Australian Government

Department of Agriculture, Fisheries and Forestry

Senate Environment and Communications References Committee - Climate-related marine invasive species – submission

13 October 2022

Contents

Introduction

The primary focus of the Senate referred inquiry into climate-related marine invasive species is the southward range extension of the native long spined sea urchin (*Centrostephanus rodgersii*). Management of *C. rodgersii* is the responsibility of environment and marine park agencies in the Commonwealth and state governments. The Department of Agriculture, Fisheries and Forestry (DAFF) is responsible for managing border biosecurity arrangements for exotic marine pests and for coordinating national arrangements for managing introduced (non-native) marine pests.

This submission will provide an overview of existing knowledge on the risks climate change presents to marine pest management in Australia, key marine environmental processes occurring as a result of climate change, and describe the responsibilities of DAFF to manage biosecurity risks associated with introduced and exotic marine pests, ballast water and biofouling.

Climate change impacts on marine pest biosecurity

Over 250 introduced marine pest species have established populations in Australia, with many more exotic marine pests at risk of introduction. Marine pests can have impacts on Australia's unique marine ecosystems, blue economy and way of life. The effects of climate change on the abundance and distribution of established marine pests, along with the potential risk of further introduction and establishment of exotic marine pests is not well understood.

International shipping, aquaculture, coastal construction, nutrient enrichment, pollution, overfishing and increased sediment loads entering marine systems, are affecting species distributions worldwide (Wernberg et al., 2016, Hughes, 1994). Rising sea temperatures associated with climate change may enhance the ability of certain exotic species to invade new regions, while simultaneously eroding the resistance to invasion of native communities by disturbing the ecosystem equilibrium.

Global maritime traffic is forecast to increase by 240% to 1,209% by 2050 (Sardain et al., 2019). Modelling of increased maritime traffic, combined with climate change projections indicates that the risk of shipping-mediated marine pest invasion will surge (Sardain et al., 2019).

Species are expected to respond to the warming climate and shift their distributions towards higher latitudes. In the southern hemisphere, southward range shifts have been observed in many regions and across different taxa (Cheung et al., 2009). This will require more wide-ranging surveillance programs, new detection and identification methodologies and increased training of biosecurity personnel in exotic marine pest identification.

Maintaining the diversity of native marine communities is a critical process in ensuring ecosystem health and resistance to marine pest introduction and establishment. Higher species diversity within marine communities enables a greater number of available niches and spaces to be occupied by native marine species, which may reduce the opportunities for introduced species to become established (Stachowicz et al., 2002, Bernhardt and Leslie, 2013).

Warming waters and potential movement in species ranges

The south-east coast of Australia has been identified as a climate change hotspot (Poloczanska, Babcock et al., 2007; Ridgway, 2007). The East Australian Current has strengthened resulting in greater poleward penetration of warm water over the past 60 years and an approximate quadrupling of ocean warming rates compared with the global ocean average (Ridgway, 2007; Ling, Johnson et al., 2009; Robinson, Gledhill et al., 2015). A well-studied example of poleward movement of a native marine species is the sea urchin *Centrostephanus rodgersii*, which has extended its pre-1960s range southward along the east coast of Tasmania (Byrne and Andrew, 2013; Byrne and Andrew, 2020). Its ability to overgraze macroalgae and maintain a barren habitat has made it a conspicuous example of a species range extension impacting the ecology of the receiving ecosystem.

The southward range extension of *C. rodgersii* is attributed to the transport of larvae, which have a long (100 day) planktonic duration (Ling, Johnson et al. 2009) in the East Australian current. Southward range extensions have been observed for other marine species, e.g. *Octopus tetricus*, from the coast of NSW to eastern Tasmania (Ramos, Pecl et al., 2018). While range extension, or contraction, is probable for marine pests, few, if any, examples have been recorded. The likely reason for this is that marine pests do not generally have a stable position in the ecosystem and are frequently transported by anthropogenic means. Also, some invasive species, e.g. European shore crab (*Carcinus maenas*), have the means to adapt their temperature tolerances (Tepolt and Somero, 2014).

Most marine pests do not have well understood temperature tolerances (Bloomfield, Summerson et al., 2021). The potential to adapt temperature tolerances and variable warming of the ocean makes modelling future potential ranges difficult, though new techniques are being developed (e.g. Lima, Ribeiro et al. 2007; Bloomfield, Summerson et al., 2021).

Marine heatwaves

Marine heatwaves are extreme oceanic warming events. These events are increasing in frequency globally due to climate change. Marine heatwaves have significant consequences for coastal marine species, ecosystems and the ecosystem services they provide. In 2011, an unprecedented marine heat wave impacted around 2,000km of Western Australian coastline, with a massive loss of genetic diversity across approximately 800 km of that coastline (Gurgel et al, 2020). This included approximately 30%–65% of average genetic diversity of two seaweeds (*Sargassum fallax* and *Scytothalia dorycarpa*) along the 800-km footprint of the heatwave. Coral bleaching at the Houtman Abrolhos Islands was also associated with the same heatwave event (Abdo et al. 2012). In many areas, coral still has not returned and some sites have now shifted to algal dominated environments.

Ocean acidification

One of the effects of increasing CO_2 in the atmosphere is the increasing acidification of the ocean as a result of CO_2 being dissolved in sea water (The Royal Society, 2005). The effects of ocean acidification (OA) on marine life are complex and not well understood across marine ecosystems (e.g. Dobretsov, Coutinho et al. 2019, Lemasson and Knights, 2021). However, OA is expected to affect the growth of many different forms of marine species. Species that form shells or skeletons out of calcium carbonate may be affected, as the increased acidification inhibits the formation of calcium carbonate. It is thought that molluscs will be particularly vulnerable due to changes in physiology and shell properties (Lemasson and Knights, 2021). Vertebrates, such as fish, may also be sensitive to OA (Heuer and Grosell,

2014) but it is not clear whether this is universal as responses to OA may be either mitigated or multiplied by warming (Hobday and Lough, 2011).

Case study – Asian green mussel *(Perna viridis)*

Climate change may impact the process of invasion by affecting pathways of introduction, and their successful establishment in new ecosystems. The exotic Asian green mussel (*Perna viridis*) is listed as a priority marine pest species and is frequently detected on vessels returning from tropical waters in south-east Asia. However, its current likelihood of establishment in temperate regions is regarded as low due to temperature tolerances.

Increased maritime traffic and warming waters may increase the likelihood of establishment of this species in temperate Australian waters. McDonald (2012) detected *P. viridis* on an Australian naval vessel docked near Freemantle, Western Australian. Waters around Freemantle would normally be too cold for Asian green mussels to spawn and for their larvae to survive and establish, however, the study found that the spawning coincided with a marine heat wave (see above). Marine heatwaves are expected to increase is frequency as a result of climate change and are also indicative of warmer waters that may become the norm due to climate change. Increased success in spawning and establishment of tropical pests in temperate regions is of key concern given likely climatic changes and our close geographical proximity to countries containing many of these pest species.

Case study – Chinese mitten crab *(Eriocheir sinensis)*

After an introduction event a species may remain geographically confined for a period ranging from years to a century, followed by a phase of active population growth and expansion. Numerous factors may trigger the rapid growth phase, usually natural or human-induced disturbances. Climate change and the associated increase in disturbance events such as intense storms or heatwaves may result in the expansion of marine pest species already established in Australia.

An example from the United Kingdom is the detection and spread of the Chinese mitten crab, (*Eriocheir sinensis)*. Isolated detections of the mitten crab occurred in the UK in 1935 and 1949, however it wasn't for another 60 years that *E. sinensis* would be identified as established and have pest status in the UK.

E. sinensis spends most of its life in freshwater and migrates to more saline water to spawn. In 1989–1990 a severe drought resulted in reduced river flow and increased salinity levels in many river systems of the UK. This is believed to have triggered a spawning event, increased larval retention and increased subsequent establishment of populations of *E. sinensis*.

In most climate change models, large areas of southern Australia will be affected by reduced rainfall. The impacts of these changes on estuarine ecosystems will stress native systems and may also affect marine pest survivorship in these environments. The Chinese mitten crab is a priority marine pest species in Australia. The modelled reduction in rainfall in southern Australia as part of climate change may increase the likelihood of establishment of this species as was seen in the UK.

Management of marine pests in Australia

Introduced marine pest biosecurity is managed through a coordinated national approach. Biosecurity agencies from the Commonwealth, state and Northern Territory governments work in collaboration with industry and community groups to prevent, detect and respond to marine pest risks. Two key national strategies drive introduced marine pest management in Australia, MarinePestPlan 2018-2023 and the National Marine Pest Surveillance Strategy.

MarinePestPlan 2018-2023 is the national strategic plan for marine pest biosecurity. The plan has five key management objectives: prevention, surveillance, preparedness and response, research and development and stakeholder engagement. The National Marine Pest Surveillance Strategy guides development and coordination of marine pest surveillance tools and techniques.

DAFF provides national leadership in marine pest biosecurity including co-ordinating implementation of MarinePestPlan 2018-2023 and the National Marine Pest Surveillance Strategy. DAFF also plays a key role in preventing the introduction and domestic spread of marine pests through vector management, including ballast water and biofouling management.

Ballast water

DAFF manages the movement of ballast water on domestic voyages within, and international voyages to, Australia. Australia is a signatory to the International Maritime Organization's (IMO) *International Convention on the control and management of ships' ballast water and sediments* and regulates ballast water using powers under Chapter 5 of the *Biosecurity Act* 2015. The convention requires ships to install ballast water management systems to protect the marine environment from the transfer of harmful aquatic organisms in ballast water carried by ships. By 2024, it will be a requirement for all domestic vessels to have ballast water management systems installed.

Biofouling management

Biosfouling refers to marine growths on the outside of vessels. On 15 June 2022, DAFF implemented regulations requiring internationally arriving vessels to provide information on their proactive biofouling management practices prior to arriving in Australia. Proactive biofouling management practices aligns with international guidelines through the IMO.

State and Northern Territory agencies are responsible for the management of biofouling associated with domestic vessel movements. The 2015 *Review of national marine pest biosecurity* states that the Australian Government does not regulate biofouling associated with domestic vessel movements following a recommendation of the Beale review (Beale et al., 2008) that *'the Commonwealth's legislative reach should be restricted to international vessels arriving in Australia'*.

References

Bloomfield, N., et al. (2021). Updating the Species Temperature Tolerances used in the Species Range Mapping Method and Incorporating Known Species Distributions. Canberra, ABARES: 90.

Beale, R. Fairbrother, J. Inglis, A. Trebeck, D. (2008). *One biosecurity: a working partnership*. Commonwealth of Australia, Canberra.

Bernhardt, J.R. & Leslie, H.M. (2013). Resilience to climate change in coastal marine ecosystems. *Annual Review of Marine Science,* 5**:** 371-392.

Byrne, M. and N. Andrew (2013). Chapter 17 - *Centrostephanus rodgersii*. *Developments in Aquaculture and Fisheries Science*. J. M. Lawrence, Elsevier. 38: 243-256.

Byrne, M. and N. L. Andrew (2020). Chapter 22 - *Centrostephanus rodgersii* and *Centrostephanus tenuispinus*. Developments in Aquaculture and Fisheries Science. J. M. Lawrence, Elsevier. 43: 379-396.

Chan, V. B. S., et al. (2012). CO2-Driven Ocean Acidification Alters and Weakens Integrity of the Calcareous Tubes Produced by the Serpulid Tubeworm, *Hydroides elegans*. *PLoS ONE* 7(8): e42718

Cheung, W.W., Lam, V.W., Sarmiento, J.L., Kearney, K., Watson, R. & Pauly, D. (2009), Projecting global marine biodiversity impacts under climate change scenarios. *Fish and Fisheries*, 10: 235-251. doi:10.1111/j.1467-2979.2008.00315.x

Cockrell, M.L. & Sorte, C.J. (2013). Predicting climate-induced changes in population dynamics of invasive species in a marine epibenthic community. *Journal of experimental marine biology and ecology,* 440**:** 42-48.

Dobretsov, S., et al. (2019). The oceans are changing: impact of ocean warming and acidification on biofouling communities. *Biofouling* 35(5): 585-595.

Dworjanyn, S. A. and M. Byrne (2018). Impacts of ocean acidification on sea urchin growth across the juvenile to mature adult life-stage transition is mitigated by warming. *Proceedings of the Royal Society B Biological Sciences.* 285(1876): 20172684.

Gurgel, Cfd., Camacho, O., Minne, Ajp., Wernberg, T., Coleman, MA. (2020) Marine Heatwave Drives Cryptic Loss of Genetic Diversity in Underwater Forests. *Current Biology,* 30, (7):1199-1206.e2, https://doi.org/10.1016/j.cub.2020.01.051.

Halpern, B.S., Frazier, M., Potapenko, J., Casey, K.S., Koenig, K., Longo, C., Lowndes, J.S., Rockwood, R.C., Selig, E.R. & Selkoe, K.A. (2015). Spatial and temporal changes in cumulative human impacts on the world's ocean. *Nature communications,* 6**,** 1-7.

Herborg, Lm., Rushton, Sp., Clare, As. & Bentley, MG. (2005) The invasion of the Chinese mitten crab (Eriocheir sinensis) in the United Kingdom and its comparison to continental Europe. *Biological Invasions* 7: 959–968.

Heuer, R. M. and M. Grosell (2014). Physiological impacts of elevated carbon dioxide and ocean acidification on fish. *American Journal of Physiology*. 307(9): R1061-R1084.

Hobday, A. J. and J. M. Lough (2011). Projected climate change in Australian marine and freshwater environments. *Marine and Freshwater Research* 62(9): 1000-1014.

Hughes, T.P. (1994). Catastrophes, phase shifts, and large-scale degradation of a Caribbean coral reef. *Science,* 265**:** 1547-1551.

Lemasson, A. J. and A. M. Knights (2021). Differential responses in anti-predation traits of the native oyster *Ostrea edulis* and invasive *Magallana gigas* to ocean acidification and warming. *Marine Ecology Progress Series* 665: 87-102.

Lima, F. P., et al. (2007). Modelling past and present geographical distribution of the marine gastropod Patella rustica as a tool for exploring responses to environmental change. *Global Change Biology* 13(10): 2065-2077.

Ling, S. D., et al. (2009). Climate-driven range extension of a sea urchin: inferring future trends by analysis of recent population dynamics. *Global Change Biology*. 15(3): 719-731.

McDonald, JI. (2012) Detection of the tropical mussel species *Perna viridis* in temperate Western Australia: possible association between spawning and a marine heat pulse. *Aquatic Invasions* (2012) Volume 7, Issue 4: 483–490 doi: http://dx.doi.org/10.3391/ai.2012.7.4.005

Orr, J. C., et al. (2005). Introduction to special section: The Ocean in a High-CO2 World. *Journal of Geophysical Research Oceans* 110(C9).

Poloczanska, E. S., et al. (2007). Climate change and Australian marine life. *Oceanography and Marine Biology Annual Review* 45: 407–478.

Ramos, J. E., et al. (2018). Population genetic signatures of a climate change driven marine range extension. *Scientific Reports* 8(1): 9558.

Ridgway, K. R. (2007). Long-term trend and decadal variability of the southward penetration of the East Australian Current. *Geophysical Research Letters* 34(13).

Robinson, L. M., et al. (2015). Rapid assessment of an ocean warming hotspot reveals "high" confidence in potential species' range extensions. *Global Environmental Change* 31: 28-37.

Sardain, A., et al (2019) Global forecasts of shipping traffic and biological invasions to 2050. *Nature Sustainability* 2: 242-282

Sorte, C.J., Williams, S.L. & Zerebecki, R.A. (2010). Ocean warming increases threat of invasive species in a marine fouling community. *Ecology,* 91**:** 2198-2204.

Stachowicz, J.J., Fried, H., Osman, R.W. & Whitlatch, R.B. (2002). Biodiversity, invasion resistance, and marine ecosystem function: reconciling pattern and process. *Ecology,* 83**:** 2575-2590.

Tepolt, C. K. and G. N. Somero (2014). Master of all trades: thermal acclimation and adaptation of cardiac function in a broadly distributed marine invasive species, the European green crab, *Carcinus maenas*. *The Journal of Experimental Biology* 217: 1129-1138.

The Royal Society (2005). Ocean acidification due to increasing atmospheric carbon dioxide. London, The Royal Society: 68. https://royalsociety.org/-/media/Royal_Society_Content/policy/publications/2005/9634.pdf. Accessed 7/10/2022.

Wernberg, T., Bennett, S., Babcock, R.C., de Bettignies, T., Cure, K., Depczynski, M., Dufois, F., Fromont, J., Fulton, C. J. & Hovey, R.K. (2016). Climate-driven regime shift of a temperate marine ecosystem. *Science,* 353**:** 169-172.