Michael J. Kingsford,

Distinguished Professor
Marine Biology and Aquaculture,
The College of Science and Engineering,
JAMES COOK UNIVERSITY, Bldg 34, Townsville,
Qld 4811, AUSTRALIA.

Ph
e-mail:
CRICOS Provider Code 00117 J
ABN 46253211955

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Senate Standing Committees on Environment and Communications
PO Box 6100, Parliament House
Canberra ACT 2600

Re: Senate Inquiry on Climate-Related Marine Invasive Species.

I welcome the opportunity to provide comment on this important inquiry as a marine ecologist with 40 years of experience of investigation of the marine environment of NSW with particular expertise in subtidal rocky reefs. It is these reefs and the associated sea urchin and kelp dominated habitats that are the focus of this inquiry. I provide a summary, list of recommendations followed by a more expansive commentary.

Please feel free to contact me if you have any questions or would like for further information.

Kind Regards,

Summary

Rocky reefs are one of the most common and spectacular environments along the coast of New South Wales. The seascape is characterized by a mosaic of habitats, including kelp forest and urchin grazed barrens. These habitats support a diversity of dependent species. Kelps form extensive forests with distinctive fish and invertebrate fauna and boulder habitat in barrens areas provide shelter and other resources for commercial and charismatic fishes and invertebrates. The Barrens are not a barren desert! The feeding activities of herbivorous invertebrates, particularly the black sea urchin, *Centrostephanus rodgersii* determine the presence of barrens habitat. Some invertebrates only survive in the presence of urchins and are in turn the food resources for many predatory fishes that use the barrens as their hunting ground. The barrens habitat in NSW has been highly stable for decades and is critical for the diversity of reef-based organisms. Due to climate change, Tasmanian waters have warmed and as a result *C. rodgersii* larvae have dispersed southward from NSW. This larval transport has lead to a range extension of this sea urchin to Tasmania where its grazing activity, along with warming water has led to the decline of kelp. The problems for Tasmania, therefore, are NSW sourced black sea urchin propagules and climate change. Importantly, the situation regarding *C. rodgersii* in Tasmania differs from the established pattern in NSW and this needs to be recognised in the approach to management of this species in the two states. Urchins in NSW should be appreciated as important habitat determiners and intentional removal of them for whatever purpose would have to be managed carefully.

Recommendations

- Recognise that *Centrostephanus rodgersii* and the barrens habitat that these urchins create are an integral component of the sea scape of New South Wales upon which a great diversity of species depend, including commercial, charismatic and endemic species.
- Understand that the role and impact of *C. rodgersii* in NSW and Tasmania differ with respect to regional ecology and especially with respect to the climate change driven alteration of the sea scape in Tasmania.
- Rigorous region-specific research is needed to inform management of *C. rodgersii* which will differ between NSW and Tasmania.
    - Intentional removal of urchins in NSW for whatever purpose would have to be managed carefully.

Justification - NSW rocky reefs are under threat

The ecology of rocky reefs in New South Wales (NSW) is receiving renewed interest due to the events unfolding in Tasmania. The centre of attention is the black sea urchin *Centrostephanus rodgersii*, a NSW native that has extended its range to Tasmania where its grazing is altering the local sea scape. The extent to which the abundance of these urchins on New South Wales rocky reefs is a natural phenomenon or reflect change due to human impacts on reef ecology has been a focus of media and policy, but extensive research points to the former. In NSW this species is critical for the diversity of reef-based habitats to the south of Port Stephens (Glasby and Gibson 2020).
Rocky reefs are one of the most common and spectacular environments along the coast of New South Wales (Andrew 1999). Critically, habitat diversity plays a key role in the functioning of these reefs. The seascape (*sensu* (Jones and Andrew 1993) is characterized by a mosaic of habitats, including shallow cunjevoi (the ascidian *Pyura stolonifera*) and tufting algae, while in deeper waters kelp forest and urchin grazed barrens abound (Fig. 1 A, B). The kelps *Ecklonia radiata* and *Phyllospora comosa* can form extensive forests with distinctive fish and invertebrate fauna. On reefs beyond 12-15m colourful sponges are the most dominant form of life (Underwood *et al.* 1991). Boulders and crevices of sandstone and the algae provide shelter and other resources for commercial and charismatic fishes (e.g. blue groper, bream and morwongs) as well as invertebrates (abalone, urchins). Black urchins also depend on shelter and move metres from shelter to feed on algae at night (Fletcher 1987; Andrew 1993).
A wide range of fishes depend on these diverse habitats for shelter, food and as spawning sites and most require multiple habitat to meet their needs (Curley *et al.* 2013a). Archival aerial photography of NSW reefs indicates that urchin grazed barrens have been a feature of the NSW seascape for ~ 50 years (Glasby and Gibson 2020). There is no indication that the representation of urchin grazed barrens on reefs, to a depth of 10 m or less, has changed more than a few percentage points (Glasby and Gibson 2020). Reef habitats have remained relatively stable over this depth range and that is despite grazing pressures, storms and freshwater runoff that can wipe out stands of kelp in the top 5-6 meters (Andrew and Underwood 1989; Davis *et al.* 2022).
The feeding activities of herbivorous invertebrates, particularly the sea urchins, *Centrostephanus rodgersii* determine the presence of barrens habitat (Andrew 1991; Byrne and Andrew 2020) . Although there are other invertebrates in the barrens such as limpets and top-shell snails (*Cellana*, *Patelloida* and *Australium* spp.) that graze algae, they can only survive in the presence of urchins (Fletcher 1987). It is this host of invertebrates that provide the food resources for many predatory fishes. Predatory fishes such as half-banded sea perch (*Ellerkeldia mccullochi*), wirrah (*Acanthistius* spp.), bream (*Acanthopagrus australis* and cod (*Pseudophycis palmata*) treat the barrens as their hunting ground for fishes and invertebrate prey, while others such as maori wrasse (*Ophthalmolepis lineolatus*) prefer a mix of barrens and algal habitats (Kingsford and Carlson 2010). Furthermore, some fishes such as the white-eared damselfish *Parma microlepis* are endemic to SE Australia and depend on well cropped algal resources in the barrens (Holbrook *et al.* 1994; Galaiduk *et al.* 2013), this is also the habitat in which

they spawn (Tzioumis and Kingsford 1995). While the term 'barrens' evokes a desert-like condition, research in NSW shows high fish and invertebrate biodiversity and abundance in the barrens (Curley *et al.* 2003) as well as high diversity of microalgae (Coleman and Kennelly, 2019).

Marine Protected Areas (MPAs) are popular locations for the public (e.g. Shelly Beach, Manly; Bushrangers Bay, Shell Harbour, Jervis Bay). The reason MPAs in NSW have a rich diversity of fishes is the mosaic of habitats they encompass. This, combined with protection (Curley *et al.* 2013b) from fishing, provides reefal environments that are enjoyed by many people in NSW. Fishers also enjoy rocky reefs for the fishes they provide (Kingsford *et al.* 1991) and their catches would be compromised in the absence of urchin grazed barrens, especially catches of bream and wirrah.

Due to climate change, the poleward flow of the East Australia Current (EAC) is intensifying and now extends about 400 km further south than previously resulting in significant warming of SE Australian waters (Ridgway 2007; Phillips *et al.* 2022) Due to warming, Tasmanian waters have become more hospitable for the larvae of *C. rodgersii* propelled southward by the EAC from NSW (Byrne *et al.* 2022). Successful colonisation by the urchin (Ling *et al.* 2009), sometimes referred to as an 'invasion' has facilitated the loss of giant kelp (*Macrocystis*) and understory kelps (e.g. *Ecklonia*) . The range extension of *C. rodgersii* has clearly influenced the abundance of kelp . However giant kelp is also threatened by warming waters (Mabin *et al.* 2019). Thus, the problem for Tasmania is NSW sourced black sea urchin propagules, another urchin, *Heliocidaris erythrogramma* (Ling *et al.* 2010) and climate change. The emerging situation regarding *C. rodgersii* in Tasmania differs from the established pattern in NSW.

In other parts of the world urchins are important engineers in the 'phase shifts' between macroalgal and barrens as alternative ecological states in temperate (Elner and Vadas 1990; Filbee-Dexter and Scheibling 2014) and tropical reefs (Feehan and Scheibling 2014). Top-down effects from urchin predators such as otters (Estes *et al.* 2011) and lobsters (Elner and Vadas 1990) effect urchin densities. However, in the Northern Hemisphere the fluctuations between kelp and barrens are often driven by sea urchin disease and mortality that results in the return of kelp and with a subsequent increase in urchins the development of barrens (Steneck *et al.* 2002; Feehan and Scheibling 2014; McPherson *et al.* 2021). In some cases the loss of urchins has caused massive and deleterious changes to marine ecosystems. For example, in the Caribbean the almost total loss of urchins (*Diadema* a cousin of *C. rodgersii*) caused a great increase in the cover of macroalgae and the loss of hard coral (Hughes 1994), these reefs are struggling to recover after four decades. In the 50+ years of research on *C. rodgersii* and the rocky reefs of NSW, such disease-driven phase shifts between urchin and kelp dominance have not been observed.

Should the black sea urchin fishery increase in NSW, be allowed in Marine Parks (as happened in 2020) or, should mass culling campaigns be considered? Can the consequences of urchin extraction can be learned from sea urchin fisheries elsewhere? Yes, there are, and have been, commercial catches of urchins worldwide. However, few fisheries are managed with robust stock assessment and even fewer have incorporated ecological information in management plans (Andrew *et al.* 2002). As for many aquatic and terrestrial ecosystems a rich and diverse community of plants, predators herbivores and small prey depend on habitat diversity and urchins play a critical role in this on

temperate reefs. Although barrens can remain functional with a drop in urchin density (Andrew and Underwood 1993), poorly managed culling is an ecological threat to the health of temperate habitat and a waste of a valuable resource. Further, although the urchin fisheries have the potential to be sustainable unconstrained fishing effort would be unwise. A major loss of urchins through 'strip mining' would result in the loss of a key habitat and would threaten habitat richness and species diversity on reefs of NSW. Because Tasmania is struggling with increased grazing pressures from a range shift of *C. rodgersii* and rising sea water temperatures from the EAC resulting in a loss of kelp, are these changes a sensible basis for advocating that urchins are bad in NSW? The answer should be an emphatic no. Organisms on reefs in NSW have coexisted with urchins well before humans arrived and facilitated post colonization overfishing of top predators such as lobsters and large fishes which prey on urchins. The extent to which the abundance of *C. rodgersii* on NSW reefs is influenced by such human impacts on reef ecology is not known. However, if anything some predators on urchins in NSW, such as blue groper (Fig 1C) , have increased in number as they are protected, but the barrens persist as critical habitat. In addition, barrens also persist following the establishment of marine park sanctuary zones where lobsters and other predators have increased (Glasby and Gibson 2020; Knott *et al.* 2021), The recent moves to expand the fishery on the black sea urchin *C. rodgersii* and to cull urchins with the intent of altering the underwater seascape is a concern. A reef dominated by macro algae is as good as any monoculture - it will reduce species diversity, catches of local fishes and the beauty of local reefs. Urchins should be recognised as important habitat determiners and intentional removal of them for whatever purpose would have to be managed carefully.

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Figure 1 – (A) A habitat transition between kelp forest (*Ecklona radiata*) and urchin grazed barrens where the black sea urchin, *Centrostephanus rodgersii*¸ is found, Montague Island, New South Wales (NSW). This photo is unusual in that the urchins usually hide in crevices during the day and come out to feed at night. (B) *C. rodgersii* with another species of urchin, *Heliocidaris tuberculata,* in a sandstone hollow engineered by the urchins and limpets that depend on the grazing of urchins abound nearby. Kelp is close on flatter rock and outside of the 'grazing halos' of the urchins, Botany Bay, NSW. (C) Blue groper *Achoerodus viridis* foraging in urchin barrens along with an *Pseudolabrus luculentus*, Coal Loader, Shell Harbour NSW.