



National Centrostephanus Workshop

1 & 2 FEBRUARY 2023

FINAL WORKSHOP REPORT



In recognition of the deep history and culture of this island, we acknowledge the palawa people as the traditional and original owners and ongoing custodians of land and sea country of lutrawita/ Tasmania and pay respects to their elders past and present, who carry and share their knowledge.

Acknowledgements

The Department of Natural Resources and Environment Tasmania (NRE Tas) would like to thank the Fisheries Research and Development Corporation (FRDC) for co-sponsoring this workshop.

We also acknowledge the significant contribution from the Abalone Industry Reinvestment Fund (AIRF), a Government initiative in partnership with the Tasmanian Abalone Council (TACL) to increase the sustainability and productivity of the Tasmanian Abalone Fishery, both biologically and economically, while addressing the impacts of the Long-Spined Sea Urchin.

We recognise the Institute for Marine and Antarctic Studies (IMAS) for their diverse research contributions regarding urchin, kelp, and abalone, and for their contributions to this workshop.

Oscar's Seafood is thanked for providing Long-Spined Sea Urchin roe dumplings for lunch on day one of this workshop, and allowing participants to sample one of the many products for which this species can be utilised.

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1. Executive Summary

The 2023 National *Centrostephanus* Workshop was convened by the Department of Natural Resources and Environment Tasmania (NRE Tas), with co-sponsorship from the Fisheries Research and Development Corporation (FRDC). The workshop brought together 130 representatives from industry, government, research, Aboriginal communities, recreational fishing groups, and the community to:

- Identify challenges and opportunities related to Long-Spined Sea Urchin across regions.
- Identify the R&D gaps across the Long-Spined Sea Urchin range.
- Foster cross-jurisdictional and inter-sectoral relationships, as well as information sharing for improved management outcomes.
- Contribute to the design of a coordinated regional approach for the sustainable management of Long-Spined Sea Urchin –the ‘Regional Management Strategy’.

The workshop included over thirty presentations from researchers, commercial divers, recreational divers, industry, and businesses. These explored the current state of Long-Spined Sea Urchin (*Centrostephanus rodgersii* or “Centro”) range expansion, marine ecosystem health across Tasmania, Victoria and NSW, potential controls and interventions to manage densities below key ecological thresholds, strategies to rehabilitate damaged ecosystems, potential new markets for Centro as a food product, and productive utilisation of waste from food processing. A series of facilitated workshops were held to identify risks, opportunities, actions and research priorities.

Presenters set the scene by sharing data on, and insights into, the range expansion of Centro, citing the warming of coastal waters of south-eastern Australia, which have increased by 2 degrees Celsius over the past 100 years. The increased frequency of marine heatwaves has also had a significant impact on marine habitats and ecosystem health. It is estimated there are now over 20 million Long-Spined Sea Urchins in Tasmania waters alone, impacting over 1,500 kilometres of coastline.

Workshop participants were invited to share what they considered to be the biggest challenges and opportunities posed by Centro. There was consensus that range expansion is having a significant impact on the ecological integrity and functioning of large areas of Tasmania’s East Coast rocky reef ecosystems, with some impacts reported along the Victorian and New South Wales coastlines. Concern was raised that incipient barrens are becoming more numerous, causing critical changes in the systems.

Protection and reestablishment of the great southern reef and kelp forests is seen as a priority. Participants and speakers see an opportunity to implement new integrated ecosystem-based management approaches based on the sound modelling programs. This will identify critical points within each

ecosystem where overgrazing by Centro will result in collapse, and will identify priority areas for action. It was recognised that management should include collaborations between states, different rights-owners, and stakeholders, and should work to drive the carbon neutrality of habitat restoration.

Co-ordinated monitoring and removal by commercial divers is seen as an economical and environmentally friendly option. The effort helps to stop growth of existing barrens, prevent new barrens from forming and promotes recovery of existing barrens. Continuation of the current subsidy in Tasmania was generally supported, although the flow-on effects in other states were noted. Development of further subsidised dive programs in all states to remove Centro from reef ecosystems was discussed as an opportunity if appropriate funding could be secured. Ranching to improve marketability was demonstrated as a potentially viable option to increase product quality in future, and utilising other divers - abalone and recreational divers – for culling operations was discussed. It was felt work was needed to better engage the recreational dive sector and incorporate citizen science programs in Centro monitoring, removal and reporting. Robotic systems were considered a potential solution for amplifying deep water activities. There was discussion that biological control via predation by enhancing Blue Grouper or Rock Lobster populations can be part of the solution, but greater consideration of this is required.

It was recognised that, unlike other over-abundant marine species such as the Crown-of-Thorns Starfish on the Great Barrier Reef, Centro presents an economic opportunity. The successful harvest of Centro has created a new fishery which provides product to the Tasmanian premium seafood market, delivering economic and employment benefits while reducing the overall impact of Centro on reefs and fisheries. Participants were keen to explore further opportunities to use Centro as a resource, and drew on the example of invasive Caribbean Lionfish. For example, the viscera shows promise as a fertiliser product and there is further opportunity to brand Centro as a luxury seafood and create new markets for product. Participants expressed the need for a strategic communication campaign that positions Centro as a luxury food while considering the negative impacts of its range expansion, and the fact it is native to NSW so marketing must be careful not to impact its perception in this regard.

Ultimately, all participants agreed there is an immediate need to implement a coordinated and integrated approach to managing Long-Spined Sea Urchin. Participants were keen to see the development of a new nationally coordinated Centro strategy which considers nuances from all jurisdictions. They stressed the need for improved political alignment, coordination, commitment, cross jurisdictional funding and continuity of the investment.

1. EXECUTIVE SUMMARY

There was broad agreement that the lack of national funding was a major factor limiting more effective control. They also declared a need for political investment in ecosystem recovery and maintenance for the Great Southern Reef, with coordination of activities to manage the impacts/expansion of urchins and the development of clear policy which gives direction on urchin control strategies. It is essential that this funding consider the unique needs of Centro control and management in Tasmania, Victoria and New South Wales, with consideration given to the various sectors and rights-holders.

A significant outcome of the workshops was a commitment to establish a Task Force comprising representatives of the three State fisheries agencies, the CSIRO and the FRDC. Additional Commonwealth agency participation will be sought, with opportunity for involvement from other organisations, including peak bodies and First Nations, to be developed in future. The immediate focus of the Task Force will be to produce a business plan for collaborative management of *Centrostephanus* by June this year.

Other priority actions agreed in the workshop include:

1. Development of a coordinated Federal & State leadership framework, which recognises marine range shifters and creates a scalable model for managing them. This framework must drive commonwealth recognition, investment and ongoing management of the Great Southern Reef and include supporting research to support knowledge into sustainable harvests, commercial viability of harvesting from barrens and harvest strategies.
2. The development of standardised methods for collecting, storing and sharing urchin management data, knowledge and practices between jurisdictions.

3. Seeking Federal Government support for a coordinated management approach between State governments, research agencies and RDCs. This coordinated effort would need to build on and complement the ongoing stewardship efforts of local communities, industry, research agencies, and government that have already been undertaken in Tasmania and other jurisdictions.
4. Research to develop clear understanding of what is an acceptable reef state (percent barren coverage) across the jurisdictional gradients. Acknowledging that eradication across all of Tasmania and Victoria is not feasible, but perhaps certain areas can be concentrated on, such as pristine areas (ecologically valuable and important to eco-tourism) and areas important to the crayfish and abalone industries.
5. Development of a national Centro management decision-making toolbox, which is delivered at an appropriate scale (e.g. regional, State, zone and/or reef). This action needs to be coordinated by a National taskforce and consider the needs of Centro control in Tasmania, Victoria and New South Wales.
6. The establishment of a First Nations southern alliance, which provides an equal place in the decision making framework.

Finally, the delegates were keen to maintain communication on next steps, timelines, targets and activities. They would like to see meaningful objectives set at the cross-state level and receive clear communication on how these are progressing. They also sought insights into funding commitments that address priority actions relevant to each jurisdiction, and how those were aligned to a broader management plan.





2. Workshop Context

The Tasmanian government in partnership with the Tasmanian Abalone Council Ltd, under the Abalone Industry Reinvestment Fund (AIRF) program, hosted forums in 2018 and again in 2019, bringing together a variety of representatives from industry, government, research and community members engaged in *Centrostephanus* research, management, mitigation and prevention efforts.

In 2022, state-based workshops were held in Victoria and New South Wales to share knowledge and address local Long-Spined Sea Urchin management and research questions. Those workshops engaged regulators, researchers, abalone and commercial dive industry representatives, cultural fishing representatives, environmental groups, and the community. Further, in 2022, a spotlight was shone upon this species at the national level by way of a Senate Inquiry into the spread of climate-related marine invasive species. The Senate Inquiry has the following terms of reference:

*The spread of climate-related marine invasive species, particularly Long-Spined Sea Urchins (*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 Long-Spined 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 co-ordinate 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*); and*
- (e) *any other related matters.*

3. About the Workshop



In light of this Senate review, the 2023 National Centrostephanus Workshop was convened by the Department of Natural Resources and Environment Tasmania (NRE Tas), with co-sponsorship from the Fisheries Research and Development Corporation (FRDC). The workshop brought together over 130 representatives from industry, government, research and the community to:

- Foster cross-jurisdictional and inter-sectoral relationships, as well as information sharing for improved management outcomes.
- Identify the R&D gaps across the Long-Spined Sea Urchin range.
- Identify challenges and opportunities related to Long-Spined Sea Urchin across regions.
- Contribute to the design of a coordinated regional approach for the sustainable management of Long-Spined Sea Urchin –the “Regional Management Strategy”.

Presentations and group discussions explored the current state of management and research, and worked to identify the knowledge and operational gaps, considering where the key challenges and opportunities lie. There was strong discussion and debate which has provided a foundation from which to advance a regional management approach. This report, and associated recommendations, will be provided to the Senate Inquiry and made available to lead and inform research, management, and education organisations in each state and at the national scale.

4. Key themes from presentations

Invited presenters worked to set the scene on the impact of climate change on Centro range expansion, provide an update on ecological thresholds, social, economic and environmental impacts of Centro, management and control opportunities and actions, plus opportunities for Centro as a food product and waste utilisation. The following themes, messages and actions emerged:

- **CLIMATE CHANGE HAS DRIVEN RANGE**

EXPANSION OF CENTRO: Presenters set a clear picture of the impact of Centro in Tasmania, with emphasis placed on the impact climate change is having on Tasmanian waters. It was reported that the coastal water temperatures around south-eastern Australia have increased by 2 degrees Celsius over the past 100 years. This is three times the average increase in global ocean temperatures. This change has impacted Tasmanian marine ecosystems, altering habitats and species distribution (in fact, there have been 198 different species have changed their distribution over the last decade in Tas), and depleting kelp forests and sea grasses. One of the major changes in species distribution has been the incursion by Long-Spined Sea Urchin, *Centrostephanus Rodgersii* (Centro). It was reported that this species arrived in Tasmania in the 1600's, moving from its endemic NSW waters through currents into eastern Victoria and Tasmania. It has been reported as south as Port Davey in Tasmania, and even into eastern New Zealand.

- **CENTRO RANGE EXPANSION HAS HAD**

SIGNIFICANT IMPACT: The impact of Centro has been significant, with researchers estimating that the ecological integrity of over 1500km² has been impacted. Range expansion now extends through southern NSW, eastern Victoria and as far south as Port Davey in Tasmania and east into northern New Zealand. This has resulted in depleted kelp forests and sea grasses, increased disease and habitat shifts.

- **BARRENS ARE BECOMING MORE NUMEROUS:**

Concern was raised that incipient barrens are becoming more numerous, causing critical changes in the system. It was stated that there are now over 20 million Long-Spined Sea Urchins in Tasmanian waters, and Tasmania has lost more than 15% of its rocky reef habitats and more than 95% of its once verdant kelp forests.

- **CENTRO IS IMPACTING INDIGENOUS**

CULTURE: Indigenous sea managers reported population declines in native elenclus and maireener shells, and sea grasses, altered ecosystems, and an impact to the social values of associated Aboriginal culture. A recent survey conducted by Joonga rangers, from the Land and Sea Corporation, found that of the 65 traditional owners and knowledge holders (who speak for up to 300 people) 70% recognise that sea urchins are a cause of sea country degradation and 100% said they would be willing to participate in programs.

The survey confirmed what the community had felt for a long time, that sea urchin are having negative effects on sea country.

- **THE ABALONE INDUSTRY IS IMPACTED**

SIGNIFICANTLY: There has also been a significant impact on industry and economic productivity. With more than \$50m of annual abalone production alone at risk with Centro outcompeting for resources and 'reef space'.

- **ERADICATION IS IMPOSSIBLE:**

Speakers presented the harsh reality that Centro incursion into Tasmania is a result of a changing climate and nature driven factors such as oceanic currents and the life span of the larval phase, therefore eradication is deemed to be impossible.

- **REDUCING URCHIN DENSITY IS ESSENTIAL:**

Reducing urchin density is essential, as once kelp forests are overgrazed they are hard to recover. It is estimated that there needs to be less than four urchins per 10m² area. It was stated that early, preventative removal before urchin density reaches a tipping point and barrens begin to form is the most effective way to control the expansion of urchin barrens.

- **DIVER SUBSIDY HAS ACCELERATED REMOVAL AND CONTROL, AND HELPED BUILD A**

CENTRO MARKET: It was recognised that the commercial dive fishery has been the primary means of controlling urchins in Tasmania, and that the subsidy (paid through the Abalone Industry Reinvestment Fund) was essential in driving down urchin abundance. Harvesting programs, such as those initiated by the Tasmanian Abalone Council in 2017/18, provide a low-cost product to processors, while effectively removing and rejuvenating reef ecosystems (and Abalone habitats). It also created a viable fishery and contributes to job and market creation. It was suggested that projects, trials and subsidies are an essential management tool, and that more dive effort within the sector should be captured. Subsidies should be continued to help direct effort into these areas, and models must be considered across Victoria and NSW.

- **CULLING CAN HELP RESTORE REEFS:**

Dedicated urchin culling by commercial divers and recreation divers can be used to restore reefs, in cooperation with harvest programs. Presenters summarised methods for urchin culling and harvest by divers and demonstrated the successful results in the Beware Reef region of Bass Strait. Pre cull

4. KEY THEMES FROM PRESENTATIONS



surveys were getting 7-8 urchins per square meter and following the first cull, there were 0.5 and no new recruitment. New kelp growth was recorded with positive results. A total of 24,000 urchins were culled and the project returned a 6.71 benefit ratio. NSW have also implemented cull programs and presented a case study on one which saw a cull over 47 diver days, achieving a culling rate of 1200 – 1800 urchins per hour. Over 270,000 urchins were culled across a 10.4 HA site. Ecosystem monitoring post cull saw an increase of macroalgae barrens and decreases in urchin barrens. There was an increase in roe quality following the cull. It must also be noted that recreational divers are culling on an ad hoc basis, with some manufacturing their own rods and returning to the same patch to destroy urchins. Further support and guidance is needed to support these efforts while encouraging safe operation.

- **MODELLING PROGRAMS ARE ESSENTIAL TO INFORM ECOLOGICAL LIMITS:** Modelling the impact of fishing on Centro density in Tasmania has provided quality insights into strategies for reaching ecological targets. Modelling considers stock dynamics, removal strategies and ecosystem conditions, such as biomass, depth, location and species mix. Modelling the stock dynamics and removal strategies enables the testing of different management strategies before management actions are undertaken. This improved knowledge can help guide sustainable fishing and density targets, and therefore help inform decisions and estimate 'bang for buck'. It was emphasised that modelling is an important tool when presenting data to Government for funding as it can help demonstrate effectiveness of proposed control options.
- **MARINE SPATIAL PLANNING IS A USEFUL TOOL:** There are new marine spatial planning tools which can allow a more integrated approach to management through analysing and allocating the spatial and temporal distribution marine areas.

- **TAKE ALL SIZE HARVESTS ARE A COST EFFICIENT CONTROL METHOD:** It was discussed that 'Take all size harvests' are cost efficient and are considered in Tasmania to be more effective than culling, considering that this process allows product utilization (both food product and waste product) and data capture, plus it supports the food sector, waste processing, jobs and the market sector. It should be noted that divers have trained and invested in equipment to harvest out to depths of 30m, which encompasses 82% of the Centro biomass.
- **NEW PROCESSING TOOLS DRIVE BETTER PRODUCT UTILISATION:** New processing techniques have allowed better processing of smaller Centro, meaning there are minimal animals being left behind in an everyday harvest. This results in more product, more usable waste and more removal. In other words, there are strong incentives to harvest small urchins and not just focus on larger individuals.
- **HARVEST PROGRAMS ARE BENEFITING THE TASMANIAN ECONOMY:** While it is recognised that the preference would be to have an ecosystem free of Centro, there is now a thriving harvest industry in Tasmania, supporting over 150 direct jobs. The quality food product (roe) is having a positive flow-on effect in the economy. Divers also report ecosystem recovery, with increased numbers of abalone, rock lobster and scale fish amid significantly lower urchin numbers. The Tasmanian annual commercial harvest, supported by subsidies, is around 500 tonnes.
- **ENGAGEMENT WITH INDIGENOUS SEA OWNERS IS ESSENTIAL:** A commercial dive training program was designed to maintain culture, Sea Country health and provide economic and commercial opportunities for the Yuin mob on the South Coast of NSW. This program is helping the community and health of Sea Country. Engagement with indigenous sea owners will be instrumental

4. KEY THEMES FROM PRESENTATIONS

to the success of Long-Spined Sea Urchin management and to restore native ecosystems as their longstanding knowledge of country will greatly assist management.

- **CITIZEN SCIENCE PROGRAMS CAN ADD VALUE TO OTHER PROGRAMS:** There is an opportunity to grow citizen science programs to assist in Centro management and surveying, with knowledge on engagement to be considered from other national and international programs. Knowledge can be better captured via images, quadrant counts and culls.
- **RECREATIONAL DIVERS WANT (AND SHOULD) BE INCLUDED IN MANAGEMENT:** Recreational divers want to be part of the Centro management solution, and can offer support through cleanup dives, citizen science, reporting, etc. Recreational divers are a big part of the community and are keen for better engagement in eradication and clean-up activities. They are also keen to have access to data on priority sites (as they often revisit so can monitor and update), plus can contribute survey data on their activities. New platforms are sought to track and log data.
- **PREDATORS CAN PLAY A LIMITED ROLE IN CONTROL:** Predators such as Gropers and Lobsters can assist 'keeping a lid on urchin numbers' if below a certain threshold. Above this, lobster control is not viable i.e. it moves past the threshold where they can impact the recruitment or settlement. Research also suggests that the divers could remove the same amount as Blue Gropers. Further investigation is required in this space to determine knowledge, and implications from the commercial lobster and abalone industry.
- **ROBOTICS CAN HELP CHART DEEP WATER CENTRO MANAGEMENT:** Managing urchins at depth is of both ecological and economic importance, as there are physical and safety limitations to the recreational and commercial diver culling methods used in shallow water. There are currently no efficient removal tools to control urchins at depth. Cull robots are a key solution to consider. New robots are equipped with vision systems for surveying,

covering trajectories, and maintaining position to cull. They can also capture data kelp cover, urchin density and test size while culling.

- **WE NEED TO LEARN FROM OTHER CONTROL PROGRAMS:** The Crown of Thorns Starfish (CoTS) management response strategy on the Great Barrier Reef received significant funding and included an effective and proven Integrated Pest Management Approach (IPM) that could be applied to the Tasmanian Centro issue. The Lion Fish project also provides valuable learnings with regards to community engagement in culls, cooking options and ongoing management to restore reef ecosystems.
- **CENTRO WASTE SHOWS POTENTIAL FOR AGRICULTURAL LIMING PRODUCT:** Centro waste is an opportunity to be captured. Initial research shows the waste offers great potential as a liming agent for agriculture.
- **BRAND DEVELOPMENT IS NEEDED:** There is a need to develop a better brand for Centro roe, which considers that it is endemic to some regions and an invasive pest in others. It will be important to manage this positioning carefully, so as not to damage Centro roe as a luxury food item.
- **CROSS JURISDICTIONAL MANAGEMENT IS A MUST:** Centro is not only an issue in Tasmania. Presenters and participants provided clear information on the impact of Centro in Victoria.



5. What are the biggest challenges posed by Centro?

Participants were invited to share what they consider to be the biggest challenges posed by Centro. Participants worked in groups to define their key challenge, with all groups reporting back on their priorities, and contributing to the wider discussion.

Participants stressed that there is a need for improved management at a National level which sees greater political alignment, coordination, commitment and investment. Many raised concerns that Centro management has not received the same level of funding, or priority in the national marine stewardship programs as the Great Barrier Reef, even though the impacted area is similar.

The range expansion of Centro is of high concern, and seen as a significant management challenge, given its impact on the ecological integrity and functioning of large areas of Tasmania's East Coast rocky reef ecosystems. Concern was raised that incipient barrens are becoming more numerous, causing critical changes in the system with many suggesting that greater monitoring and cross jurisdictional management is needed to better understand and identify the critical points within each ecosystem where overgrazing by Centro will result in collapse.

Participants raised concern that Centro invasion may just be the start of the expansion of a range of non-native marine species into Tasmanian waters, given the climate change

predictions the location at the end of the East Australia Current. It was noted that 198 species have changed their distribution over the last decades in Tasmania, and that more changes are likely to occur. Participants discussed the severity of this problem at an ecosystem level, with many raising concerns over the lack of coordinated funding, cross jurisdictional management and policies.

Concern was also raised about the impact of Centro expansion on the social, economic and productivity of cultural, recreational and commercial fishery businesses. Participants discussed the need for ongoing forecasting, modelling and planning to ensure we are prepared for the management implications. They also discussed the need to better engage the community through improved communication, education and engagement campaigns, such as citizen science. Communication needs to be balanced so the perception of sea urchin as a luxury food product is not impacted.

To better define and understand the issues and challenges associated with Centro, participants worked in groups to identify and describe the key issues of Centro (Table 1). A general consensus was the need to recognise the diversity of management strategies and the mechanisms needed in each State. The following themes were identified as priority challenges / issues by the working groups:

TABLE 1: Major issues caused by Centro range expansion into Tasmanian waters.

ISSUE	DESCRIPTION
National funding	There is a lack of national funding, which impacts how we can manage Centro. Large scale coordinated national funding, which allows different management approaches per region, is needed to ensure more coordinated efforts and larger scale action. It was noted that there may be an opportunity to consider market based incentives to complement public funds.
Continuity of funding	Short term, disjointed funding impacts the long-term success of management. Continuity of funding, on an ongoing basis, is needed to support control and industry development activities. This also ensures better project design, more robust research knowledge and outcomes, and support better jobs security.
Need for a national strategy	There is a lack of national mapping which clearly defines Centro management activities across Australia. Work is required to underpin the development of a national strategy, which brings together RDCs, government agencies, industry, commercial and recreational divers and Indigenous Sea owners. It should be noted that we have the knowledge and opportunity to define the approach, so the funding and support is now required to implement this.
Political alignment and funding	There are different perceptions of the key challenges between states and among different groups. This is hindering the management response. There is a need for improved political alignment, coordination, commitment and investment. Plus, a need for political investment in ecosystem recovery and maintenance, coordination of activities to manage the impacts/expansion of urchins and the development of clear policy which gives direction on urchin control strategies. Political alignment must be backed with bipartisan funding and work to recover the habitat. Agreement on a management approach is required ASAP and we must work collaboratively to prioritise prevention vs cure.
Improved knowledge mapping	Improved knowledge is required, with participants seeing worth in the mapping of historical impacts through to current time. It is also essential to use indigenous knowledge to understand range expansion and what this has meant to Sea and Country.
Public literacy of Centro	General public awareness and improved marine literacy of the issue is required. Education and engagement programs are needed which help build awareness and understanding of the science, impact and management options.
Public awareness of Centro	There is a lack of strategic communication of the Centro issue (and its complexity). A national communication campaign is required to help raise awareness of the need for management, drive funding calls, and help build citizen science initiatives. Communication needs to be balanced so the perception of sea urchin as a luxury food product is not impacted.
Harvest subsidy	A harvest subsidy could help direct effort and keep areas in check. The current subsidy disruption is hindering the market development. Harvest subsidies need to be considered on an ongoing basis.
Development of domestic markets for urchin products	There is a need to keep growing the consumer uptake of urchin purchase, and look at ways this could support/fund ongoing intervention. Urchin roe is a delicacy and important seafood product, so the development of new markets should be driven to increase consumption, awareness of how to prepare and where to purchase.
Scale and magnitude of Centro invasions	It was recognised that the scale of the problem is one of the major issues with over 2,000km (which is equivalent to the Great Barrier Reef) being impacted. Need ways to segment this region into manageable areas, and utilise models to prioritise areas for harvest / culling, and then monitor response.
Climate change	Continued impacts of climate change is seen as a major concern as this will impact further dispersal and species distribution. There is a need for continual modelling and forecasting. The extremely fast rate of change in Tasmanian ecosystems makes it difficult to manage the problem, however, there is a potential social benefit of using 'cure' management approaches. NOTE: Having a species specific view on urchins can come at the cost of broader ecosystem management.
Access to the resource / marine parks	Concerns were raised regarding the bureaucracy around access to reefs and marine parks. Consideration needs to be given to sanctuary zones in NSW. It was suggested that there is a need to review the Sea Urchin Management Plan failure in the VIC Eastern Zone.

5. WHAT ARE THE BIGGEST CHALLENGES POSED BY CENTRO?

Lack of support for the commercial dive sector	Ensuring that the commercial dive sector is profitable is essential. Need to ensure that divers are able to continue removing urchins, so populations sit under the set thresholds. Need better communication products to support the commercial dive sector, and identify and track progress.
Skilled labour availability	<p>There is a lack of skilled labour to adequately service the Centro control issue. Community engagement and awareness may help attract more people to this industry and see value in a seafood career.</p> <p>It will be important to engage with the Skills Commission should large scale funding be awarded, so the skills needs can be promoted.</p>
Access to appropriate facilities	Access to appropriate facilities to support Centro management is essential to underpin successful management, processing and marketing. Participants are keen to see support for the set up of urchin processing facilities, as these are often unique and usually have to be purpose-built, requiring specialist infrastructure. Therefore, funding is needed to ensure the industry has the facilities needed to manage the control on an ongoing / long term basis.
Aligning control of urchins with viable cost-effective commercial opportunities.	Aligning control of urchins with viable cost-effective commercial opportunities is needed to ensure funding and responsibility is shared across stakeholders. A stakeholder mapping plan needs to be conducted to ensure we understand who and how to engage.
Managing sustainable fisheries and healthy ecosystems.	Changing the status quo should be a priority i.e. challenge our thinking and approach to how we have sustainable fisheries and healthy ecosystems. Research is needed to strike a balance, set benchmarks for different regions and identify unknown gaps in sustainability targets for specific regions.
Stemming the tide (TAS/VIC) - trying to control a population with continued input of larvae	It was recognised that it is a challenge to control the Centro population with a continued input of larvae. There is a need to recognise the different places which are impacted, and the huge range of risk contexts (e.g NSW, VIC, TAS) which result from this larval dispersal. It has different impacts and these need to be assessed, measured and managed on a case by case basis.
Stop them moving into Tasmanian waters	Participants questioned how to stop Centro from coming south, recognising it is challenging to manage this at a larval stage. It was discussed that stopping incipient barrens from becoming extensive is essential.
Inter-jurisdictional coordination between research and management programs, including increased investment and strategic communication	<p>Navigating and co-ordinating the jurisdictional approach is essential to ensure Federal funding. i.e. There is a need to ensure a nationally co-ordinated approach, which will enable larger investments and make greater impact. We need agreement and acceptance of the science so we can work to re-establish habitats for the benefit of whole ecosystems and critical species, not just socio-economic motivators.</p> <p>Ongoing liaison is required to ensure there is agreement across sectors/groups as to what is the goal for Centro management.</p> <p>Jurisdiction coordination of control and management efforts is required as there is currently a lack of:</p> <ul style="list-style-type: none"> • Support / review multiple actions of management. • Applied research / Fisheries information. • Research in NSW regarding the ecology of barren formations.
Balancing commercial (harvesting) versus conservation objectives	More knowledge is needed to define the acceptable extent of barrens, given past and ongoing ecosystem changes. From here, a plan is needed to balance commercial harvesting vs conservation objectives. Should we allow/ facilitate culling?
Finding and balancing a sustainable system	Finding some sustainable solutions to the multiple pressures (e.g. climate change, overfishing). Mitigating the impact of Centro (time, resources, funding)

The above challenges were not voted upon, so are not presented in the order of importance or ranking. Instead, each table was asked to discuss what they think the priority challenge is.

6. What are the biggest opportunities posed by Centro?

Workshop participants were asked to consider the biggest opportunities posed by Centro. In a facilitated session, participants worked as groups to identify and define opportunities. In these discussions it was recognised that unlike other over-abundant marine species such as the Crown-of-Thorns Starfish on the Great Barrier Reef, Centro provides a significant economic opportunity.

The urchin roe is a valued food source locally, nationally and globally and the viscera shows promise as a fertiliser product. Another opportunity includes commercial harvesting of urchin, which is increasingly being undertaken alongside other, more

locally targeted control efforts by recreational divers, Aboriginal sea country rangers, researchers and citizen scientists.

The potential for economic growth through the development of new products and markets, new integrated ecosystem-based management approaches, and creating a sustainable industry were common themes discussed. To underpin these opportunities, there is the need for a strategic communication campaign which carefully positions Centro as a luxury food, while considering the impact it has through range expansion. Table 2 presents the opportunity themes which were identified by the working groups.

TABLE 2: Opportunities to explore considering the Centro range expansion into Tasmanian waters.

Key Theme	Opportunity Description
New products and markets with commercial value.	It was discussed that there is an opportunity to use Centro as a 'resource', and work on the creation of sea urchin commercial products (e.g. organic fertilisers). There is also a real opportunity to create local, national and international markets for Centro products and build its brand as a luxury seafood. Industry should be exploring the use of middle/lower quality urchin roe in food avenues such as dumplings, or the use of by-product in fertilisers and in Chinese medicine. A piece of work is needed to map the economic opportunities (employment, industry) and inter-industry collaboration space, with industry working to achieve 'triple-bottom line' benefits (economic + social + environmental).
Ecotourism	There is an opportunity to create new local eco-tourism experiences (i.e. replicate the community incentive initiatives to remove lionfish). Such programs can build local employment, markets, awareness and opportunities. There is potential to engage the recreation and tourism sectors, so they contribute to addressing / funding management options.
New technologies	Innovators have scope to explore opportunities to build regional bespoke harvest industries, along with associated new technological developments. There are opportunities to develop new technologies for Centro management, including camera sensing, robots, mapping, control strategies and harvesting.
Restoring habitat and productivity to the benefit of traditional owners and all stakeholders	Engagement and working in partnership with First Nations is an essential action. There is scope to use First Nations' voice to pressure change, e.g. the establishment of indigenous special protected areas (NSW). There is scope to explore new opportunities for regionally coordinated approaches and consider the creation of value from urchin harvests and restoring reef ecosystem-based fisheries using traditional knowledge. Also, opportunities to explore the potential for both regional and interstate cooperation which works towards restoring reef ecosystem fisheries and building commercial opportunities from harvesting. Note the need to rehabilitate reefs to preserve important ecosystems.
Nationally co-ordinated harvest strategy	Participants are keen to see the development of a new nationally coordinated harvest strategy which considers nuances from all jurisdictions. This must consider: IP transfer from international processing sector and post harvest methodology research.
New integrated ecosystem-based management of the Great Southern Reef	Reestablishment of Tasmania's great southern reef and kelp forests is a priority. There is great opportunity to develop a new, integrated ecosystem-based management approach of the Great Southern Reef via new collaborations between states and among different rights-owners and stakeholders. This collaboration should be exploring carbon neutrality of habitat restoration.
Habitat restoration opportunities	There is also an opportunity to use urchin management as a case study on how to manage other range extending species and develop new models for sustainable management including cross state, cross sector collaborations.

6. WHAT ARE THE BIGGEST OPPORTUNITIES POSED BY

Exploring and testing new fisheries and ecosystem management approaches	There is an opportunity to experimentally test fisheries and ecosystem management approaches including, where acceptable or even desirable, the results of over-fishing. Consider how to diversify fisheries opportunities to provide increased flexibility.
Centro fishery -Development of a commercially viable but sustainable industry	Centro has a commercial value, unlike COTS, that enables/ incentivises removal of urchins. There is the potential to create a new industry based on the Centro fishery, and work is needed to map / capture the flow-on benefits while considering ecosystem management.
Creating a sustainable industry	Creating a sustainable industry could help self-fund this issue. It will be important to demonstrate control achievements at small scale to warrant investment in expanded efforts at larger scales. There is the potential to drive strategic collaboration among stakeholders/ sectors /states to address the shared issues and create a shared industry outcome of benefit. There is also a need to have area-specific control measures which allow for a tailored management approach given the nuances of each system. It will require regulated sustainable fishery opportunities/ ecosystem-based fishery management, including MPA's.
Improved habitat for abalone and other species	There is ongoing support from the abalone industry to manage Centro, so ongoing engagement and working collaboratively on management approaches is required. The recovery of the abalone and lobster fisheries might see ~\$25 million in abalone value restored. It will be important to engage well and engage early with this sector to ensure collaboration and buy-in.
Development of a sustainable supply of protein and utilisation of waste	There is the potential to develop a sustainable supply of protein and productive utilisation of waste, e.g. in liming amendments for agriculture. This process should involve mapping and identifying extensive barrens where yield is low but there is commercial opportunity for other uses.
Holistic strategy based on knowledge	The development of a holistic strategy based on knowledge is a great opportunity to generate progress. The knowledge exists (e.g. CSIRO report) so this should be captured. The strategy should consider spatial planning for a diversity of values/stakeholders and a unified market approach, including telling the story to community.
Communication to public	<p>Queensland created a successful public engagement campaign around the Crown of Thorns Starfish. This strategy should be considered in developing a Centro Management comms campaign, given the scale of the problem is similar. Participants all agreed that there is a need to develop a strategic communication campaign which raises awareness of the Centro issue, while promoting the opportunities to develop food and waste management industries. Communication provides an opportunity to demonstrate the impact of climate change, and how science in collaboration with indigenous land and sea owners, industry and government is working collaboratively to mitigate the impacts.</p> <p>It is seen as important to get Australians excited about eating urchins to help strengthen a sustainable domestic commercial market.</p> <p>There is also a need to create an education program for recreational fishers which promotes urchins as a food source not just culling.</p>
Build workforce	There is a need and opportunity to build an ongoing workforce i.e. by increasing the use of all parts of the urchin you can provide continuity for a labour force. There is the potential to fill in gaps in seasonal harvest of other species (e.g. oysters) and develop cross sector seafood / marine ecosystem jobs.
Stakeholder collaborations to mobilise impact	Stakeholder collaboration can be utilised to drive momentum and impact. It is important to ensure cross-jurisdictional integration with an ecosystem view of managing the sea urchin issue. There is also a need of developing a carefully constructed stakeholder management plan which maps all groups involved.

7. Key actions to improve Centro management

Participants were given the opportunity to present priority ideas to improve Centro management. Participants worked in groups to develop and define these ideas (Table 3). All participants then had the opportunity to vote on the top three actions which they thought would have the greatest impact.

A significant outcome from the workshops was a commitment to establish a Task Force comprising representatives of the three State fisheries agencies, the CSIRO and FRDC. Additional Commonwealth agency participation will be sought over the

coming weeks. The Task Force intends to produce a business plan for collaborative management of *Centrostephanus* by June 2023.

Management recognised that action needs to be taken over the coming months, and committed to having the steering group and business plan completed by June. They will also seek opportunities to engage a person who is committed to the delivery of this work.

Table 3: Priority actions to improve management of Centro in Tasmanian waters.

ACTION	# VOTES
<p>Development of a coordinated Federal & State leadership framework, which recognises marine range shifters and creates a scalable model for managing them. This framework must drive Commonwealth recognition, investment and ongoing management of the Great Southern Reef. It must also:</p> <ul style="list-style-type: none"> • Include development of a national strategy / business plan, which defines the aims, actions and outcomes sought at a state level. • Address ongoing funding to ensure the desired results are achieved. • Include research to: <ul style="list-style-type: none"> - Determine and define what is a sustainable harvest, and what is viable for different areas, noting different parts of the state may require different approaches (i.e. removal or sustainable fishery). - Define the commercial viability of harvesting from barrens for pre spawning windows, and how this impacts the ecological community. - Identify how to harvest most effectively, as it is felt that there is a need to prioritise harvest over culling. - Review what decision-making models work in a cross-jurisdictional setting. 	27
<p>Creation of a multi-sector, cross-regional steering committee with a dedicated coordinator.</p> <p>This must include paid committee positions and representation from First Nations to ensure their voices are heard and knowledge utilised, respected and valued.</p>	22
<p>The development of standardised methods for collecting urchin management data and the development of centralised database for storing and sharing knowledge between jurisdictions.</p> <p>Points to note:</p> <ul style="list-style-type: none"> • Need consistent and comparable data collection and reporting across jurisdictions, underpinned by commitment to sharing data to allow for holistic, cross-jurisdictional management of <i>Centrostephanus</i> and predators. • Information sharing and knowledge transfer is required (i.e. standardised terminology, measurement, modelling, monitoring, etc). 	20
<p>Research to develop clear understanding of what is an acceptable reef state (percent barren coverage) across the jurisdictional gradients.</p> <ul style="list-style-type: none"> • Acknowledge that eradication across all of Tasmania is not feasible but perhaps certain areas can be concentrated on, such as pristine areas (ecologically valuable and important to eco-tourism) and areas important to the crayfish and abalone industries. • Need to define desired outcomes by region, including the social, cultural, and economic objectives (what is the shared vision?) bearing in mind that these are likely to vary across jurisdictions and at different spatial resolutions. 	16
<p>Development of a national Centro management decision-making toolbox, which is delivered at an appropriate scale (e.g. regional, State, zone and/or reef). This action needs to be coordinated by a National taskforce, and should:</p> <ul style="list-style-type: none"> • Be centred on the overarching/underpinning objective of ecologically resilient reef ecosystems. • Must be inclusive of NRM's / Be multi-sectoral. • Sit under the steering committee, and be established after the overarching agreed goals/shared vision has been defined. 	16

Funding and structure of national subsidy program to mobilise the commercial dive sector.	13
Establish a First Nations southern alliance, with parallels for management and science. First Nations need an equal place in the decision making framework. The alliance will need:	12
<ul style="list-style-type: none"> • Consistent and comparable data collection and reporting across jurisdictions, underpinned by a commitment to sharing data. • Access to quota information, as it currently seems as if this is only available to the commercial fishing sector. • More reporting on the percentage of abalone harvested, so this is transparent to all groups. • A process for gaining consent to dive in traditional waters (people can currently dive without consulting traditional owners or local communities). We need to work better together. 	
Market development and urchin product promotion, underpinned by a cross-fishery coordinated market development strategy. Points to note:	10
<ul style="list-style-type: none"> • Processors and fishers need to be part of the discussion to develop the industry. • Tasmanian First Nations communities are concerned that fisheries goals (money/efficiency) are prioritized over ecological goals /conservation. This needs to be monitored, with the ecosystem prioritised. 	
Addressing depletion of predator and competitor species of Centro in general	8
Seek funding for post-harvest innovation. Points to note:	9
<ul style="list-style-type: none"> • Successful private sector involvement will be necessary to make inroads into management of the species. • Communicate advances in industry with stakeholders, including customers. • Investigate carbon neutrality from habitat restoration. 	
Development of an overarching cross-jurisdictional objective for ecological resilience for the reef system, which is ecosystem central. We cannot afford to manage <i>Centrostephanus</i> in isolation.	8
Innovation in processing to reduce operational costs and encourage industry growth.	8
<ul style="list-style-type: none"> • A cross-fishery coordinated market development strategy would help support this. 	
Review and map existing projects, management activities and research, identify gaps and then direct funding accordingly. Points to note:	6
<ul style="list-style-type: none"> • Removing barriers to control densities in MPAs is important. • Develop a process to identify knowledge gaps and determine context dependent actions supporting a national strategy. • This must consider analysis of historical data and baseline bottom structure analysis. • Create a decision-making process for addressing actions to take in an area. 	
Take research and management actions and communicate these to industry and the public (communication action plan). Include strengthening public perceptions of urchins as a desirable delicacy.	5
A national co-management group which includes diver awareness and education in all states.	4
Protection of Eastern Blue Groper!	3
Standardised approach to monitoring and assessment.	3
<ul style="list-style-type: none"> • Requires a consistent funding model. • Needs to account for different baselines across jurisdictions. 	
National state agreements - coordinate to get things moving in a sensible way	1

8. World Cafe Style: What R&D is needed to improve Centro control in the next 2 – 5 years?

Participants contributed to a World Café style session where they were able to select topics of interest and share research ideas, opportunities and priorities. These ideas were captured under the broad themes of commercial dive, volunteer dive, Sea Country stewardship programs, processing systems,

governance, innovative funding, research and monitoring needs, citizen science opportunities and community education / engagement, Urchin Ranching in Aquaculture, deep water management. The ideas were not prioritised, and all concepts are presented below (Table 4).

TABLE 4: Research ideas to support Centro control and management

RESEARCH AREA	DETAILS
Commercial Diver Programs	<p>The following research and projects should be considered in the commercial dive space. These will be important to ensure the long-term sustainability of the industry, and to maintain effort into the future.</p> <ul style="list-style-type: none"> • A scoping report to determine if this can work without subsidy? • Development of a shared platform which provides access to survey data to assist industry. • Development of a strategic plan to integrate and work with cultural fishers. • Special variability management research which tracks effort distribution, and priority areas. • Plan complementary management in areas with less existing commercial effort. • Better reporting processes to capture diver observations as a potential tool to aid research. • Development of a platform which enables access to diver data as an information/business tool. <p>Note: It was discussed that long term funding commitments are important to drive results.</p>
Volunteer Diver Programs	<p>The following research areas and projects should be considered in the commercial dive space:</p> <ul style="list-style-type: none"> • Explore the potential of having urchin cull 'derbies' or events. • Review government sanctioning of recreational culling, providing information, safety, identification and coordination of recreational divers, commercial divers and science. • Development of best practice guidelines considering the need to avoid spawning time (winter) i.e. concentrate on winter, reporting, data gathering on numbers culled 10, 100s, 1000s. • Explore the development of an app to record recreational culling, including education, recipes to encourage consumption, identify areas for commercial harvest, where harvesting has occurred. <p>Other points to note:</p> <ul style="list-style-type: none"> • Recreational divers should have a volunteer representative on a Centro advisory panel, to assist, review and inform culling plans. • Urchin culling on barrenns might improve urchin quality for commercial harvest. • Predators should not be an issue when culling, as no blood is released. Most activity is wrasse feeding on innards. • Focus on reef restoration rather than culling. • There is a need to create awareness of the Centro problem and the value of recreational cullers. Strategic communication needed. • Acceptance by commercial sector to progress as a formal tool, and address issues around culling devaluing the product.

Sea Country Stewardship Programs

Management needs to be indigenous-led and controlled, with management plans that understand and pay attention to First Nations science. There is an opportunity to build community capacity to manage sea country plans ('Capacity' meaning legislative support, funding structures into community, training programs to support "leadership, business, and skills", and provision of trust and autonomy for community to manage and make decisions for their country).

Sea country plans and native title processes may also need to encompass compliance plans (and can these be self/community-managed?).

Points to note:

- Review "Japanese prefecture system", which may have applications here - the entire coast of Japan is run with each community owning their own off-shore reefs. Likewise, Fiji/Solomon Islands has(had?) a chieftain permission system where chieftains/villages own individual reefs and carried traditional knowledge of which species at which time of year would be on each reef.
- Review buy-outs of existing commercial licenses to facilitate handing back sea country stewardship. This should involve indigenous voices from the very start.
- Desire for 'more action, less papers and talk'. Feasibility studies are perceived to end there without further funding to create action. This includes translating indigenous related research/process into actions.
- Concept of a hand up, not a hand out. Develop the infrastructure, supports and structures to enable indigenous owners to run businesses and manage sea country competently – then have government step back.
- Business mentorship to enable First Nations to build their own enterprises and build business plans and provide employment for community.
- Joonga won a grant for a boat and allow individuals to use it for their business. This is a risk management approach to ensure a high ticket item isn't at risk if someone business changes, folds or is sold.
- Having Departments include things like "must support indigenous opportunities" built into management plans and strategic frameworks, puts an onus on government to meet this standard and support indigenous tenders for work (i.e., for shark drum programs, for urchin cull/harvest programs).
- After tailored capacity building, the next step is to find employment and employers. Joonga tackled this by creating businesses to employ indigenous only and seek funding and options (i.e. shark drum line programs tendered for and won "indigenous procurement").
- Provide support for continuing education of indigenous individuals to build their capacity to come in and engage in land and sea country care.
- Look to land country management successes and recognise how that can be applied to sea country too.
- NSW has had success with university collaborations for language development, and with DPI to build processes that support individuals to earn income and have joy in their work e.g. dive programs need to be tailored to be culturally relevant.
- Government and indigenous parties can both find communication difficult. Capacity to communicate with mob and understand terminology needs to be built on both sides.
- Working with industry and building partnerships can make it easier for governments to hand back to indigenous groups (i.e., reform of rights/legislation is simpler when the parties are already on board or there is majority support).
- Restitution should be looked at - so many industry members profit from sea country resources that were taken, and have had their take/rights enshrined in legislation. It is now difficult to break the entitlement and build indigenous capacity to take over stewardship, at least in some areas.
- Sea country management needs to be holistic, not just targeted to species management and compartmentalised issues.
- Stewardship programs may not look like white programs. For example there may not be nominated 'Rangers', but rather whole of community is involved at different times.
- Enact legislative reform where required, as that is often the reason given for why things can't be done.
- Allow indigenous people autonomy in how money is spent, i.e. not "we will give \$X funding to be spent in this manner..." but rather "we pledge \$X amount to these custodians to determine how best to spend it".
- Requires recognition of land rights with action, not just write/say "we acknowledge this..."
- Capacity building and research projects right from the start, not at the end. Ask sea countries people for their aspirations and have them participate in research processes (e.g. training, dive certification, and having researchers facilitating for indigenous people rather than just doing the work).
- There hasn't been a voice. How can indigenous people gain leverage to effectively voice their input on sea country management? Requires time spent on land, bringing decision-makers and agency staff on country (Dep Secs, Secretaries, etc).

Processing Systems

- Research and projects in the processing systems space could consider:
- Waste management and no-waste product research on packaging and methods to improve product during transport from sea to processing centre.
 - Market development and promotion is required at a national and international level.
 - Automation within the harvest, post-harvest and value-adding processes.
 - Explore opportunities to enhance the value of lower grade product.
 - Improved post-harvest processing and the development of value-added products.

Research and Monitoring Needs

- Research and monitoring needs include:
- Spatial mapping, fine-scale barren levels, urchin density surveys
 - Trajectories of climate change, variability, extremes, frequency of events to better understand trends.
 - Subsurface temperature monitoring.
 - Disease pressures and outbreaks.
 - Pollutants and run off effects.
 - Profile reefs to target action.
 - Carbon sequestration (note possible evidence that it doesn't work but still worth looking into).
 - Density of urchins and spawning relating to egg production, for the whole life-cycle work out.
 - What data exists and is needed (gap analysis)? Identify which data is relevant to the decision being made - guided by strategy.
 - Spatial genetic mapping/profiling.
 - Density control.
 - Portfolio perspective (control / research / monitoring / action – monitoring - state by state). Ensure research along the entire range i.e.
 - spatial monitoring at (time and distance) intervals from NSW to TAS (and NZ!).
 - size structure, biomass, density, barren level, predator levels, fishing intensity levels.
 - data repository - data sharing, communication between states regions eg Dashboard GBRMPA research needs.
 - being clear about depths.
 - Deciding on key terminology used in surveillance and prioritisation.
 - Post-harvest improvements.
 - Socio-economic research to determine the impact on tourism. What is the actual cost of losing a reef to barren, the value of a healthy reef, and the return on investment.
 - Value-adding, including economic, cultural, indigenous, ecological value.
 - Research into frequency of culling/removal/harvesting action that is needed in different areas.
 - Understanding baselines through time - choosing/deciding on a baseline/target.
 - Small-scale experiments into urchin removal from extensive barrens to get kelp regrowth THEN reseed with giant kelp/abalone/lobster/predators.
 - MPA or restoring ecosystem, not just the kelp.
 - Standardised monitoring techniques especially for deep (consider doing night transects / videos to count urchins densities when they are more active).
 - Developing data that is relevant to predictive modelling of populations and removals (e.g. put temp sensors on depth and GPS loggers of commercial divers).
 - Interaction between development fisheries.
 - Fisheries and catch rates (problem of hyperstability) using logger data - e.g. abalone.
 - Effect of smaller urchins.
 - Eastern Vic data - using abalone and urchin logger data (going back in time).
 - Feedback to the divers of where to dive for sea urchins based on where the higher densities are, according to the towed-vid surveys. Consider providing open data. Also, capture diver feedback for scientists about where regrowth is occurring (divers could photograph areas).
 - Maximise diver collected data, e.g. seimap project coastkit (Vic) high resolution habitat map (combined different habitat maps/sources into one) / DiversOBs Vic ab divers recording urchin density.

Governance

It was discussed that coordination rather than management should be the main function and responsibility of a cross jurisdictional cross sector governance entity. Formation of a governance entity must include partners and members which fairly reflects spatial spread of reef areas of interest. Focus of governance to be reef health (any governance initiative which is Centro focused will have to work out how it intersects with broader reef health and conservation and Sea Country governance).

Improved governance could be achieved by implementing the following:

- Set up a taskforce with a Terms of Reference to develop agreed objectives, and a proposed cross jurisdictional and cross sector governance framework.
- A proposed cross jurisdictional and cross sector framework to have means of including both the breadth of interests, rights and stakes as well as ability for sector-focused action.
- Table a bill under Commonwealth law for a 'Great Southern Reef Authority' Act.

Points to note:

- Extension with stakeholders to be a function of the governance entity.
- Scope of the cross-jurisdictional cross-sector governance entity to include tabling of spillover effects from sector management in specific states, and create a focus for discussion.
- Include Tasman sea partners (i.e. our cousins in NZ) in governance framework.
- Environmental focal areas need to include carbon mitigation.
- Formation of a cross-jurisdictional cross-sector framework supported by some form of coordinating entity, with resources to meet its brief.
- Aboriginal peoples recognised and involved as rights holders.
- FRDC to fund a project to identify available R&D and how it can be used to support decision making and management.
- A lead agency to propose a taskforce and seek funding and establish an administrative arrangement.

Innovative Funding

Key need is a funding strategy which considers the overall value of ensuring funding collaborations (blended funding?). This could be related to the regional Centro strategy. Note that it must also consider:

- Carbon credits – for reef and kelp value maintenance (review the lack of accreditation, risk, governance (Japanese example), global space, and Mars as an example of global investor).
- Natural Capital/Ocean Accounting/Biodiversity Credits i.e. emerging markets, endangered species, ESG investments, new methods for capturing value, Resilience Investment Funds (e.g. reef resilience funds), insurance, offset funds (e.g. wind farms on reefs) and innovation funding challenges (i.e. Develop proof of concepts – requires expertise on how to create value and credibility).
- Review Sectoral support as we need other sectors involved.
- Need more diverse products by processors.
- Seek royalties from processors.
- Philanthropy (Myer example – GSR - \$2M)
- Localised Funding - Go fund me
- Communications/Branding as it will be key to tell story well to raise funding. It is suggested that the TCDA needs to be more proactive and tell stories, work on maintaining the social licence of fishing.
- Review innovative funding structures such as capital/project funding vs recurrent funding, or blended funding. Look into leveraging private and public funds or the FRDC as public good anchor funding.
- Work on new communication, events and promotions e.g. Urchin wars TV series / Food profiling w/ celebrity chefs / Community events / Abalone bake-off / Florida lionfish derbies / Annual sea urchin festival.
- Work on developing industry champions program, doing case studies on the people and their impact.
- Work with First Nations to do a campaign on Indigenous Investment and their work in kelp protection, mariner shells - ILSC.
- Look at the beneficiaries i.e. Hotels, cruise ships, chambers of commerce, tackle shops, community groups, etc.
- Review levies e.g. recreational fishing levy/licence fee, reef restoration fund? Diver/tourism levy with clear accountability on how funds are used, car parking revenues in coastal towns.

Citizen Science Opportunities & Community Education and Engagement

Across the three tables of discussion it was broadly agreed that community education is essential for broad support (funding), filling research gaps and direct action. Community education is critical to building momentum and longevity for a management solution. Agreed terminology is essential, as are key messages (although these can be regionally based). There is a strong desire for citizen scientist involvement, and it can support the industry in gaining efficiencies. It was agreed that citizen science could assist in the following:

- Citizen scientists can contribute to longitudinal studies of barrens (e.g., Reef Life Survey). This will require training and coordination.
- Citizen scientists can fill a role in mapping and density measurements (heat mapping) and will require training; this is complementary to the urchin industry and may improve efficiencies in targeting for harvest.

Points to note:

- Visual analysis is important for monitoring purposes and also supporting narrative about issues.
- Data collected by citizen scientists should be made publicly available (e.g., through platforms such as Tasmanian Marine Atlas).
- Cumulative impact is a difficult story to tell. Review how this may be done. Different audiences will require different methods of communication and different communicators. Note that visual narrative is critical for education.
- Marine literacy is a problem in parts of the Tasmanian community (it is also very good in some parts).
- It's important not to persecute the species. This will be challenge in creating key messages across regions and the messaging will need to be tailored by region).
- Education has multiple purposes - we need it to attract community support for funding, and also for active participation in the solution.
- Citizen science could also include exploration into other uses for Centro (it doesn't just have to be environmental).
- Terminology has been raised numerous times, e.g. don't use the word pest – if you call it a pest, people will treat it like a pest.
- Education will lead to an uptake in citizen science.
- A need to build emotion and value for what we have; citizens talking to citizens.
- How to cook and consume - this is important for recreational fishing audiences, restaurant markets and consumers.
- Image-based citizen science could be effective, using distributed systems.
- Key messages need to be agreed (across and within jurisdictions).
- Education about species identification and specific terminology to ensure a coordinated and collaborative approach to control.
- Citizen science can occur over small spatial scales.
- Both citizen science and education require coordination (funded roles) for quality control, training and data management.
- Broad community education about the Great Southern Reef, range extension, climate change and adaptation is required.
- There are a range of citizen science roles, both in and out of the water.

Ecosystem and Habitat Recovery

- Recognition that ecosystem recovery is slow. Often we have rapid recovery of Ecklonia but reef biodiversity in general is slow. We need to recognise that kelp does not represent ecosystem recovery *per se*.
- It will be critical to identify the core biodiversity and ecological functions that we would like to recover. This will differ geographically and so local-regional baselines are necessary.
- In the absence of and in addition to reference conditions - consensus on desirable reef state/conditions will be necessary. What is feasible (cost-benefit) will also be an important consideration for recovery.
- Detailed quantification of the benefits/ecosystem services provided by reef habitats will be useful. This will allow us to demonstrate and track the benefits of habitat recovery.

Regional Scale Approaches

The following regional opportunities and approaches could be considered:

- Develop options for connected local solutions e.g. kelp restoration.
- Local events connected by 'Urchin Champions' to share and amplify what works.
- How to act local but collaborate nationally – eg Lion Fish work on local science and solutions.
- Development of a strategy to increase urchin consumption.
- Development of local chef / tourism strategy to increase consumption e.g. a 'Guilt Free Treat', or 'kill for conservation'.
- Share local regional pilot study outcomes that are based on local community programs - restoration, harvesting, culling and other approaches.
- Need improved technology from harvest to processing to ensure best product that arrives at the processor.
- Noted - that in most instances in resource management the paradigm is that it is a limited resource with conflict over access - The Centro discussion is quite different.

Deep Water

Action and communication surrounding deep water is important, as it is beyond recreational dive engagement. Deep water requires tech to overcome increased operational challenges, qualification of divers, risks and costs. Alternative harvest methodologies need to be considered and developed to harvest urchins at depth, including the use of a trap fishery (as seen in Norway). Note that it is possible to dive to 26-30m depth, 500-600kg harvest per dive, 67 minutes, decompression diving).

NSW urchin barrens are extensive and extend into deep water. Technology represents a significant increase in data collection capacity in these areas, addressing knowledge gaps. We need robust survey data to look at urchin barren density across depth ranges. Monitoring and surveying is needed in deep water for before and after harvest or culling. Technology and robotic solutions are essential here to enact monitoring at meaningful temporal and spatial scales. The following projects and actions are suggested:

- Development of 3D models from deep habitat, which could be used to bridge education gaps and engage corporate funding.
- Historical data of barren distribution is based on aerial photos, good baseline data is required for deep habitat.
- Quantifying kelp cover across deeper habitat could assist in producing cost-benefit analyses of intervention or harvest options considering blue carbon potential. Deep, cold, nutrient rich water is also very valuable for seaweed aquaculture, so managing urchins in these areas may be required.
- Deep habitats can have lower quality urchin roe, harvest operations can work here if they are then nourished with feed.
- Estimation of spawning production by depth and level of barrenness - spawning requires energy and without food/energy, spawning levels may be overestimated relative to the area.

Questions

- Impact of urchin barrens on coral and sponge communities: Are these habitats impacted, what is their vulnerability and recovery rate?
- Does deep water habitat represent untargeted, reproductive abalone stock?
- How may urchin barrens at depth affect these habitats and fishery?

Points to note:

- AUV surveys can be used to identify contextual differences to apply appropriate management actions.
- Robotic solutions are essential here, and require more funding to facilitate development.
- 3D models from deep habitat can be used to bridge education gaps and engage corporate funding. Communication surrounding deep water is important - beyond recreational dive engagement.
- Use robots to quantify kelp recovery at all depths and get cost-benefit analysis including blue carbon. Robots have a potential to impact the blue economy and support aquaculture e.g. seaweed farms in deep water, which is a suitable environment due to cold, nutrient rich conditions).

Fishery Management

Identifying TO interests and ensuring groups are embedded into the entire fisheries management process, from objective setting through to implementation, is an important management action. Research is needed to determine:

- How to implement a spatial management framework that supports setting different objectives at a zonal/ reef-based level and also opportunities for different rights holders.
- How to manage natural forces (and climate change impacts) under a fisheries management framework.
- How to ensure the research and science (including gap analysis - competitor/ predator dynamics) needed to inform EBFM is undertaken and funded. (Should all funds come from cost recovery if there are broader ecosystem benefits?)
- Getting the fishery management objectives right while encapsulating an integrated approach and protecting the interests of all rights holders.
- How to schedule diving with processing to ensure capacity to process is optimized.
- Innovative harvest strategy that has dual objectives for Urchins and Abalone and Habitat - with novel targets.
- How to improve the rights for Urchin fishers so they will invest for the future.
- Note the need to improved collaboration across fisheries management jurisdictions, to improve consistency of approaches.
- Fisheries management is by nature restrictive – and will need to allow scope for innovation in how Urchins are managed.
- Implementation of VMS/Depth loggers and point source data collection across all states for both abalone and urchins - to improve localized spatial management.
- Opportunity to implement an EBFM/EBM approach that couples Urchins and Abalone.
- Key challenge is how to structure fishery management to achieve a functional and viable fishery which balances ecological, economic and cultural returns more broadly than just urchins. “We need less talking, more action in decision making and policy. We have enough science and tools to do this. Government and Fisheries Managers need to establish clear objective for each jurisdiction.”

Urchin Ranching in Aquaculture

- Need an identification of suitable species for ranching, considering most valuable species for the market price, consumer perceptions.
- Improve public perception of Centro from ‘pest’, which has a negative effect on obtaining support to develop the industry.
- Need a Biosecurity strategy to avoid disease transfer, and need to undertake a disease surveillance for a baseline.
- Establish a way to transport Centro to improve survival at ranching sites - commercial feasibility test.
- Need more data on percentage urchin grading to determine how aquaculture can enhance roe yield.
- Aquaculture research to improve roe recovery.
- Japanese style ranching may be too expensive as relocation is needed, but ranching improves quality control.
- Branding strategy is important for ranched urchins.
- Validate if land-based feeding with artificially manufactured feeds can improve the percentage of urchin roe recovery - nutrition research
- One solution would be culturing Seaweed.

9. Summary and actions

The workshop enabled the capture of significant information regarding the issues, opportunities, actions and research priorities to progress the control, management and utilisation of Centro.

Participants agreed that there is an immediate need and opportunity to establish a comprehensive regional control program for Centro. It was pleasing to see that stakeholders are willing to collaborate and are seeking guidance to coordinate the next steps, in order to reduce the threat to Great Southern Reef health and protect the livelihoods of those dependent on the Reef.

Key themes identified throughout the workshop suggest that the potential for economic growth through the development of new products and markets, the opportunity to develop new integrated ecosystem-based management approaches, and the establishment of a strong and sustainable industry are achievable, and that a coordinated approach to management will enable the most success.

It will be important to maintain communication on the next steps, timelines, targets set and subsequent actions from this meeting, to maintain the collective momentum. Participants are keen to understand the State's commitment to progress the workshop discussions and what are the coordinated next steps for this group to ensure it doesn't 'die by steering committee'.

Participants are also keen to gain insights into the commitment and plan to fund immediate priority actions relevant to each jurisdiction, and see that they align with a greater plan. It will be important to ensure all are kept aware of the actions and who is responsible for delivery. The following considerations were also suggested in the moving forwards pathway:

- Need to set meaningful objectives at the cross-state level, given the varied values associated with Centro, and provide clear communication on how these are progressing.

- The development of a communication strategy which is inclusive of all stakeholders and partners will be of great importance. Many are keen to know how to best address (and communicate to public and stakeholders) the differences of Centro between jurisdictions, so they still value the product in some regions but understand its impact in others.
- It will be essential to include First Nations people in the strategic framework and associated actions. Engagement is essential from the outset to ensure we work together in a meaningful manner.
- The development of the funding strategy is essential to ensure concepts are implemented in an effective manner.
- The development of a governance framework will be important to underpinning sound management of all actions going forward.
- Strategies to share data across jurisdictions are needed, as there are currently challenges to sharing information transparently and equally. There was discussion that a shared data portal may benefit many by helping to track progress and monitor trends. The science community needs raw data to use for modelling and research. It was noted that there is a commitment to share information in a modern and accountable way.

APPENDIX 1: Presentations and Speakers

Presentations from the two day workshop are available for download here:

- Presentations Part 1 (1.62GB): <https://fishing.tas.gov.au/Documents/National%20Centro%20Workshop%202023%20Presentations%20Part%201.zip>
- Presentations Part 2 (1.46GB): <https://fishing.tas.gov.au/Documents/National%20Centro%20Workshop%202023%20Presentations%20Part%202.zip>

Wednesday, 1 February 2023

8:15 – 9:00 am	Registration and Smoking Ceremony	
9:00 – 9:30 am	Welcome to Country	Fiona Hughes
	Welcome and Introductions	Ian Dutton
	Opening Address	The Hon Jo Palmer MP
	Overview of the Workshop	David Maynard/Belinda Cay
9:30 – 10:00 am	Scene Setting	Gretta Pecl/ Scott Ling
	- Climate change in SE Australia: General overview of the changing marine climate and what it means	
	- Centrostephanus: Brief introduction to the species and range extension	
10:00 – 10:30 am	Breakout Session 1 (# x concurrent small groups)	
	What is the biggest challenge and opportunity posed by Centro?	15 mins
	Report your top one “challenge” and top one “opportunity”	15 mins
10:30 – 11:00 am	BREAK	
11:00 – 12:30 pm	Overview of the Status, Impacts, and Fishery of Centrostephanus	
	a) Regional Overview:	30 mins
	- John Keane (Tas)	
	- Michelle Wenner (Vic)	
	- Thor Saunders (NSW)	
	Questions and Answers	15 mins
b) Sector Overview:		30 mins
	- Bryan Denny (Tas)	
	- Helen Burvill (Vic)	
	- Bridget de Lange (Tas)	
Questions and Answers	15 mins	
12:30 – 1:15 pm	LUNCH (Complemented with urchin roe dumplings by Oscar’s Seafood)	
1:15 – 1:50 pm	Commercial Harvest Opportunities	25 mins
	- Craig Sheppard (NSW)	
	- Chris Theodore (NSW)	
	- TBA (Vic)	
	- Tom Chadwick (Tas)	
	- Mark Allsopp (Tas)	
Questions and Answers	10 mins	

Wednesday, 1 February 2023 Continued

1:50 – 2:40 pm	Commercial Harvest Enhancement and Value Adding - Yukinori Shitautsubo (Japan, translation from Makoto Hostips) - Katie Cresswell (Tas) - Harriet Walker (Tas) Questions and Answers	40 mins 10 mins
2:40 – 4:00 pm	Other Control Mechanisms - Sean Larby (Tas) - Mike Irvine (Vic) - Justin Bell (Vic) - Siobhan Threllfall (NSW) - Scott Ling (Tas) - Jennie Smith (Tas) - TBA Hullbot Robotics (NSW) - Peter King (Tas) Questions and Answers	65 mins 15 mins
4:00 – 4:20 pm	BREAK	
4:20 – 4:50 pm	Panel Discussion: Recap of Day 1 Discussion What have I learned? What am I most curious to learn more about? Panellists TBA (Chris Izzo, Simon Reeves, Morgan Pratchett, Siobhan Threllfall)	Alistair Hobday
4:50 – 5:00 pm	Close and Plans for Evening/Day 2	David Maynard
5:00 – 6:00 pm	<i>Pre-Dinner Drinks, Tonic Bar with International Participants</i>	
6:00 – 9:00 pm	EVENING RECEPTION Dinner and networking in the Clarendon and Entally room	

Thursday, 2 February 2023

8:45 – 8:55 am	Preview of Day 2	David Maynard
8:55 – 9:30 am	Breakout Session 2 (# x concurrent small groups) Should we foster cross-jurisdictional and inter-sectoral relationships, beyond just information sharing, for improved management outcomes? If so, how? Report your top response from each table	20 mins 15 mins
9:30 – 10:45 am	Learning from Global Experience Managing High Impact Species - Nick Shears (New Zealand Urchins) - Keith Rootsart (California Urchins) - Alli Candelmo (Florida Lionfish) - Morgan Pratchett (Great Barrier Reef COTS) Questions and Answers	60 mins 15 mins
10:45 – 11:00 am	BREAK	
11:00 am – 12:15 pm	How do we work towards a Regional/Integrated Management Framework? - Ian Dutton (Tas) - Cameron Fletcher (CSIRO) - Myriam Lacharite (Tas) - John Keane (Tas) - Michelle Wenner (Vic) - Adriana Vergés (NSW) - Robert Chewying (NSW) Questions and Answers	60 mins 15 mins
12:15 – 1:00 pm	LUNCH	
1:00 – 2:45 pm	Breakout Session 3: World Café Style What are the challenges and R&D needed to improve <i>Centrostephanus</i> control in the next 2 – 5 years? 1. Commercial Diver Programs (Tom Chadwick) 2. Volunteer Diver Programs (James Parkinson) 3. Sea Country Stewardship Programs (Rob Chewying or Jarrod Edwards) 4. Processing Systems (Ryan Morris) 5. Research and Monitoring Needs (Katie Cresswell) 6. Governance (Emily Ogier) 7. Innovative Funding (Ian Dutton) 8. Citizen Science Opportunities (Rachel Kelly) 9. Community Education and Engagement (Jen Hemmer) 10. Ecosystem and Habitat Recovery (Scott Bennett) 11. Urchin Waste Recycling (Harriett Walker) 12. Subsidies (Sharna Rainer) 13. Regional Scale Approaches (Trav Dowling) 14. Deep Water (Caleb Gardner) 15. Fishery Management (Michelle Wenner) 16. Urchin Ranching in Aquaculture (Yukinori Shitautsubo) Report your top one challenge and R&D priority from each table	3x30 min rotations 15 mins
2:45 – 3:30 pm	Panel Discussion – Where to From Here <i>Panellists TBA</i> (Ian Dutton, Trav Dowling, Patrick Hone, Thor Saunders, Peter Whish-Wilson)	Alistair Hobday 45 mins
3:30 – 4:00 pm	Afternoon Tea/ Departure	

