# FRDC submission to the inquiry into climate-related marine invasive species

**20th October 2022**

**Submitted to the Committee Secretary**

**Senate Standing Committee on Environment and Communications**

**via email: ec.sen@aph.gov.au**

**Australian Government**

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# Introduction

The Fisheries Research and Development Corporation (FRDC) welcomes the opportunity to contribute to the Environment and Communications References Committee 'Climate-related marine invasive species' Inquiry.

FRDC's submission addresses the terms of reference as defined by the Senate relevant to the FRDC's research, development and extension as it relates to the fishing and aquaculture sectors. Where applicable, under each of the outlined terms of reference, this submission draws upon a broad range of FRDC funded projects that relate to the spread of climate-related marine invasive species, particularly *Centrostephanus rodgersii* (Longspined Sea Urchin) along the Great Southern Reef.

**Recommendation**

FRDC recommends the need for a large-scale and coordinated approach to monitor, mitigate and manage ecosystem impacts that result from the distributional shift and increased abundances of invasive Longspined Sea Urchins.

## Background

Scientific evidence confirms that the world's oceans are warming at an accelerated rate due to anthropogenic activities. The waters off of the south-east coast of Australia are warming at almost four times the global average, caused in part by the strengthening of the East Australian Current (EAC) (FRDC project 2016-139 *Decadal scale projection of changes in Australian fisheries stocks under climate change*).

Shifts in the spatial distribution of marine organisms are a pervasive impact of climate change driven by increases in water temperature, changes in ocean currents (such as the EAC) and chemistry (FRDC project 2016-139). To date, distribution shifts have been documented for 198 species from nine phyla (Gervais et al. 2021). Of these shifts, 87.3% have been poleward (Gervais et al. 2021).

Species that have expanded their distribution due to climate change are considered 'invasive', although these species are generally native in the true sense of the term. While the Senate Inquiry highlights Longspined Sea Urchin (*Centrostephanus rodgersii*) as a marine invasive species, FRDC acknowledges that this species is native to south-eastern Australia and is experiencing a climate-induced range extension from coastal waters around mainland Australia into Tasmania.

The expansion, or shift, of a species into new areas can have considerable ecological and economic impacts – these impacts can be positive or negative, depending on the species involved and their interactions with other ecosystem components. Climate change science draws on ecological disturbance theory that proposes changes in ecosystems as they shift from an equilibrium. What is being found is that there is significant difference between prediction and actual change, as it is extremely difficult to model ecosystem changes. Local management agencies are therefore challenged to understand the positive or negative impacts of emergent distribution shifted species, and account for them accordingly within their policy and decision-making frameworks.

## Terms of Reference

On 5 September 2022, the Senate referred an inquiry into the spread of '*Climate-related marine invasive species'* to the Environment and Communications References Committee for inquiry and report by 1 March 2023, with the following terms of reference:

The spread of climate-related marine invasive species, particularly Longspined Sea Urchin (*Centrostephanus rodgersii*) along the Great Southern Reef, with reference to:

A. the existing body of research and knowledge on the risks for and damage to marine biodiversity, habitat and fisheries caused by the proliferation and range shifting of non-endemic Longspined Sea Urchins

B. management options, challenges, and opportunities to better mitigate or adapt to these threats, and governance measures that are inclusive of First Nations communities

C. funding requirements, responsibility, and pathways to better manage and coordinate stopping the spread of climate-related marine invasive species

D. the importance of tackling the spread of invasive urchin 'barrens' to help facilitate marine ecosystem restoration efforts (such as for Tasmanian Giant Kelp *Macrocystis pyrifera*)

E. any other related matters

## This submission

This submission to the 2022 Senate Inquiry into *Climate-related marine invasive species,* addresses the Terms of Reference as defined by the Senate relevant to FRDC's research, development, and extension (RD&E) in fishing and aquaculture. This submission builds on the FRDC's RD&E investments to understand and manage the distribution and abundance of Longspined Sea Urchin as well as their fisheries and ecosystem interactions. The submission includes references to activities undertaken over the previous 25 years as well as ongoing research investments.

While many Australian marine species are either susceptible to, or already undergoing distributional shifts, this Senate inquiry specifically cites Longspined Sea Urchin (*Centrostephanus rodgersii*), and this species is the focus of this submission. FRDC has therefore restricted the focus of this submission to range expansion by Longspined Sea Urchin.

## Longspined Sea Urchin

Longspined Sea Urchins are found on shallow, rocky reefs from northern New South Wales (NSW) to Victoria and Tasmania. They inhabit macro-algae dominated shallow waters (< 50 m depth). At high population densities, these urchins are associated with denuded reefs through overgrazing of kelps, referred to as 'urchin barrens'.

The biology and ecology of Longspined Sea Urchin are well studied (Attachments 1 and 2), and the species possesses a reproductive strategy with a prolonged planktonic larval life phase that facilitates wide dispersal of this species by local currents, such that there may only be a single biological stock. Further detail on this aspect of urchin biology is provided by FRDC Project 2001-044 *Establishment of the long-spined sea urchin (Centrostephanus rodgersii) in Tasmania: a first assessment of the threat to abalone and rock lobster fisheries*, as listed in Attachment 1. Moreover, the species displays a high adaptive capacity in response to changes in density and local environmental conditions which is likely to increase the resilience of the population (FRDC Project 1999-128 *Research to develop and manage the sea urchin fisheries of NSW and eastern Victoria*).

Longspined Sea Urchin populations have increased considerably on the Australian east coast, largely attributed to changing local climate conditions. In addition, climate-induced strengthening of the East Australian Current is implicated in the southern expansion of the species' distribution into Tasmanian waters (FRDC Project 2001-044).

For the status of the Longspined Sea Urchin fishery resource in Australia (Table 1 and Figure 1), refer to the 2020 edition of the Status of Australian Fish Stocks. FRDC is currently funding a project to synthesise the science for NSW (FRDC project 2021-060 *Analysis of historical sea urchin research for improved management of nearshore fisheries in NSW*).

**Table 1. Stock status overview of Australia's Longspined Sea Urchin fisheries**. *Source: Status of Australian Fish Stocks, published June 2021.*

| Stock status determination | | | |
|---|---|---|---|
| **Jurisdiction** | **Stock** | **Stock status** | **Indicators** |
| New South Wales | New South Wales | Sustainable | Catch, fishery-independent survey estimates of biomass |
| Tasmania | Tasmania | Sustainable | Catch, effort, CPUE trends, fishery-independent survey estimates of biomass. |
| Victoria | Victoria | Sustainable | Catch, effort, CPUE trends |

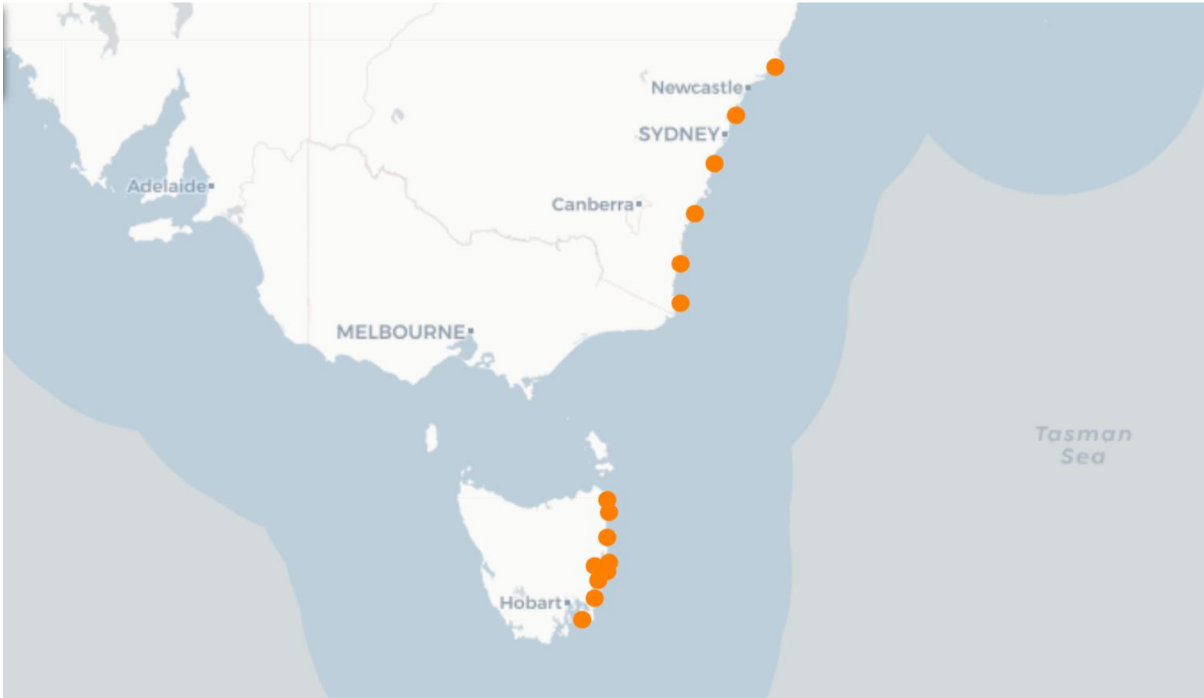


**Figure 1. Distribution Australia's Longspined Sea Urchin fisheries**. *Source: Status of Australian Fish Stocks, published June 2021.*

## Fisheries Research and Development Corporation

FRDC is a co-funded partnership between the Australian Government and the fishing and aquaculture sectors. FRDC's role is to plan and invest in fisheries research, development, and extension activities in Australia. Investment in RD&E is undertaken to support the management of Australia's fisheries and aquaculture resources for ongoing sustainability, profitability, and productivity. FRDC's funding is directed at research that supports Indigenous, commercial, and recreational fishing as well as aquaculture, while also delivering a public good benefit to the Australian community.

Key partners of FRDC include the Australian, State and Territory Governments, Indigenous Australians, the commercial wild catch sector, recreational fishing, the aquaculture sector and leading research providers in Australia, including universities, CSIRO and ABARES.

Refer to Attachment 1 for a list of FRDC funded projects that relate to Longspined Sea Urchin.

## Responses to the Terms of Reference

Where applicable, under each Term of Reference we draw on information generated from FRDC-funded RD&E activities that relate to the spread of climate-related marine invasive species, particularly Longspined Sea Urchins along the Great Southern Reef to address these points. FRDC project numbers and project titles (with hyperlinks to the final reports where available) are provided to assist the reader.

### A. The existing body of research and knowledge on the risks for and damage to marine biodiversity, habitat and fisheries caused by the proliferation and range shifting of non-endemic Longspined Sea Urchins

There is a considerable body of research and knowledge (i.e., environmental monitoring data) that documents change in the abundance and distribution of the Longspined Sea Urchins, both within their historic distribution along the mainland's east coast (NSW and Victoria), as well as their movement from the waters of mainland Australia into Tasmanian marine waters.

This submission will largely focus on research funded by FRDC (Attachment 1). Refer to Attachment 2 for a bibliography of published research that relates to Longspined Sea Urchin – i.e., their biology, ecology, associated fisheries, and impacts on rocky reef ecosystems.

FRDC projects 1993-102, 1999-128 and 2001-044 document the relatively rapid expansion of Longspined Sea Urchin distribution and abundance from southern NSW to Victoria and into Tasmania over recent decades. In particular, FRDC project 2001-044 describes the impacts of invasive Longspined Sea Urchin on Tasmania's kelp-reef habitats. The species was first recorded in these ecosystems in 1978, presaging rapid reduction in algal coverage and the development of urchin barrens.

The initial adaptive capacity of Longspined Sea Urchins to successfully establish populations in locations outside their natural range may be enhanced by factors including:

- synergistic consequences of long-term fishing of predatory species (i.e., rock lobster or large predatory fishes), and/or
- anomalous heat wave events that stress ecosystems, causing mortalities in keystone species and kelp die offs.

FRDC Project 2019-130 (*Larval dispersal for Southern Rock Lobster and Longspined Sea Urchin to support management decisions*) aims to utilise oceanographic modelling to understand the larval flow of Longspined Sea Urchin in Tasmania with a particular focus on understanding sources and sinks for the population. The project will model different climate scenarios to understand the likelihood of self-recruitment in the Tasmanian population and incursion of Longspined Sea Urchins into currently unpopulated regions.

Throughout its expanded distribution, Longspined Sea Urchins at high ('uncontrolled') densities pose risks to local ecosystem structure and function. These risks stem from the species' ability to overgraze algal communities, such as kelp beds, transforming kelp-rocky reef ecosystems into denuded rocky reefs known as urchin barrens. Barrens can vary in spatial scale from relatively small (incipient) to extensive, covering considerable expanses of reef.

The transformation of kelp-reef habitats into urchin-barren, rocky-reef habitats also change the ecosystem services provided by these inshore habitats – e.g., buffering waves, nutrient cycling – which in turn, impacts the overall inshore ecosystem.

In the absence of natural predation or sustained harvesting, the species is effective at maintaining barren conditions, especially in ecosystems that have undergone a regime shift. In NSW, approximately 50% of shallow reefs are characterised as 'barren' (Andrew & O'Neill 2000), with similar levels of barren coverage now at sites in north-eastern Tasmania (Ling & Keane 2019).

The ability of Longspined Sea Urchins to maintain barren conditions makes restoration of reef habitats and associated kelp and algal communities challenging. FRDC projects 2013-026 & 2011-087 indicate that effective restoration efforts require the near-complete removal of Longspined Sea Urchins to improve the likelihood of kelp and broader ecosystem recovery. Hence, efforts to manage the impacts of Longspined Sea Urchin have focused on removing urchins at rates that exceed recruitment, thus reducing abundances and enabling habitat recovery (also refer to response to Terms of Reference B and D).

Given the critical function of kelp-rocky reef ecosystems, the barrens created by Longspined Sea Urchins radically alter the local diversity of associated species e.g., kelp over-grazing has resulted in the loss of over 150 species inhabiting Tasmanian kelp beds (Ling 2008), including commercially and recreationally fished species. FRDC project 2001-044 provides evidence of a negative relationship between Longspined Sea Urchin abundance and the density of Blacklip Abalone (*Haliotis rubra*) and Southern Rock Lobster (*Jasus edwardsii*). Similarly, FRDC project 1993-102 highlights the negative impacts of urchin barrens on the NSW abalone fishery.

FRDC project 1999-128 also highlights economic opportunities offered by increased abundance of Longspined Sea Urchin through potential development of fisheries for urchin roe. Subsequent FRDC projects have further explored the establishment of commercial fisheries as a management control and economic venture (also refer to response to Term of Reference B).

The recently funded FRDC project 2021-060 provides an opportunity to contrast results through time and improve understanding of the dynamics of the Longspined Sea Urchin on NSW reefs and in associated fisheries, such as those for abalone.

## B. Management options, challenges, and opportunities to better mitigate or adapt to these threats, and governance measures that are inclusive of First Nations communities

Overall, efforts to manage and mitigate the impacts of Longspined Sea Urchin are focused on the removal of urchins at rates that exceed recruitment, thus reducing abundances.

FRDC's research investment has primarily focused on trialling and measuring the efficacy of management options to control abundances. Management options have sought to mitigate further increases in Longspined Sea Urchin distribution and abundance through various means including: (i) culling, (ii) harvesting, and (iii) predation.

Chemical treatments have also been suggested as a control measure. For example, quicklime was used to reduce urchin densities with some success at intermediate spatial scales in California and Norway. However, chemical treatment has not yet been used in Australia.

Relative to the management approaches trialled and, or researched in Australia:

### *(i) Culling*

FRDC project 2011-087 (*Tactical Research Fund: Trial of an industry implemented, spatially discrete eradication/control program for Centrostephanus rodgersii in Tasmania*) demonstrated that a systematic culling of Longspined Sea Urchin in spatially discrete plots was successful in reducing urchin densities. The trial cull program also reduced the patchiness of urchin distribution, reducing overgrazing. Likewise, FRDC project 2007-045, showed that direct culling by abalone divers during their operations can be successful in regenerating seaweed cover on targeted barrens.

The highly targeted nature of these culling operations at small spatial scale is unlikely to have any significant effect at the whole-of-reef level unless it is sustained. There are a number of non-FRDC funded projects or programs supporting Longspined Sea Urchin culls across NSW, Victoria, and Tasmania.

Although culling can deliver ecological benefits, the costs involved are considerable. FRDC project 2011-087 highlighted that manually controlling Longspined Sea Urchin at two Tasmanian sites could cost up to $1 million per site. Conversely, failure to control urchins risked loss of 50% of reef-kelp habitat, negatively impacting Indigenous, commercial and recreational fishing for abalone and rock lobster, as well as ecosystem biodiversity and function.

Enlisting the support of citizen scientists, such as recreational divers, has the potential to overcome the costs associated with culling a target area of Longspined Sea Urchins. However, anecdotal evidence indicates that enthusiastic recreational divers will cull any urchin they encounter (i.e., including species other than Longspined Sea Urchin), inadvertently doing more harm than good.

### *(ii) Harvesting*

In terms of harvesting as a management control, FRDC projects 1993-102 and 2013-026 (*Can commercial harvest of Long Spined Sea Urchins reduce the impact of urchin grazing on abalone and lobster fisheries?*) demonstrate that commercial harvesting of the species in Tasmania reduces destructive grazing by urchins, or at least prevents expansion of barrens, even at low fishing pressure. These projects also suggest that harvesting urchins has positive benefits for abalone and lobster habitat, and in turn, can promote increased abalone abundance and growth.

In addition, the potential to transition from a subsidised activity (as is the case in Tasmania) to a standalone commercially viable fishing sector is appealing as it reduces State government and/or industry investment (i.e., subsidies).

FRDC projects 2011-087 and 2013-026 identified the disposal of urchin waste as a key logistical issue and financial burden in the commercial processing operation. However, there are also potential commercial opportunities to utilise urchin waste, with research qualifying nutrient, biochemical, and nutraceutical properties of urchin roe and viscera (a processing waste by-product) – refer to FRDC projects:

- 2019-128 *Assessing the benefits of sea urchin processing waste as an agricultural fertiliser and soil ameliorant*
- 2017-050 & 2016-208 *Waste to profit in urchin fisheries: developing business opportunities to ensure fishery sustainability and safeguard reef dependent fisheries from destructive urchin grazing*

While elements of this research are commercial in nature, there is potential for urchin viscera to be used as an agricultural fertiliser. Research on this issue is underway.

FRDC project 2013-026 suggests that harvesting urchins is only partially effective as a management option to control population abundances, in part due to the inability for divers to access populations at depth (> 30 m) without specialist equipment. In this manner, harvesting (or culling) might be effective at removing all individuals in shallow waters accessible by hookah or SCUBA, but potentially dense populations remain at depth and can re-colonise the fished area, impeding the recovery of the reef.

Moreover, FRDC project 1999-128 identified that Longspined Sea Urchin roe quality is seasonally variable, with low grade roe quality fetching considerably lesser prices acting as a disincentive for divers to harvest urchins. Research to develop approaches to improve roe quality (i.e. through conditioning, ranching, and dietary supplements) is underway (see also efforts to improve roe quality in other urchin species: 1999-319 *Aquaculture nutrition subprogram: Post-harvest enhancement of sea urchin roe for the Japanese market*). This is being commercialised by companies like https://www.urchinomics.com/).

Urchin roe quality is also influenced by conditions including the availability of algal feed, the severity of the barren, and the location of the urchin within the barren (i.e., in the centre vs. the fringe). In addition, roe quality is density dependent, so there is the potential for a positive-feedback loop from urchin fishing with reduction in densities increasing roe production and quality while enhancing industry profitability.

*(i) Predation*

FRDC is aware of only one study that has assessed the role of predation as a Longspined Sea Urchin management control. FRDC project 2007-045 demonstrated that on incipient (small) urchin barrens, populations of large (>140 mm carapace length) Southern Rock Lobsters had some efficacy in reducing densities of Longspined Sea Urchins and promoted algal recovery. Rock Lobsters had less success on more established urchin barrens, with further evidence suggesting that Rock Lobster have a dietary preference for other urchin species as opposed to Longspined Sea Urchins. FRDC project 2010-564 (*FRDC-DCCEE: Preadapting a Tasmanian coastal ecosystem to ongoing climate change through reintroduction of a locally extinct species*) undertook a desk-top study to test the feasibility of 're-introducing' the Eastern Blue Groper (*Achoerodus viridis*) from NSW to Tasmania, as a control measure for Longspined Sea Urchin. Evidence from NSW suggest groper may reduce barren formation, rather than assist barren recovery. While desk-top in nature, no implementation action resulted from this research.

Abundances of Longspined Sea Urchin predators are controlled through fisheries management practices. Thus, efforts to maintain and rebuild populations of rock lobsters, gropers, and other predatory species have the potential to yield dual benefits – to improve populations of predatory species and increase predation pressure on Longspined Sea Urchins.

When considering the efficacy of management options to control Longspined Sea Urchins, the available research suggests that in isolation these control measures are unlikely to make substantial reductions in impacts on existing reefs or to mitigate further expansion. For example, FRDC project 2007-045 recommended that simultaneously rebuilding populations of predatory lobsters and harvesting or culling is likely the most effective way to mitigate the risk of ongoing urchin barren formation. This project recommended that effort is invested in developing the commercial Longspined Sea Urchin sector, while providing opportunities for abalone divers to cull urchins while fishing for abalone.

It is worth noting that the management options to controlling the distributional shift of Longspined Sea Urchin are limited in their efficacy at relatively small spatial scales (i.e., at the reef scale) and so are unable to mitigate the issue. Given the mobile nature of issue, there is a need for adaptive solutions that are flexible in time and space, whereby static solutions such as marine parks are unlikely to be effective at managing impacts of Longspined Sea Urchin and other invasive species 'on the move' (as highlighted by FRDC projects 2007-045 and 2013-029 *The Comparative Performance of Management of the Individual Threats to Marine Environments and Fisheries Resources*). Furthermore, displacing fishing effort from protected areas can place additional stress on adjacent areas, exacerbating stock depletion and invasive species impacts, resulting in negative outcomes for biodiversity conservation and fisheries management (see also FRDC project 2010-226 *An assessment of the threats to marine biodiversity and their implications for the management of State and Commonwealth fisheries*).

Further effort is required to consider the entire south-eastern Australian distribution of the species and address issues such as population connectivity (i.e., sources and sinks of larvae), such as FRDC project 2019-130 that is currently investigating larval dispersal patterns to identify potential source populations between historic Longspined Sea Urchin populations and new areas. As efforts to identify appropriate spatial scale of management controls are progressed in south-eastern Australia, there will be a need for effective coordination among relevant stakeholders in NSW, Victoria, Tasmania, and the Commonwealth to develop a collaborative, regional approach to control and manage Longspined Sea Urchins (see also response to Term of Reference C).

### C. Funding requirements, responsibility, and pathways to better manage and coordinate stopping the spread of climate-related marine invasive species

There has been considerable investment into the management of urchin populations. For example, FRDC has invested in 15+ RD&E activities, valued at approximately $3 million with considerable in-kind contributions from government, research, and industry partners.

Investments have been made through local State governments, the fishing industry, private enterprises, and natural resource management agencies addressing the risks and opportunities created by the increased distribution and abundance of Longspined Sea Urchins. These investments reflect the differing objectives and responsibilities of the stakeholders, for example:

- State government agencies investing in ongoing environmental/fisheries monitoring and assessment activities
- Private commercial entities investing in product and market development based on urchin roe and by-products
- Impacted industry and natural resource management agencies investing in targeted culling activities

Yet much of this investment has been done in isolation – either focused at one element of the issue or targeted at one specific location (i.e., jurisdiction specific). While this has yielded a considerable knowledge base, the lack of coordination is an impediment to reducing impacts on existing reefs and limiting further expansion to facilitate recovery, while promoting commercial endeavours.

FRDC is aware of the positive efforts that State governments are making to coordinate research, monitoring, and planning as it relates to their shared urchin issue. The Australian Fisheries Managers Forum (AFMF) is an important forum to ensure that each of the State and Territory based directors of fisheries are kept abreast of their peers' activities.

Underpinning this planned coordination, Department of Natural Resources and Environment Tasmania (NRE Tas) will host the National *Centrostephanus* Workshop in February 2023. NRE Tas have hosted two such stakeholder workshops in recent years. The workshop planned for 2023 will bring together relevant stakeholders from NSW, Victoria, Tasmania, and the Commonwealth to build on the above-mentioned investment and outcomes to develop a coordinated, regional approach to control and management of Longspined Sea Urchins and to promote commercial endeavours.

If observed shifts in the distribution of Longspined Sea Urchin and abundance increases are a consequence of climate change (e.g., due to increases in water temperature and changes in ocean currents), then efforts to better mitigate or adapt to these threats and opportunities (as per term of reference B) are, in part, dependent on addressing climate change. But such climate change related challenges are not limited to the Longspined Sea Urchin, with large cohorts of marine species considered susceptible to distributional shifts as well as demographic and phenotypic changes – refer to FRDC projects:

- 2011-039 *FRDC-DCCEE: Preparing fisheries for climate change: identifying adaptation options for four key fisheries in south-eastern Australia*
- 2011-233 *FRDC-DCCEE: Growth opportunities and critical elements in the value chain for wild fisheries and aquaculture in a changing climate*
- 2016-139 *Decadal scale projection of changes in Australian fisheries stocks under climate change*.

Hence, there is a need for Australian fisheries management to find options to better adapt to climate change and the positive and negative impacts on reproduction, recruitment, and distribution of marine species (FRDC project 2016-139). Refer to FRDC project 2016-059 (*Guidance on adaptation of Commonwealth Fisheries management to climate change*) for further information on the range of options available to fisheries managers to adapt their decision making to consider climate induced changes.

### D. The importance of tackling the spread of invasive urchin 'barrens' to help facilitate marine ecosystem restoration efforts (such as for Tasmanian Giant Kelp *Macrocystis pyrifera*)

Algal communities (including kelps) provide a range of ecosystem services.

From a commercial wild harvest, recreational fishing, and Indigenous Australian perspective, the preferred habitat of Longspined Sea Urchin overlaps with the habitat requirements of abalone, rock lobster and reef fishes, species that are the basis for nationally significant and well established commercially fisheries. Specifically for abalone and rock lobster, urchin grazing of algal communities renders rocky reefs unsuitable habitat for abalone and rock lobster. FRDC project 2001-044 provides evidence that declines in Blacklip Abalone and Southern Rock Lobster are related to increased Longspined Sea Urchin abundances.

Fortunately, research has shown that the reduction or removal of Longspined Sea Urchins from rocky reefs can result in the rapid re-establishment of algal communities and recovery from barren conditions. FRDC project 2013-026 for example, shows that harvesting urchins had positive benefits for abalone and lobster habitat, which in turn can increase abalone densities.

The implementation of effective management controls for the Longspined Sea Urchins will ensure the integrity and biodiversity value of rocky reef ecosystems and the sustainability of the commercial and recreational species (e.g., abalone, rock lobster and reef fish) that they support.

FRDC notes that addressing uncontrolled abundances of Longspined Sea Urchins is critical in restoring reef-kelp ecosystems. However, the loss of kelp forests is not likely due entirely to Longspined Sea Urchins, but likely an interaction among climate related stressors to the marine environment, commercial and recreational fishing reducing predator densities, creating opportunities for urchins to maintain barrens. Therefore, effective restoration efforts will need to take a holistic approach to recovering from the effects of Longspined Sea Urchins. This will likely include active efforts to promote the re-establishment of algal communities (e.g., through selective breeding programs and enhancement), given the likelihood that algal recruitment will be impacted by warmer waters.

### E. Any other related matters

The expansion of the Longspined Sea Urchin's distribution and increased abundances has created both ecological risks and impacts (e.g., urchin barrens and loss of key habitat for commercially, socially, and culturally valuable species) as well as commercial opportunities (e.g., developing a commercial urchin roe industry). This has the potential to create tensions among stakeholders with competing interests and objectives i.e., eradication vs. exploitation.

Longspined Sea Urchins are potentially just one example of issues that may arise with climate change and the changing distribution of marine creatures (in a general poleward movement). This submission has discussed the evidence of various species showing this migration in Australia.

Regardless of the species, there is a need for State government agencies to explore approaches that strike the balance between these stakeholders and their objectives in understanding and managing the impacts of species expansion and distribution under future climate scenarios, ensuring that ecosystem processes and diversity are maintained, while enabling recreational and commercial opportunities to flourish.

Given the likelihood that targeted fishing effort at key locations is needed to control urchin abundances, fisheries management may be required to adopt an ethos to 'sustainably overfish' Longspined Sea Urchin populations or explore flexible approaches to harvesting e.g., taking urchins from within marine sanctuaries, rotational harvesting etc.

Effective communication among all relevant stakeholders – including the community – will be critical to ensure there is a collective understanding of objectives between different parties and to assist in aligning and collaborating where there is a shared purpose. This will also assist in coordinating investment to maximise impact.

## Concluding comments

Climate induced distributional shifts of the Longspined Sea Urchin from Australia's east coast to Tasmania have transformed large tracts of inshore kelp-rocky reefs into rocky landscapes punctuated by urchin barrens at various scales. This has had considerable impacts on the structure and function of these inshore habitats (e.g., through declines in species densities, altered species diversity, and the loss of critical habitat services).

While there has been considerable effort and investment made to monitor, mitigate, and manage the distributional shifts and increased abundances of Longspined Sea Urchin, research undertaken thus far indicates that active intervention is the most effective approach to managing current impacts and safeguarding from future impacts of Longspined Sea Urchin. This has been demonstrated at relatively small spatial scales and within individual jurisdictions, with commercial fishing and culling proving to be effective at reducing Longspined Sea Urchin abundance and promoting ecosystem recovery.

To tackle the challenges associated with the Longspined Sea Urchin, all relevant stakeholders and jurisdictions will need to collaborate so that actions are more effective and not done in isolation. The National *Centrostephanus* Workshop in early 2023 is an example of how such collaboration can be initiated.

The next stage in managing invasive Longspined Sea Urchins is to scale up current efforts and coordinate them across partners and jurisdictions, such that:

- the targeted removal of urchins (through culling or harvesting) occurs in locations: (i) of functional importance, (ii) that are at the greatest risk of becoming barrens, or (iii) provide the greatest return on investment (e.g., are important sources of urchin larvae)
- urchin removal is done in a way that promotes the harvesting for the roe market while also facilitate targeted culling in areas that would otherwise not be commercially viable – thus balancing ecosystem restoration and commercial fishing objectives
- efforts across partners are synergistic and not competitive

Coordinated management of the control measures should be underpinned by broad scale data collection programs to direct management efforts (e.g., data to inform urchin population models of south eastern Australian, as per FRDC project 2019-130) and to monitor the efficacy of intervention activities.

To date, the small scales and jurisdictional approach to researching and managing the impacts of invasive Longspined Sea Urchin have been funded by the FRDC and through local State governments, the fishing industry, private enterprises, and natural resource management agencies. A well-coordinated and large-scale whole of south eastern Australia program to addressing the impacts of Longspined Sea Urchin would likely require appropriate and enduring Federal Government support.

The Longspined Sea Urchin is one of many marine species undergoing shifts in distribution. Given predicted continued climate change, more species are expected to do the same. The shift of a species into new areas can have considerable ecological and economic impacts. These impacts can be positive or negative depending on species interactions.

Local management agencies are likely to be further challenged to understand the positive or negative impacts of shifting species, and to make the necessary adaptations in regulations and decision-making. This will require innovative and flexible approaches to management and regulation. Australian fishery and natural resource management would be improved by developing a national policy to inform science and management with respect to what degree society wants to preserve the historic ecosystems or develop approaches to manage climate change modified ecosystems.

Completed and ongoing research by FRDC, as outlined in this paper (see Attachment 1), and by other agencies, as referenced in Attachment 2, will play a vital role in informing management options and future actions to mitigate the environmental, economic, and social impact of invasive marine species.

**Attachment 1. Summary of FRDC RD&E project investment related to Longspined Sea Urchins**

| Project No. | FRDC Project Title | Jurisdiction |
|---|---|---|
| 2021-060 | Analysis of historical sea urchin research for improved management of nearshore fisheries in NSW | NSW |
| 2019-130 | Larval dispersal for Southern Rock Lobster and Long Spined Sea Urchin to support management decisions | Tas |
| 2019-128 | Assessing the benefits of sea urchin processing waste as an agricultural fertiliser and soil ameliorant | Tas |
| 2017-050 | Waste to profit in urchin fisheries: developing business opportunities to ensure fishery sustainability and safeguard reef dependent fisheries from destructive urchin grazing | Tas |
| 2017-049 | Monitoring abalone juvenile abundance following removal of *Centrostephanus* and translocation | Vic |
| 2016-208 | Waste to profit in urchin fisheries: developing business opportunities to ensure fishery sustainability and safeguard reef dependent fisheries from destructive urchin grazing | Tas |
| 2014-224 | Rebuilding abalone populations to limit impacts of the spread of urchins, abalone viral ganglioneuritis and other external impacts | Vic |
| 2013-026 | Can commercial harvest of Longs Spined Sea Urchins reduce the impact of urchin grazing on abalone and lobster fisheries? | Tas |
| 2012-058 | Tactical Research Fund: Limiting impacts of the spread of urchins by rebuilding abalone populations | Vic |
| 2011-087 | Tactical Research Fund: trial of an industry implemented, spatially discrete eradication/control program for *Centrostephanus rodgersii* in Tasmania | Tas |
| 2010-564 | FRDC-DCCEE: Preadapting a Tasmanian coastal ecosystem to ongoing climate change through reintroduction of a locally extinct species | Tas |
| 2010-506 | FRDC-DCCEE: Adaptive management of temperate reefs to minimise effects of climate change: developing new effective approaches for ecological monitoring and predictive modelling | |
| 2007-045 | Rebuilding Ecosystem Resilience: assessment of management options to minimise formation of 'barrens' habitat by the Long Spined Sea Urchin (*Centrostephanus rodgersii*) in Tasmania | Tas |
| 2001-044 | Establishment of the long-spined sea urchin (*Centrostephanus rodgersii*) in Tasmania: a first assessment of the threat to abalone and rock lobster fisheries | Tas |
| 1999-319 | Aquaculture nutrition subprogram: Post-harvest enhancement of sea urchin roe for the Japanese market | Vic |
| 1999-128 | Research to develop and manage the sea urchin fisheries of NSW and eastern Victoria | NSW & Vic |
| 1993-102 | Interactions between the abalone fishery and sea urchins in NSW | NSW |

**Attachment 2. Bibliography of peer reviewed research related to Longspined Sea Urchins (note that this list is inclusive of FRDC and non-FRDC funded activities)**


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