TASMANIAN LONGSPINED SEA URCHIN FISHERY ASSESSMENT 2018/19

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2019

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 season 2018/19 annual catch increased fivefold from the first 10 years of the fishery since 2009. Despite this large increase, catch is spatially concentrated, with 80 to 90% of catch coming from a small area of the east coast, around the St Helens region. While stock for the entire east coast of Tasmania is likely to be sustainable despite the increases in total catch, there is evidence of a decrease in catch rates in the most heavily fished areas over time. This suggests that for the more heavily fished areas at the current level of fishing we would expect to see a further decrease in catch rates and localised depletion in these areas. • 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 2009 to 2019 but has a downward trend in the most heavily fished area.	
STOCK	Tasmanian Longspined sea urchin fishery
INDICATORS	Catch, effort, CPUE trends and transects.

The first Longspined sea urchin, *Centrostephanus rodgersii*, was officially reported on the northeast coast of Tasmania in 1978 (Edgar and Barrett 1997), with surveys and studies suggesting initial establishment of this species in the Kent group, Bass Straight (to the north) in the mid 1960s (Johnson et al. 2005). Since then, populations have expanded in Tasmania, being most abundant in the north but occurring with increasing abundance between Eddystone Point in the north and Recherche Bay in the south (Johnson et al. 2005). *C. rodgersii* has been harvested commercially in Tasmania since 2009. The annual catch remained below 100 tonnes until increasing to 185 tonnes in 2018 and 560 tonnes in 2019. This fishery is now the third largest in Tasmania per wet tonnage harvested. Despite the catch increase there is no evidence of widespread decrease in biomass as catch rates have remained stable except in the most heavily fished area of Sloop Reef in the northeast.

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). 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. 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.

Biomass was estimated through a scientific survey in 2001/02 in the 6 to 24 m depth region (the depth of the dive fishery) to be 2523 tonnes (Table 1). This depth band covered 80% of the urchin biomass. A resurvey was conducted in 2016/17 and biomass was estimated at 4434 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 annual biomass increase was 153 tonnes. Catch in each of the three years since the last survey has exceeded this amount.

Table 1. Biomass estimated from scientific survey in 2001/02 and 2016/17, with average biomass increase and removals from harvesting. Average biomass increase during this time period is 153 tonnes per year, accounting for the removals from harvesting.

Year	Estimated biomass at 6 to 24m (tonnes) from survey	Average annual biomass increase (tonnes)	Minus removals through harvesting (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		41
2017/18			185
2018/19			560
2019/20			400*

*Estimated catch based on partial data for the season

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

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Introduction

Overview

Centrostephanus rodgersii (the Longspined sea urchin or Centro) is not endemic to Tasmania, 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 started and remained at 100 tonnes or less until the 2017/18 season, when the catch increased to 185 tonnes, then tripling in 2018/19 to 560 tonnes. 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 2018/19 beginning September 1st 2018, there were 29 divers involved in the fishery. Most fishing effort occurs from December/January to June when roe quality is suitable for harvest.

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) = $0.0032*TD^{2.566}$ (data collected in May 2020 from Complete Harvest project, unpublished)

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 for more than 17 years. 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 of <70g/m^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. This has maintained catches 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). That modelling was conducted at a time when the current high catches taken by the urchin fishery were not anticipated.

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-size range of ~85mm test diameter (Johnson 2016), 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 (Personal communication John Minehan). 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, with other methods available for removing sea urchins with diving depths, quicklime offers potential for removing urchins from depths deeper than 25m.

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 4). 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 2019/20 season GPS and depth logger units are being installed, 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 (Figure 1). A subsidy was introduced for the 2016/17 season (in Figure 2) to encourage harvesting of urchins as a way to prevent extensive barrens forming. In total the commercial harvest has removed more than 1100 tonnes of Longspined urchins over the last 10 years, with more than half of this tonnage taken in the 2018/19 season.

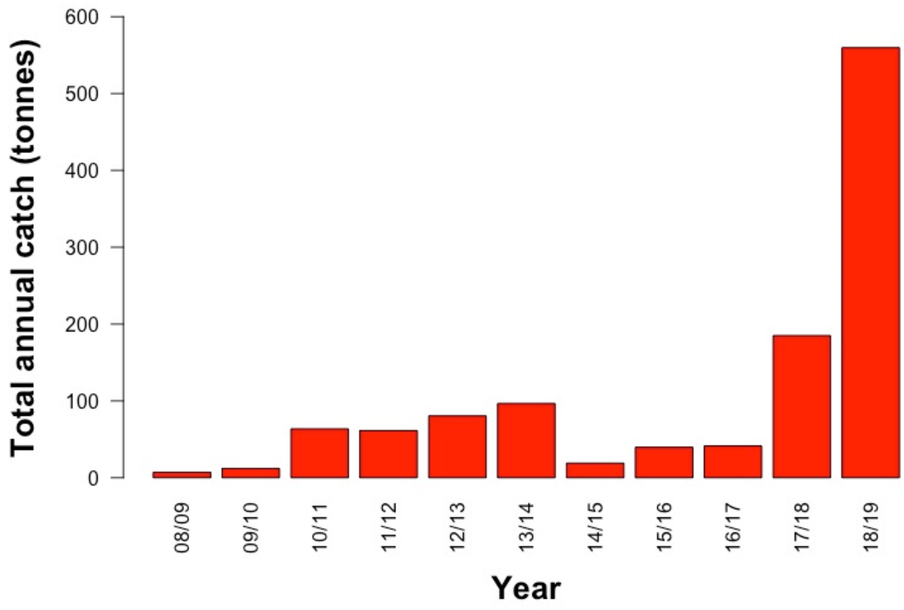

Figure 1. Annual catch of Longspined sea urchins.

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).

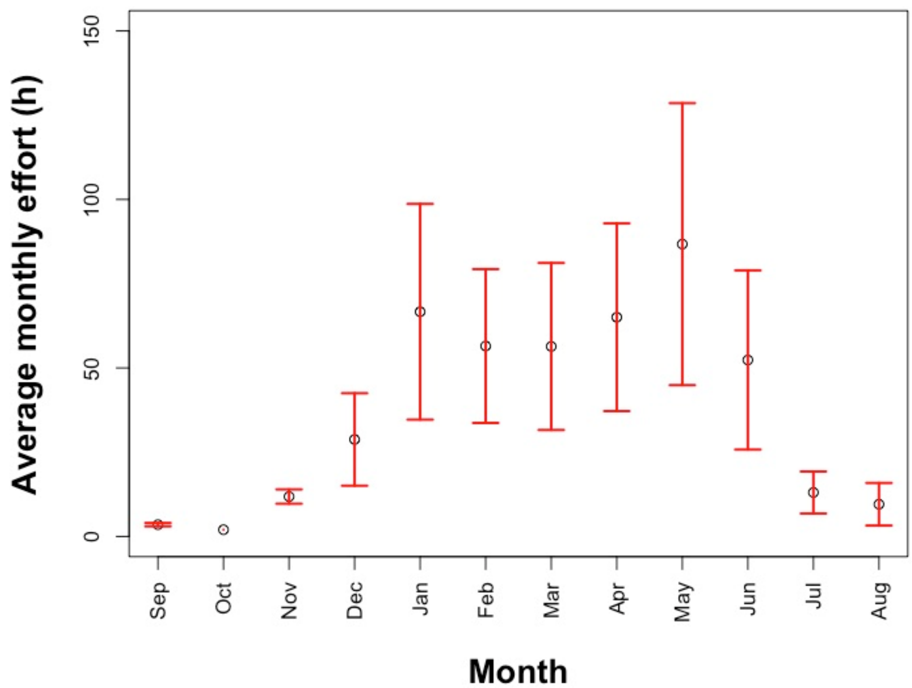

Figure 2. Monthly effort (hr) averaged by year since the beginning of the fishery, error bars represent standard error.

Spatial distribution of the catch

The total catch in each commercial fishing block for the most recent season 2018/19 shows a similar spatial distribution to the preceding 10 years of the fishery (2008/09 to 2017/18) (Figure 3). The majority of the catch was concentrated in commercial fishing block AW46, which is in the St Helens area on the northeast coast of Tasmania, however in the most recent season (2018/19) a slightly higher concentration of catch in the blocks surrounding AW46 (AV46 and AX46) as well as a slightly higher catch around Schouten Island (block BH46) were recorded.

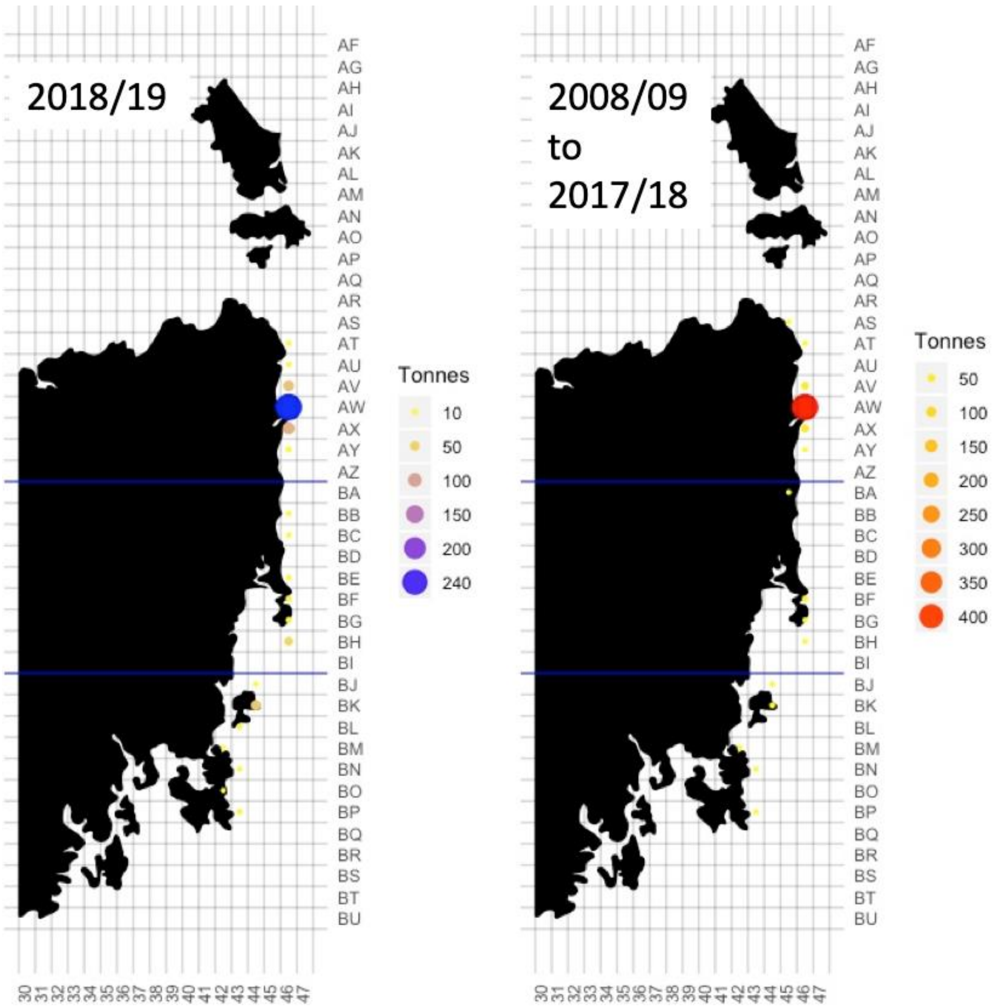

Figure 3. Total catch summed over each commercial fishery block for the 2018/19 season (left) and summed over the previous 10 years of the fishery (right), tick labels show the commercial fishing block names. Blue lines show the divisions between the northern, central and southern subsidy zones.

A subsidy was paid to commercial divers of Longspined sea urchins from late 2016 to early 2019 at a cost of $0.75/kg wet weight of harvest in all areas in an effort to control increasing sea urchin numbers and associated destructive grazing of kelp forests. The structure of the subsidy was changed on March 11th 2019 with different rates for different zones of the coast in an attempt to spread catch along the coast (Figure 4). Payment structure from March of the 2018/19 season was $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 September 1st 2019 (the start of the licensing year) with $0 subsidy in the northern zone, $0.75 in the central zone and $1.50 in the southern zone (Table 3).

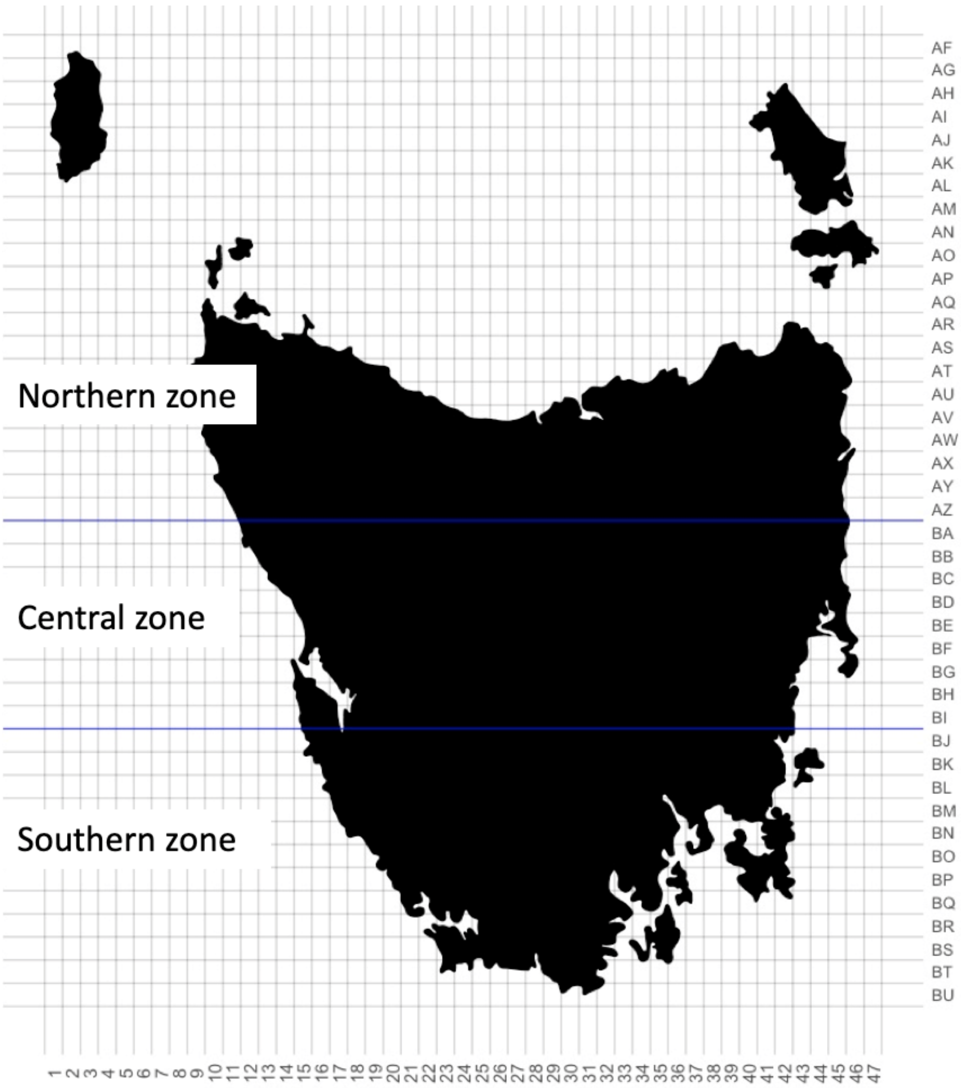

Figure 4. Zones boundaries for the subsidy in effect from March 11th 2019, labelled with the commercial fishing blocks based on latitude and longitude divisions.

Table 3. Subsidy structure by latitudinal zone over time including the subsidy that has been announced for the coming 2019/20 season.

	2017 to March 2019	March 2019 to end of 2018/19 season	Predicted for 2019/20 season
Northern zone	$0.75/kg	$0.50/kg	$0/kg
Central zone	$0.75/kg	$0.75/kg	$0.75/kg
Southern zone	$0.75/kg	$1/kg	$1.50/kg

Catch has historically been concentrated in the northern zone (see Figure 4), making up almost 100% of the relative catch between the zones until the 2016/17 season (Figure 5). With the introduction of the first subsidy ($0.75/kg across the board) catch began to spread to the central and southern zones, with an increase for the 2017/18 season. A further shift in catch southward occurred in the 2018/19 season in response to the spatial structuring of the subsidy (N $0.5/kg, C $0.75/kg, S $1/kg) (Figure 5).

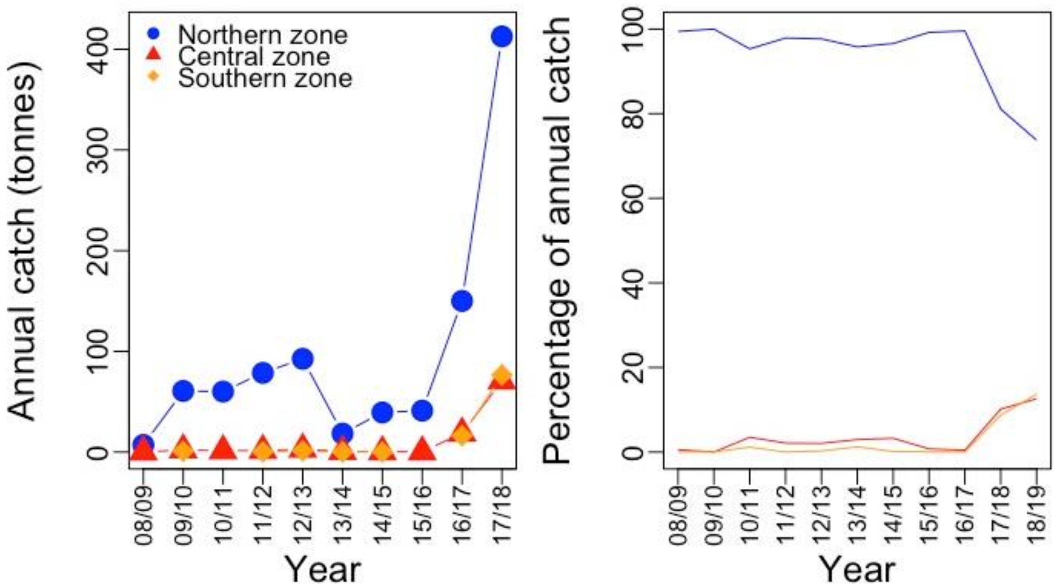

Figure 5. Total annual catch (left) and relative annual catch (right) for each of the subsidy zones over time.

Comparing relative catch between zones with relative effort between zones shows that for the 2018/19 season the relative effort in the southern zone increased proportionally more than the catch (Figure 6). This was because the subsidy was increased in 2019 to be higher per weight of catch in the southern zone compared to the northern and central zones.

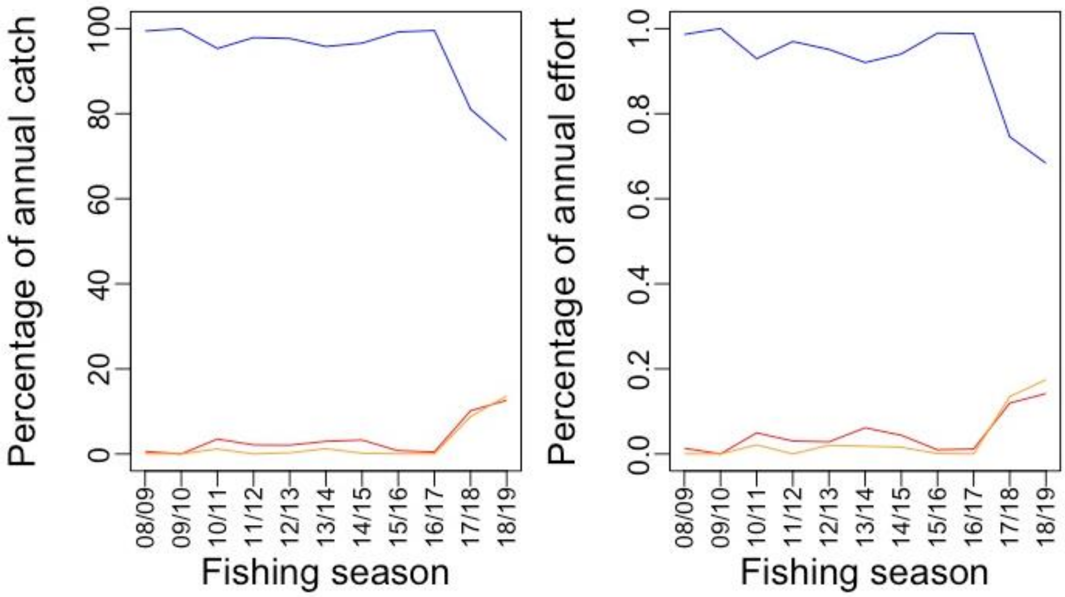

Figure 6. Relative catch (left) and effort (right) per latitudinal zone over time.

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 spatially-aggregated/patchy 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 different 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.

We standardised the catch rate by taking into account the effects of individual diver ID, time of year (season) and latitudinal region (Figure 7). The regions are identified below (Figure 9). Annual CPUE for the east coast of Tasmania has remained stable over the course of the fishery.

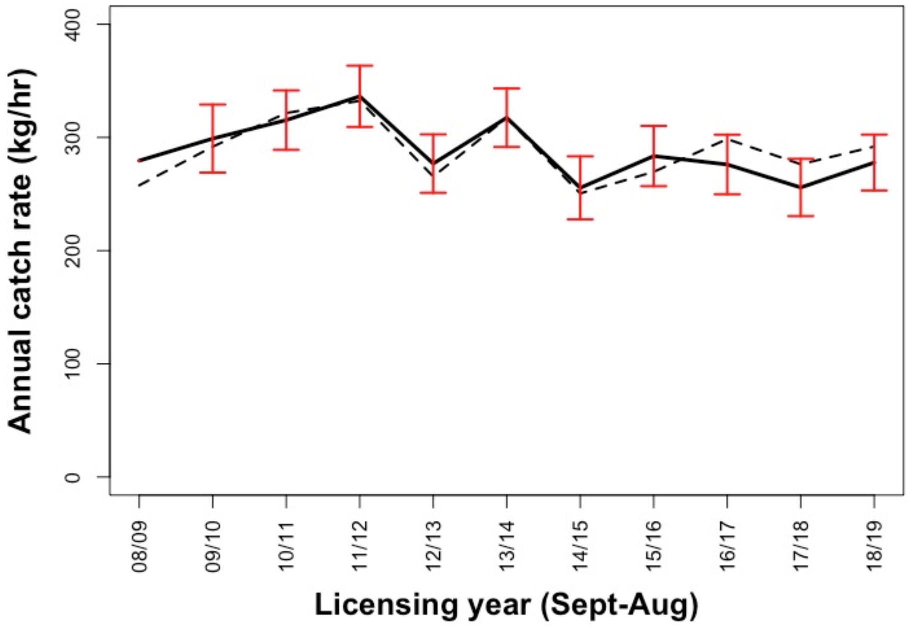

Figure 7. Standardised catch per unit effort (CPUE) relative to the geometric mean. Dashed line is unstandardized mean over time. Error bars show the standard error for the standardised CPUE.

Catch rate was further examined for the Sloop Reef site near St Helens, which is in the region with the greatest abundance of urchins and the longest history of fishing on the east coast (region 2). As per the data for the whole fishery, catch rate from Sloop Reef was standardised for the effects of diver ID and month (Figure 8**Error! Reference source not found.**). In this region there appears to be a modest decrease in CPUE over time, and divers have reported depletion in more accessible areas.

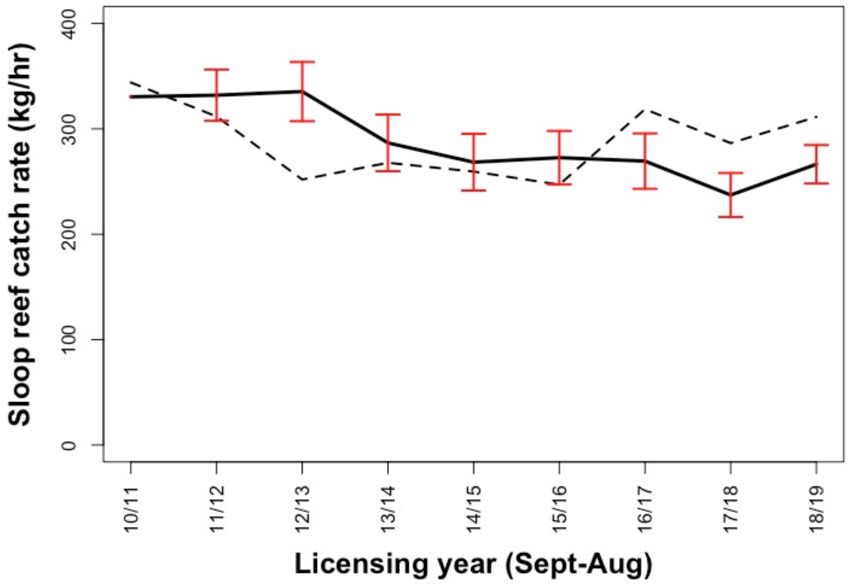

Figure 8. Standardised catch per unit effort (CPUE) (solid line) for Sloop Reef relative to the geometric mean (dashed line) for Sloop Reef. Error bars show the standard error for the standardised CPUE.

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) (Figure 9). For this assessment we used regions 1 to 9, because surveyed abundance of Longspined sea urchins in regions 10 to 13 was negligible for both transect surveys. Catch rate from these different regions clearly decreases from north to south along the coast (Figure 10). 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 earlier.

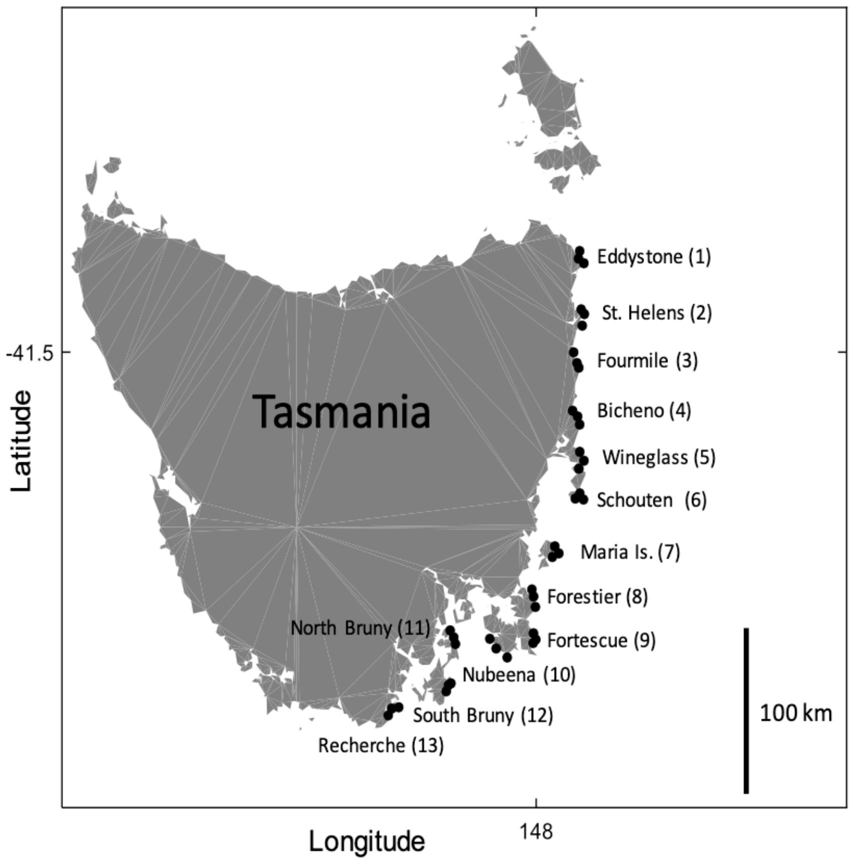

Figure 9. Latitudinal regions based on the surveys completed in 2001/02 and 2017/18 (Johnson et al. 2005, Ling and Keane 2018).

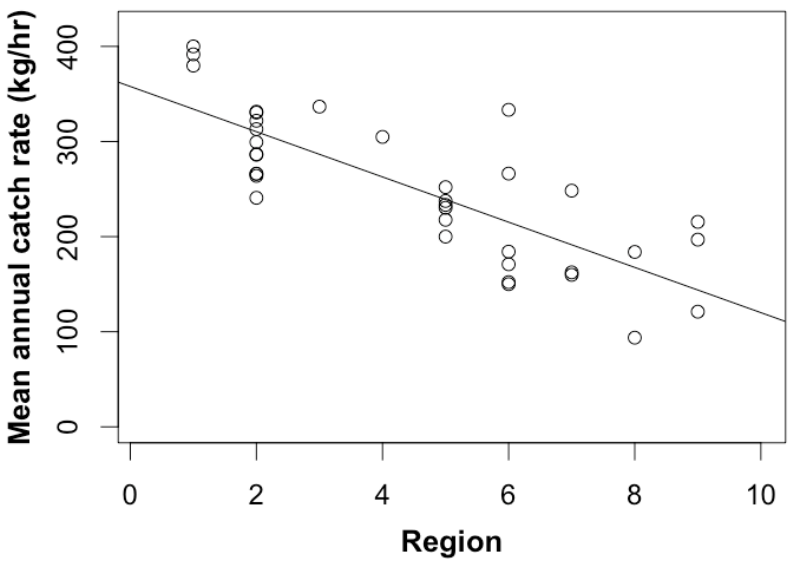

Figure 10. CPUE from logbook blocks within regions north (1) to south (9).

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 the same gear has been assessed as negligible risk in abalone fishing. Handfish ranges potentially overlap with the urchin fishery with interaction considered positive because urchin harvesting reduces the risk of change in the reef ecosystem.

Habitat interaction

Interaction between the habitat and fishery is limited to catch bags and considered negligible risk.

Indigenous fishing

There is no regulation of 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

Culling of urchins by commercial and recreational divers is known to occur but no data is collected. It is believed to be a far smaller source of mortality than harvesting at present.

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