionary principle (Froese et al. 2016).

The life history and selectivity parameters described above were further used to run two alternative length-based stock assessment approaches. The first of these two approaches, which is founded on classic Beverton-Holt life history theory and empirical knowledge available from FishBase (Dureuil and Froese 2021), is the Length-based Bayesian Biomass (LBB) estimation approach. LBB requires a representative sample of length frequencies combined with an optional prior for *Linf* based on which it estimates relative fishing mortality (*F*/*M*) and relative biomass (*B*/*B0*); i.e., current (fished) biomass (*B*) relative to past unfished biomass (*B0*), including 95% credible intervals. Estimates of biomass depletion *B*/*B0* can be assessed against common target reference points of 0.4-0.5 *B*/*B0* (i.e., 40%-50% of unfished levels) to determine whether stocks are overfished, i.e., supporting the maximum ecological or economic yield. Values of *B*/*B0* of 0.2 (20% of unfished levels) and below are commonly used to determine whether stocks are depleted, i.e., whether reproductive output and recruitment could be impaired to an extent that populations are unable to recover. We will refer to these biomass target and limit reference points for management throughout this report, because they have been adopted in fishery harvest strategy policies across Australia.

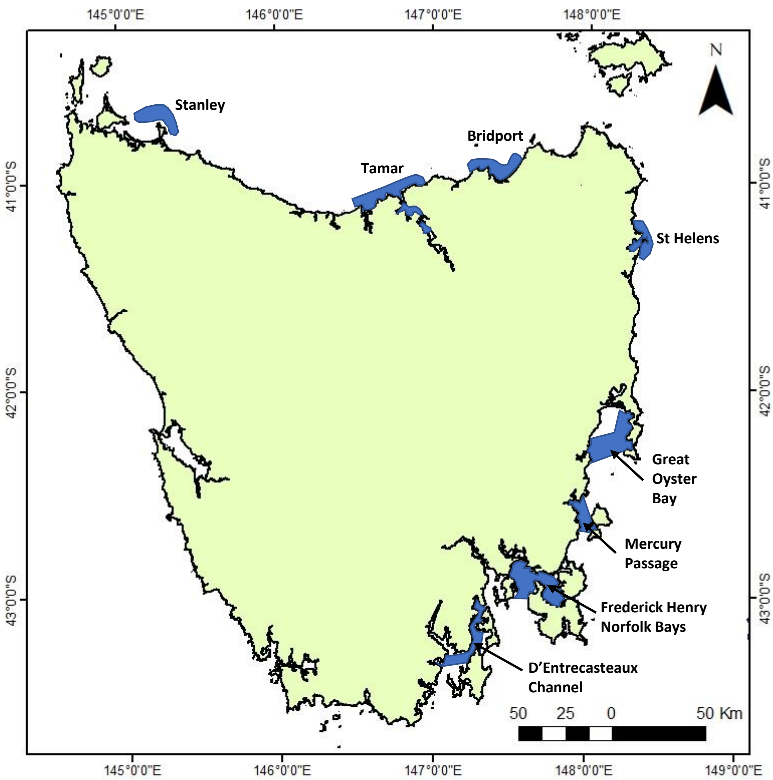


Figure 2: Map showing eight survey regions around Tasmania: (1) D'Entrecasteaux Channel, (2) Frederick Henry-Norfolk Bay, (3) Mercury Passage, (4) Great Oyster Bay, (5) St Helens, (6) Bridport, (7) Tamar Estuary, and (8) Stanley. Flinders Island off the northeast corner of the state was also surveyed for the first time in 2023 (see detailed maps here).

The second length-based stock assessment approach, which is also founded on classic fishery life history theory and now widely applied for data-poor fisheries management worldwide, is the Length-Based Spawning Potential Ratio (LBSPR) estimation approach (Hordyk et al. 2015a, Hordyk et al. 2015b). LBSPR requires estimates of *Linf*, *M*/*k*, *L50*, *L95*, *SL50*, and *SL95* as input parameters. LBSPR then calculates the relative fishing mortality (*F*/*M*) and the relative spawning potential ratio (*SPR*/*SPR0*), i.e., the current (fished) *SPR* relative to an expected unfished *SPR* (*SPR0*). The *SPR* is a term used synonymously to “spawning biomass per recruit” or the “fraction of lifetime egg production” (FLEP), which compare the average reproductive output of individuals in a fished population with the average level of reproductive output expected for an unfished population. A value of *SPR*/*SPR0* = 0.2 (i.e., 20% of unfished levels) is widely recognized as the ‘replacement level’, where fish populations might persist at current levels, but have little ability to rebuild, or decline over time. When the *SPR* reaches 10% of unfished levels (*SPR*/*SPR0* = 0.1), recruitment is expected to decline rapidly, eventually resulting in local extinction. The default target reference points for *SPR* are 40%-50% of unfished levels (*SPR*/*SPR0* = 0.4-0.5), where reproductive output and recruitment is expected to result in maximum sustainable ecologic or economic returns.

The accuracy of outcomes from both length-based assessment approaches described above depends on representative length frequency samples and cannot readily be applied with confidence if sample sizes are smaller than 100. Ideally, sample sizes of n > 1000 are used. Outcomes for pooled regions implicitly assume that fishing pressure is uniform across the state. This assumption was clearly violated. Thus, annual samples over the last three years were pooled to provide a regional breakdown of outcomes with a similar level of confidence.

Outcomes from all length-based assessments represent female biomass and fishing mortality, because: (1) female biomass is generally used to infer the reproductive potential (egg production capacity) of fish populations; (2) females grow to higher *L50* and *Linf*, which makes them more vulnerable to the impacts of fishing; and (3) females represent the majority of samples available from surveys.

4.3 Risk assessment of recruitment impairment

This report further includes a routine risk analysis for generally data-poor scalefish species that follows protocols by the Marine Stewardship Council (MSC) based on an approach established by the CSIRO (Hobday et al. 2011). The MSC is globally recognised and produces a widely used Fisheries Standard for assessing if a fishery is well managed and sustainable. The Risk-Based Framework (RBF) described within the MSC Standard is suitable for assessing fisheries with limited data and for which primary indicators may be unavailable or problematic. Although this is not the case for Sand Flathead, application of the RBF is straight-forward and provides an alternate perspective.

The RBF draws on information about the productivity of a target species and its susceptibility to fishery-related impacts (Productivity Susceptibility Analysis), as well as the consequence of fishing activity for the species (Consequence Analysis). Application of the RBF approach culminates in an overall score, which is indicative of the relative sustainability of the fishery. Scores > 80 are regarded as passing the assessment with a low risk of stock damage. Scores of 60 – 80 are also regarded as passing the assessment, but with a moderate risk of stock damage. Scores < 60 fail the assessment with a substantial risk of stock damage. We note that the RBF is precautionary and will likely result in a lower score than the default MSC assessment method.

Given the RBF is designed for data-poor fisheries, a cautious (worst-plausible) approach is recommended in the absence of credible information, meaning that limited species information likely results in a lower final score. The RBF approach assumes that fisheries operating at high levels of exploitation inherently pose a greater risk to target species and the associated ecosystem than under-utilised fisheries. Therefore, lower scores will be derived for highly utilised species unless credible information is available to indicate otherwise. More information, including details on the RBF scoring system, is available on the TasFisheriesResearch webpage.

5 Trends in catch and effort

Sand Flathead has only been distinguished from Tiger Flathead in commercial fishery returns data since 2007/08. Previous stock assessment reports show back-calculated estimates of species-specific catches up to almost 15 t prior to 2007/08 (Krueck, Hartmann, and Lyle 2020; Fraser, Hartmann, and Krueck 2021). Total commercial catch for Sand Flathead in the 2021/22 financial year was only 3.8 t, which is a slight increase (0.5 t) from last season but lower than peak specific-specific commercial catches of 13 t reported in 2008/09. However, commercial catches are dwarfed by estimates of recreational catches available from statewide recreational fishing surveys conducted since 2000/01 (Lyle 2005; Lyle et al. 2009; Lyle, Stark, and Tracey 2014; Lyle et al. 2019). In 2017/18, the recreational catch of Sand Flathead was estimated at 184.4 t (Lyle et al. 2019), which was approximately 98% of the estimated total catch (recreational and commercial combined) in that season, and is representing 56 times the commercial catch in the current season (see Figure 3A).

Catch and effort is concentrated in the most populated regions across Tasmania. Almost all commercially harvested Sand Flathead has recently been taken by handline on the east, southeast, and northwest coasts (Figure 4A). Based on the recreational fishery survey in 2017/18, just over half of the estimated total recreational catch was taken from the southeast coast, with the central east (including Great Oyster Bay) and northwest coasts also representing important regions (Lyle et al. 2019).

Although commercial catches are relatively insignificant, we note that both commercial handline effort and CPUE show an overall declining trend (Figure 4B and C). Regional differences indicate that this trend is least pronounced in the northwest coast region (Figure 4 and Figure 5).

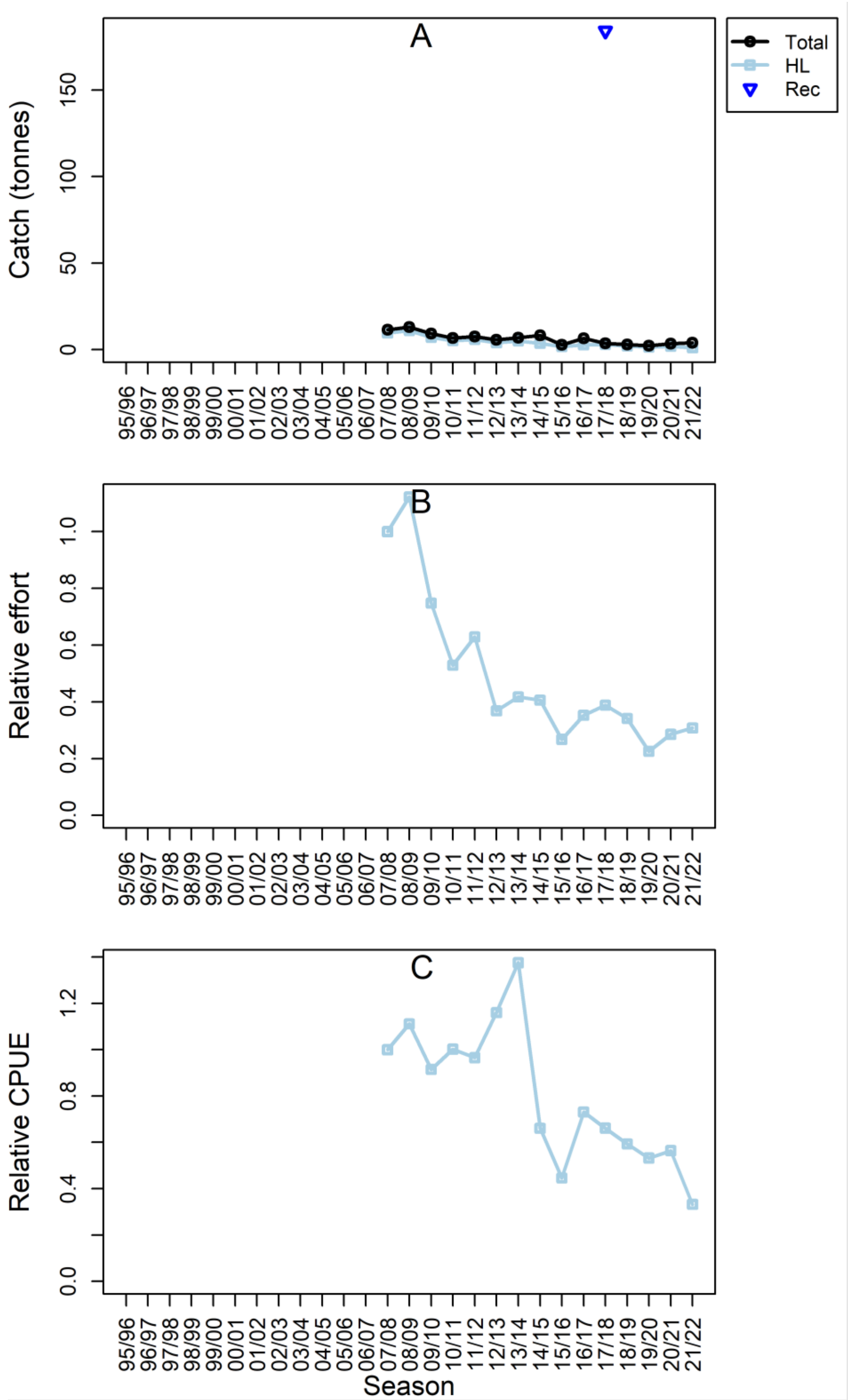


Figure 3: (A) Annual commercial Southern Sand Flathead catch (t) by gear; (B) annual commercial effort for main gear type(s) based on days fished relative to 2007/08; (C) annual commercial catch per unit effort (CPUE) based on weight per days fished relative to 2007/08. HL = handline, Rec = estimated recreational catch.

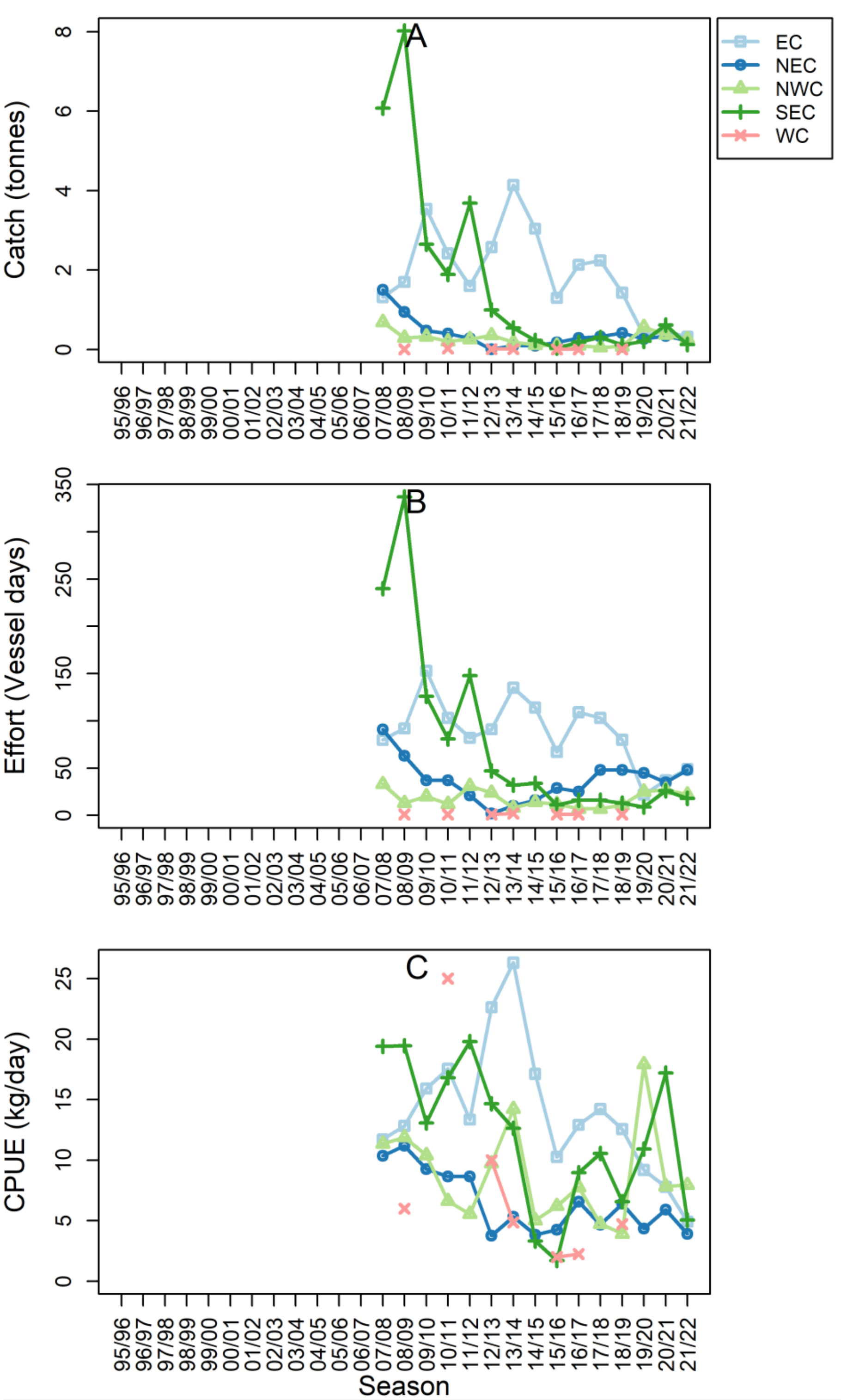


Figure 4: Regional commercial Southern Sand Flathead catch (A), effort (B), and catch per unit effort (CPUE) (C) recorded for hand line. EC = east coast, NEC = northeast coast, NWC = northwest coast, SEC = southeast coast, WC = west coast.

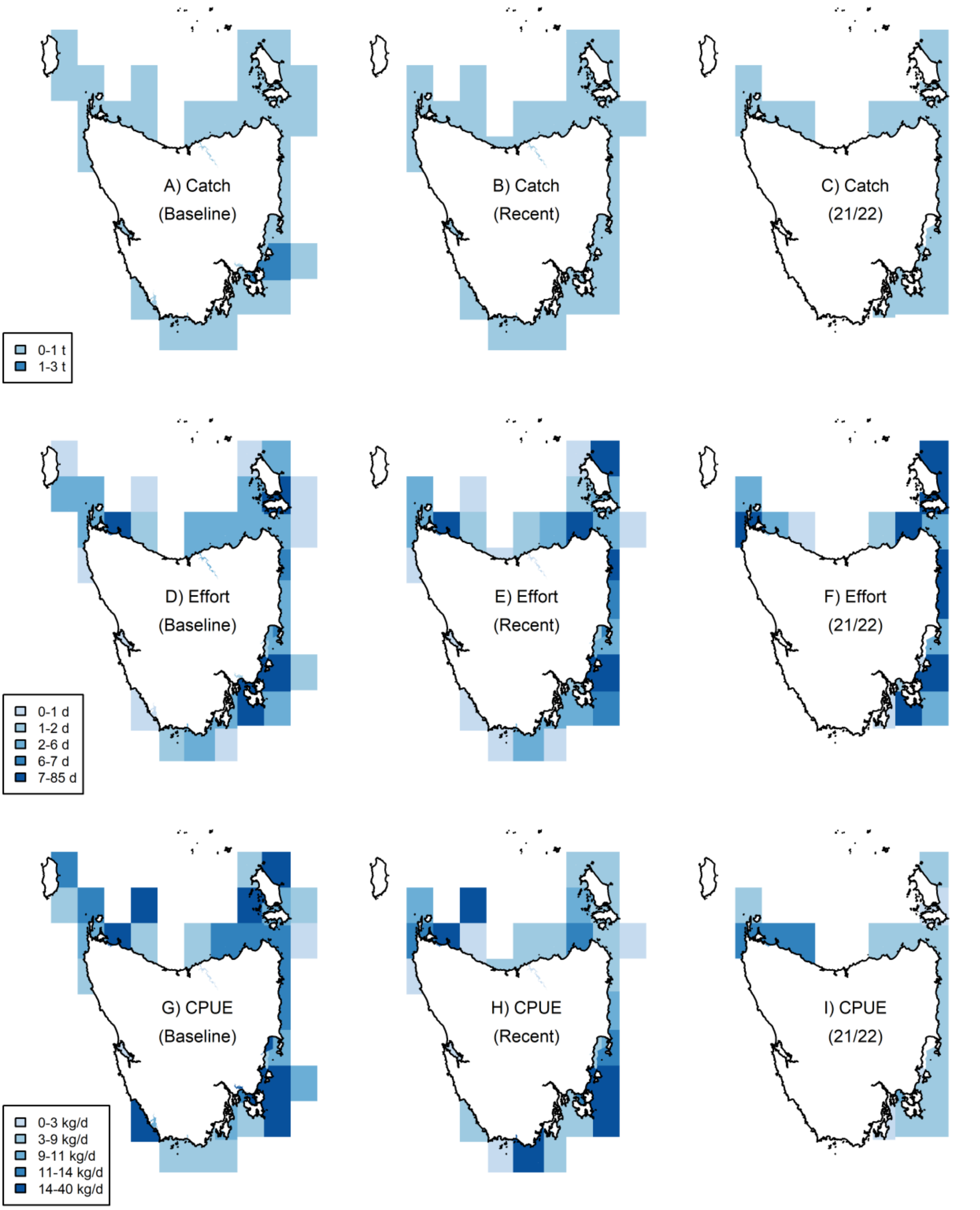


Figure 5: Southern Sand Flathead catches (t), effort (fishing days), and CPUE (kg/day) by fishing block for all main gear types combined. 'Baseline' data represent the average per fishing block across the ten-year period from the reference year (2007/08 to 2016/17 for this species). 'Recent' data represent the average per fishing block across the last five fishing seasons (2016/17 to 2020/21). '21/22' represent data from the 2021/22 fishing season.

6 Length- and age composition

Fishery-independent surveys provide length- and age frequency data for Sand Flathead which are used to analyse trends and assess stock status against management reference points

Between January and March 2023, a total of 946 Sand Flathead were collected across nine locations within five regions, including additional sites on Flinders Island (Table 1). Fish length ranged from 179 mm (caught in the Tamar estuary) to 542 mm (caught off Flinders Island) (Table 1).

Except for Flinders Island, the proportion of Sand Flathead caught below the minimum legal size at the time of survey (< 320 mm) ranged between 73% and 92% (Table 2; Figure 6). In contrast, only 21% of fish caught off Flinders Island were smaller than 320 mm.

Catches of legal-sized fish were dominated by females. Females comprised up to 100% (in the south-east coast (SEC) region and Bridport) of fish > 320 mm. Off Flinders Island and Stanley the proportion of females > 320 mm was lowest, with 67% and 78%, respectively. With the recent increase of the MSL to 350 mm, the proportion of legal-sized fish would increase to 100% female across most survey locations (Table 2).

All length-frequency data is available for public access on the Tas Fisheries research website.

All 946 Sand Flathead caught in 2023 were also aged. Fish as young as 2 years old were caught in all regions (Table 2). The oldest fish in Tasmanian coastal regions varied between 8 and 14 years, and a 20-year-old male (506 mm) was recorded off Flinders Island. This individual is the oldest Sand Flathead recorded from Tasmanian waters.

In the SEC and east coast (EC) regions, a large percentage (88% and 74%, respectively) of fish were between 3 and 7 years of age (Figure 7). The age composition of Sand Flathead from the north-east coast (NEC) region was dominated by 2 to 4-year-old fish, with very few fish ≥ 5 years of age. Very few fish ≥ 4 and 6 years of age were caught in the NEC and north-west coast (NWC) region, respectively. Although the catches of Sand Flathead off the NWC and Flinders Island were dominated by 3- and 4-year-old fish, respectively, fish up to 12 and 16 years were also present, plus a single 20-year-old fish at Flinders Island. Age-frequency data is available for public access on the Tas Fisheries research website.

Table 1: The total number (*n*), minimum (Min), maximum (Max) and mean total length (TL, mm) and age (years) of Sand Flathead caught from nine locations within five regions around Tasmania in 2023.

Region	Location	*n*	Min TL	Max TL	Mean TL	Min Age	Max Age	Mean Age
SEC	D'Entrecasteaux Channel	131	183	365	270	2	14	5
	Frederick Henry & Norfolk Bays	106	184	360	267	2	9	4
EC	Mercury Passage	89	208	380	301	2	9	5
	Great Oyster Bay	100	219	416	296	2	12	6
	St Helens	48	216	399	316	2	8	3
NEC	Bridport	81	251	443	303	3	11	5
	Tamar	80	179	341	275	2	9	3
NWC	Stanley	89	226	432	303	2	12	5
FI	Flinders Island	222	215	554	384	2	20	7

Table 2: The number (*n*) and percentage of Sand Flathead below and above the minimum size limit (MSL) of 320 mm (until May 2023) and 350 mm (fromt May-2023) caught at nine locations within five regions around Tasmania in 2023. %F denotes the percentage of females.

		< 320 mm			> 320 mm			> 350 mm		
Region	Location	*n*	%	%F	*n*	%	%F	*n*	%	%F
SEC	D'Entrecasteaux Channel	123	94	70	8	6	100	1	1	100
	Frederick Henry & Norfolk Bays	96	91	59	10	9	100	1	1	100
EC	Mercury Passage	61	69	80	28	31	93	5	6	80
	Great Oyster Bay	77	77	53	23	23	96	7	7	100
	St Helens	22	46	64	26	54	100	8	17	100
NEC	Bridport	64	79	31	17	21	82	8	10	88
	Tamar	74	93	57	6	8	83	0		
NWC	Stanley	57	64	60	32	36	78	11	12	100
FI	Flinders Island	47	21	34	175	79	67	144	65	72

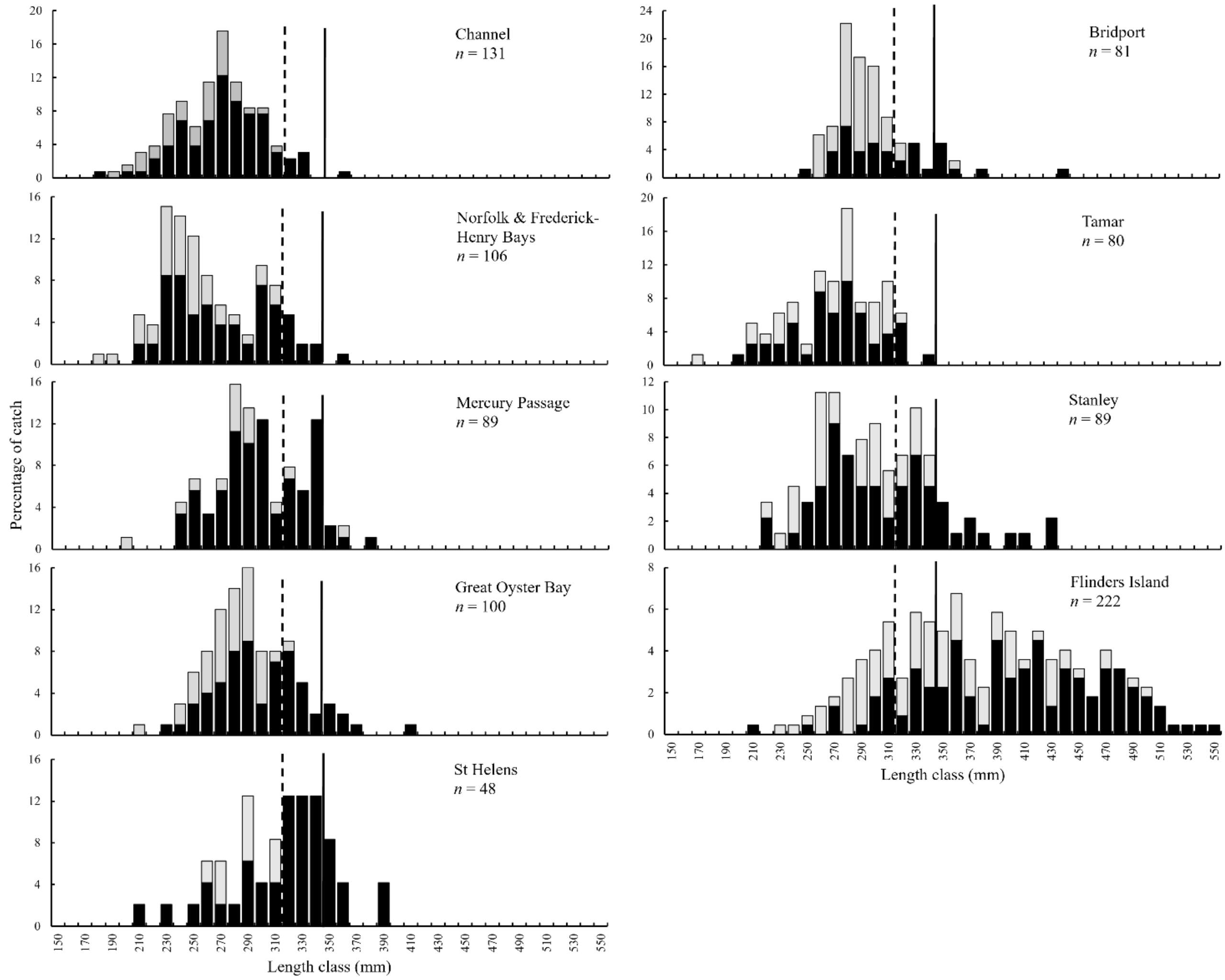


Figure 6**:** Length frequency distributions for female (black bars) and male (grey bars) Sand Flathead caught at nine locations around Tasmania in 2023. The dotted lines indicate the previous minimum size limit (MSL) of 320 mm, while the solid lines indicate the new MSL of 350 mm.

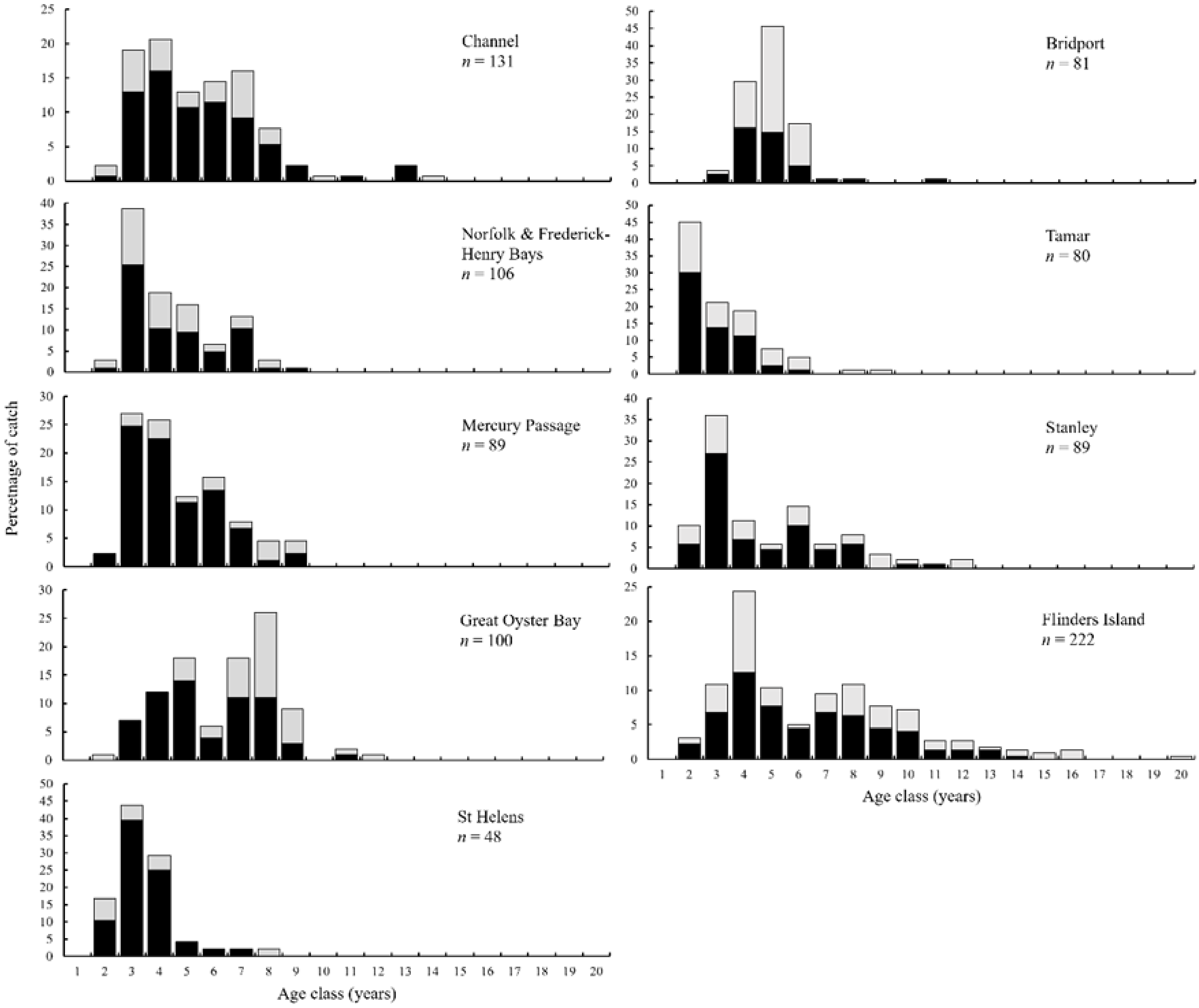


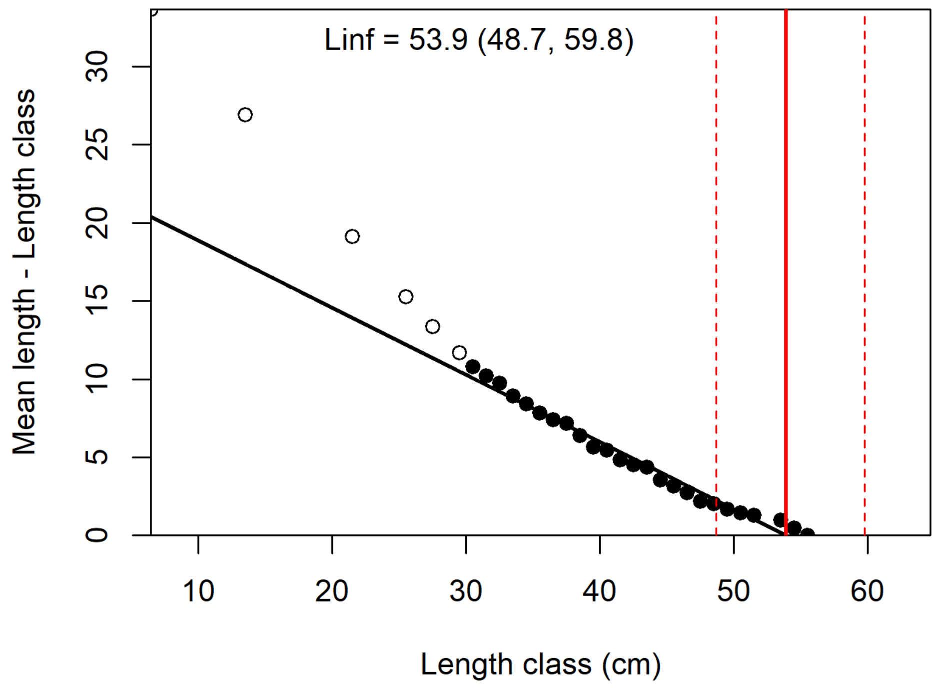
Figure 7: Age frequency distributions for female (black bars) and male (grey bars) Sand Flathead caught at nine locations around Tasmania in 2023.

7 Length-based assessments

Estimating representative life history parameters for length-based stock assessment from fishery-independent survey data was complicated by the size- and age-truncation of populations before surveys commenced in 2012. Consequently, infinite or asymptotic length (*Linf*), which is the mean length of fully grown adults if there was no fishing, could not reliably be inferred using standard fits of the von Bertalanffy growth function (VBGF). This is because heavy fishing pressure in the past has led to the rarity or complete absence of the largest individuals in most regions across Tasmania, which in turn caused standard VBGF regression-based estimates of *Linf* to be closely aligned with the longer-term minimum size limits of 30-32 cm (VGBF estimates of *Linf* for females at traditional south-east coast sampling sites is 33 cm). Powell-Wetherall regressions were used as an alternative approach for *Linf* estimation in the last assessment as this approach was found to be less sensitive to the bias introduced by size truncation and gear selectivity.

In this assessment, *Linf* was re-estimated based on the extended survey dataset, which included size and age frequency information from Flinders Island, where populations are lightly fished compared to other regions across Tasmania. Confirming this assumption, Powell-Wetherall regressions revealed estimates of *Linf* for Flinders Island that were closely aligned with those from standard VBGF fits to the same data (53.9 cm vs 52 cm). These estimates were higher than last year's estimates based on pooled length frequencies that did not yet include surveys from Flinders Island (53.9 cm vs 49.1 cm). However, *Linf* estimates from both the last assessment report as well as VBGF fits to Flinders Island data were within the confidence interval of those resulting from Powell-Wetherall regressions (48.7-59.8 cm). To capture the uncertainty range around *Linf* and the associated growth rate *k*, we parameterised baseline conditions for an unfished female population of Sand Flathead for subsequent estimates of fishing mortality and biomass depletion by analysing three alternative scenarios: 1) the best "Estimate" scenario (default assumption: *Linf* = 53.9 cm; *k* = 0.19); 2) the "Fast growth" scenario (*Linf* = 48.7; *k* = 0.32); and 3) the "Slow growth" scenario (*Linf* = 59.8 cm; *k* = 0.15) (see Figure 8).

A)



B)

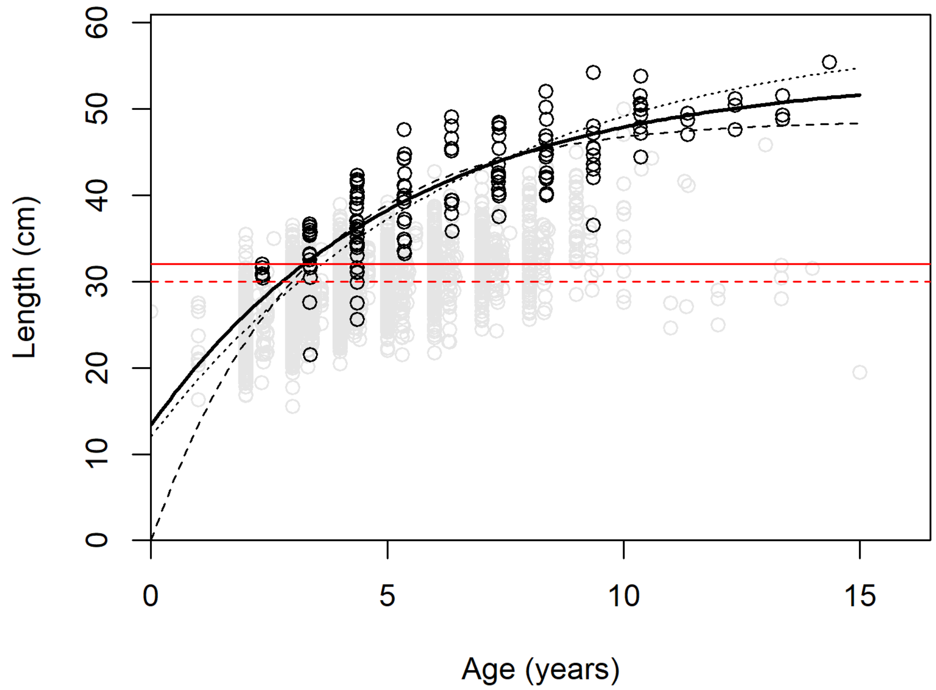


Figure 8: A) Powell-Wetherall regression to estimate the asymptotic length (*Linf*) of female Sand Flathead based on data from lightly fished survey sites on Flinders Island. Filled circles highlight data for individuals ≥ 30 cm in length, which was the estimated length of "full" gear selectivity (95% of individuals). Red vertical lines mark the estimate of *Linf* (solid) and associated confidence intervals (dashed). (B) Alternative fits of the von Bertalanffy model to estimate growth (*k*) of an unfished female population. The black solid line represents the best "estimate" scenario (default assumption) while the dashed and dotted lines represent the alternative "fast growth" and "slow growth" scenarios, respectively. Black dots in B represent data from Flinders Island while grey dots represent data from other survey sites across the state where fishing has caused more substantial size truncation (see Figure 6 above). Red lines represent the long-term initial (dashed: 30 cm) and revised (solid: 32 cm) minimum size limit. The updated minimum size limit is 35 cm.

The growth rate *k* for the default scenario (0.19) was almost identical to last year's estimate of 0.2. Similarly, the updated estimate of natural mortality of females was revised down only slightly to a value of 0.28 (compared to 0.3 in last year's assessment), which was due to an updated maximum recorded age of females in Tasmania of 15 years. We note again that, in comparison, the oldest recorded age for males in Tasmania is now 20.4 years, which results in a natural mortality estimate of 0.21. It is possible that females reach a similar age, which would warrant additional sensitivity analyses in the future, considering that reduced mortality is generally associated with a higher sensitivity to fishing pressure, affecting estimates of both fishing mortality as well as biomass depletion.

Plausible combinations of *Linf*, *k* and *M* captured by our three alternative growth scenarios (Table 3) were used (1) for length-based estimates of mortality using catch curve analyses and (2) to estimate spawning biomass depletion and relative fishing mortality (*F/M*) using LBB and LBSPR. If not otherwise specified, results refer to the best estimate scenario, including an associated life history ratio *M*/*k* of 1.47 (0.28/0.19), which is closely aligned with assumptions according to classic life history theory (median *Mk* = 1.5).

Table 3: Key parameters used for length-based assessments of stock status and trends. *Linf*: infinite or asymptotic length; *k*: von Bertalanffy growth rate; *M*: instantaneous rate of natural mortality; *M*/*k*: the ratio between natural mortality and growth determines the shape of the estimated unfished length-frequency distribution. All results represent females only.

Scenario	***Linf***	***k***	***M***	**M/k**
“Estimate”	53.93 cm	0.19	0.28	1.47
“Fast growth”	48.72 cm	0.32	0.28	0.87
“Slow growth”	59.77 cm	0.15	0.28	1.87

Outcomes from length-based catch curves revealed a high instantaneous rate of total annual mortality *Z* of 1.75 at locations in the southeast and east coast region sampled from 2012 (D'Entrecasteaux Channel, Frederick Henry & Norfolk Bays and Great Oyster Bay). This value translates to approximately 83% mortality of adults per year. The instantaneous rate of annual fishing mortality was estimated at 1.47, translating to an annual mortality of 77% (95% confidence interval: 65%-85%) caused by fishing (Table 4). In other words, fishing mortality was estimated to account for 93% of total annual deaths of adult females at traditionally surveyed locations in the south-east and east coast regions over recent years. This level of fishing mortality is substantial as further highlighted by the estimated ratio of fishing mortality relative to natural mortality (*F*/*M*), which far exceeded putatively sustainable levels of *F*/*M* below 1. The inclusion of survey data from additional sites on the east and north coasts, now including Flinders Island, resulted in substantially reduced levels of estimated fishing mortality (25%) and *F/M* (1) for pooled data. However, these estimates for pooled data masked concerning levels of both fishing mortality and biomass depletion of females in all coastal waters sampled around Tasmania, which became evident when Flinders Island samples were excluded (Table 4). Flinders Island itself, where fishing pressure was expected to be very low, revealed an estimate of total mortality *Z* of 0.16 (0.02-0.3). Thus, the uncertainty range around *Z* in this region captured our default estimate of natural mortality *M* of 0.28, confirming that (1) fishing pressure on Finders Island is likely to be low to negligible, and that (2) *M* of females could be lower than estimated here according to the maximum currently recorded female age in Tasmania (15 years).

Table 4: Estimates of recent total mortality (*Z*), fishing mortality (*F* = *Z*-*M*), and fishing mortality relative to natural mortality (*F*/*M*) based on length-based catch curves using fishery-independent survey data between 2021 and 2023. Results for the southeast coast region represent females from three traditionally sampled survey sites (D'Entrecasteaux Channel, Frederick Henry & Norfolk Bays and Great Oyster Bay). All results state 95% confidence intervals in brackets.

Region	***Z***	***F***	***F/M*** (Target: 0.5-1)
Pooled	0.56 (0.46-0.66)	0.28 (0.18-0.38)	1 (0.64-1.36)
Pooled - Flinders excluded	1.24 (1.16-1.32)	0.96 (0.88-1.04)	3.43 (3.14-3.71)
Southeast coast traditional	1.75 (1.34-2.16)	1.47 (1.06-1.88)	5.25 (3.79-6.71)

Outcomes from the Length-based Bayesian Biomass (LBB) estimation approach corroborated the findings above by highlighting that relative fishing mortality in the south-east coast region might far exceed putatively sustainable levels (Table 4, Figure 9A). Moreover, LBB results indicated that substantial overfishing in the south-east coast region might have caused biomass depletion of female Southern Sand Flathead below putatively critical levels of 20% of the unfished biomass (Table 4, Figure 9B). These general findings were robust to alternative assumptions about growth and asymptotic lengths. Results for the best "estimate" and "slow growth" scenarios were almost identical while those for the "fast growth" scenario revealed higher estimated depletion and relative fishing mortality.

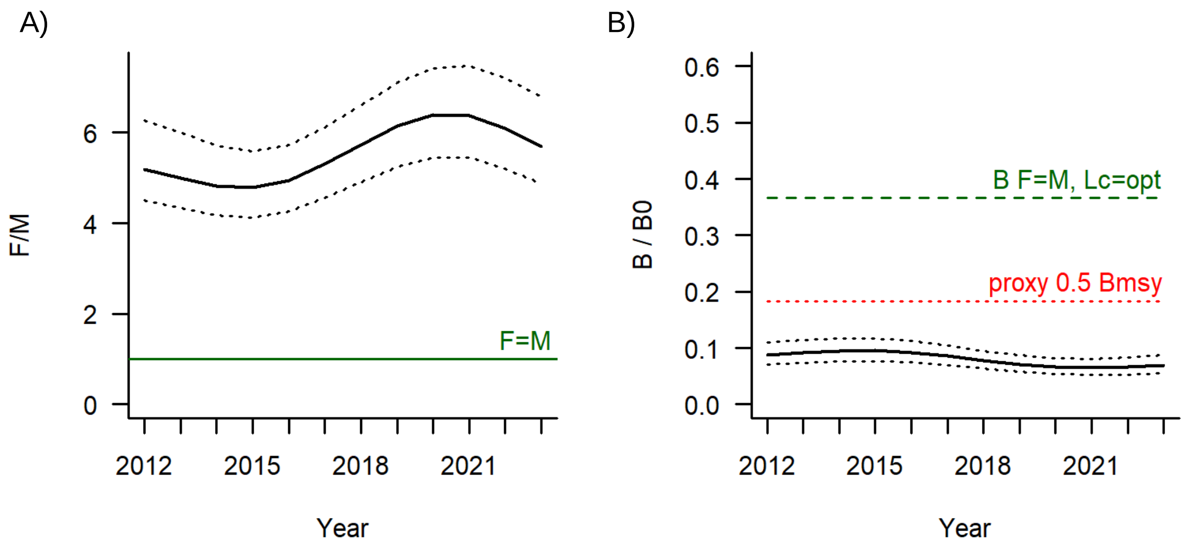


Figure 9: Smoothed trends in relative fishing mortality (A) and biomass depletion (B) for female Sand Flathead in the south-east coast region using the Length-based Bayesian Biomass (LBB) estimation approach. Fishing mortality relative to natural mortality (*F*/*M*) ratios of 1 are widely used as a threshold to identify unsustainable levels of fishing (solid line in A). LBB estimates a possible biomass target reference point where catch equals the maximum sustainable yield (Bmsy; i.e., *B* where *F* = *M* and mean length at first capture (*Lc*) is optimal) when *B*/*B0* = 0.37 (dashed black line in B). An estimated limit reference point for critical biomass depletion at 0.5 Bmsy is also highlighted (red dotted line in B).

Table 4: Estimates (and 95% CIs) of relative fishing mortality *F/M* and biomass depletion B/B0 (B) of female Sand Flathead at traditionally sampled sites in the south-east coast region using the Length-based Bayesian Biomass (LBB) estimation approach. See text above and Table 3 for details on scenarios.

Scenario	***F/M* in 2023**	***B/B0* in 2023**
Estimate	4.1 (3.5-4.9)	0.09 (0.07-0.11)
Fast growth	5.3 (4.24-6.34)	0.07 (0.05-0.09)
Slow growth	4.4 (4.0-5.0)	0.08 (0.07-0.09)

A regional breakdown of LBB outcomes, representing samples collected over the past three years from multiple additional locations on the east and north coast, indicated that current levels of population depletion and the risk of further depletion are high across Tasmania (Table 5). That is, in all but two regions (Flinders Island and Stanley) populations were estimated to be depleted below putatively critical levels of 20% of the unfished biomass. Similar outcomes were evident for estimated fishing mortality, with *F/M* exceeding values of 3 in all regions on the east and south coasts. Only areas on the north coast revealed lower *F/M* values. LBB estimates of biomass depletion and relative fishing mortality were low for Flinders Island but could not reliably be quantified due to the limited sample size.

Table 5: Regional estimates of fishing mortality and biomass depletion for female Sand Flathead collected between 2021 and 2023.

Location	***Fishing mortality (F/M)***	***Female Biomass (B/B0)***
Bridport (NC)	Unsustainable	Below limit
D'Entrecasteaux Channel (SEC)	Highly unsustainable	Below limit
Flinders Island (FI)	Sustainable	Sustainable
Frederick Henry & Norfolk Bays (SEC)	Highly unsustainable	Below limit
Great Oyster Bay (SEC)	Highly unsustainable	Below limit
Mercury Passage (SEC)	Highly unsustainable	Below limit
Stanley (NC)	Unsustainable	Above limit
St Helens (EC)	Highly unsustainable	Below limit
Tamar (NC)	Highly unsustainable	Below limit

The Length-Based Spawning Potential Ratio (LBSPR) results were consistent with LBB results (Figure 10). Estimated fishing mortality was even higher (Table 6) and, thus, more closely aligned with length-based estimates from catch curves.

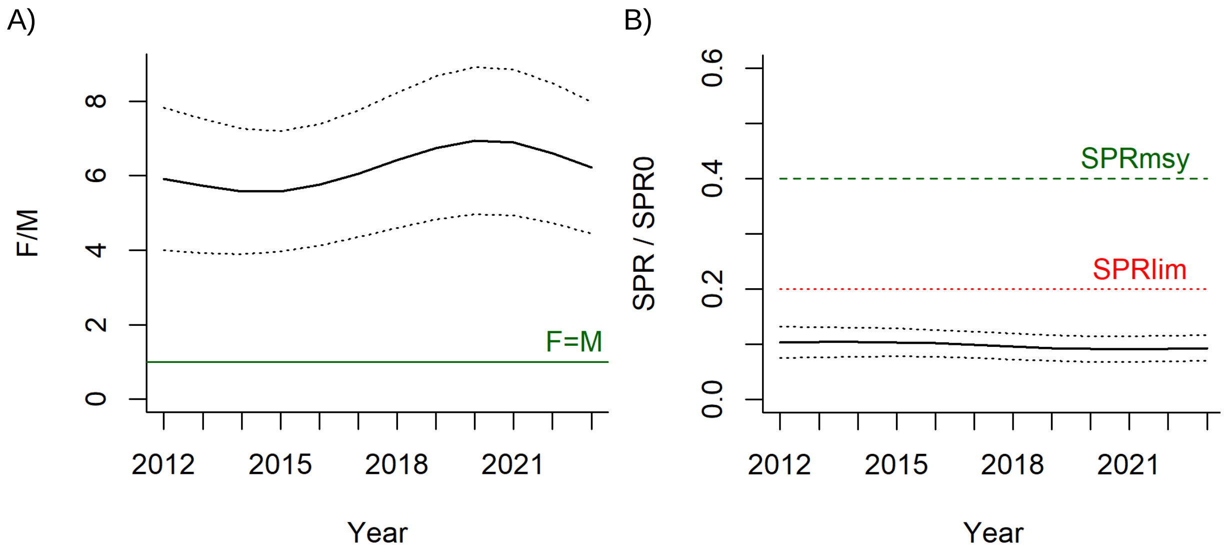


Figure 10: Estimates of relative fishing mortality (A) and spawning potential (B) of female Sand Flathead in the south-east coast region using the Length-Based Spawning Potential (LBSPR) assessment approach. Fishing mortality relative to natural mortality (*F/M*) ratios > 1 are widely used to infer overfishing (solid line in A). Estimates of the current spawning potential ratio relative to unfished levels (*SPR/SPR0*) is assessed against an acceptable limit of 0.2 (20% of unfished levels) to infer depletion and against a desirable target of 0.4 (40% of unfished levels) to assess performance.

Table 6: Estimates of relative fishing mortality (*F/M*) and spawning potential (*SPR/SPR0*) of female Sand Flathead at traditional sampling areas in the south-east coast region using the Length-Based Spawning Potential Ratio (LBSPR) assessment approach. See text above and Table 3 for details on scenarios.

Scenario	***F/M* in 2023**	***SPR/SPR0* in 2023**
Estimate	5.01 (3.47-6.55)	0.1 (0.07-0.12)
Fast growth	6.57 (4.66-8.48)	0.07 (0.05-0.09)
Slow growth	5.06 (3.48-6.64)	0.09 (0.07-0.12)

A regional breakdown of LBSPR outcomes confirmed that populations in all regions except Flinders Island and Stanley have likely been depleted below critical levels and that estimated levels of fishing mortality are highly unsustainable (Table 7). As expected, the spawning potential of females on Flinders Island was estimated to be close to unfished conditions (87%). The spawning potential of females at other sites was estimated to be below the putatively critical limit of 20% of unfished levels, with Stanley representing the only exception (22%). However, even in Stanley, estimates of *F/M* indicate that fishing pressure is likely to be unsustainable (*F/M* = 2).

Table 7: Regional estimates of fishing mortality (*F/M*) and the spawning potential ratio (*SPR/SPR0*) for female Sand Flathead sampled between 2021 and 2023.

Region	**Fishing mortality *(F/M)***	**Spawning Potential *(SPR/SPR0)***
Bridport (NEC)	Highly unsustainable	Below limit
D'Entrecasteaux Channel (SEC)	Highly unsustainable	Below limit
Flinders Island (FI)	Sustainable	Sustainable
Frederick Henry & Norfolk Bays (SEC)	Highly unsustainable	Below limit
Great Oyster Bay (EC)	Highly unsustainable	Below limit
Mercury Passage (EC)	Highly unsustainable	Below limit
Stanley (NWC)	Unsustainable	Above limit
St Helens (EC)	Highly unsustainable	Below limit
Tamar (NEC)	Highly unsustainable	Below limit

8 General risk assessment

The Sand Flathead fishery scored < 60 in the risk analysis, failing assessment with a high risk of recruitment impairment and stock damage. The key reasons are that Sand Flathead is a moderately productive species, because individuals are relatively long lived (up to 20 years) (Bani 2005), mature early (Bani and Moltschaniwskyj 2008), and occupy a relatively high trophic level (Ayling, Wilson, and Ratkowsky 1975). Sand Flathead are not highly susceptible to capture by the commercial fishery in Tasmania, and thus the impact from this fishery is likely to be minor. In contrast, Sand Flathead are heavily targeted by the recreational fishery in their preferred habitat with evidence of depletion in age and size structure (Ewing and Lyle 2020), female biomass, and reproductive capacity (Fraser et al. 2022). Detailed information on the scoring that led to this outcome is available from the TasFisheriesResearch webpage.

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10 Appendix 1: Data quality control

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

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 daily 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 the whole weight. In 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 the catch of a species is reported as gilled and gutted, then the equivalent whole weight can be estimated based on a conversion factor[1].

Without correcting for product form, old logbook and revised logbook catch weights are not strictly compatible. In an attempt to correct for this issue 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.

ii) Effort Problems

Records of effort (based on gear units) of zero or null, or appearing to be recorded incorrectly (implausible), were flagged. While catch can then still be included in catch summaries, such records need to be excluded from calculations of gear unit effort, complicating associated calculations of CPUE for most species. However, all records of effort can be considered in calculating daily CPUE.

iii) Vessel restrictions

In all analyses of catch and effort, past catches from six vessels (four Victorian based and two Tasmanian based) have been excluded from historic records. 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.

[1] 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.

11 Appendix 2: History of stock status classifications

Annual stock status classifications of Southern Sand Flathead. Terminology of status classifications has changed over time; however, colours represent equivalent classifications. Yellow: Depleting; Red: Depleted; NA indicates catch, effort, and CPUE data for the species were included in an assessment report, but no classification was conducted. Blanks indicate the species was not assessed.

97/ 98	98/ 99	99/ 00	00/ 01	01/ 02	02/ 03	03/ 04	04/ 05	05/ 06	06/ 07	07/ 08	08/ 09	09/ 10	10/ 12	12/ 13	13/ 14	14/ 15	15/ 16	16/ 17	17/ 18	18/ 19	19/ 20	20/ 21	21/ 22
													NA	NA	NA								