TASMANIAN OCTOPUS ASSESSMENT 2022/23

Ruth Sharples, Kate Fraser, Nils Krueck, Sushmita Mukherji and Katie Cresswell

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This assessment is produced by the Institute for Marine and Antarctic Studies (IMAS) using data downloaded from the Department of Natural Resources and Environment, Tasmania (NRE Tas) Fisheries Integrated Licensing and Management System (FILMS) database. The information presented here includes all logbook returns for the 2022/23 season.

IMAS Fisheries and Aquaculture
Private Bag 49
Hobart TAS 7001
Australia

Email : katie.cresswell@utas.edu.au

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Octopus are caught commercially in Tasmanian waters across multiple fisheries using a range of gear types. The three recorded species are Pale Octopus (*Octopus pallidus*), Gloomy Octopus (*Octopus tetricus*), and Māori Octopus (*Macroctopus maorum*). Most catch comes from a targeted unbaited trap fishery for Pale Octopus in northern Tasmania, primarily Bass Strait, by fishers operating under the fishing licence (octopus). This fishery is referred to as the Tasmanian Octopus Fishery (TOF) in this report, and by the Department of Natural Resources and Environment Tasmania (NRE Tas). Holders of the fishing licence (octopus) also retain low quantities of Māori Octopus as by-product and take occasional landings of Gloomy Octopus in years when the fishery extends towards eastern Bass Strait. Given that the TOF targets Pale Octopus and represents the majority of octopus catches in Tasmania, it is the focus of this report. Developmental permits for targeting Pale Octopus in the remainder of Tasmanian state waters have also been issued in recent years, but operators retain substantially smaller quantities than in the Bass Strait. For the purposes of this assessment, the Pale Octopus stock in Tasmania has been separated into the Bass Strait stock, delineated by the boundaries of the licenced fishery (TOF), and the Tasmanian Shelf stock, which covers the remainder of state waters. These stock names are based on those used for similar broad biogeographic regions identified by the Integrated Marine and Coast Regionalisation of Australia framework (Australia 2006).

The Scalefish and Rock Lobster fisheries take octopus as by-product. The Giant Crab fishery operates using similar gear to the Rock Lobster fishery; however, the fishery is about 2% of the size of the Rock Lobster fishery (by catch volume) and fishing depths are typically much greater. No octopus have been recorded in Giant Crab fishery returns data. Species information is not always recorded for octopus landed within the Scalefish and Rock Lobster fisheries, but the majority is Māori Octopus. Based on the low incidence of Gloomy Octopus and Pale Octopus in observer sampling from these fisheries, landings of these two species are considered negligible.

Until late 2009, a targeted fishery for Māori Octopus existed in Eaglehawk Bay using hand collection and barrier nets. Catches in this local fishery declined significantly and remained very low after the permit ceased to allow the use of barrier nets.

Aboriginal cultural catch and recreational catch of octopus species is known to occur, mainly as bycatch from line fishing or diving, but catches appear negligible based on survey data from recreational fishers.

Pale Octopus – TOF

The Scalefish Fishery Management Plan (revised in 2015) provides the legislative framework for the northern Tasmanian commercial unbaited trap fishery targeting Pale Octopus (the TOF). The Pale Octopus stock accessed by this fishery is identified in this report as the Bass Strait stock. The TOF has been a sole operator fishery since its commencement in 1980, with two vessels operating in Bass Strait and on the eastern side of Flinders Island. The main management controls for the fishery include limited access via licensing and gear restrictions.

Pale Octopus are found in southeast Australian waters, including Tasmania. The reproductive biology of Pale Octopus suggests low resilience to fishing pressure as small numbers of eggs are actively brooded by females producing large, benthic hatchlings.

The status of the Bass Strait Pale Octopus stock is assessed annually using data on catch, effort, and catch per unit effort (CPUE) from the TOF as well as catch-only assessments of maximum sustainable yield (MSY) and biomass depletion. Catch and effort data now cover the period from 2000/01 to 2022/23. Fishing pressure on Pale Octopus is assessed using catch as a proxy for absolute mortality and effort (number of pot-lifts) as a proxy for exploitation rate.

The total catch of Pale Octopus in 2022/23 was 101 tonnes (t), a slight decline from the previous year's catch of 109 t. These catches are consistent with the average of ~100 t observed during the decade from 2004/05 to 2013/14, and 2022/23 represents the first occurrence of five consecutive years with TOF catches greater than 100 t. In addition, effort in the fishery increased from the previous year's total of 258,500 pot-lifts, with 314,708 pot-lifts recorded in 2022/23. The majority of Pale Octopus catch (67.1%) and effort (53.3%) in

2022/23 occurred in only three fishing blocks, to the north, north east and east of Flinders Island. This differs notably from the previous three years where the majority of catch and effort was from near King Island and offshore from Stanley. The distribution of catch and effort in 2022/23 shows more similarities with that of the decade from 2004/05 to 2013/14 during when catch and effort were concentrated in the eastern Bass Strait around Flinders Island (as well as in the key area offshore from Stanley).

Standardised CPUE for Pale Octopus across the TOF was 0.76 in 2022/23. This is a decline from the previous two years (1.07 in 2021/22 and 1.56 in 2020/21). CPUE derived from the 50-pot sampling programme (data collected in addition to standard logbook data) also showed a decline from previous years, but in 2022/23 was still higher than the reference year (2004/05),

The utility of total catch and CPUE data for detecting changes in local abundance is limited for Pale Octopus in the TOF. Pale Octopus are known to seek fishing gear (pots) for refuge and breeding and are likely to represent multiple local populations. Therefore, there is a high risk of “hyperstability” in this fishery, whereby catch and CPUE remain high despite potentially significant declines in population size. The same problems affect the reliability of research data from the 50-pot sampling programme.

To assess potential biomass depletion and estimate maximum sustainable yield (MSY) of Pale Octopus, we utilised a catch-only stock assessment approach (“CMSY”) developed for data-poor fisheries like the TOF. CMSY was run based on regional trends in catch and estimates of stock resilience or natural mortality. The results indicated that Pale Octopus biomass in traditionally fished areas offshore of Stanley might be depleted below desirable levels (50% of biomass delivering MSY), which is a common target reference point in fisheries management. However, changes in fishing fleet dynamics may also be the cause of the drop in catch from this region.

To complement quantitative assessments of biomass depletion and sustainable catches, we incorporated a risk assessment of recruitment impairment for the TOF. The risk assessment approach used procedures established by the Marine Stewardship Council based on CSIRO’s “Ecological risk assessment for the effects of fishing” (Hobday et al. 2011). The outcomes highlighted that the TOF is a high-risk fishery, failing the pass mark for sustainable fishing in three assessment categories. Key concerns included: (1) an energy-intense reproductive strategy (active brooding of a relatively small number of eggs (450 – 800); Table 1.3), (2) the high probability of capture, specifically females brooding eggs, that seek pots as refuges, and (3) a high associated risk of recruitment impairment.

In summary, broadscale trends in catch and CPUE do not indicate stock depletion. However, the ecology of Pale Octopus and the species’ interaction with fishing gear means this is a high-risk fishery. There is evidence of regional biomass depletion in some traditionally fished areas, which suggests that previous levels of fishing pressure in these regions may have been unsustainable. Catches across the fishery have been high for the past five seasons, with notably high catches and effort in a relatively small geographic area. This level of concentrated effort has the potential to be applied in the future, which could cause the fishery to become depleted. On the basis of this evidence, the Pale Octopus stock in northern Tasmanian waters is classified as Depleting.

Pale Octopus – developmental fishery

Pale Octopus catch from the remainder of Tasmanian state waters – excluding the Bass Strait area of the TOF – is landed under developmental fishing permits, and the stock is identified in this report as the Tasmanian Shelf stock. Total catch for this stock was 4.8 t in the 2022/23 season, with 32,708 pots deployed. Catches have been recorded since 2019/20 and, along with effort, have remained very low. Prior to the issue of developmental fishing permits in 2016/17, no commercial fishing for Pale Octopus occurred outside the TOF. Minimal catch and effort from this fishery suggest that exploitation of the stock remains low. Hence, the Tasmanian Shelf Pale Octopus stock is classified as Sustainable.

Gloomy Octopus – TOF

Catch of Gloomy Octopus within the TOF was 7.1 t in the 2022/23 season, the highest it has been since the peak of 18.6 t in 2017/18. In 2022/23, octopus landings from the Southern Rock Lobster fishery were for the second time identified to species level, with 2.2 t of Gloomy Octopus recorded. It is uncertain whether species level identifications in the Southern Rock Lobster fishery returns were accurate. Gloomy Octopus are found along the eastern Australian coastline, with northeast Tasmania considered to be at the southern end of the species' distribution (Edgar 2008). This species has been reported in TOF catches primarily around Flinders Island, and a small number of sightings have been reported through Redmap near St Helens and Bicheno, with a single sighting near Hobart (2022). In contrast to this known distribution, the Rock Lobster fishery returns data show Gloomy Octopus landings from the east, southeast, southwest, and west coasts, as well as around King Island.

In general, Gloomy Octopus catch seems to be driven by the distribution of effort in the TOF. Unless substantial TOF fishing activity occurs in the eastern Bass Strait around Flinders Island, catches have been generally close to zero. Catches from the TOF come from only a small part of the species' overall range. Effort and catch in eastern Bass Strait in 2022/23 increased relative to recent years, with increased fishing activity around Flinders Island. In 2022/23, 7.2 t of gloomy octopus were recorded in TOF data. The reproductive biology of Gloomy Octopus – relatively large numbers of planktonic larvae are produced from active benthic brooding (~278,500 eggs; Table 1.3) – suggests that this species may be more resilient to fishing pressure than Pale Octopus. This likely moderate resilience, coupled with minimal catch in recent years and over the duration of the fishery, is evidence to support classifying the Tasmanian Gloomy Octopus stock as Sustainable.

Māori Octopus – multiple fisheries

A total of 12.4 t of Māori Octopus was landed by Tasmanian commercial fishers in 2022/23. This comprised 7.2 t of by-product from the Southern Rock Lobster fishery, 4.4 t of by-product from the TOF and 0.45 t of by-product from the Scalefish fishery. This is the second year of recording octopus landings to species level for the Southern Rock Lobster fishery and it is uncertain whether species level identifications in the Southern Rock Lobster fishery returns were accurate, however observer data suggests that the majority of octopus landed by this fishery are Māori Octopus, therefore this catch total is likely to be a close approximation of actual catch. The formerly productive Eaglehawk Bay fishery targeting Māori Octopus has not been fully operational since the ban of gillnets in 2009, and thus did not contribute any catch to recent records. All other catch figures stated above are based on the assumption that records of landed octopus without species identification are Māori Octopus.

Rock Lobster and Scalefish fishing licences have a trip limit of 100 kg of retained octopus. In the Rock Lobster fishery, octopus are captured in crustacean traps where they prey on the target species, Southern Rock Lobster (Brock and Ward 2004). Unidentified octopus is a dominant by-product ‘species’ in the Rock Lobster fishery (León et al. 2020), and additional unknown quantities of captured octopus are killed and discarded by rock lobster fishers to prevent future lobster depredation. Data presented here represent the retained, landed by-product only, rather than total fishing mortality.

Uncertainty about discard mortality in the Rock Lobster fishery challenges reliable estimates of total catch and sustainability for Māori Octopus. Unpublished IMAS data from video observation suggests selectivity of rock lobster gear for octopus may be low. Captured octopus will kill lobster in a pot thereby providing a strong incentive for lobster fishers to minimise octopus bycatch. For example, the time of day that pots are hauled is anecdotally considered a critical factor by lobster fishers.

The life-history of Māori Octopus suggests this species may be moderately resilient to fishing pressure, producing relatively high numbers of planktonic larvae from active benthic brooding (< 196,000 eggs; Table 1.3). Māori Octopus are found along the southern Australian coastline, including the whole Tasmanian coast. In a risk-assessment of common bycatch and by-product species in the Southern Rock Lobster fishery, using only productivity/life-history traits of a species and its susceptibility to capture without considering catch or population size, Māori Octopus return a low-risk ranking (León et al. 2020). On the basis of this evidence, the Tasmanian Māori Octopus stock is classified as Sustainable.

1. Introduction

History of octopus harvesting in Tasmania

Development of commercial octopus harvesting (Māori Octopus)

Pre-colonial harvesting of seafood by Tasmanian Aboriginal communities mainly involved hand collection. However, historical reports of octopus catch from the pre-colonial or colonial period do not appear to be available, even if it is likely that catches occurred (Frijlink and Lyle (2013)).

The commercial rock lobster fishery in Tasmania has had long-term interaction with Māori Octopus populations. In the late 19th century, there was a large expansion of rock lobster fishing from vessels using rings and pots, which led to depletion and concern about the sustainability of rock lobster harvests. There was controversy around the use of lobster pots relative to rings because of their greater effectiveness in depleting rock lobster on reefs, and the problem that lobsters in the pots were vulnerable to depredation by Māori Octopus. Pots were first legalised in the north of the state in 1903 and then in the rest of the state in the 1920s. Octopus were caught as bycatch throughout this period but were generally not retained until consumption patterns changed with greater immigration from Mediterranean Europe after the second world war.

Commercial landings of octopus from the lobster fishery are currently constrained by management imposing a landing limit of 100 kg per trip. Annual recorded landings for the fleet generally fluctuate between 5 and 10 t. As a consequence of the trip limit, the fishing mortality of Māori Octopus will exceed the landed catch because commercial lobster fishers generally kill octopus rather than release them to reduce lobster depredation.

A targeted octopus fishery has operated in Eaglehawk Bay since the 1970s. Most catch came from one operator who used a barrier net that trapped the octopus as they moved along the southern side of the bay, although hand collection also occurred. When the use of barrier nets was banned under this fishing permit in late 2009, the fishery declined substantially. In fisher reports to IMAS, declines in catch were also attributed to observed increases in seal abundance in the bay and significant assumed depredation of octopus.

Development of commercial Pale Octopus harvesting

Targeted fishing for Pale Octopus has occurred since 1980 and operated under permit for many years. The targeted Pale Octopus fishery represents the focus of this report and is referred to officially by NRE Tas as the Tasmanian Octopus Fishery (TOF). Since 1996, under the Offshore Constitutional Settlement (OCS) with the Commonwealth of Australia, Tasmania has assumed management control of the TOF within state waters (up to 200 nm offshore and south of 39°12'S). Since December 2009, a specific octopus licence (fishing licence (octopus)) was required to participate in this fishery, which operates within Bass Strait, including waters to the east of Flinders Island. Two licences were issued, both to the same operator.

The TOF primarily targets Pale Octopus using unbaited moulded plastic pots (‘shelter pots’; volume 3,000 mL) with no doors, which are attached to a demersal longline that is 3–4 km long and set on the sea floor at variable depths of 15–85 m (Leporati et al. 2009). Currently, a maximum of 1,000 pots per line is allowed (Table 1.1; Table 1.2). Octopus are attracted to these pots as refuges; pots are generally hauled after 3–6 weeks soak time. An abundant food supply may support a large population of octopus. When combined with a shortage of suitable shelters, this results in high catch rates. TOF geographic regions within the Bass Strait, as discussed in this report, can be seen in Figure 1.1.

From 2000/01 to 2005/06 catches of Pale Octopus in the TOF increased substantially and, up until the 2020/21 season, fluctuated around 80 tonnes, ranging from 55 t to 132 t. The 2020/21 season saw a significant increase in Pale Octopus catch, with a total of 154 t, representing the highest catch value in the history of the TOF. Catch in 2021/22 and 2022/23 have returned to just over 100 t.

While no further octopus licences can be issued for the Bass Strait area, the remaining state waters are classified as developmental and could be opened to licensed commercial fishing provided necessary research is undertaken. Four permits were issued in 2022/23 for octopus traps targeting Pale Octopus (but permitted to take Gloomy and Maori octopus) in Tasmanian state waters outside the area encompassed by the TOF. Specific areas of permitted use vary among permits, but generally encompass waters south of 41° South. The Pale Octopus stock accessed under these permits is identified in this report as the Tasmanian Shelf stock. Each fishing permit is subject to specific limitations on the number and type of gear allowed in designated state waters. The first permit restricts the deployment of 1000 unbaited pots in the area south of Little Swanport (approximately 42°39'00.1"S) and east of 147°19'20.2"E, aligning with the latitude around mid-South Bruny (this permit has not been fished). The second permit allows for the use of 4000 unbaited pots in the region south of Eddystone Point and to the east of South West Cape.

Moreover, two additional permits authorize the use of 50 unbaited trigger traps and 500 unbaited shelter pots in state waters spanning from just north of St Helens Point to just south of Maria Island. It is noteworthy that one of these permits has a restricted season, operating exclusively from the beginning of September to the end of October.

Commercial Gloomy Octopus harvesting

Gloomy Octopus are believed to be uncommon in Tasmania and recorded mainly around the northeast, which is assumed to represent the southern end of their geographic distribution (Edgar 2008). The most recent and first species level records of octopus catches from the Rock Lobster fishery indicate that Gloomy Octopus might be distributed much more widely, however these species identifications are likely to be inaccurate. Gloomy Octopus are found on both reef and sediment habitat so may be taken by commercial operators in both the Rock Lobster fishery and the TOF. Based on observer observations, catch of Gloomy Octopus taken by the Rock Lobster fishery appears to be negligible. Gloomy Octopus has only been reported from the TOF since 2010/11.

Catches of Gloomy Octopus peaked at 18.6 t in 2017/18, which was unprecedented and thus interpreted as evidence of range expansion (Ramos et al. 2014; Ramos et al. 2015). However, annual trends in catch of Gloomy Octopus can more likely be explained by targeted effort in eastern Bass Strait. When TOF effort shifted westward after the 2017/18 season, catches of Gloomy Octopus reduced back to previously low levels. In the 2022/23 season, effort returned to eastern Bass Strait, and Gloomy Octopus catch within the TOF was again high (7.1 t). In the previous season, 2021/22, 2.4 t were recorded, with the three seasons preceding that being well under a tonne. In 2021/22, octopus landings from the Rock Lobster fishery were identified for the first time to species level, with 1.6 t of Gloomy Octopus recorded. In 2022/23, 2.2 t of Gloomy Octopus were reported from the Rock Lobster fishery.

Table 1.1 Summary of the management and reporting changes for octopus fishing in Tasmania.

Date	Management changes
1903	Legislation banning the use of rock lobster pots overturned, which enabled increased retention of Māori Octopus
1980-90s	Various modifications made to licencing that affected retention of octopus bycatch including access provided to holders of a personal fishing licence, a vessel licence, and a scalefish (or rock lobster) licence. Trip limit of 100 kg applied which limited by-product from lobster pots of Māori Octopus.
2000/01	Commercial fishing for Pale Octopus and other minor species approved under permit using unbaited pots in Bass Strait (TOF).
December 2009-ongoing	Two licences issued for the operation of two vessels (sole operator) using unbaited octopus pots (TOF).
2004/2005	50-pot sampling programme implemented in the TOF Pale Octopus fishery.
2016/2017	Two developmental permits issued (no reportable catches) for east coast Pale Octopus fishery.
2017/2018	Two developmental permits issued (reportable catches) for east coast Pale Octopus fishery.
2019/2020	Two developmental permits issued (reportable catches) for east coast Pale Octopus fishery.
2020/2021	Three developmental permits issued (reportable catches) for east coast Pale Octopus fishery.
2021/2022	Four developmental permits issued (three with reportable catches) for east coast Pale Octopus fishery.
2022/2023	Four developmental permits issued (three with reportable catches) for east coast Pale Octopus fishery.

Table 1.2 Summary of the current management systems for octopus fishing in Tasmania.

Fishery characteristics	Management changes
Fishing methods	Access provided to holders of fishing licence (octopus), a vessel licence, and a scalefish or rock lobster licence. Trip limit of 100 kg if not the holder of a fishing licence (octopus).
Octopus licences	Two licences issued for the operation of two vessels.
Management methods	Input control: Fishing licence (octopus) allows the use of 10,000 pots (maximum of 1,000 pots per line) to target Pale Octopus, Gloomy Octopus, and Māori Octopus. Fishing zone restriction for fishing licence (octopus): East and West Bass Strait Octopus zones only.
Main market	Tasmania and mainland Australia
Active vessels	5 targeting octopus with unbaited pots (2 operating the licences and one permit; 3 operating permits only); additional ~ 200 vessels taking small tonnage (<15 tonnes total) of by-product, mainly Māori Octopus.

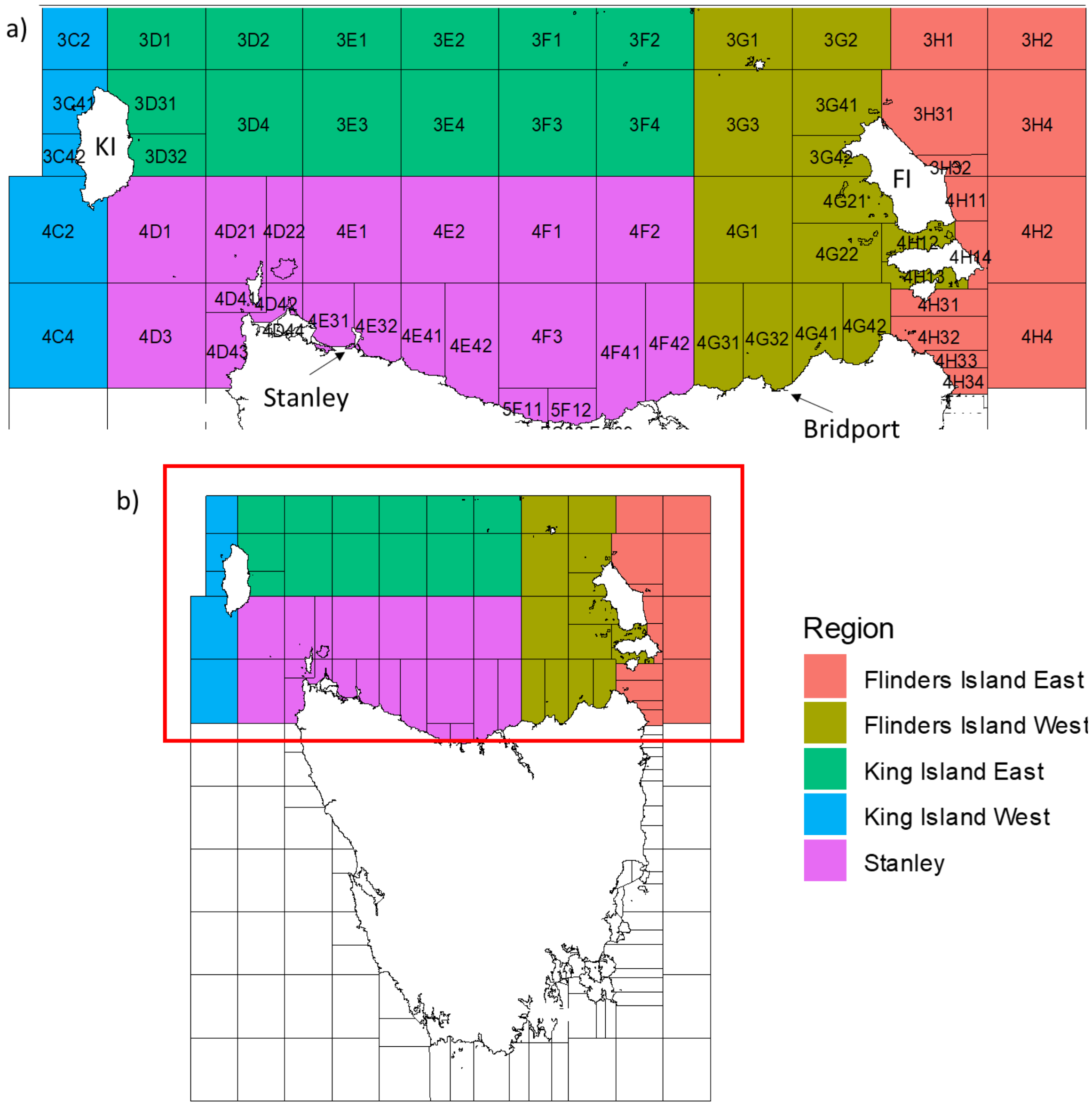

Figure 1.1 Map of fishing blocks in Tasmania highlighting the Bass Strait target area for Pale Octopus within the TOF, including the 50-pot sampling regions: a) fishing blocks within regions – the TOF reports in latitude and longitude but for the purpose of this report, fishing areas are reported in fishing blocks; KI = King Island, FI = Flinders Island; b) red box indicates the area shown in a). Note: no catch or effort data were recorded for the King Island West region during the time series assessed here.

Species Biology

Table 1.3 Life history and biology of Pale Octopus (*Octopus pallidus*), Gloomy Octopus (*Octopus tetricus*) and Maori Octopus (*Macroctopus maorum*). In the 'Source' column, [1] refers to *O. pallidus*, [2] to *O. tetricus* and [3] to *M. maorum*.

Species	**Pale octopus** *Octopus pallidus*	**Gloomy octopus** *Octopus tetricus*	**Maori octopus** *Macroctopus maorum*	**Source**
Illustration	 (Illustration © R.Swainston/anima.fish)	 (Illustration © R.Swainston/anima.fish)	 (Illustration © R.Swainston/anima.fish)	
Habitat	Sand and mud habitats to depth of 600m.	Rocky reefs and sand habitats in shallow waters, up to 30 m depth.	Rocky reefs, beds of seagrass or seaweeds, sand down to 549 m.	Norman (2000)[1,2,3] Edgar (2008)[1,2,3]
Distribution	South-east Australia, including Tasmania.	Subtropical eastern Australia and northern New Zealand, increasingly found in northeast Tasmania.	Temperate and sub-Antarctic waters of New Zealand and southern Australia.	Norman (2000)[1,2] Stranks (1996)[3]
Diet	Crustaceans and shellfish (bivalves).	Crustaceans (crabs, lobster) and shellfish (gastropods, bivalves).	Crustaceans (crabs, lobsters), fish, shellfish (abalone, mussels) and other octopuses.	Norman and Reid (2000)[1,2] Norman (2000)[1,2,3]
Movement and stock structure	Limited movement and dispersal from natal habitat. Eastern and western Bass Strait populations likely to be two discrete sub-populations.	Undefined.	• Several genetically distinct populations. • At least 2 populations in Tasmania: North-east Tasmanian population and South-west Tasmanian populations (which extends to South Australia). • Adults of the species aggregate all year-round in Eaglehawk Bay in the Tasman Peninsula).	Doubleday *et al*. (2008)[1] Doubleday *et al*. (2009)[3]

Natural mortality	Undefined but potentially high	Undefined.	Undefined.	
Maximum age	Up to 18 months.	Maximum of 11 months	Maximum of 7.3 months from ageing study but lifespan potentially up to 3 years.	Leporati *et al*. (2008b)[1] Doubleday *et al*. (2011)[3] Grubert and Wadley (2000)[3] Ramos et al. (2014)[2]
Growth	• Highly variable, partly dependant on water temperature and hatching season. • Max weight: 1.2 kg • Growth is initially rapid in the post-hatching phase, before slowing down. Growth has been represented by a 2-phase growth model with an initial exponential growth phase followed by a slower growth phase. Average growth in the first 114 days was estimated at $W = 0.246e^{0.014t}$ in spring/summer and $W = 0.276e^{0.018t}$ in summer/autumn, where *W* is the weight in g and *t* is the age in days.	• Max weight: up to 2.6 kg • Growth between 49 g to 2.64 kg described by the growth equation: $W = 3.385(1 - e^{-0.07642t})^3$ where *W* is the weight in kg and *t* is the age in days. Growth in the field might however only be about 40% of growth in aquarium.	• Max weight: 15 kg • Growth equation undefined	Leporati *et al*. (2008a)[1] André *et al*. (2008)[1] Joll (1977; 1983)[2] Stranks (1996)[3]
Maturity	Size at 50% maturity for females reached at 473g. Males appear to mature earlier (<250 g).	• Size-at-50% maturity was 132g for females and 92g for males. • Age at 50% maturity 224 days for females and 188 days for males.	• Size-at-50% maturity undefined. • Females mature between 0.6 to 1 kg. • Weight-specific fecundity range from 6.82 to 27.70 eggs/gram body. • Mating activity is independent of female maturity.	Leporati *et al*. (2008a)[1] Grubert and Wadley (2000)[3] Ramos et al. (2015)[2]
Spawning	• Semelparous (i.e., reproduces only once before dying).	• Semelparous (i.e., reproduces only once before dying).	• Semelparous (i.e., reproduces only once before dying).	Leporati *et al*. (2008a)[1] Joll (1983)[2] Anderson (1999)[3]

	• Spawns all year round with peaks in late summer/early autumn • Around 450-800 eggs per spawning event. Egg length: 11-13 mm.	• Spawning season undefined but likely all year round. • Average fecundity is 278,448 eggs ± 29,365 se Average size (maximum length) of ripe eggs is 2.2 mm ± 0.1 se	• Spawning season: spring-summer in New Zealand but appear to mate and lay all year round in Tasmania. • Lay around 7,000 eggs in captivity but up to 196 000 eggs in ovaries of wild caught animals. • Egg length: 6.5-7.5 mm.	Grubert and Wadley (2000)[3] Ramos *et al* (2015)[2]
Early life history	Large benthic hatchlings (0.25g) settling directly in the benthos.	Planktonic hatchlings (2-5mm length) settling at 0.3g (8 mm).	Planktonic hatchlings (5 mm length).	Leporati *et al*. (2007)[1] Joll (1983)[2] Anderson (1999)[3]
Recruitment	Variable.	Variable. No stock-recruitment relationship defined.	Variable. No stock-recruitment relationship defined.	

2. Methods

Data sources

Pale Octopus commercial data from the TOF

Commercial catch and effort data used in the main component of this assessment are based on Pale Octopus landings recorded in TOF Commercial Catch, Effort & Disposal Record logbook returns. TOF fishing records comprise individual demersal unbaited trap longline lifts, with catches per line reported as weight, and effort per line reported as the number of unbaited pots (i.e., 'pot-lifts').

Since November 2004, a 50-pot sampling programme was conducted within the TOF, where fishers are required to collect all octopus caught in 50 randomly selected pots from a single line, representing 10% of a standard commercial line. From these 50-pot samples, the numbers of males and females of each species and the percentage of pots with eggs are recorded. However, no data on eggs in sample pots has been reported in 2021/22 and 2022/23. The total and gutted weight of the catch was also recorded from 2004 to 2010. Fishers are required to sample at least 50 pots per line from at least one line per fishing day, and at least one line per distinct area fished in each day. Areas are distinct when lines are located entirely on different substrates or are separated by more than 10 nautical miles. Data from the 50-pot sampling programme are separated into geographic regions, as indicated in Figure 1.1.

Weight-at-age is highly variable in octopus due to a high individual variability and a rapid response to environmental factors (Leporati et al. 2008b; André et al. 2009). This introduces stochasticity in catch weight so that it becomes difficult to use when interpreting trends in population size. The 50-pot samples provide numbers of octopus, which is more representative of the state of the stock. This practice aims to enhance the understanding of the stock status, particularly at a finer spatial scale (i.e., block level). New logbook requirements recently implemented will lead to improved data collection for the 50-pot samples.

In the 2022/23 season, commercial data for Pale Octopus also exist for the developmental permits for the east coast of Tasmania. This fishing is outside of the normal TOF operations analysed here; hence it has not been included in the above analysis and has been summarised separately below (Table 3.2).

Māori and Gloomy Octopus commercial data

To assess the status of Māori and Gloomy Octopus we used commercial catch data from the Scalefish and Rock Lobster fishery logbook returns, as well as records of these species in the TOF logbook returns, which include data from the developmental permits. Octopus catch in the Eaglehawk Bay targeted fishery are recorded in the Scalefish logbook returns.

Data analysis

TOF Pale Octopus Fishery

Catch, Effort, and CPUE

A fishing year from 1st March to the last day of February has been adopted for annual reporting, which reflects the licensing year. Catches have been analysed both fishery-wide and by fishing blocks (Figure 1.1). For the purpose of this assessment, catch, effort and CPUE analyses were restricted to commercial catches of Pale Octopus for the period March 2000 to February 2023.

Data on TOF logbook returns include gutted and non-gutted (i.e., whole) weights. All gutted weights were converted to whole weight as follows:

$$\textit{Whole weight} = 1.23 * \textit{Gutted weight}$$

where *Whole weight* and *Gutted weight* are in kilograms. This relationship between *Whole* and *Gutted* weight was estimated from 8,510 individuals recorded in the 50-pot sampling dataset between December 2004 and April 2010.

The number of pots pulled (pot-lifts) was used as a measure of effort in this assessment. Catch returns for which effort information was incomplete were flagged and excluded when calculating effort or catch rates. However, in recent years the amount of incomplete logbook entries has been negligible to nil. All records were included for reporting catches.

The impact of soak time (the time during which the fishing gear is actively in the water) was determined by analysing CPUE trends (in catch number per pot) through time for the 50-pot sampling data. Exploration of this influence was discussed in detail in the 2015/16 stock assessment (Emery et al. 2017), where no relationship between soak time and CPUE was apparent. Therefore, soak time was not considered in the resultant catch standardisation process.

The difference in numbers of female and male Pale Octopus in the 50-pot sampling data over the timeseries was assessed using a two-way ANOVA (number of octopus ~ sex + licensing year).

CPUE of Pale Octopus has been standardised using a generalised linear model (GLM) to reduce the impact of obscuring effects, such as fishing year or season on the underlying trends (Kimura 1981; Kimura 1988). However, while standardised catch rates are preferred over the simple geometric mean, other factors may remain unaccounted for that obscure the relationship between standardised catch rates and stock size, such as increasing fisher efficiency or spatial shifts in fishing effort from areas of low to higher catch rates.

There is currently only one operator representing the TOF, which uses two different vessels. The vessels cooperate, with the vessel pulling the gear not necessarily being the same vessel that set it. Consequently, vessel and skipper were not included in the GLM. The depth at which the gear is set is variable; however, the inclusion of the term Depth in the GLM did not significantly explain variation in CPUE ($p > 0.05$), and this term was excluded from the final model. Catch and effort data for many fishing blocks across multiple years were absent or insufficient for testing the interaction between Licensing Year and Fishing Block (i.e., for testing whether CPUE distribution among fishing blocks varied among licensing years), and this interaction term was excluded from the final model. Factors considered in the final GLM were year, month, and block. A lack of spatial block data for multiple trips early in the time series led to 229 t of catch data (12.5% of total catch over the time series) being omitted from the subsequent catch standardisation process.

The GLM was applied to weight per pot for the whole commercial dataset and number per pot for the 50-pot sampling dataset. An additional GLM was applied to a subset of CPUE data from the Stanley region (see 50-pot sampling regions in Figure 1.1), and a subset of CPUE data from only the 2022/23 licensing year. Catch and effort data from all other regions within the TOF did not meet the model assumptions of homogenous and normal distribution of residuals, therefore this analysis was not run for other regions.

Temporal changes in the spatial distribution of catch, effort, and CPUE were assessed by mapping binned data for each metric across fishing blocks. Current fishing data for the 2022/23 season were compared with data averaged across a ten-year period following the reference year (2004/05 to 2013/14), and with data averaged across the most recent five-year period (2017/18 to 2021/22).

Catch-only approach

In addition to analysing temporal and spatial trends in catch and effort data, we utilised a "catch-only" approach to estimate the status of the Tasmanian Pale Octopus stock – "CMSY" (Martell and Froese 2013; Froese et al. 2017). CMSY has been consistently applied to data from multiple commercial stocks within Australia (Haddon et al. 2019; Piddocke et al. 2021), including the Tasmanian Pale Octopus stock for the 2020/21 Tasmanian Octopus Assessment (Fraser et al. 2022). CMSY can be used to estimate stock depletion and the maximum sustainable yield (MSY) from trends in catch data, and was implemented for the TOF using the R package "datalimited2" (Free 2018).

CMSY is a model-assisted stock assessment approach suitable for data-poor conditions. The approach relies on the Schaefer production model, which assumes that the biomass delivering MSY is equal to 50% of the unfished biomass and uses a Monte-Carlo based form of stock reduction analysis to estimate management reference points according to the assumed resilience of the target species and a time series of catch records. In the absence of empirical data on intrinsic population growth rates (r) but considering both a short life span (up to 1.5 years) and reproductive behaviour (active brooding of a relatively small number of eggs (~450 – 800); Table 1.3), the CMSY approach was run by assuming that the resilience of Pale Octopus is likely to be "medium" (r = 0.2 – 0.8). In agreement with the precautionary principle, confidence intervals of CMSY outputs are generally taken into account when making management decisions.

CMSY simulations were run based on regional subsets of the TOF data, which represented those chosen for the 50-pot sampling programme (Figure 1.1). However, some regions could not be meaningfully analysed given that they have not been consistently fished in the past. Recent shifts in the distribution of fishing effort and catch to the King Island East region, for example, meant that catch data from both this region and the entire fishery were not suitable for CMSY simulations. Therefore, results are presented for the Stanley, Flinders Island West, and Flinders Island East regions only.

Formal risk assessment of recruitment impairment (MSC approach)

We further introduced a formal risk assessment of recruitment impairment following 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. If the TOF were assessed under the MSC Fisheries Standard, it is likely that there would be sufficient information to use the default assessment method. However, application of the RBF is straight-forward and provides an alternative 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 this susceptibility (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. It should be noted that the RBF is more precautionary and will likely result in a lower score than the default assessment method.

Given that 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 relatively high levels of exploitation inherently pose a greater risk to ecological components with which they interact than under-utilised fisheries. Therefore, lower scores will be derived for highly utilised species unless credible information is available to indicate otherwise.

Reference points

During the decade from 2004/05 to 2013/14 (the reference period for the TOF), fishing activity was concentrated in the eastern Bass Strait around Flinders Island and in fishing blocks close to Stanley (Figure 3.11). Total catch for the fishery fluctuated around approximately 75 – 100 t per year (Figure 3.3) and effort fluctuated around approximately 250,000 to 350,000 pot-lifts per year (Figure 3.5). Stock assessment methods were developed based on the assumption of ‘negligible shifts in the distribution of fishing effort’.

In 2019/20, catch and effort data from TOF no longer met this assumption and were deemed inappropriate for assessing against fishery-wide performance metrics. This is because, in 2019/20, substantial shifts in fishing effort and catch occurred within the fishery, leading to the introduction of additional analyses and regional assessment approaches.

Following the 2019/20 assessment of the TOF Pale Octopus stock as Depleting, fishery stakeholders initiated a meeting among representatives of the Institute for Marine and Antarctic Studies (IMAS), the Department of Natural Resources and Environment Tasmania (NRE Tas), and the Tasmanian Seafood Industry Council (TSIC). During the meeting, IMAS presented stock assessment outcomes for the 2019/20 season for extended subsequent discussion. The meeting concluded with the aim to establish potential reference points for future management of effort in all different regions currently monitored in the context of the 50-pot sampling programme (Figure 1.1). Reference points for sustainable effort, rather than catch, were considered desirable in terms of both practical implementation as well as fishery impact. Summary statistics of annual effort in the different fishery regions from the reference period (2004/05 to 2013/14) and over recent years (2018/19 to 2020/21) highlight the above-mentioned shift in the distribution of fishing activity (Table 2.1, Figure 3.11).

Table 2.1 Summary statistics of annual effort (number of pot-lifts) by region for the reference period 2004/05 to 2013/14.

Region	Mean	Standard deviation	Minimum	Maximum	Median
King Island East	1,900	3,414	0	11,000	500
Stanley	176,100	86,323	51,500	304,500	171,250
Flinders Island West	68,855	62,480	2,000	215,000	44,500
Flinders Island East	34,900	52,537	0	174,500	20,500
All regions combined	281,755	113,675	93,550	447,500	281,250

Māori and Gloomy Octopus – multiple fisheries

Landed by-product catch of all octopus species from the Scalefish and Rock Lobster logbook returns were assessed spatially and temporally, across fishing blocks and available time series. For Māori and Gloomy Octopus, these catches also included retained by-product recorded for the TOF. Effort and CPUE data were not included in these assessments because they are unlikely to be informative for by-product species, and because of the high uncertainty about underreported catches and discard mortality of the main species (Māori Octopus). Observer sampling has suggested that octopus catch from the Scalefish, and Rock Lobster fisheries is almost entirely Māori Octopus. In cases where landed octopus were not recorded to species level, we therefore made the simplistic but realistic assumption that these are primarily Māori Octopus. However, for transparency, data with no species name have been assessed and presented here as 'Octopus, unidentified'. Octopus landings from the Rock Lobster fishery were first reported at species level in 2021/222. It is uncertain whether species identifications were accurate, however data have been presented as reported. The risk assessment of recruitment impairment described above was also used to assess the risk of damage to the stocks of Māori and Gloomy Octopus, with the susceptibility component of the Productivity Susceptibility Analysis based on the fisheries that retained the highest reported catch of each species in 2022/23: the Rock Lobster fishery for Māori Octopus and TOF for Gloomy Octopus.

Assessment of stock status

Stock status definitions

To assess the status of Octopus in a manner consistent with the national approach (and other jurisdictions), we adopted the national stock status categories used in the 2020 Status of Australian Fish Stock (SAFS) report (Table 2.2) (Piddocke et al. 2021). These categories define the assessed state of the stock in terms of recruitment overfishing, which is often treated as a limit reference point. If a stock falls below this limit reference point, it is deemed that recruitment is impaired and its productivity reduced. Determination of stock status into the below categories (Table 2.2) was based on temporal and spatial trends in commercial catch, effort and standardised CPUE data from the TOF, as well as catch-only simulations and the MSC risk assessment of recruitment impairment. Fisheries are ideally also managed towards targets that maximise benefits from harvesting, such as economic yield or provision of food. While the SAFS scheme does not attempt to assess the fishery against any target reference points, this report uses catch-only simulation results to assess fishery performance (i.e., predicted biomass depletion) against levels expected to support the maximum sustainable yield (B_{MSY}, which is a common target reference point), thereby supporting future management objectives.

Table 2.2 The stock status classifications that were adopted for this assessment.

Stock status	Description	Potential implications for management of the stock
SUSTAINABLE	Biomass (or proxy) is at a level sufficient to ensure that, on average, future levels of recruitment are adequate (recruitment is not impaired) and for which fishing mortality (or proxy) is adequately controlled to avoid the stock becoming recruitment impaired (overfishing is not occurring)	Appropriate management is in place.
RECOVERING ↑	Biomass (or proxy) is depleted, and recruitment is impaired, but management measures are in place to promote stock recovery, and recovery is occurring.	Appropriate management is in place, and there is evidence that the biomass is recovering.
DEPLETING ↓	Biomass (or proxy) is not yet depleted, and recruitment is not yet impaired, but fishing mortality (or proxy) is too high (overfishing is occurring) and moving the stock in the direction of becoming recruitment impaired.	Management is needed to reduce fishing mortality and ensure that the biomass does not become depleted.
DEPLETED	Biomass (or proxy) has been reduced through catch and/or non-fishing effects, such that recruitment is impaired. 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

TASMANIAN OCTOPUS FISHERY (TOF) FOR PALE OCTOPUS

Broad scale patterns in Pale Octopus catch, effort, and CPUE from TOF

Influence of soak time

As per the 2015/16 report (Emery et al. 2017), an analysis of the 50-pot sample data indicated that soak time had no discernible relationship with CPUE by number or weight and was disregarded when standardising CPUE. The number of pots continues to be used as the measure of effort when calculating catch rates.

Sex ratio

No significant difference in the ratio of female to male Pale Octopus ($p > 0.5$), based on raw abundance data from the 50-pot sampling programme, was observed on a licensing year basis from the start of the programme (2004/05) to 2020/21. (Figure 3.1). The proportion of females brooding eggs from the total number of females sampled for the 50-pot sampling programme fluctuated around 25% and did not vary significantly among licensing years ($p > 0.5$) (Figure 3.2).

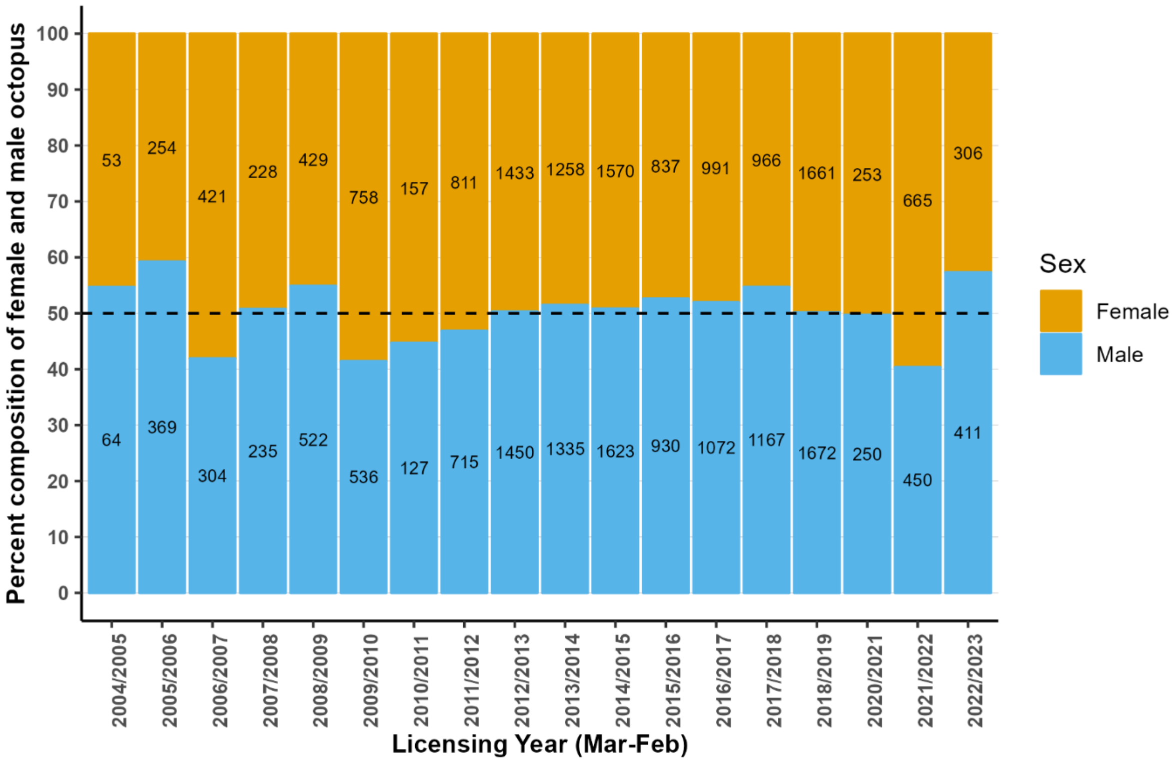

Figure 3.1 Ratio of female to male octopus from 50-pot samples, represented by percent composition of each sex from total number of 50-pot sample octopus in each licensing year. Printed on each bar is the total number of sampled octopus of each sex for the licensing year. Note that 50-pot sampling data were not provided for 2019/20.

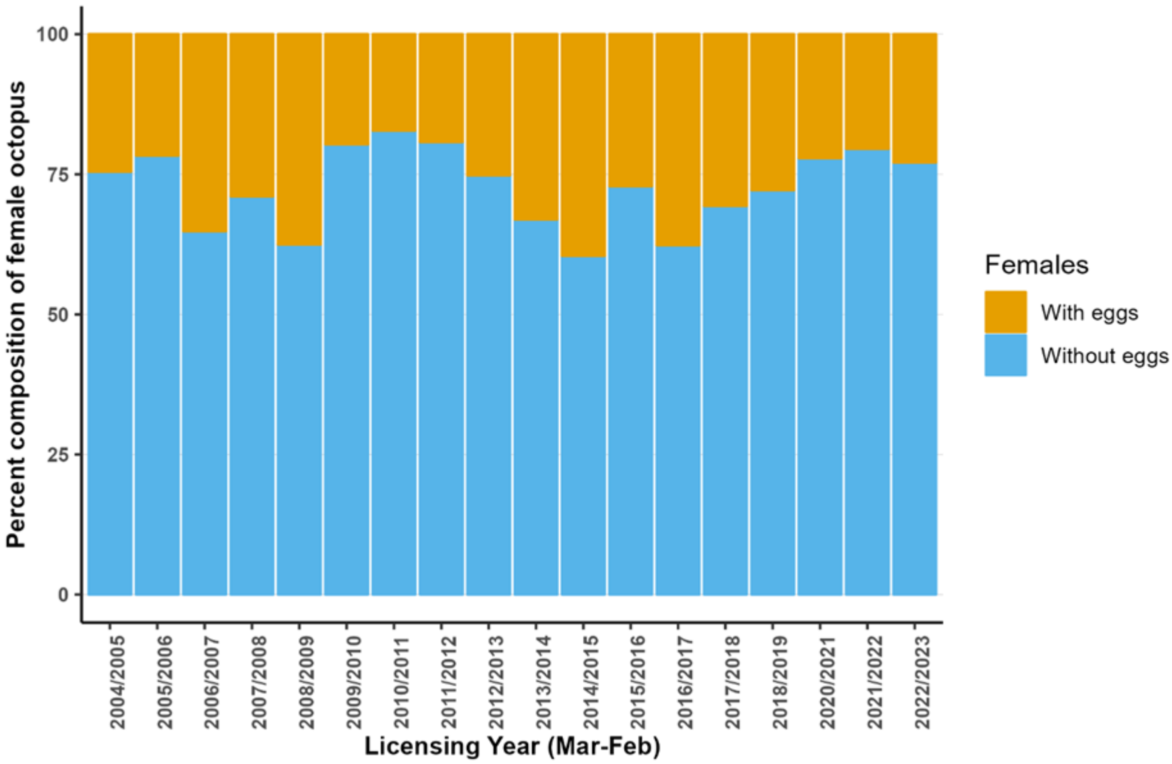

Figure 3.2 Ratio of female octopus from 50-pot sampling with and without eggs, represented by percent composition of number with eggs from total number of females sampled in each licensing year. Figure 3.1 shows the total number of females sampled each year. Note that 50-pot sampling data were not provided for 2019/20.

Catch and effort

The total catch of Pale Octopus in the TOF in 2022/23 was 101 t (Figure 3.3). This year's catch represents a decline from the historical peak of 154 t in 2020/21. This is the first occurrence of five consecutive years with TOF catches greater than 100 t. Catches in the fishery have varied between ~60 t and ~130 t since 2003/04.

Pale Octopus catches within the TOF vary seasonally (Figure 3.4). During most years, catches peak in autumn. In 2022/23 peak catch was seen in winter with 29.4% caught in winter. This was followed by autumn (20.9%), spring (20.9%) and summer (14.8%).

Total fishing effort from the TOF in 2022/23 was represented by 313,348 pot-lifts, an increase compared with 2021/22 total effort of 258,500 pot-lifts (Figure 3.5). Notably, effort in 2022/23 is only slightly lower than the year when historical catch peaked in 2020/21 but catch in 2022/23 is significantly lower than the peak year. Seasonal effort follows the same pattern as catch with winter having the greatest effort (53.8%), followed by autumn (25%), spring (24.4%) and summer (23.4%) (Figure 3.6).

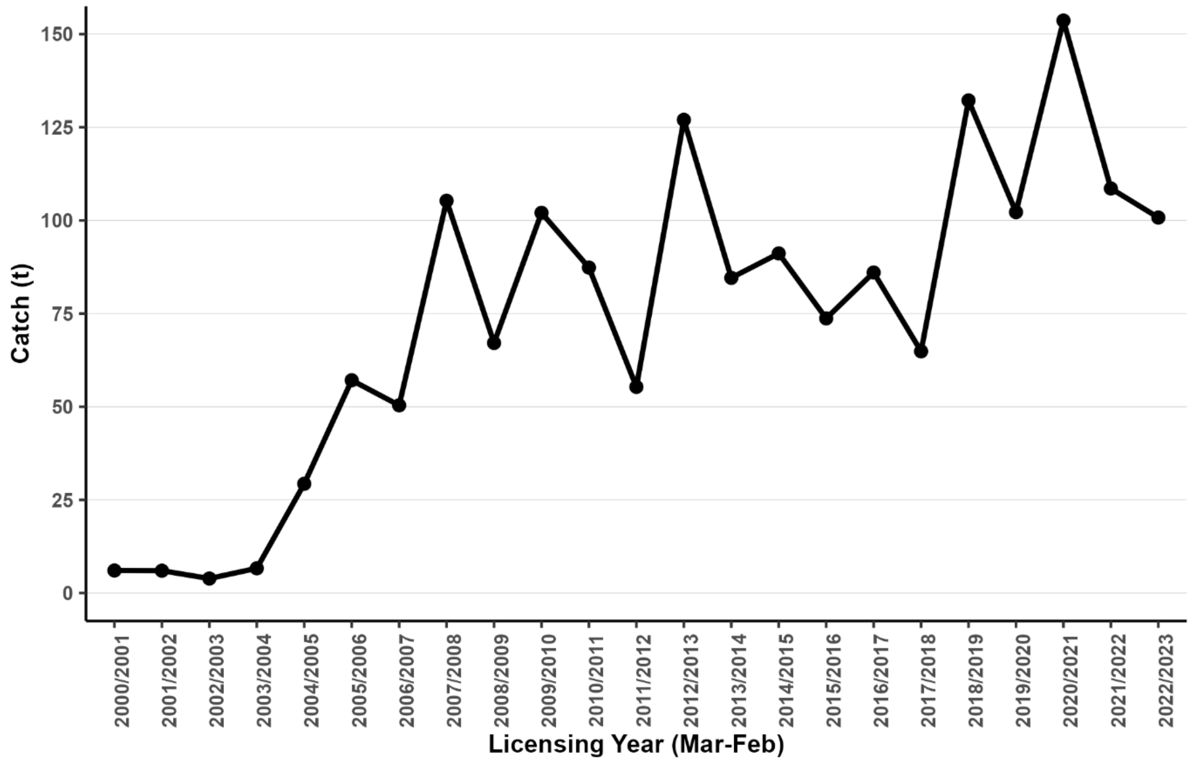

Figure 3.3 Total catches of Pale Octopus in the Tasmanian Octopus Fishery since 2000/01.

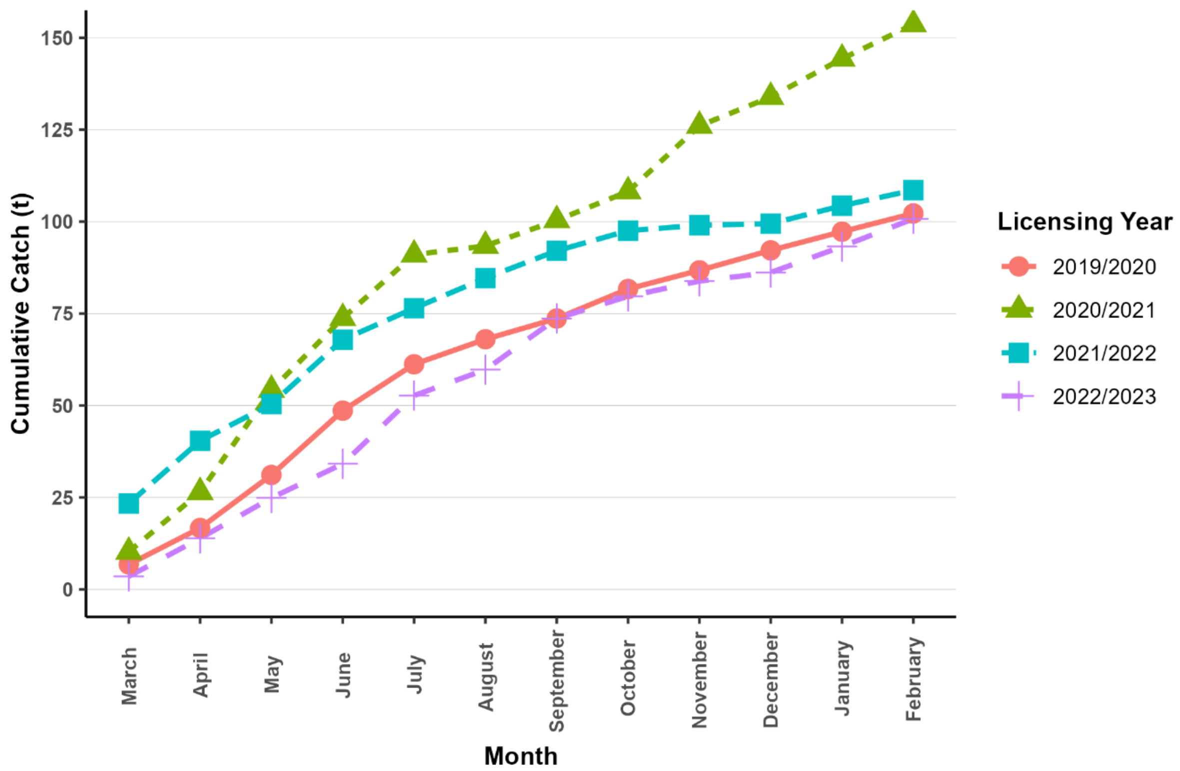

Figure 3.4 Cumulative catches of Pale Octopus landed in the Tasmanian Octopus Fishery over the last four licencing years showing seasonal trends.

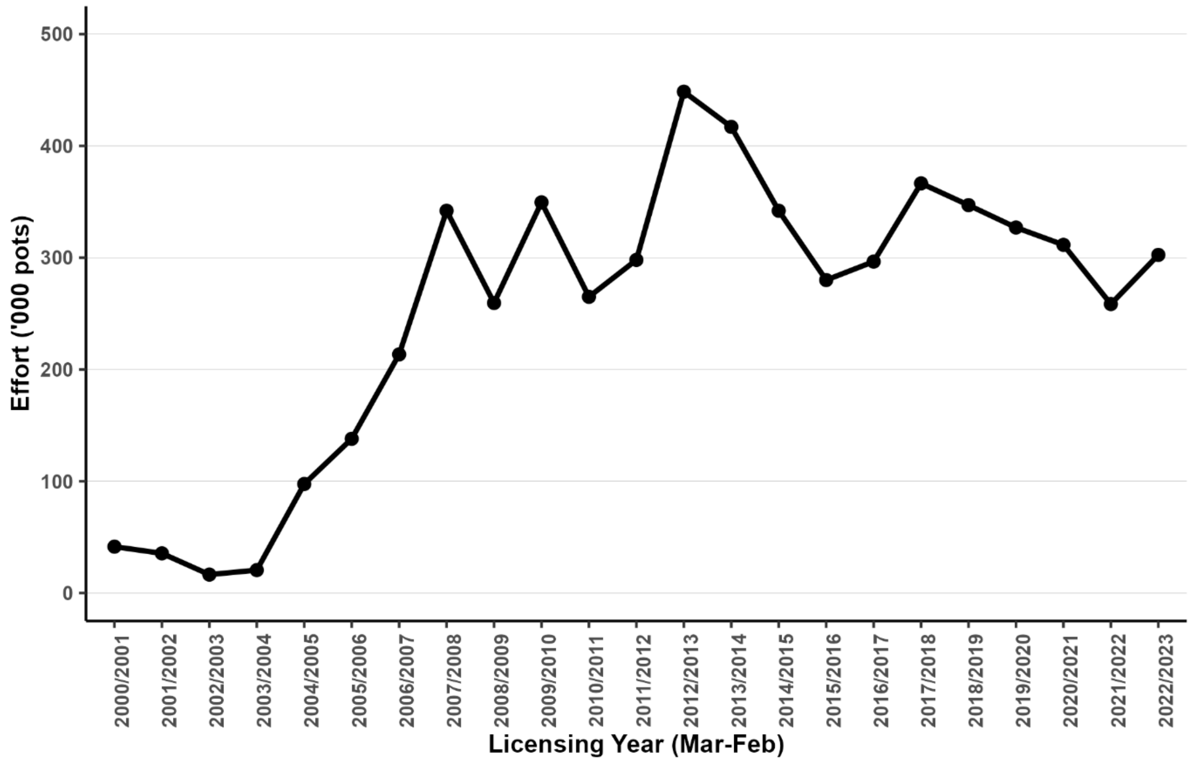

Figure 3.5 Effort (thousands of pot-lifts) for Pale Octopus in the Tasmanian Octopus Fishery since 2000/01.

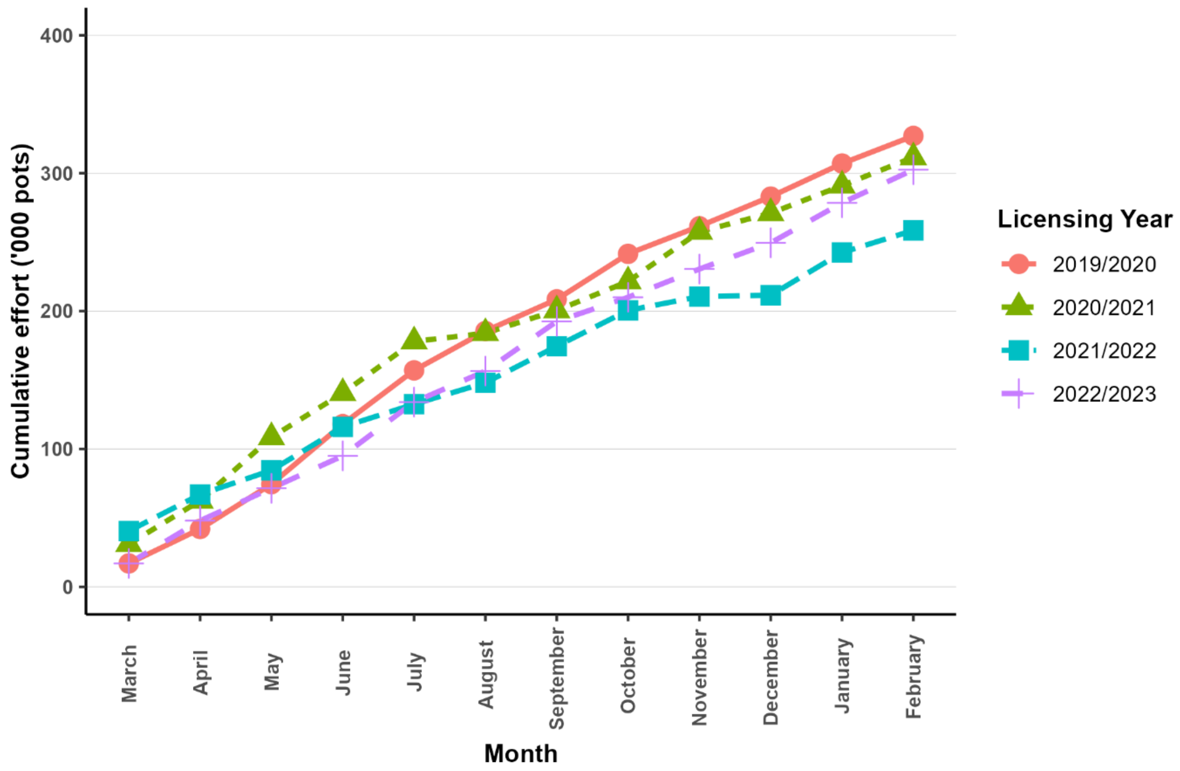

Figure 3.6 Cumulative effort (thousands of pot-lifts) for Pale Octopus landed in the Tasmanian Octopus Fishery over the last four licensing years.

Catch per unit effort

The final Generalised Linear Models (GLM) used to test variation in both commercial catch per unit effort (CPUE) and CPUE from the 50-pot sampling programme included the terms CPUE ~ Licensing Year + Month + Fishing Block. Standardised CPUE varied significantly among licensing years and months, with less significant variation among fishing blocks (see Appendix Table A1 for model coefficients).

The licensing year 2004/05 was chosen as a reference year for CPUE, in correspondence with the commencement of the 50-pot sampling programme (Figure 3.7). Historical trends indicate that standardised CPUE for the total commercial catch from logbooks can fluctuate annually, with a higher CPUE year generally followed by a lower CPUE year. From 2011/12 to 2017/18 these fluctuations were minor, with CPUE remaining close to 60% of the reference year. From 2018/19 to 2022/2023, these annual fluctuations continued to occur, however CPUE was generally higher and interannual differences were greater. In 2018/19, a notable increase in CPUE occurred, reaching 92% of the reference year. This was followed by a decline in 2019/20 to 72%, a record peak of 132% in 2020/21, 107% in 2021/22 and a decline to below the reference year to 76% in 2022/23. Estimates of CPUE from the 50-pot sampling have followed a trend similar to the logbook data, reaching 116% of the reference year in 2022/23. Data were not collected for the 50-pot sampling programme during 2019/20.

The inter-annual variation to some extent is likely due to the biological characteristics of Pale Octopus, which are inherently linked to environmental conditions, influencing hatching success and timing, larval mortality, recruitment, growth, and spawning success. Stocks may be relatively abundant in one year but decline in the following year due to less favourable environmental conditions and/or changes in fishing pressure (Boyle and Boletzky 1996; Rodhouse et al. 2014). Notably, the fishery is removing brooding females, which use fishing pots as shelters to deposit their eggs. As Pale Octopus is a holobenthic species (i.e., they produce egg batches in the hundreds with benthic hatchlings) there is limited dispersal and the stock is presumably highly structured (Doubleday et al. 2008). Genetic studies corroborate this assumption, identifying at least two differentiated sub-populations of Pale Octopus across the northern Tasmanian coast, which suggests limited movements of benthic hatchlings and adults (Higgins et al. 2013) and a high associated potential for localised depletion if fishing effort becomes concentrated.

In 2022/23, as with previous assessments (Figure 3.9), CPUE peaked in autumn (Figure 3.10), coinciding with the brooding peak for the species (Leporati et al. 2009). While seasonal CPUE estimates across previous assessment periods indicate a decline in late winter, before stabilising at around 75% of March levels from August to February (Figure 3.9), 2022/23 data show an increase in CPUE from March to May, followed by a decline in July and August before stabilising through to February. (Figure 3.10). Seasonal trends in CPUE from the 50-pot sampling programme have followed a similar trend to logbook data both across all previous assessments and for the current licensing year, 2022/23.

The ability to use CPUE based on total commercial catch data to help detect declines in local abundance is limited by spatial shifts in fishing effort from areas of low to high productivity. Given that octopus are known to seek pots for breeding and are likely to be targeted most effectively at breeding aggregation sites, there is also a notable risk of “hyperstability” in this fishery, whereby CPUE remains high despite potentially significant declines in population size. Although research pot sampling data are an important source of information to assess trends in CPUE in addition to logbook derived CPUE trends alone, the same problems remain for these data, too.

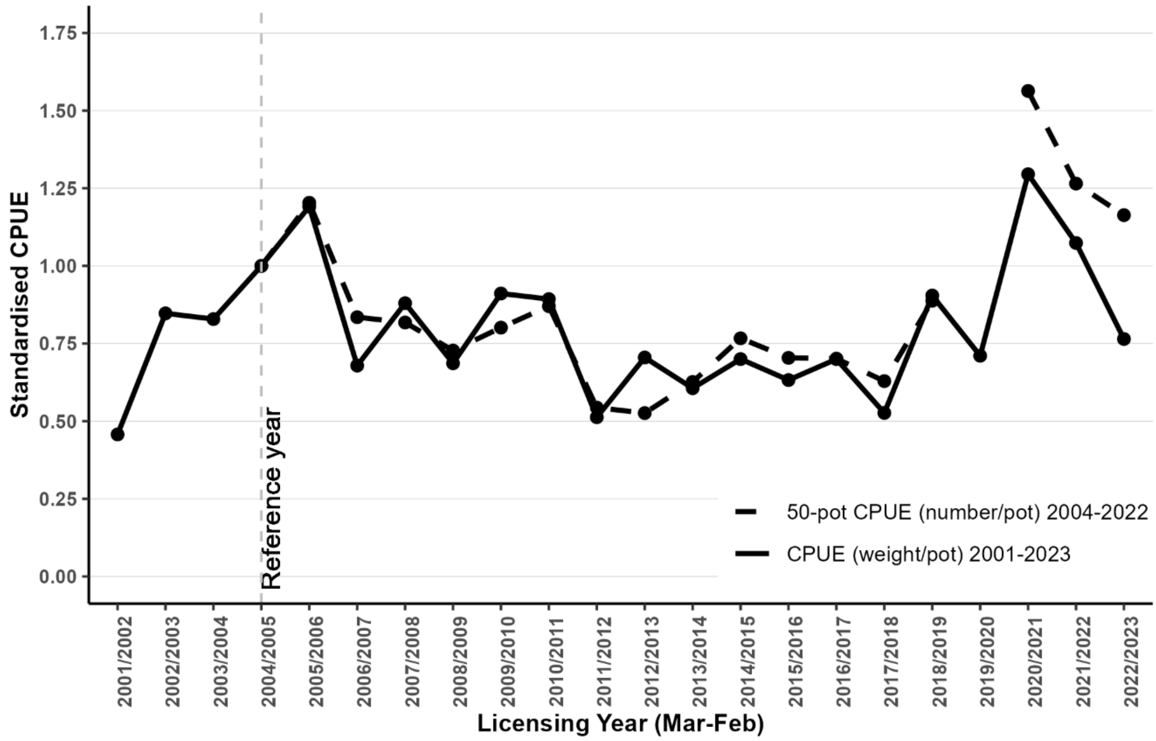

Figure 3.7 Pale Octopus standardised catch per unit effort (CPUE) from the Tasmanian Octopus Fishery relative to 2005/05 levels in weight per pot (total commercial) and in number per pot (50-pot sampling). Note that 50-pot sampling data were not provided for 2019/20.

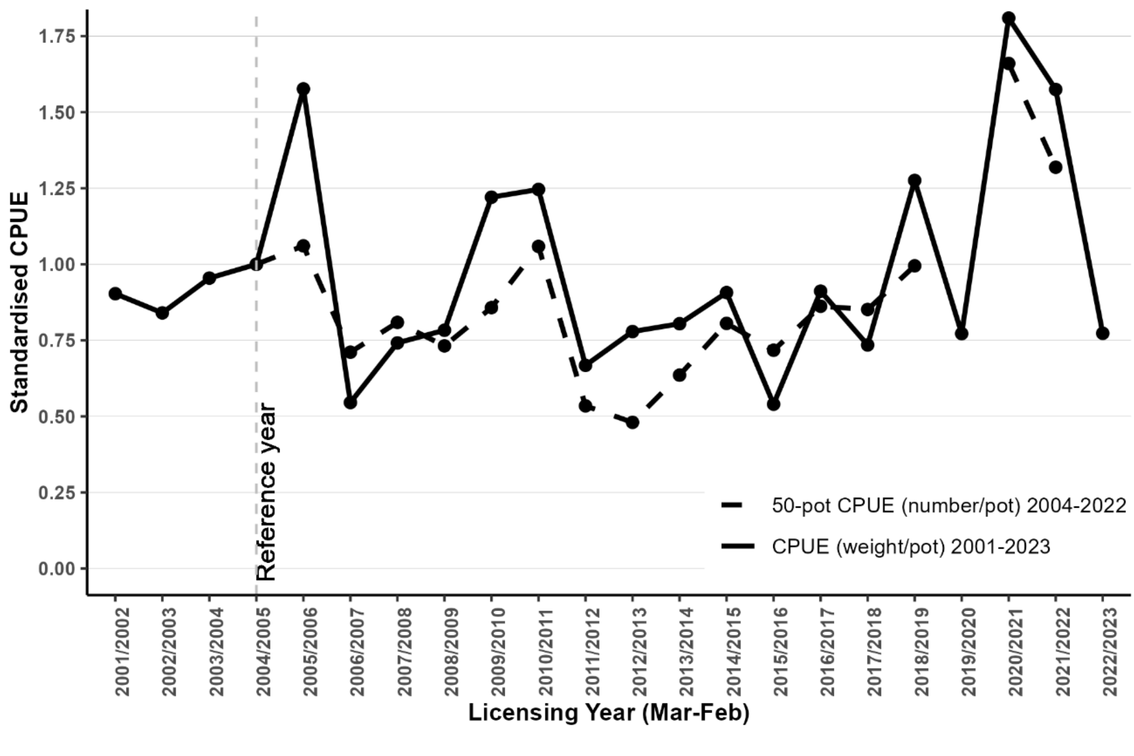

Figure 3.8 Pale Octopus standardised catch per unit effort (CPUE) from the Tasmanian Octopus Fishery for the Stanley region relative to 2004/05 levels in weight per pot (total commercial) and in number per pot (50-pot sampling). Note that 50-pot sampling data were not provided for 2019/20. Insufficient data were available to conduct similar analyses for other regions within the TOF.

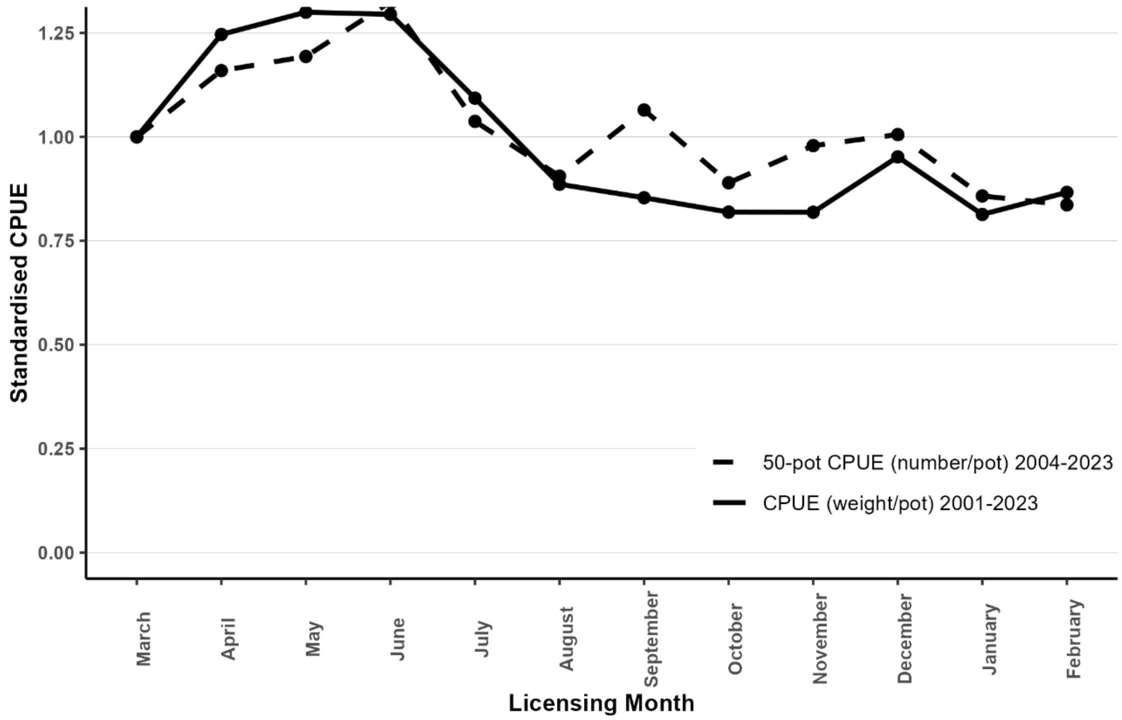

Figure 3.9 Pale Octopus seasonal trend in standardised catch per unit effort (CPUE) for the Tasmanian Octopus Fishery relative to March levels in weight per pot (total commercial) and in number per pot (50-pot sampling).

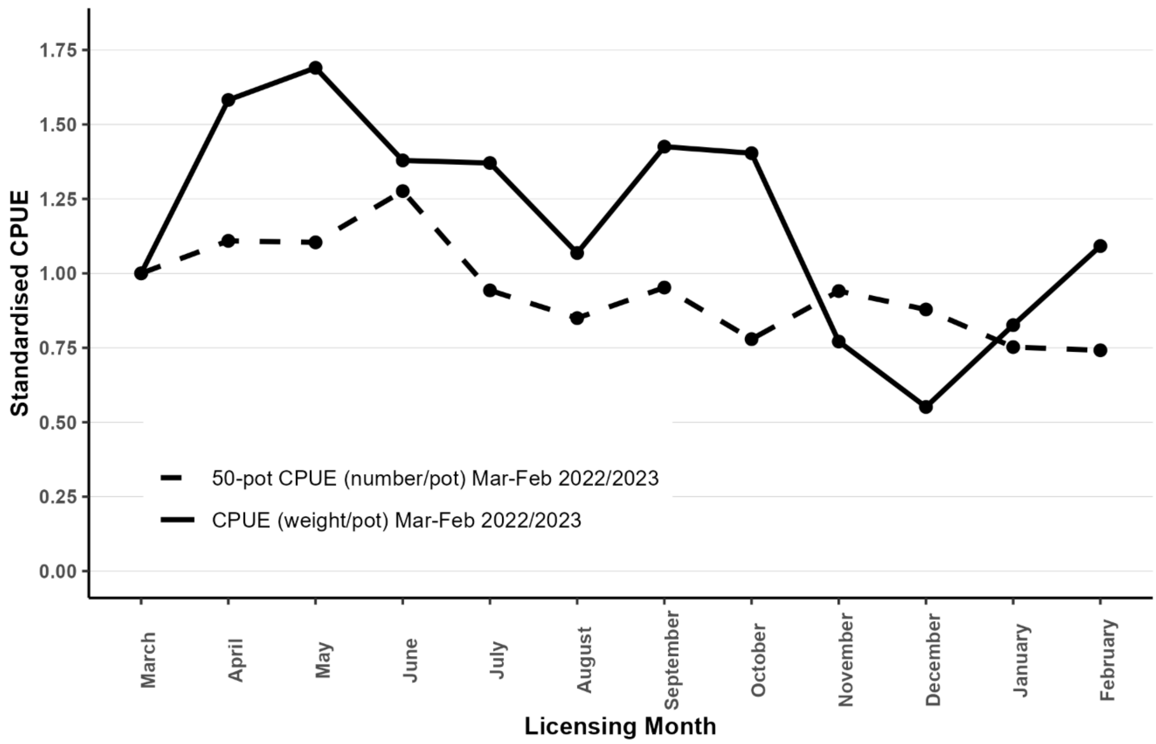

Figure 3.10 Pale Octopus seasonal trend in standardised catch per unit effort (CPUE) for the Tasmanian Octopus Fishery relative to March levels in weight per pot (total commercial) and in number per pot (50-pot sampling) for the licencing year 2022/2023.

Local patterns in Pale Octopus catch, effort, and CPUE from TOF

Spatial distribution over time

Notably, all results based on total catch and effort data presented above implicitly assume that fishing activities are comparable over the period from the reference year in 2004/05 to the current assessment year in 2022/23. This assumption does not hold, given that both fishing effort and catches have expanded to previously unexploited areas. The 2019/20 TOF assessment report (Krueck et al. 2021) highlighted shifts in effort and catch away from 'traditional' octopus fishing grounds – most notably away from historically productive fishing blocks in eastern Bass Strait and around Flinders Island to blocks east of King Island. These analyses suggested that fishing activities have changed considerably since the reference year in 2004/05 and that localised depletion of octopus biomass is a possible matter of concern in multiple traditionally fished areas.

The distribution of catch, effort, and CPUE from the TOF in 2022/23 was visualised compared to both an averaged reference decade (2004/05 to 2013/14) and an data average over the last five years (2016/17 to 2021/22) (Figure 3.11). Mapping the fishery over time shows that the concentration of higher catch, effort and CPUE has shifted from the recently dominant fishing ground in western Bass Straight around King Island to a traditionally fished region in the north and east past Flinders Island. Catch has dropped notably to the east of King Island and offshore of Stanley, while the usage of the area to the north of Flinders Island appears to be a relatively new, particularly the blocks furthest offshore. (blocks 3H1 and 3G2; see Figure 1.1 for block numbers).

2022/23 spatial distribution

In 2022/23, all blocks with the highest effort were to the north, northeast and east of Flinders Island. Secondary was one fishing block offshore of Stanley and one east of King Island (block 3D4; see Figure 1.1 for block numbers) (Figure 3.11).This concentration of effort and catch to the north of Flinders Island is dissimilar to the previous three licensing years (2019/20, 2020/21 and 2021/22) where concentration of effort and catch has been east of King Island and offshore from Stanley.

Such a shift and localised concentration of effort and catch is likely to indicate low productivity elsewhere and could be unsustainable in the longer term. However, with only two vessels in operation, fleet behaviour is also likely to be influenced by individual decisions that may be independent of catch rates.

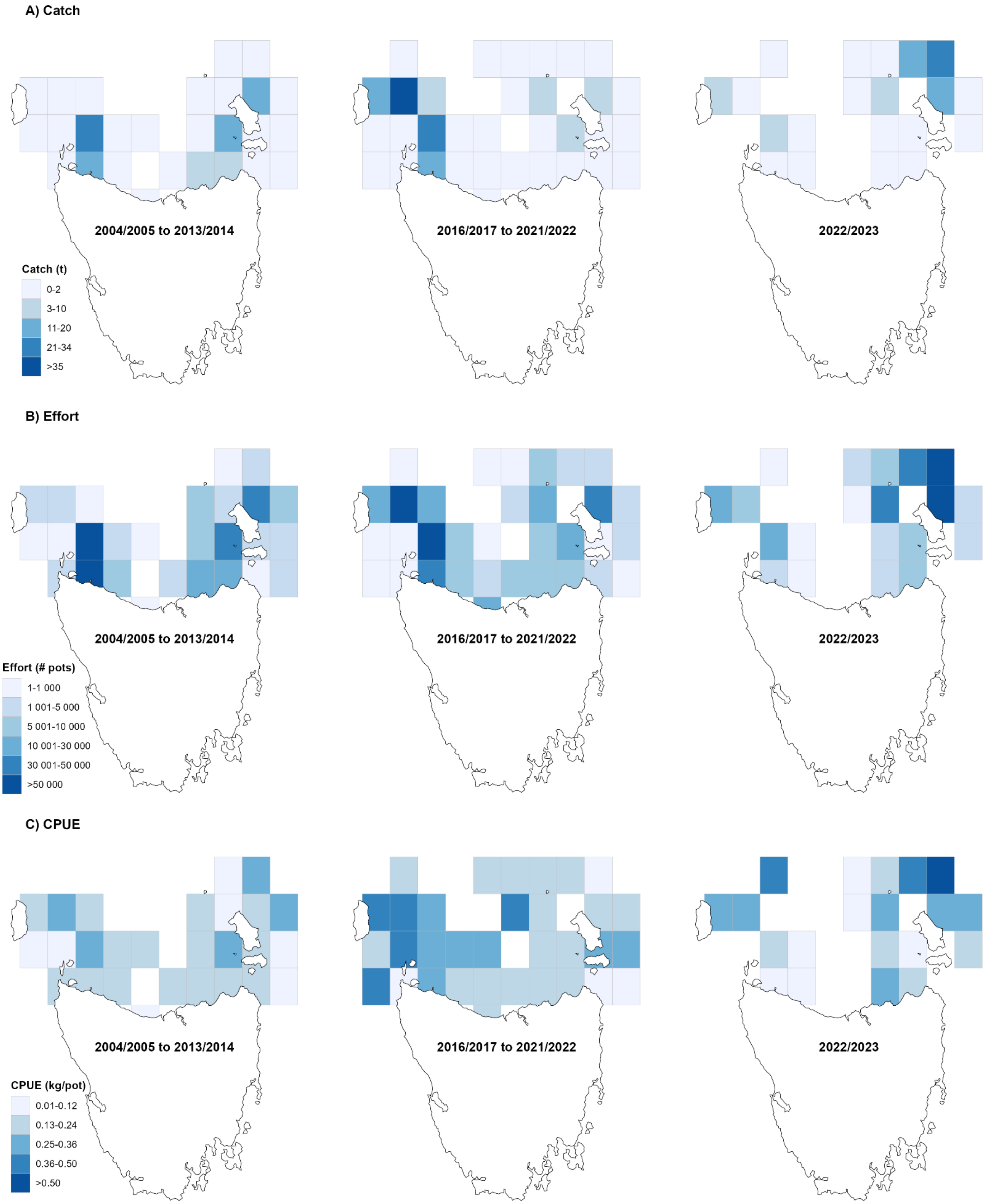

Figure 3.11 Tasmanian Octopus Fishery (A) catch, (B) effort (pot-lifts), and (C) nominal CPUE averaged over a ten-year reference period 2004/05 to 2013/14 (left), averaged over the last five years 2016/17 to 2021/22 (centre), and for the current licensing year 2022/23 (right).

Pale Octopus catch-only results – TOF

CMSY results based on the assumption of “medium” resilience showed clear regional variation within the TOF.

Stanley Region

CMSY results suggested that Pale Octopus biomass in the Stanley region has been decreasing steadily over the last 5 years and to below 25% of the unfished biomass over the last 2 years (red line; Figure 3.12), which is a commonly suggested limit reference point. This indicates the biomass level in the Stanley region could be at its lowest since the start of the data series in 2000/01 (Figure 3.12).

CMSY simulations further indicated that the maximum sustainable yield (MSY) of Pale Octopus in the Stanley region is approximately 39.6 t, with a lower 95% confidence interval of approximately 34.2t (Figure 3.13). The catch in this region in 2022/23 was 6.7t (Figure 3.13).

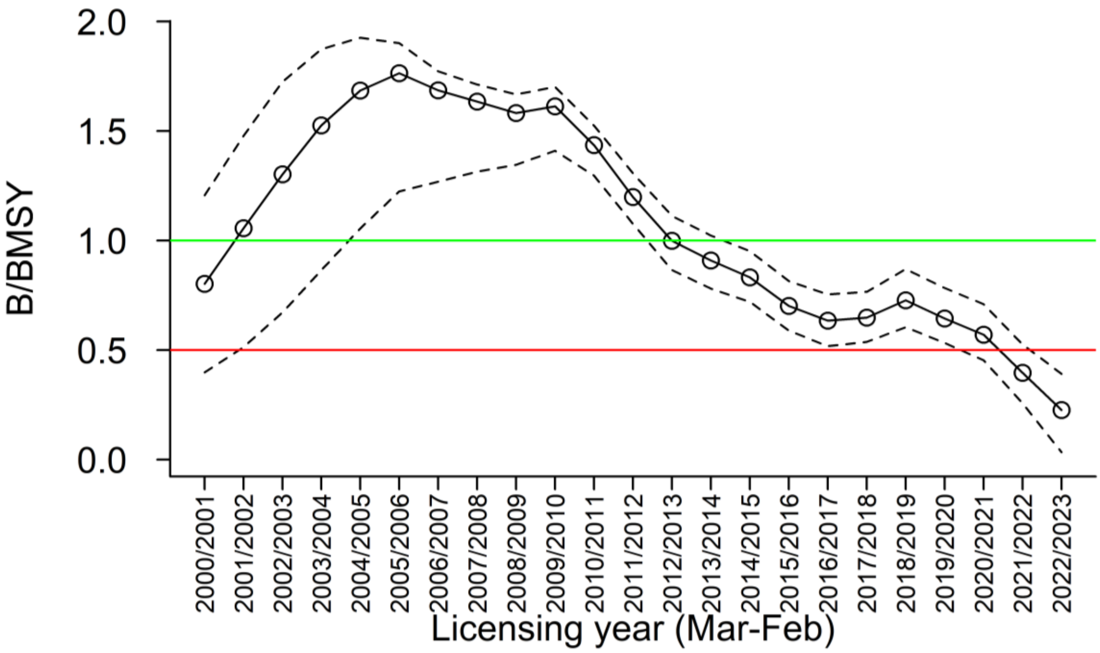

Figure 3.12 Trend in estimated depletion (biomass divided by biomass at maximum sustainable yield (MSY), including 95% confidence intervals) in the Stanley region. Results assume “medium” resilience. The green line marks biomass delivering MSY (50% of unfished levels), and the red line marks a possible limit reference point of 50% of the biomass delivering MSY (25% of unfished levels).

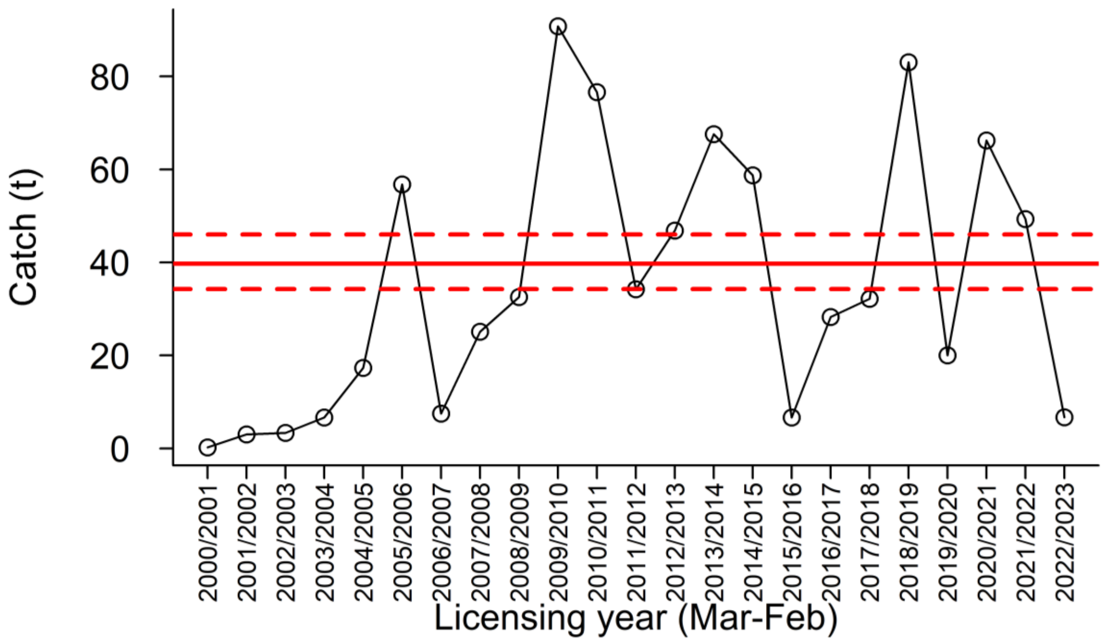

Figure 3.13 Trends in catch from the Stanley region relative to estimated maximum sustainable yield (MSY). Results assume "medium" resilience. The solid red line represents MSY; dotted red lines represent 95% confidence intervals.

Flinders Island West Region

CMSY results suggested that Pale Octopus biomass in the Flinders Island West region may have been depleted below commonly stated target levels (50% of unfished biomass; green line, Figure 3.14) from 2014/15 and notably below the common limit reference point of 0.5 B/BMSY (i.e. 25% of unfished biomass; red line, Figure 3.14) from 2018/19, but show an upward trend in biomass over the last three seasons increasing back up to the biomass delivering MSY of 50% of unfished levels (green line, Figure 3.14) which was last reached in 2014/15.

CMSY simulations further indicated that the maximum sustainable yield (MSY) of Pale Octopus in the Flinders Island West region is approximately 19.0 t, with a lower 95% confidence interval of approximately 16.2 t (Figure 3.15). The catch for this region in 2022/23 was well over the estimated MSY at 31.6 t (Figure 3.15), and more than double the last five fishing seasons.

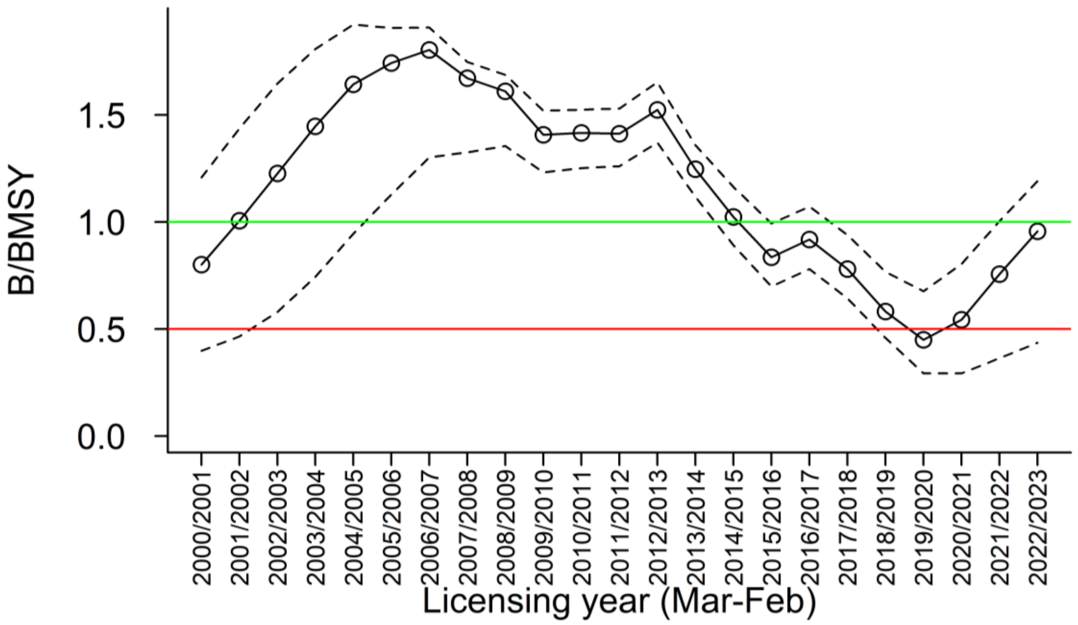

Figure 3.14 Trend in estimated depletion (biomass divided by biomass at maximum sustainable yield (MSY), including 95% confidence intervals) in the Flinders Island West region. Results assume “medium” resilience. The green line marks biomass delivering MSY (50% of unfished levels), and the red line marks a limit reference point of 50% of biomass delivering MSY (25% of unfished levels).

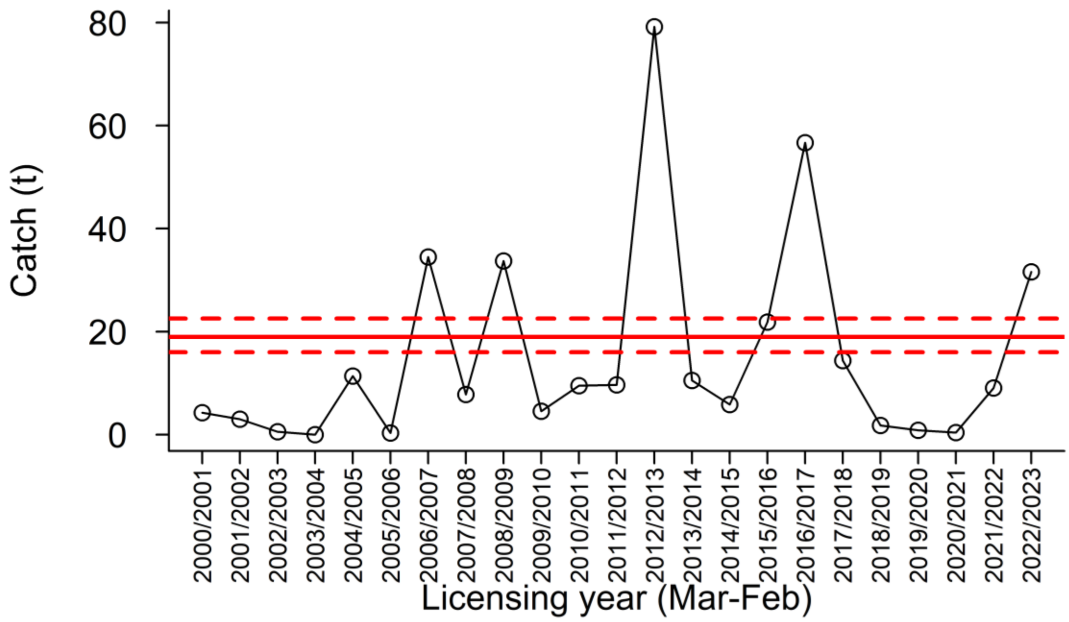

Figure 3.15 Trends in catch from the Flinders Island West region relative to estimated maximum sustainable yield (MSY). Results assume “medium” resilience. The solid red line represents MSY; dotted red lines represent 95% confidence intervals.

Flinders Island East Region

CMSY results suggested that Pale Octopus in the Flinders Island East region may have been depleted below commonly stated target levels (50% of unfished biomass; green line, Figure 3.16) since 2009/10, however there has been a general upward trend in estimated biomass over the last 3 seasons with biomass approaching 50% of the unfished biomass level in the most recent season, as indicated by the green line in Figure 3.16.

CMSY simulations further indicated that maximum sustainable yield in the Flinders Island East region is approximately 9.4 t, with a lower 95% confidence interval of 7.9 t (Figure 3.17). The catch for this region in 2022/23 was 54.3 t, the highest it has been since 2007/08 and more than five times higher than the previous season (Figure 3.17).

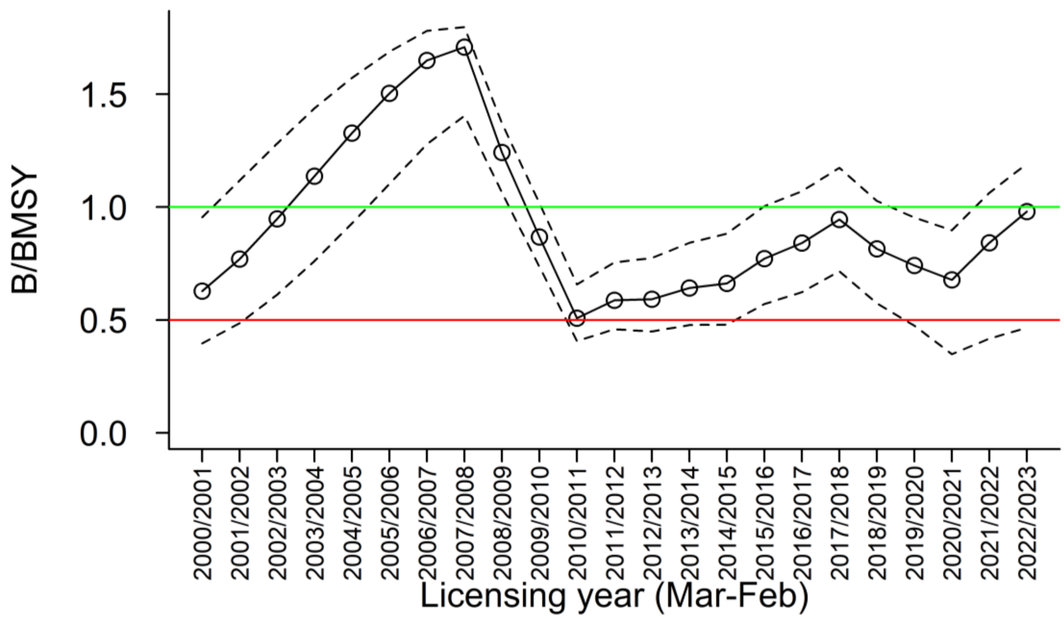

Figure 3.16 Trend in estimated depletion (biomass divided by biomass at maximum sustainable yield (MSY), including 95% confidence intervals) in the Flinders Island East region. Results assume “medium” resilience. The green line marks biomass delivering MSY (50% of unfished levels), and the red line marks a limit reference point of 50% of biomass delivering MSY (25% of unfished levels).

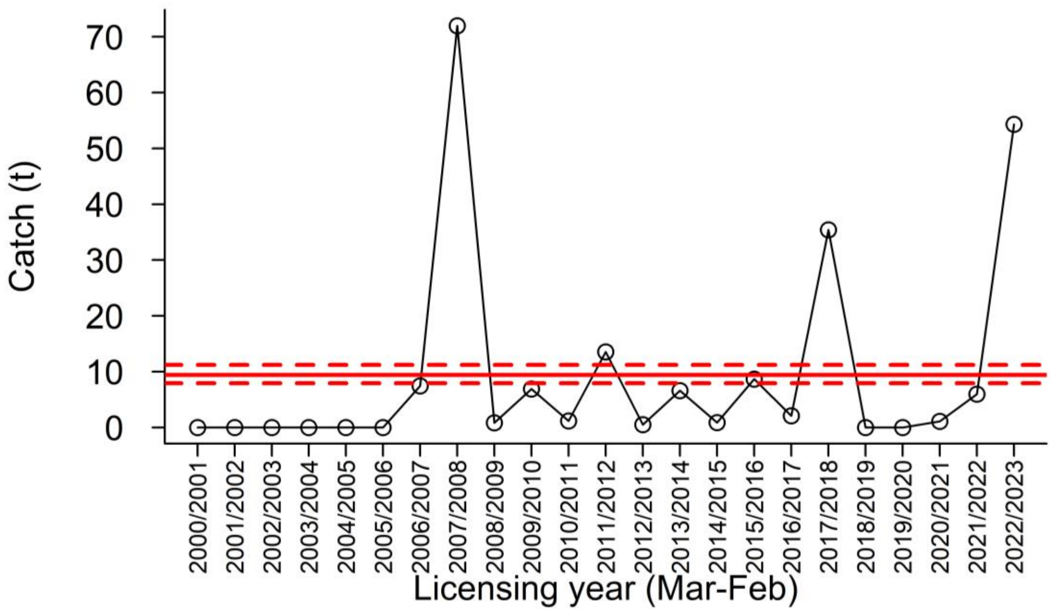

Figure 3.17 Trends in catch from the Flinders Island East region relative to estimated maximum sustainable yield (MSY). Results assume “medium” resilience. The solid red line represents MSY; dotted red lines represent 95% confidence intervals.

Pale Octopus risk assessment of recruitment impairment - TOF

The Pale Octopus Fishery within the TOF scored < 60 in the Marine Stewardship Council – Risk Based Framework (MSC-RBF) analysis, failing assessment with high risk of stock damage (Table 3.1). The Productivity Susceptibility Analysis score was based on the assumption that Pale Octopus is a moderately productive secondary consumer, with a short generation time (< 1 year), and a relatively energy-intense reproductive strategy whereby females actively brood egg clutches. Pale Octopus is highly susceptible to capture and the stock susceptible to damage by the fishery. Fishing effort overlaps with > 30% of the stock distribution in Tasmania, suggesting that the stock is readily available to the fishery. The major risk factor identified by the analysis was the high probability of individual octopus encountering and being captured by fishing gear, given that octopus actively seek out fishing gear (pots) as refuges. This risk is exacerbated by the behaviour of female octopus, which use pots as sheltered habitats to lay and brood eggs, and the fact that fishing effort is concentrated in the peak brooding season (autumn). In consequence, commercial fishery CPUE and other catch data (e.g., sex ratio) are unreliable metrics of stock status over time, as octopus might be effectively caught largely regardless of population density. That is, population depletion might occur even if only minor or no declines in CPUE are evident. Furthermore, the attraction of brooding females to fishing gear indicates a high likelihood of damage to recruitment.

The Consequence Analysis indicated full exploitation of the stock, with population size representing the most vulnerable subcomponent. Although there is no clear evidence of damage to recruitment, the frequent capture of brooding females suggests that without suitable management there is a high risk of stock damage and recruitment impairment by this fishery.

Table 3.1 Risk-Based Framework scoring of the Pale Octopus fishery for the consequence analysis, productivity susceptibility analysis, and the combined total.

Consequence Analysis		
Most vulnerable subcomponent	**Score**	**Score interpretation**
Population size	60	Full exploitation rate but long-term recruitment dynamics not adversely affected
Productivity Susceptibility Analysis		
Productivity attribute	**Score**	**Score interpretation**
Average age at maturity Average maximum age Fecundity Reproductive strategy Trophic level Density dependence	1 1 2 2 2 3	< 5 years < 10 years 100 – 20 000 eggs per year Demersal egg layer 2.75 – 3.25 Depensatory dynamics at low population sizes (Allee effects) demonstrated or likely
Susceptibility attribute	**Score**	**Score interpretation**
Availability (areal overlap of fishing effort with stock distribution)	3	> 30% overlap
Encounterability (position of stock/species in water column or on habitat relative to position of gear)	3	High overlap with fishing gear. Default score for target species.
Selectivity (potential of gear to retain immature individuals)	3	a) Individuals < size at maturity a frequently caught. b) Individuals < half size at maturity are retained by gear.
Post-capture mortality (the chance that captured individuals will be released, and their chance of survival if released)	3	Default score for target species.
Total Productivity Susceptibility Score **Total RBF Score**	**< 60** **< 60**	

DEVELOPMENTAL PALE OCTOPUS FISHERY

Four fishing permits (for five vessels in total), allowing access to Pale Octopus in Tasmanian state waters below latitude 41° 0’ 00’’ South (approximately all state waters not encompassed by the TOF, subject to exclusion zones), were issued for the 2022/23 season, and landings were reported for three of these permits. Total catch of Pale Octopus under permits in 2022/23 was 4.8 t from a total of 32,768 pot-lifts.

Reported data for landings under permit are available for Pale Octopus from the eastern and southern coasts of Tasmania for 2017/18, 2019/20, 2020/21, 2021/22 and 2022/23 (Table 3.2). Although a single permit was issued in 2016/17, no data were reported for this licensing year. Prior to the issue of permits, no commercial fishing for Pale Octopus occurred outside of the Bass Strait area covered by the TOF. Minimal catch since permits were issued is a result of minimal effort, and exploitation of the stock remains low.

Table 3.2 Pale Octopus fishery data from the developmental octopus fishery in state waters outside of the area encompassed by the TOF. Data include total catch (tonnes), effort (pot-lifts), number of issued permits, and number of vessels for which landings were reported.

Licensing year	Catch (t)	Effort (pot-lifts)	Number of permits	Number of vessels with reported landings
2016/17	0	0	1	0
2017/18	3.1	24,000	1	1
2019/20	6.0	31,500	2	1
2020/21	4.6	22,500	3	3
2021/22	3.0	21,655	4	4
2022/23	4.8	32,708	4	4

MĀORI AND GLOOMY OCTOPUS FISHERIES

Total catches of Māori and Gloomy Octopus (mostly Māori Octopus) in Tasmania have fluctuated around 5-25 t since 2002/03 (Figure 3.18). Highest catches in the past can be attributed to the targeted Māori Octopus fishery in Eaglehawk Bay. Two anomalously high catches in the Rock Lobster fishery match 2021/22 when species level reporting began and the first year of required reporting within that fishery (2000/01, see Figure 3.21).

In recent years, catches appear to have been dominated by the Rock Lobster fishery, with the exception of 2017/18, when the TOF appeared to target Gloomy Octopus near Flinders Island. Total reported commercial catch in 2022/23 of both Māori and Gloomy Octopus combined was 22.1 t, comprising 9.64 t from the Rock Lobster fishery, 11.6 t from the TOF, 0.46 t from the Scalefish fishery and developmental permits for Pale Octopus, and 0.39 t from the Eaglehawk Bay Māori Octopus fishery.

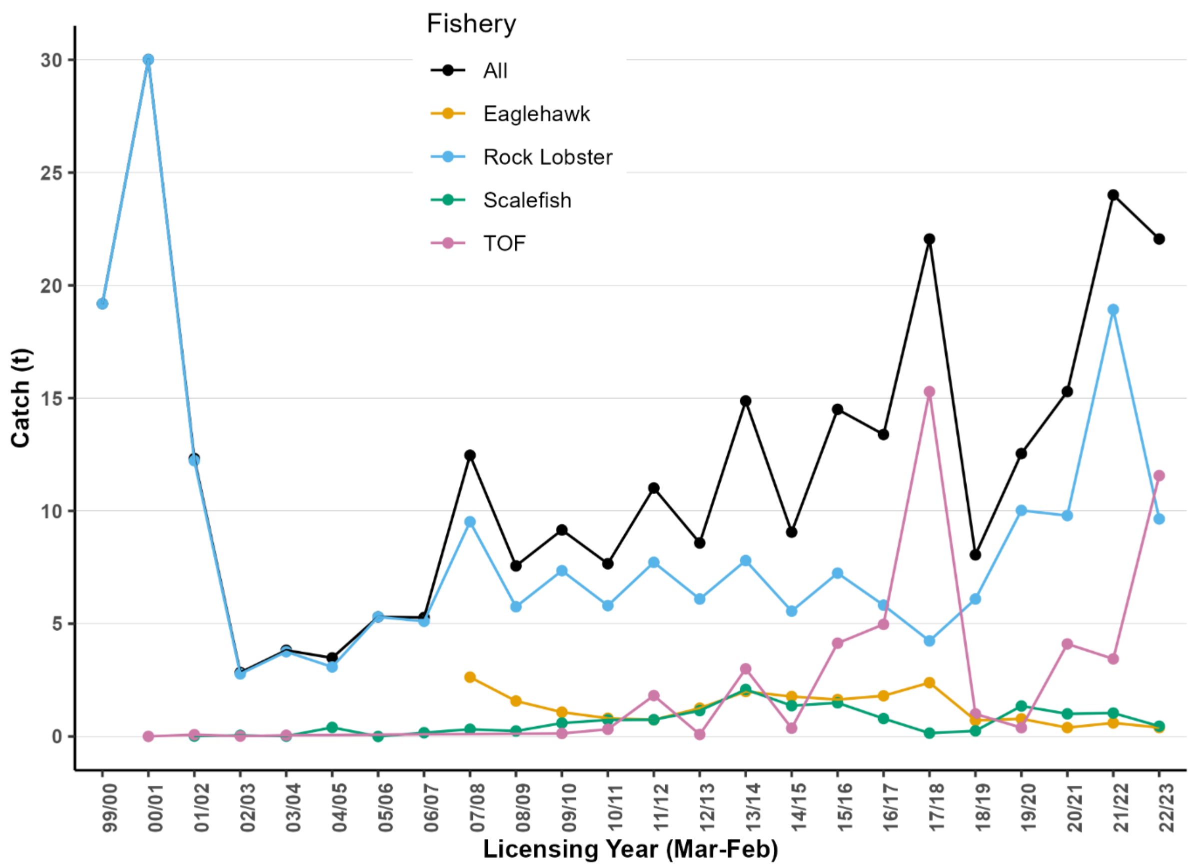

Figure 3.18 Total catches of octopus across all fisheries since octopus returns were first reported in each fishery. Excludes Pale Octopus catch in the TOF under fishing licence (octopus) and Pale Octopus caught under developmental permits for this species.

Māori and Gloomy Octopus catch from TOF and developmental permits

Total Māori Octopus catch from fisheries targeting Pale Octopus using unbaited traps – the TOF and the developmental fishery – was 4.8 t in 2022/23, comprising 39 kg from the developmental fishery and the remainder from the TOF (Figure 3.19). Previous annual catches fluctuated between 0 – 2 t, with the exception of a 6.6 t peak in 2020/21.

Total Gloomy Octopus catch from these fisheries in 2022/23 was 7.1 t, all of which was landed by the TOF, with no landings under developmental permits (Figure 3.19). The highest catch from these fisheries was 18.6 t in 2017/18, when the TOF appeared to target this species around Flinders Island. In 2022/23 the TOF again concentrated targeting in this area, resulting in notably high catches of Gloomy Octopus (Figure 3.19).

Both species were considered to be at negligible risk from unbaited trap fishing in the 2012/13 Ecological Risk Assessment (ERA) due to their low catches and biological traits, including their reproductive biology (Bell et al. 2016). In particular, both species have a strategy of a large number of eggs and planktonic larval dispersal (Gloomy Octopus: ~ 278,500 eggs; Māori Octopus: < 196,000 eggs; Table 1.3), which contrasts with the holobenthic strategy of Pale Octopus.

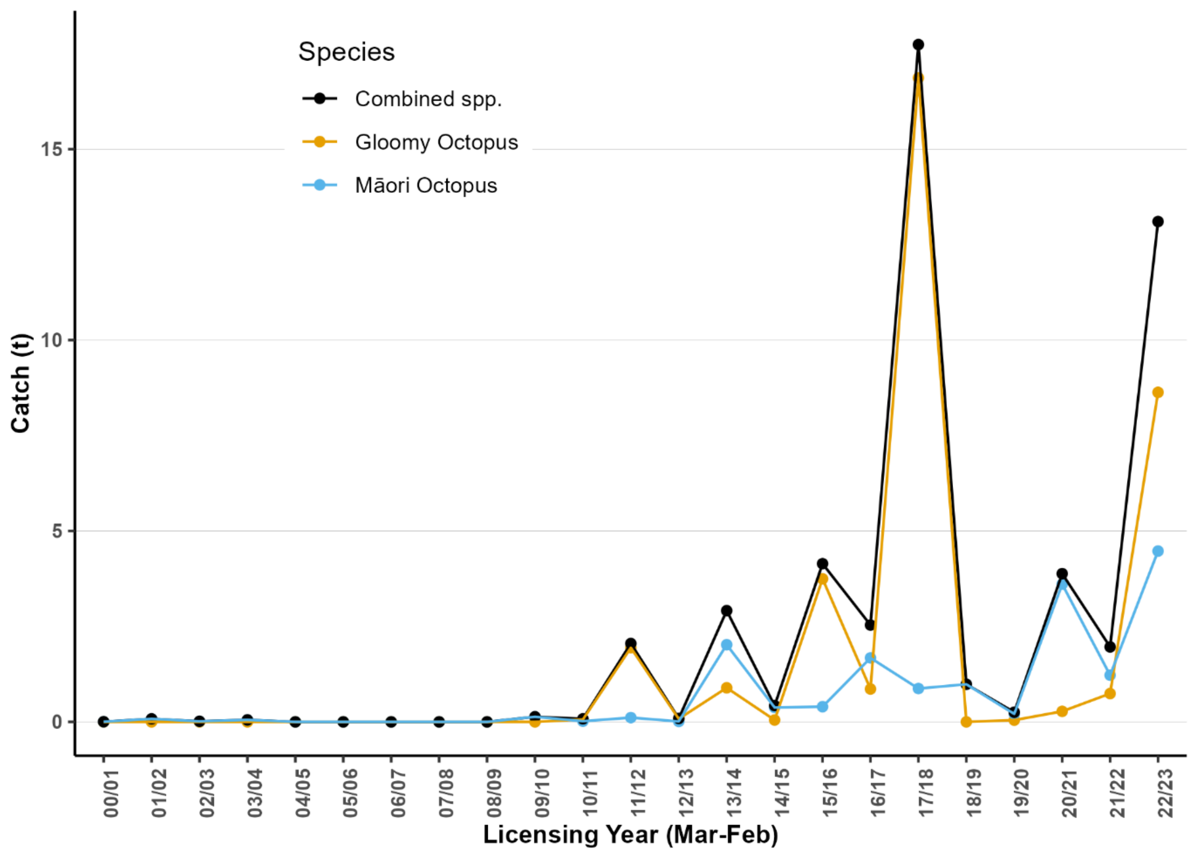

Figure 3.19 Total catches of Māori Octopus (*Macroctopus maorum*) and Gloomy Octopus (*Octopus tetricus*) from unbaited traps in the TOF and east coast developmental fishery for Pale Octopus since 2000/01.

Octopus catch from the Scalefish Fishery

Annual octopus catch within the Scalefish fishery has remained below 3 t since 2001/02 (Figure 3.20). Spear and hand collection are the main gear with which octopus are landed in this fishery, however a diversity of gear types and operations are responsible for octopus landings. In 2022/23, total octopus catch from this fishery was 455 kg, comprising 8 kg Gloomy Octopus, 0 kg Pale Octopus reported, and 447 kg Māori Octopus.

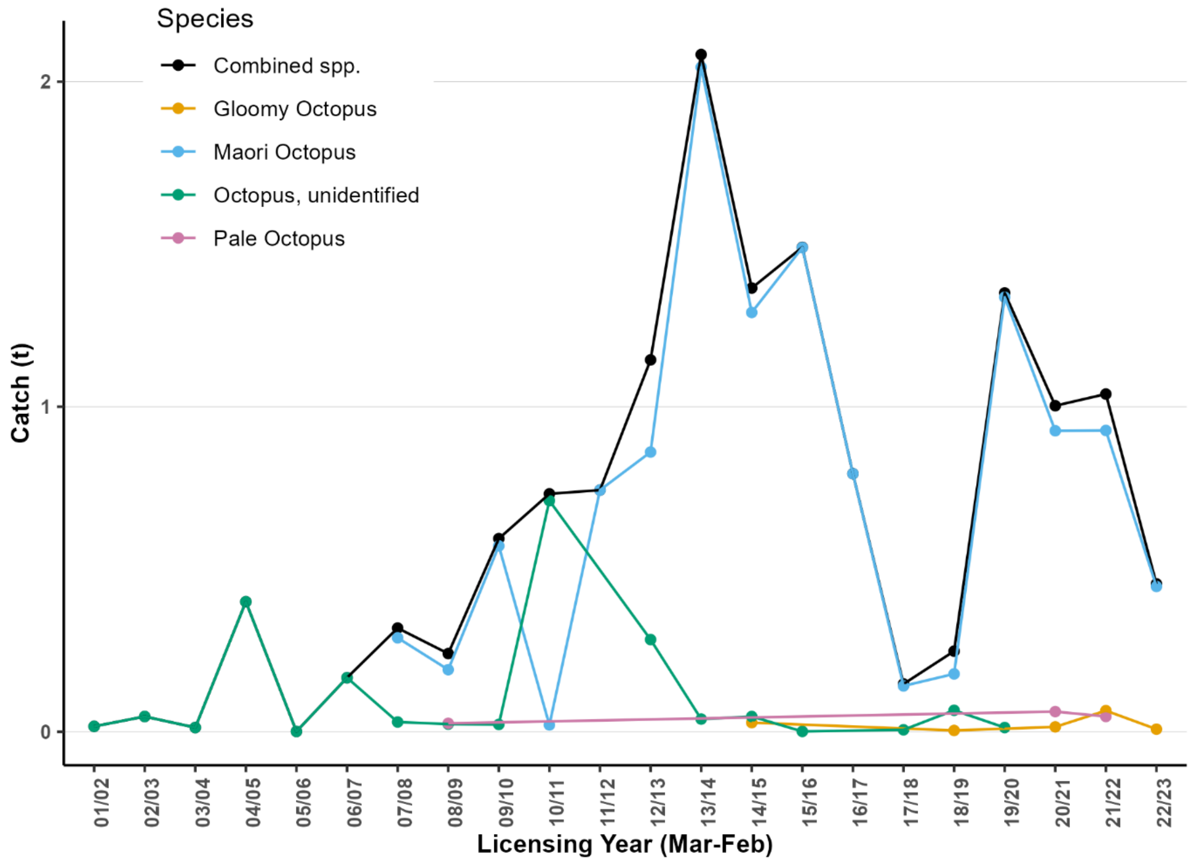

Figure 3.20 Total catches of octopus from diverse operations within the Scalefish fishery since 2001/02.

Octopus catch from the Rock Lobster Fishery

Octopus catch was not required to be reported by the Rock Lobster fishery before 2000/01. Since then, annual retained, landed octopus catch within this fishery has remained below 10 t (Figure 3.21). An outstanding exception is the first reporting year, 2000/01, when reported catch was 20.6 t. Since then, reported octopus catch has remained below 10 t, with a return to higher levels in 2021/22. In 2021/22, octopus landings from the Rock Lobster fishery were first identified to species level, however it is uncertain whether these species identifications are accurate. For 2022/23 reported octopus catch in the rock lobster fishery was 9.64 t, comprising 7.17 t Māori Octopus, 2.24 t Gloomy Octopus and 0.24 t Pale Octopus.

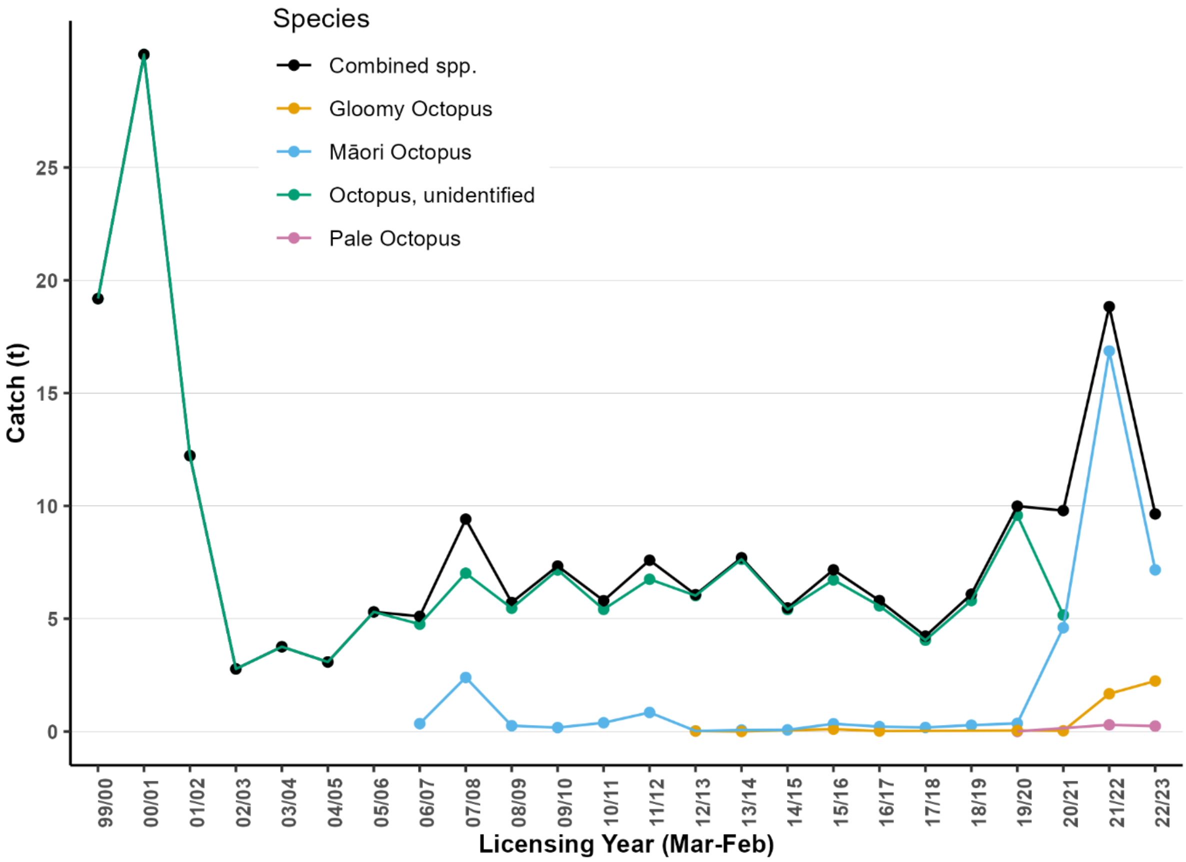

Figure 3.21 Total catches of octopus from the Rock Lobster fishery since 1999/00. Note that octopus were identified to species level in Rock Lobster fishery returns for the first time in 2021/22, however the accuracy of species identification is uncertain.

Octopus catch from the Eaglehawk Bay Māori Octopus Fishery

Annual octopus catch within the Eaglehawk Bay fishery fluctuated around 10 – 20 t until 2003/04 (Figure 3.22). Catches were dominated by 'Octopus, unidentified' (presumably mostly Māori Octopus) prior to 2008/09, and Māori Octopus since then. There was a notable decline in 2008/09, preceding a ban on the use of barrier nets in this fishery in late 2009. Fishers also observed an increase in seal densities in the bay over time, and attributed catch declines to increased octopus predation by seals. Catch has remained below 3 t since 2008/09. In 2022/23, less than 0.5 t catch was recorded, following four seasons with catch < 1 t.

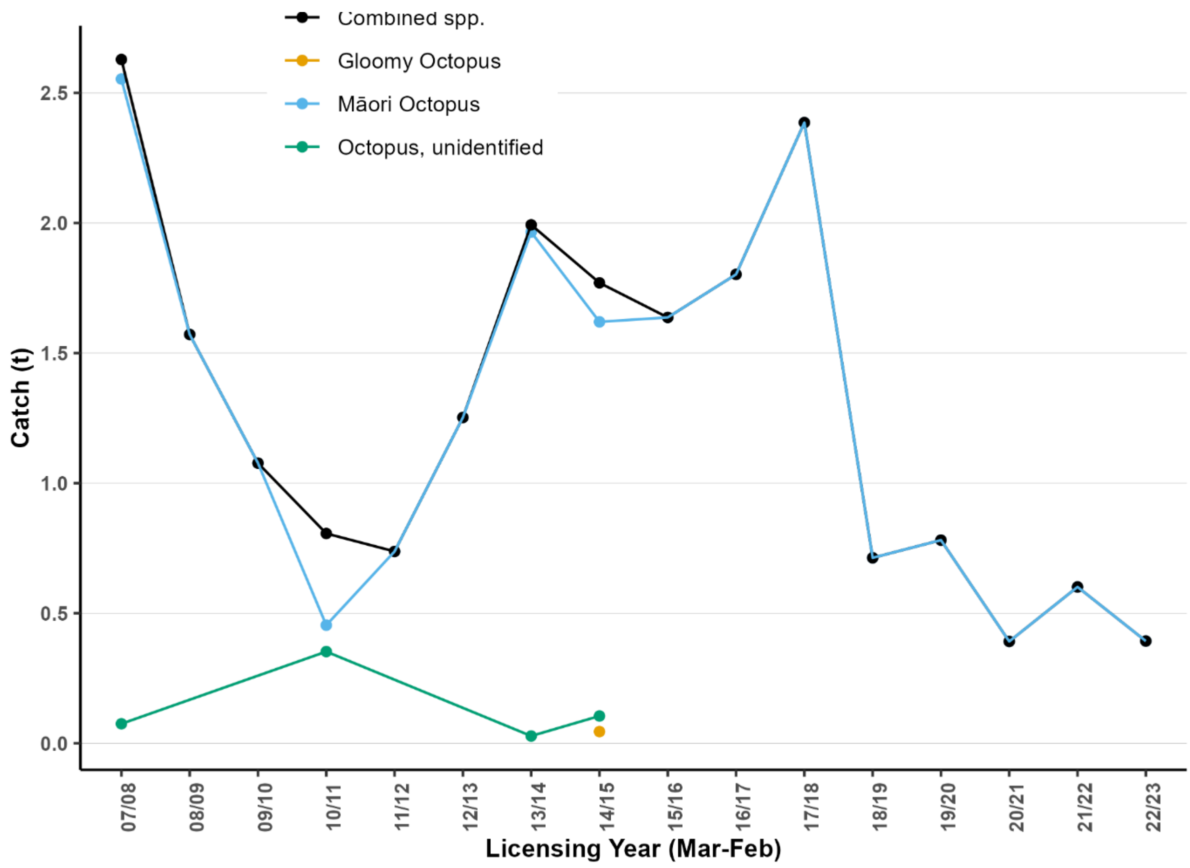

Figure 3.22 Total catches of octopus from the Eaglehawk Bay targeted Māori Octopus fishery since 2007/08.

Māori and Gloomy Octopus risk assessment of recruitment impairment

The Māori and Gloomy Octopus fisheries in Tasmania both scored 60 – 80 in the Marine Stewardship Council – Risk Based Framework (MSC-RBF) analysis, passing assessment with medium risk to stock damage (Table 3.3, Table 3.4). The Productivity Susceptibility Analysis scores for both species were based on the assumption that these species are moderately productive secondary consumers with short generation times (Māori Octopus < 3 years; Gloomy Octopus <1 year) and relatively energy intense reproductive strategies whereby females actively brood large clutches of eggs. Both species are highly susceptible to capture as catches overlap with >30% of stock distribution in Tasmanian waters, and there is a high risk of juveniles being retained by fishing gear. The Consequence Analysis for both species showed no evidence of impact to any subcomponent, meaning recruitment impairment is unlikely.

Table 3.3 Risk-Based Framework scoring of the **Māori Octopus** fishery for the consequence analysis, productivity susceptibility analysis, and the combined total.

Consequence Analysis		
Most vulnerable subcomponent	**Score**	**Score interpretation**
All	100	Change to any subcomponent unlikely to be detectable against natural variability for this population.
Productivity Susceptibility Analysis		
Productivity attribute	**Score**	**Score interpretation**

Average age at maturity Average maximum age Fecundity Reproductive strategy Trophic level Density dependence	1 1 1 2 3 3	< 5 years < 10 years 100 – 20 000 eggs per year Demersal egg layer > 3.25 Depensatory dynamics at low population sizes (Allee effects) demonstrated or likely
Susceptibility attribute	**Score**	**Score interpretation**
Availability (areal overlap of fishing effort with stock distribution)	3	> 30% overlap
Encounterability (position of stock/species in water column or on habitat relative to position of gear)	3	Medium overlap with fishing gear
Selectivity (potential of gear to retain immature individuals)	3	a) Individuals < size at maturity a frequently caught. b) Individuals < half size at maturity are retained by gear.
Post-capture mortality (the chance that captured individuals will be released, and their chance of survival if released)	3	All individuals are retained, or the majority are dead if released due to damage.
Total Productivity Susceptibility Score **Total RBF Score**	**60 – 80** **60 – 80**	

Table 3.4 Risk-Based Framework scoring of the **Gloomy Octopus** fishery for the consequence analysis, productivity susceptibility analysis, and the combined total.

Consequence Analysis		
Most vulnerable subcomponent	**Score**	**Score interpretation**
All	100	Change to any subcomponent unlikely to be detectable against natural variability for this population.
Productivity Susceptibility Analysis		
Productivity attribute	**Score**	**Score interpretation**
Average age at maturity Average maximum age Fecundity Reproductive strategy Trophic level Density dependence	1 1 1 2 2 3	< 5 years < 10 years > 20 000 eggs per year Demersal egg layer 2.75 – 3.25 Depensatory dynamics at low population sizes (Allee effects) demonstrated or likely
Susceptibility attribute	**Score**	**Score interpretation**
Availability (areal overlap of fishing effort with stock distribution)	3	> 30% overlap
Encounterability (position of stock/species in water column	3	Medium overlap with fishing gear

or on habitat relative to position of gear)		
Selectivity (potential of gear to retain immature individuals)	3	c) Individuals < size at maturity a frequently caught. d) Individuals < half size at maturity are retained by gear.
Post-capture mortality (the chance that captured individuals will be released, and their chance of survival if released)	3	All individuals are retained, or the majority are dead if released due to damage.
Total Productivity Susceptibility Score	**60 – 80**	
Total RBF Score	**60 – 80**	

Distribution of all octopus catch in Tasmanian waters

The geographic distribution of annual octopus catch per species was illustrated by averaging catch within fishing blocks over the last five years (2018/19 to 2022/23), including data from all fisheries – the TOF, the developmental fishery for Pale Octopus, the Rock Lobster fishery, the Scalefish fishery, and the Eaglehawk Bay Māori Octopus fishery (**Error! Reference source not found.**). Pale Octopus catch was predominantly taken from the Bass Strait, with some catch recorded from south-eastern waters. Gloomy Octopus was mostly taken from the eastern Bass Strait around Flinders Island, with Rock Lobster fishery returns first distinguishing among species in 2022/23, unexpectedly showing that Gloomy Octopus appeared to be taken from the east, southeast, southwest, and west coasts, as well as around King Island. It is uncertain whether species identifications in Rock Lobster returns data are accurate. Landings identified as Māori Octopus were generally recorded mostly from the western Bass Strait and southeast coast. First species-level Rock Lobster fishery returns from 2022/23 showed Māori Octopus were also taken from the entire west and southwest coasts. 'Octopus, unidentified' (presumably mostly Māori Octopus) were taken from most parts of the Tasmanian coast, with notably less catch in the central Bass Strait/north coast area.

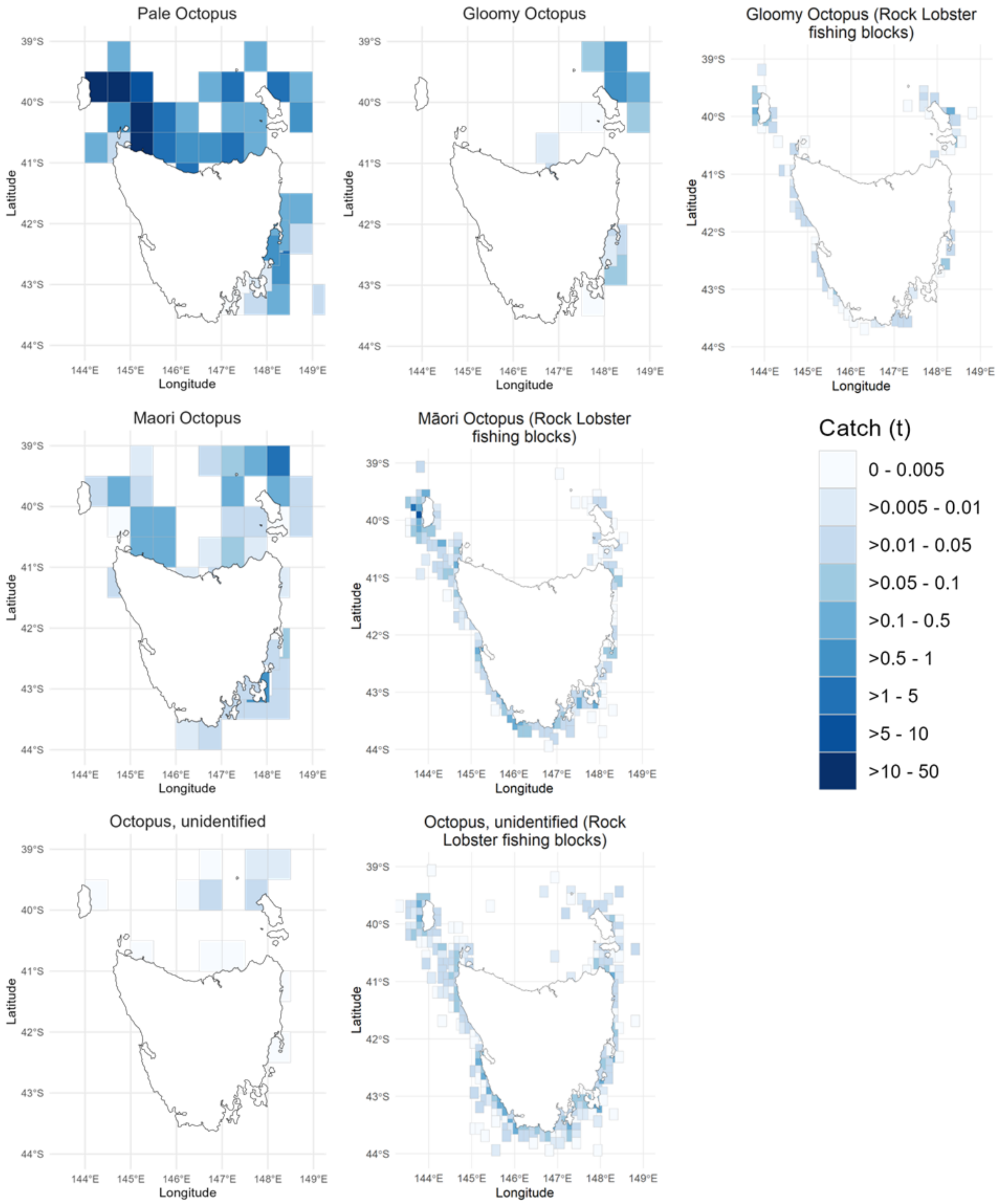

Figure 2.23 Distribution of catch per species by fishing block, averaged over the last five years (2017/18 to 2021/22). Rock Lobster fishing blocks are smaller than other fisheries, so data are presented separately. Octopus species were first distinguished in Rock Lobster fishery returns in 2021/22, however the accuracy of species identification is uncertain. Māori Octopus, Gloomy Octopus, and 'Octopus, unidentified' data from Rock Lobster returns have been presented separately by smaller fishing blocks; state-wide catch for Pale Octopus from the Rock Lobster fishery was negligible (< 1).

4. Stock status

Pale Octopus (*Octopus pallidus*) – Bass Strait Stock

STOCK STATUS	DEPLETING

In 2022/23, the total catch of Pale Octopus in the Tasmanian Octopus Fishery (TOF) although high (101 t), represents a significant decline from the record high of 154 t in 2020/21 despite a similar amount of effort. Effort across the fishery was recorded at 313,348 pot-lifts in 2022/23, a slight increase from the previous year but still concentrated in a small area. Standardised CPUE from logbook data and from the 50-pot sampling programme both showed a significant decrease from record high levels in 2020/21.

Combined with a decrease in CPUE across the whole fishery which could indicate stock depletion, regional analyses indicate a shift in effort and catch away from previously productive areas in the western Bass Strait to the east. The Stanley region in particular is now showing signs of being unable to sustain the current fishing pressure, showing a significant decrease in both catch rate and catch, in addition to a continuing downward trend in CMSY estimated biomass results. The ecology of Pale Octopus and the species' interaction with shelter pot gear means that the TOF is a high-risk fishery. Pale Octopus produce small numbers of large benthic larvae from active brooding, and females seek out pots as refuges in which to brood their eggs. Non-brooding adults also actively seek pots as refuges. Catch and CPUE are likely to be "hyper-stable" because of this behaviour, which means there is considerable risk that recruitment may be impaired and sudden declines in biomass might occur without a notable prior change in catches or CPUE. Coupled with evidence of potential depletion in the Stanley region and the recent concentration of effort in new fishing grounds in north eastern regions, the pale octopus stock might be at risk of depletion. Hence, Pale Octopus in the Bass Strait stock is classified as Depleting.

Pale Octopus (*Octopus pallidus*) – Tasmanian Shelf Stock

STOCK STATUS	SUSTAINABLE

Pale Octopus catch from the developmental fishery operating in state waters outside the TOF was 4.8 t in 2022/23. This stock has been minimally accessed by the commercial fishery. Developmental fishing permits have been issued since 2016/17 (excluding 2018/19); however, no catch was recorded prior to 2019/20 and, since then, both catch and effort have remained very low. In 2022/23, an additional 0.23 t of Pale Octopus was reported by the Rock Lobster fishery. Given the low levels of exploitation, the Pale Octopus stock in east, west, and southern Tasmanian waters is classified as Sustainable.

Gloomy Octopus (*Octopus tetricus*)

STOCK STATUS	SUSTAINABLE

Catch of Gloomy Octopus within the TOF and developmental fishery was 8.4 t in the 2022/23, a tenfold increase from the previous season of 815 kg. Gloomy octopus catch has otherwise remained close to zero since an outlier peak of 18.6 t in 2017/18. Gloomy Octopus catch reported from the Rock Lobster fishery was 2.2 t in 2022/23, however the accuracy of species identification in these data is uncertain. Gloomy Octopus catch from other fisheries was negligible. The reproductive biology of Gloomy Octopus suggests that this species may be more resilient to fishing pressure than Pale Octopus, but still under moderate risk of recruitment impairment. Gloomy Octopus catches in Tasmania appear to be driven by the distribution of effort in the TOF. Aside from apparent 2022/23 catches around the state from the Rock Lobster fishery, this species has been caught primarily in the eastern Bass Strait near Flinders Island. The 2022/23 season saw a return in effort to this region, hence the increased catch. In the previous five seasons, fishing effort within the TOF was concentrated almost exclusively in western Bass Strait and Gloomy Octopus catch had been negligible. It is unknown whether the biomass of Gloomy Octopus in Tasmanian waters is sufficient for a more substantial fishery. However, given the generally low exploitation of the stock, Gloomy Octopus in Tasmania is classified as Sustainable.

Māori Octopus (*Macroctopus maorum*)

STOCK STATUS	**SUSTAINABLE**

A total of 12.4 t of Māori Octopus was landed by Tasmanian commercial fishers in 2022/23. Assuming correct identification, these catches comprise 7.2 t landed by-product from the Rock Lobster fishery, 4.8 t landed by-product from the TOF and developmental Pale Octopus fisheries, 0.45 t landed by-product from the Scalefish fishery, and 0.39 t from the targeted Eaglehawk Bay octopus fishery.

Similarly to Gloomy Octopus, Māori Octopus is likely to be more resilient to fishing pressure than Pale Octopus, albeit under moderate risk of recruitment impairment according to its assessment score. Quantities of Māori Octopus killed and discarded by the Rock Lobster fishery are unknown, which challenges a reliable assessment of both catch and potential biomass depletion. When catch data and trip limits for octopus are compared with the total number of Rock Lobster trips per year, it appears that overall catch and, hence, discard mortality of Māori Octopus in this fishery might be low. Video observations suggest that the gear selectivity for Māori Octopus within the Rock Lobster fishery may also be low. Thus, the Tasmanian Māori Octopus stock is classified as Sustainable.

5. Environmental interactions within the TOF

By-product and by-catch

Aside from Māori and Gloomy Octopus, no by-product or bycatch species are taken with the TOF or the east coast developmental fishery for Pale Octopus, other than small invertebrates and fouling organisms that attach to the gear and are released back to the sea as the gear is redeployed.

Protected and threatened species interactions

The nature of the fishery and the gear used make interactions with protected and threatened species unlikely. Boats do not operate at night hence seabirds are not attracted to working lights. There are also no bait-discarding issues since the pots are unbaited. Furthermore, surface gear is minimal (two buoys and two ropes for each demersal line). Thus, the 2012/13 ERA considered that risks from octopus potting to protected and threatened species were negligible (Bell et al. 2016).

Entanglement of migrating whales in ropes of pot fisheries have been reported in Western Australia (WA Department of Fisheries 2010). While the Tasmanian Octopus Fishery operates in Bass Strait, part of which is in the migratory route of southern right whales (TAS Parks and Wildlife Service), no such interactions have been reported in Tasmania. Furthermore, the limited amount of surface gear, typically 40 buoys in the entire fishery at any one time is negligible in contrast to other pot fisheries. For example in the Tasmanian Rock Lobster Fishery a single operator may set up to 50 sets of pots and ropes and there are approximately 1.3 million pot-lifts set annually, or in the Western Australia Rock Lobster Fishery where there are approximately 2 million pot-lifts set annually (De Lestang et al. 2012; Hartmann et al. 2013).

Ecosystem and habitat interactions

The octopus pots currently used in the fishery are lightweight and set in a sandy bottom environment, which is the preferred substrate for Pale Octopus. The impact of commercial potting has been found to have little impact on benthic assemblages (Coleman et al. 2013) and the 2012/13 ERA considered that octopus potting was of low risk to both the ecosystem and habitat (Bell et al. 2016).

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7. Appendix

Table A1 Coefficients of the Generalised Linear Model (GLM) comparing the influence of licensing year, month, and spatial fishing block on standardised commercial CPUE within the TOF. Estimate refers to the difference in CPUE between a year/month/block and the intercept (the first year/month/block in the series). Significance codes: *** < 0.001 < ** < 0.01 < * < 0.05 < **.** < 0.01

	Estimate	Standard Error	t value	Pr(>|t|)	Significance
(Intercept)	-2.47136	0.36636	-6.746	1.60e-11	***
2001/2002	0.04693	0.16526	0.284	0.77645	
2002/2003	0.6574	0.19972	3.292	0.000999	***
2003/2004	0.63836	0.18132	3.521	0.000432	***
2004/2005	0.83392	0.13279	6.28	3.52E-10	***
2005/2006	1.01024	0.12397	8.149	4.07E-16	***
2006/2007	0.44847	0.12255	3.659	0.000254	***
2007/2008	0.7085	0.12179	5.817	6.14E-09	***
2008/2009	0.45927	0.12193	3.767	0.000166	***
2009/2010	0.74242	0.12169	6.101	1.09E-09	***
2010/2011	0.72236	0.12218	5.912	3.48E-09	***
2011/2012	0.16744	0.12183	1.374	0.169324	
2012/2013	0.48594	0.12115	4.011	6.08E-05	***
2013/2014	0.33479	0.12145	2.757	0.005851	**
2014/2015	0.47874	0.12164	3.936	8.35E-05	***
2015/2016	0.37768	0.12187	3.099	0.001946	**
2016/2017	0.47823	0.1216	3.933	8.45E-05	***
2017/2018	0.19424	0.12141	1.6	0.109653	
2018/2019	0.73517	0.12168	6.042	1.57E-09	***
2019/2020	0.49412	0.12216	4.045	5.27E-05	***
2020/2021	1.09427	0.12181	8.983	2.00E-16	***
2021/2022	0.91039	0.12204	7.46	9.31E-14	***
2022/2023	0.56336	0.12251	4.599	4.30E-06	***
April	0.22058	0.0217	10.166	2.00E-16	***
May	0.26212	0.02135	12.278	2.00E-16	***
June	0.25842	0.02201	11.738	2.00E-16	***
July	0.08814	0.02237	3.939	8.22E-05	***
August	-0.12076	0.02323	-5.199	2.04E-07	***

September	-0.15803	0.02333	-6.774	1.32E-11	***
October	-0.19949	0.02268	-8.796	2.00E-16	***
November	-0.19773	0.0229	-8.635	2.00E-16	***
December	-0.04932	0.02396	-2.058	0.039599	*
January	-0.20633	0.02208	-9.345	2.00E-16	***
February	-0.14303	0.02301	-6.217	5.26E-10	***
Block 3D3	0.52079	0.3468	1.502	0.133202	
Block 3D4	0.6868	0.34578	1.986	0.047031	*
Block 3E1	0.84706	0.59795	1.417	0.156626	
Block 3E3	0.6339	0.3464	1.83	0.06728	.
Block 3E4	0.78588	0.59812	1.314	0.188901	
Block 3F1	0.65086	0.59812	1.088	0.27654	
Block 3F2	-0.02977	0.40941	-0.073	0.942035	
Block 3F4	0.37893	0.37641	1.007	0.31411	
Block 3G1	0.14949	0.35723	0.418	0.675605	
Block 3G2	0.76076	0.35029	2.172	0.029893	*
Block 3G3	0.58619	0.34677	1.69	0.09098	.
Block 3G4	-1.03476	0.40934	-2.528	0.011489	*
Block 3H1	0.86099	0.34886	2.468	0.013602	*
Block 3H3	0.33148	0.3463	0.957	0.338489	
Block 3H4	0.26784	0.34952	0.766	0.443512	
Block 3I2	0.55909	0.59847	0.934	0.350225	
Block 4D1	-0.09743	0.44763	-0.218	0.827698	
Block 4D2	0.62735	0.37802	1.66	0.097027	.
Block 4D3	1.13426	0.42327	2.68	0.007378	**
Block 4D4	0.09027	0.36448	0.248	0.804407	
Block 4E1	0.49828	0.3459	1.441	0.149746	
Block 4E2	0.31302	0.34909	0.897	0.369912	
Block 4E3	0.18118	0.34602	0.524	0.600564	
Block 4E4	-0.10164	0.34703	-0.293	0.769611	
Block 4F1	0.33869	0.44605	0.759	0.44769	
Block 4F3	0.20795	0.36954	0.563	0.573635	
Block 4F4	0.0364	0.34937	0.104	0.917014	
Block 4G1	0.22242	0.3475	0.64	0.52214	

Block 4G2	0.66523	0.3463	1.921	0.054764	.
Block 4G3	0.12028	0.34678	0.347	0.728712	
Block 4G4	0.49188	0.34698	1.418	0.156338	
Block 4H1	0.14863	0.37599	0.395	0.692627	
Block 4H2	-0.2541	0.35842	-0.709	0.478386	
Block 4H3	-0.50841	0.37893	-1.342	0.179716	
Block 4H4	-1.38674	0.39225	-3.535	0.000409	***
Block 5F1	0.15587	0.34857	0.447	0.654771	