

Chapter 4

Consequences of climate change for fishing, aquaculture and other ocean-based activities

4.1 The previous two chapters have provided an overview of the available evidence indicating the existing and future consequences of climate change for individual species and ecosystems in the marine environment. This chapter focuses on the implications of these changes for commercial, recreational and Indigenous fishing and other water-based activities, including associated effects for economic activity and employment. As this chapter will demonstrate, changing distributions and numbers of individual species, particularly commercially, recreationally and culturally important species, is expected to have significant consequences for commercial fishing and aquaculture, as well as for recreational fishing efforts.¹

Commercial fishing and aquaculture

4.2 The implications of climate change for commercial fishing and aquaculture were a principal focus of this inquiry and attracted significant comment. Just as climate change can have both positive and negative implications for certain species and ecosystems, evidence received during this inquiry indicated that the consequences of climate change for commercial fishing and aquaculture activities can vary, depending on location, species targeted and ability of the industry to adapt.

General observations

4.3 The Department of Agriculture and Water Resources (DAWR) submitted that 'climate change is anticipated to result in greater seasonal variability in the availability, abundance and location of species targeted by commercial fishers'. The nature and extent of these changes, however, are 'difficult to predict'.²

4.4 The Australian Fisheries Management Authority (AFMA) considered that climate change may affect fisheries in various ways, including as a result of:

- spatial and temporal variances in stock abundance;
- changes in range and life history of specific stocks;
- stock abundance, with some specific increasing in abundance while others decrease;
- increased variability affecting 'the predictive capacity for fisheries scientists to advise on fishing effort or allowable catch'; and

1 Institute for Marine and Antarctic Studies (IMAS), *Submission 1*, p. 16.

2 Department of Agriculture and Water Resources (DAWR), *Submission 18*, p. 4.

- weather changes, including extreme weather for greater periods of time, which may 'restrict access to stocks and constrain effort'.³

4.5 AFMA also suggested that developments linked to climate change could lead to 'increased workplace safety issues and risk-taking by crews'.⁴ In addition, the Northern Territory Seafood Council expressed concern about 'increased costs and difficulties in retaining workers due to increased temperature making working conditions difficult and increased cyclone activity or intensity leading to unsafe work places at sea or on land'.⁵

4.6 The DAWR considered that available research indicates 'climate change will result in both challenges and opportunities for the commercial fishing industry'. The DAWR submitted that climate change could, for example, 'result in the decline in abundance of some fish stocks or limit aquaculture operations for certain species, but concurrently may lead to increased production or range extension for other fish stocks'.⁶

4.7 More specifically, the Fisheries Research and Development Corporation (FRDC) advised that the barramundi aquaculture industry could spread south as the climate warms, and there could be an opportunity to farm warm temperate species (such as eastern lobster, southern bluefin tuna and yellowtail kingfish) in Tasmania. However, southern bluefin tuna farmed in South Australia 'will be impacted by increasing summer water temperatures through changes in their metabolic demand'.⁷

4.8 Consequences for the Tasmanian salmon aquaculture industry were highlighted in particular. The Institute for Marine and Antarctic Studies (IMAS) noted that the industry is 'confined to Tasmania due to the cooler waters of Tasmania being those suited to its survival'. IMAS further noted that the industry is 'worth \$0.5 billion and seeking to expand to \$1 billion over the next 20 years'.⁸ Government and scientific stakeholders accept that warming waters will present productivity and disease challenges for the industry. For example, the DAWR noted that 'increasing temperatures already evident in Tasmania will result in Atlantic salmon being cultivated close to their upper thermal limits of optimal growth and may therefore result in decreased productivity'.⁹

3 AFMA, *Submission 9*, p. 3.

4 AFMA, *Submission 9*, p. 3.

5 Northern Territory Seafood Council, *Submission 22*, p. [2].

6 DAWR, *Submission 18*, p. 4.

7 Fisheries Research and Development Corporation (FRDC), *Submission 2*, p. 11.

8 IMAS, *Submission 1*, p. 27.

9 DAWR, *Submission 18*, p. 4. See also FRDC, *Submission 2*, p. 11.

4.9 IMAS, which has commented on the potential impacts of climate change on salmon aquaculture in its publications, concluded that:

...without strategic research and specific changes in farming practice climate change would negatively impact on salmon aquaculture production through temperature related increases in physiological stress and diseases and decreased feeding, growth and growth efficiency.¹⁰

Specific developments that have been observed and other potential outcomes

4.10 In considering the future consequences of climate change for commercial fisheries, past examples of fisheries affected by warming waters were noted. IMAS referred to Tasmania's jack mackerel fishery, which in the 1980s was Australia's largest single species fishery by volume. IMAS explained that the krill schools the jack mackerel fed on had disappeared by the mid-1990s, along with the jack mackerel, leaving a local processing plant and associated jobs 'defunct'. IMAS referred to CSIRO research that observed the effects of warm waters on plankton, and related consequences for krill; this research provided 'anecdotal evidence that the warming east coast waters play[ed] an important role in the disappearance of this fishery'.¹¹

4.11 Changes in commercial fisheries linked to climate change have been observed. Austral Fisheries advised that its operations have been 'directly impacted already by climate change in our fisheries'. For example, rainfall reductions and warmer ocean temperatures 'has, and will continue, to impact on levels of prawn stocks, and impacts on ecologically related species to prawns, such as die-back of mangroves that we have seen in the past year, around the Eastern Gulf of Carpentaria'.¹² On banana prawns in the Northern Prawn Fishery, Austral Fisheries explained that this species is:

...well known to be reliant on adequate rainfall and consequent river flows at the correct time of the life cycle of the prawn, to ensure the stocks are productive and generate good recruitment. If climate change leads to longer periods of lower rainfall in northern Australia, or if river flows are negatively impacted due to either lower rainfall, or other diversions of the available water, then we will see direct negative impacts on prawn stock abundance.¹³

4.12 Austral concluded that such a development would 'result in lost income, higher carbon emissions generated as operators spend longer at sea burning diesel fuel to search for prawns, and lower catches of prawns'.¹⁴

10 IMAS, *Submission 1*, p. 27.

11 IMAS, *Submission 1*, p. 26.

12 Austral Fisheries, *Submission 6*, p. [2].

13 Austral Fisheries, *Submission 6*, p. [5].

14 Austral Fisheries, *Submission 6*, p. [5].

4.13 Regarding the sub-Antarctic fishery at Heard Island and McDonald Islands, Austral believes the record high sea surface temperatures recorded from May to July 2016 'may have had detrimental impacts on the availability of toothfish in our fishery'.¹⁵ Austral explained:

Toothfish stocks in the sub Antarctic underwent a dramatic shift in availability in May 2016, for a period of nearly 5 months, after which the availability of the fish returned (equally as dramatically) to previous levels.¹⁶

4.14 As another example, IMAS submitted that the east coast Tasmanian abalone fishery has 'seen declines in productivity that have resulted in changes in allocated quota'. IMAS acknowledged that some reduction in fleet size was part of planned management outcomes; however, IMAS considered that 'the effects of climate change may have compounded the reduction in fleet size'.¹⁷

4.15 Potential effects for the oyster industry include:

- fixed height water infrastructure that 'will need adjustment under different sea-level scenario';
- changes in phytoplankton species, distribution and abundance, leading to 'increased occurrence of harmful algal blooms, which has the potential to shut down production for extended periods';
- ocean acidification that will thin the walls of shellfish; and
- increased storm intensity that 'will see greater damage to cultivation gear and coastal infrastructure (e.g. oyster sheds, wharfs, marinas, etc.)'.¹⁸

4.16 Mr Neil Stump, Executive Officer, Oysters Tasmania, informed the committee that rising sea levels within areas used for growing oysters will have implications for existing operations. He explained:

...if we have increasing sea-level rises within growing areas—particularly in the intertidal areas where the oysters rely on being submerged for part of the day and out in the open for part of the day—that will change the way our industry needs to operate. Currently, we do have growers that operate subtidally; however, they do have to do that interspersed with intertidal operations as well, because it is a characteristic of the animal that, when it is subtidal, it is open all the time feeding 24/7 and its adductor muscle does not develop properly. So it requires placement in intertidal areas for the shell to open and close and strengthen its adductor muscle so, when you are

15 Austral Fisheries, *Submission 6*, p. [2].

16 Austral Fisheries, *Submission 6*, p. [5].

17 IMAS, *Submission 1*, p. 26.

18 OceanWatch Australia, *Submission 3*, p. [4].

selling it as a live product, it has to have the capacity to close its shell while it is in live transport. It is a very simple thing.¹⁹

4.17 As noted above, scientists expect the Tasmanian salmon aquaculture industry to face productivity pressures due to warming waters resulting in Atlantic salmon being cultivated close to their upper thermal limits of optimal growth. Evidence of warming waters already negatively affecting the industry emerged in 2016 when Tassal announced that it had decided to withdraw tenders for two domestic retail supply contracts involving the supermarket chain Coles 'in light of warmer waters impacting growing conditions for near term supply'.²⁰ More recently, it was reported that warming surface temperatures had contributed to elevated salmon mortalities at Tassal's operations at Macquarie Harbour.²¹

Marine pests and diseases

4.18 There are over 250 introduced marine plants and animals established in Australian waters, some of which become pests.²² These pests have consequences for a wide range of marine activities, however, consequences for the commercial fishing industry were highlighted in particular. In addition, fisheries and aquaculture can be susceptible to outbreaks of bacterial, fungal and parasitic infections.²³ The FRDC advised that Australia has 'a unique and poorly understood range of endemic pathogens'. The FRDC added that these pathogens include 'local strain variations of pathogens of international concern, which is becoming increasingly important and of significance to our export trade'.²⁴

4.19 Several submitters acknowledged that it is difficult to link the outbreak of marine pests and diseases to climate change;²⁵ for example, marine pests are

19 Mr Neil Stump, Executive Officer, Oysters Tasmania, *Committee Hansard*, 21 February 2017, p. 19.

20 Tassal, 'Tassal rebalances sales channels to optimise returns', Statement to the ASX, 7 April 2016.

21 A Humphries, 'Harbour fish deaths', *The Mercury*, 28 November 2017, p. 3.

22 DAWR, 'Marine pests', www.agriculture.gov.au/pests-diseases-weeds/marine-pests (accessed 6 February 2017).

23 New South Wales Department of Primary Industries (NSW DPI), 'Disease management in aquaculture', www.dpi.nsw.gov.au/fishing/pests-diseases/animal-health/aquaculture/poms (accessed 6 February 2017).

24 Examples given by the FRDC include: nervous necrosis virus in finfish; local genotypes of YHV (YHV2, YHV7) in prawns; *Bonamia* sp. in edible oysters; oedema oyster disease in pearl oysters; *Edwardsiella ictaluri* in catfish; abalone viral ganglioneuritis; and *Penaeus monodon* hepatopancreatitis. FRDC, *Submission 2*, p. 19.

25 See FRDC, *Submission 2*, p. 10; Australian Marine Sciences Association, *Submission 5*, p. 3; Austral Fisheries, *Submission 6*, p. 5 and Sydney Institute of Marine Science (SIMS), *Submission 8*, p. 3. For example, SIMS submitted that 'ascribing the appearance or abundance of novel marine pests and diseases to climate change parameters is less straight forward than trends in biodiversity or fish stocks'.

introduced to new areas through ships' biofouling and in the ballast water carried by ships.²⁶ However, there are concerns that the effects of climate change may enable marine pests to become established in previously uncontaminated areas. It is also considered that the effects of climate change may lead to changes in disease occurrence or prevalence.²⁷

4.20 AFMA stated that climate change projections 'suggest that there may be a redistribution of marine pests and diseases'.²⁸ The committee received evidence that some marine pests have shifted their geographic range due to elevated water temperatures. For instance, the long-spined sea urchin (*Centrostephanus*), a native species of New South Wales, has been detected in Tasmanian waters and is considered a pest as it destructively overgrazes seaweed.²⁹ Dr Neville Barrett from IMAS provided the following evidence regarding the implications of the long-spined sea urchin entering Tasmanian waters:

That [species] is coming down in huge numbers, the currents are bringing it down, and it is probably becoming reproductively established in our waters now, so it is self-sustaining. That has a major negative impact, because that particular species forms what we call urchin barrens on our rocky reef systems. It denudes the reefs of pretty much all algae and all other forms of life. It causes a major decline in productivity for rock lobster, for abalone, because there is no algae there to support the food chains they need; it also just wipes out everything else that is on the reef systems. That is a real negative.³⁰

4.21 Mr Jon Bryan from the Tasmanian Conservation Trust, however, questioned whether climate change is the principal cause of the change in distribution of the long-spined sea urchin. Mr Bryan argued that 'urchin barrens are primarily caused by overfishing of rock lobster' and that, in his view, 'there is no way that we can really tell how much climate change is contributing to this'. Mr Bryan continued:

One would expect that the warmer water temperatures, which increase the growth of invertebrate animals normally—until the water gets hot enough to kill them—is a contributing factor. But primarily, rock lobsters are the key to this problem and climate change is secondary. So I think it is quite misleading for people to say, 'Look, this is a climate change problem.' It is a fisheries management problem.³¹

26 DAWR, *Submission 18*, p. 6.

27 For example, see CSIRO, *Submission 15*, pp. 16–19.

28 AFMA, *Submission 9*, p. 3.

29 IMAS, *Submission 1*, p. 26; CSIRO, *Submission 15*, pp. 16–17.

30 Dr Neville Barrett, IMAS, *Committee Hansard*, 21 February 2017, p. 4.

31 Mr Jon Bryan, Tasmanian Conservation Trust, *Committee Hansard*, 21 February 2017, p. 28.

4.22 Evidence was presented indicating that marine diseases can be stimulated by environmental stressors, including stressors linked to climate change such as warming water temperatures (which affect the immune response of cool water aquatic animals).³² Storm events, heavy rainfall and floods are other stressors for marine ecosystems that can make species more prone to disease and introduce nutrients that cause algal blooms.³³

4.23 Pacific Oyster Mortality Syndrome (POMS), which is a disease that affects only Pacific oysters, was put forward as an example of a disease that is linked to warming waters. POMS can result in rapid mortalities and outbreaks of the disease are believed to be temperature dependent. POMS was first detected in Australia in New South Wales in November 2010.³⁴ An outbreak was subsequently detected in Tasmania in January 2016. That outbreak killed in excess of \$12 million worth of Pacific oysters.³⁵ Prior to the 2016 outbreak, the Tasmanian industry also supplied most of the spat juvenile oysters to South Australia, with overall hatchery sales of \$6–\$8 million. However, South Australia has since prohibited the importation of live oyster products from Tasmania as a preventative measure to reduce the risk of the disease spreading.³⁶

4.24 The employment implications of an outbreak are considerable. Overall, Mr Stump advised that in an industry where approximately 350–400 people are directly employed, approximately 100 people lost their job. He added:

The flip side of that too is not only those people lose their job but if they lose it for any period of time they are likely to go somewhere else. What it meant in the recovery process for growers was when it came time to ramp up or get back on their farms and start handling product again, they were behind the eight ball because they did not have the workforce. They had to make some very strategic decisions about how many people they could afford to rehire and for how long and what order they had to do the work. I was talking to a farmer the other day who had to make the decision between handling more stock to get it into the market and doing repairs required so he could stock up again for the next winter. There are very real business impacts trying to handle those sorts of things.³⁷

32 FRDC, *Submission 2*, p. 10.

33 Professor Gustaaf Hallegraef, IMAS, *Committee Hansard*, 21 February 2017, p. 13.

34 NSW DPI, 'Pacific Oyster Mortality Syndrome (POMS)', www.dpi.nsw.gov.au/fishing/pests-diseases/animal-health/aquaculture/poms (accessed 17 January 2017).

35 I Catizone, 'National impact from Tasmanian POMS outbreak', *FISH*, vol. 24, no. 2 (June 2016), FRDC, http://frdc.com.au/stories/Pages/26_National-impact.aspx (accessed 17 January 2017).

36 Mr Neil Stump, Oysters Tasmania, *Committee Hansard*, 21 February 2017, p. 20.

37 Mr Neil Stump, Oysters Tasmania, *Committee Hansard*, 21 February 2017, p. 20.

4.25 In response to the POMS outbreak, the Tasmanian Government announced fee relief, concessional loans and clean-up assistance.³⁸

4.26 Harmful algal blooms (HABs) have also affected commercial fisheries. HABs occur when, under the right conditions, colonies of algae grow out of control and produce effects that are toxic or harmful for people, fish, shellfish, marine mammals and birds. The human illnesses caused by HABs, though rare, can be debilitating and even fatal.³⁹

4.27 Research indicates that HAB species are expanding their range, with some expansions likely related to the changing climate.⁴⁰ For example, IMAS explained that in 2012, 2015 and 2016, toxic dinoflagellate bloom outbreaks occurred on Tasmania's east coast in a region that was previously considered a low biotoxin risk area. The outbreaks led to lengthy closures of mussel, oyster, scallop and rock lobster fisheries. The 2015 outbreak on Tasmania's east coast resulted in four people being hospitalised with paralytic shellfish poisoning. Preliminary evidence indicates that the strain of dinoflagellate is a previously rare genotype in the area that has been newly stimulated by the southward extension of the East Australian Current.⁴¹

4.28 Professor Gustaaf Hallegraeff, who has worked on HAB research for 40 years, explained that he 'did not see these [outbreaks] coming' as HABs are 'actually a cold-water phenomenon'. He added:

...something happened in the cold-water winter period. The water column stratification has changed, and this has had an enormous impact, for example, on the shellfish in Australia and on the east coast of Tasmania, to the extent where we expect that the mussel industry has a very limited future. In general, these systems are becoming less predictable and that is what is causing the problems for human society.⁴²

38 Tasmanian Department of Primary Industries, Parks, Water and Environment, 'Government Assistance for Oysters Growers', <http://dpiuwe.tas.gov.au/sea-fishing-aquaculture/marine-farming-aquaculture/government-assistance-for-oysters-growers> (accessed 17 January 2017).

39 National Oceanic and Atmospheric Administration, 'What is a harmful algal bloom?', www.noaa.gov/what-is-harmful-algal-bloom (accessed 7 December 2016).

40 P Thompson, P Bonham and K Swadling, 'Phytoplankton blooms in the Huon Estuary, Tasmania: top down or bottom up control?', *Journal of Plankton Research*, 2008, vol. 30, no. 7, pp. 735–53; cited by CSIRO, *Submission 15*, p. 18.

41 G Hallegraef and C Bolch, 'Unprecedented Toxic Algal Blooms Impact on Tasmanian Seafood Industry', *Microbiology Australia*, 2016, vol. 37, no. 3, pp 140–42; cited by IMAS, *Submission 1*, p. 24.

42 Professor Gustaaf Hallegraeff, IMAS, *Committee Hansard*, 21 February 2017, p. 2.

4.29 Austral explained that algal blooms off the east coast of Tasmania 'have necessitated temporary closures of fisheries such as oysters, scallops, abalone and rock lobster to ensure public health and safety is maintained'.⁴³ Mr Stump explained that, unlike other diseases the HABs do not harm the oysters themselves, but they present 'a food safety issue...because the toxins produced by these algae are harmful to humans', potentially causing sickness or resulting in death.⁴⁴

4.30 A further issue discussed during this inquiry is amoebic gill disease. IMAS explained that salmon in aquaculture stressed by warmer water temperatures have an increased likelihood of amoebic gill disease.⁴⁵ Professor Stewart Frusher from IMAS provided the following evidence on this topic:

When most aquaculture or animals get to the ends of their thermal tolerances we see a lot more diseases occur. Animals that are confined in regions, whether they be salmon or cattle in herd lots and things of this nature, are prone obviously to higher disease incidences.⁴⁶

4.31 IMAS noted that the increased prevalence of amoebic gill disease in salmon aquaculture has resulted in increased mortality and management costs for treatment.⁴⁷

4.32 Although it is predicted that the consequences of climate change might cause certain outbreaks such as HABs to occur more often, direct links between the consequences of climate change and the incidence and prevalence of other marine pests and diseases are less clear. For example, POMS is a disease that is linked to temperature; however, evidence received by the committee indicated that explicitly linking outbreaks to climate change is difficult. Professor David Raftos emphasised that:

The relationship between pests and pathogens in terms of the marine environment is complex because it is a three-way street. You have got the environment, you have got the infected host species and you have got the infectious agent, which adds a level of complexity.⁴⁸

4.33 On the arrival of POMS in New South Wales and the subsequent outbreak in Tasmania, Professor Rathos commented:

It is difficult to see immediately a climate change link. It is probably just transportation—it has gotten into the container terminal at Botany. Identifying direct climate change links in those situations can be difficult,

43 Austral Fisheries, *Submission 6*, p. [2].

44 Mr Neil Stump, Oysters Tasmania, *Committee Hansard*, 21 February 2017, p. 19.

45 IMAS, *Submission 1*, pp. 23, 27. The FRDC has undertaken research into the comparative susceptibility and responses of endemic fishes and salmonids affected by amoebic gill disease in Tasmania: see FRDC, *Submission 2*, p. 40.

46 Professor Stewart Frusher, IMAS, *Committee Hansard*, 21 February 2017, p. 11.

47 IMAS, *Submission 1*, p. 27.

48 Professor David Raftos, SIMS, *Committee Hansard*, 16 March 2017, p. 28.

and it is certain that that particular virus has a temperature threshold, and disease only occurs above certain temperatures.⁴⁹

4.34 Nevertheless, in light of the concerns regarding links between climate change and marine pests and diseases, the committee received evidence questioning aspects of current biosecurity arrangements. IMAS explained that Australia 'has strong diagnostic capabilities for seven aquatic diseases determined as priority; however, it argued that greater consideration is given to the 'early detection of emerging pathogens and strategic research'.⁵⁰ The FRDC explained that its research investment in biosecurity is confined to 'endemic diseases and to risks associated with exotics that currently or potentially have an impact on or by fishing and aquaculture activities'.⁵¹

Future of commercial fishing and aquaculture

4.35 Overall, CSIRO advised that ecosystem models suggest that, for south-east Australia, sustainable fisheries and aquaculture 'will be possible under climate change'; however, 'a change in species mix, including more invertebrates and pelagic fish' will likely be required. Furthermore, although fisheries will be profitable, 'the employment projections are more mixed'. CSIRO provided the following reasoning:

If there are strong restrictions on the use of large vessels, which can shift with species then the landings, value and economic health can be negatively impacted. However, if such large vessels can be used (with suitable management in place for them to remain sustainable) the economic health of fisheries is good (potentially improving substantially versus the current state). However, employment will contract as smaller boats—which are socially tied and do not have the capacity to shift with stocks or ride out the potential increases in variability—leave fisheries...If this outcome is to be avoided the smaller fishers would need additional livelihood support to help their capacity to shift as required.⁵²

4.36 In discussing the consequences for commercial fishing, it was noted that the Australian industry has changed and adapted throughout its history. For example, IMAS noted that 'Flinders Island once supported a thriving lobster fishing community yet now only one part-time lobster fisher is based on the island'. In addition, St Helen's in Tasmania was considered one of the state's major fishing ports, but 'over the last 30 years [it] has seen over 60% of the fishing fleet disappear'.⁵³

49 Professor David Raftos, SIMS, *Committee Hansard*, 16 March 2017, p. 28.

50 IMAS, *Submission 1*, p. 38.

51 FRDC, *Submission 2*, p. 19.

52 CSIRO, *Submission 15*, pp. 19–20.

53 IMAS, *Submission 1*, pp. 25–26 (citation omitted).

4.37 The DAWR observed that '[f]lexibility and resilience have long been characteristic of the commercial fishing industry, owing to changes in the business environment over recent decades and the natural variability of marine ecosystems'. The DAWR added:

Fishers adapt how, when and where they fish so as to optimise their operations for their professional requirements. These features demonstrate a capacity to respond to uncertainty and change, whatever form it may take.⁵⁴

4.38 AFMA also noted that, although the scope of potential climate change-related impacts is 'wide', climate change 'is still only one of many factors affecting commercial fishing'.⁵⁵ A similar point was made in the submission from the Government of South Australia, which stated:

There are many and varied factors which challenge the management of fisheries resources, including climate change, environmental variability, population growth, coastal development, competition for resources by a variety of stakeholder groups, advancements in fishing technology and catching capacity, among others.⁵⁶

4.39 The DAWR submitted that CSIRO research has reached the following conclusion:

...while climate change is an important issue for Commonwealth fisheries, other issues such as markets, input costs and overexploitation are likely to have a greater effect and be a higher priority for fisheries policy and management in the short term.⁵⁷

4.40 It was also noted that Australia's commercial fishing industry is relatively small, with catch tonnage ranked 60th globally.⁵⁸ Nevertheless, it is recognised that commercial fishing companies need to 'understand [the] potential impacts of climate change on their businesses and build resilience and adaptive capabilities in their operations and planning'.⁵⁹ In this regard, Austral advised that it considers the impact of climate change on its operations is 'a critical priority, if not the highest priority, for our business'.⁶⁰ Austral stated that it has implemented monitoring programs with scientists 'in an ad hoc manner'; however, it considers there needs to be 'a coordinated,

54 DAWR, *Submission 18*, p. 4.

55 AFMA, *Submission 9*, p. 3.

56 Government of South Australia, *Submission 21*, p. 2.

57 DAWR, *Submission 18*, p. 4.

58 DAWR, *Submission 18*, p. 3. The reasons for this were questioned in the Australian Environment Foundation's submission, which argued that Australian fisheries are under-utilised. See *Submission 12*.

59 Queensland Government, *Submission 14*, p. 2.

60 Austral Fisheries, *Submission 6*, p. [2].

calibrated, program of research that is developed by scientists'. Austral advised that it is willing to contribute to such a program.⁶¹

4.41 More broadly, however, the committee received evidence indicating that the industry is not prepared for climate change. Mrs Patricia Beatty, who represented the New South Wales Professional Fishermen's Association, stated:

We as an industry do not have a very strong grasp on climate change and what it means for us, but we do understand one thing and that is that it will create change in our industry; in how we fish, fish availability, the catch availability; basically the productivity of our systems. We also understand there is a potential for increase in biosecurity issues, such as diseases et cetera in our system.⁶²

4.42 Mrs Beatty continued:

This change is not what we believe we are prepared for. The research and monitoring is not occurring in the real time and, even if it was, we do not have a real understanding of the causes; rather, we have a tokenistic understanding of what is a symptom. So we will understand through our log books that, for example, catches might be down. But is that because there is an abundance issue or is it because the fish have gone deep or gone somewhere else? We do not have an understanding of the actual causes. It could be that market forces are involved or changes in fisheries habitats. Our fear is that as soon as catches go down commercial fishers are considered the first risk and threat. Even if we did have all this research and monitoring and strong understanding in real time, we still do not believe we have a responsive, flexible and adaptive management system of our industry.⁶³

4.43 It was also noted that commercial fishing and aquaculture businesses have to deal with other challenges and prioritise their responses to various challenges. Professor David Raftos provided insight into this by referring to his experience with the oyster industry. Professor Raftos commented:

I work quite a lot with oyster farmers, and most oyster farmers are very aware of the situation and know that it is a threat. But they are routinely hammered by all sorts of different problems. It is a standard farming sort of industry. So they are prioritising. If you are a Pacific oyster farmer at the moment, your major threat is Pacific oyster mortality syndrome, because it is going to wipe out your farm.

61 Austral Fisheries, *Submission 6*, p. [4].

62 Mrs Patricia Beatty, Executive Officer, New South Wales Professional Fishermen's Association, *Committee Hansard*, 16 March 2017, p. 14.

63 Mrs Patricia Beatty, New South Wales Professional Fishermen's Association, *Committee Hansard*, 16 March 2017, p. 14.

So they prioritise. And generally, because it is not tangibly immediate, the climate change issues go a couple of steps down that priority list, I think.⁶⁴

4.44 Another issue put forward was the implications of climate change for the governance of fishing companies. Mr Exel from Austral referred the committee to a legal opinion from Noel Hutley SC and Sebastian Hartford Davis to the effect that 'climate change risks are something that you have to take account of in a governance sense as a business'.⁶⁵ Austral outlined its approach as follows:

That is our planet, and that is why we as Austral decided to offset all of our carbon emissions. We already had the sustainability side of things knocked out with fisheries, but it is clear that climate change is major and in our way of doing things it goes without saying that we had to move to economic sustainability. From our perspective, as things change it is costing us a lot of money. Some of the changes mentioned in our report there—I was doing a quick estimation—cost us as a company somewhere between \$10 million and \$15 million last year.

Social sustainability is the other thing. Keeping up with community expectations is a nightmare—I am so glad that you guys are the ones that deal with that. As fishermen, we cop some of the flak. We deserve some of that and, in many cases, a lot of it, but at the same time without a framework for us to deal with it as an industry it makes it really hard to keep up with the community.⁶⁶

Recreational fishing

4.45 It was noted that recreational fisher behaviour will need to adapt to ecological changes to the distribution, abundance, and seasonality of target species caused by climate change.⁶⁷ The Sydney Institute of Marine Science (SIMS) argued that highly mobile target species 'such as pelagic fish (tuna, billfish, sharks), will alter the timing of their annual migrations and recreational fishers will need to adapt to these temporal and spatial changes in species distributions'.⁶⁸

4.46 Positive outcomes for recreational fishers in certain locations were noted. Professor Stewart Frusher from IMAS explained that some recreational species, including snapper and King George whiting, may enter Tasmanian waters as the waters warm. He advised that some recreational fishers are 'quite positive' about this change as the species are 'iconic fish to catch'.⁶⁹

64 Professor David Raftos, SIMS, *Committee Hansard*, 16 March 2017, p. 29.

65 Mr Martin Exel, General Manager Environment and Policy, Austral Fisheries, *Committee Hansard*, 21 February 2017, p. 22.

66 Mr Martin Exel, Austral Fisheries, *Committee Hansard*, 21 February 2017, p. 23.

67 IMAS, *Submission 1*, p. 29; SIMS, *Submission 8*, p. 4.

68 SIMS, *Submission 8*, p. 4.

69 Professor Stewart Frusher, IMAS, *Committee Hansard*, 21 February 2017, p. 1.

4.47 Based on the evidence presented to the committee, how significant the expected consequences for recreational fishing will be is unclear. SIMS referred to research indicating that recreational fishers are 'particularly vulnerable to climate change as they have less capacity to adapt to altered target species and distributions'.⁷⁰ However, IMAS suggested that, compared to commercial fishers, individual fishers generally 'have greater capacity to adapt based on the flexibility in their decisions about fishing activities and these will be influenced by how much they value particular species'. Nevertheless, IMAS acknowledged that 'the regional impacts of altered recreational fisher behaviour should not be underestimated' given that '[m]any regional areas in Australia are highly reliant on the economic benefits of recreational fishing'.⁷¹

Indigenous fishing and management of sea country

4.48 The impacts of climate change on Indigenous fishing were noted in the submissions from AFMA, the Northern Land Council and the Torres Strait Regional Authority (TSRA). Submissions commented on Indigenous fishing generally and Indigenous Protected Areas (IPAs).⁷²

4.49 The implications of climate change for the Torres Strait region were highlighted. AFMA provided the following observations:

Fish remain a major source of protein and income for many Indigenous communities so any changes in distribution or abundance of marine species can have significant economic and social impacts. Also, the Torres Strait is more susceptible to the impacts of sea level change as many islands are low lying.⁷³

4.50 The TSRA submitted that, for the Torres Strait region, current climate projections indicate that climate change 'will almost certainly become a significant threatening process to the marine ecosystems of the region'. The TSRA explained that the shallow sea basin in the region 'contains over 300 islands and approximately 1,200 coral reefs', as well as 'extensive seagrass meadows and coastal mangrove systems'. The TSRA emphasised that the coral reefs in the Torres Strait 'are

70 SIMS, *Submission 8*, p. 4.

71 IMAS, *Submission 1*, p. 29.

72 As part of the IPA program, since 1997 the Australian Government has assisted Indigenous communities to dedicate their land or sea country as IPAs on a voluntary basis. IPAs are recognised as part of the National Reserve System and IPA projects are supported through a multi-year funding agreement. Department of the Prime Minister and Cabinet, 'Indigenous Protected Areas – IPAs', www.pmc.gov.au/indigenous-affairs/environment/indigenous-protected-areas-ipas (accessed 26 October 2017). Further information about the IPAs in the Northern Territory was provided by the Northern Land Council: see Mr Matthew Salmon, Manager, Caring for Country, Northern Land Council, *Committee Hansard*, 20 October 2017, p. 2; Northern Land Council, *Submission 17*, p. 6.

73 AFMA, *Submission 9*, p. 6.

undeniably of great cultural and economic importance for the Torres Strait Islanders and Aboriginal people of the region'. Furthermore, the marine fisheries in the region are 'the backbone of the regional Indigenous economy'.⁷⁴

4.51 The Northern Land Council submitted that apparent impacts of climate change in the Northern Territory include the 'severe dieback of mangroves in the Gulf of Carpentaria' and 'coral bleaching in coastal areas of east Arnhem'.⁷⁵ There is also concern that tropical rock lobster adults 'may become rare and harder to harvest in the shallower waters where most of the traditional and community fishing takes place'.⁷⁶

4.52 AFMA explained that it is working with the TSRA and the Queensland Government to 'assist Traditional Inhabitants to adapt to changes in their fisheries'. AFMA added that it 'addresses climate change directly in the Torres Strait through the use of fishery independent stock assessments'.⁷⁷ The DAWR also noted that the Australian Government has committed to recognise the interests of Indigenous fishers (and recreational fishers) in Commonwealth fisheries legislation.⁷⁸

4.53 However, the Northern Land Council expressed concern that 'customary practices and traditional economies will be unsubstantiated in government policy and programs for climate change adaptation'. It submitted:

Formulating and resourcing an appropriate engagement framework is imperative for Traditional Owners to inform policy and programs respective of their rights, interests and knowledge of marine fisheries and biodiversity. Resources should provide necessary expertise to inform management practices and support existing or the establishment of Traditional Owners governance frameworks to engage in this issue.⁷⁹

4.54 Continuing on from the above evidence about the need to provide expertise to support management practices, Mr Matthew Salmon, Manager, Caring for Country, Northern Land Council, advised that research 'generally remains inaccessible to our members'.⁸⁰ Mr Salmon explained:

...people have a suspicion that some of the local changes they're seeing could be linked to climate change, but they tend not to have access to the science or the research which might, as far as it can, definitively back that

74 Torres Strait Regional Authority, *Submission 16*, p. [2].

75 Northern Land Council, *Submission 17*, p. 5.

76 It is considered that these animals will migrate to deeper waters in response to higher sea temperatures. Northern Land Council, *Submission 17*, p. 5.

77 AFMA, *Submission 9*, p. 6.

78 DAWR, *Submission 18*, p. 3.

79 Northern Land Council, *Submission 17*, pp. 7–8. The Council lists several recommendations at page 8 of its submission.

80 Mr Matthew Salmon, Northern Land Council, *Committee Hansard*, 20 October 2017, p. 1.

view up. The critical question for these guys is they suspect some of these things might be going on, but they don't have access to the research. And so a central part of our submission is: how do we connect people better to the science that's happened? And the other thing is: how do we provide a gateway for people to be able to say to researchers, 'We've noticed these things in our environment. We've got some suspicions about what might cause them. How do we work together to get that answer?'⁸¹

4.55 Mr Salmon added:

...where we have Indigenous protected areas, for example, most of our groups will have at least some kind of cursory discussion with their science partners about potential impacts. But that doesn't represent any kind of joined-up specific or deliberate effort to have a think about how these things might affect people right across the 84 per cent of the coast that we own. I would say that the trouble is that the engagement isn't deliberate; it isn't designed from scratch with the idea that that would happen. It tends to happen coincidentally as a result of our other engagement with our science partners.⁸²

4.56 Mr Salmon noted that, although engagement about climate change issues 'tends to be fragmented and coincidental', when it comes to other issues there are 'good research relationships', such as those with the CSIRO. Mr Salmon concluded:

It would be nice to see some deliberately designed regional-scale effort which would work with people to build on their local observations of change, help them describe whether they think it's climate related and then help people think about what kind of deliberate, practical, local actions they could take away from this.⁸³

Fishing on the high seas, fishing activity in other countries and illegal fishing

4.57 A range of other issues related to climate change arise due to the migratory nature of fish stocks and the mobile nature of fishing efforts. For example, AFMA noted that as 'Australia accesses a number of important highly migratory and high seas fish stocks, along with many other nations', the effect of climate change on these fisheries will likely require negotiations with international fisheries organisations.⁸⁴

81 Mr Matthew Salmon, Northern Land Council, *Committee Hansard*, 20 October 2017, p. 3.

82 Mr Matthew Salmon, Northern Land Council, *Committee Hansard*, 20 October 2017, p. 3.

83 Mr Matthew Salmon, Northern Land Council, *Committee Hansard*, 20 October 2017, p. 4.

84 AFMA, *Submission 9*, p. 6.

4.58 AFMA also suggested that stock shifts associated with climate change may lead to an increase in illegal, unregulated and unreported fishing by Australian or foreign fishers. AFMA observed:

Australia's Exclusive Economic Zone abuts several other nations which are facing significant challenges in managing their fisheries most often for domestic human consumption. Like Australia they will face pressures on their fisheries from climate change and it will be important that we continue to work with them to solve the regional issues that may arise.⁸⁵

4.59 Likewise, CSIRO noted that populations in many nearby nations rely on fish as a major daily source of protein. For example, CSIRO noted that 3.3 million people in Indonesia 'rely directly on fishing activities for part or all of their income...the numbers rise to 6 million Indonesians if aquaculture farmers are included'. Accordingly, it can be expected that:

...climate impacts on our neighbours will have flow on effects to Australia both in terms of supply of fish and possible declines in our neighbours' fisheries and hence their income and food security.⁸⁶

4.60 Dr Hobday from CSIRO added that, in relation to illegal fishing:

We have been seeing more vessels—for example, in northern Australia—in recent years. That is perhaps related to regional conflict in South-East Asia as much as it is to declining fish stocks in that region. But the kind of disruption that we expect through climate change will have the same result. There will be vessels that attempt to go to other places in order to provide food for their countries.⁸⁷

4.61 When asked about the potential for increased illegal, unregulated or unreported fishing activity as a result of climate change, Mr Exel from Austral Fisheries agreed that this is a concern. In addition, Mr Exel provided the following evidence regarding changes to fisheries and tensions between competing interests that might become more evident due to climate change:

Globally, it already has, as fish stock shift range, or range-shift. The redfish in the North Atlantic is a classic; it moved into Icelandic waters and out of the high seas, and the Icelandic fishers said, 'Thank you very much; we'll have that.' Southern bluefin tuna are rapidly returning; they are coming back. They are one of the beneficial species. Even there, you have got a really interesting play in Australia where the recreational share of the overall catch versus commercial share is now a big issue. And there will be

85 AFMA, *Submission 9*, p. 6.

86 CSIRO, *Submission 15*, p. 8.

87 Dr Alistair Hobday, Senior Principal Research Scientist, CSIRO, *Committee Hansard*, 17 March 2017, p. 7.

a lot of those sorts of issues. People are going to have to start dealing with things on an international basis rather than, 'This is mine.'⁸⁸

Tourism and recreational water-use

4.62 The terms of reference for this inquiry focus on the impacts of climate change on certain specific industries and activities, including commercial fishing and aquaculture, and recreational fishing. However, the committee also received evidence suggesting that the impacts of climate change on marine fisheries could also have implications for tourism linked to marine ecosystems.

4.63 One area where this is a particular concern is for diving activities. Mr Michael Baron, who owns a diving business located on the east coast of Tasmania, explained that international visitors are interested in diving in the region to see 'kelp forest, seals and the little weedy sea dragons...more or less in that order'. Mr Baron explained that the destruction of the kelp forest in Munro Bight has caused a reduction in business from international visitors. Mr Baron stated:

From a business perspective, international visitors now are our prime source of income. We have estimated that this year, which is the first year we have no forest at all, we have probably lost roughly 25 per cent of our clientele. They ring up. 'I'd like to dive the forest.' 'Sorry.' 'Okay. Thank you.' It is 25 per cent at this stage. We potentially forecast that it may drop more because the international visitors tend to organise their holidays one or two years in advance. They will come if they are already booked to come.⁸⁹

4.64 The risk of negative publicity from toxic marine diseases is also considered to present a risk to international tourism in particular regions. Professor Gustaaf Hallegraeff commented:

...when we did some research we found that some of the most pristine areas near Coles Bay were also toxic. I was there and saw Chinese tourists picking periwinkles from the rocks. I got in touch with the department of health and community services and right now, for the first time, they are signposting that whole area, because they realised it just needs one Chinese tourist to die from this phenomenal shellfish poisoning—and it could also damage the tourism industry. So there is still a lot of debate, and a lot of research to do, about the extent to which this links to climate change, but something has changed and we have to respond to it. We have to respond to the unpredictability of ecosystems.⁹⁰

88 Mr Martin Exel, Austral Fisheries, *Committee Hansard*, 21 February 2017, p. 25.

89 Mr Michael Baron, Owner, Eaglehawk Dive Centre, *Committee Hansard*, 21 February 2017, pp. 14, 15

90 Professor Gustaaf Hallegraeff, IMAS, *Committee Hansard*, 21 February 2017, p. 10.

4.65 The implications of coral bleaching for tourism activity at the Great Barrier Reef were also explored. Mr John Edmondson, Owner/Director, Wavelength Reef Cruises, provided the following observations about how recent changes in the Great Barrier Reef is affecting tourism operators:

The reality is that there's been a very dramatic change and a shifting baseline in a lot of areas. You can still go out and have a fantastic day, and the reef is still probably the best managed reef in the world, but it's an expensive day—it's \$250 for most boats to go out to the outer reef—and people have got very high expectations. To give them value for their money and to give them a good product is getting harder and harder, because it's harder to get the coral and show people what they expect to see, and that is just really in the last two years.⁹¹

4.66 The committee was also advised that tourism activity in the Reef has been affected by the widespread distribution of incorrect information about bleaching events. Mr Steven Moon from the Association of Marine Park Tourism Operators told the committee:

Unfortunately, the back-to-back bleaching event has been catastrophic, but what's been worse is the way it has been reported. There's no doubt about that...We were in Asia representing our industry at various trade shows and we actually had people coming up to us and saying, 'I wish I had seen it before it died.' What we struggled with was the fact that nobody—no regulator, no authority—came out and discounted those initial claims.⁹²

4.67 Professor David Booth stated that it is generally expected that the Great Barrier Reef will 'persist in some form' despite coral bleaching and other climate change-related issues. Professor Booth added, however, that the Reef 'just may not be the sort of structure that attracts the multibillion dollar tourist industry that now exists there'.⁹³

4.68 Despite the real and potential negative outcomes, some potential positive changes for particular types of tourism in certain areas were envisaged. As an example, Professor Hallegraeff noted that the effects of climate change might mean that a marlin fishery and a related tourism industry could be created on the east coast of Tasmania.⁹⁴

91 Mr John Edmondson, Owner/Director, Wavelength Reef Cruises, *Committee Hansard*, 29 August 2017, p. 10.

92 Mr Steven Moon, Member, Association of Marine Park Tourism Operators, *Committee Hansard*, 29 August 2017, p. 17. Other witnesses also commented inaccurate media reporting of the 2016 bleaching incident on. For example, see Dr Andrew Hoey, Reef Ecologist, Australian Research Council Centre of Excellence for Coral Reef Studies, James Cook University, *Committee Hansard*, 30 August 2017, p. 7.

93 Professor David Booth, *Committee Hansard*, 16 March 2017, p. 2.

94 Professor Gustaaf Hallegraeff, *Committee Hansard*, 21 February 2017, p. 11.

4.69 Finally, whether climate change could result in changes to the distribution of marine animals that are potentially dangerous for people swimming or undertaking other ocean-based activities was considered. Whether the Irukandji or box jellyfish would spread poleward into New South Wales coastal waters was discussed at public hearings, with anecdotal evidence of incidents in northern New South Wales waters noted.⁹⁵

4.70 Professor Iain Suthers from SIMS described the potential for Irukandji jellyfish to move southward as 'a real concern...perhaps for our kids or grandkids to deal with'. Professor Suthers noted:

...the Irukandji are a little jellyfish that are dependent upon mangroves for the other side of their life cycle, and we have plenty of habitat for them.⁹⁶

4.71 Dr Alan Jordan, Principal Research Scientist, New South Wales Department of Primary Industries advised that there is no evidence of the Irukandji jellyfish in New South Wales waters to date and the possibility has not been identified a short- or medium-term concern. However, he acknowledged that, based on a long-term projection of water temperatures and currents, 'it is not out of the question at some point'.⁹⁷

95 Mrs Patricia Beatty, New South Wales Professional Fishermen's Association, *Committee Hansard*, 16 March 2017, p. 17.

96 Professor Iain Suthers, SIMS, *Committee Hansard*, 16 March 2017, p. 26.

97 Dr Alan Jordan, Principal Research Scientist, NSW DPI, *Committee Hansard*, 16 March 2017, pp. 51–52.