TASMANIAN LONGSPINED SEA URCHIN FISHERY ASSESSMENT 2020/21

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Contents

Executive Summary

STOCK STATUS	SUSTAINABLE
- Fishing mortality in the *Centrostephanus rodgersii* fishery is represented by the use of catch (tonnes) as a proxy. In the most recent 2020/21 season, the annual catch in Tasmania increased to 497 tonnes, the second highest catch in the history of the fishery. The region with the highest catch is St Helens, consistent with previous years. - There is no evidence of biomass depletion through the observed catch rates, however the standardised catch rate appears to have levelled off when examining the whole east coast and has dropped slightly in the most heavily fished blocks in the northeast. In addition, the mean depth of the fishery has increased over time, suggesting depletion of stock in the shallower depths. - 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 2020/2120 season even in the most heavily fished blocks.	
STOCK	Tasmanian Longspined sea urchin fishery
INDICATORS	Catch, effort, CPUE trends and transects.

C. rodgersii has been harvested commercially in Tasmania since 2009. The annual catch remained below 100 tonnes for the first 10 years of the fishery, but in 2017 increased markedly, averaging around 500 tonnes for the last 3 seasons with 497 tonnes for the most recent 2020/21 season. To date there is no evidence of widespread decrease in biomass when comparing catch rates over time, and only the slightest decrease in annual catch rate in the most heavily blocks around St Helens in the northeast of the state.

Catch rates would not necessarily decline as biomass falls because divers can shift 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 data; the mean depth of the fishery has increased over time, suggesting depletion of stock in the shallower depths. Fisheries-independent surveys indicate that biomass increased between 2001 and 2017 on the east coast of Tasmania, during which period only small fishing catches were taken from 2009 onwards. The survey showed a general trend of highest biomass/densities in the northeast to the lowest in the southeast (Johnson et al. 2005, Ling and Keane 2018). Given that this species is not endemic to Tasmania and has a negative impact on the ecosystem here, a depleting status for the fishery may be desired. This is supported by our observed latitudinal trend in catch rates, which clearly decrease from north to south.

Biomass was estimated through a scientific survey in 2001/02 in 6 to 24 m depth (the depth of the dive fishery) to be ~2500 tonnes (Table 1). This depth band covered 80% of the urchin biomass. A resurvey was conducted in 2016/17 and biomass was estimated at ~4400 tonnes. Some small-scale removals from harvesting occurred through this period. Over the period between the two surveys, and accounting for removals from fishing, the average (linear) biomass increase was 153 tonnes/year. Catch in each of the four years since the last survey has exceeded this amount.

Table 1. Biomass estimated from scientific survey in 2001/02 and 2016/17 in bold and asterix, with average biomass increase (assuming a linear relationship) and removals from harvesting, culling and the complete harvest project (explained in text). Average linear biomass increase from the 2001/02 season to the 2016/17 season is 153 tonnes per year, accounting for the removals from harvesting.

Year	Estimated biomass 6 to 24m depth (tonnes)	Average linear biomass increase (tonnes)	Removals from harvesting (tonnes)	Removals from culling (tonnes)	Removals from "take-all" harvest (tonnes)
2001/02	**2523**	153			
2002/03		153			
2003/04		153			
2004/05		153			
2005/06		153			
2006/07		153			
2007/08		153			
2008/09		153	7		
2009/10		153	12		
2010/11		153	64		
2011/12		153	61		
2012/13		153	81		
2013/14		153	97		
2014/15		153	19		
2015/16		153	40		
2016/17	**4434**	153	41		
2017/18			185		
2018/19			560		
2019/20			327	14.8	34.9
2020/21			493.6		3.4

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 the support for this research which came from CSRIO (via support from quantitative research through the postdoctoral scholarship of K. Cresswell), funding from the Tasmanian Government (DPIPWE), 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, evidence suggests that 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 a number of 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 4 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 2019/20 season beginning September 1st 2019, there were 29 divers involved in the fishery. Most fishing effort occurs from December/January to June when roe quality is suitable for harvest.

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 and again in 2016/17, with a current survey taking place 2021/22. 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 24m depth for regions 1-9 was estimated to be ~2523 tonnes in 2001/02 and had increased to ~4434 tonnes for the 2016/17 survey, however some regions showed a greater increase than others. The results of the most recent survey are anticipated this year.

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). 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 the sea urchins' roe, which can vary greatly between individuals depending on many factors (Blount and Worthington 2002, Blount et al. 2017). 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 short-spined 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 urchins were first reported on the east coast of Tasmania in 1978 (Edgar and Barrett 1997) but now extend 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).

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, so that urchin density is 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 and has led to stock rebuilding that will continue into the future. The interactions between seaweed, Longspined sea urchins 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.

Other strategies have been explored in Tasmania to reduce urchin densities in an effort to prevent or reverse urchin barren formation. Culling is an alternative removal method to harvesting in diveable depths. When harvesting, divers remove urchins generally in the mid-large size range of >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 spawning season, with most harvesting taking place between approximately December and June. In comparison, divers that are culling can kill urchins of most size ranges (that are visible) 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 costly compared to subsidised harvesting depending on subsidy rate, whether divers are paid for culling, and the density of urchins (Tracey et al. 2015, Cresswell et al. 2019). Culling by commercial divers has been funded in small areas on the Tasman Peninsula and there is also volunteer culling by abalone and recreational divers.

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 in excess of 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 *Centrostephanus* 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 be best 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, *C. Rodgersii* are harvested by commercial divers, about half of whom also dive commercially for abalone. Commercial urchin divers in Tasmania tend to target individual *C. rodgersii* of a size between the range of 85 to 125mm test diameter (Johnson 2016). 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). Depth is not recorded. 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 2020/21 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) 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 100 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 2020/21 season increased to 497 tonnes from the previous year's catch of 376 tonnes. In total the commercial harvest has removed more than 2000 tonnes of Longspined urchins over the last 13 years.

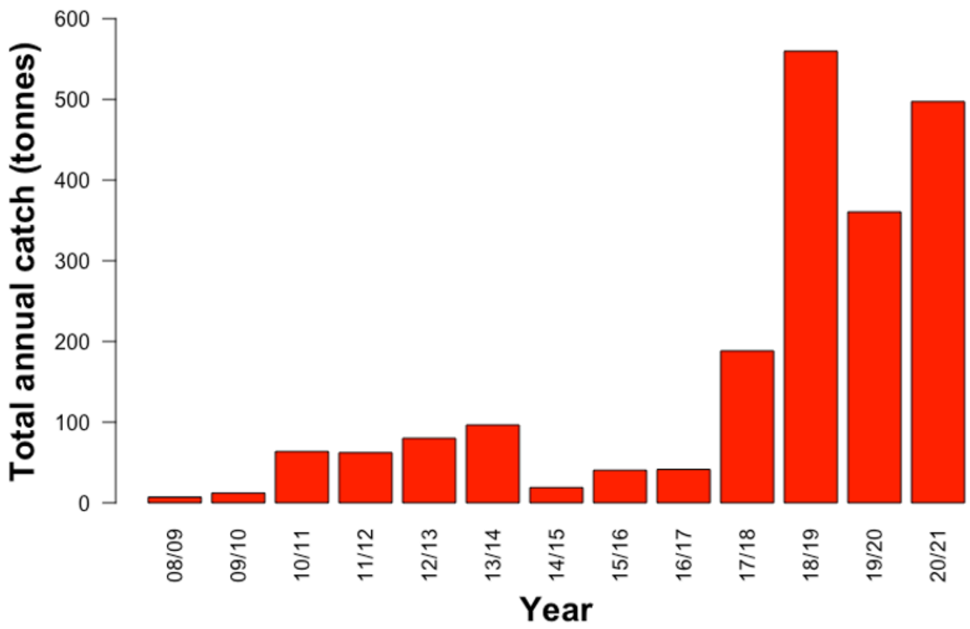

Figure 1. Annual catch of Longspined sea urchins.

Monthly effort for the fishery is focussed between January and June (Figure 2), which is complementary to the spawning season which occurs around August (Ling et al. 2008).

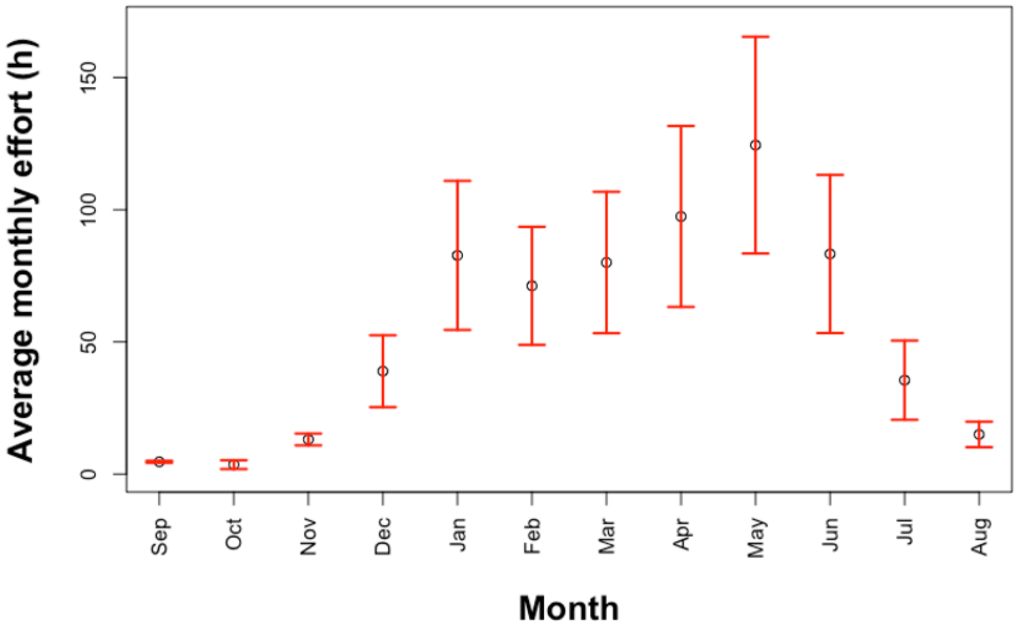

Figure 2. Monthly effort (hr) averaged by year since the beginning of the fishery 2009 to the current season 2020/21, error bars represent standard error.

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 used regions 1 to 9 (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 at $0.75/kg in all subsidy zones. The structure changed on March 11th 2019 to be $0.50/kg in the northern zones, $0.75/kg in the central zone and $1/kg in the southern zone. A new subsidy structure was implemented from March 1st 2020 (the start of the licensing year) with 2 extra zones added north of Eddystone Point (Figure 3). This subsidy structure remained for the 2020/21 season until changes were made from 13th June 2021, with a further zone added and some prices changed.

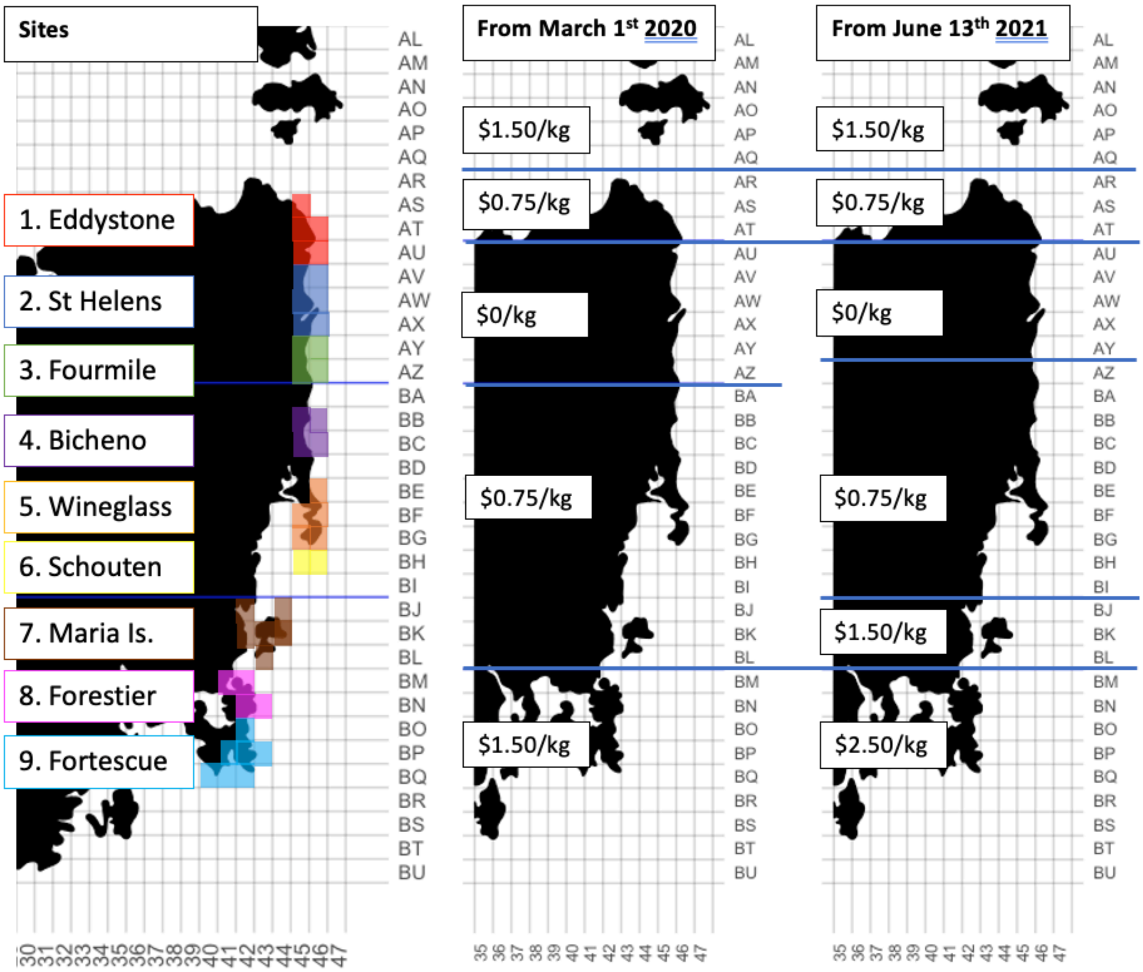

Figure 3. Map of regions referred to in this report (left), coloured labelled areas show which blocks have contributed catch to each of the regions. Subsidy zone boundaries for the subsidy in effect from March 1st 2020 (centre), and further changes in effect June 13th 2021 (right) labelled with the commercial fishing blocks used in the fishery.

The total catch in each commercial fishing block for the most recent season 2020/21 shows a different spatial distribution to the summed preceding 12 years of the fishery (2008/09 to 2018/19) (Figure 4). While most of the catch was concentrated in commercial fishing blocks AW45 and AW46, which are in the St Helens region (region 2), a higher relative catch was removed from blocks BH46 (Schouten Island) and BK44 (Maria Island) suggesting higher numbers of urchins in these areas than previously.

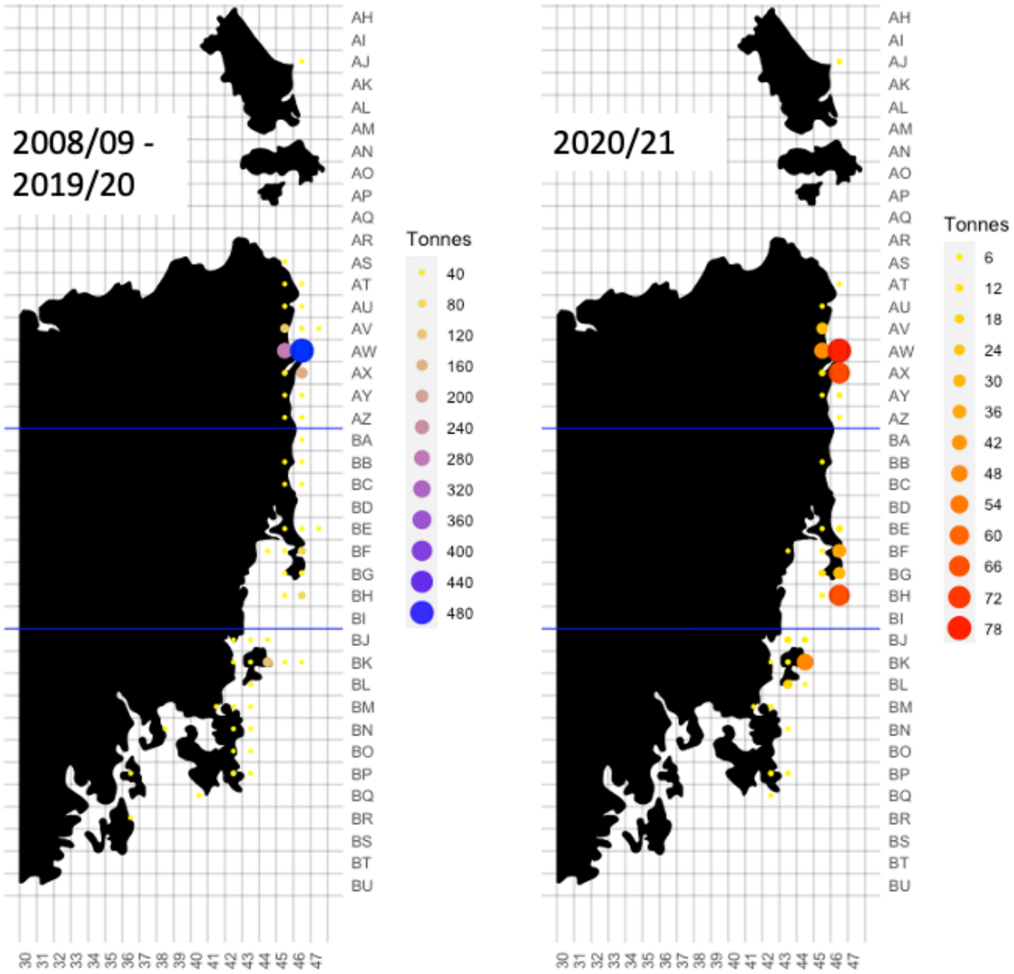

Figure 4. Total catch summed over each commercial fishery block for the 2020/21 season (right) and summed over the previous 12 years of the fishery (left). Tick labels show the commercial fishing block names. Blue lines show the divisions between the northern, central and southern subsidy zones.

Length and weight of the catch

A selection of the catch, measuring the weight and test diameter 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 caught were within 80 to 125mm, with a mean length of 102.4mm in 2019/20 and 101.7mm in 2020/21. A histogram of length frequency indicates that smaller size classes of urchins were caught proportionally more in the 2020/21 season compared to the previous 2019/20 season, which may indicate the impact of fishing on the stock (Figure 5).

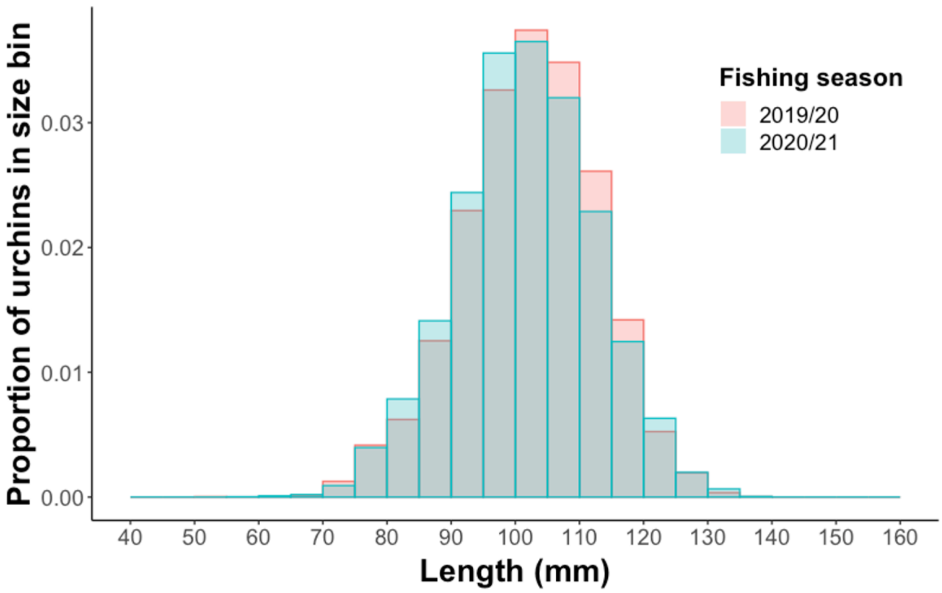

Figure 5. Proportion of urchins in different size categories in the catch for all factory data combined over each of the 2019/20 and 2020/21 seasons.

The difference in size of catch between 2019/20 and 2020/21 is greatest in the Schouten Island region (Figure 6). Size of caught individuals is similar for each of the recorded regions.

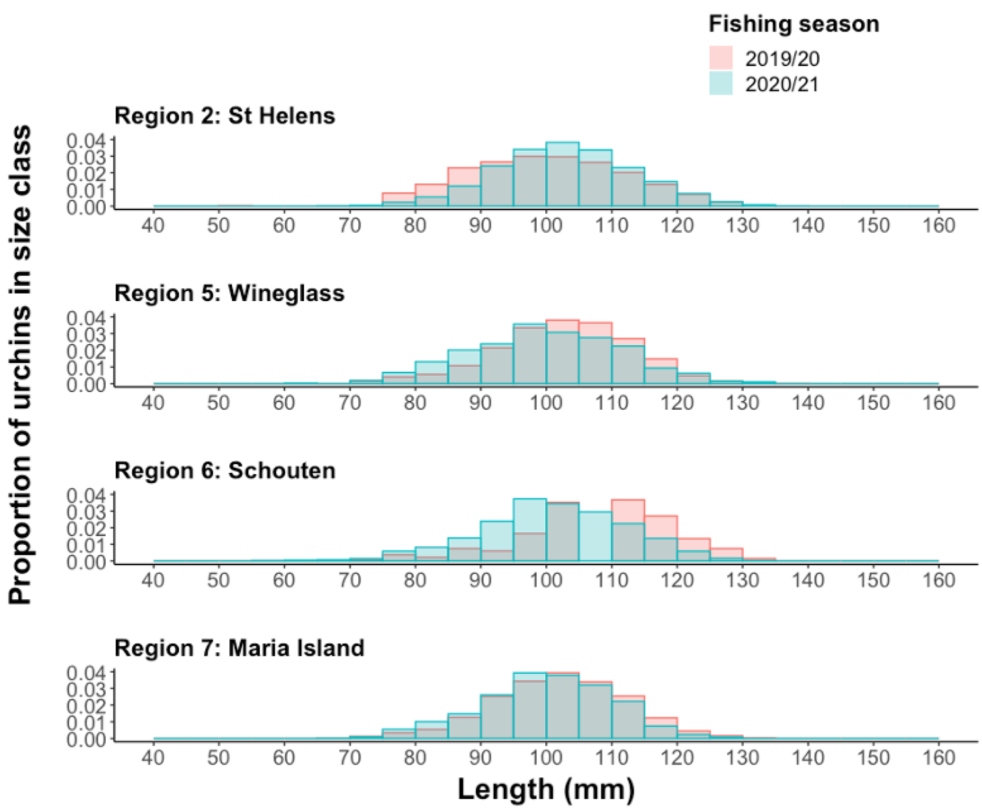

Figure 6. Length frequency of the catch from the main regions measured, top to bottom is north to south.

Depth of catch

In the logbook data, divers record the estimated depth of their catch. The annual mean depth of fishing has increased since the 2015/16 season until last season, levelling out during the 2020/21 season (Figure 7). The mean depth of fishing has increased markedly since the beginning of the fishery, indicating that divers are forced into deeper depths to maintain catch rates. Longspined sea urchins are located in high densities at depth in Tasmania (Perkins et al. 2015, Ling and Keane 2018).

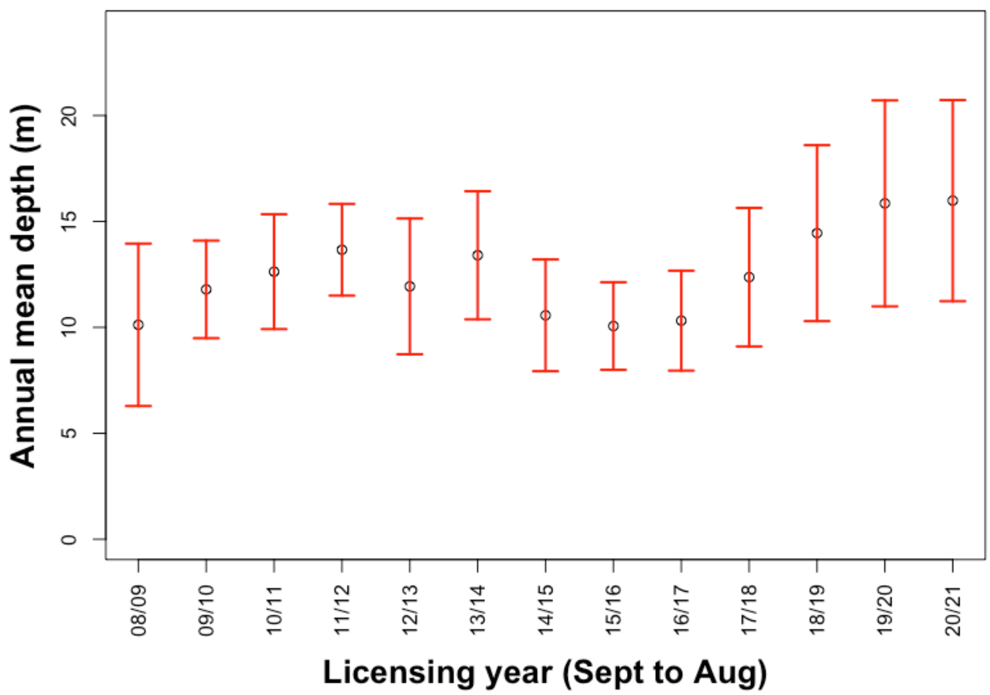

Figure 7. Annual mean depth of the catch as reported by the diver, with error bars showing standard deviation.

Catch rate

Catch rate or catch-per-unit-effort (CPUE) 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 being depleted. 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 effort (hours per dive). Annual catch rate was calculated by averaging all individual dive catch rates for the year. We then standardised the catch rate by the effects of individual diver ID, latitudinal region and time of year (month) (Figure 8). The regions are identified above (Figure 3). There is no discernible trend in CPUE for the entire east coast of Tasmania over the course of the fishery, and the catch rate has remained stable for the last 3 years of the fishery.

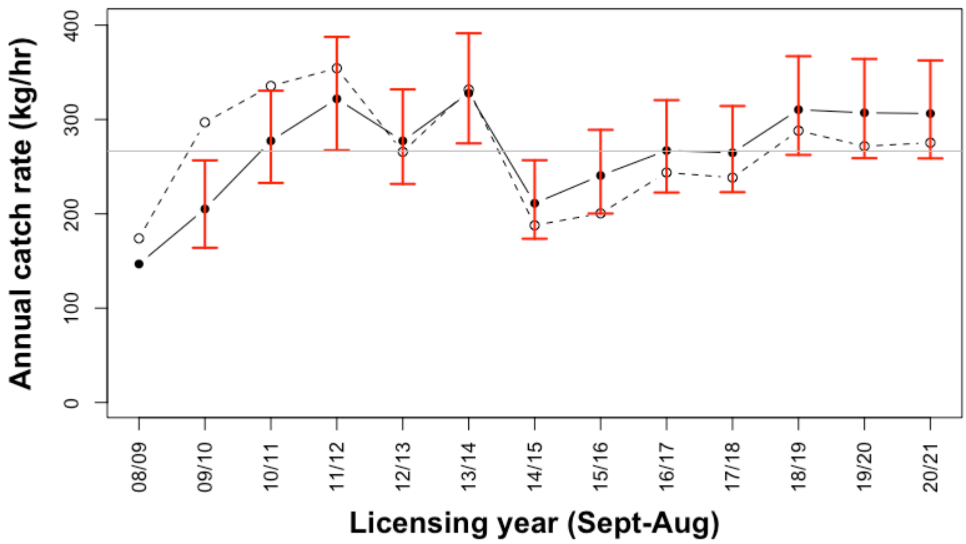

Figure 8. Standardised annual catch per unit effort (CPUE) (solid black line and points) averaged for the entire Tasmanian east coast relative to the annual geometric mean (dashed line). Error bars show the log normally distributed 95% confidence intervals for the standardised model. Horizontal grey 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 diver ID and month (Figure 9). There is no discernible trend in catch rate in the St Helens region over time

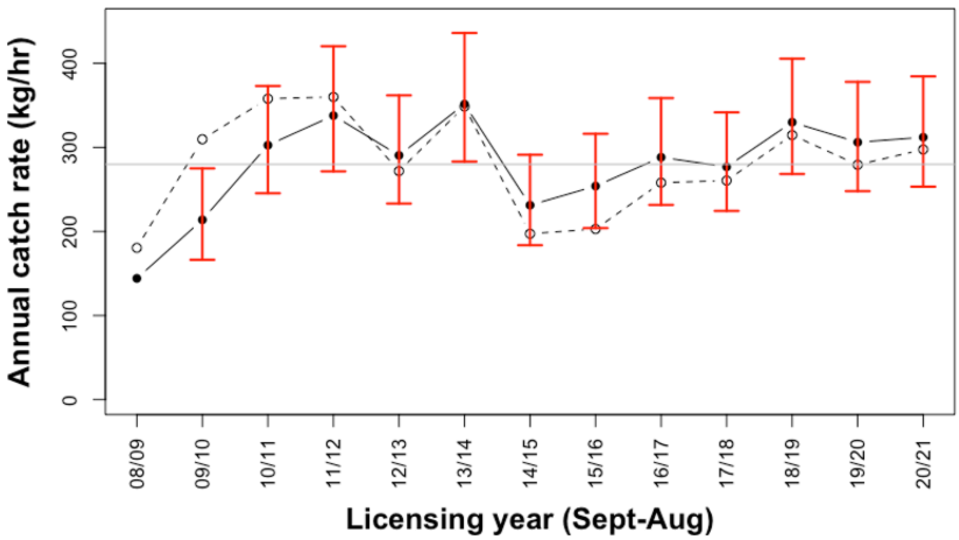

Figure 9. Standardised catch per unit effort (CPUE) (solid line) for the St Helens region relative to the geometric mean (dashed line). Error bars show the 95% confidence intervals for the standardised model. The horizontal grey line is the geometric mean of all the catch rate data.

Finally, we examined the catch rate in the most heavily and consistently fished blocks of the highest fished region, blocks AW45 & AW46 in region 2, St Helens (Figure 10). There is no noticeable trend for the average annual CPUE recorded in these blocks over time, although there is a slight decrease in CPUE over the last 3 years.

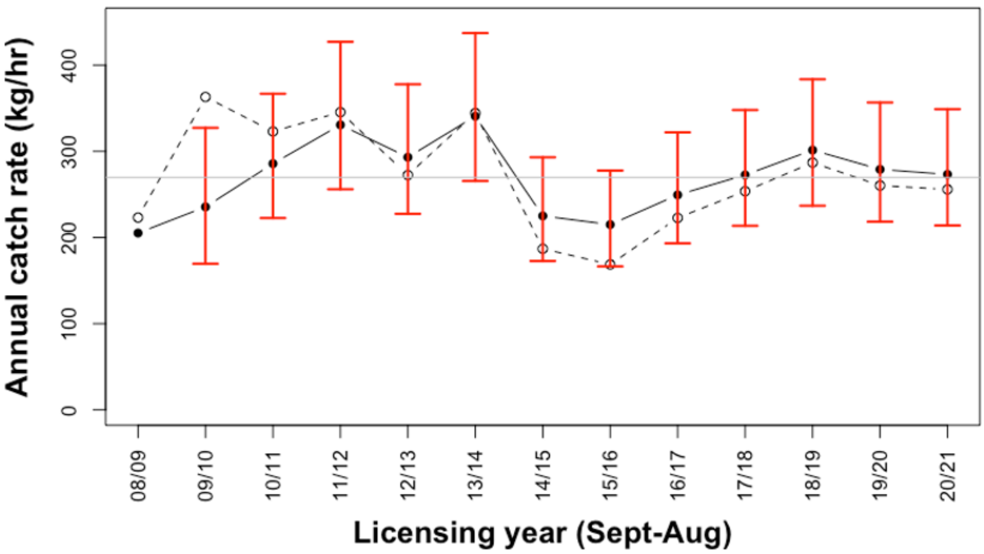

Figure 10. Standardised catch per unit effort (CPUE) (solid line) for blocks AW45 and AW46 in the St Helens region relative to the geometric mean (dashed line). Error bars show the 95% confidence intervals for the standardised model. The horizontal grey line is the geometric mean of all the catch rate data.

Unstandardised mean annual CPUE decreases from north to south (region 1 to 9) along the east coast (Figure 11). 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.

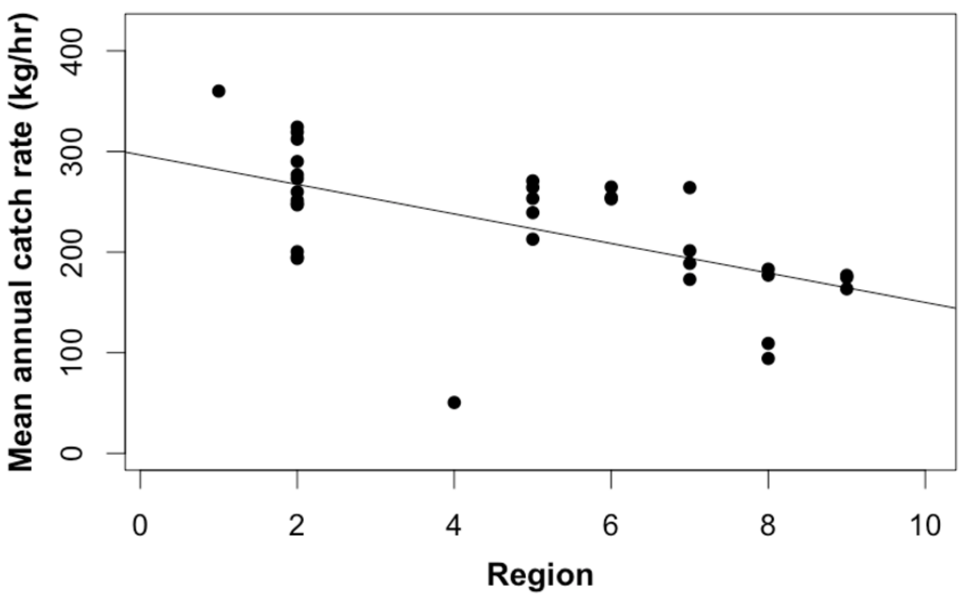

Figure 11. Latitudinal annual trend in CPUE from north (region 1) to south (region 9), unstandardised. Solid line is linear regression trend in data for annual latitudinal catch rate.

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

A three day ‘take-all’ harvest was conducted April 9th to 11th 2021 from around 7,500m coast line on Babel, Cat and Storehouse Islands in the very north of the east coast (2016). This was a joint project between commercial urchin divers (Tasmanian Commercial Dive Association) and IMAS researchers were involved, sponsored by the Abalone Industry Reinvestment Fund. The ‘take-all’ harvest removed all (detectable) size classes of *C. rodgersii* from target regions and transported viable urchins to a mother boat where they were held in live tanks as well as in bulk bins on the final day, after which True South Seafood received and processed the urchins. Measurements of urchin size and weight were taken, along with urchin density and depth of harvested areas. A total of 3.44 tonnes of urchins were removed.

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