TASMANIAN LONGSPINED SEA URCHIN FISHERY ASSESSMENT

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Executive Summary

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- Fishing mortality in the *Centrostephanus rodgersii* fishery is represented by annual catch (tonnes) as a proxy. In the most recent 2022/23 season, the annual catch in Tasmania was 549 tonnes, making the total 2460 tonnes over the last 5 years of the fishery. The region with the highest catch was St Helens, consistent with previous years. Despite high catches in recent years, there is no evidence of depletion of urchins through fishing. The mean depth of the fishery has increased over time, suggesting depletion of stock in the shallower depths. Shift in effort to different regions has been influenced by changes to the catch subsidy program, so cannot be interpreted as evidence of stock depletion by fishing.
- Biomass in the *Centrostephanus rodgersii* fishery is indicated by two methods: extrapolation from counts obtained from fishery-independent transect surveys; and trends in catch per unit effort (CPUE). Biomass assessed by fishery-independent transect data has increased over the last two decades. State-wide CPUE has not decreased over the span of the fishery from the first 2008/2009 season to the most recent 2022/23 season even in the most heavily fished blocks.
- The fishery is assessed as sustainable because biomass appears to be above that which would affect recruitment and because fishing mortality is not likely to cause recruitment overfishing. There is evidence that recruitment in Tasmania is partially decoupled from Tasmanian biomass with some larvae originating from interstate.

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<tr><td>STOCK</td><td>Tasmanian Longspined Sea Urchin fishery</td></tr>
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C. rodgersii has been harvested commercially in Tasmania since 2009. The annual catch remained below 100 tonnes for the first 9 years of the fishery but has increased to 549 tonnes for the most recent 2022/23 season, totalling 2460 tonnes for the last 5 seasons combined. To date there is no evidence of a decrease in biomass when comparing catch rates over time, even in the most heavily fished blocks around St Helens in the northeast of the state. The link between catch rate and abundance is known to be unclear in dive fisheries due to hyperstability. This is because at high stock density the abundance of urchins is less limiting on catch rate than the logistics of diving operations. Any possible declines in catch rate may be further masked by serial depletion with divers shifting to new areas.

A recent survey of the commercial divers has suggested that in some areas divers have been forced into deeper waters by using Nitrox to sustain high catch rates (Cresswell et al. 2019). This is supported by the fishery data; the mean depth of the fishery has increased over time, suggesting depletion of stock in the shallower depths. Fisheries-independent surveys are underway and will provide stock information unaffected by catch rate biases.

One major change in the 2022/23 season is that reporting blocks for commercial dive catch have changed from the previous commercial dive fishing blocks to the same format as the abalone fishery. Previous years of catch have been translated into the new block format and will reported this way going forward.

When examining estimates of total biomass increase per year, compared to catch removed each year, the total catch removed exceeds the estimated biomass increase since the 2017/18 season (Table 1).

Table 1. Biomass estimated from scientific survey in 2001/02, 2016/17 and 2020/21 in bold, with average biomass increase (assuming a linear relationship between each survey) and removals from harvesting, culling and the 'take all' harvest. Average linear biomass increase from the 2001/02 season to the 2016/17 season is 139 tonnes per year, and from 2016/17 to 2020/21 is 435 tonnes per year (growth in estimated biomass plus total removals divided by number of years between surveys). We calculated biomass using the densities recorded to 18m depth in the scientific surveys then multiplying by the reef area recorded to 26m.

Year	Estimated biomass 6 to 26m depth (tonnes)	Average annual linear biomass increase between surveys (tonnes)	Removals from harvesting (tonnes)	Removals from culling (tonnes)	Removals from "take-all" harvest (tonnes)
2001/02	**4147**	139			
2002/03		139			
2003/04		139			
2004/05		139			
2005/06		139			
2006/07		139			
2007/08		139			
2008/09		139	7		
2009/10		139	12		
2010/11		139	64		
2011/12		139	61		
2012/13		139	81		
2013/14		139	97		
2014/15		139	19		
2015/16		139	40		
2016/17	**5856**	435	41		
2017/18		435	185		
2018/19		435	560		
2019/20		435	327	14.8	34.9
2020/21	**6435**		493.6		3.4
2021/22			493.9		
2022/23			548.9		

Stock status definitions

We have adopted the most recent guidelines for national stock status categories, as specified by the Fisheries Research and Development Corporation.

	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.
	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.
	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.
	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.
	Negligible	Catches are so low as to be considered negligible and inadequate information exists to determine stock status.	Assessment will not be conducted unless catches and information increase.

Acknowledgements

IMAS wish to acknowledge funding from the Tasmanian Government (NRE), access to urchins and other support in data collection by True South Seafood and many divers involved in the fishery.

Introduction

Overview

Centrostephanus rodgersii (the Longspined Sea Urchin or Centro) is not native to Tasmania historically, nor is it considered an introduced marine pest. Rather, this species has recently undergone a range extension to Tasmania from NSW due to extensions in the warm East Australia Current brought about by climate change (Johnson et al. 2005, Ridgway 2007, Ling 2008). Increased populations of Longspined Sea Urchins are of concern because they can damage kelp forests through overgrazing (Ling et al. 2009a, Johnson et al. 2011, Marzloff et al. 2016). Once established on a reef, increases in urchin density and subsequent grazing pressure of this species leads to discrete patches of bare rock termed 'incipient' barrens (Johnson et al. 2005). If urchin density continues to increase in incipient barrens, the grazed patches grow and join together into larger patches, leading to the formation of 'extensive' urchin barrens (Flukes et al. 2012), a habitat largely devoid of macroalgae (Lawrence 1975, Chapman 1981, Andrew and Underwood 1989). This fundamental change in the ecosystem has a substantial impact on a broad range of species and reduces the utility for human activities including diving, and recreational and commercial fishing of many species.

A commercial fishery for Longspined Sea Urchins began in 2009 in response to their increased biomass and densities in Tasmania. The total annual catch was low for the first 10 years of the fishery but has increased fivefold over the last 5 years. The Tasmanian commercial fishery now exports nationally and internationally. Catch can only be taken by holders of a commercial dive license. There are no recreational regulations. In the 2022/23 season beginning September 1st 2022, there were 30 divers involved in the fishery, with 18 of those harvesting 10 tonnes or more. Most fishing effort occurs from December/January to June when roe quality is suitable for harvest, before spawning occurs.

Fishery-independent biomass data

The abundance of *Centrostephanus rodgersii* and the extent of its impact on kelp beds in eastern Tasmanian has been surveyed by divers and underwater towed-video in 2001/02, 2016/17, and 2020/21. A total of 13 regions have been surveyed along the east coast of Tasmania, containing four transects within three subsites for each of the larger regions (Ling and Keane 2018). The fishery and most of the biomass is contained within regions 1-9, with minimal abundances (near zero or zero observed) south of region 9. The biomass of urchins from 4 to 26m depth for regions 1-9 was estimated to be ~4150 tonnes in 2001/02 and had increased to ~5860 tonnes for the 2016/17 survey (Ling and Keane 2018) and 6440 tonnes in the most recent 2021/22 survey (using methodology consistent to previous surveys – extrapolation of data from 4-18m to 26m depth; John Keane personal communication), however some regions showed a greater increase than others.

Species biology

The Longspined Sea Urchin is a large, fast growing Diadematidae that inhabits temperate reefs at varying depths up to 60m around southeast Australia, Norfolk and Lord Howe Islands, the Kermadec Islands and northern New Zealand (Schiel et al. 1986, Andrew 1993, Andrew and Byrne 2007, Pecorino et al. 2012, Perkins et al. 2015, Thomas et al. 2021). In Australia, evidence suggests that the species arrived to the east coast of Tasmania via larval transport from spawning communities in coastal NSW and Victoria; it was first recorded in the northeast coast of Tasmania in 1978 (Edgar and Barrett 1997, Johnson et al. 2005, Ling 2008). The species matures sexually at around 4 to 5 years old at a test diameter (TD) of 40-60mm (Table 2), approaching a maximum TD of ~120mm (Ebert 1982) at ~25 to 35 years of age, after which, growth slows considerably (Ling et al. 2009a). The skeleton of a sea urchin is known as the "test". The diameter of the test is measured using callipers placed between the spines to measure the diameter of the skeleton without the spines.

Table 2. Biological parameters for Longspined Sea Urchins.

Parameter	Meaning	Value
Test diameter at maturity	Size at which 50% of population becomes mature	40 to 60 mm (King et al. 1994) (NSW) 60 to 70 mm (Andrew and Byrne 2007) (NSW)
Maximum test diameter	The asymptotic length at which growth in zero	>110 mm (Andrew and Byrne 2007) (NSW) 120 mm (Ebert 1982) (NSW) 126 mm (Pecorino et al. 2012) (New Zealand) 133 mm (Ling et al. 2009b) (TAS)
Lifespan	Time to reach 95% maximum test diameter	20 years (Andrew and Byrne 2007) (NSW) 15 to 20 years (Pecorino et al. 2012) (New Zealand) 25 to 30 years (Ling et al. 2009b) (TAS)
Weight	Weight calculated from test diameter (TD)	Weight (g) = 0.0032*$TD^{2.566}$ (live weight) Weight (g) = 0.0035*$TD^{2.5257}$ (factory weight) *data collected in May 2020 from Complete Harvest project, John Keane unpublished data)

Sea urchin gonads or "roe" have been consumed by some cultures for millennia and are now highly appreciated worldwide as a gourmet product, comparable to caviar (Andrew et al. 2002, Sun and Chiang 2015, Lourenco et al. 2019). The profitability of a sea urchin fishery relies heavily on the marketable condition of its roe, which can vary greatly between individuals depending on many factors (Blount and Worthington 2002, Blount et al. 2017, Campus 2022). Gonad yield (as a percentage of body weight) and quality (judged by texture, colour, granularity and many other factors) are both affected by food availability, diet, season and individual movement, not just size and age (Lawrence et al. 1997, Lawrence et al. 2001, Andrew and Byrne 2007, Phillips et al. 2009, Phillips et al. 2010). Roe quality varies seasonally, with energy intake increasingly proportioned towards gonad development resulting in higher roe quality in the lead up to spawning, which for this species occurs around August (Ling et al. 2008). During and immediately following spawning, the roe/gonads are at low quality for the fishery, so the bulk of harvesting in Tasmania occurs between December and June (see below). The native Tasmanian Shortspined Sea Urchin *Heliocidaris erythrogramma* has a complementary spawning season to the Longspined, meaning factories can continue processing sea urchins in Tasmania all year around.

Sea urchin populations, like other low-mobility resources, are spatially structured with aggregations occurring primarily because of habitat structure and food availability, making them highly patchy as a resource (Ouréns et al. 2015, Gutierrez et al. 2017). Longspined Sea Urchins have low mobility, homing strongly to available crevices, but do not show directional movement towards food sources (Flukes et al. 2012) unlike other sea urchins, where directional movement towards available food results in mobile grazing fronts (Lauzon-Guay et al. 2006). Tracey et al. (2015) demonstrated this lack of directional movement in a culling experiment conducted in 2012 in Wineglass Bay Tasmania, showing that when plots were surveyed a year after targeted culling efforts, *C. rodgersii* densities had not increased. Because of this patchiness in stock, assessment methods should avoid the assumption of uniform distribution, and keep in mind that fishers will be concentrating their efforts in the higher density patches (Hernández-Flores et al. 2018, Casal et al. 2020).

Species ecological role

Longspined Sea Urchins have a pelagic larval stage of ~100 days (Huggett et al. 2005) meaning this species can travel long distances in ocean currents under the right conditions for their temperature limits (Ling et al. 2009b). Larvae have likely travelled to Tasmania through the poleward advance of the warm East Australia Current, which has extended further south with greater frequency over the past 60 years due to climate change (Ridgway 2007, Banks et al. 2010). Longspined Sea Urchin was first reported on the east coast of Tasmania in 1978 (Edgar and Barrett 1997) but now extends down most of the east coast (Johnson et al. 2005, Ling and Keane 2018). The first major fisheries-independent survey conducted in 2001/02 established a baseline estimate of the biomass of this species in Tasmania at 6.7 million individuals (Johnson et al. 2005). A repeat survey conducted 15 years later estimated the population to have grown to almost 20 million individuals (Ling and Keane 2018).

The Institute for Marine and Antarctic Studies (IMAS) have been researching Longspined Sea Urchins and their associated barrens since the late 1990s. Above threshold densities of ~700g/m^2 the species can have devastating impacts on reefs due to overgrazing which can lead to the formation of extensive urchin barrens (Ling et al. 2015). The barren state is problematic because urchins can exist in a starvation state on an extensive barren for decades (Filbee-Dexter and Scheibling 2014). To convert extensive barren back to forest nearly all Longspined urchins need to be removed to an urchin density below 70g/m^2, or around one 350g urchin per 5m^2 (Ling et al. 2009a, Filbee-Dexter and Scheibling 2017). Removal experiments, such as those conducted by Tracey et al. (2015) in Wineglass Bay, Tasmania, show that after targeted and systematic removals, kelp forest regrows. The regrowth of kelp after a reduction in urchin density below a given threshold is a pattern that has been demonstrated repeatedly elsewhere in Australia and around the world (Keats et al. 1990, Leinaas and Christie 1996, Ling et al. 2015, Tracey et al. 2015, Kriegisch et al. 2016, Sanderson et al. 2016).

Urchin density control

In Tasmania, there has been research into various strategies for reducing urchin densities to prevent or reverse barren formation, one of which is to increase numbers of their predators. Worldwide, there are numerous examples of where overfishing the apex predator has led to a loss of kelp forests through the creation of urchin barrens (Steneck et al. 2002) and also the reverse effect where reduced harvest rates on urchin predators have resulted in the reestablishment of kelp forests, such as rebuilding sea otter populations in Alaska (Estes and Palmisano 1974) and rock lobster populations in South Africa (Mayfield and Branch 2000).

Southern Rock Lobster, *Jasus edwardsii*, is the key predator for the native sea urchin *Heliocidaris erythrogramma* in Tasmania (Pederson and Johnson 2006). Southern Rock Lobster has also been shown to predate the Longspined Sea Urchin and is the only known predator of large emergent urchins in Tasmania (Ling et al. 2009a). As a result of prolonged intense fishing pressure, the Southern Rock Lobster biomass off eastern Tasmanian had dropped to extremely low levels prompting the development of the East Coast Rock Lobster Stock Rebuilding Strategy in 2013. Catches have been maintained at below half the recent peak in the mid 2000s, which has led to ongoing stock rebuilding. The interactions between seaweed, Longspined Sea Urchin and Southern Rock Lobster in Tasmania have been examined in detail by a simulation model of Tasmania reef communities, called TRITON (Marzloff et al.

2013, Johnson et al. 2014). One of the main findings of the model was that the initial prevention of urchin barren formation through increased predator numbers would be more effective than reversal through the same strategy, and that reduced catch of lobster on incipient barrens could mitigate the formation of extensive barrens in these areas within a 20 year time frame (Johnson et al. 2014). Recent work found that the rebuilding of lobster populations (in sites not targeted by the urchin fishery) could prevent the formation of urchin barrens, especially in areas of incipient barren rather than extensive barren (Ling and Keane 2021), agreeing with previous studies that lobsters would be more effective at aiding the prevention of urchin barrens rather than as a cure. However, recent work shows that the Longspined Sea Urchin is not the preferred prey of Southern Rock Lobster in Tasmania, preferring abalone, native Shortspined Sea Urchin and periwinkle by an order of magnitude, and implying that potential control of Longspined Sea Urchins by rock lobsters could be limited in the presence of other prey species (Smith et al. 2022).

Other strategies have been explored in Tasmania to reduce urchin densities to prevent or reverse urchin barren formation. Culling is an alternative removal method to harvesting in diveable depths. When harvesting, divers remove urchins generally >85mm test diameter leaving smaller urchins and are limited to finding urchins with roe quality that is acceptable to the processor. This means urchin harvesting takes place outside of the spawning season, with most harvesting taking place between approximately December and June. In comparison, divers that are culling can kill urchins down to around 50mm test diameter at any time of year by smashing them with a spike or similar instrument. When culling, divers are not limited to choosing urchins of high roe quality or transporting urchins to the boat and truck. On extensive barrens in Victoria, the rate of culling is reported to be close to 3x faster than harvesting (John Minehan, *pers. comm.*). However, culling is labour-intensive and can be highly costly compared to subsidised harvesting depending on subsidy rate for that region, the price per hour paid for culling, and the density of urchins on the reef (Tracey et al. 2015, Cresswell et al. 2019). Culling by commercial divers has been funded in small areas on the Tasman Peninsula, and there has been occasional volunteer culling by abalone and recreational divers as well as a scientific culling experiment in Wineglass Bay (Tracey et al. 2015).

In other parts of the world, problems of high urchin densities and associated extensive urchin barrens have been dealt with by use of quicklime (Leighton et al. 1966). Quicklime, which is made by heating limestone and is used in cement, has been used to control starfish in oyster bed and sea urchins in commercially harvested kelp beds (Bernstein and Welsford 1982). It releases heat when combined with water and kills echinoderms by causing epidermal lesions that permit bacteria to enter (Bernstein and Welsford 1982). Kill rates greater than 96% can be achieved with an apparatus that mixes quicklime with sea water at the surface and then pumps the slurry through a hose to the bottom. In some cases, greater precision is achieved by a diver who directs the flow onto sea urchins (Bernstein and Welsford 1982). In Tasmania, recent trials of quickliming showed mortality in *C. rodgersii* at rates as high as 100%, but was also shown to induce mortality in Blacklip Abalone at concerning rates (Keane 2021). For this reason, it may only be suited for application to extensive barrens with negligible abundances of abalone. There are difficult technical challenges and associated costs in transporting sufficient dosages of quicklime at depth, with the cost of using quicklime in shallow waters equivalent of what is already being spent on a subsidised fishery (Keane 2021).

The Commercial Fishery

Catch and effort

In Tasmania, Longspined Sea Urchins are harvested by commercial divers, about half of whom also dive commercially for abalone. Commercial urchin divers in Tasmania tend to target individual Longspined Sea Urchins of a size range of >85 tmm test diameter (see below). Catch weight is confirmed by a log recording from the processor who receives the catch. The location of the catch is recorded using the blocks of the commercial fishery (shown in Figure 3). However, for the current season reporting will shift to blocks based on the abalone fishery. Depth is estimated by a single depth recorded on the docket. A finer-scale approximate location, such as name of the point or bay, is recorded in the log by the diver, along with diver ID, date, and total time of dive/s (effort in hours). For the 2022/23 season GPS and depth logger units have been used by most divers, which will provide more accurate data both spatially and temporally. Divers are paid either by total wet weight of catch ($/kg; most common) or by weight and quality of roe from the processor.

Commercial harvesting began in March 2009. The total annual harvest began at less than 10 tonnes a year and gradually increased to 96 tonnes in 2013/14, followed by a decline in 2015 following the closure of the main processor (Figure 1). The catch in the most recent 2022/23 season was 549 tonnes. In total the commercial harvest has removed more than 3000 tonnes of Longspined urchins over the last 15 years, with 2460 tonnes of that in the last 5 years.

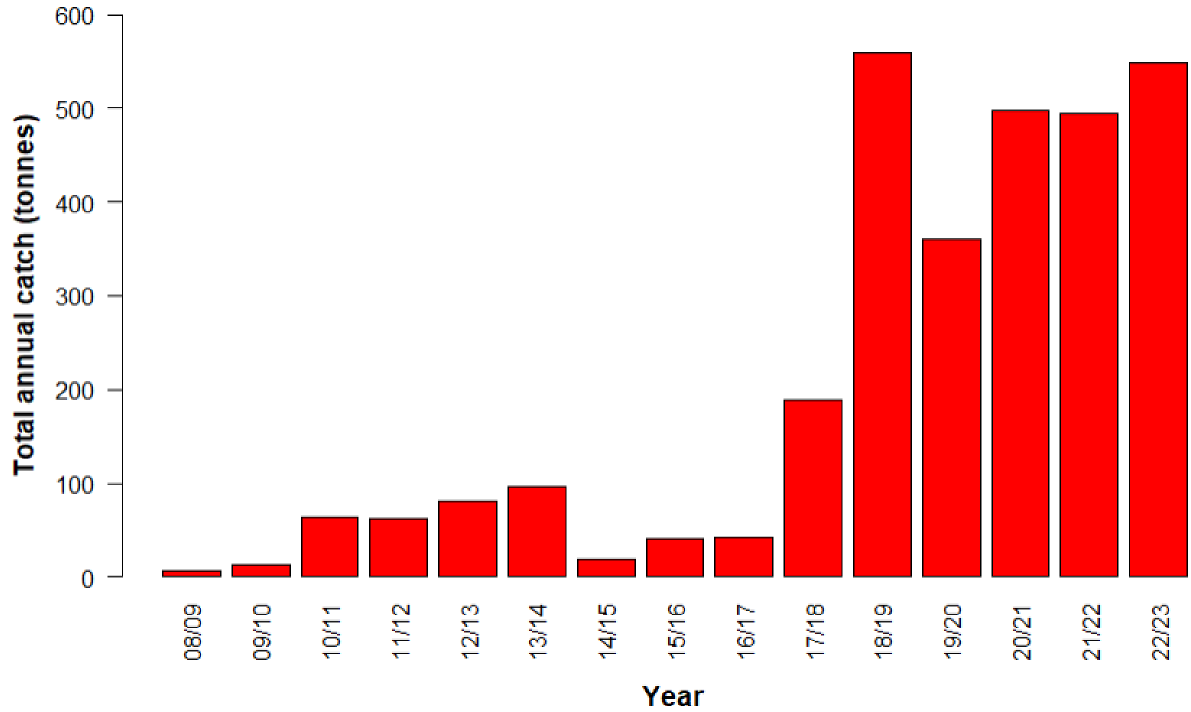

Figure 1. Annual catch of Longspined Sea Urchins. Fishing season runs from September 1st through to August 31st the following year.

Monthly effort for the fishery is focussed between January and June (Figure 2), which precedes the late winter spawning around August (Ling et al. 2008).

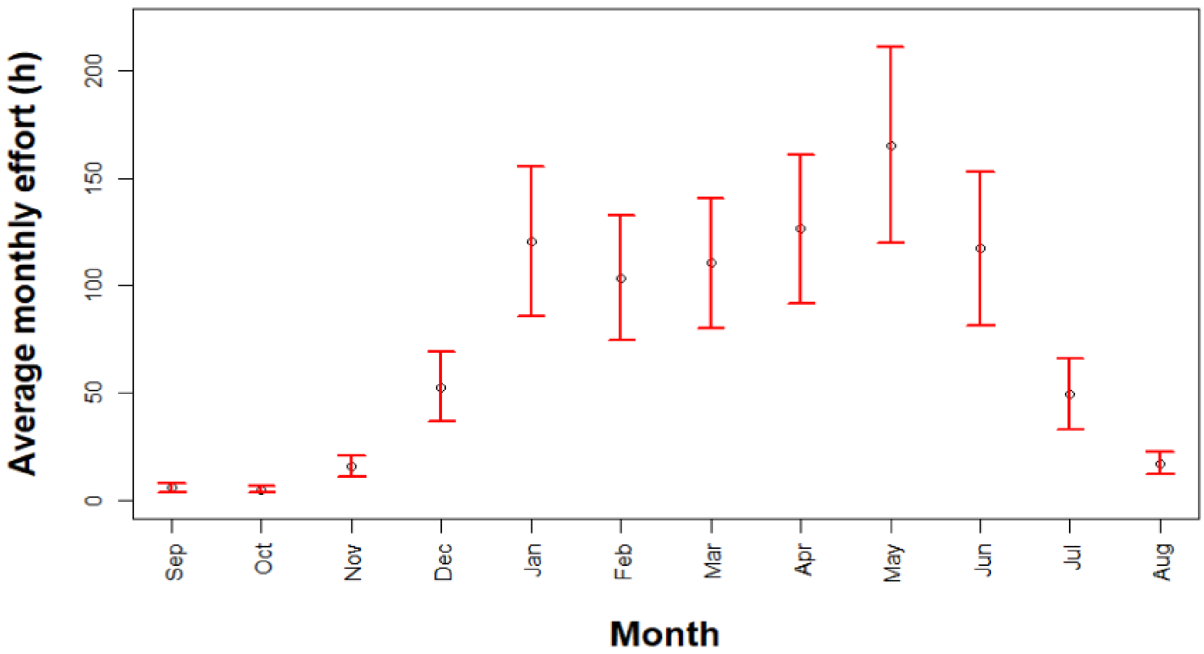

Figure 2. Monthly effort (hr) averaged by year since the beginning of the fishery 2008/09 to the current season 2022/23, error bars represent standard error.

Spatial distribution of the catch

The fishery-independent transect survey of the east coast involved segmenting the coast into thirteen regions, numbering 1 to 13 from north to south (Johnson et al. 2005, Ling and Keane 2018). For this assessment we show the catch in relation to regions 1 to 9 from the survey (Figure 3), because surveyed abundance of Longspined Sea Urchins in regions 10 to 13 was negligible for both transect surveys. A subsidy began in late 2016 and has changed in structure many times, see previous report, with the most recent structure for 2022/23 shown below, where blocks 22B in the south up to 27E were subsidised at \$0.75/kg from December 1st 2022 to June 2023, with additional blocks 21A, 22A and 21C subsidised at \$2.50/kg from May 2nd 2023 to June 2023 (Figure 3).

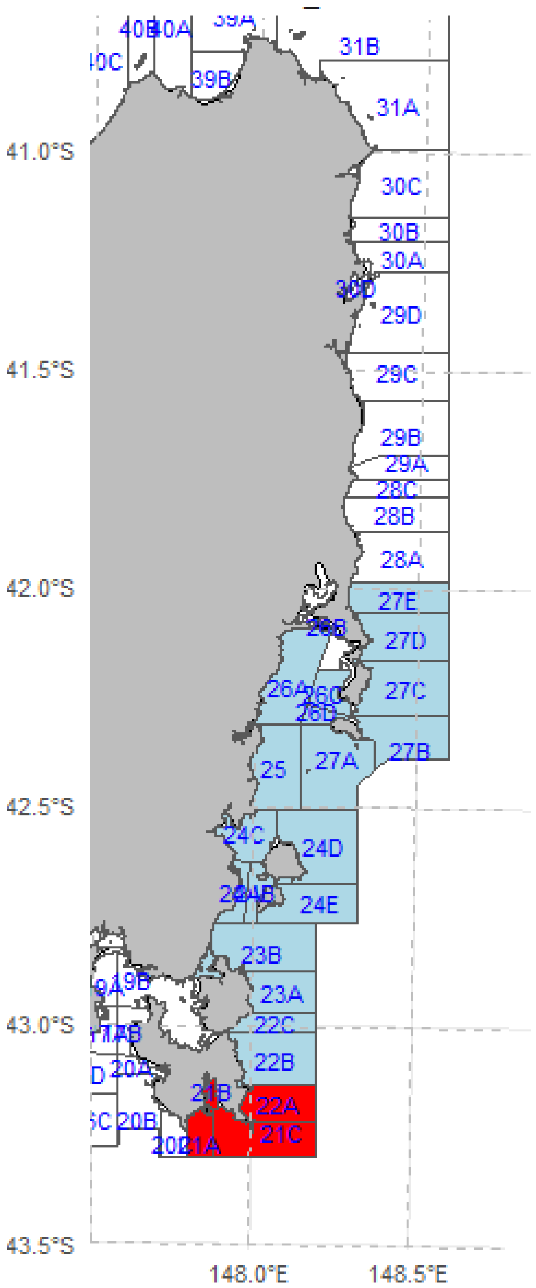

Figure 3. Map of subsidised area from December 1st 2022 to June 30th 2023, with the blue highlighted blocks showing area subsidised at $0.75/kg. Red highlighted blocks were where a subsidy began from 2nd May 2023 to June 30th 2023 at $2.50/kg labelled with the new fishing blocks used in the fishery, the same as the abalone fishery sub blocks.

The spatial composition of the catch has changed with the addition and alterations to the subsidy, which began in the 2017/18 season. Prior to a subsidy, nearly all the catch came from region 2, the St Helens region. A higher proportion of catch has been taken from further south since the subsidy began and was restructured for this purpose (Figure 4). Despite the proportion of catch from region 2 decreasing since the start of the subsidy, the tonnage from this region has not decreased over time, averaging 228 tonnes over the last 5 years of the fishery.

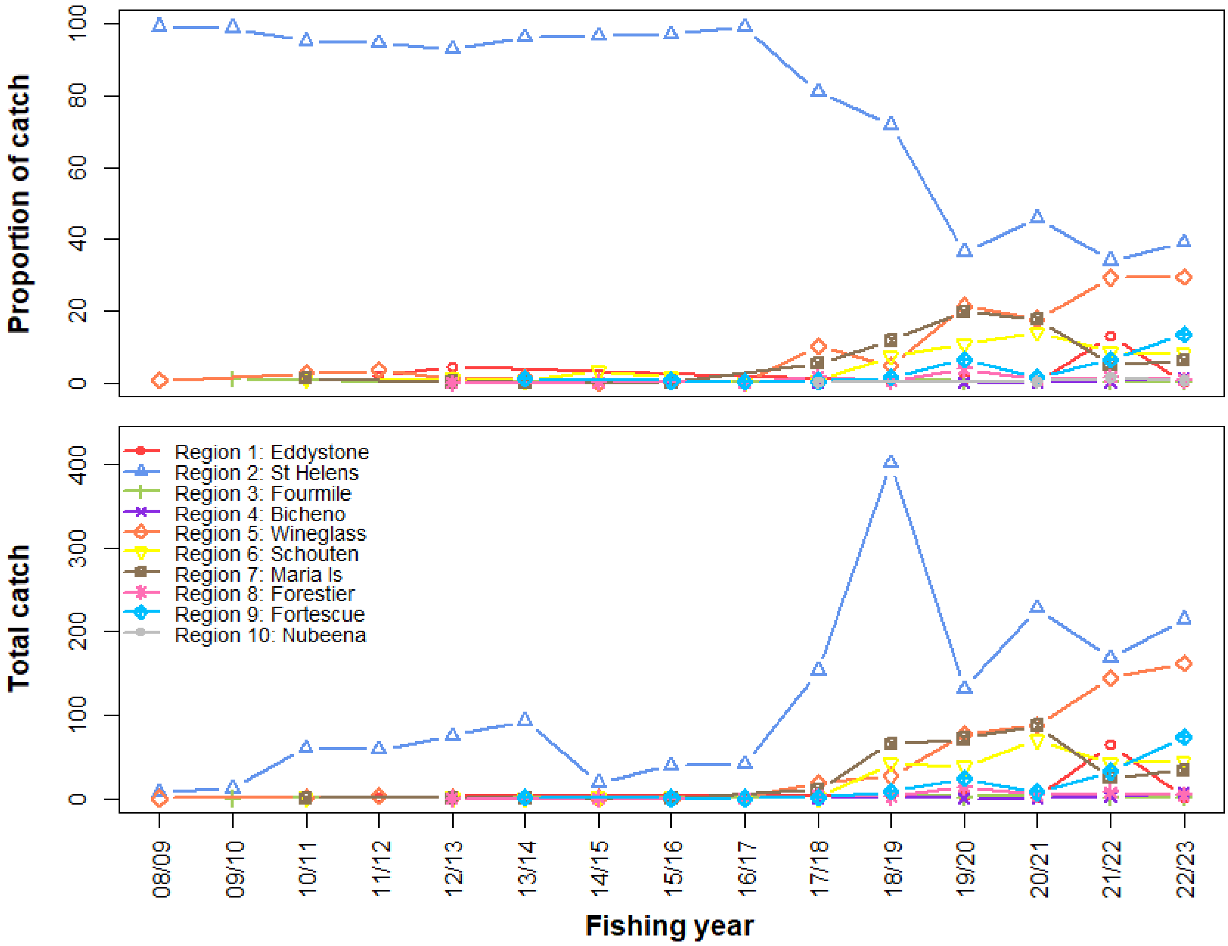

Figure 4. Spatial distribution of the annual catch shown by A) proportion of total catch in each region and B) total tonnage for each region.

There was a higher catch in the 2022/23 season in blocks 27D (Freycinet region) and 22A (Fortescue region) compared to previous years (Figure 5).

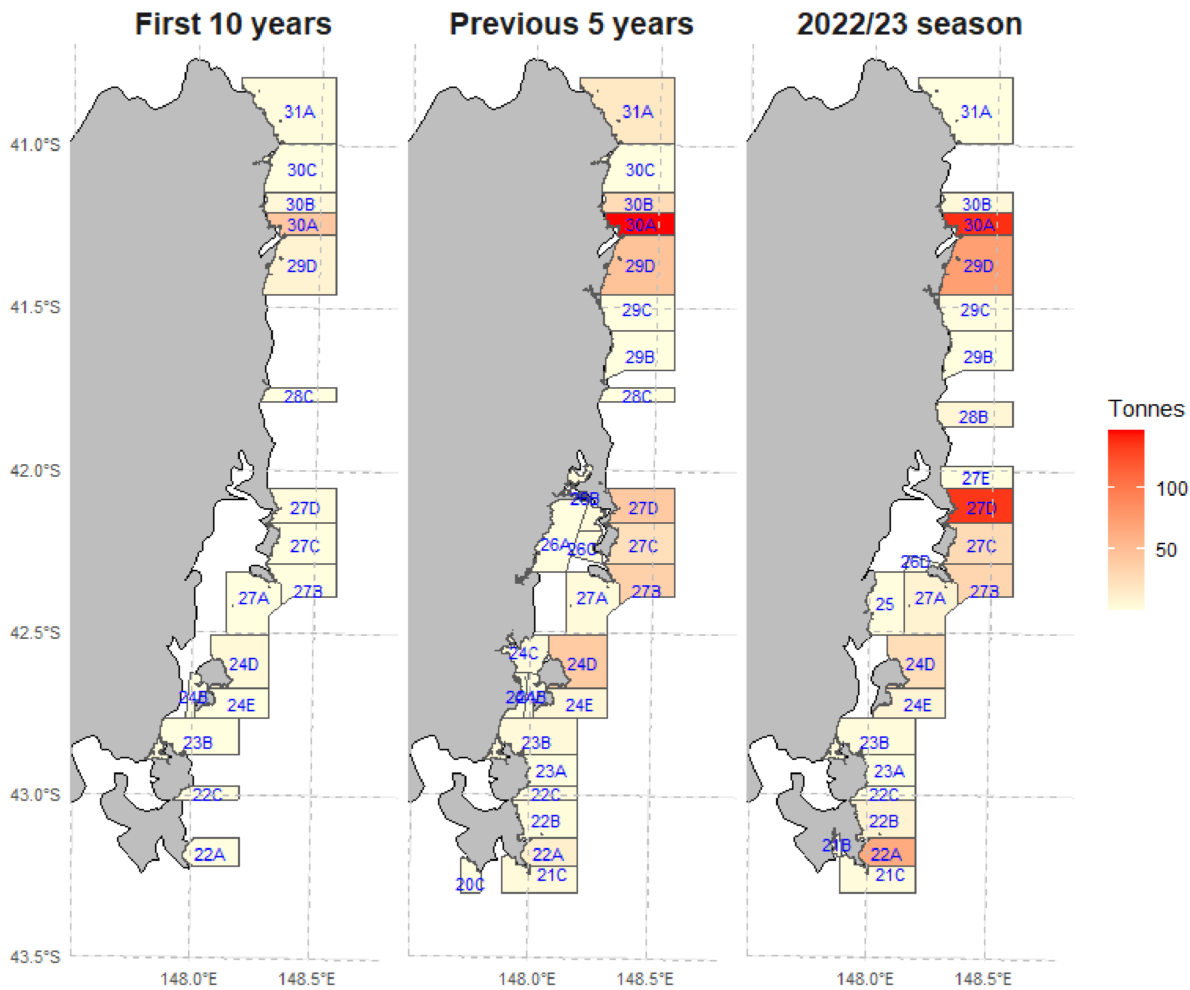

Figure 5. Total catch summed over each commercial fishery block averaged for the first 10 seasons of the fishery 2008/09 to 2017/18 (left), the previous 5 years of the fishery 2017/18 to 2021/22 (centre) and the most recent 2022/23 season (right). Tonnes per block > 1 tonnes are shown. Block names are shown where catch was recorded (> 1 tonne).

The spread of catch over time through incentivising the southern blocks can be seen more clearly when comparing proportion of total catch per block (Figure 6). Here, it is clear that a lower proportion of the catch was removed from the St Helens area (30A) than in earlier seasons of the fishery, with the higher catches in 27D and 22A as seen in the previous figure also standing out in terms of their proportion.

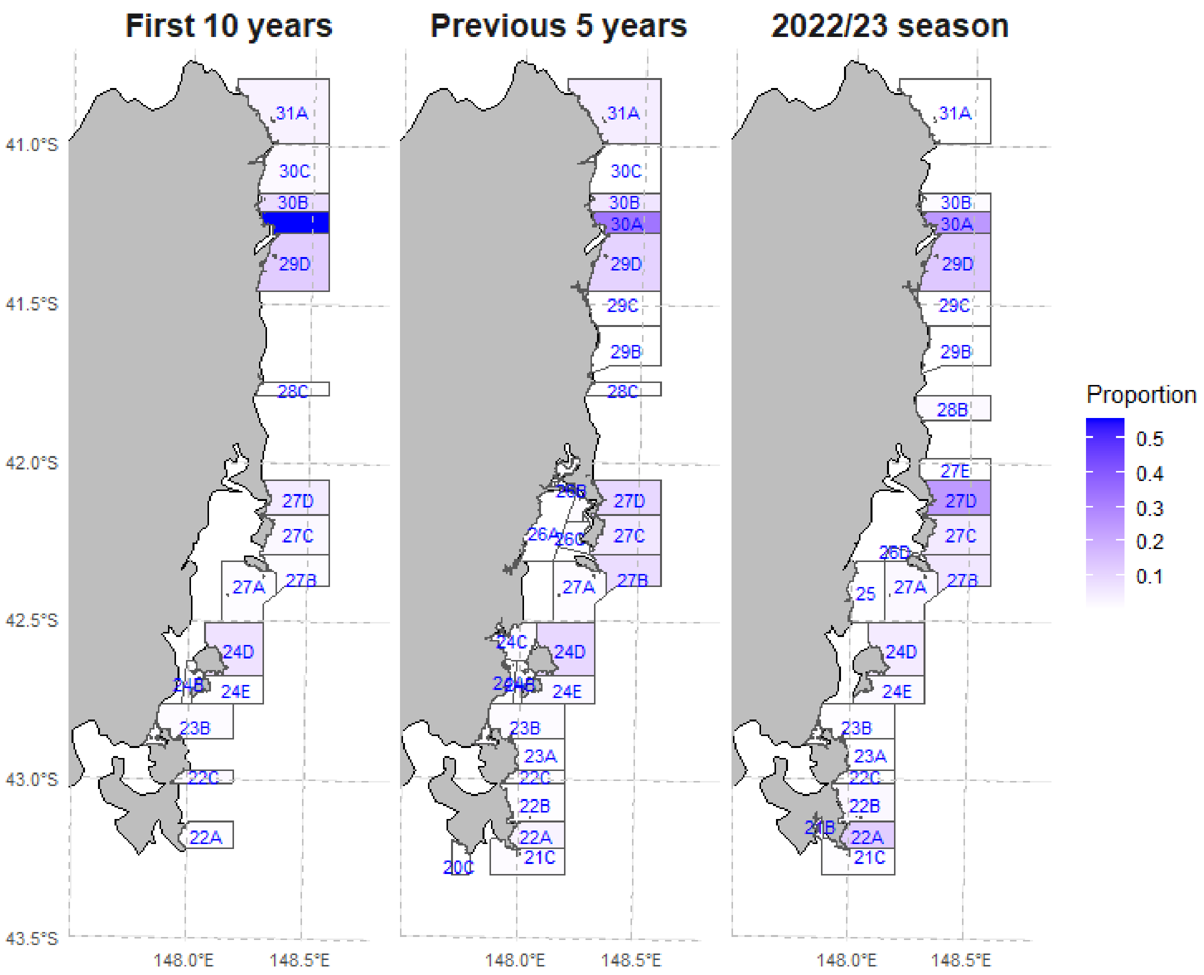

Figure 6. Total catch summed over each commercial fishery block averaged for the first 10 seasons of the fishery 2008/09 to 2017/18 (left), the previous 5 years of the fishery 2017/18 to 2021/22 (centre) and the most recent 2022/23 season (right). Tonnes per block > 1 tonnes are shown. Block names are shown where catch was recorded (> 1 tonne).

Length and weight of the catch

A selection of the catch, measuring the weight and test diameter (i.e. size or length) of individual urchins, has been sampled for a part of each season since early 2020. The measurements were taken at True South Seafood processing facility, with the aim to measure at least 250 to 300 urchins from a minimum of 3 different divers for each factory visit. Most urchins measured were within 80 to 125mm, with a mean diameter of 102.4mm in 2021/22 that decreased to 93.5 in 2022/23. A length frequency histogram of the recorded urchin test diameters indicates that smaller size classes of urchins were caught proportionally more in the 2022/23 season compared to the previous 2021/22 season (Figure 7).

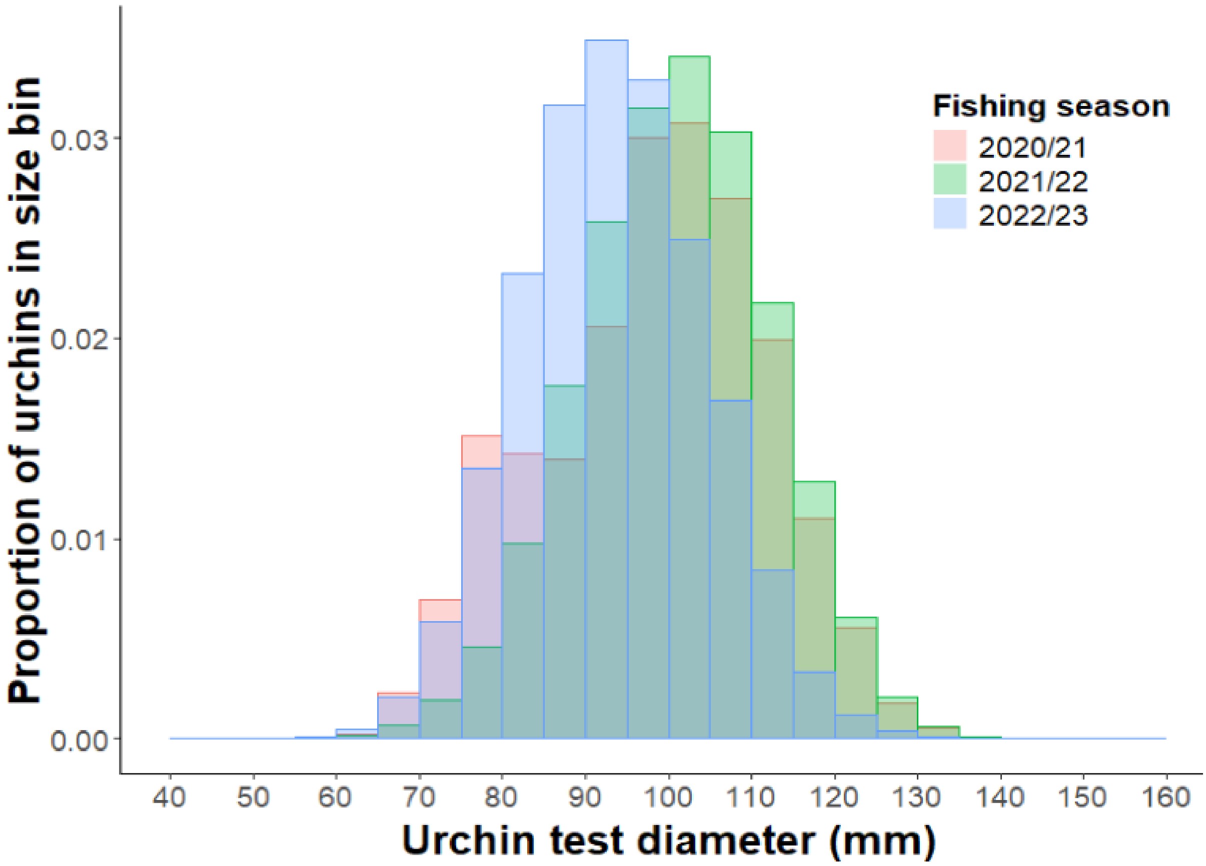

Figure 7. Proportion of urchins in different size categories (test diameter is the diameter of the shell without spines) in the catch for all factory data combined over each of the 2020/21, 2021/22 and 2022/23 seasons, with size bins of 5mm.

In the Wineglass and Maria Island regions, the size of the urchins caught by the fishery has noticeably decreased in 2022/23 compared to the previous seasons, with a less pronounced decrease in size in the Wineglass Bay region (Figure 8). Sizes also decreased in St Helens in 2022/23 compared to 2021/22. Changes in the size frequency of the catch are not noticeable for the Schouten region.

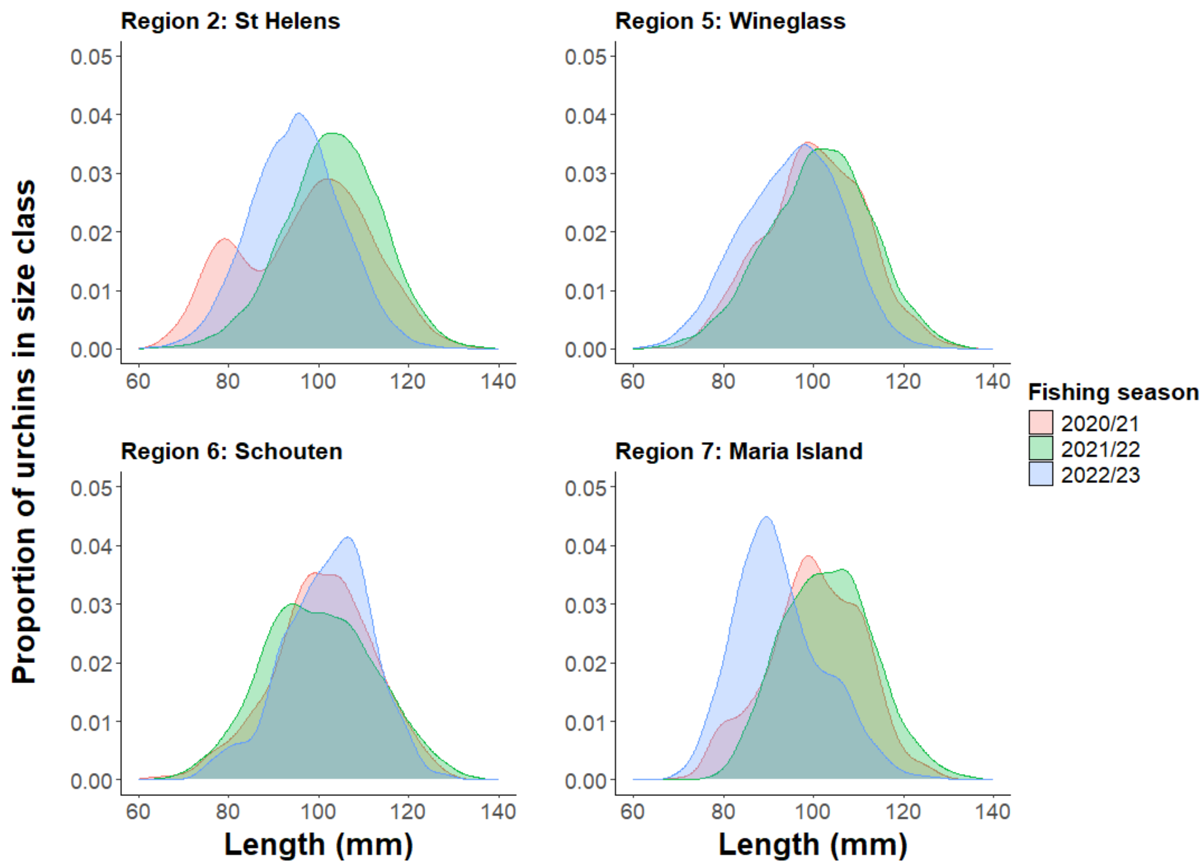

Figure 8. Length frequency of the catch from the four most heavily fished regions .In the St Helens region a total of n=6229 (2020/21), n =7684 (2021/22) & n =16061 (2022/23) urchins were measured, in Wineglass n=1141 (2020/21), n=8038 (2021/22) & n =9715 (2022/23), in Schouten n=820 (2020/21), n=2903 (2021/22) & n =301 (2022/23) and for Maria Island n=1579 (2020/21), n=257 (2021/22) & n =563 (2022/23).

Depth of catch

In the logbook data, divers record the estimated depth of their harvest dive. The annual mean depth of fishing has increased since the 2014/15 season until the 2018/19 season, then the standardised depth has remained fairly constant since (Figure 9). We standardised depth for the effects of individual diver ID, latitudinal region and time of year (month). The mean depth of fishing has increased since the beginning of the fishery, suggesting that divers have been harvesting in deeper depths to maintain catch rates. Longspined Sea Urchin aggregations are found deeper in Tasmania (16-58m) than NSW (7-27m) (Perkins et al. 2015, Ling and Keane 2018).

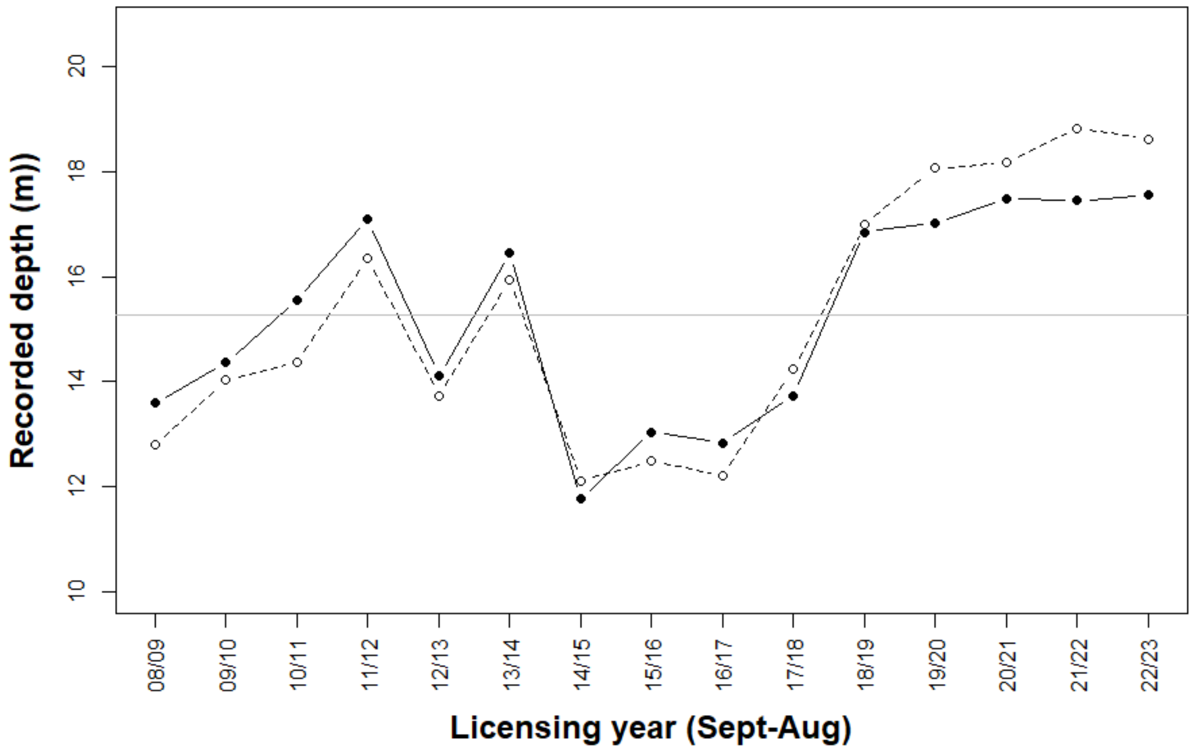

Figure 9. Standardised annual mean depth of the catch (black points and solid line) with the annual geometric mean depth (dashed line) as reported by the diver, with error bars showing standard deviation. Error bars show the log normally distributed 95% confidence intervals for the standardised model. Horizontal grey line is the geometric mean of all the reported depths across all years.

Catch rate

Catch rate or catch-per-unit-effort (CPUE in kg/hr) is calculated per dive day by the total wet weight of harvest (in kg, measured at the boat ramp) divided by the dive time (hr). CPUE can give an indication of relative biomass over time. However, with a highly aggregated species such as sea urchins, CPUE throughout the range of the fishery may remain stable as the stock is depleting. This is especially the case for developing fisheries that target spatially structured stocks, because fishers may continue to move to new areas and/or depths while maintaining a high CPUE but sequentially depleting reefs over time and space. Longspined Sea Urchins are patchy because of low movement rates and homing to crevices (Flukes et al. 2012), so density is highly dependent on substrate. In addition, the fishery data is currently recorded at a very coarse spatial scale, with commercial fishing blocks at the scale of 11.1 km by 11.1 km. An area of this size may contain many reefs. Due to the coarse spatial scale, divers may be undertaking a rotational or sequential harvest of different reefs within the one block without affecting CPUE data. The results here should be considered in the context of these limitations.

Data was filtered to exclude dives with the top and bottom 5% of catch rates. We then standardised the catch rate by the effects of individual diver ID, latitudinal region, depth category and time of year (month) (Figure 10). The regions are identified above (Figure 3). When examined together there is no discernible trend in CPUE for the entire east coast of Tasmania over the course of the fishery.

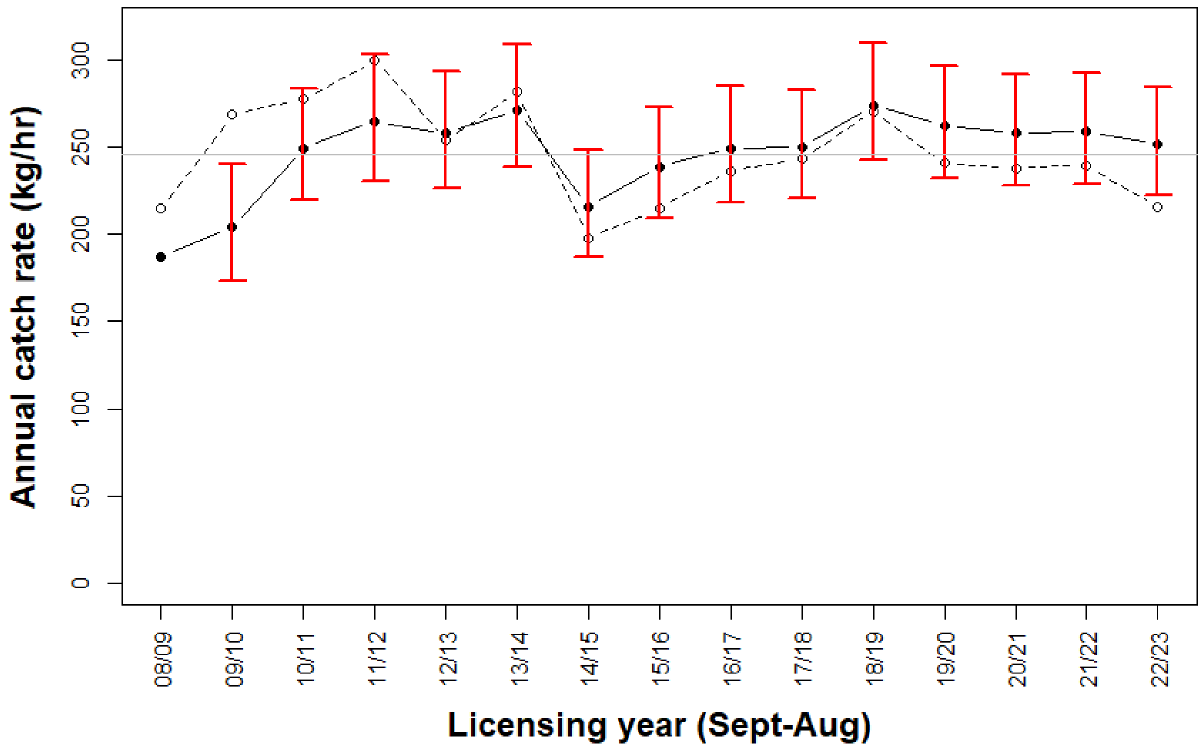

Figure 10. Standardised annual catch per unit effort (CPUE) (solid black line and points) averaged for the entire Tasmanian east coast relative to the annual geometric mean (dashed line). Error bars show the log normally distributed 95% confidence intervals for the standardised model. Horizontal grey line is the geometric mean of all the catch rate data.

Catch rate was further examined for the most heavily fished region (region 2) St Helens, which is the region with the greatest abundance of urchins and the longest history of fishing on the east coast. Catch rate was standardised for the effects of individual diver ID, depth category and time of year (Figure 11). Again, there is no discernible trend in catch rate for the St Helens region over the course of the fishery.

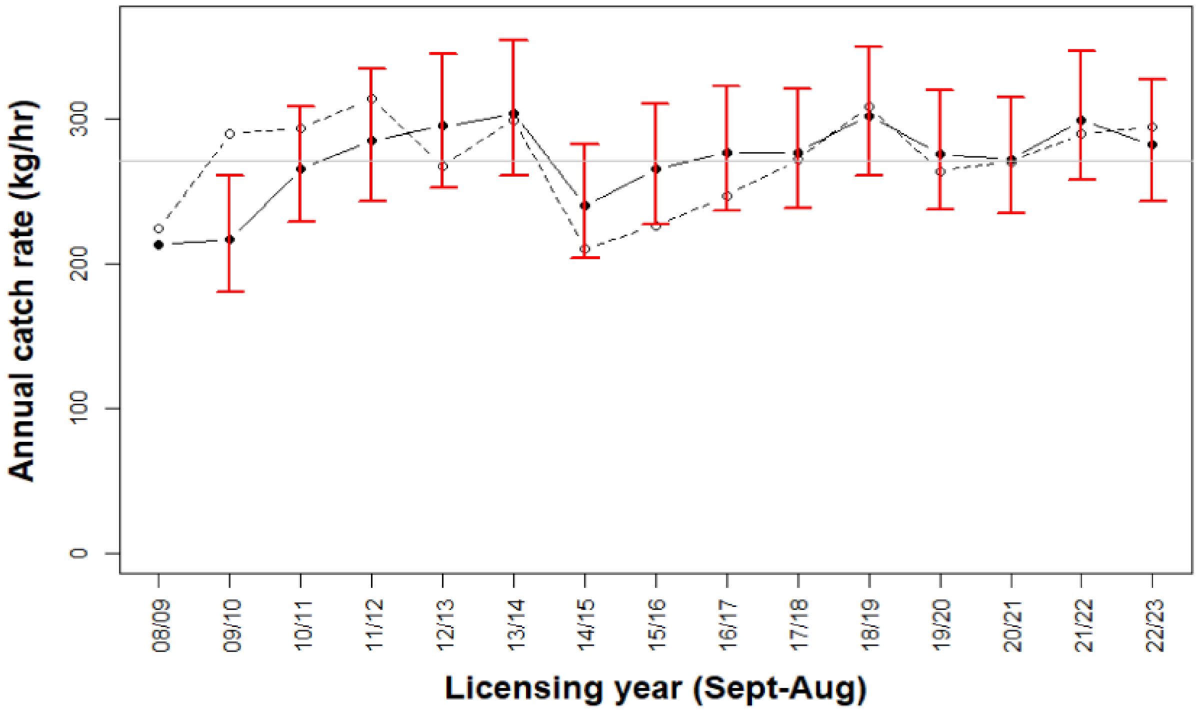

Figure 11. Standardised catch per unit effort (CPUE) (solid line) for the St Helens region relative to the geometric mean (dashed line). Error bars show the 95% confidence intervals for the standardised model. The horizontal grey line is the geometric mean of all years of catch rate data in the St Helens region.

We then examined catch rate for the most heavily fished block (30A), with catch rate standardised for the effects of individual diver ID, depth category and time of year (Figure 12). Again, there is no discernible trend in catch rate for block 30A over the course of the fishery.

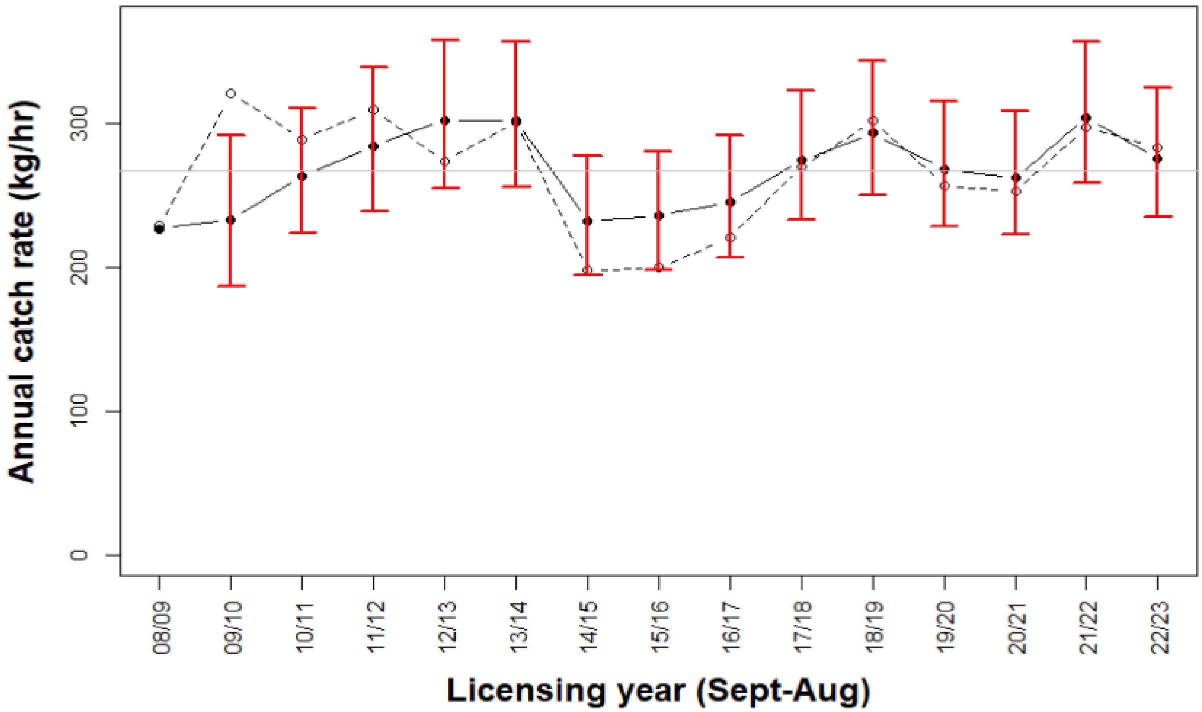

Figure 12. Standardised catch per unit effort (CPUE) (solid line) for block30A relative to the geometric mean (dashed line). Error bars show the 95% confidence intervals for the standardised model. The horizontal grey line is the geometric mean of all years of catch rate data for these two blocks combined.

We examined the trend in mean annual CPUE for each region over all years, standardising for the effects of year, diver ID and time of year (month) (Figure 13). Regional CPUE decreases from north to south (region 1 to 9). This is consistent with observations from fishery-independent surveys and is important as it demonstrates a link between CPUE and density. This is evidence that CPUE provides value as an indicator for assessing this fishery despite issues around hyper-stability as noted previously.

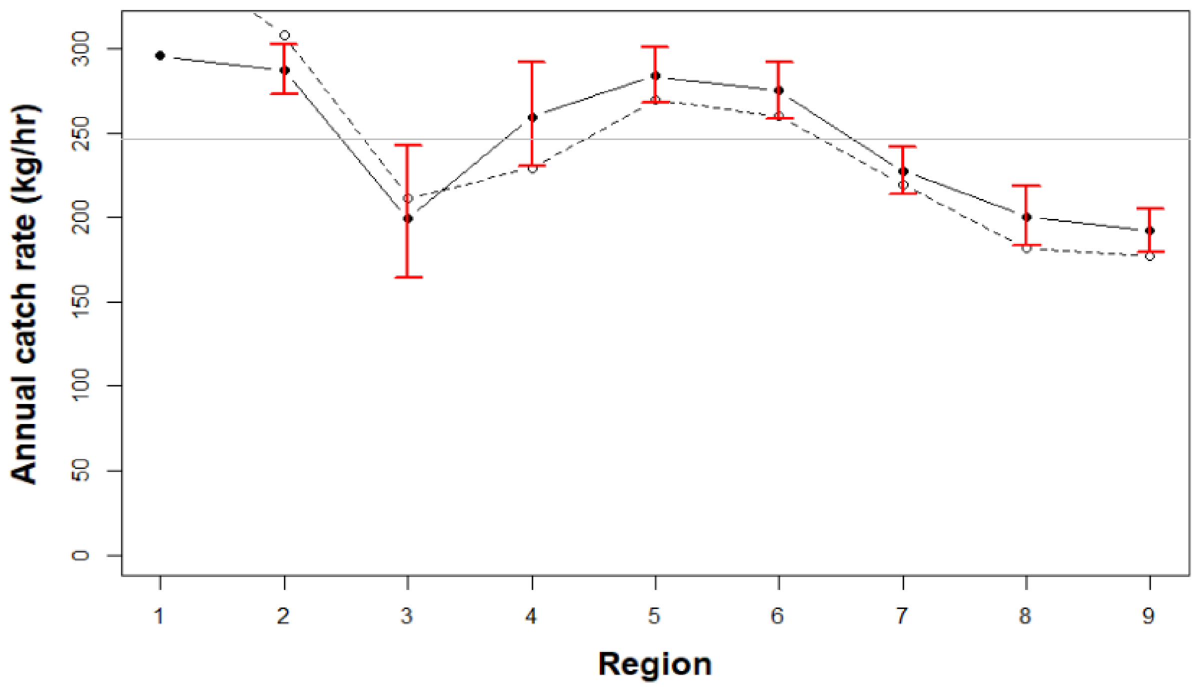

Figure 13. Latitudinal annual trend in CPUE from north (region 1) to south (region 9), standardised (solid line) and unstandardised (dashed line), with red error bars representing the 95% confidence intervals for the standardised model.

Conclusions

Over the last 5 years of the fishery, the catch has remained at the highest level since the inception of the fishery, averaging 492 tonnes a year. Despite the large tonnage removed, there has been no detectable decline in catch rate, even when examining data from the most heavily fished region St Helens. This suggests that there is currently no sign of depletion of the stock using CPUE as an indicator. A trend in decreasing catch rate with increasing latitude indicates that urchins are generally less abundant in the south east coast of Tasmania compared to the north east, which is supported by fisheries-independent survey findings (Ling and Keane 2018) and likely because Longspined Sea Urchin recruits established first in the north of the state due to proximity to the East Australian Current. An increase in recorded dive depth over time is the only indication that this species may be becoming more difficult to find in shallower depths.

Bycatch, habitat and other sources of mortality

Bycatch

There is no bycatch in this fishery as urchins are harvested by hand.

Protected species interaction

Interactions with protected species and the vessel or dive gear are possible although unlikely. The same gear has been assessed as negligible risk in abalone fishing.

Habitat interaction

Interaction between the habitat and fishery is limited to catch bags and considered negligible risk. The fishery (removal of urchins) will promote habitat recovery.

Indigenous fishing

The species has only been present in Tasmanian waters since 1978 thus there was no historic Indigenous harvesting. There is no regulation of current Indigenous harvesting. No information has been collected but the volume of catch is considered negligible relative to commercial harvesting.

Recreational fishing

There is no regulation of recreational harvesting. No information has been collected but the volume of catch is considered negligible relative to commercial harvesting.

Culling

No official culling events were sponsored for this season.

“Take-all” harvest project

No official take-all harvesting events were sponsored for this season.

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