The Senate

Environment and Communications References Committee

In hot water: the impacts of climate change on marine fisheries and biodiversity

December 2017

ISBN 978-1-76010-682-9

Committee contact details

PO Box 6100
Parliament House
Canberra ACT 2600

Tel: 02 6277 3526
Fax: 02 6277 5818
Email: ec.sen@aph.gov.au
Internet: www.aph.gov.au/senate_ec

This document was printed by the Senate Printing Unit, Parliament House, Canberra

Committee membership

Committee members

Senator Peter Whish-Wilson, Chair from 7 February 2017 to 4 September 2017 and from 14 September 2017	AG, Tasmania
Senator Jonathon Duniam, Deputy Chair from 7 September 2017	LP, Tasmania
Senator Linda Reynolds CSC, Deputy Chair from 16 February 2017 to 7 September 2017	LP, Western Australia
Senator Anthony Chisholm	ALP, Queensland
Senator Sam Dastyari	ALP, New South Wales
Senator Anne Urquhart	ALP, Tasmania

Former members

Senator Janet Rice from 4 to 7 September 2017	AG, Victoria
Senator Larissa Waters, Chair to 7 February 2017	AG, Queensland
Senator David Bushby, Deputy Chair from 15 September 2016 to 5 December 2016	LP, Tasmania
Senator James Paterson, Deputy Chair from 5 December 2016 to 15 February 2017	LP, Victoria

Participating member for this inquiry

Senator the Hon Ian Macdonald	LP, Queensland

Committee secretariat

Ms Christine McDonald, Committee Secretary

Mr Colby Hannan, Principal Research Officer

Ms Kate Campbell, Senior Research Officer

Ms Fattimah Imtoual, Senior Research Officer

Ms Georgia Fletcher, Administration Officer

Ms Michelle Macarthur-King, Administration Officer

Table of contents

Abbreviations

AFMA	Australian Fisheries Management Authority
AIMS	Australian Institute of Marine Science
AMCS	Australian Marine Conservation Society
ANZECC	Australian and New Zealand Environment Conservation Council
ARC	Australian Research Council
Ballast Water Convention	International Convention for Control and Management of Ship's Ballast Water and Sediment
Biosecurity Act	*Biosecurity Act 2015* (Cth)
CoTS	Crown-of-thorns starfish
CPRS	Carbon Pollution Reduction Scheme
CPUE	Catch per unit effort
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DAWR	Department of Agriculture and Water Resources
DoEE	Department of the Environment and Energy
EDO NSW	Environmental Defenders Office New South Wales
EDOA	Environmental Defenders Offices of Australia
EKE	Eddy kinetic energy
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Cth)
Fisheries Management Act	*Fisheries Management Act 1991* (Cth)
FRDC	Fisheries Research and Development Corporation
GBRMPA	Great Barrier Reef Marine Park Authority
HAB	Harmful algal bloom

IMAS	Institute for Marine and Antarctic Studies
IMOS	Integrated Marine Observing System
IPA	Indigenous Protected Area
ITQ	Individual transferrable quota
MPA	Marine protected area
NCRIS	National Collaborative Research Infrastructure Strategy
NRM	Natural resource management
NSW DPI	New South Wales Department of Primary Industries
OCS	Offshore Constitutional Settlement
PC	Productivity Commission
POMS	Pacific Oyster Mortality Syndrome
Redmap	Range Extension Database and Mapping
Reef 2050 Plan	*Reef 2050 Long-term Sustainability Plan*
SIMS	Sydney Institute of Marine Science
SST	Sea surface temperature
TAC	Total allowable catch
TSRA	Torres Strait Regional Authority
UNESCO	United Nations Educational, Scientific and Cultural Organization

List of recommendations

Recommendation 1

7.10 The committee recommends that the Australian Government review the funding provided for research into the effects of climate change on the marine environment and possible adaptation measures to ensure the funding is appropriate for facing the challenges of climate change.

7.11 The committee further recommends that the Australian Government commit to allocating long-term funding for climate monitoring, such as the Integrated Marine Observing System.

Recommendation 2

7.12 The committee recommends that the Australian Government review the funding provided to operate the RV *Investigator* with a view to:

- **increasing the long-term funding provided by the Government; and**
- **obtaining greater financial support from other parties, such as through industry research partnerships.**

7.13 The committee further recommends that the Australian Government review the processes associated with researchers gaining access to the RV *Investigator* with a view to increasing the number of days the vessel can be used for research.

Recommendation 3

7.16 The committee recommends that the Australian Government take a national leadership role in funding and supporting connections between the fishing and aquaculture industry and research organisations to help industry understand and adjust to the effects of climate change.

Recommendation 4

7.17 The committee recommends that the Australian Government direct the Department of Agriculture and Water Resources to engage with industry representatives to consider how information about responding to biosecurity challenges can be shared more effectively within the fisheries industry.

Recommendation 5

7.19 The committee recommends that, as part of the National Landcare Program, greater emphasis be placed on marine natural resource management and projects be supported that will improve marine biodiversity and deliver sustainable fisheries and aquaculture outcomes in the face of climate change.

Recommendation 6

7.20 The committee recommends that the Australian Government investigate options to formalise and enhance engagement between Traditional Owners involved in Indigenous Protected Areas, universities and relevant Commonwealth departments and agencies regarding the effects of climate change on the marine environment, including appropriate local management responses to changes and emerging threats.

Recommendation 7

7.22 The committee recommends that the Australian Government expedite work to update offshore constitutional settlement agreements regarding the jurisdictional boundaries between fisheries.

Recommendation 8

7.26 The committee recommends that state and Northern Territory governments give effect to recommendation 4.1 of the Productivity Commission's report *Marine fisheries and aquaculture* relating to licence arrangements for recreational fishers.

Recommendation 9

7.27 The committee recommends that state and Northern Territory governments explore innovative methods to capture recreational fishing data.

Recommendation 10

7.30 The committee recommends that the Australian, state and territory governments review all environmental and resource management legislation to ensure that adequate consideration of the effects of climate change is expressly required as part of assessment and decision-making processes.

7.31 In particular, the committee recommends that establishing a greenhouse trigger be included in the upcoming independent review of the *Environment Protection and Biodiversity Conservation Act 1999*.

Recommendation 11

7.34 The committee recommends that the Australian Government commission a feasibility study into the creation of a National Oceans Commission or consider establishing a dedicated oceans outcome as part of the Department of the Environment and Energy's responsibilities.

Recommendation 12

7.41 The committee recommends that the network of marine parks established in 2012 by the Gillard Government be maintained and that additions to the network be made if developments since 2012 mean that greater conservation efforts in particular areas are requred.

Recommendation 13

7.42 The committee recommends that the Australian and Queensland Governments amend the *Reef 2050 Long-Term Sustainability Plan* so that the plan:

- **includes climate change adaptation and mitigation actions;**
- **has a focus on a sustainable, functional Reef in the face of emerging cumulative impacts; and**
- **provides greater emphasis on empowering local people and communities to deliver on-ground action that will benefit the Reef.**

Recommendation 14

7.43 In light of climate change pressures, the committee recommends that the Australian Government review the funding provided to the Great Barrier Reef Marine Park Authority to ensure it is adequately resourced to meet its functions under the *Great Barrier Reef Marine Park Act 1975*.

Chapter 1

Introduction

1.1 On 14 September 2016, the Senate referred the following matter to the Environment and Communications References Committee for inquiry and report:

> The current and future impacts of climate change on marine fisheries and biodiversity, including:
>
> (a) recent and projected changes in ocean temperatures, currents and chemistry associated with climate change;
>
> (b) recent and projected changes in fish stocks, marine biodiversity and marine ecosystems associated with climate change;
>
> (c) recent and projected changes in marine pest and diseases associated with climate change;
>
> (d) the impact of these changes on commercial fishing and aquaculture, including associated business activity and employment;
>
> (e) the impact of these changes on recreational fishing;
>
> (f) the adequacy of current quota-setting and access rights provisions and processes given current and projected climate change impacts;
>
> (g) the adequacy of current and proposed marine biodiversity protections given current and projected climate change impacts;
>
> (h) the adequacy of biosecurity measures and monitoring systems given current and projected climate change impacts; and
>
> (i) any other related matters.[1]

Conduct of the inquiry

1.2 In accordance with its usual practice, the committee advertised the inquiry on its website and wrote to relevant individuals and organisations inviting submissions. The date for receipt of submissions was 4 November 2016.

1.3 The committee received 25 submissions, which are listed at Appendix 1. The public submissions are available on the committee's website at www.aph.gov.au/senate_ec.

1.4 The committee also held six public hearings for this inquiry, as follows:

- Hobart, 21 February 2017;
- Sydney, 16 March 2017 and 17 March 2017;
- Cairns, 29 August 2017;

---

1 *Journals of the Senate*, 14 September 2016, p. 197.

- Townsville, 30 August 2017; and
- Canberra, 20 October 2017.

1.5 A list of witnesses who appeared at the hearings is at Appendix 2.

1.6 The committee was initially required to report by 30 June 2017. To enable further public hearings to be conducted, however, the committee sought and received two extensions to the reporting date (first to 13 September 2017, and subsequently to 29 November 2017).[2] On 28 November 2017, the reporting date was extended further to 6 December 2017.[3]

1.7 The committee thanks all of the individuals, organisations and government departments and agencies that contributed to the inquiry

Structure of the report

1.8 This report comprises seven chapters, as follows:

- Chapter 1 has outlined introductory matters regarding the referral and conduct of the inquiry.
- Chapter 2 summarises evidence received regarding recent and projected changes in ocean temperatures, currents and chemistry associated with climate change.
- Chapter 3 discusses evidence received regarding changes in fish stocks, marine biodiversity and marine ecosystems.
- Chapter 4 examines the evidence received regarding the consequences of climate change for fishing, aquaculture and other economic activities such as tourism. Included in this chapter is an examination of the recent and projected changes in marine pests and diseases associated with climate change.
- Chapter 5 commences the report's discussion of climate change adaptation by focusing on regulatory responses. The chapter commences by discussing the overall approach to how the effects of climate change on the marine environment is considered under existing environmental and resource management legislation. The chapter then examines climate change adaptation in more specific areas, including fisheries management, protecting marine biodiversity, and biosecurity.
- Chapter 6 continues the consideration of current and potential climate change adaptation efforts, with a particular focus on the fishing and aquaculture industries, and the Great Barrier Reef. Research efforts are also discussed.
- Chapter 7 contains the committee's overall conclusions and recommendations.

2 *Journals of the Senate*, 28 March 2017, p. 1202; 19 June 2017, p. 1472.

3 *Journals of the Senate*, 28 November 2017, p. 2312.

Note on references

1.9 Many submissions to this inquiry cited published research extensively. This report cites the evidence presented to the committee in the submissions, however, where the author of a submission refers to original research, the citation is generally omitted from this report. Readers should refer to the submissions for details of the research relied on for the evidence presented to the committee; as noted above, the public submissions are available on the committee's website.

Chapter 2

Changes in ocean temperatures, currents and chemistry associated with climate change

2.1 This chapter provides an overview of the evidence presented to the committee regarding warming ocean temperatures, changing ocean chemistry and altering ocean currents. Projections of further rises in ocean temperatures, rising sea levels and more extreme weather events due to climate change are also discussed.

Rising ocean temperatures

2.2 The Institute for Marine and Antarctic Studies (IMAS) advised that '[s]ea-surface temperatures trends for the period 1901 to 2012 are rising everywhere except in the northern Atlantic'. Since 1901, the global average temperature change has been recorded as approximately 0.89ºC [0.69–1.08ºC], with an average change of 0.075ºC to 0.083ºC (±0.013ºC) per decade.[1] The Bureau of Meteorology has reported that surface temperatures were the highest on record in 2016 both globally and in the oceans around Australia. For the oceans around Australia, the Bureau reported that the annual mean sea surface temperatures were 0.73°C above average (records date back to 1910). The previous record of 0.64ºC above average occurred in 2010.[2]

2.3 IMAS explained that the largest temperature changes have been recorded in the surface ocean, with smaller changes occurring in deeper layers. Available evidence includes the following:

- the top 75 metres of the ocean has warmed at a rate of 0.11ºC [0.09–0.13ºC] per decade since 1971, which is the same rate, within errors, as the rate of global average surface temperature warming; and
- below the top 75 metres, '[t]here is good evidence that the deep ocean below 3000 metres has warmed, and that the mid-depth ocean (between 2000 to 3000 metres) has not warmed, consistent with our understanding of global ocean circulation'.[3]

---

1 Institute for Marine and Antarctic Studies (IMAS), *Submission 1*, p. 11. The research cited is (Stocker et al 2013) TF Stocker et al, 'Technical Summary', in TF Stocker et al (eds), *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, 2013, Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

2 Bureau of Meteorology, 'Annual climate statement 2016', 5 January 2017, www.bom.gov.au/climate/current/annual/aus/2016 (accessed 5 January 2017).

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

2.4 IMAS added that the 'south east region of Australia is recognised as one of the fastest warming regions globally'. Evidence supporting this includes:

- direct observations since the 1940s indicating that warming in this region 'is approximately 3.8 times the global average'; and
- sea surface temperatures over a 50-year period indicating that this region 'is warming faster than 90% of the ocean'.[4]

2.5 Professor Stewart Frusher from IMAS observed that although it 'is often very difficult to attribute the exact cause of why something has occurred…the weight of evidence that underpins the changes we are seeing on particularly our south-eastern seaboard indicates that our waters are warming'. To demonstrate, Professor Frusher continued by referring to warming waters off Maria Island, which is located off the east coast of Tasmania. Professor Frusher stated:

> One of the few long-term datasets we have is off Maria Island. Fortunately, they have maintained measuring the water temperature there since the 1940s. The consistent trend in that data is an increase in water temperature over that period to the extent that the water that was off Eden in southern New South Wales in the 1940s is now equivalent to what we see off Maria Island. That water body is now equivalent. When you think about the changes, it includes looking at those ecosystems which were off Eden in the 1940s and the ones off Maria Island now.[5]

2.6 Dr Neville Barrett, also from IMAS, added that the climate predictions for this area of Tasmania is that the climate will be the same as Batemans Bay in New South Wales by 'at best case, 2100 and, at worst case, 2060'.[6]

2.7 High temperatures have also been recorded elsewhere. IMAS explained that the term 'marine heat wave' has been coined to account for observations of extreme temperatures in regions of the oceans.[7] Marine heat wave events were recorded in Western Australia (2011) and the Great Barrier Reef (2016).[8]

---

4 IMAS, *Submission 1*, p. 3 (emphasis omitted).

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

6 Dr Neville Barrett, IMAS, *Committee Hansard*, 21 February 2017, p. 5.

7 IMAS, *Submission 1*, p. 12. A marine heat wave event has been defined as 'a discrete prolonged anomalously warm water event', where 'discrete implies the [marine heat wave] is an identifiable event with clear start and end dates, prolonged means it has a duration of at least five days and anomalously warm means the water temperature is warm relative to a baseline climatology'. This definition was articulated in A Hobday et al, 'A hierarchical approach to defining marine heatwaves', *Progress in Oceanography*, vol. 141, 2016, pp. 227–238; cited in E Oliver et al, 'The unprecedented 2015/16 Tasman Sea marine heatwave', *Nature Communications*, vol. 8, July 2017, p. 10.

8 Australian Marine Sciences Association, *Submission 5*, p. 2; IMAS, *Submission 1*, p. 12; Fisheries Research and Development Corporation (FRDC), *Submission 2*, p. 5.

2.8 During the major El Niño Southern Oscillation Event of late 2015 to April 2016, the oceanic temperature at Thursday Island reached an average daily peak of 31.90ºC on 13 March 2016, which is 0.4ºC higher than the peak of 2010.[9] The Western Australian marine heat wave event 'resulted in the highest sea surface temperatures off south-western Australia on record'.[10] A journal article on the heat wave event provided the following overview of recorded temperature changes:

> Following temperature anomalies within ±1 °C for most of 2010, as well as the dominantly negative temperature anomalies off the upper west coast during the first half of 2010 (likely a result of the 2009/2010 El Niño event), the water began to warm from October and climbed steadily into summer. There was a rapid phase transition from the "warm pool" El Niño to La Niña conditions in 2010, probably due to the Indian Ocean warming…The peak anomaly at Ningaloo was 3 °C in January, and there were even higher peaks between Shark Bay and the Abrolhos Islands in February. Down at Cape Leeuwin, the peak temperature was about 2.5 °C and occurred in March. These elevated temperatures gradually decayed to more typical levels between April and July.[11]

2.9 The frequency of these marine heat wave events is increasing.[12] Dr Janice Lough, Senior Principal Research Scientist, Australian Institute of Marine Science (AIMS), explained that core records based on isotopic records trapped in coral skeletons indicate that recent warm events 'are exceptional, going back to at least…about 1600'.[13]

2.10 Figure 2.1 illustrates how sea surface temperatures in the oceans around Australia in 2016 compare to historical records. Figure 2.2 provides detailed maps illustrating surface sea temperatures off the coast of Tasmania between 2010 and 2017. Further graphs and charts indicating historical trends in temperature changes were provided by CSIRO.[14]

---

9 Torres Strait Regional Authority, *Submission 16*, p. [4].

10 A Pearce and M Feng, 'The rise and fall of the "marine heat wave" off Western Australia during the summer of 2010/2011', *Journal of Marine Systems*, 111–112, 2013, p. 154.

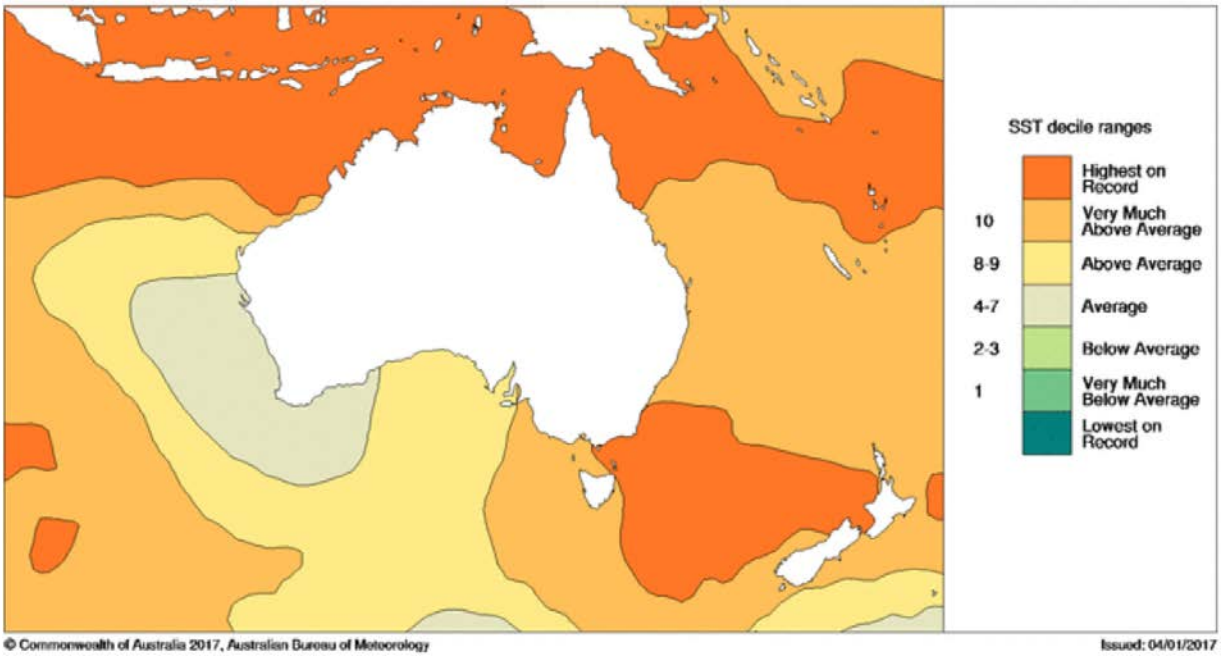
11 A Pearce and M Feng, 'The rise and fall of the "marine heat wave" off Western Australia during the summer of 2010/2011', p. 143.

12 Australian Marine Sciences Association, *Submission 5*, p. 2; IMAS, *Submission 1*, p. 12; FRDC, *Submission 2*, p. 5.

13 Dr Janice Lough, Senior Principal Research Scientist, Australian Institute of Marine Science (AIMS), *Committee Hansard*, 30 August 2017, p. 35.

14 See CSIRO, Answers to questions on notice, 17 March 2017 (received 20 April 2017).

Figure 2.1: Australian region sea surface temperature (SST) deciles: annual 2016



Note: distribution based on gridded data.

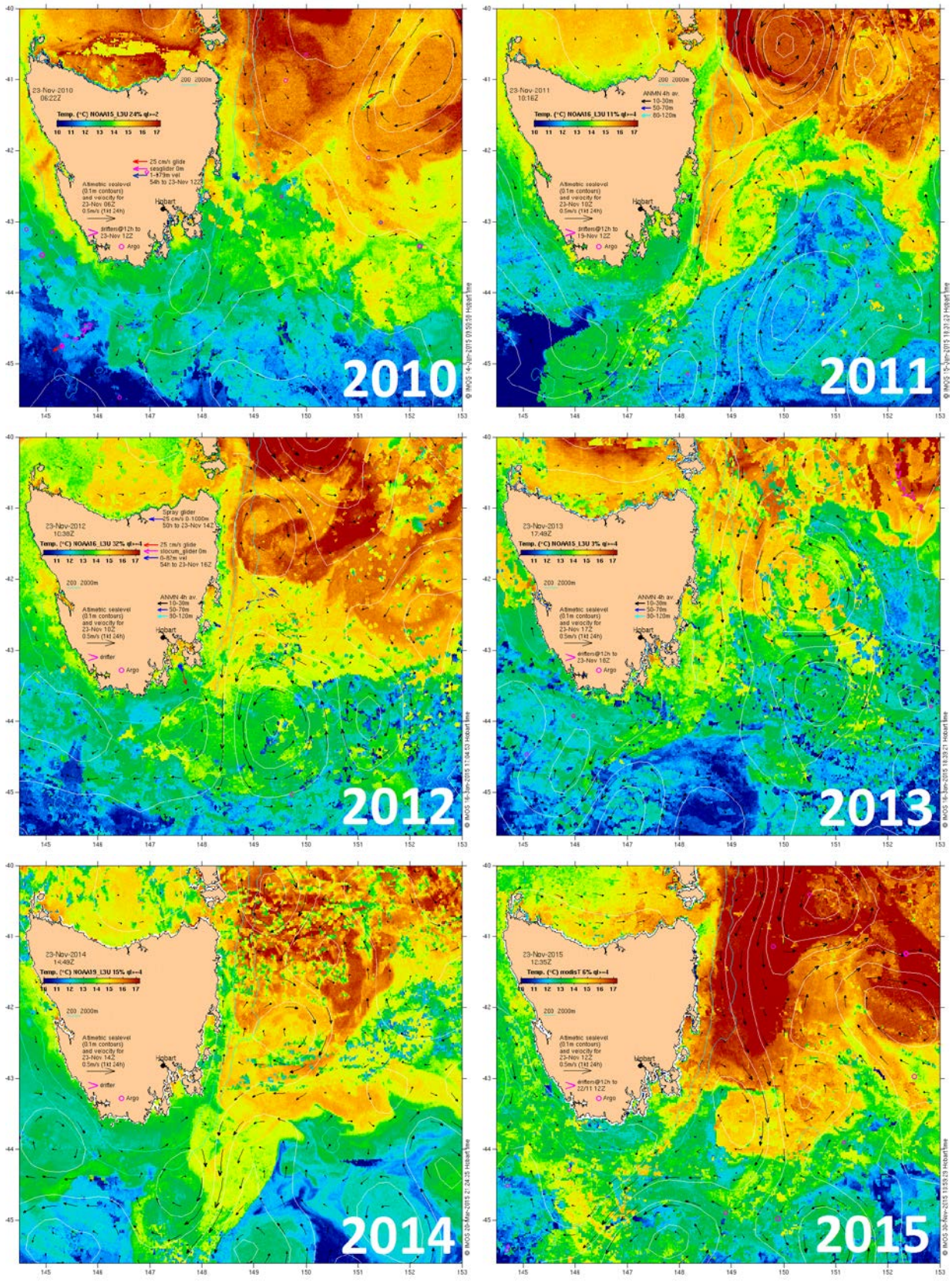
Source: Bureau of Meteorology, 'Annual climate statement 2016', 5 January 2017, www.bom.gov.au/climate/current/annual/aus/2016 (accessed 5 January 2017); from the NOAA Extended Reconstructed Sea Surface Temperature dataset, ERSST v4.

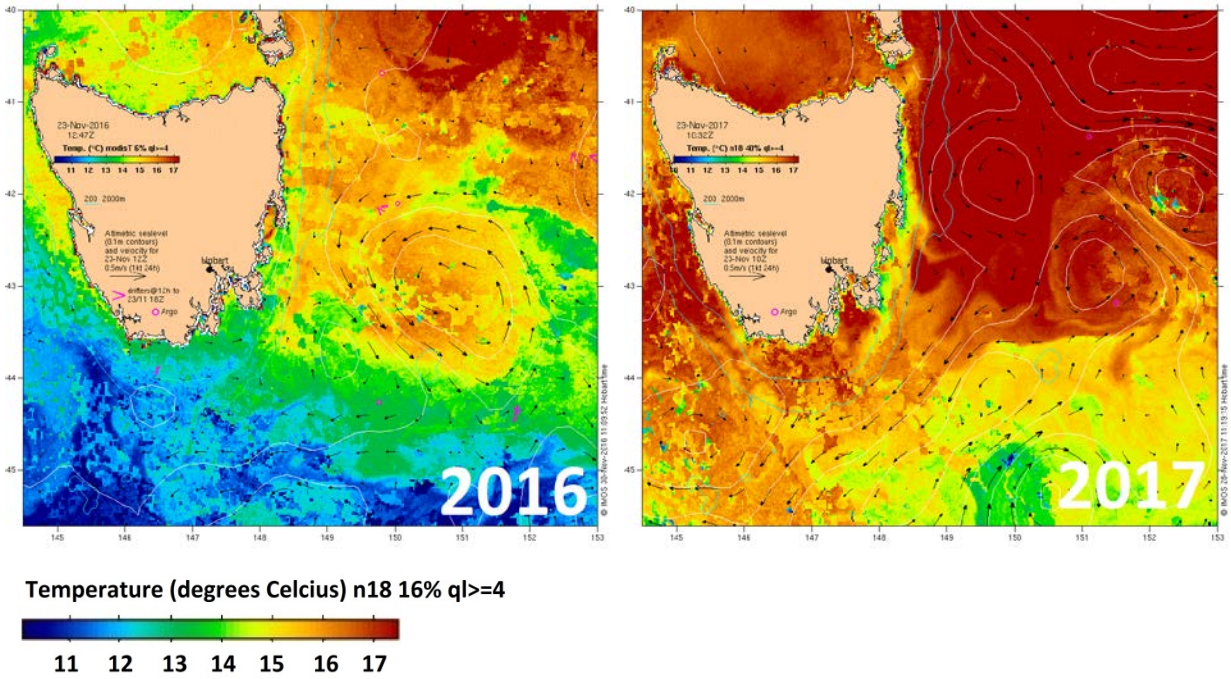
2.11 IMAS explained that projected changes in ocean temperatures 'depend very strongly on the emissions pathway taken by society'. IMAS advised that:

- under the Intergovernmental Panel on Climate Change's low emissions pathway (RCP2.6), by the end of the 21st century Australian marine temperatures are projected to rise by a further 0.5–1.0ºC from the 1986–2005 base period; and
- under the high emissions pathway (RCP8.5), it is projected that Australian marine temperatures will rise by 2–4ºC (over the same period as above).[15]

15 IMAS, *Submission 1*, p. 12.

Figure 2.2: Sea surface temperatures on 23 November 2010–2017 off the coast of Tasmania





Source: IMOS, Sea Surface Temperature maps, http://oceancurrent.imos.org.au/sst.php (accessed 28 November 2017).

Changing ocean currents

2.12 Evidence received during this inquiry commented on developments regarding the East Australian Current and the Leeuwin Current.

2.13 The East Australian Current is the largest ocean current close to the Australian coastline. The current is formed from the remnants of the South Equatorial Current that flow southward after crossing the Coral Sea. It has a significant influence on the marine environment off the east coast of Australia due to the warmer ocean water it carries southward. The current is around 100 kilometres wide and transports 40 million cubic metres of water southward each second at up to 3 kilometres per hour.[16]

2.14 The warming observed off Maria Island, Tasmania, since the 1940s referred to in paragraph 2.5 is related to the increased strength of the East Australian Current.[17] CSIRO advised that climate models suggest that, by 2060, the strength of the current will have increased by 12 per cent in the core area and by 35 per cent in the poleward extension.[18]

16 FRDC, *Submission 2*, p. 29; E van Sebille, E Oliver and J Brown, 'Can you surf the East Australian Current, Finding Nemo-style?', *The Conversation*, 6 June 2014, https://theconversation.com/can-you-surf-the-east-australian-current-finding-nemo-style-27392 (accessed 13 November 2017).

17 IMAS, *Submission 1*, p. 3.

18 CSIRO, *Submission 15*, p. 11 (citations omitted).

2.15 In addition to the evidence of a strengthening East Australian Current with an increased southwards reach, changes in the formation of eddies[19] are also of concern to scientists. IMAS and the Sydney Institute of Marine Science (SIMS) explained that the frequency of eddy formation is a key feature of the East Australian Current.[20] IMAS submitted that 'an increased frequency of sudden warming events off Tasmania's east coast' could occur as a result of potential increases in eddy activity, with eddies lasting longer.[21] The Fisheries Research and Development Corporation (FRDC) provided the following evidence about eddies observed in that region:

> Scientists have noted a trend in eddies off Tasmania becoming larger, stronger and more frequent. Following the 1990s, eddy kinetic energy (EKE) increased gradually both north…and south…of Bass Strait, with a huge spike in eddy activity off Tasmania (8 times the average EKE of the 1990s) in 2014…This trend is in agreement with climate modelling but there has been a dramatic increase over the last couple of years.[22]

2.16 Similarly, CSIRO submitted that:

> For the Tasmanian coast, it is expected the water will continue to warm faster than the rest of the world as more warm East Australian Water moves southward with a strengthening…[East Australian Current] and increased generation of its eddies.[23]

2.17 A detailed description of how changing ocean currents are affecting Australian waters was provided by Dr Barrett as part of an explanation of the attributes that are making Tasmania a global hot spot for ocean warming. Dr Barrett stated:

> A big part of it, really, is the fact that we are at the confluence of a range of different current systems. We have the East Australian Current coming down the eastern Australian coastline, obviously, and influencing Tasmania on that side. Then we have subantarctic water that bathes the southern parts of Tasmania to some degree and we have the tail end of the Leeuwin Current coming over from Western Australia. All these things are in a dynamic balance over the years and have influenced us in various ways.
>
> But as the waters have warmed up in eastern Australia, that East Australian Current is starting to flow more strongly down the eastern Australian coastline and it is starting to overdominate the other current systems that

---

19 Eddies, which are circular currents of water, cause nutrients in colder, deeper waters to come to the surface. US National Oceanic and Atmospheric Administration, 'What is an eddy?', http://oceanservice.noaa.gov/facts/eddy.html (accessed 13 December 2016).

20 IMAS, *Submission 1*, p. 12; Sydney Institute of Marine Science (SIMS), *Submission 8*, p. 3.

21 IMAS, *Submission 1*, p. 12.

22 FRDC, *Submission 2*, p. 29.

23 CSIRO, *Submission 15*, p. 12.

> typically have influenced us. So we have had a real increase through time of the temperature that this water actually brings onto our coastline.[24]

2.18 Increased eddy formation in this region is expected to have implications for fish stocks, which are discussed in Chapter 3.

2.19 Although the East Australian Current attracted significant comment, evidence was also received about the Leeuwin Current. The Leeuwin Current is off the coast of west and south-western Australia: it 'sweeps down Australia's west coast, from about the North West Cape and can extend as far as the Great Australian Bight and the southwest of Tasmania'.[25] The current 'brings warm, low-salinity tropical waters southwards and then eastwards along the south coast of the continent'.[26] CSIRO explained that, unlike the East Australian Current, the Leeuwin Current has weakened in strength over the past 50 years by 10–30 per cent. The current is predicted to weaken further by 15 per cent by 2060.[27]

Rising sea levels

2.20 Rising sea levels linked to climate change were noted. The Australian Fisheries Management Authority (AFMA) referred to research indicating that, globally, the average sea level has risen by 0.19 metres between 1901 and 2010. Furthermore, the rate of sea level rise has increased: for the period 1901–2010 it was measured at 1.7 millimetres per year whereas over the period 1993–2010 the rate was 3.2 millimetres per year.[28] By 2100, it is projected that sea levels could have risen by up to 0.8 metres.[29]

2.21 Rates of sea level rise that are greater than the global average have been observed in and near Australian waters. In the Torres Strait, research published in 2010 indicated that the sea level had risen at approximately six millimetres per year. In waters near Papua New Guinea, an annual average increase of seven millimetres since 1993 has been measured.[30]

---

24 Dr Neville Barrett, IMAS, *Committee Hansard*, 21 February 2017, p. 2.

25 Bureau of Meteorology, 'Forecast help', www.bom.gov.au/oceanography/forecasts/forecast-help.shtml (accessed 13 November 2017).

26 A Pearce and M Feng, 'The rise and fall of the "marine heat wave" off Western Australia during the summer of 2010/2011', p. 139.

27 CSIRO, *Submission 15*, p. 11.

28 Australian Fisheries Management Authority (AFMA), *Submission 9*, p. 8 (citation omitted).

29 AFMA, *Submission 9*, p. 9.

30 Torres Strait Regional Authority, *Submission 16*, p. [3].

Changing ocean chemistry

2.22 Rising carbon dioxide levels in the atmosphere has caused the surface ocean to acidify and this trend is expected to continue. AIMS provided the following explanation of how rising levels of carbon dioxide in the atmosphere leads to ocean acidification:

> Concentrations of carbon dioxide (CO_2) are rising rapidly in the atmosphere, due to the burning of fossil fuels and deforestation, and about 25% of this extra CO_2 added to the atmosphere is being absorbed by the oceans.
>
> When atmospheric CO_2 dissolves in seawater, it first forms carbonic acid and triggers a cascade of other chemical changes. The concentrations of hydrogen ions increase and carbonate ions decline. In fact, the concentrations of hydrogen ions have already increased by 30% in the seawater compared with preindustrial times.[31]

2.23 IMAS explained that the 'pH of surface waters of the ocean has decreased by about 0.1 since the pre-industrial era, an increase of 26% in hydrogen ion concentrations'.[32] AIMS added that the pH of the ocean is 'predicted to further decline by 0.2–0.4 by the end of this century'. This acidification of the ocean reduces the ability of marine organisms such as corals to calcify and may also 'lead to behavioural changes in fishes and invertebrates'.[33]

2.24 IMAS also noted that the 'concentration of oxygen in the oceans is changing'. IMAS explained:

> …in the main thermocline it has decreased and the tropical oxygen minimum zones have expanded, and these changes have also been attributed to human influence.[34]

2.25 The FRDC submitted that changes to ocean chemistry are 'the less understood' of the changes to physical attributes of oceans.[35]

---

31 AIMS, *Submission 10*, p. 4.

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

33 AIMS, *Submission 10*, p. 4.

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

35 FRDC, *Submission 2*, p. 5.

Extreme weather events

2.26 In tropical Australia, coastal areas are projected 'to experience more intense storms and severe weather events'.[36] An increase in average cyclone intensity is also projected as the climate warms. Incidences of strong tropical cyclones are expected to increase for particular regions as follows:

- southern Great Barrier Reef—from one every 25 or more years at present to one every 6–12 years; and
- Western Australian coast (Pilbara to southern Kimberley)—from one every 10 years to one every 7.5 years.[37]

2.27 Among other things, the increased frequency and intensity of severe weather events are expected to have implications for fish stocks and the health of coral reefs. These consequences are discussed in Chapter 3.

Overview of monitoring arrangements

2.28 This chapter has provided an overview of the recent and projected changes in ocean temperatures, currents and chemistry associated with climate change. This following section briefly outlines the infrastructure used to observe and monitor these changes. Key knowledge gaps and challenges faced in considering changes in ocean temperatures, currents and chemistry associated with climate change are then discussed.

2.29 At present, the Integrated Marine Observing System (IMOS) provides key monitoring infrastructure for observing developments in Australia's marine environment. IMOS, which was established in 2006, is operated by several institutions as a joint venture. It receives core funding from the Australian Government under the National Collaborative Research Infrastructure Strategy (NCRIS). Co-investment from state governments and operational partners also support IMOS.[38]

2.30 IMOS is 'a national collaborative research infrastructure' involving the deployment of a wide range of observing equipment in the oceans around Australia. More specifically, IMOS is 'a fully-integrated, national system, observing at ocean-basin and regional scales, and covering physical, chemical and biological

36 CSIRO, *Submission 15*, p. 12.

37 AIMS, *Submission 10*, p. 7.

38 Integrated Marine Observing System (IMOS), 'What is IMOS', http://imos.org.au/about/ (accessed 14 November 2017).

variables'.[39] IMOS utilises a wide range of techniques including: Argo Floats (autonomous profiling floats), Ships of Opportunity (volunteer commercial and research vessels), deep water moorings, ocean gliders, autonomous underwater vehicles, a national mooring network,[40] ocean radar, animal tracking, wireless sensor networks and satellite remote sensing.[41] Some of these techniques utilise long-running measurement programs, such as a 70-year history of recording temperature and salinity off Sydney.[42]

2.31 IMOS observations focus on the following five major research themes: long-term ocean change; climate variability and weather extremes; boundary currents; continental shelf and coastal processes; and ecosystem responses. The data collected as part of IMOS are available for use 'by the entire Australian marine and climate science community and its international collaborators'.[43]

2.32 Dr Alan Jordan, Principal Research Scientist, New South Wales Department of Primary Industries, described IMOS as the 'fundamental building block' of the data relied on for ocean temperatures. Dr Jordan explained:

> If we did not have that nationally approved infrastructure process underway, we would not have the sort of data that we collect. It has managed to massively increase our understanding of how the system operates, why we get upwelling events in certain places, and the derivation of the satellite imagery and the temperature loggers. Unless you have got instrumentation out there that is measuring this stuff, it is purely speculative. It is a big water column out there, and the satellites only see about the top five centimetres, so what is going on under that five centimetres is where the whole three-dimensional nature of the ocean works, and having things like the gliders that profile the water column is fundamental. The New South Wales government has supported the IMOS

39 The Lead Agent of IMOS is the University of Tasmania, which operates IMOS in partnership with CSIRO, AIMS, Bureau of Meteorology, SIMS (encompassing the University of New South Wales, The University of Sydney, Macquarie University and University of Technology Sydney), University of Western Australia, Curtin University and the South Australian Research and Development Institute. IMOS, 'What is IMOS', http://imos.org.au/about/ (accessed 14 November 2017).

40 The moorings network measures physical and biological parameters of Australian coastal waters using a network of national reference stations, regional arrays of shelf moorings, acidification moorings and acoustic observatories. The national reference stations are located at Kangaroo Island, SA; Yongala and Stradbroke Island, QLD; Darwin, NT; Maria Island, TAS; Port Hacking, NSW; Rottnest Island, WA. IMOS, 'National Mooring Network', http://imos.org.au/facilities/nationalmooringnetwork/ (accessed 14 November 2017).

41 IMOS, 'Facilities', http://imos.org.au/facilities/ (accessed 14 November 2017).

42 Professor Iain Suthers, SIMS, *Committee Hansard*, 16 March 2017, p. 20.

43 IMOS, 'What is IMOS', http://imos.org.au/about/ (accessed 14 November 2017).

> program for a long time, and we see no reason not to continue that support. It will be a fundamental component of our long-term monitoring program.[44]

2.33 Research is also informed by the real-time global sea surface temperature (SST) analysis developed in the United States of America by the National Oceanic and Atmospheric Administration. For example, research into the 2011 marine heat wave off the coast of Western Australia utilised Reynolds SST analysis (named after Richard Reynolds from the National Climatic Data Center, now the National Centers for Environmental Information, who developed the analysis). This large-scale SST analysis supplemented local temperature monitoring that also informed the research.[45]

2.34 Another example of long-term monitoring is at the Great Barrier Reef. The long-term monitoring program undertaken by AIMS has been surveying the health of 47 midshore and offshore reefs across the Great Barrier Reef region for over 20 years.[46] In addition to the AIMS monitoring program, Professor David Booth explained that there is a smaller monitoring effort undertaken 'on a shoestring'. Professor Booth advised that, in the early 1990s, he was located with a team undertaking monitoring at the Great Barrier Reef. The professor stated that the team has 'done some amazing work', which enables assessments to be made about causes of change in the Reef, such as the degree to which damage has been caused by crown-of-thorns starfish and coral bleaching.[47]

Knowledge gaps and other considerations

2.35 In considering changes in ocean temperatures, currents and chemistry associated with climate change, it is important to note the difficulties scientists face in determining whether, and to what extent, developments are linked to climate change. This was recognised by the scientific organisations that presented evidence to the committee; for instance, the FRDC noted 'there will always be levels of uncertainty due to the confounding nature of separating climate variability from climate change'.[48]

2.36 Professor Gustaaf Hallegraeff from IMAS also made observations about the difficulties faced by researchers considering the implications of climate change on the marine environment. He stated 'there is no doubt' that Earth's climate has been changing throughout time; however stated that '[t]he only thing that is different is that

---

44 Dr Alan Jordan, Principal Research Scientist, New South Wales Department of Primary Industries, *Committee Hansard*, 16 March 2017, p. 51.

45 A Pearce and M Feng, 'The rise and fall of the "marine heat wave" off Western Australia during the summer of 2010/2011', p. 141.

46 AIMS, 'Monitoring Australia's tropical reefs', www.aims.gov.au/docs/research/monitoring/reef/reef-monitoring.html (accessed 14 November 2017).

47 Professor David Booth, *Committee Hansard*, 16 March 2017, p. 6.

48 FRDC, *Submission 2*, p. 5.

it is changing so rapidly now'. The professor explained that this has implications for research conclusions:

> The only thing that is different is that it is changing so rapidly now. We cannot find any precedents in the history of this planet. We are trying desperately to understand what is going on. We are trying to predict what a good spot is going to be or which fisheries could be aquaculture in the future. We have some successes, but in general that is the experience of my discipline: marine ecosystems, under climate change, are becoming much more unpredictable.[49]

2.37 Professor Hallegraeff added that within the scientific community, even at a localised level in cities such as Hobart, there is an ongoing debate about how close the correlation between rising emissions and warming oceans or rising ocean temperatures is. Regarding the warming water temperatures on the east coast of Tasmania, Professor Hallegraeff noted:

> …we can see a global signal of warming, but the much bigger signal is a shift in east Australian currents. Even within our institute there is still a big discussion: is that shift in that warm current part of the global warming signal? A scientist at CSIRO, Andrew Lenton, claims that this actually links to the ozone hole and the atmospheric air currents going faster and spinning with it the east Australian currents signal.
>
> And then, of course, what we had in 2016, this marine heatwave, was yet another warming signal on top of an El Nino event that affected the whole Pacific. The heatwave did not just happen on the east coast of Tasmania; it also happened in Chile, where it did enormous damage to salmon aquaculture, and on the northwest coast of America, where they had all kinds of strange problems with what they call the hot block. So there are a lot of different phenomena that cause this warming, and attribution to greenhouse warming per se—any reputable scientist would say there is lots of uncertainty.[50]

2.38 These comments notwithstanding, Professor Hallegraeff concluded:

> The end product of what we are dealing with now, this warm water, that is what we have to deal with and we have to adapt to it.[51]

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

50 Professor Gustaaf Hallegraeff, IMAS, *Committee Hansard*, 21 February 2017, p. 3.

51 Professor Gustaaf Hallegraeff, IMAS, *Committee Hansard*, 21 February 2017, p. 3.

2.39 Scientific organisations also noted that there are gaps in knowledge about how climate change will affect the physical attributes of the oceans. They argued that further research is required and, in particular, that there is a need for long-term climate monitoring of the marine environment. For example, IMAS submitted:

> It is crucial that investment in IMOS, sensor arrays, and modelling capacity at the regional scale is maintained to provide us with the physical basis for assessing and understanding changes on ecosystems and fisheries.[52]

2.40 IMAS informed the committee that, due to the small number of long-term data sets, there is a lack of information available for understanding the implications of climate change. Professor Frusher referred to work undertaken by IMAS scientists in marine protected areas, which are 'one of the few areas where we actually have continued long-term monitoring'. He added:

> We have very little long-term monitoring in any other areas, and it would be prudent, I would have thought, to actually have a range of these around Australia as scientific sites. But, of course, being able to maintain science in these areas is not a cheap prospect.[53]

2.41 The FRDC submitted that 'there is an ongoing need for continued science investment', such as the deployment of sensor arrays from RV *Investigator* and using the AIMS Sea Simulator (SeaSim) to understand the implications of changing pH.[54]

2.42 Evidence regarding the need for long-term funding arrangements for climate monitoring and research is considered further in Chapter 6.

2.43 Ocean acidification was highlighted as an issue that, in particular, needs further research. AIMS submitted that although changes to ocean chemistry from carbon dioxide were 'recognised more than 50 years ago', this development has 'only recently emerged as an important knowledge gap in marine science, and has now become a global research priority'. In particular, AIMS noted that although changes in the carbonate chemistry from rising atmospheric carbon dioxide levels 'are relatively well understood' for the open ocean, this is not the case for nearshore and shallow marine environments such as the Great Barrier Reef where 'conditions are more variable due to biological processes'. AIMS advised that the 'evidence base of how the ongoing changes in the seawater chemistry will affect marine ecosystems continues to develop', including as a result of research undertaken by AIMS scientists.[55]

---

52 IMAS, *Submission 1*, p. 12.

53 Professor Stewart Frusher, IMAS, *Committee Hansard*, 21 February 2017, p. 7.

54 FRDC, *Submission 2*, p. 5.

55 AIMS, *Submission 10*, pp. 4–5. Research outlined in the submission includes field research at three shallow volcanic carbon dioxide seeps in eastern Papua New Guinea, studies of carbonate chemistry in the Great Barrier Reef and carbon dioxide enrichment experiments in the National Sea Simulator (SeaSim) in Townsville.

2.44 The committee was also informed of efforts to improve the knowledge base and address some of the uncertainties regarding ocean warming hot spots. Regarding the uncertainties and limited knowledge about the hot spot off the south east coast of Australia, Professor Stewart Frusher from IMAS explained that researchers are looking to other hot spot regions globally to attempt to improve their understanding. Professor Frusher stated:

> We have identified the 24 top to see if we can learn and provide lessons for them, as well. We may have to draw a lot of our global community to actually see what happens, because places like the south-eastern seaboard of Australia are almost like global experimental laboratories because they are those things. That is where we are going to see these events happen earliest.[56]

2.45 Finally, it was noted that climate change is one of several stressors on the marine environment. In addition to climate change, Dr Alistair Hobday, Senior Principal Research Scientist, CSIRO, identified coastal development, pollution and marine plastics as the other main risks for the oceans. Dr Hobday added that which risk ranks as the most serious varies in different locations. Dr Hobday stated:

> …for offshore species like tuna, I think climate change is No. 1. For species that rely on estuaries for completing their life cycle, it is coastal development, which is taking away mangroves or salt marsh or seagrass habitat. Plastics I think is a big sleeper, and we are only just starting to become aware of how big a problem plastics might be.[57]

56 Professor Stewart Frusher, IMAS, *Committee Hansard*, 21 February 2017, p. 13.

57 Dr Alistair Hobday, Senior Principal Research Scientist, CSIRO, *Committee Hansard*, 17 March 2017, p. 6.

Chapter 3

Changes in fish stocks, marine biodiversity and marine ecosystems

3.1 As noted in the previous chapter, evidence received by the committee noted that climate change represents only one threat to the marine environment; for example, the Environmental Defenders Offices of Australia (EDOA) noted that coastal development, pollution and over-exploitation of fisheries are other concerns.[1] It was also noted that effects of climate change 'are likely to be cumulative' and initially may be non-lethal (such as 'reduced reproduction, changes in timing of reproduction and reduced rates of calcification in some species').[2]

3.2 Nevertheless, there is evidence of various changes in Australian ecosystems that have been attributed to climate change. For example, the Australian Fisheries Management Authority's (AFMA's) submission provided the following list:

- changes to phytoplankton productivity;
- changes to macroalgal species abundance;
- changes to growth rates in abalone, rock lobster, fish and coral;
- changes to the life cycle of southern rock lobster;
- changes to the distribution of seaweeds, plankton, fish and sea urchins;
- coral bleaching on the Great Barrier Reef and Ningaloo Reef;
- reduced calcification rates of corals; and
- various developments relating to microalgae, including warm water macroalgae extending ranges poleward and reduced ranges of coldwater macroalgae.[3]

3.3 AFMA's submission also provided a list of predicted changes, as follows:

- increased sediment discharge to estuaries and reef waters;
- acidification expected to affect 'various calcifying taxa' such as corals, coralline algae and calcareous plankton;
- the Great Barrier Reef and other low latitude reefs to be negatively affected by warming and acidification, with thermal stress, reduced calcification and increased frequency of bleaching resulting;

---

1 Environmental Defenders Offices of Australia (EDOA), *Submission 4*, p. 3.

2 Australian Marine Sciences Association, *Submission 5*, p. 2.

3 Australian Fisheries Management Authority (AFMA), *Submission 9*, pp. 8–9 (citations omitted).

- 'uncertain but potentially major negative impacts to krill abundance in Southern Ocean';
- 'scouring of benthic habitats by sea ice/icebergs around Antarctica';
- increased phytoplankton production in the Southern Ocean;
- continued changes to warm water and cold water macroalgae ranges;
- increased disease outbreaks;
- stressors to seagrasses exacerbated by temperature increases; and
- benefits for mangroves (where space is available) arising from temperature and sea level impacts.[4]

3.4 This chapter discusses the current and projected implications of climate change in Australian waters for fish stocks, marine biodiversity, marine ecosystems, and marine pests and diseases.

Implications for fish stocks, marine biodiversity and ecosystems

3.5 The Australian Institute of Marine Science (AIMS) advised that several factors will influence the extent that rising ocean temperatures will affect individual marine species. Some of these factors include:

- 'current species distribution and thermal thresholds';
- 'generation time and capacity to adapt/evolve to changing conditions';
- habitat dependence (for example, obligate coral reef dwellers); and
- mobility.[5]

3.6 Much of the evidence received by the committee related to the consequences of warming ocean temperatures. This issue is discussed first, followed by consequences arising from other changes to the physical attributes of the oceans. Particular consequences for coral reefs, which have an especially important role in marine biodiversity, are also examined.

Consequences of rising temperatures

3.7 Professor Stewart Frusher from the Institute for Marine and Antarctic Studies (IMAS) explained that 'most animals have what we call a thermal envelope—a temperature which they can survive in'. Professor Frusher added that temperature tolerances vary among species, and that some species 'can enjoy a wide range and so warming temperatures are not that much of an issue'.[6] However, if temperature

4 AFMA, *Submission 9*, pp. 9–10.

5 Australian Institute of Marine Science (AIMS), *Submission 10*, p. 2.

6 Professor Stewart Frusher, Institute for Marine and Antarctic Studies (IMAS), *Committee Hansard*, 21 February 2017, pp. 1, 2.

increases cause species to reach their thermal limit, to survive those some species will need to adjust in-situ or, if able, move to an area where the temperature is suitable.[7] AIMS submitted the following overview of how species can respond:

> Movement to new areas would result in range shifts in distribution. Species that have low mobility or rely on specific habitats for survival may or may not be able move to new or more suitable habitats. Sessile species such as marine plants, corals and other invertebrates obviously cannot move. In these cases, if species cannot evolve quickly enough their distribution range may shrink as populations are no longer viable in areas beyond their thermal tolerance.[8]

3.8 Professor Frusher noted that, for species with narrow temperature tolerance ranges, 'a slight change in temperature can spell doom for them'.[9] Likewise, Dr Alistair Hobday, a senior principal research scientist at CSIRO, commented that species which cannot move further south in response to warming temperatures 'will not persist in the way that we would like them to'. Using the flathead species in southern Tasmanian waters as an example, Dr Hobday explained that 'there is nowhere south of Tasmania…that is shallow enough for those animals to live'. Dr Hobday summed up the lack of suitable habitat southward for that species as follows: 'Imagine being pushed off the top of [a] mountain'.[10]

3.9 Numerous observations of mortalities and changes to species distributions were presented to the committee, a selection of which is discussed in the following paragraphs. Overall, however, the Sydney Institute of Marine Science (SIMS) advised that the poleward shift in the distribution of marine organisms is up to 'ten times faster' than the species responding on land. The average speed is 72 kilometres per decade, with the fastest poleward distributions being phytoplankton (470 kilometres/decade) and bony fish (278 kilometres/decade). The changes in distributions are expected to 'become faster in the next few decades'.[11] At present, Dr Hobday advised that there is 'really strong evidence of over 100 species of fish changing distribution down the east coast of Australia'.[12]

---

7 IMAS, *Submission 1*, p. 15; AIMS, *Submission 10*, p. 2.

8 AIMS, *Submission 10*, p. 2.

9 Professor Stewart Frusher, IMAS, *Committee Hansard*, 21 February 2017, p. 2.

10 Dr Alistair Hobday, Senior Principal Research Scientist, CSIRO, *Committee Hansard*, 17 March 2017, p. 5.

11 Sydney Institute of Marine Science (SIMS), *Submission 8*, p. 2.

12 Dr Alistair Hobday, CSIRO, *Committee Hansard*, 17 March 2017, p. 2.

3.10 In Western Australia, the 2011 heat wave in the Indian Ocean caused substantial mortalities in some species, such as 99 per cent mortality in Roe's abalone (*Haliotis roei*) in a particular region. Reductions in the recruitment of scallops and prawns were also observed.[13] In addition, the heat wave appears to have resulted in the 'tropicalisation' of fish in waters off Western Australia.[14]

3.11 In south-east Australia, a southward shift in certain species has been observed and further changes are predicted. IMAS explained:

> The warming observed off Maria Island, Tasmania, since the 1940s is a function of the increase in strength of the East Australian Current, and represents a shift in the coastal water isotherms such that the water seen off Maria Island today would be equivalent to what was recorded off Eden in the 1940s—a 350km southern shift in water temperatures. Thus those animals adapted to the water temperatures off Eden in the 1940s would now find their preferred niche off Maria Island. We are seeing a large number of species beginning to make Tasmania their home, or an increase in abundance of species that were previously rare or uncommon in Tasmanian waters.[15]

3.12 The Fisheries Research and Development Corporation (FRDC) submitted that east coast species that have undergone a southward shift or extended their range include mahi-mahi (*Coryphaena hippurus*) caught recreationally in Tasmania, 'many recreational target species' and long-spined sea urchins (*Centrostephanus rodgersii*). Modelled predictions also suggest that along the Tasmanian east coast, the southern rock lobster will be replaced by eastern rock lobster (*Sagmariasus verreauxi*).[16]

3.13 The poleward shift of species to Tasmanian waters is considered 'especially noteworthy' for certain species as 'the capacity for further shifts poleward is limited in this region due to a lack of suitable habitat, especially for coastal and shelf species'.[17] Professor Frusher commented:

> One of the problems we have in Tasmania is that the animals that are specific to cold and shallow water have nowhere to shift to once our waters warm. So we would expect to see, as our waters warm, extinctions. It is a long hop, step and jump to get to Macquarie Island, and they are not going to be able to do that. Some species can move into deeper waters which are cooler, but if you are dependent on, for instance, algae for food and light sources then shifting into deeper water is not an option for you as far as habitat goes.[18]

---

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

14 Australian Marine Sciences Association, *Submission 5*, p. 2.

15 IMAS, *Submission 1*, pp. 3–4 (emphasis omitted).

16 FRDC, *Submission 2*, p. 7.

17 Australian Marine Sciences Association, *Submission 5*, p. 2.

18 Professor Stewart Frusher, IMAS, *Committee Hansard*, 21 February 2017, p. 2.

3.14 Other developments observed include the loss of kelp beds in Western Australia and eastern Tasmania due to higher ocean temperatures.[19] The loss of kelp forests[20] off the coast of eastern Tasmania was highlighted by several witnesses; for example, Dr Barrett from IMAS submitted:

> There are lots of species of algae out there—literally 1,500 red algae and another 400 or 500 brown and green algae in southern Australia. A lot of those are endemic and a lot of those will be lost. A classic example is *Macrocystis*, the giant string kelp. This is not endemic to Tasmania—it is found globally—but it is an indication of the sorts of changes we are going to see. The particular species formed extensive forests up our east coast, since from forever until 30 years ago. Those forests were up to 30 metres in height and could extend one kilometre, or more, offshore where there was enough reef habitat. They were a major three-dimensional structural habitat, really important to a whole range of our species on the coastline. With that warming, we have basically tipped over their upper thermal limit and we have seen a major decline. We do not see those forests at all on our east coast…the forests are gone. The species has not gone and there are still some forests on our south coast that are subject to more Antarctic water influence, or subantarctic water influence, but the forests themselves and the habitat are gone. The forests are now listed under the [*Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)] as a threatened ecological community. That is a major negative change.[21]

3.15 Mr Michael Baron, who owns a diving business located on the east coast of Tasmania, described the changes to the kelp forest as 'devastation…like a natural disaster in the scheme of things'. He remarked:

> Not only is it the forest that disappears…it is the disappearance of what I would consider a natural reserve. Try to imagine huge acreages—and I am talking huge areas—of forest that you could not net in, you could not pot in, you could not run a hooker through. They acted as a natural marine reserve. As a result of that, I would suggest from an amateur point of view that some of the decreases in a lot of the species down our way are a direct result of the loss of the reserve for the juveniles of those species and the settlement of, for example, rock lobster.[22]

---

19 IMAS, *Submission 1*, p. 4. Giant kelp forests in south-east Australia were listed under the EPBC Act in 2012 'with one of the major threats identified to be associated with climate change'. CSIRO, *Submission 15*, p. 10.

20 Dr Barrett explained that the giant kelp is important for the productivity of the east coast of Tasmania. He described the giant kelp as being an 'extremely productive plant—it produced a large amount of biomass that drifted off and fed grazers like abalone and fed the other invertebrates that rock lobsters feed on'. Dr Neville Barrett, IMAS, *Committee Hansard*, 21 February 2017, p. 5.

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

22 Mr Michael Baron, Owner, Eaglehawk Dive Centre, *Committee Hansard*, 21 February 2017, p. 14.

3.16 It was noted that the changes have both positive and negative implications. As an example of a positive development, Dr Barrett from IMAS observed that yellowtail kingfish and snapper are starting to be found in Tasmania.[23] However, it is considered that, for Tasmania, most of the developments have been negative for biodiversity. Dr Barrett explained:

> There are a lot of species here [in Tasmania] that are endemic to this part of the world. They are not found anywhere else; they are only found in Tasmania or southern parts of southern Australia. If it warms up another degree it is outside of their thermal tolerance; they have nowhere else to go. We are going to lose species like red handfish, spotted handfish, bull kelp—and there are hundreds of others I can list where we have modelled their likely disappearance over the next one degree Celsius temperature increase that, under the best-case scenario, will happen by the end of the century and, under the worst-case scenario, will happen, at the latest, by the 2060s. We will lose a whole lot of species and have major issues needing to manage them in aquaria or just wave them goodbye.[24]

3.17 Potential implications of rising temperatures for the migration and reproduction of certain species were also noted. AIMS explained that rising temperatures 'may have more profound effects on long-lived species (which are unlikely to evolve quickly enough to adapt to the change) or those requiring specific temperature cues as part of their life cycle'. For example, AIMS advised that the sex of marine turtles 'is dictated by sand temperature with females typically more common in nests in warm sands'. AIMS referred to recent evidence of female bias in hatching production for several species and added that female biased populations will continue to be created if temperatures at nesting beaches increase.[25]

3.18 Rising temperatures may also affect the size of individuals within a species. AIMS noted that 'some species may be [a] smaller size in warmer water and growth rates may change', although the extent of this outcome would vary by species.[26]

3.19 IMAS added that the change in distribution of certain species has consequences for the population of other species. IMAS used the example of long-spined sea urchins to demonstrate the effects:

> Temperatures off Tasmania's east coast are now warm enough for long spined sea urchin larvae to survive during their winter spawning period, leading to a climate-driven increase in the distribution and abundance of

---

23 Dr Neville Barrett, IMAS, *Committee Hansard*, 21 February 2017, p. 3.

24 Dr Neville Barrett, IMAS, *Committee Hansard*, 21 February 2017, p. 4. On the handfish, which is a species that is endemic to Tasmania and which cannot live in the Southern Ocean, Mr Jon Bryan from the Tasmanian Conservation Trust noted that it 'is basically stuck here in Tasmania, and, if the habitat becomes unsuitable here, they will become extinct'. Mr Jon Bryan, Marine Campaigner, Tasmanian Conservation Trust, *Committee Hansard*, 21 February 2017, p. 27.

25 AIMS, *Submission 10*, p. 3.

26 AIMS, *Submission 10*, p. 4.

> this species. Urchins have now extensively overgrazed kelp forests to form extensive sea-urchin barrens largely devoid of kelp and other seaweeds. Formation of urchin barrens creates a massive loss of biodiversity and local collapse of abalone and rock lobster stocks.[27]

3.20 The arrival of particular species due to the 'tropicalisation' of southern waters can have negative consequences for existing habitats. When discussing the movement of tropical fishes southward past Sydney through the East Australian Current, Professor Booth noted that increases in the population of the tropical surgeonfish in those waters is concerning as they 'are known to denude algal beds and could potentially destroy temperate ecosystems'.[28]

3.21 Expected regional variances in the consequences for biodiversity of climate change-induced species shifts were highlighted. The Australian Marine Sciences Association explained that modelling suggests northern Australia and Papua New Guinea 'will experience the highest drops in species richness (number of species) of anywhere on the planet'. For Australia overall, however, 'a modest increase is actually expected (as tropical species not currently present move poleward into temperate Australian waters)'. The Association cautioned that the 'makeup of the species assemblage is quite likely to be changed considerably in any given location'.[29]

3.22 It was noted, however, that the effects of climate change can be more complex to identify in particular areas. For example, Professor Suthers contrasted the waters off New South Wales with those around Tasmania. Professor Suthers explained that fluctuations in the East Australian Current over a ten-year cycle have implications for observing changes in New South Wales waters as, during this cycle, there are changes in 'how much goes off to the east towards New Zealand and Lord Howe Island, and how much goes down to Tasmania'. As Tasmania is 'at the bottom of the pipe', changes can be observed more readily. Furthermore, Professor Suthers noted that New South Wales has 'a very urbanised coastline', which means that there are effects linked to population pressures and increasing urbanisation as well as climate.[30]

3.23 A different perspective about the changing distribution of marine organisms was presented in the submission prepared by Dr Alan Moran for the Australian Environment Foundation. Dr Moran argued:

> If temperatures in the ocean change animal and plant life responds by migrating. This process has been evident throughout history—fossil remains of tropical fish have been identified in places where they now could not conceivably survive.[31]

---

27 IMAS, *Submission 1*, p. 4.

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

29 Australian Marine Sciences Association, *Submission 5*, p. 2.

30 Professor Iain Suthers, SIMS, *Committee Hansard*, 16 March 2017, p. 19.

31 Australian Environment Foundation, *Submission 12*, p. 9.

Consequences arising from other changes

3.24 Changing ocean currents are also expected to alter marine environments. As noted in Chapter 2, the eddies that are a feature of the East Australian Current are expected to increase in formation. This is expected to result in increased plankton production. The stronger currents and greater mixing of ocean layers also may 'increase the production of pelagic fish, albeit in more southern latitudes'.[32]

3.25 Changes in currents and temperatures are also expected to be particularly problematic for species with a long larval lifetime. Dr Hobday explained that these species need to be able to release their eggs 'in one part of the coast and have them float around and come back'. Dr Hobday continued:

> As the currents change, you now end up maturing somewhere where the coast is nowhere near you or you are in the wrong part of the climate. So we think very long lived larval species will be particularly challenged. That includes species like rock lobster, which are very valuable for the Australian economy.[33]

3.26 More frequent and intense severe weather events are also expected to affect marine ecosystems. CSIRO submitted that 'cyclones have the capacity to destroy inshore critical nursery habitat for fishery species and cause recruitment failure in subsequent years'. Furthermore, an 'increase in the frequency of category 4 and category 5 cyclones increases the likelihood of regular major impacts to shallow coastal regions that may cause the loss of habitats such as seagrass and mangroves and restrict their reestablishment'.[34]

3.27 In relation to the Spencer Gulf and Gulf St Vincent in South Australia, the South Australian Government submitted that 'predicted increases in the frequency of storms and rises in temperature…are likely to adversely impact seagrass habitats which support the recruitment of early life history stages of many commercially important species'. The Government added that changes in 'gulf hydrological processes due to climate change may also affect larval transport processes and impact recruitment success'.[35]

3.28 Acidification is expected to affect corals and other organisms that form calcium-based skeletons and shells by reducing their ability to calcify.[36] This is discussed below.

---

32 SIMS explained that '[r]ecent observations suggest that eddies (swirls or vortexes) of the East Australian Current provide significant offshore habitats for larval fish compared to those on the continental shelf'. SIMS, *Submission 8*, p. 3 (citation omitted).

33 Dr Alistair Hobday, CSIRO, *Committee Hansard*, 17 March 2017, p. 5.

34 CSIRO, *Submission 15*, p. 13.

35 Government of South Australia, *Submission 21*, p. 4.

36 AFMA, *Submission 9*, p. 9; CSIRO, *Submission 15*, p. 11.

Particular consequences for coral reefs

3.29 When considering biodiversity in the marine environment, particular attention should be given to coral reefs. Globally, coral reefs cover less than one per cent of the Earth's surface, yet contain 25 per cent of all marine fish species.[37] The Great Barrier Reef, which is the largest living structure on Earth, is home to a vast array of species, including among others:

- 1625 species of fish, including 1400 coral reef species;
- more than 3000 species of molluscs;
- 630 species of echinoderm (starfish, sea urchins);
- 14 breeding species of sea snakes;
- 215 species of birds, including 22 species of seabirds and 32 species of shorebirds;
- six of the world's seven species of marine turtle;
- 30 species of whales and dolphins;
- dugongs; and
- 133 species of sharks and rays.[38]

3.30 Climate change presents particular challenges for corals and coral reef ecosystems. The committee received evidence discussing the impacts of climate change on reefs, particularly the Great Barrier Reef and reefs in Western Australia.

Warming ocean temperatures

3.31 Recent coral bleaching events caused by higher ocean temperatures have had 'significant ecological impacts' in the Great Barrier Reef and in Western Australian reefs.[39] Essentially, higher ocean temperatures cause corals 'to first bleach and then, if the warmth continues, to die'.[40] The higher temperatures also 'reduce the intervals for recovery after disturbances such as coral bleaching, by causing reduced calcification rates of corals and coral reproduction for several years'.[41]

---

37 L Burke, D Bryant, J McManus, and M Spalding, *Reefs at Risk*, World Resources Institute, 2008; cited in Reef Resilience Network, 'Value of Reefs', www.reefresilience.org/coral-reefs/reefs-and-resilience/value-of-reefs (accessed 27 October 2017).

38 Great Barrier Reef Marine Park Authority (GBRMPA), 'Animals', www.gbrmpa.gov.au/about-the-reef/animals; 'Facts about the Great Barrier Reef', www.gbrmpa.gov.au/about-the-reef/facts-about-the-great-barrier-reef (accessed 27 October 2017).

39 Dr Janice Lough, Senior Principal Research Scientist, AIMS, *Committee Hansard*, 30 August 2017, p. 34.

40 GBRMPA, *Submission 20*, p. 2.

41 AIMS, *Submission 10*, p. 2. See also CSIRO, *Submission 15*, p. 11.

3.32 The first bleaching event in the Great Barrier Reef occurred in 1998, followed by three further events in 2002, 2016 and 2017. Bleaching events in Western Australian reefs occurred in 1998, 2011 and 2016.[42] The AIMS submission discusses these bleaching events in detail.[43] The Reef and Rainforest Research Centre and tourism operators in the area also provided evidence regarding the Great Barrier Reef bleaching event.[44] Furthermore, the committee was advised of bleaching events that have occurred at Lord Howe Island[45] and of coral bleaching in coastal areas of east Arnhem.[46]

3.33 The current health of, and outlook for, the World Heritage listed Great Barrier Reef was a major focus of the evidence received. The Great Barrier Reef Marine Park Authority (GBRMPA) noted that the *Great Barrier Reef Outlook Report 2014* 'found the overall outlook for the Reef ecosystem is poor and worsening'. In its submission, GBRMPA explained that 'climate change remains the most serious threat to the Great Barrier Reef'.[47] GBRMPA added that:

> The current global mass coral bleaching event has caused significant damage to the Great Barrier Reef and demonstrates the potential of climate change to cause harm that cannot be ameliorated through local management or adaptation.[48]

3.34 The committee was advised that in the 2016 bleaching event, 80 per cent of reefs in the far northern Great Barrier Reef were 'severely bleached', with approximately two-thirds of corals on those reefs lost.[49] Furthermore, AIMS explained that bleaching events severely weaken corals, making them more susceptible to disease and affecting spawning. AIMS expects that the corals damaged by the most

42 Dr Janice Lough, AIMS, *Committee Hansard*, 30 August 2017, p. 34.

43 See AIMS, *Submission 10*, pp. 2–3.

44 See Sheriden Morris, Managing Director, Reef and Rainforest Research Centre, *Committee Hansard*, 29 August 2017, p. 1; Mr John Edmondson, Owner/Director, Wavelength Reef Cruises, *Committee Hansard*, 29 August 2017, p. 9.

45 See Dr Alan Jordan, Principal Research Scientist, New South Wales Department of Primary Industries (NSW DPI), *Committee Hansard*, 16 March 2017, pp. 50–51.

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

47 GBRMPA, *Submission 20*, p. 1. Other threats to the Reef include poor water quality from land-based run-off, impacts from coastal development and risks related to fishing, particularly illegal fishing. See GBRMPA, *Great Barrier Reef Outlook Report 2014*, 2014, pp. v–vi.

48 GBRMPA, *Submission 20*, p. 2.

49 Dr Andrew Hoey, Reef Ecologist, Australian Research Council (ARC) Centre of Excellence for Coral Reef Studies, James Cook University, *Committee Hansard*, 30 August 2017, p. 3.

recent bleaching event are unlikely to spawn during the annual coral spawning season for the Reef (that is, November 2017).[50]

3.35 In addition to the direct impact of bleaching events on corals, the committee was informed of how climate change affects the fish and other organisms in the reef ecosystem. Dr Andrew Hoey from the Australian Research Council Centre of Excellence for Coral Reef Studies, explained that bleaching events affect the structure of the ecosystem as '[d]ifferent fish will drop off at different times'. For example, Dr Hoey advised that butterfly fish, which eat live coral, have no food source once coral dies and 'are one of the first groups that drop off following a bleaching or a [severe] storm'. Dr Hoey added that species which rely on the habitat provided by live coral 'will drop off as well quite quickly'. Dr Hoey added that, once the coral structure starts to be lost, species which 'don't rely on live coral per se but rely on the physical structure' become affected. Dr Hoey explained:

> …there's evidence that around three-quarters of all fish species on the reef rely on live coral at some stage in their lifecycle—whether that be when they first come out of the plankton as larval fish and settle on the reef. The barcheek coral trout, for instance, settles around a particular type of coral surrounded by sand. So if that coral is missing that fish suddenly doesn't have its recruitment habitat. Where does it go?[51]

3.36 The future of coral trout was discussed by several witnesses. Dr Hoey indicated that, in his view, coral trout will 'most likely' disappear. Dr Hoey explained:

> We had a program looking at the effects of temperature. As temperature increases, they require more food. To keep up the metabolic rate, they do not move as much, and they are more susceptible to fishing. We have size limits on coral trout. If you catch a juvenile fish and release it, it is 50 per cent more likely to die in elevated temperatures.[52]

3.37 Evidence given by other witnesses, however, was less certain about the future of the coral trout. Dr Michelle Heupel, Senior Research Scientist, AIMS, stated:

> There are a few studies that are happening. Some of them are looking at the physiology, at the thermal tolerance of these species. So at what point do they start feeding less and moving more slowly, which can affect their survival by changing their behaviour? Bleaching per se is a little bit complicated because if the habitat structure is still there, they can still use

50 Dr Fabricius from AIMS explained that: 'We have done experiments in the past, with consistent results from all around the world—which show that corals that had bleached depleted their energy reserves so much that they were unable to spawn for one or two years after the bleaching stress'. Dr Katharina Fabricius, Senior Principal Research Scientist, AIMS, *Committee Hansard*, 30 August 2017, p. 37.

51 Dr Andrew Hoey, ARC Centre of Excellence for Coral Reef Studies, *Committee Hansard*, 30 August 2017, p. 2.

52 Dr Andrew Hoey, ARC Centre of Excellence for Coral Reef Studies, *Committee Hansard*, 30 August 2017, pp. 10–11.

> it. It will depend on the broader community. So do they have a prey base if they are still to survive? So there are a lot of factors that go into answering that question, and it is one that we are certainly aware of, and are thinking about, but there are lots of pieces to that puzzle.[53]

3.38 Dr David Wachenfeld, Director, Reef Recovery, GBRMPA, commented:

> Unfortunately, temperatures in the northern Great Barrier Reef in the past 18 months have exceeded 30 degrees Celsius for extended periods, and that's the temperature at which the reproduction, the larval development and the health of common coral trout are compromised. The implications of climate change for fisheries in the marine park are still unfolding, but a more cautious approach to fisheries management is being developed for both fisheries and biodiversity conservation purposes.[54]

3.39 Overall, Dr Hoey concluded that, although some fish numbers will increase after a bleaching event due to the availability of algae on dead coral skeletons, 'the vast majority of fishes decline in numbers following bleaching'. Evidence received from Professor David Booth supports this finding: Professor Booth noted that some of the fishes that feed on algae 'do well', however, he indicated that the same could not be said for many other species of fish.[55]

Ocean acidification and changes in water quality

3.40 In addition to bleaching events, as noted in Chapter 2, ocean acidification will have a significant effect on the ability of corals to calcify. Although acidification does not kill coral, AIMS explained that it makes coral 'grow more slowly and makes them recover more slowly'. Acidification, along with poor water quality, can also support the growth of seaweed, which competes with coral. Furthermore, acidification and poor water quality also 'make reefs more brittle and cause bio-erosion'.[56]

3.41 Water quality has implications for the impact of events which can damage the Reef, such as marine heat waves. Dr Katharina Fabricius, AIMS, explained that the current scientific understanding is that water quality can 'made a difference' to the speed of recovery following moderate heat stress events. Dr Fabricius explained:

> Our understanding is that during a moderate heat stress event water quality can still make a difference. If heat stress becomes as severe as it was in 2016-17 then the water quality is already starting to be almost irrelevant because the dominant stressor is the one which is killing the corals. From all the data we have got at this stage there is some evidence that we

---

53 Dr Michelle Heupel, Senior Research Scientist, AIMS, *Committee Hansard*, 30 August 2017, p. 42.

54 Dr David Wachenfeld, Director, Reef Recovery, GBRMPA, *Committee Hansard*, 30 August 2017, p. 46.

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

56 Dr Katharina Fabricius, AIMS, *Committee Hansard*, 30 August 2017, p. 40.

> can buy some time by cleaning our water quality because the thermal tolerance of corals is weakened if they are stressed from other causes, like poor water quality. But the main mechanism of how water quality affects the state of the reefs is that, in particular, sedimentation but also nutrient enriched sediments severely slow down the recovery of the reefs. After those stress events, if there are sediments in the ground or in the system, on the reef surfaces, then coral larvae don't like to settle and give severely delayed recovery.[57]

3.42 Other climate-related events also threaten reefs. AIMS submitted that '[l]ong-term warming of the ocean around Australia has been shown to increase the likelihood of record rainfall in north-eastern Australia, as occurred in early 2011'. This high rainfall 'can lead to substantial inputs of low salinity freshwater (and associated terrestrial contaminants)' into the Great Barrier Reef, which can lead to an outbreak of crown of thorns starfish (a predator of corals).[58]

Crown-of-thorns starfish outbreaks and cyclones

3.43 Although bleaching events have recently presented a significant threat to the Reef, over past decades cyclones and crown-of-thorns starfish outbreaks have been responsible for most coral losses. The damage caused by these different categories of events has cumulative impacts. Dr David Wachenfeld from GBRMPA explained that, since January 2016, three-quarters of the Great Barrier Reef Marine Park has been affected by either the 2016 or 2017 bleaching event or Tropical Cyclone Debbie (2017). Dr Wachenfeld added that the 'impacts of these events…have come on top of nine other severe cyclones since 2005'.[59]

3.44 Dr Hoey advised that it is generally considered its takes approximately 10–15 years for a reef to recover from a disturbance event. Accordingly, Dr Hoey concluded that 'it's simply the frequency of these disturbances that are causing real problems'.[60]

3.45 Although recent coral bleaching events have been the subject of much attention, cyclones and outbreaks of crown-of-thorns starfish continue to be significant threats to the health of the Great Barrier Reef.[61] AIMS submitted that when

---

57 Dr Katharina Fabricius, AIMS, *Committee Hansard*, 30 August 2017, p. 36.

58 AIMS, *Submission 10*, pp. 5–6.

59 Dr David Wachenfeld, GBRMPA, *Committee Hansard*, 30 August 2017, p. 46.

60 Dr Andrew Hoey, ARC Centre of Excellence for Coral Reef Studies, *Committee Hansard*, 30 August 2017, p. 1.

61 Dr Fabricius explained that coral losses observed in the Great Barrier Reef through long-term monitoring over 27 years up to 2012 were attributed to cyclones (48 per cent of losses), crown-of-thorns starfish (42 per cent) and bleaching (10 per cent). As a result of the two severe bleaching events since 2012, however, Dr Fabricius reasoned that these three sources of damage could now be 'almost equal in their destructiveness'. Dr Katharina Fabricius, AIMS, *Committee Hansard*, 30 August 2017, p. 43.

crown-of-thorns starfish populations reach 'plague proportions', the living coral cover on the Great Barrier Reef can be reduced to 'a few per cent'. AIMS advised that since the 1960s, populations of crown-of-thorns starfish have 'erupted at approximately 15 year intervals', with four major outbreaks overall. AIMS advised that at present, prediction of the effects of climate change on the factors that lead to outbreaks has a high level of uncertainty, however, AIMS submitted that 'the current most widely accepted hypothesis is that primary outbreaks are promoted through increased nutrient availability, such as observed after significant flood events'.[62] AIMS further added that:

> A change in the magnitude and timing of floods due to climate change, as indicated in an analysis of long-term rainfall records, might result in changes to the frequency and/or severity of [crown-of-thorns starfish (CoTS)] outbreak.[63]

3.46 AIMS noted that how other climate change effects for oceans generally affect crown-of-thorns populations is unclear. AIMS explained:

> The direct influence of rising temperature and ocean acidification on CoTS is still debated. Recent research indicated positive effects on early life stages of CoTS, such as increased larvae survival and growth of juveniles, and that CoTS have a high potential for adaptation to climate change. Conversely, in other studies, ocean acidification decreased fertilisation rates and reduced settlement induction by crustose coralline algae.[64]

3.47 There are also potential consequences for the health of coral reefs arising from the projected increase in average cyclone intensity.[65] AIMS noted that cyclones 'can be a major driver of reef ecological condition' in the Great Barrier Reef. AIMS explained:

> The extent of development of coral communities on a reef depend on the time since disturbances such as cyclones, on the intensity of disturbance (extent of damage), and the rate of recovery through recolonisation by coral larvae and through regrowth of coral fragments. Thus if disturbances of any kind become more intense (requiring more extensive recolonisation and regrowth) or more frequent (allowing less time for recovery) or the rate of recovery is slowed (for instance through adverse effects of poor water quality on larval survival) then the reef community will be degraded from its former state. The predicted increase in intensity of cyclones, as well as

62 AIMS explained that increased nutrient availability 'increases phytoplankton, the food source of the planktonic CoTS larvae, which in turn increases their survival, ultimately increasing likelihood of CoTS population outbreaks'. AIMS, *Submission 10*, p. 6.

63 AIMS, *Submission 10*, p. 6.

64 AIMS, *Submission 10*, p. 6.

65 See AIMS, *Submission 10*, pp. 6–8.

> increased frequency of bleaching conditions will increase the overall rate of disturbances.[66]

3.48 Personal observations of damage to the Reef from cyclones were put before the committee. Ms Hayley Morris, Executive Director, Morris Group, which owns several tourism accommodation properties in north Queensland, provided the following account of changes caused by Cyclone Yasi (2011) given by the manager of Morris Group's Orpheus Island property:

> When at Lizard Island the swell caused by Cyclone Yasi devastated the Cod Hole (even though it crossed the coast south of Cairns) the site was unrecognisable and devoid of not only the fragile corals but also the smaller fish. Our guests were vocal about the damage 6 months on and it was several years before the employees felt that the reef was healthy again.[67]

3.49 It was noted that weather events, such as small storms and cloud cover, provide reefs with some protection from negative consequences associated with warming waters.[68] In fact, the southern part of the Great Barrier Reef escaped the 2016 bleaching event because of cloud cover from Cyclone Winston.[69]

3.50 More generally, the interrelationships between the three different categories of threats to the Great Barrier Reef and the cumulative pressure placed on the health of the Reef is demonstrated by the following evidence from Professor Burrows on how to respond to bleaching events. Professor Burrows likened severe bleaching events to bushfires; that is, an event which will override any management work that may have occurred. Professor Burrows stated:

> All you can do is manage it to as good a quality as you can between bleaching events, and make sure that it's as resilient as possible to bounce back after bleaching events. All those things are important—the zoning, the water quality, the [crown-of-thorns starfish] are important to that. If those 2,000 starfish hadn't been removed before that bleaching event, they would still be there after bleaching. They are not perturbed by the temperature. They are still there. You only have a much smaller remaining number of coral. Those crown-of-thorns are going to converge on that remaining coral and eat it. The coral that survived that bleaching event nominally may be more thermo-tolerant than their brethren that died. We don't know that yet, but it is a reasonable assumption. We are commissioning research to look at that under the next program that I manage.

---

66 AIMS, *Submission 10*, p. 7.

67 Ms Hayley Morris, Morris Group, *Submission 25*, p. 2

68 Sheriden Morris, Managing Director, Reef and Rainforest Research Centre, *Committee Hansard*, 29 August 2017, p. 5.

69 Dr Andrew Hoey, ARC Centre of Excellence for Coral Reef Studies, *Committee Hansard*, 30 August 2017, p. 11.

> If those coral are more thermally tolerant, and that is the reason they survived the bleaching, then you want them to propagate the next generation and spread their preferential thermo-tolerant genes. You don't want them to survive the bleaching and then get eaten by a crown-of-thorns starfish, a cyclone or whatever. You want to do the best you can to protect them. In that sense, people say to me, What do we do in a post-bleaching event?' The number one thing we can do is increase crown-of-thorns control.[70]

Particular consequences for mangroves

3.51 The implications of climate change for mangrove systems is another topic that was examined in detail during this inquiry. Mangroves are considered to be 'critically important habitats for a wide range of species' as they provide 'nursery, feeding and refuge areas and underpinning coastal food webs that support many commercial and non-commercial species'.[71] Mangroves also provide protection for coral reefs. Professor Damien Burrows explained:

> Mangroves are major trappers of sediments in particular; that is, mangroves are actually very good at colonising sediment. They trap it, they colonise it and stabilise those estuarine systems. So they are very much performing a protective role for the reef environment, especially for riverine sediments and nutrients coming down the river. They're reasonably tolerant, obviously. Unlike, say, the [Great Barrier Reef], which is sensitive to reef sediment nutrients, the mangroves are much more tolerant; hence why they are good at that trapping environment. So they are particularly important, and they are very important for fisheries as well. In particular, a lot of recreationally important fishery species will spend part of their lifecycle in mangrove and estuarine ecosystems.[72]

3.52 Mangroves are also considered to provide a wide range of other benefits. The Queensland Department of Environment and Heritage Protection has published the following overview of how mangroves protect the coast, absorb pollution and provide carbon sequestration:

> Mangroves protect the coast by absorbing the energy of storm-driven waves and wind. The only two yachts undamaged by Cyclone Tracy in Darwin in 1974 were sheltered in a mangrove creek. In 2006, mangroves protected vessels and the coastline during Cyclone Larry in far north Queensland. The damage bill would have been much higher if it wasn't for the existence of intact mangrove forests. As well as providing a buffer for the land, mangroves also interact with the sea. Sediment trapped by roots prevent

---

70 Professor Damien Burrows, *Committee Hansard*, 30 August 2017, p. 22.

71 Queensland Department of Environment and Heritage Protection, 'Mangroves', 30 January 2017, https://wetlandinfo.ehp.qld.gov.au/wetlands/ecology/components/flora/mangroves/ (accessed 28 July 2017).

72 The mangroves provide a nursery for these fish species. Professor Damien Burrows, *Committee Hansard*, 30 August 2017, pp. 14–15.

> silting of adjacent marine habitats where cloudy water might kill corals or smother seagrass meadows. In addition, mangrove plants and sediments have been shown to absorb pollution, including heavy metals. Mangroves are also very effective at storing carbon.[73]

3.53 Recent degradation of mangroves has been linked to extreme weather events. In 2017, researchers at the Centre for Tropical Water and Aquatic Ecosystem Research at James Cook University published a study on large-scale dieback of mangroves in the Gulf of Carpentaria.[74] The Northern Land Council also submitted that apparent impacts of climate change in the Northern Territory include the 'severe dieback of mangroves in the Gulf of Carpentaria'.[75]

3.54 Although there is research about mangrove dieback, it was suggested that what happens to marine species that live in and rely on mangrove systems is unknown. Mr Simon Rowe from OceanWatch Australia commented that 'hypothetically…maybe they will die', but he considers surveys of what is occurring under the water need to be undertaken to ascertain what is happening.[76] Professor Burrows noted that research has identified that mangroves are more tolerant of high temperatures than corals.[77] However, the ability of mangroves affected by dieback to recover is concerning due to the timeframe required and the potential for other events, such as cyclones, to disrupt the recovery. Professor Burrows explained:

> The thing that concerns us is that, of the 1,000 kilometres of that coastline where there is a lot of dieback, 200 kilometres of it is the actual mangroves right along the actual shorefront. The Gulf of Carpentaria is very flat, very low land, very prone to storm surges and things like that, and changes in the geomorphology from those storm surges. The mangroves provide a strong service in holding together those coastlines. Now those coastlines aren't being held together by those forests anymore. So they are particularly vulnerable to storm surges or cyclones in that area. They will recover—hopefully, in 15 years or so, if we don't get too many cyclones or big storms in that area.[78]

---

73 Queensland Department of Environment and Heritage Protection, 'Mangroves', 30 January 2017, https://wetlandinfo.ehp.qld.gov.au/wetlands/ecology/components/flora/mangroves/ (accessed 28 July 2017). Many of these points were also made by Mr Simon Rowe, Program Manager, Environment, OceanWatch Australia (see *Committee Hansard*, 16 March 2017, p. 39).

74 Norman Duke et al, 'Large-scale dieback of mangroves in Australia's Gulf of Carpentaria: a severe ecosystem response, coincidental with an unusually extreme weather event', *Marine and Freshwater Research*, CSIRO, 2017.

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

76 Mr Simon Rowe, OceanWatch Australia, *Committee Hansard*, 16 March 2017, p. 39.

77 Professor Damien Burrows, *Committee Hansard*, 30 August 2017, p. 15.

78 Professor Burrows clarified that the full recovery of the mangroves will take longer than 15 years; however, 15 years should allow 'a reasonable degree' of recovery. Professor Damien Burrows, *Committee Hansard*, 30 August 2017, p. 16.

3.55 Despite the link between extreme weather events and mangrove degradation, the committee was also informed that, if climate change led to areas receiving greater levels of rainfall, this fresh water could enable mangroves to grow taller and faster, and possibly expand.[79]

Knowledge gaps and other considerations

3.56 As is the case with changes in ocean attributes arising from climate change generally, there are apparent knowledge gaps about the effects of these changes on the marine environment. For example, IMAS submitted that '[e]xtensive change in the distribution of our species will result in extensive change in the structure, and therefore function, of our ecosystems.[80] However, IMAS advised that there is a 'limited understanding of how the climate impacts on many individual species, and the new combinations of species, will collectively change the structure and function of marine ecosystems as a whole'.[81] IMAS added:

> There are substantial differences among species in the magnitude of responses to warming…and we have little knowledge about the processes responsible for this vast variation in species responses.[82]

3.57 In particular, IMAS noted there is limited knowledge of the effects of climate change on key parameters, such as selectivity, growth and reproduction. It observed that '[d]ue to natural variability in many of these key parameters, long term data sets are required to determine trends'.[83]

3.58 Dr Hobday from CSIRO similarly noted:

> The major uncertainty we have is around how much the productivity of Australia's oceans will change. The temperature signal is very clear, but the question is whether the ocean becomes more or less productive, and in what parts of Australia that happens. We are working very hard to try and resolve that at the moment.[84]

3.59 The Government of South Australia submitted that, although some of the expected impacts of ocean acidification from climate change for ecosystems and species, particularly shellfish, 'may be predicted', it advised that 'the magnitude of each response remains largely uncertain as the effects on fish stock biomass are poorly understood'.[85] Dr Hobday noted that information about these fisheries, such as the

---

79 Professor Damien Burrows, *Committee Hansard*, 30 August 2017, p. 19.

80 IMAS, *Submission 1*, p. 16.

81 IMAS, *Submission 1*, p. 4.

82 IMAS, *Submission 1*, p. 15 (citation omitted).

83 IMAS, *Submission 1*, p. 32.

84 Dr Alistair Hobday, CSIRO, *Committee Hansard*, 17 March 2017, p. 2.

85 Government of South Australia, *Submission 21*, p. 4.

scallop fishery, can be limited due to the economic realities of the fishery. Dr Hobday explained:

> We call the scallop fishery in Australia a 'boom and bust' fishery. Some years it is open; some years it is closed. That means that the research interest or research funds available to study that are sometimes quite limited and, because we fund fisheries research through cost recovery, if the fishery is not worth very much it does not get very much attention. So I think the scallop fishery is likely to be quite low on the priority list for that effort, even though it is going to be very important to the people involved in that fishery.[86]

3.60 IMAS submitted that models need to be developed that 'can predict changes in species composition *and* abundance simultaneously'. IMAS considers such models would assist in 'understanding the interacting impacts of fisheries and climate change on ecosystems' and in making 'integrated ecosystem assessment of climate change a reality'.[87]

3.61 As noted in Chapter 2, scientific organisations explained that there is a lack of information available for understanding the implications of climate change due to the small number of long-term data sets. The lack of long-term data was also highlighted by Austral Fisheries, which explained how the absence of monitoring data has implications for understanding and managing particular fisheries. Mr Exel from Austral Fisheries discussed the effects of a heatwave on the Patagonian toothfish fishery off Heard Island and McDonald Island on fishing catch in 2016 and recounted Austral's surprise at the lack of data available. He explained:

> It was actually a combination of the El Nino from 2015, which travels across the top of Australia, and a thing called the Indian Ocean dipole, which is where there is very warm water off the east coast of Africa. It creates a very warm current. That gave us the record warmest temperatures at Kerguelen Plateau since records have been made, which is something like 80 or 90 years. The toothfish fishery catch rates reduced overnight by over 50 per cent. They stayed low for probably four months. By the end of the season we—and there was another company also fishing for toothfish there—left somewhere in the region of 650 tonnes of toothfish swimming that normally we would have caught very easily as part of our quota allocation.
>
> That was really the absolute pinnacle of what is wrong with the climate change debate, because when we then started to ask where is the monitoring and the oceanographic information, we were scrabbling for everything. We realised that there is no long-term monitoring dataset; there is no cohesive program looking at it.[88]

---

86 Dr Alistair Hobday, CSIRO, *Committee Hansard,* 17 March 2017, p. 6.

87 IMAS, *Submission 1,* p. 16.

88 Mr Martin Exel, General Manager Environment and Policy, Austral Fisheries, *Committee Hansard,* 21 February 2017, p. 23.

3.62 Since this discovery, Mr Exel advised that Austral, along with IMAS, the Australian Antarctic Division (of the Department of the Environment and Energy), CSIRO and other industry stakeholders, have invested in is conductivity temperature depth recorders and cameras to start compiling a dataset. Mr Exel noted that Austral has, to date, spent approximately $150,000–$200,000 on these efforts.[89]

3.63 In relation to marine pests, the Department of Agriculture and Water Resources (DAWR) submitted that the water temperature tolerance range of invasive marine species is not well established. Typically, invasive species are adaptable to a broad range of environmental conditions. While DAWR acknowledged that climate change will alter environmental conditions at ports, it expects that the rate of change will be relatively gradual.[90]

3.64 Research has been undertaken to consider possible responses to marine pests that become established in new areas. For example, IMAS has conducted research into potential management strategies of the long-spined sea urchin at Elephant Rock (near St Helens) and Southerly Bottom (near North Bay) on the easterly side of Forestier Peninsula. After the two research areas had restrictions placed on fishing for lobsters by the Tasmanian Department of Primary Industries, Parks, Water and Environment, the researchers found that rock lobsters are one of the few known predators of the long-spined sea urchin.[91]

3.65 Finally, a concern shared by stakeholders is that the significance of the transformations in the marine environment caused by climate change is not widely appreciated. In relation to the kelp forest losses off the coast of Tasmania, Mr Jon Bryan from the Tasmanian Conservation Trust stated:

> One can only imagine that if this sort of thing happened on land—if, for example, all the blue gums disappeared, or all the eucalypt forests or some similar terrestrial vegetation disappeared—it would create an uproar.[92]

3.66 On the same kelp bed development, Mr Michael Baron from Eaglehawk Dive Centre similarly commented:

> And I put it to you, as I said here, if this is how it had occurred on land, you would have been there having this inquiry over 25 years ago. But nobody sees it and therefore it does not have any effect. I have just been interviewed by three different TV stations. Yes, they are all keen to talk to you. As soon as you finish, they are off. It does not mean anything to them.[93]

---

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

90 Department of Agriculture and Water Resources, *Submission 18*, pp. 5–6.

91 Tasmanian Department of Primary Industries, Parks, Water and Environment, 'Long Spined Sea Urchin Research Project', http://dpipwe.tas.gov.au/sea-fishing-aquaculture/recreational-fishing/area-restrictions/long-spined-urchin-research (accessed 8 December 2016).

92 Mr Jon Bryan, Tasmanian Conservation Trust, *Committee Hansard*, 21 February 2017, p. 27.

93 Mr Michael Baron, Eaglehawk Dive Centre, *Committee Hansard*, 21 February 2017, p. 17.

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 Hallegraeff, 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://dpipwe.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 is 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.

Chapter 5

Adapting to climate change: Policy and regulatory responses

5.1 The following two chapters examine measures that can be taken in response to the effects of climate change on marine fisheries and biodiversity. Submissions and witnesses called for greater attention to be given to the impacts of climate change as well as urgent action to address the influence of human activities on the climate.[1] Given the targeted focus of this inquiry, however, this report instead concentrates on proposals that specifically address how to respond to the effects of climate change on the marine environment.

5.2 This chapter focuses on the evidence received about the adequacy of regulatory regimes involving the marine environment in the face of climate change. These include fisheries management arrangements, marine protected areas and whether relevant legislation and approaches to decision-making are adequate for dealing with the known and projected effects of climate change.

5.3 In considering these proposals, it is instructive to take into account the Australian Government's overall approach to managing climate risks. This is outlined in the *National Climate Resilience and Adaptation Strategy*, which was released in December 2015.[2] The Fisheries Research and Development Corporation (FRDC) explained that this strategy informs '[m]uch of Australia's climate science investment'. The FRDC noted that the strategy 'specifically affirmed a set of principles to guide effective adaptation practice and resilience building'. The principles are as follows: shared responsibility; factoring climate risks into decision making; an evidence-based, risk management approach; helping the vulnerable; collaborative, value-based choices; and revisiting decisions and outcomes over time.[3]

5.4 In addition, evidence was received about the Australian Government's responsibilities under Commonwealth legislation regarding the risks of climate change for marine biodiversity and fisheries, as well as research, information and reporting relating to climate change that the government supports. Policies and programs are

---

1 For example, see Australian Institute of Marine Science (AIMS), *Submission 10*, p. 8; Mr Michael Baron, Owner, Eaglehawk Dive Centre, *Committee Hansard*, 21 February 2017, p. 16; Professor Iain Suthers and Dr Adriana Verges, Sydney Institute of Marine Science (SIMS), *Committee Hansard*, 16 March 2017, pp. 30–31.

2 See Department of the Environment and Energy (DoEE), 'National Climate Resilience and Adaptation Strategy', www.environment.gov.au/climate-change/adaptation/strategy (accessed 15 December 2016).

3 Fisheries Research and Development Corporation (FRDC), *Submission 2*, p. 4.

discussed in this chapter where relevant; however, the submissions from government departments and agencies provide further detail about these matters.[4]

5.5 This chapter commences with the evidence received arguing there is merit in updating environment and resource management legislation and decision-making processes to account expressly for the implications of climate change. How regulatory arrangements could be changed to aid climate change adaptation in various sectors is also discussed. Specifically, this chapter examines fisheries management arrangements, marine biodiversity protections, and biosecurity measures and monitoring systems.

Accounting for climate change in legislation, decision-making practices and administrative arrangements

5.6 The objects of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) include the protection of the environment, especially those aspects of the environment that are matters of national environmental significance, the promotion of 'ecologically sustainable development through the conservation and ecologically sustainable use of natural resources' and promoting the conservation of biodiversity.[5] Among other things, principles of ecologically sustainable development include:

- that decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations;
- the principle of inter-generational equity—that the present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations; and
- the conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making.[6]

5.7 The Environmental Defenders Offices of Australia (EDOA) called for 'Commonwealth legislation, particularly conservation and natural resource management legislation…to be fundamentally re-oriented to focus on, and be ready for, a future affected by climate change'. EDOA noted the existing objects of the EPBC Act, but argued that 'to assist species to adapt under future climate change scenarios, the EPBC Act should incorporate a new object specifically referring to strengthening ecosystem resilience and adaptive capacity of ecosystems, and facilitating adaptation'. Similarly, the EDOA submitted that the *Great Barrier Reef Marine Park Act 1975* 'does not specifically refer to the need to promote climate change adaptation'. In particular, the EDOA argued that the Act 'does not specifically

4 For example, see DoEE, *Submission 19*.

5 *Environment Protection and Biodiversity Conservation Act 1999*, s. 3(1).

6 *Environment Protection and Biodiversity Conservation Act 1999*, s. 3A.

facilitate the inclusion of climate change concerns within zoning plans and plans of management'.[7]

5.8 EDOA envisaged that refocusing and realigning Commonwealth laws in response to climate change would involve the development of 'clear objectives'. Ms Susan Higginson, Chief Executive Officer, Environmental Defenders Office New South Wales (EDO NSW), explained:

> Like all good laws, the objectives and goals need to be clearly articulated, so that we are all on the same page. Those goals need to promote ecosystem resilience and adaptive capacity; recognise that ecosystems need to be the foundation of decision-making, planning and management; and adopt risk and management frameworks that can actually respond to climate change. Climate-ready laws provide a decision-making framework containing robust and rigorous climate change mitigation and adaptation principles that are appropriate and adaptable to implement actions to local conditions.
>
> A whole-of-law approach is what we need, and it needs to be adopted, including necessary amendments to current legislation. That has to include legislation that is relevant, but not necessarily specifically focused on conservation. It is essential that climate change considerations for adaptation are included in policy formulation, planning, program management, project design and project implementation.[8]

5.9 Examples of state government laws and management reports which do not directly reference climate change were also noted.[9] However, the committee was also informed of state legislation and policies that refer to climate change. Dr Alan Jordan, Principal Research Scientist, New South Wales Department of Primary Industries (NSW DPI), provided the following explanation of how climate change is approached in New South Wales marine legislation:

> There are four major categories. At the highest level—there is a hierarchical approach to tease out the level of detail required—one of those key ones is climate change. It stands out there, and land based impacts and resource use are the other two key ones. The difference with the climate change one—we recognise that a lot of the data out there in terms of projections are 2100 projections. We recognised early on that the time frame for the other risk assessments around land based risks et cetera were more a 20-year horizon, recognising that that is still a long horizon for government to work towards. We recognised that a 20-year horizon in the climate change space was

7 EDOs of Australia (EDOA), *Submission 4*, pp. 4, 7, 10. See also Ms Susan Higginson, Chief Executive Officer, Environmental Defenders Office New South Wales (EDO NSW), *Committee Hansard*, 16 March 2017, p. 9.

8 Ms Susan Higginson, EDO NSW, *Committee Hansard*, 16 March 2017, p. 8.

9 For example, Professor David Booth referred to a report on the status of fish stocks compiled by the New South Wales Department of Primary Industries (NSW DPI), which he described as 'an amazing document of over 400 pages', but which 'makes almost no mention of the effect of climate change on those species'. The professor added that 'temperature is mentioned a number of times but not directly the change in climate'. *Committee Hansard*, 16 March 2017, p. 3.

> probably inadequate, so we also added in a 50-year horizon in the risk assessment, and you will see within the documentation that it is the only area where we took a 20-year and a 50-year projection, with a clear understanding that risks are generally trending up.[10]

5.10 In its submission, EDOA commented in detail on how it considers the EPBC Act should be amended to improve the regulatory framework for how the effects of climate change on marine fisheries and biodiversity are managed. Overall, EDOA argued that:

> …climate change impacts should be mandatory considerations in the various decision-making processes under the EPBC Act, and incorporated throughout assessments and management plans. This should include marine bioregional planning, critical habitat listings, and threat abatement planning.[11]

5.11 In particular, EDOA considered that a 'key gap in the climate readiness of the EPBC Act' is the lack of a 'greenhouse trigger'; that is, a requirement for proposals to be referred to the Commonwealth if they are likely to be a significant contributor to climate change.[12] Essentially, a greenhouse trigger would require that a project which generated levels of greenhouse gas emissions over a certain threshold would be referred to the Minister for the Environment and Energy for determination as to whether it is a 'controlled action', in which case environmental assessment and approval of the project under the EPBC Act would be required.

5.12 The introduction of a greenhouse trigger has been considered previously, most notably by the 2009 independent review of the EPBC Act conducted by Dr Allan Hawke. The greenhouse trigger proposed by the Hawke Review would have 'a threshold of at most 500,000 tonnes of carbon dioxide equivalent emissions'. However, Dr Hawke's recommendation was made with reference to the Carbon Pollution Reduction Scheme (CPRS), a cap and trade emissions trading scheme proposed by the Rudd Government. Dr Hawke recommended that an interim greenhouse trigger be introduced until the CPRS commenced (after which the trigger would sunset).[13]

5.13 Legislation to establish the CPRS did not pass the Senate and the introduction of an interim greenhouse trigger was not pursued as part of the carbon price subsequently developed by the Gillard Government. In discussing the recommendation for an interim greenhouse trigger, the Gillard Government's 2011 response to the Hawke Review explained that an interim greenhouse trigger was not required because it expected investors would account for the carbon price in their

---

10 Dr Alan Jordan, Principal Research Scientist, NSW DPI, *Committee Hansard*, 16 March 2017, p. 48.

11 EDOA, *Submission 4*, p. 8.

12 EDOA, *Submission 4*, p. 7

13 A Hawke, *Report of the Independent Review of the EPBC Act 1999*, 2009, Part 1, pp. 22, 30.

investment decisions.[14] Accordingly, the government response did not agree to the introduction of an interim greenhouse trigger. However, the carbon price developed by the Gillard Government was abolished in 2014 by the Abbott Government.

5.14 EDOA also expressed concern that the *Reef 2050 Long-term Sustainability Plan*[15] is, in its view, unenforceable. Ms Higginson argued that attention should be given to enforcing strategies such as the Reef 2050 Plan. Ms Higginson explained:

> I know there are many different philosophical approaches to regulation, but, at the end of the day, the jury is well and truly in—and has been in for a long time—on the idea that when something is unenforceable the likelihood of achieving it is much lesser than if something is enforceable. The reef plan, while it has some good aspirations, is unlikely to receive the type of funding and attention that is required when it is simply not enforceable. It is clear how we make things enforceable; we pass laws and we work hard to get those laws right, and then it is enforceable. It makes sense: treasuries and departments are willing to put more resources into mechanisms that are required to be achieved by governments and agencies.[16]

5.15 Finally, a proposal for a fundamental change in how ocean-related responsibilities are distributed between government departments and agencies was put forward. Dr Trevor Ward and Professor David Booth argued that over decades policymakers have attempted, but failed, to 'resolve the conundrum of management of the "Ocean Commons"'. Dr Ward and Professor Booth argued that there is a need to establish an 'effective integrated system for management of our oceans', and that the establishment of a National Oceans Commission could be assist in this endeavour.[17] Professor Booth explained that such a Commission would support 'better governance for the oceans' through by coordinating existing Commonwealth and state agencies without taking on direct regulatory functions.[18]

5.16 Their vision for the roles and responsibilities of a National Oceans Commission was articulated in detail in Dr Ward and Professor Booth's joint submission. The submission stated:

> …the National Oceans Commission would be statutory but non-regulatory, in the sense that the Commission would not legally control the activities of other agencies, governments, companies or citizens. There are (probably)

---

14 Australian Government, *Response to the report of the independent review of the Environment Protection and Biodiversity Conservation Act 1999*, 2011, www.environment.gov.au/system/files/resources/605a54df-7b33-4426-a5a8-51de24b29c71/files/epbc-review-govt-response.pdf (accessed 30 November 2017, p. 27.

15 The Reef 2050 Plan, which was released by the Australian and Queensland Governments in March 2015, provides a framework for protecting and managing the Reef. The Plan is discussed in Chapter 6.

16 Ms Susan Higginson, EDO NSW, *Committee Hansard*, 16 March 2017, p. 12.

17 Dr Trevor Ward and Professor David Booth, *Submission 23*, pp. 1–2.

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

> largely sufficient mechanisms in place to implement any required changes to onground actions. The Commission envisaged here would act with 'carrot' rather than 'stick' to coordinate emerging activities, issue public information about key aspects of ocean health, performance assessments about existing and proposed resource activities, and set directions for future innovations and activities that support enhanced resilience of the oceans ecosystems and environments. To be an effective force in the public arena, the Commission will need to be fully independent, authoritative, internally consistent, and public in all its activities, with a funding base and support that is commensurate with the high level of importance of the issues/activities.[19]

5.17 The submission argued that the Commission would help enhance the quality of ocean ecosystems through various primary objectives. These objectives would 'be framed to provide support to agencies, the private sector, and community groups for the purpose of maintaining and enhancing (where necessary) integrated ecosystem-based management of Australia's Oceans'. It was suggested that these primary objectives would involve setting outcome-based ocean quality standards, coordination and advocacy, producing publicly available reports on ocean quality, and supporting collaborative research activities.[20]

5.18 Although few stakeholders commented on the concept of a National Oceans Commission, those that did expressed support.[21]

5.19 Examples of coordinating mechanisms formed to improve governance of the oceans and to overcome gaps in existing bureaucratic arrangements have been pursued in other countries, such as the United States of America. Under President Barack Obama, an Interagency Ocean Policy Task Force was established that led to the creation of a National Ocean Council. The National Ocean Council comprised cabinet secretaries, agency heads and other key officials and was charged with implementing the Obama Administration's National Ocean Policy.[22]

---

19 Dr Trevor Ward and Professor David Booth, *Submission 23*, p. 4 (emphasis omitted).

20 *Submission 23*, pp. 4–5 (emphasis omitted). The joint submission provides further detail on how the Commission could be structured and its possible functions.

21 See Ms Lowri Pryce, Executive Officer; Mr Simon Rowe, Program Manager—Environment, OceanWatch Australia, *Committee Hansard*, 16 March 2017, p. 45.

22 See National Archives (United States), The Obama White House, 'National Ocean Council', https://obamawhitehouse.archives.gov/administration/eop/oceans (accessed 13 November 2017).

Fisheries management

5.20 Based on international experience, there is potential for a changing environment to challenge existing fisheries management arrangements and access rights. For example, the Institute for Marine and Antarctic Studies (IMAS) noted:

> …as waters warmed, mackerel has expanded rapidly into Iceland since 1996 and now supports a commercial fishery (1700 t in 2006 to 120,000 t in 2009). This climate-driven change in distribution underpinned the 'mackerel wars' between EU and Iceland…[23]

5.21 Austral Fisheries noted that the 'specific adaptations to climate change which our fisheries will be subject to are hard, if not impossible, to evaluate with certainty'. Austral suggested that responses to issues presented by climate change should be considered on a 'fishery-by-fishery basis, if not on a species-by-species basis'.[24] Austral added that any changes 'should only be made after careful scientific assessment of the impacts which, in turn, necessitates an effective, comprehensive, long-term scientific program to monitor and evaluate indicators of climate change'.[25]

5.22 Evidence from entities involved in fisheries management suggested there is a strong basis for current management arrangements to cope with challenges that climate change may present. CSIRO submitted:

> Australia has a strong record in fisheries management supported by robust science that positions us well to cope with the impacts of climate change. By global standards our fisheries are well managed. For example, it has been estimated that less than 15% of assessed fisheries are overfished, with an improving trend, compared to 30% globally. Australia's fisheries jurisdictions have generally adopted ecosystem-based fishery management as a policy goal. This is consistent with the growing international demand for environmentally friendly products. Spatial management and participatory or co-management are also key features of the fishery management system.[26]

5.23 Similarly, the FRDC stated that 'Australia's policy and management frameworks are well placed to respond because they are already adaptive and flexible'.[27] In addition, the Australian Fisheries Management Authority (AFMA) advised that it is 'planning to assess the ability of our management system to cope under various future scenarios'.[28] AFMA's Chief Executive Officer provided the

---

23 Institute for Marine and Antarctic Studies (IMAS), *Submission 1*, p. 25 (citations omitted).

24 In developing this point, Austral discussed the particular circumstances of the Northern Prawn Fishery and the sub-Antarctic fisheries. See Austral Fisheries, *Submission 6*, p. [6].

25 Austral Fisheries, *Submission 6*, pp. [4], [6].

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

27 FRDC, *Submission 2*, p. 2.

28 Australian Fisheries Management Authority (AFMA), *Submission 9*, p. 4.

following summary of how the fisheries management regime and AFMA's management approach can take climate change related effects into account:

> Sound fisheries management by definition seeks to be robust to changes in the distribution and abundance of living marine resources. There are many drivers that change the distribution and abundance of those resources in addition to fishing. Those drivers are both living and non-living. They can be complex and difficult to predict, and climate change is one of those. AFMA is actively working to understand the threats and opportunities as a result of impacts of climate change. We seek to ensure that our management is robust to climate change impacts. We're helping to assist industry to adapt to the impacts of climate change on their fishing practises and seeking to remove management barriers to adaptation, and also seeking to understand and mitigate the impacts of climate change on illegal foreign fishing threats in Australian waters in our region.[29]

5.24 Changes to fisheries management arrangements have been implemented at a state level; for example, in New South Wales 'a more holistic approach to coordinated management of the coastal zoning in marine estate' has been pursued through the creation of the New South Wales Marine Estate Management Authority. Dr Alan Jordan from the NSW DPI provided the following evidence about the new arrangements:

> We have been conducting a comprehensive statewide environmental social and economic risk assessment over the last two years or so to identify the environmental assets and the social and economic benefits that the New South Wales community derives from marine estate, and what the threats are to those benefits. A key component of that threat assessment is clearly climate change, as one of the overarching components of pressures or stressors that are impacting on the marine environment.[30]

5.25 As noted previously, climate change is also one of many factors affecting commercial fishing. The Government of South Australia submitted that the 'many and varied factors which challenge the management of fisheries resources…are a key driver for fisheries management to be responsive and flexible to changing needs and requirements'.[31]

5.26 Nevertheless, the FRDC argued that 'fisheries management needs to be more agile in order to take advantage of opportunities that arise through climate change'. Although the FRDC considered 'it is generally too early to specifically constrain/increase quota and access provisions due solely to climate change', it argued

---

29 Dr James Findlay, Chief Executive Officer, AFMA, *Committee Hansard*, 20 October 2017, p. 8.

30 Dr Alan Jordan, NSW DPI, *Committee Hansard*, 16 March 2017, p. 46.

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

that harvest management arrangements should be continually improved, in accordance with key 'smart principles'.[32]

5.27 In addition, IMAS indicated that some specific challenges for fisheries management arising from climate change will be encountered. It submitted:

> As with other impacts of climate change, impacts of climate change on marine species will create 'winners' (i.e., a new commercial species in an area) and 'losers' (i.e., loss of an important species, or introduction of a new pest), re-shaping the pattern of human well-being between regions and different sectors and potentially leading to substantial conflict (i.e., Who accesses a new resource? Who pays to remove a new damaging pest?). Successful management changes will therefore involve trade-offs and complex decisions around who pays for adaptation and how could/should resource allocation change—communication on climate change thus becomes very important.[33]

5.28 EDOA argued that the legislation administered by AFMA should be amended to include specific references to climate change. EDOA argued that the *Fisheries Management Act 1991* is generally focused on 'managing species rather than ecosystems'. In the face of climate change, EDOA argued that '[h]ealthy ecosystems, supporting sustainable fishing opportunities, must become the new focus'. To ensure this, the EDOA argued that AFMA should be given robust obligations to consider climate change' when performing functions under the Fisheries Management Act. According to EDOA, these obligations could include:

> …requirements to develop strategies and scenarios through modelling of future impacts and changes in location of fish habitats, and for accommodating adaptive management strategies into plans of management. Consideration should also be given to explicit powers to make emergency declarations or management decisions based on climate change impacts, for example to prevent fishing in a particular area if oceanic conditions change and it becomes a critical breeding area. AFMA requires the tools to allow it to react quickly and efficiently as climate change impacts are realised.[34]

5.29 Another challenge arises from the limited 'socio-economic data for the marine sector and associated communities'. IMAS considered that this lack of data would present difficulties for evaluating the 'effects of potential management changes and/or adaptation options'.[35]

---

32 The smart principles identified by the FRDC are sustainability, adaptability, flexibility and responsiveness 'all underpinned by science such as stock assessment and bio-economic knowledge commensurate to the size and value of the particular fishery. FRDC, *Submission 2*, p. 16.

33 IMAS, *Submission 1*, p. 41.

34 EDOA, *Submission 4*, p. 12.

35 IMAS, *Submission 1*, p. 5.

Quota setting and access rights

5.30 AFMA highlighted the measures it uses to manage fisheries, including harvest strategies, total allowable catches (TACs) and individual transferrable quotas (ITQs).[36] AFMA considers that the output controls it uses are 'robust and flexible and, along with other management strategies, are able to adapt to the variability inherent in fisheries including climate change'. AFMA added that it:

> …is aware that climate change will lead to greater variability in the distribution and abundance of fish and other marine species, both spatially and temporally, and that management strategies will need to adapt accordingly.[37]

5.31 AFMA is updating its fisheries management strategies with respect to climate change. As part of this process, existing fishery management strategies and their ability to cope with climate change under various scenarios will be tested.[38] AFMA also advised that it is working with CSIRO on a 'decadal projections project' which aims to determine 'which fish stocks in which areas may increase or decrease and whether there are any spatial range movements in those species as well'. This project, which is due to be completed early in 2018, is intended to inform consideration of fisheries management arrangements.[39]

5.32 CSIRO commented on output controls used to manage fisheries. CSIRO suggested that the targets and reference points set 'will need to be conservative to consider species resilience in the face of change'. In addition, current and projected climate change impacts should be incorporated in management strategy evaluation models to improve the reliability of future stock status projections.[40] A similar recommendation was made by IMAS.[41]

5.33 On the Great Barrier Reef specifically, the GBRMPA submitted that, to support commercial fishing, recreational fishing and the future biodiversity of the Reef, management arrangements need to 'protect the resilience of target and non-target fisheries species and their habitats'. The GBRMPA suggested that maintaining high stock levels would provide a useful buffer to protect fish populations from extreme weather impacts and 'cumulative pressures from human activities'.[42]

---

36 AFMA's existing management strategies are outlined at AFMA, *Submission 9*, pp. 3–4.

37 AFMA, *Submission 9*, p. 1.

38 AFMA, *Submission 9*, p. 5.

39 Dr Nick Rayns, Executive Manager, Fisheries, AFMA, *Committee Hansard*, 20 October 2017, p. 9.

40 CSIRO, *Submission 15*, p. 23.

41 IMAS recommended that climate change impacts on key assessment parameters should be incorporated into routine fishery stock assessments and the development of harvest strategies that account for a changing environment. IMAS, *Submission 1*, p. 32.

42 Great Barrier Reef Marine Park Authority (GBRMPA), *Submission 20*, p. 2.

5.34 CSIRO reasoned that any changes to the availability or sustainability of a stock due to climate change should 'impact on quota setting rather than on access rights'; as such, CSIRO concluded that the proportional distribution of access rights 'should be relatively unaffected by climate change'. Nevertheless, CSIRO observed:

> Inflexible access rights where any change requires involved and costly legal processes could hamper adaptive management. The access provisions and their implementation will need to take account of potentially rapidly changing conditions and therefore should not hamper the need for equally rapid management responses.[43]

5.35 IMAS, however, is of the view that '[g]reater innovation in the development of rights-based systems should be considered. IMAS noted that that the ITQ regime has generally 'resulted in a move away from owner-operators that personally harvest the resource, to investors who own the access rights and lease it to harvesters'. IMAS argued that investors 'often have limited connection to the operating area and tend to be less accepting of negative impacts that reduce quota'.[44] IMAS acknowledged that 'access rights are unlikely to be changed'; however, it suggested that governments 'should look at ways that they can be used for improved socio-economic benefits that can enhance benefits to society and be more flexible to adapt and respond to climate change'. IMAS referred to the Community Development Quota Program in Alaska as an example of a 'more innovative use of rights based systems'.[45]

5.36 Austral Fisheries reasoned that shifts in species ranges of toothfish stocks observed in the sub-Antarctic fisheries may, if they become more regular or occur with greater intensity, necessitate changes to 'our operations, and possibly management regimes, to take those shifts into account'. Austral explained:

> For example, like in situations where fisheries are temporarily closed due to hazardous algal blooms, it may be necessary to change seasonal access to sub Antarctic fisheries, at times of the year when toothfish availability may be more stable.[46]

5.37 The Productivity Commission (PC) recently considered quota arrangements and fishery access arrangements in its 2016 inquiry into marine fisheries and aquaculture. In its final report, released in May 2017, the PC recommended that the Australian, Victorian, Queensland and Tasmanian Governments should develop policies 'to guide the allocation of access to fisheries stocks between different sectors'. The PC recommended that, at a minimum, these policies should outline triggers for review of existing allocations between sectors; the review process; and the key

---

43 CSIRO, *Submission 15*, p. 23.

44 IMAS referred to analyses of ITQ systems in Australia and New Zealand that indicate access right holders generally resist lower TACs 'when cuts were required during periods of low recruitment consistent with climate change…' IMAS, *Submission 1*, p. 32 (citation omitted).

45 IMAS, *Submission 1*, p. 32.

46 Austral Fisheries, *Submission 6*, p. [6].

considerations that will guide decisions. The PC further recommended that the Commonwealth, state and Northern Territory governments should 'consider a move to trading of access rights between the commercial and recreation sectors in the longer term for suitable, higher value fisheries'.[47]

5.38 In its response to the PC's report, the Australian Government expressed support for these recommendations and noted that a Commonwealth resource sharing policy is under development.[48]

Fishery boundaries and jurisdictional arrangements

5.39 Responsibility for fisheries management in Australia depends on geographical boundaries. Under current arrangements, determined by the Offshore Constitutional Settlement (OCS) agreement between the Commonwealth, states and the Northern Territory:

- the states and the Northern Territory have jurisdiction over waters up to three nautical miles seaward of the low water mark; and
- the Commonwealth has jurisdiction over waters from three nautical miles to the edge of Australia's exclusive economic zone (200 nautical miles seaward of the low water mark.[49]

5.40 Under the OCS, the Commonwealth, states and the Northern Territory may agree to alter management responsibility arrangements for particular fisheries. That is, the parties could agree to pass management responsibility exclusively to the Commonwealth or to an adjacent state/Northern Territory. Fisheries can also be managed as part of a joint authority between the Commonwealth and the States/Northern Territory. At present, there are 59 OCS agreements that determine how cross-jurisdictional stocks are to be managed and four joint fisheries authorities.[50] Recreational fishing is regulated by the states/Northern Territory.[51]

---

47 Productivity Commission, *Marine fisheries and aquaculture*, no. 81, 19 December 2016, pp. 81, 83

48 Australian Government, *Response to the Productivity Commission report: Inquiry into regulation of the Australian marine fisheries and aquaculture sectors*, May 2017, pp. 3–4.

49 Productivity Commission, *Marine fisheries and aquaculture*, p. 47.

50 Productivity Commission, *Marine fisheries and aquaculture*, p. iv.

51 Productivity Commission, *Marine fisheries and aquaculture*, p. 188; Dr James Findlay, AFMA, *Committee Hansard*, 20 October 2017, p. 10; D Borthwick, *Review of Commonwealth fisheries: legislation, policy and management*, p. 16; cited in Senate Environment and Communications References Committee, *Factory freezer trawlers in the Commonwealth Small Pelagic Fishery*, November 2016, pp. 5–6.

5.41 The PC has published the following background information regarding the origin and purpose of OCS fisheries arrangements:

> In their early conception, OCS fisheries arrangements were to improve the management of cross-jurisdictional fisheries by having such fisheries operate under a single law, a single set of management rules and a single licensing regime. From the first OCS fisheries arrangement, however, the 'single jurisdiction' model has not always been followed. The first arrangement was for the Bass Strait Scallop Fishery in 1986, where jurisdiction was shared between the Commonwealth—which was given responsibility for the central portion of Bass Strait—and Tasmania and Victoria, which were given responsibility for areas within 20 nautical miles of their respective coasts. This arrangement remains in effect today.
>
> The 1991 OCS fisheries arrangements between the Australian and New South Wales Governments, and 2006 amendments to the *Fisheries Management Act 1991* (Cth) marked further moves away from the single jurisdiction model. New South Wales' 18 OCS fisheries arrangements all involve shared jurisdiction with the Commonwealth over a number of stocks. The 2006 amendments provided for a fishery to be managed according to the laws of different jurisdictions in different areas provided those areas do not overlap—that is, the amendments explicitly provided for the shared management of a single fishery.[52]

5.42 Due to the expected changes in the distribution of fish stocks, submitters considered that existing fishery boundaries and jurisdictional arrangements might need to be reviewed in future. IMAS submitted:

> Management within State jurisdiction boundaries is likely to become ineffective for species that straddle these borders and are likely to change their distribution under climate change impacts. Consideration of a whole of stock management approach as climate change alters the dynamics and distribution of fish stocks may be required. Increased cooperation between fisheries management agencies across State boundaries and across State–Commonwealth waters is essential.[53]

5.43 AFMA also noted that:

- current fishery boundaries 'may have to change or be removed as a result of climate change or else may impact fisher ability to capture fish when fish abundance shifts geographically'; and
- 'there may be a need to amend current [OCS] arrangements between Australian jurisdictions as species move and/or change in abundance'.[54]

52 Productivity Commission, *Marine fisheries and aquaculture*, p. 190.

53 IMAS, *Submission 1*, p. 30.

54 AFMA, *Submission 9*, pp. 4–5.

5.44 Dr James Findlay, Chief Executive Officer, AFMA, commented:

> The current fisheries are all defined by a combination of the species area and method. Over time, we have seen that those are becoming less efficient. If they were initially a good idea, they are becoming less of a good idea as we are seeing changes occur in the distribution of the abundance of fish. We have lines on water…that fish don't take too much notice of, and so we're seeing this blurring of fish between management jurisdictions and it's starting to undermine the initial intent of those agreements.[55]

5.45 Ms Jo-anne McCrea, Australian Fisheries and Seafood Manager, World Wildlife Fund, noted that the multi-jurisdictional arrangements are linked to issues with access rights. Ms McCrea stated:

> A traditional fisheries management arrangement would give a particular entity access rights usually to a species, or series of species, in a particular area. As species move and change, those access rights may become less relevant. If you have access rights to snapper on the east coast of Australia, which are in Queensland but are all now in New South Wales, those systems do not work for that. This also brings in the issue of the multiple jurisdictional nature of our Australian fisheries, particularly for those coastal fisheries…I can certainly see benefits from a climate change adaptation perspective around better cross-border arrangements with those.[56]

5.46 In response to these challenges, Ms McCrea considers that access rights should be in a form that 'is flexible enough to respond to changing species distributions and also respond to changing levels of productivity'.[57]

5.47 Ms McCrea called for an 'ecosystem-based approach to management'. Ms McCrea explained:

> Climate change, marine species and habitats…do not recognise jurisdictional limits and boundaries. Nothing short of a fully-integrated regulatory system is what is required now if we are to get this right.
>
> Sectorial legislation is currently oriented around activities, projects and non-ecosystem-based delineations. For example, fisheries management is centred on a species or on catch techniques rather than on ecosystems. This clearly limits the ability to respond to marine ecosystem changes. Currently across Australia, there are inconsistencies in approaches to marine fisheries and biodiversity which are resulting in inconsistent protection measures for individual species across jurisdictions. Only some states currently mention and recognise climate change in relevant marine legislation, and even in these jurisdictions there is no proper integration of

55 Dr James Findlay, AFMA, *Committee Hansard*, 20 October 2017, p. 12.

56 Ms Jo-anne McCrea, Australian Fisheries and Seafood Manager, World Wildlife Fund, *Committee Hansard*, 16 March 2017, p. 33.

57 Ms Jo-anne McCrea, World Wildlife Fund, *Committee Hansard*, 16 March 2017, p. 34.

> climate change and climate change adaptation into decision-making frameworks.[58]

5.48 AFMA advised that it is considering regional management strategies 'as an alternative to fixed fishery boundaries where multiple fisheries areas are combined and harvest is managed for the entire area'.[59]

5.49 The PC considered jurisdictional arrangements in its 2016 inquiry into marine fisheries and aquaculture. In its final report, released in May 2017, the PC stated that:

> The rigidly defined geographic boundaries specified in many OCS fisheries arrangements are not suited to providing dynamic regulatory responses to changing fish populations and distributions arising from climate change.[60]

5.50 The PC also noted that the management of fisheries according to jurisdictional borders can create other adverse consequences.[61] The PC stated:

> Multiple regulatory systems add to the cost of managing a cross-jurisdictional fishery. Further, where the rules of those systems are inconsistent or do not sufficiently take each other into account, there are higher risks of over- and under- fishing, unequal treatment of fishers, higher compliance costs and administrative inefficiency. Problems with a number of cross-jurisdictional fisheries have been recognised for many years, but reform in this area has generally been limited.[62]

5.51 The PC noted that effects related to climate change are likely to increase these adverse consequences.[63]

5.52 In response to the issues presented by the multi-jurisdictional approach to fisheries management, the PC did not recommend pursuing a single-jurisdictional model. In doing so, the PC noted that it considers changes to the OCS are unlikely as the current arrangements were set following agreement and legislation passed by all affected jurisdictions. The PC added that, in its view, 'it is unlikely that the OCS will change unless all jurisdictions agree that there are sufficient problems (or foregone opportunities) to warrant such a reform'.[64] Moreover, the PC identified other issues with a single jurisdiction model. The PC explained its reasoning as follows:

---

58 Ms Susan Higginson, EDO NSW, *Committee Hansard*, 16 March 2017, pp. 8–9.

59 AFMA, *Submission 9*, p. 5.

60 Productivity Commission, *Marine fisheries and aquaculture*, p. 197.

61 These included 'additional administrative and compliance costs, unequal treatment of fishers, constraints on productivity growth, high levels of waste through discarding of fish, and sub-optimal management of both target stocks and bycatch'. Productivity Commission, *Marine fisheries and aquaculture*, p. 187.

62 Productivity Commission, *Marine fisheries and aquaculture*, pp. 187–88.

63 Productivity Commission, *Marine fisheries and aquaculture*, p. 187.

64 Productivity Commission, *Marine fisheries and aquaculture*, p. 188.

> In principle, the single jurisdiction model, which would bring all fisheries under a consistent management approach, has the most merit. In practice, the costs of shifting all fisheries to management under a single jurisdiction (which, for practical reasons, would have to be the Commonwealth) are likely to be prohibitive and create new efficiency costs associated with federal management of inshore fisheries…The case for reform is also somewhat diminished by the relatively small number of stocks affected by shared management and the existence of well-working intergovernmental arrangements for a number of those stocks. In short, the model would have merit if governments were starting from scratch, but they are not, and it is very uncertain that the benefits from reform would outweigh the costs.[65]

5.53 Instead, the PC concluded that:

> The costs and risks of shared fishery management will be reduced if all governments adopt known best practice approaches to core tasks (such as stock assessments and harvest controls), routinely seek to implement reciprocal or consistent arrangements in relation to catch controls and data collection, and regularly review the terms of intergovernmental agreements underpinning shared management.[66]

5.54 AFMA and the Department of Agriculture and Water Resources (DAWR) agreed that it would be desirable to streamline the OCS arrangements. Dr James Findlay, CEO, AFMA, advised that work is underway to change memorandum of understanding and underlying OCS agreements regarding the management arrangements between AFMA and the states/Northern Territory. Dr Findlay stated:

> The minister signed off on changes in Western Australia last year, with regard to the jurisdictional boundaries between fisheries, and we're working actively at the moment with South Australia, Victoria and New South Wales on making further changes to those agreements.[67]

65 Productivity Commission, *Marine fisheries and aquaculture*, p. 204.

66 Productivity Commission, *Marine fisheries and aquaculture*, p. 25.

67 Dr James Findlay, AFMA, *Committee Hansard*, 20 October 2017, p. 12.

Recreational fishing

5.55 Options proposed in response to the likely impact of climate change on recreational fishing included:

- ocean forecasting tools 'to monitor and help recreational fisheries adapt to a changing ocean';[68]
- licensing for recreational fishing, with the revenue collected to be used for improving resilience (habitat and fisheries productivity) and to 'enhance recreational amenity';[69] and
- acquiring 'regular, comprehensive data collection across Australia' about recreational fishing to inform fishery stock assessments and ecosystem risk assessments, and to ensure protected species interactions are monitored.[70]

5.56 On the need to enhance data collection arrangements for recreational fishing, AFMA submitted:

> Given recreational fishers now take more catch than commercial fishers for some key fish stocks and a major proportion of many others, a greater investment in this area would be beneficial. This equally applies to protected species interactions with recreational fishing for which there is little monitoring or data at all.[71]

5.57 Dr James Findlay, AFMA's Chief Executive Officer, explained AFMA's position on recreational fishing further at a public hearing. Dr Findlay stated:

> Recreational use of our resources is a major and growing component. It's important socially and economically, and it's also important biologically. Any natural resource manager seeking to manage fisheries in Australia needs to take account of the impact of recreational fishing but also its economic and social importance in terms of ensuring its performance is maintained and improved in the future. We are strong believers that you can't manage what you don't measure. At the moment we're concerned there are significant gaps in the data collection around recreational fishing, and the anecdotal report suggests that that catch is increasing. But we're also seeing recreational fishers playing a significant role in policy-making and playing a more significant role in management, and we think that's critical,

---

68 The Sydney Institute of Marine Science (SIMS) referred to 'forecasting tools are being used to predict the seasonal migration of dolphinfish to inform anglers of fish distribution and to improve the deployment of Fish Aggregation Devices'. SIMS, *Submission 8*, p. 4 (citation omitted).

69 FRDC, *Submission 2*, p. 13.

70 AFMA, *Submission 9*, p. 4. See also AFMA, *Submission 50 to Productivity Commission inquiry into marine fisheries and aquaculture*, April 2016, www.pc.gov.au/__data/assets/pdf_file/0003/198462/sub050-fisheries-aquaculture.pdf (accessed 21 August 2017), pp. 4–5.

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

> but, again, we need to understand what their impact is and what they want to achieve.[72]

5.58 The FRDC noted that in regions which are more populous 'recreational fishing effort is substantial'. The FRDC submitted that 'it is timely to start tracking recreational effort and catch as a major input to fisheries management arrangements'.[73]

5.59 Several other submitters expressed support for improved monitoring of recreational fishing. Mrs Patricia Beatty, Executive Officer, New South Wales Professional Fishermen's Association, argued that commercial fishing is 'absolutely monitored' with licence requirements necessitating catch records. Whereas it is considered that 'a magnifying glass' is on commercial fishing under the current management arrangements, Mrs Beatty argued that 'very little' is understood about recreational and Indigenous fishing efforts.[74]

5.60 Professor Iain Suthers from the Sydney Institute of Marine Science (SIMS) agreed with AFMA's concerns about the need to enhance data collection arrangements for recreational fishing. Professor Suthers provided the following comments to explain his concerns:

> It is true that for a number of species such as the famous red snapper *Pagrus auratus* the recreational catch is likely to be bigger, and in some areas twice as big, as the commercial catch. If you are trying to manage a system and understand the effects of climate, you need to understand recreational catch. We only have these sorts of output controls—by that I mean a bag limit, a size limit, a season or even a spatial closure—but we do not have any input controls and we cannot regulate it if you want to go fishing with your kid.[75]

5.61 Dr Alistair Hobday from CSIRO argued that recreational fishers 'offer a great opportunity for collecting additional information' given the number of recreational fishing vessels widely dispersed around the coast. Dr Hobday stated:

> If recreational fishers used logbooks, as commercial fishermen do, we would have much more information on catch and effort. It is the effort part of fishing that is the most important part in understanding whether abundance is increasing or decreasing. So there could be more voluntary programs that encourage fishers to record their catches and provide them. We do that in dedicated research projects, but there is no comprehensive program that I am aware of.[76]

---

72 Dr James Findlay, AFMA, *Committee Hansard*, 20 October 2017, p. 10.

73 FRDC, *Submission 2*, p. 13.

74 Mrs Patricia Beatty, Executive Officer, New South Wales Professional Fishermen's Association, *Committee Hansard*, 16 March 2017, p. 18.

75 Professor Iain Suthers, SIMS, *Committee Hansard*, 16 March 2017, p. 25.

76 Dr Alistair Hobday, Senior Principal Research Scientist, CSIRO, *Committee Hansard*, 17 March 2017, pp. 10–11.

5.62 In demonstrating how non-scientists, including recreational fishers, can contribute to improved understanding of the marine environment, the success of the Redmap (Range Extension Database and Mapping project) program developed by IMAS was noted. The Redmap website enables fishers and divers to submit photographic records of 'species they observe outside their expected distributions'; that is, 'species that may be shifting where they live as a function of warming waters'.[77]

5.63 CSIRO added that 'many jurisdictions in Australia, including the Commonwealth, do take into account recreational catches as far as they can when they are doing assessments on the status of fish stocks'.[78] Dr Alan Jordan, Principal Research Scientist, NSW DPI, also noted that the New South Wales Government has 'a very active program in monitoring assessment of recreational catch and effort and distribution'. Dr Jordan explained:

> I think it was only early last year that we published a very comprehensive report—which is a publicly available document—that was part of a standardised national survey approach to quantifying the catch of recreational fishers. That was based on a nationally agreed methodology where we would ring a randomised number of people and interview them about their catch, and then we would have a subset of them that would actually keep a diary and they would log every time they went out there and fished: what species they caught, where they went, what their effort was et cetera. So there is a very detailed report. I think the science that underpins that understanding now is orders of magnitude better than it was even five years ago. We are now starting to explore opportunities to use newer technologies to do that in terms of using both helicopter surveys and drones for monitoring the distribution of fishers up and down the coast.[79]

5.64 Nevertheless, there is a view that the greater use of technology could support improvements in how recreational fishing activity is accounted for in fisheries management. Professor Suthers explained:

> We can now monitor boat movements. With increasing technology, efficiency of motors, GPS technology and weather forecasts, these recreational boats are moving far beyond the traditional three-nautical-mile limit and going well out towards the continental shelf sometimes. It is staggering. There are fairly simple commercial radar systems—they are worth about 40 grand, which is a lot, with the software and so on—that monitor boat activity. If you have boat activity, then you have effort, and from effort you can apply certain parameters based upon the boat-ramp surveys to say how many fish have been caught in two hours of fishing.[80]

---

77 IMAS, *Submission 1*, p. 9.

78 Dr David Smith, Acting Science and Deputy Director, Oceans and Atmosphere, CSIRO, *Committee Hansard*, 17 March 2017, pp. 10–11.

79 Dr Alan Jordan, NSW DPI, *Committee Hansard*, 16 March 2017, p. 49.

80 Professor Iain Suthers, SIMS, *Committee Hansard*, 16 March 2017, p. 25.

5.65 Licensing arrangements were suggested as a means by which information about recreational fishing could be obtained. As part of its inquiry into marine fisheries and aquaculture, the PC compared the licensing regimes in place across Australia. In New South Wales, the PC noted that a licence is required for all recreational fishing activities and in 2014–15 nearly 500,000 licences were in force. However, the New South Wales licensing system includes several categories of exemptions.[81] Similar exemptions apply in the Victorian licensing scheme. The Western Australian and Tasmanian licensing systems are limited in scope; instead of applying to all recreational fishing they are 'oriented to valuable species and to certain methods of fishing'. In South Australia, the only regulatory requirement applies to rock lobster pots (which must be used to catch southern rock lobster for personal use) and in Queensland and the Northern Territory, no licence is required for marine fishing (although in the Northern Territory a temporary licence is required for fishing on and over Indigenous land and adjoining waters).[82]

5.66 The PC further noted that, with the exceptions of Victoria and Tasmania, jurisdictions have licensing arrangements for charter boat operators.[83] Although the keeping of logbooks that capture information about fishing catch and effort is required as part of licensing regimes,[84] stakeholders consider there are limitations with this reporting framework. Mrs Patricia Beatty, Executive Officer, New South Wales Professional Fishermen's Association noted that, in addition to the various licensing exemptions in New South Wales, voluntary logbooks mean that complete coverage of fishers is not achieved. Mrs Beatty observed:

> There is no doubt that there is a large range of recreational fishers. It might be us, who go out once a year or a couple of times of year, but there are also those who go out every weekend with mates and hit it hard. There is such a range of users in the recreational fishing sector that we have not been able to track their impact on the resource. We do know for a fact that there are a number of species across the Australian east coast where the recreational take is higher than the commercial take, yet, from the creel surveys that were undertaken, there is no additional monitoring on those species.[85]

---

81 Categories exempted from the licence requirement include: people under 18 or over 60 years of age; an adult assisting a person under the age of 18 years; an Aboriginal Australian; and the holders of pension or veterans affairs concession cards. See Productivity Commission, *Marine fisheries and aquaculture*, p. 126; Mrs Patricia Beatty, New South Wales Professional Fishermen's Association, *Committee Hansard*, 16 March 2017, p. 18.

82 Productivity Commission, *Marine fisheries and aquaculture*, p. 126.

83 Productivity Commission, *Marine fisheries and aquaculture*, p. 126.

84 Productivity Commission, *Marine fisheries and aquaculture*, p. 126.

85 Mrs Patricia Beatty, New South Wales Professional Fishermen's Association, *Committee Hansard*, 16 March 2017, p. 18.

5.67 The PC considered the regulatory treatment of recreational fishing in its report on marine fisheries and aquaculture. The PC concluded that:

> The management of recreational fishing should be based more on evidence about the extent, nature, impact and value of recreational fishing activities. This would contribute to improved management of catch-constrained stocks and resource allocation decisions, and more generally support sound decision making on the management of fishing activity, and on additional services and facilities for fishers.[86]

5.68 The PC recommended that 'well-designed licensing systems provide the means for collecting this information without imposing undue regulatory burden on fishers or government'. The PC continued:

> Licensing systems already exist in some States. They deliver current, although partial, information on participation. In comparison to States without licensing, which rely on periodic surveys for participation data, licensing systems provide governments ready and reliable sampling frames for the collection of other information that may be needed to inform management, such on fishing methods, catch, locations and the value derived from fishing.[87]

5.69 Consequently, the PC recommended that licence frameworks should be introduced in jurisdictions without licensing for independent recreational marine fishing (Queensland, South Australia and Northern Territory). The PC further recommended that existing regimes be expanded; that is, the exemptions used in New South Wales and Victoria should be reduced, and the scope of licencing regimes in Western Australia and Tasmania broadened to include all recreational fishing activity. Furthermore, the PC recommended that the Victorian and Tasmanian Governments introduce licensing for marine charter boat operators. In addition, the PC recommended that the Australian Government 'should consider licensing if it takes on greater responsibility for the management of recreational catch'.[88]

5.70 Finally, OceanWatch Australia, which is recognised by the Australian Government as the natural resource management (NRM) organisation for Australia's marine environment, argued that greater funding for marine NRM activities would, in addition to commercial fishing outreach, enhance its ability to reach recreational and Indigenous fishers. Ms Lowri Pryce, Executive Officer, OceanWatch Australia

86 Productivity Commission, *Marine fisheries and aquaculture*, p. 129.

87 Productivity Commission, *Marine fisheries and aquaculture*, p. 129.

88 Productivity Commission, *Marine fisheries and aquaculture*, p. 131–32.

commented that greater investment in marine NRM operations would 'given our track record, would be a low-risk and high-return investment'.[89]

More timely management responses

5.71 Stakeholders commented on the timeliness of management responses. One issue is the need to collect information more frequently so that up-to-date information is used. Mrs Patricia Beatty from the New South Wales Professional Fishermen's Association commented on this with reference to how information from logbooks is used:

> Currently, log books are the major commercial monitoring tool. Log books are required to be provided to DPI Fisheries once every month, and then that is entered into the system. I think the last New South Wales status report was in 2014, so it is not compiled and looked at an analysed on the spot or within six months—that is my impression from the discussions we have had with DPI Fisheries. And the log book is the way the majority of our fisheries are monitored. We do have two fisheries in New South Wales—lobster and abalone—that are currently under quota, and therefore the data on their catch statistics is captured electronically, so it is a lot faster for them, but we do not have that across New South Wales fisheries for the majority of our fisheries. It is a very antiquated, paper-based system that is filled out by the fishers, sent in after a month or so and then sent in to be hand entered by DPI Fisheries. You can imagine that that does take time.

5.72 Mrs Beatty argued that research and monitoring needs to occur in real-time to support adaptive management responses. Mrs Beatty explained:

> When we talk about real time, we are looking at the moment at a very antiquated system where you are not seeing data and then data analysis; you are probably looking at a year before you are getting an absolute understanding of what is going on. Then we have the added issue that most catch log books are based on CPUE—catch per unit effort. CPUE is well known to be not the best indicator of how a stock abundance is going on. If you have an aggregating species per se—such as a lot of the offshore species, which might be considered aggregating species—CPUE is not a good indicator of the abundance of the aggregating species, because it is not until the species is pretty much gone that you start seeing a drop in the

89 Ms Lowri Pryce, OceanWatch Australia, *Committee Hansard*, 16 March 2017, p. 37. The following examples of activities intended to result in voluntary change of attitudes, behaviours and practices were provided: '…helping recreational fishers understand the link between marine debris and their abandoned waste fishing tackle, bait or line; helping farmers understand the link between river estuarine health and fencing cattle from riparian zones; helping port authorities understand the connection between vessel anchorages and avoiding marine habitat degradation; helping fishers on the back of vessels understand the connection between good product quality and better animal welfare; and helping ordinary people understand that their actions at school, at work and at home have an impact downstream'.

> levels. So there is a number of species that CPUE should not be used for, but that is what your systems are based on.[90]

5.73 It was suggested that management responses needed to more rapidly respond to the information collected. CSIRO's submission commented on how it can be up to two years before data collection informs management action. Dr Hobday from CSIRO noted that this timeframe is often the case for stock assessments 'where information has to be gathered, cleaned and processed, and there is a model to produce some answers, and then the management group decides on what it is going to implement'. Dr Hobday observed, however, that other management processes 'can be much more rapid'. Dr Hobday explained:

> One example is with in-season closures. That would be when the quota is reached earlier in the season. A fishery can be closed at that particular time. Other examples are with dynamic spatial management. We provide information to [AFMA] on the likely distribution of tuna on the east coast of Australia. They were updating that six hours after we provided them with information, and then fishers would have two days to respond to those new zoning arrangements on the east coast of Australia.[91]

5.74 Dr Hobday concluded that, in some instances, reducing the duration of the management process would be 'very difficult'. To address this issue, Dr Hobday suggested that a precautionary approach can be taken to assessments to account for how 'a two-year time gap might mean that things have changed over that period of time'.[92]

Marine biodiversity protections

5.75 Submitters commented on the effectiveness of efforts to protect biodiversity through the use of marine protected areas, as well as the arrangements for threatened, endangered and protected species.

Marine protected areas

5.76 Marine protected areas (MPAs), which include marine parks/reserves, are intended to help protect and maintain biodiversity. Australia has the largest network of marine reserves in the world.[93] This network was established in 2012 by the Gillard Labor Government, however, the reserves were put on hold by the Abbott–Turnbull Government.

---

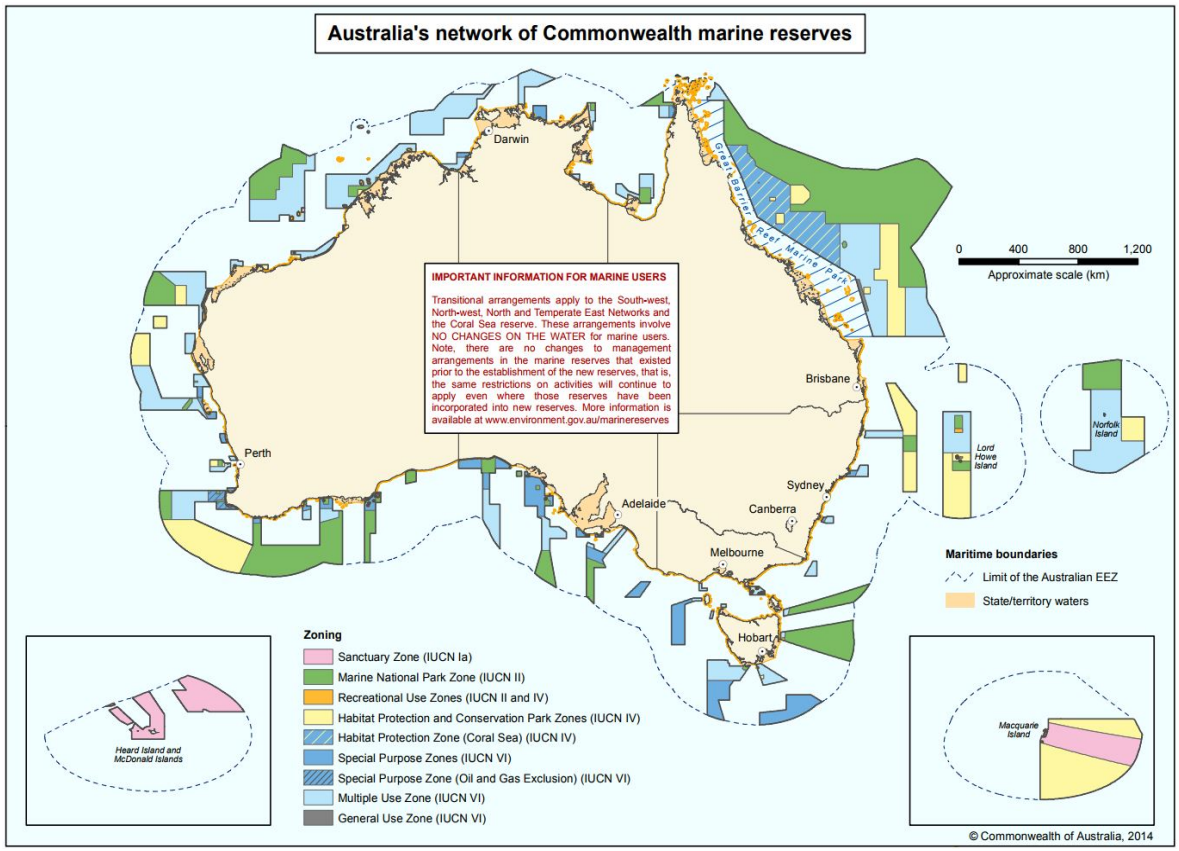
90 Mrs Patricia Beatty, New South Wales Professional Fishermen's Association, *Committee Hansard*, 16 March 2017, p. 15.

91 Dr Alistair Hobday, CSIRO, *Committee Hansard*, 17 March 2017, p. 6.

92 Dr Alistair Hobday, CSIRO, *Committee Hansard*, 17 March 2017, p. 6.

93 DoEE, 'Commonwealth marine reserves – Overview', www.environment.gov.au/topics/marine/marine-reserves/overview (accessed 15 December 2016).

Figure 5.1: Australia's network of marine parks



Source: DoEE, 'Australian marine parks', www.environment.gov.au/topics/marine/marine-reserves (accessed 27 October 2017).

5.77 The current Government's draft management plans propose deep cuts to the protective zoning declared by the Governor-General in 2012 in marine parks around Australia's coastline, including iconic areas such as the Coral Sea, the Great Australian Bight, Geographe Bay, the Kimberley and the Gulf of Carpentaria.

5.78 Downgrades to protective zoning are also proposed to a number of longstanding marine parks declared over the last 30 years, including at Middleton Reef in the Lord Howe Island Marine Park and Mermaid Reef at the Rowley Shoals.

5.79 The draft plans propose to revoke 40 million hectares of high-level green zone/marine national park (sanctuary zones which keep marine ecosystems functioning in their natural state without the pressure of mining or fishing). This is an area twice the size of the state of Victoria and representing almost half of the marine national parks in the network of 44 marine parks. What is proposed by the Turnbull Government is equivalent to revoking half of Australia's national parks on land, and is unprecedented globally.

5.80 Australia used to have a bipartisan legacy of marine protection, stretching back over 40 years to the Whitlam and Fraser Governments. In 1998, having secured an agreement from the Australian and New Zealand Environment Conservation Council (ANZECC) to declare the world's first network of science-based marine

parks, in 2004 the Howard Government set what has been described as the 'gold standard' for marine park management by declaring green zones in 34 per cent of the Great Barrier Reef Marine Park.[94] Between them, the Howard and Gillard Governments declared 60 federal marine parks and completed the network.

5.81 The current government's proposed cuts are not science-based—CSIRO recommends that each marine park should have at least one green zone/marine national park. Yet 16 of the marine parks would have no high-level protection under the Government's 2017 proposals.

5.82 The Government's own Expert Science Panel recommended that all primary conservation features have at least some representation within green zones/marine national parks. Yet the draft plans leave 259 of Australia's primary conservation features and 20 entire biological regions unrepresented in high protection.

5.83 Reefs protected in green zones/marine national parks have significantly higher numbers of fish, and are recovering much faster from cyclone and coral bleaching damage than adjacent unprotected reefs. One study in the Great Barrier Reef found that: 'The difference in the amount of Coral Trout between the protected areas and what's next door is 80%, an 80% difference in the biomass between the protected areas and what's immediately adjacent to it'.[95]

5.84 Between July and 20 September 2017, the Director of National Parks consulted on draft management plans for the marine parks. The final plans will require approval by the Minister for the Environment and Energy and will be in place for ten years from the date specified by the Minister after they have been tabled in both Houses of Parliament.[96] At the time of writing, the final management plans had not been made.

5.85 Various submitters highlighted the benefits of MPAs for building resilient marine ecosystems in the face of climate change. For example, IMAS noted that effective MPAs 'comprise one key tool for reducing future climate-related changes in biodiversity'.[97] The FRDC submitted that no-take marine reserves provide 'important

94 See UNESCO, Mission Report: Reactive Monitoring Mission to Great Barrier Reef (Australia) 6th to 14th March 2012, June 2012, http://whc.unesco.org/mwg-internal/de5fs23hu73ds/progress?id=iFhLHlkxWS8QC2gdXKuruIxjSIrnkCiyPfHugH0FAPw,&dl (accessed 30 November 2017, p. 34.

95 AIMS, 'Twice the coral trout in Great Barrier Reef protected zones', www.aims.gov.au/docs/media/latest-releases/-/asset_publisher/8Kfw/content/27-march-twice-the-coral-trout-in-great-barrier-reef-protected-zones (accessed 29 November 2017)

96 DoEE, 'Australian marine parks', www.environment.gov.au/topics/marine/marine-reserves (accessed 27 October 2017).

97 IMAS, *Submission 1*, p. 34. A list of reasons is provided at pages 34 to 35 of the submission.

benchmarks or reference points to understand and track change and to gauge the effectiveness of our marine management'.[98]

5.86 Professor Iain Suthers, SIMS, stated:

> In New South Wales there is a complication for MPAs because of urbanisation and run-off from the land, which has a synergistic effect. Nevertheless, where you have these MPAs you do find increased biodiversity. Even the harshest critics of MPAs—of which there are a lot in this state—agree that biodiversity is definitely protected within these MPAs. Partly that is because you have space that is taken up by the native species. If you have, say, harvesting of timber, you allow in weeds that can move into that space. So I think my colleagues are absolutely correct, and there is evidence that these marine protected areas do support greater biodiversity, including a persistence of kelp. Also, the abundance of fish that derive benefit from the habitat is quite remarkable, and that then has tourism benefits as well.[99]

5.87 However, IMAS is of the view that the current MPAs are inadequate for safeguarding marine biodiversity and the current MPA network 'is poorly-designed for resisting impacts of climate change'. It argued that there are 'numerous large gaps' in the current MPA network and that most no-take zones are of a small size.[100] IMAS outlined features it considers should be included in an MPA network to best maintain biodiversity in a changing climate.[101]

5.88 Professor David Booth argued that building resilience in marine ecosystems is a necessary response to climate change. Professor Booth stated that increased resilience can occur if other stressors, such as pollution and fishing, are controlled. Professor Booth argued that marine park networks can assist in this regard; however, he is concerned by the current approach to these parks. Professor Booth explained:

> One solution that will help in part will be marine park networks where fish can thrive, at least in sanctuary zones, and where we can see the full size spectrum of fish species, which an ecosystem needs to function properly. At the moment I am concerned the Commonwealth marine reserve network is floundering—pardon the fishy pun. It has been eroded and it has also

98 FRDC, *Submission 2*, p. 17.

99 Professor Iain Suthers, SIMS, *Committee Hansard*, 16 March 2017, p. 22.

100 IMAS, *Submission 1*, pp. 34–35.

101 IMAS cited a paper that argued features needed for MPAs include: '(i) no-take zones with large north-south dimensions, allowing species to shift internally with warming climate, (ii) such zones to be distributed without major (>200 km) gaps as a north-south network, facilitating poleward range shifts, (iii) all major marine habitat types and biodiversity features to be protected from exploitation within at least one MPA, (iv) the MPA network to include considerations of connectivity with deeper water and adjacent habitats'. The paper cited is AD Olds, KA Pitt, PS Maxwell, RC Babcock, D Rissik, RM Connolly, 'Marine reserves help coastal ecosystems cope with extreme weather', *Global Change Biology*, vol. 20, 2014, pp. 3050–58. IMAS, *Submission 1*, pp. 34–35.

> been delayed. So I would like to see the management plan for that brought to fruition. [102]

5.89 EDOA argued that the 'establishment of a comprehensive, adequate and representative system of no-take marine protected areas…is vital'. EDOA stated:

> In a climate change context, appropriately placed MPAs should be provide climate refugia, maximise functional connectivity between protected areas to enhance the potential for range shifts, protect areas in which key ecological processes occur e.g. feeding aggregations and breeding or spawning grounds, and be situated to allow for a range of species dispersal distances, which for some species, are predicted to change with increasing sea temperatures.[103]

5.90 Witnesses from SIMS acknowledged that the split in jurisdictional responsibilities between Commonwealth and state waters has complicated marine management for decades. Nevertheless, it was suggested that 'connectivity' between Commonwealth and state reserves could be improved. Dr Adriana Verges explained:

> In terms of the Commonwealth marine reserves, one of the problems that we have identified with them is that there is no connectivity between them and the state reserves. I think that is important. This could be easily fixed, because connectivity is probably one of the things that can be helpful in terms of protecting ecosystems from climate change. By protecting an entire corridor that is connected between the coast and inshore, you would be helping with that.[104]

5.91 AFMA, however, argued that from a fisheries management perspective, no-take MPAs 'are relatively clumsy' compared to other regulatory tools AFMA can use. In particular, AFMA highlighted the various management approaches available to it which can be adjusted rapidly if needed.[105] AFMA explained that a key distinction between its management tools and no-take MPAs is that MPAs 'are developed over a long period of time using particular criteria and when the underlying environment changes they tend not to be moved in response'.[106] Overall, Dr Findlay summed up AFMA's views on MPAs as follows:

> [O]ur position is not no MPAs. At the end of the day, the public has the right to decide on its use of the marine environment. If MPAs are going to be used to manage some particular elements of biodiversity, which they're good at, then we support that. Our concern is that if there's a view that they

---

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

103 EDOA, *Submission 4*, p. 5 (footnotes omitted).

104 Professor Iain Suthers; Dr Adriana Verges, SIMS, *Committee Hansard*, 16 March 2017, p. 27.

105 These include regulating the type of gear fishermen use, the types of species they are allowed to catch, and spatial and temporal management techniques.

106 Dr James Findlay; Dr Nick Rayns, AFMA, *Committee Hansard*, 20 October 2017, p. 13.

> could be well used to manage fisheries resources or manage the impacts from fishing then we think we have better tools available to us to do that.[107]

Threatened, endangered and protected species

5.92 One of the challenges IMAS identified regarding the effects of climate change on commercial fishing relates to changes in the behaviour of conservation species. For example, changes in the spatial or temporal overlap between conservation and commercial species could occur or conservation species could move out of protected areas. As a result, conservation species could become more vulnerable to 'overexploitation or accidental by-catch'.[108]

5.93 The Department of the Environment and Energy (DoEE) noted that many conservation advices and recovery plans for listed threatened marine species and ecological communities 'recognise changes in ocean temperature, salinity, water clarity, ocean acidification, sea level and/or the frequency or severity of cyclones and storms as potential threats'. The DoEE added:

> Managing the impacts of climate change on listed species and ecological communities remains a significant challenge, as there is limited information on the full extent of the impacts and limited options to directly alter marine ecosystems. Recovery efforts therefore focus on increasing the resilience of species and ecological communities by reducing the human impact on the marine environments, such as by minimising disturbance to coastal and beach environments and managing any significant impacts of commercial and recreational fishing.[109]

5.94 Ms Susan Higginson, Chief Executive Officer, EDO NSW, argued that the threatened ecological communities and critical habitat lists 'are in desperate need of attention' to ensure adequate protection under the EPBC Act is provided. Ms Higginson argued:

> An assessment of ecological communities and species at risk from climate change is urgently required. We have not done that work and there is no proposal yet to do that work. This could be included, for example, in a comprehensive national ecosystems assessment for Australia. Greater flexibility and the development of recovery and threat-abatement plans could enhance their use for marine regions and ecosystems in the key principles of marine biodiversity adaptation—being the need to reduce human threats and stresses to build resilience and well-functioning ecosystems—to focus on ecosystem or landscape-scale management. Marine bioregional planning could also be an effective tool in the management of the marine environment on an ecosystem basis, but the

107 Dr James Findlay, AFMA, *Committee Hansard*, 20 October 2017, p. 13.

108 IMAS, *Submission 1*, p. 25.

109 DoEE, *Submission 19*, p. 5.

> EPBC Act provisions need to be expanded to include climate change impacts as a mandatory consideration in the planning process.[110]

Biosecurity measures and monitoring systems

5.95 In its submission, the DAWR recognised that increased water temperatures will cause biosecurity challenges. Under the current biosecurity arrangements, the Commonwealth coordinates 'the response and preparedness and promotes consistency in national policies, underpinned by the *Biosecurity Act 2015*'. The states and the Northern Territory jurisdictions are responsible for the detection, response and management of current, new and emerging diseases and pest issues.[111]

5.96 The Queensland Government submitted that 'part of the prevention and preparedness strategy is to predict the pest species most likely to arrive and establish in the changed environmental conditions'.[112]

5.97 On the transportation of marine pests to new environments from ballast water, which is regulated by the Australian Government, the DAWR highlighted the International Convention for Control and Management of Ship's Ballast Water and Sediment (Ballast Water Convention), which commenced on 8 September 2017. The Ballast Water Convention establishes standards and procedures for the management and control of ships' ballast water and sediments.[113] Amendments made to the Biosecurity Act were made in 2017 to ensure Australia is compliant with the Ballast Water Convention.[114]

5.98 The DAWR has been developing a regulatory approach to manage the risks of marine pests being introduced through biofouling. The DAWR submitted that the regulatory system would be based on guidelines developed by the International Maritime Organization and 'will require active and regular management of biofouling on vessels to reduce the risk of translocation of exotic species'.[115] The 2017 amendments to the Biosecurity Act enable the DAWR to 'look at hull fouling as a biosecurity risk'.[116]

5.99 Mr Ian Thompson, a first assistant secretary at the DAWR, explained that the DAWR is implementing a national biosecurity surveillance program to enable better identification of biosecurity threats before they arrive. Mr Thompson added that, in

---

110 Ms Susan Higginson, EDO NSW, *Committee Hansard*, 16 March 2017, p. 9.

111 Department of Agriculture and Water Resources (DAWR), *Submission 18*, p. 6.

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

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

114 *Biosecurity Amendment (Ballast Water and Other Measures) Act 2017*.

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

116 Mr Ian Thompson, First Assistant Secretary, Sustainable Agriculture, Fisheries and Forestry Division, DAWR, *Committee Hansard*, 20 October 2017, p. 13.

response to threats that have arrived, the DAWR is working on developing a mechanism 'for responding to marine emergencies with industries and for acting quickly when they happen'. This mechanism, which is intended to 'provide the same sort of partnership response in the marine environment that we have for incursions on land at the present time', is expected to be finalised in 2018.[117]

5.100 However, the committee received evidence expressing concern about the attention given to biosecurity matters at present. IMAS argued that there are 'limited' research and development capabilities and investment in fish health in Australia, which it considers is surprising given the value of marine industries, the size of Australia's ocean territory, and the concentration of Australia's population in coastal areas. IMAS argued that these limited capabilities and investment are 'inadequate to support ever increasing aquaculture growth, which at the same time faces largely unpredictable threats from climate change'.[118] IMAS suggested that long-term funding is required for 'comprehensive, coordinated biodiversity monitoring systems' to assist in improved understanding of the implications of climate change for natural systems.[119]

5.101 It was also argued that biosecurity efforts focus on individual industries and suffer from a lack on overall coordination. Mr Martin Exel from Austral Fisheries observed:

> As to biosecurity, you have got a huge problem with white spot virus at the moment in prawns in Queensland; you have got the problems with the algal blooms…you have got the issues with moving of lobster or abalone or toothfish or whatever. But it is not coming into a cohesive place; each area has their own expertise and they are all dealing with it separately.[120]

5.102 Mr Exel agreed that a government taskforce on improving coordination in biosecurity matters 'would be a damned good start'.[121]

117 Mr Ian Thompson, DAWR, *Committee Hansard*, 20 October 2017, p. 13.

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

119 IMAS, *Submission 1*, p. 40.

120 Mr Martin Exel, General Manager Environment and Policy, Austral Fisheries, *Committee Hansard*, 21 February 2017, p. 24.

121 Mr Martin Exel, Austral Fisheries, *Committee Hansard*, 21 February 2017, p. 24.

Chapter 6

Adapting to climate change: Measures to support fisheries, marine ecosystems and biodiversity

6.1 This chapter continues the report's consideration of responses to climate change by examining measures that can be taken by industry, government and scientific organisations. First, this chapter examines measures that can be considered within the fishing and aquaculture industries to ensure the sustainability of these industries in the face of climate change. Secondly, the chapter discusses the evidence received about rehabilitation work in the Great Barrier Reef. Finally, this chapter considers the evidence received relating to research into the effects of climate change on the marine environment.

Changes to fishing and aquaculture activities

6.2 In considering how climate change will affect fisheries and what can be done about it, the general view among witnesses is that the industry will need to adapt to any changes in conditions. In doing so, it is also apparent that there will be 'winners and losers'.[1] This section focuses on the more direct implications of climate change for marine fisheries, although it was noted that climate change could have wide-ranging implications for fishing and aquaculture industries, such as disruption to supply chains. Dr Alistair Hobday, CSIRO, provided the following evidence on this:

> Many fishing and aquaculture businesses also deliver product to market, and there may be impacts along the supply chain as a result of climate change. An example of one of those is if an extreme event disrupts a supply chain route like a road, a bridge or an airport and it is difficult to get those products through. So climate change will also increasingly have impacts on infrastructure that affects fisheries.[2]

6.3 Two of the key ways in which industry may adapt is by targeting different species—for wild fisheries, this would mean adjusting to any changes in distribution of species; for aquaculture species that are currently farmed in certain locations may need to be replaced by other species. Alternatively, breeding programs and other research may be possible to develop stock that is resilient in the face of changing conditions. In summary, it was suggested that '[w]e need to think outside the box a bit more'.[3] This section discusses this evidence.

---

1 Professor Gustaaf Hallegraeff, Institute for Marine and Antarctic Studies (IMAS), *Committee Hansard*, 21 February 2017, p. 11.

2 Dr Alistair Hobday, Senior Principal Research Scientist, CSIRO, *Committee Hansard*, 17 March 2017, p. 2.

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

Relocating and changing target species

6.4 Witnesses suggested that industry could adjust by changing the species it targets. As noted in Chapter 4, warming waters in Tasmania may result in decreased productivity of the salmon aquaculture industry as salmon reach their upper thermal limit.[4] On this issue, Professor Gustaaf Hallegraeff referred to a report that examined the implications of climate change for salmon aquaculture, which suggested 'shifting to different species and looking at areas which had less fluctuation in water temperatures and remained cooler'.[5]

6.5 The committee was also informed of research that may change where salmon is farmed. Professor Stewart Frusher told the committee that as the coastal zone is expected to have 'a lot of issues with an increasing population', offshore and onshore locations for salmon aquaculture are being considered. Professor Frusher referred the committee to research being undertaken at the Institute for Marine and Antarctic Studies (IMAS) that is examining recirculated systems. The professor stated that the experimental aquaculture facility at IMAS:

> …is the first of its type to have cages large enough to hold large fish and to have sufficient cages to be able to do the replication in that work. Part of the research that has been undertaken there is to look at recirculation systems.[6]

6.6 Professor Hallegraeff also commented that, if in the future salmon 'is beyond its normal range of temperature tolerance, we should consider growing another fish'.[7]

6.7 Potential changes for the oyster industry were also noted. As Pacific Oyster Mortality Syndrome (POMS) is a disease that only affects the Pacific oyster, it was observed that the Sydney rock oyster could be introduced and cultivated in areas such as Tasmania that have been affected by POMS.[8] Parts of the oyster industry have also needed to adjust their infrastructure in response to changes in the marine environment. Mr Simon Rowe from OceanWatch Australia provided the following comments on these developments by referring to the New South Wales industry:

> The New South Wales oyster industry have noticed changes in level rise. They are stuck on their set infrastructure, so they are having to modify that, and there are other things along the lines of early warning systems for plumes and that sort of thing coming from downstream. They are starting to utilise some of those technological solutions in response to climate change. So they are aware of it and they are dealing with it slowly…It is a little bit unpredictable at times as to how it is going to affect their local area.

---

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

5 Professor Stewart Frusher, IMAS, *Committee Hansard*, 21 February 2017, p. 12.

6 Professor Stewart Frusher, IMAS, *Committee Hansard*, 21 February 2017, p. 12.

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

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

> They may start noticing some mortality or some changes and they may respond to those specifically, but I do not think they get up in the morning and think, 'I am going to change this today because of climate change.' It is very ad hoc.[9]

6.8 In discussing the ability of the fishing industry to adapt to climate change, it was emphasised that successful adaptation could enable the industry to take advantage of potential opportunities that climate change could create. Professor Hallegraeff stated:

> I would add that, again, adaptation is not necessarily something that is a bad thing. There are great opportunities, we believe, for climate change in fisheries, for instance. It just depends on whether or not the management framework is flexible enough to be able to deal with considerable changes. I am sure you have heard from New South Wales how much change is happening to the management of New South Wales fisheries at the moment, and the industry is going through a restructure. It is hard to work with an industry when the attention is elsewhere. But certainly there will be opportunities. That is the expectation that we see from research.[10]

Breeding programs to develop resilient stock and other responses

6.9 As noted above and in Chapter 4, increasing temperatures in Tasmania may result in decreased productivity in the Atlantic salmon industry. Despite this, the Fisheries Research and Development Corporation (FRDC) suggested that such an outcome could potentially be countered 'through selective breeding for a higher thermal tolerance'.[11]

6.10 Businesses can also adjust to climate change by reviewing and adjusting their planning. Dr Hobday explained:

> One example we might provide to an industry is: 'If you are going to experience an extreme event, what contingency plans would you have in place?' As any good business, they will have strategies for what they will do if they saw this or that event, and it might be harvesting your species over a longer period of the year, or it might mean diversifying your markets. The actual range of options that are available if you do that future planning is quite remarkable, and our challenge is to get industry, management and policy to really consider that spectrum.[12]

---

9 Mr Simon Rowe, Program Manager, Environment, OceanWatch Australia, *Committee Hansard*, 16 March 2017, p. 44.

10 Ms Lowri Pryce, Executive Officer, OceanWatch Australia, *Committee Hansard*, 16 March 2017, p. 44.

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

12 Dr Alistair Hobday, CSIRO, *Committee Hansard*, 17 March 2017, p. 3.

6.11 Returning to the salmon industry in Tasmania, Dr Hobday stated:

> They understand climate is a risk to their future operation and one way you could manage that risk is with environmental information about the future. We have developed seasonal forecasts that can give some probability estimates of whether the upcoming conditions are going to be hotter than average or colder than average. They used those to, I think, manage their production schedules and also what they would be able to deliver to market, based on those environment conditions.[13]

Great Barrier Reef

6.12 The vulnerability of the Great Barrier Reef to climate change was discussed in Chapter 3. This section examines the various approaches underway and other approaches which could be considered to protect biodiversity and fisheries in the Great Barrier Reef.

6.13 Evidence received on how to address the health of the Great Barrier Reef went to:

- the need for global action to address human interference with the climate system; and
- local responses to enhance the resilience of the Reef, including research, management strategies and recovery efforts.

6.14 As noted earlier, this report does not focus on the need for global action on climate change. However, in the context of the Great Barrier Reef, the following comment provides an example of the points made by witnesses regarding the need for emissions reduction to protect the Reef:

> We would hope that they replace this target with a new target of 65 to 85 per cent reduction in greenhouse emissions based on 2005 levels by 2030, setting Australia on a pathway to meet a limiting 1.5 degrees, which may give us some reef in the future.[14]

6.15 The remaining paragraphs of this section focus on local responses to Reef rehabilitation, including the actions outlined in the *Reef 2050 Long-term Sustainability Plan*.

13 Dr Alistair Hobday, CSIRO, *Committee Hansard*, 17 March 2017, p. 9.

14 Mr Tony Fontes, Reef Campaigner, Australian Marine Conservation Society (AMCS), *Committee Hansard*, 30 August 2017, p. 27.

Current strategies and recovery efforts

6.16 The *Reef 2050 Long-term Sustainability Plan*, which was released by the Australian and Queensland Governments in March 2015, provides a framework for protecting and managing the Reef.[15] The Plan includes the following summary of programs intended to support the health of the Reef:

> The Australian Government is investing $200 million over five years to improve the resilience of the Reef, including supporting delivery of the Reef Water Quality Protection Plan. In particular, the new $40 million Reef Trust will fund water quality improvements, habitat restoration and species recovery, important for enhanced Reef health. In addition to maintaining its $35 million a year expenditure on water quality initiatives, the Queensland Government has committed an additional $100 million over five years towards water quality initiatives, scientific research and helping business transition to better environmental practices in the primary production and fishing industries.[16]

6.17 In addition to the $100 million committed by the Queensland Government for water quality and other initiatives, in June 2017 the Queensland Government announced a further commitment of $175 million ($35 million per year) over five years from 2017–18 for the Great Barrier Reef Water Quality Program.[17]

Regulation of activities in the Marine Park

6.18 One of matters addressed in the Reef 2050 Plan is sustainable fishing. The Great Barrier Reef Marine Park Authority (GBRMPA), which explained that it is supporting the Queensland Government to deliver its sustainable fisheries strategies, provided the following overview of how the sustainable fishing actions will support a more resilient Reef ecosystem:

> The strategy seeks to set sustainable catch limits to maintain targeted populations at around 60 per cent of pre-fishing levels. That's a more conservative target than typical in fisheries management. It also includes the introduction of satellite vessel monitoring systems on all commercial fishing vessels operating in the marine park to improve compliance, both

15 Department of the Environment and Energy, 'The Reef 2050 Plan', www.environment.gov.au/marine/gbr/long-term-sustainability-plan (accessed 18 October 2017).

16 Australian Government and Queensland Government, *Reef 2050 Long-Term Sustainability Plan*, March 2015, www.environment.gov.au/system/files/resources/d98b3e53-146b-4b9c-a84a-2a22454b9a83/files/reef-2050-long-term-sustainability-plan.pdf (accessed 18 October 2017), p. iii.

17 The Hon Steven Miles MP, 'Budget delivers record funding for environment', *Media Release*, 13 June 2017; Queensland Government, 'Budget highlights: Environment', https://budget.qld.gov.au/budget-highlights/environment/ (accessed 19 October 2017).

> with the zoning rules and also the fisheries rules. Both of these initiatives are critical contributions to the resilience of the marine park.[18]

6.19 The benefits of effective fisheries management were highlighted by the following evidence indicating how populations of fish species reefs recovered from cyclone damage:

> Two recent studies have indicated positive effects of protection from fishing on cyclone impacted reefs. Among reefs that were affected by [Tropical Cyclone] Hamish, the biomass of coral trout declined after the cyclone on reefs that were open to fishing, while there was no substantial change in biomass on reefs that were protected from fishing. A 12 year study of recovery of both benthic communities and fish communities on GBR reefs following disturbances found evidence that time to recovery following storms was 9% shorter for benthic communities and 18% shorter for fish communities on reefs that were closed to fishing compared with reefs where fishing was permitted.[19]

6.20 GBRMPA also explained that it is seeking to improve compliance with its zoning plan that regulates activities permitted in the Great Barrier Reef Marine Park:

> One of our key management tools is the zoning plan, which specifies the types of use allowed in different areas of the marine park. Fishing is prohibited in the marine national park zones, commonly referred to as 'green zones', which make up about 33 per cent of the park's 344,000 square kilometres. Together, ecologically sustainable fisheries and zoning contribute to enhancing the reef's resilience and that of the industries which depend on it to a range of threats, including climate change.[20]

Crown-of-thorns starfish management

6.21 As noted in Chapter 3, crown-of-thorns starfish outbreaks have been one of the major long-term causes of damage to the health of the Reef. Under the Reef 2050 Plan, efforts to reduce crown-of-thorns starfish outbreaks are focused on improving water quality and a targeted control program 'as needed'.[21] The Plan includes the following explanation regarding the scope of the control program:

> The Australian Government is…continuing a crown-of-thorns starfish control program, investing $10.5 million from 2012 to 2015 to protect high value reefs and increase knowledge of crown-of-thorns starfish biology. The program includes coordinating control activities, providing training for industry divers and community members, and undertaking industry

18 Dr David Wachenfeld, Director, Reef Recovery, Great Barrier Reef Marine Park Authority (GBRMPA), *Committee Hansard*, 30 August 2017, p. 46.

19 AIMS, *Submission 10*, p. 8.

20 Dr David Wachenfeld, GBRMPA, *Committee Hansard*, 30 August 2017, p. 46.

21 Australian Government and Queensland Government, *Reef 2050 Long-Term Sustainability Plan*, March 2015, p. 37.

> communication and awareness-raising activities. The aim is to maintain coral cover on targeted reefs at greater than the 20 per cent considered essential for reef health and resilience.[22]

6.22 Ms Hayley Morris, Executive Director, Morris Group, provided an example of control efforts. Ms Morris advised that crown-of-thorns starfish have been in 'plague numbers' in some areas, with 'up to 35,000 culled within reefs just off Orpheus Island in the last two months'.[23] Ms Morris added that there is research underway to enhance the effectiveness of culling efforts. Ms Morris advised that the Morris Group is funding a research project undertaken by James Cook University to support the eradication of crown of thorns starfish earlier in their lifecycles. Ms Morris explained:

> What they are trying to do is to have a detection program in place so that when the baby crown of thorns start to hatch an alert system goes off which allows organisations involved in the eradication project to get in there quickly before they become an issue that can really destroy the reef. Part of the issue is that if an outbreak happens it is almost too late and then the job becomes so much bigger because they are already spreading so fast. Whereas if you can get them at the early juvenile stage before an outbreak happens, an alert system helps to gives us the understanding of the conditions that make it right for outbreaks to happen. So that was $100,000 to James Cook University, and that project is in the early stages.[24]

6.23 However, others questioned the value of localised culling efforts for the overall health of the Reef. Dr Katharina Fabricius, Australian Institute of Marine Science (AIMS), stated that localised culling efforts are:

> …effective at a very small, local scale to keep available some spots that the tourist operators are visiting available. From an economic point of view, it is effective for those operators. From an ecological perspective, it is like killing flies in the outback. There are millions of crown-of-thorns starfish out there, and all the efforts that have been made to kill crown-of-thorns have reduced the number by maybe half a million starfish so far. With a single female producing 30 million eggs per spawning season, that reduction, through a lot of effort, in my mind is ecologically not important.[25]

22 *Reef 2050 Long-Term Sustainability Plan*, p. 25.

23 Ms Hayley Morris, Executive Director, Morris Group, *Committee Hansard*, 29 August 2017, p. 29.

24 Ms Hayley Morris, Morris Group, *Committee Hansard*, 29 August 2017, p. 31.

25 Dr Katharina Fabricius, Senior Principal Research Scientist, AIMS *Committee Hansard*, 30 August 2017, p. 38.

Work underway to account for recent developments

6.24 As significant coral bleaching events occurred since the release of the Reef 2050 Plan, GBRMPA advised that further work has been underway to account for these developments. GBRMPA noted that the Commonwealth and Queensland environment ministers recently announced their intention to bring forward the mid-term review of the Reef 2050 Plan. In addition, in May 2017 GBRMPA hosted a summit of 70 national and international experts in the use and management of coral reefs with the aim of developing a 'blueprint for protecting corals and coral reefs into the future'. The blueprint, which as at September 2017 was in development, will focus on '10 priority initiatives, including the need to accelerate global action on climate change, improve compliance with zoning and other rules and enhance crown-of-thorns starfish control'.[26]

Overall approach to building resilience of the Great Barrier Reef

6.25 As noted above, some stakeholders argued strongly for urgent action to address climate change by reducing emissions. For example, the Australian Marine Conservation Society's (AMCS's) overarching criticism of the Reef 2050 Plan is that it does not contain any actions to mitigate carbon emissions.[27] There was also debate about the effectiveness of localised recovery and resilience programs compared to action targeting carbon emissions.

6.26 Calls for changes to be made to the Reef 2050 Plan were made during this inquiry. Of particular note, in May 2017, the Reef 2050 Plan Independent Expert Panel announced that, in its view, when the mid-term review of the Plan takes place in 2018, the following changes should be made:

- climate change adaptation and mitigation actions should be included;
- the Plan should include 'a focus on a sustainable, functional Reef in the face of emerging cumulative impacts'; and
- there should be a 'greater emphasis on empowering local people and communities to deliver on-ground action that will benefit the Reef'.[28]

6.27 This section discusses some of the localised recovery projects drawn to the committee's attention and the evidence received about the success and limitations of such programs.

---

26 Dr David Wachenfeld, GBRMPA, *Committee Hansard*, 30 August 2017, pp. 46–47, 49.

27 Mr Tony Fontes, Reef Campaigner, AMCS, *Committee Hansard*, 30 August 2017, p. 28.

28 Reef 2050 Plan Independent Expert Panel, Communiqué of seventh meeting, 5 May 2017, www.environment.gov.au/system/files/pages/abff0d5e-b94d-4495-b79b-90dc52274f69/files/expert-panel-communique-5may2017.pdf (accessed 15 November 2017).

6.28 The committee received evidence about specific assisted recovery projects and suggestions for such projects. The crown-of-thorns starfish management programs are one example. Another example was given by Professor Damien Burrows, who noted that in response to a cyclone, 'some teams went out to tip corals and move coral rubble off the beaches back into the water to create substrate for coral larvae to settle on'.[29] Professor Burrows argued that more of this type of work is required.[30]

6.29 Dr David Wachenfeld, GBRMPA, informed that committee that it is aware of research underway to improve coral recruitment rates by controlling the conditions in which coral spawn. Dr Wachenfeld referred to the spawning events during which corals synchronise their spawning to maximise fertilisation rates. Dr Wachenfeld explained that a few weeks after the spawning event, when the fertilised eggs have settled, the eggs turn into larvae and then 'a tiny little creature that goes down onto a coral reef and transforms into a new coral polyp'. Dr Wachenfeld advised that the research project involves collecting and maintaining the spawn in an aquarium 'so that much more of it survives than it would in the natural environment and then to put the spawn, at the right time, back onto the reef to deliver higher recruitment rates'. Dr Wachenfeld added:

> At the moment there have been some successful trials of this by an Australian scientist in the Philippines. We've just begun trials on the Great Barrier Reef. I should emphasise at the moment that this is a very small-scale endeavour. At the scale it is at the moment, it would be a site management tool. But the ambition, obviously, is to do the research to try to scale this up. This is really just one of the intervention and restoration tools that are being thought about and investigated.[31]

6.30 Localised resilience programs were also discussed. An example is an initiative to support the health of commercially significant reefs involving destratification. Sheriden Morris from the Reef and Rainforest Research Centre explained that the program involves technology developed by the Queensland University of Technology which can 'address localised climate impacts on coral reef systems'. Sheriden Morris stated:

> That technology is being widely used. Cairns Regional Council has adopted it into their dams for destratifying the water—for cold water pollution and for blue-green algae control. So it's already been built and used here in the tropics and we know that the mechanics of this are possible. The flow dynamics and modelling are currently being done; we've raised sufficient funds for those, and we are looking at running a pilot very shortly. We have put in a request for funds to help to run that pilot.

29 Professor Burrows explained that coral larvae prefer to settle on other coral.

30 Professor Damien Burrows, *Committee Hansard*, 30 August 2017, p. 23.

31 Dr David Wachenfeld, GBRMPA, *Committee Hansard*, 30 August 2017, pp. 51–52.

> We know that this will not save the entire Great Barrier Reef, but it will be able to be deployed at key tourism sites, which get about 120,000 visitors a year. This is about their only experience of the reef. We are fortunate: we have very, very clever scientists and we have clever engineers. We could, potentially, lead the way in protecting some of these zones. This is a very applied, very practical response, but only really for the tourist industry. It doesn't protect the GBR, but it will potentially provide a refugia for the tourist industry.[32]

6.31 As the above statement indicates, Sheriden Morris recognised that this technology is only a practical option to provide a refugia for small areas of the Reef. This point was reinforced by other witnesses; for example, Mr Tony Fontes from the AMCS noted that these projects 'might prop up a tourist operation' but otherwise were a 'tiny bandaid [that] is not going to make any difference at all in the long run'.[33] Dr Andrew Hoey from the Australian Research Council (ARC) Centre of Excellence for Coral Reef Studies similarly expressed scepticism about using pumped water. Dr Hoey stated that if such solutions work, and he is not convinced that they do, there is still a need to consider the interconnected nature of the Reef. Dr Hoey explained:

> The reef is obviously a complex system. So if you protect one, with a lot of the fish that you want to protect for fisheries, you're not going to be taking them from a tourism reef. They're interconnected between different reefs and different habitats. Some settle out of the plankton to inshore habitats before they move offshore. So it is not a matter of protecting one little spot. Even if we do those things, that's largely targeting the coral bleaching itself; it's not going to get those direct physiological effects that are impacting the fish, either.[34]

6.32 A counterargument, however, is that refugia work may help to ensure that some species of coral will survive that might not otherwise survive. Sheriden Morris stated:

> I know there are purists who disagree with this, but the concept around refugia is that, if, by some wonderful outcome, we do decarbonise the economy and if by 2050 we actually enable carbon to be stabilised around the atmosphere—if lots of things: if the Paris agreement's upheld and all those things happen, and by 2050 we stop below two degrees—refugia has a very, very special place, because this is what will save the complexity of the 330 species of corals, plus or minus a few, that we have. Otherwise, we will lose quite a large number of species…[T]he reality is that, if we want to keep some of those species, we're going to have to do something. We are locked in for 20 years of temperature increase, regardless of whether we decarbonise the economy tomorrow. So, with that in mind, do we look to

32 Sheriden Morris, Managing Director, Reef and Rainforest Research Centre, *Committee Hansard,* 29 August 2017, p. 2.

33 Mr Tony Fontes, Reef Campaigner, AMCS, *Committee Hansard,* 30 August 2017, p. 31.

34 Dr Andrew Hoey, Reef Ecologist, Australian Research Council (ARC) Centre of Excellence for Coral Reef Studies, James Cook University, *Committee Hansard,* 30 August 2017, pp. 4–5.

> protect some of the biodiversity or do we let it all just get slaughtered? The second point is: do we expose Australia's marine tourist industry—the 64,000 jobs and the $5 billion to $6 billion—when we have an opportunity to give it some protection?[35]

6.33 The committee also received evidence about assisted evolution with the aim of making corals more tolerant of higher temperatures. It was noted that some corals already have 'a pre-existing adaption capacity' that can help them adapt to changing conditions. Sheriden Morris stated:

> Corals also, remember, are old, like you inferred, and they can reach back into their back pocket for a pre-existing adaptation capacity. Not all corals but some corals have that existing adaptation capacity. Those that can adapt to these extreme events will be the ones that survive; those that can't access that adaptation capacity will be the ones that die. But, interestingly enough, it is not necessarily species wide. You'll have some corals—and you'll hear this over and over again—in a big patch of *Acropora* that have died and some that survive. So it's like high-speed evolution happening. But it's not really evolving; it's just pre-existing adaptation capacity.[36]

6.34 Differences between the degree of thermal tolerance within the Great Barrier Reef and the potential these differences present for assisted evolution efforts were noted. Dr Fabricius explained that the Reef 'has a greater thermal tolerance in the far north compared to the south', with evidence from the reefs in Papua New Guinea are also more tolerant of warmer waters. Dr Fabricius noted that currents are transporting larvae, which over time would support the growth of coral with a greater thermal tolerance in southern areas of the Reef. Dr Fabricius added that, potentially, research and rehabilitation work could assist this process. However, Dr Fabricius acknowledged that:

> …there are a lot of huge knowledge gaps and we are really just starting to dabble with ideas. And, yes, that won't be an easy thing. There certainly are very great challenges about scale. I don't believe in technology fixes. There will be no 3-D printing of our Great Barrier Reef and fish are happy again.[37]

6.35 Dr Janice Lough, Senior Principal Research Scientist, AIMS, also referred to assistant evolution research underway between AIMS and the University of Hawaii that is, at this time, 'just exploring the possibilities'. Dr Lough provided the following insights into the reasoning behind the project:

> …there are winners and losers when you have these major, say, thermal-stress events of reefs. You can look at a reef that has been bleached and

35 Sheriden Morris, Reef and Rainforest Research Centre, *Committee Hansard*, 29 August 2017, p. 3.

36 Sheriden Morris, Reef and Rainforest Research Centre, *Committee Hansard*, 29 August 2017, p. 4.

37 Dr Katharina Fabricius, AIMS, *Committee Hansard*, 30 August 2017, pp. 39–40.

> there is one coral that hasn't bleached. What are the attributes of those particular organisms that survive?
>
> This is a complex project that is running over about five years, I think, that is examining: can we help the photosynthetic algae in the coral? They have very fast generation times. Maybe we can help them confer greater thermal tolerance on their hosts. There are a range of other activities that they are looking at.[38]

6.36 Despite the evidence received about the potential for assisted recovery and evolution and the willingness of scientific organisations to pursue further research in these areas, it was emphasised that such efforts:

> …are not seen by the scientists as an alternative for mitigating climate change, they are a strategy to give reefs time to adapt, but we still do need to achieve the objectives of the Paris Agreement…[39]

Further research and better utilisation and coordination of research efforts

6.37 The committee received a significant amount of evidence about the importance of further scientific research and the need to better utilise the results of research and the resources available for research.

6.38 The benefits of existing research programs were highlighted. In particular, the Integrated Marine Observing System (IMOS) was discussed. As noted in Chapter 2, funding for IMOS is provided by the Australian Government under the National Collaborative Research Infrastructure Strategy (NCRIS), with co-investment from other research partners supporting this core funding.

6.39 Concern shared by those involved in IMOS about the need to secure funding under the NCRIS for IMOS to continue is clear. For example, the University of Tasmania, as lead agency for managing IMOS, prepared a five year plan (2017–2022) designed to secure NCRIS funding. The five-year plan links IMOS to a range of government policies and research plans to 'make…the case for IMOS to be maintained as a world class research infrastructure'. As the document observes, although co-investment 'is essential to the functioning of IMOS as a whole', without the core investment provided by the Australian Government 'there will be no IMOS in which to co-invest'.[40]

---

38 Dr Janice Lough, Senior Principal Research Scientist, AIMS, *Committee Hansard*, 30 August 2017, p. 39.

39 Dr David Wachenfeld, GBRMPA, *Committee Hansard*, 30 August 2017, p. 52.

40 University of Tasmania, *IMOS Five Year Plan (2017–22)*, http://imos.org.au/fileadmin/user_upload/shared/IMOS%20General/documents/IMOS/Plans___Reports/5_year_plan/IMOS-Five-Year-Plan-Final-23-09-16.pdf (accessed 14 November 2017), pp. 1, 31.

6.40 This issue was also raised during the March 2017 public hearings. Professor Iain Suthers from the Sydney Institute of Marine Science (SIMS), explained that the operators of IMOS 'now need to compete' for NCRIS funding. Professor Suthers noted that this uncertainty has implications for retaining staff:

> We expanded through the Kevin Rudd inspired NCRIS funding. That has now been contracted. That was about $18½ million per year to run the program. We have now cut and trimmed it down to about a $16 million-a-year request. That is what Tim Moltmann [Director, IMOS] has made to the NCRIS committee. That is still being assessed. They still do not know. Yet many of the people in the IMOS program, including the New South Wales IMOS, who have salaries that are dependent upon that are now looking over their shoulders for other jobs.
>
> So there is a great risk of losing that talent and that corporate knowledge, because these people are really specialists. They can move. They are very numerate. They can move into the banking sector, if they need to. But they love marine science; they love looking at climate—and we want to keep them. We had that signal 12, 18 months ago, but they are still now going through this NCRIS procedure to allocate the funds to these other capabilities.[41]

6.41 Professor Suthers added:

> IMOS is, without a shadow of a doubt, a stand-out. It has delivered for the public, for industry. We have quality-assured, quality-controlled data. It is being used, and how it is being used is being monitored and tracked. So I think that is a substantial feather in the cap for Australia. Even the US and Europe are looking at the way IMOS does business. I would hate to lose that.[42]

6.42 As part of the operational funding for 2017–2019 under the NCRIS, $29.5 million was allocated for IMOS.[43]

6.43 Another example of the need for funding to support long-term monitoring involves the Great Barrier Reef. As noted in Chapter 2, Professor David Booth referred to a team undertaking monitoring work on the Reef. Despite the existing scientific work, the need for further scientific research and funding for this research was emphasised. Professor Booth stated:

> …from a scientist's and ecologist's point of view, we just do not understand these natural systems well enough. I think long-term monitoring is so important but so underfunded. At the big end of town we have things like the IMOS—the integrated marine observing system—and AIMS's

41 Professor Iain Suthers, SIMS, *Committee Hansard*, 16 March 2017, p. 20.

42 Professor Iain Suthers, SIMS, *Committee Hansard*, 16 March 2017, p. 20.

43 Department of Education and Training, 'NCRIS Operational Funding 2017–2019', https://docs.education.gov.au/system/files/doc/other/ncris_projects_2017_funding_allocations.pdf (accessed 14 November 2017).

> long-term monitoring. They are great examples at the institutional level. There is smaller monitoring that we have done, but going for a quarter of a century that has been done on a shoestring. I think we need to build them to make them more secure.[44]

6.44 Professor Booth explained that, although the ARC provides grants that enable fisheries research with monitoring possible 'as a side issue', ARC funding cycles are for three year periods. Therefore, Professor Booth explained that ARC grants are not suitable for monitoring as three years of data 'is useless…[w]e know 25 years is not even enough'.[45] Professor Stewart Frusher, IMAS, also argued that there is a need for better coordination between state governments regarding secure funding to establish long-term data sets.[46]

6.45 Further examples of limited and short-term funding arrangements that do not enable the long-term monitoring necessary for analysing changes in the ocean environment were provided. Mr Simon Rowe from OceanWatch Australia stated:

> There was some money that was put aside to the NESP, the National Environmental Science Program—I think it was $142.5 million over six years—but that basically gets allocated towards priorities at the time. To respond to something like this calamity over this scale, I think they have available about $400,000, which they have under emerging priorities, which is quite a small amount. For those people who wanted to go out and act on this drama, it was very difficult to get some funds to go and start looking at the scale of the problem and what could be done about it.[47]

6.46 Gaps in monitoring are also evident. For example, in relation to the mangrove dieback in the Gulf of Carpentaria discussed in Chapter 3, the committee was advised that the dieback occurred in November 2015, however, the first report of dieback was not received by relevant experts until April 2016. Professor Burrows provided the following evidence regarding how he received initial reports of dieback and established that a large event had occurred:

> …in April 2016…we received an email from a fisherman in the Karumba area. He said, 'Guys, there's some dieback here. What do you reckon?' I remember that I was kayaking on the Ross River and I got a phone call. I was in the middle of kayaking and I was speaking to this fisherman: 'We'll have a look at it. But dieback is common. It does happen all the time. It's just one stand.' But we passed the photograph around to a few of our colleagues, and another colleague said, 'I'm going near Burketown; I'll have a look.' He said, 'I saw some dieback there as well, and the locals said it happened in November 2015, which is what the fisherman in Karumba said.' I said, 'That's interesting; they both said the same thing.' We passed

---

44 Professor David Booth, *Committee Hansard*, 16 March 2017, p. 3.

45 Professor David Booth, *Committee Hansard*, 16 March 2017, p. 4.

46 Professor Stewart Frusher, IMAS, *Committee Hansard*, 21 February 2017, p. 7.

47 Mr Simon Rowe, OceanWatch Australia, *Committee Hansard*, 16 March 2017, p. 38.

> the word around to a few of our colleagues and said, 'Have you heard anything?' People from Borroloola in the Northern Territory said, 'Yes, we've got some dieback in our area too. It happened in about November 2015.' I thought, 'This is a coincidence; three different locations, all the locals saying it.' This was five months later.[48]

6.47 It was also argued that research efforts involving the marine environment could benefit from greater coordination. Mr Martin Exel, General Manager Environment and Policy, Austral Fisheries, commented on this by contrasting the coordination in meteorological matters with the various entities involved in marine research. Mr Exel stated:

> You have got the Bureau of Meteorology; they are doing a lot of work for us on the meteorological side of things but then, when you move into the oceanographic stuff, you have got IMOS here, you have got IMAS, you have got CSIRO—and everyone is vying for a little bit of pie. Setting up a single group where it could be said, 'You're responsible for looking at that marine side of things,' would help a great deal. I do not think it would be very expensive, personally.[49]

6.48 There were also suggestions that existing resources, such as the RV *Investigator*, need to be used more effectively. The vessel is capable of spending up to 300 days a year at sea;[50] however, evidence presented to the committee indicated that this capacity is not used in full. Professor Iain Suthers, SIMS, explained:

> One of the tools that we have that Australian taxpayers funded is the *Investigator*, this magnificent ship, 94 metres long, which is state of the art, and it is funded for only six months of the year. In the other six months, it is tied up at the wharf. You have marine scientists who are already funded and who have the expertise who are desperate to get to sea, even looking at perched sediment, which could cause a tsunami risk—unrelated to this issue—and yet we have this arcane formula to fund that vessel. It goes back, again, 20 years to the days of the Franklin and even before that. If I could make one plea: we already have the tool; we have the resource; can we just get it out there and operate it? It could help you with MH370 and all kinds of things.[51]

6.49 Witnesses representing CSIRO acknowledged that additional time on the *Investigator* would assist to gather 'higher resolution, more accurate information'. Dr Andreas Schiller from CSIRO, however, also highlighted practical issues with the process for obtaining use of the vessel. Dr Schiller provided the following evidence

---

48 Professor Damien Burrows, *Committee Hansard*, 30 August 2017, p. 16.

49 Mr Martin Exel, General Manager Environment and Policy, Austral Fisheries, *Committee Hansard*, 21 February 2017, p. 24.

50 CSIRO, 'Research vessel: Investigator', www.csiro.au/en/Research/Facilities/Marine-National-Facility/RV-Investigator (accessed 30 October 2017).

51 Professor Iain Suthers, SIMS, *Committee Hansard*, 16 March 2017, p. 29.

that outlines the existing process and the difficulties researchers face in ensuring the time on the vessel suits their funding arrangements:

> Scientists write proposals to the national committee to seek time on that vessel. At the moment, you are having to write a proposal for two to three years ahead of time for allocation of time on that vessel. That can be problematic because you are granted time on the vessel but you have not yet got your other research project funded in order to support the ancillary work around that time. So aligning the vessel's scheduling with the time scale of other funding opportunities would be very advantageous. Sometimes we have the situation of a scientist obtaining the national facility time but their other grant that will pay for their people, the travel, the processing of samples and all of that fails, and they have to give back that time on the national facility because the timing of the proposals from group A and the national facility group do not line up.[52]

6.50 In response to a question taken on notice, however, CSIRO advised that there has been an increase in the number of days the *Investigator* is used for research. CSIRO explained:

> The *Investigator* is funded by the Australian Government to operate up to 180 days at sea per annum. In 2015/16 the ship delivered 248 research days at sea, through a combination of Australian Government funding and research charters. In 2016/17 with collaboration through a CSIRO/industry research partnership, the *Investigator* is planned to be at sea for an additional 19 days, and also a further 13 days for the Australian Hydrographic Service making an expected total of 204 research days at sea in 2016/17.[53]

6.51 Another area explored during this inquiry were the relationships between scientific organisations and industry. The report has previously referred to specific examples, such as the work involving CSIRO and the Tasmanian salmon industry. However, it was suggested that relationships between scientific bodies and industry need to be developed further. Ms Lowri Pryce, Executive Officer, OceanWatch Australia, remarked that knowledge is 'not being transferred effectively from the science community to the fishing and aquaculture sector'. Ms Pryce argued that the building of trusting relationships is required. Ms Pryce explained:

> It is difficult for a science community to engage with stakeholders who may be operating five kilometres offshore. They are not an easy stakeholder to wait around for. Communicating with on-water people—or saltwater people, as we call them—is somewhat of an expertise. That is the crucial link between science and them: somebody to translate as well as to extend. It is literally being on wharves and understanding how best to communicate. It is an acquired skill. It is an acquired skill that NRM is

52 Dr Andreas Schiller, Acting Director, Oceans and Atmosphere; Dr Alistair Hobday, Senior Principal Research Scientist, CSIRO, *Committee Hansard*, 17 March 2017, pp. 4–5.

53 CSIRO, Answers to questions on notice, 17 March 2017 (received 13 April 2017), p. 1.

> building. It is a skill OceanWatch has been flexing for the last 27 years. The capability is there. We have had the opportunity to extend information nationally from an environmental perspective through programs in the past—very successful, award-winning programs—and it is about giving us the opportunity to do what we do best as an NRM.[54]

6.52 The evidence received about privately commissioned research also demonstrates the need for further research, the limitations of existing government-supported research efforts and the relationship between scientists and industry. The committee was advised that Morris Group, which owns several tourism accommodation properties in north Queensland, is funding several research projects related to the health of the Great Barrier Reef. The first project supported by the Morris Group, which is in partnership with James Cook University and Earthwatch, operates on Orpheus Island and seeks to better understand how the Reef recovers following shocks such as cyclones and disease so as to improve understanding of what conditions are needed to support the Reef's recovery. The second project is a crown-of-thorns starfish early eradication project (this was discussed at paragraph 5.23). The third project is support to Great Barrier Reef Legacy, which is a not-for-profit 'research-educational institute'.[55] The support provided by Morris Group comprises $160,000 and the use of a vessel for research to search for and better understand corals that have survived bleaching events.[56]

54 Ms Lowri Pryce, OceanWatch Australia, *Committee Hansard*, 16 March 2017, p. 39.

55 Mr John Rumney, Managing Director, Great Barrier Reef Legacy, *Committee Hansard*, 29 August 2017, p. 38.

56 Ms Hayley Morris, Executive Director, Morris Group, *Committee Hansard*, 29 August 2017, p. 31; Ms Hayley Morris, Morris Group, *Submission 25*, p. 2.

Chapter 7

Conclusions and recommendations

7.1 Human induced climate change presents a grave threat to the environment and our way of life. For the sake of the planet and the future generations who will inhabit it, effective action at every level—globally, nationally and locally—is essential to stop the effects of climate change from worsening. The committee emphasises that Australia needs to substantially reduce our greenhouse gas emissions and push for meaningful international action to address climate change.

7.2 Much can be said about how the consequences of human induced climate change will be significant and disruptive for many parts of the environment and for human activity. This inquiry, however, has focused on a specific issue that, to date, the committee considers has received less attention: the consequences of climate change for marine fisheries and biodiversity. During this inquiry, compelling expert evidence was presented to the committee about the current and projected impacts of climate change on the marine environment. Rising ocean temperatures, changes to ocean currents, increasing sea levels and acidification of the surface ocean (from rising carbon dioxide levels in the atmosphere) have been observed or are projected.

7.3 The implications for Australia will be significant. The south-east region of Australia is already considered a 'hot spot' globally for warming, with sea surface temperatures in that area warming faster than 90 per cent of the world's oceans. Recent marine 'heat waves' and events such as coral bleaching in the World Heritage listed Great Barrier Reef and other reefs have already been observed.

7.4 Changes to the physical attributes of the ocean and other developments linked to climate change, such as increased intensity of extreme weather events, are expected to have implications for commercial fishing and aquaculture, recreational fishing, Indigenous fishing and other industries that rely on healthy oceans, such as tourism. Among other things, the distribution and stock abundance of fish stocks may change and there could be an increased variability of catch. This will have implications for the suitability of existing approaches to fisheries management and for the structure of, and employment in, the commercial fishing industry. The suitability of locations for aquaculture may also change; for example, warmer ocean temperatures could allow aquaculture of barramundi to extend south, however, salmon farming in Tasmania is approaching its thermal limit.

7.5 There is also concerning evidence of disease outbreaks and biosecurity risks linked to climate change. These events are already costing industry lost production and revenue and may ultimately threaten businesses, investment and employment. Governments will likely incur direct costs in response to outbreaks of marine pests and diseases.

7.6 Effective adaptation to the effects of climate change on the marine environment requires action by governments, industry and the community at large. While many actions can be identified, the committee has focused on recommendations that can be readily pursued by the Australian Government.

7.7 One area in which the Australian Government can make a significant difference is by supporting research, specifically, by providing adequate research funding and by ensuring industry can access and utilise scientific findings. There are gaps in scientific knowledge about how climate change will affect the physical attributes of the oceans and the implications this will have for marine fisheries and biodiversity. At present, significant developments are also likely to go unnoticed—in particular, the committee notes the evidence received that mangrove dieback in the Gulf of Carpentaria was only reported to experts five months after the event occurred. Evidence presented to the committee clearly indicates that well-resourced monitoring and further research to assess and understand changes on ecosystems and fisheries is required.

7.8 During this inquiry, the committee received evidence about private businesses committing to improving scientific understanding of the effects of climate change by funding research. The committee commends these efforts. Well-resourced government-backed research, however, remains vital. The committee urges the Australian Government to increase the funding available for such research and to ensure funding is provided on a stable, long-term basis. This is particularly important for long-term monitoring efforts such as the Integrated Marine Observing System (IMOS).

7.9 In addition to the need for the overall funding allocated to climate change research to be increased, the committee considers there are specific matters that require government attention. For example, the committee notes that the taxpayer funded RV *Investigator* is capable of spending 300 days at sea, yet it is only funded by the government for 180 days at sea. Evidence presented to the committee indicated that, in addition to the gap in government funding, there are practical issues with the process for obtaining use of the vessel, with researchers facing difficulties in ensuring the time granted for using the vessel suits their funding arrangements. The committee urges the government to increase the funding available for the use of this state-of-the-art vessel and to work with CSIRO to improve processes associated with researchers gaining access.

Recommendation 1

7.10 The committee recommends that the Australian Government review the funding provided for research into the effects of climate change on the marine environment and possible adaptation measures to ensure the funding is appropriate for facing the challenges of climate change.

7.11 The committee further recommends that the Australian Government commit to allocating long-term funding for climate monitoring, such as the Integrated Marine Observing System.

Recommendation 2

7.12 The committee recommends that the Australian Government review the funding provided to operate the RV *Investigator* with a view to:

- **increasing the long-term funding provided by the Government; and**
- **obtaining greater financial support from other parties, such as through industry research partnerships.**

7.13 The committee further recommends that the Australian Government review the processes associated with researchers gaining access to the RV *Investigator* with a view to increasing the number of days the vessel can be used for research.

7.14 There is also a pressing need for the Australian Government to support connections between researchers and industry so that research findings are used to the full extent possible. The committee welcomes existing efforts, such as CSIRO's collaboration with the aquaculture industry; however, far more work is required.

7.15 In addition, the committee is concerned by the evidence received from the fishing industry regarding the need for greater sharing of expertise and coordination on biodiversity issues between different parts of the industry. Lessons learnt from addressing challenges encountered in one part of the industry or that arise in one particular geographic area may be of relevance to others. The committee considers there would be benefit in the Australian Government establishing a taskforce to consider how to facilitate greater coordination and knowledge sharing on biosecurity matters within the fisheries and aquaculture industries.

Recommendation 3

7.16 The committee recommends that the Australian Government take a national leadership role in funding and supporting connections between the fishing and aquaculture industry and research organisations to help industry understand and adjust to the effects of climate change.

Recommendation 4

7.17 The committee recommends that the Australian Government direct the Department of Agriculture and Water Resources to engage with industry representatives to consider how information about responding to biosecurity challenges can be shared more effectively within the fisheries industry.

7.18 The Australian Government can also provide further support to efforts by organisations and Traditional Owners working to ensure Australia's marine environment is healthy and productive and is used sustainably. Examples include OceanWatch Australia (the marine NRM organisation) and the Indigenous Protected Areas program.

Recommendation 5

7.19 The committee recommends that, as part of the National Landcare Program, greater emphasis be placed on marine natural resource management and projects be supported that will improve marine biodiversity and deliver sustainable fisheries and aquaculture outcomes in the face of climate change.

Recommendation 6

7.20 The committee recommends that the Australian Government investigate options to formalise and enhance engagement between Traditional Owners involved in Indigenous Protected Areas, universities and relevant Commonwealth departments and agencies regarding the effects of climate change on the marine environment, including appropriate local management responses to changes and emerging threats.

7.21 The Australian Government also needs to ensure that regulatory and administrative arrangements are up-to-date and as effective as possible for responding to the challenges presented by climate change. The committee accepts the evidence provided by a range of government agencies that Australia's fisheries management framework is responsive and well placed to adapt to climate change. The committee also notes the evidence received that the offshore constitutional settlement agreements for fisheries, which set out jurisdictional arrangements for fisheries, are in the process of being updated. The committee supports this work and urges the Australian Government to pursue this as a matter of urgency.

Recommendation 7

7.22 The committee recommends that the Australian Government expedite work to update offshore constitutional settlement agreements regarding the jurisdictional boundaries between fisheries.

7.23 During this inquiry, gaps in knowledge available to regulators involved in fisheries management were brought to the committee's attention. One such gap is in relation to recreational fishing. The committee was advised that recreational fishers take more catch than commercial fishers for some key fish stocks, yet the data about recreational fishing effort currently available for informing fishery stock assessments and ecosystem risk assessments appears to be inadequate.

7.24 To enhance data collection arrangements for recreational fishing, the committee considers that consistent licensing arrangements should be in place in all state/Northern territory jurisdictions. In making the recommendation, the committee notes the Productivity Commission recently made a recommendation that, within the next three years, all jurisdictions should require recreational fishers to obtain licences for marine fishing activities. Although this is a matter for the states and the Northern Territory, this recommendation was supported by the Australian Government and is supported by the committee.

7.25 Noting the evidence received during this inquiry regarding how recreational fishing boats can be tracked and how citizen science projects such as the Redmap program have been effective, the committee considers that the state and Northern Territory governments should also consider how technology could be used more effectively to support how recreational fishing activity is accounted for in fisheries management.

Recommendation 8

7.26 The committee recommends that state and Northern Territory governments give effect to recommendation 4.1 of the Productivity Commission's report *Marine fisheries and aquaculture* relating to licence arrangements for recreational fishers.

Recommendation 9

7.27 The committee recommends that state and Northern Territory governments explore innovative methods to capture recreational fishing data.

7.28 More generally, the committee considers there is a need to ensure that consideration of climate change is a mandatory requirement as part of decision-making under Commonwealth, state and territory environmental and resource management legislation.[1] In particular, the *Environment Protection and Biodiversity Conservation Act 1999* should be amended to establish a greenhouse trigger that ensures Commonwealth oversight of proposed actions that will have, or are likely to have, a significant impact on greenhouse emissions.

7.29 Incorporating the need to mitigate and adapt to climate change in decision-making frameworks would complement and reinforce well-understood principles, such as inter-generational equity, and is appropriate given the seriousness of Australia's exposure to climate change related threats. Decision-makers should have the impacts of climate change at the forefront of their mind when assessing proposals under environmental and resource management legislation.

Recommendation 10

7.30 The committee recommends that the Australian, state and territory governments review all environmental and resource management legislation to ensure that adequate consideration of the effects of climate change is expressly required as part of assessment and decision-making processes.

7.31 In particular, the committee recommends that establishing a greenhouse trigger be included in the upcoming independent review of the *Environment Protection and Biodiversity Conservation Act 1999*.

---

1 Examples of Commonwealth legislation include the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act); *Fisheries Management Act 1991* and the *Great Barrier Reef Marine Park Act 1975*.

7.32 The committee has also considered a proposal for the creation of a National Oceans Commission to coordinate existing Commonwealth and state agencies activities and set a direction for future innovation and activities that support enhanced resilience of the marine environment. The proposal was raised at the second public hearing and it became apparent during the remaining stages of the inquiry that key stakeholders have not considered it. Consequently, the committee is not in a position to endorse or reject the proposal based on the evidence received during this inquiry.

7.33 The committee considers that whether a National Oceans Commission should be created is a question that requires further dedicated consideration and consultation. Moreover, the committee notes that the aims of a National Oceans Commission could potentially be achieved by other means. As an alternative, the committee considers the addition of a dedicated oceans outcome to the Department of the Environment and Energy's responsibilities should also be considered. The committee recommends that the Australian Government commence a process for examining these proposals in detail.

Recommendation 11

7.34 The committee recommends that the Australian Government commission a feasibility study into the creation of a National Oceans Commission or consider establishing a dedicated oceans outcome as part of the Department of the Environment and Energy's responsibilities.

7.35 Finally, the committee comments on marine parks. Marine parks provide a means to actively protect species and habitats in the marine environment, resulting in healthier ecosystems that are more resilient to the effects of climate change. Effective networks of marine parks are particularly important as they ensure that species can move between protected areas and allow for the benefits of marine parks to be maximised. Given the changing climate and the other cumulative pressures the oceans face due to human activity, the committee regards a large and well-managed network of marine protected areas as being essential for conserving marine ecosystems and biodiversity. Accordingly, the committee recommends that the network of marine parks established by the Labor Government in 2012 be maintained. Additions to the national network should also be made if developments since 2012 mean that greater conservation efforts in particular areas are required.

7.36 On the Great Barrier Reef Marine Park, the committee has carefully considered the evidence received during this inquiry about the content and operation of the *Reef 2050 Long-Term Sustainability Plan*. Despite being described as the overarching framework for protecting and managing the Reef until 2050, the plan inadequately addresses climate change, which the Great Barrier Reef Marine Park Authority (GBRMPA) acknowledges is the most serious threat to the Great Barrier Reef.

7.37 The committee considers that the Australian and Queensland Governments need to take further action urgently to protect the Great Barrier Reef. The committee has already emphasised the need to substantially reduce Australia's greenhouse gas

emissions and for the Australian Government to push for meaningful international action to address climate change. These actions are essential to protect the Reef for future generations.

7.38 Other specific actions can also be taken. The committee notes that in May 2017, the Reef 2050 Independent Expert Panel called for the Reef 2050 Plan to be amended to:

- include climate change adaptation and mitigation actions;
- provide a focus on a sustainable, functional Reef in the face of emerging cumulative impacts; and
- provide a greater emphasis on empowering local people and communities to deliver on-ground action that will benefit the Reef.

7.39 At a minimum, these changes to the Reef 2050 Plan that were recommended by the Independent Expert Panel should be made.

7.40 In addition, a straightforward action the Australian Government can take is to increase funding for the GBRMPA to ensure it is resourced appropriately for addressing the various pressures the Reef is under. The committee notes that additional funding was recently provided to GBRMPA, nevertheless, the recent review of the governance of the Great Barrier Reef Marine Park Authority undertaken by Dr Wendy Craik AM noted a decline in staffing numbers over time as departmental funds for core staffing decreased in real terms.[2]

Recommendation 12

7.41 The committee recommends that the network of marine parks established in 2012 by the Gillard Government be maintained and that additions to the network be made if developments since 2012 mean that greater conservation efforts in particular areas are required.

Recommendation 13

7.42 The committee recommends that the Australian and Queensland Governments amend the *Reef 2050 Long-Term Sustainability Plan* so that the plan:

- **includes climate change adaptation and mitigation actions;**
- **has a focus on a sustainable, functional Reef in the face of emerging cumulative impacts; and**
- **provides greater emphasis on empowering local people and communities to deliver on-ground action that will benefit the Reef.**

2 W Craik, *Review of Governance of the Great Barrier Reef Marine Park Authority*, July 2017, www.environment.gov.au/system/files/resources/6a038c9a-34dd-42cb-a0b4-a688bd284658/files/final-report-review-governance-gbrmpa.pdf (accessed 29 November 2017), p. 26.

Recommendation 14

7.43 In light of climate change pressures, the committee recommends that the Australian Government review the funding provided to the Great Barrier Reef Marine Park Authority to ensure it is adequately resourced to meet its functions under the *Great Barrier Reef Marine Park Act 1975*.

7.44 This inquiry has provided a valuable and timely opportunity to focus on the health of the oceans and the consequences of climate change. The oceans cover more than 70 per cent of the Earth and the health of the global ocean is vital for life on this planet. However, in the committee's view, discussion of the consequences of climate change for the oceans has not received the attention it deserves. Likewise, the actions taken to date to mitigate the harm caused by climate change, and the other pressures oceans are under due to human activity, have not been sufficient.

7.45 The committee reiterates its comments made at the start of this report thanking the individuals and organisations that contributed to this important inquiry. The committee urges the Australian and state governments to act on the committee's recommendations and to take whatever additional actions are necessary to support healthy oceans.

Senator Peter Whish-Wilson
Chair

Australian Greens' additional comments:

Warming oceans – the canary in the coal mine

1.1 The Australian Greens would have preferred the committee's report to have been titled "Warming oceans – the canary in the coal mine". This cuts straight to the point: our carbon emissions—especially from burning coal—are the primary cause of our warming oceans; and the consequential and terrible impacts on our fisheries and biodiversity. We are disappointed that the major parties would not agree to this. This is symptomatic of a bigger problem where the role of coal is continually downplayed as a result of bipartisan political support for the industry in this country.

Funding of the RV *Investigator* and GBRMPA

1.2 Whilst the Australian Greens accept the committee's recommendations that the Government should review funding for research into the impacts of climate change on our oceans, increased funding should be provided without delay:

- for the RV *Investigator* to conduct a full year of scientific ocean research (above the current 180 days); and
- to the Great Barrier Reef Marine Park Authority for more scientific research on the impacts of coral bleaching, ocean acidification and other climate impacts.

1.3 With the World Heritage Committee looking at the future health of the Great Barrier Reef—and, more broadly, the health of the world's coral reefs—and a potential 'world heritage in danger' listing within two years, now is the time to commit funds to conduct the necessary surveys and research and development. A recent review into Australia's climate science capability by the Australian Academy of Science is just one of a number of pieces of evidence that supports the need for funds to be committed urgently to climate research. To quote Bill McKibben, a world-renowned climate activist, winning slowly is the same as losing.

Recommendation 1

1.4 That the Australian Government provide further funding to increase the number of days the RV *Investigator* can be at sea.

Recommendation 2

1.5 That the Australian Government immediately increase funding provided for researching the effects of climate change and weather, with an emphasis on the marine environment and possible adaptation measures.

An Oceans Commissioner

1.6 The Greens believe a key recommendation from this inquiry should be the immediate appointment of an Oceans Commissioner. Both the public service and the Parliament need an oceans champion, a public figure who can without fear or favour stand up and advocate for the health of our oceans, play a co-ordination role across many government departments, and drive change and action to help fix an ocean that is fast becoming 'broken'.

1.7 The Australian Greens note that the establishment of a National Oceans Commissioner could be compared to the Government's appointment of a Threatened Species Commissioner, which has not been without its detractors. However, we feel that a short consultation process on how the Threatened Species Commissioner position could be better resourced and more independent of government could help remedy this. Similarly, a National Oceans Commissioner should be adequately resourced and have an appropriate degree of independence from government.

1.8 The Australian Greens would also like to see the selection process for an Oceans Commissioner involving a public submissions and nomination process for a suitably qualified person who has broad stakeholder support, to avoid the potential for any political appointments.

Recommendation 3

1.9 That the Australian Government appoint a National Oceans Commissioner.

Recommendation 4

1.10 That, within the first twelve months after the appointment of a National Oceans Commissioner, the Australian Government direct the Commissioner to undertake consultation and report on whether the current allocation of policy, regulatory, coordination and research responsibilities within the Commonwealth public sector is appropriate for addressing the most pressing challenges facing Australia's oceans and seas.

Senator Peter Whish-Wilson
Chair

Coalition Senators' additional comments

Marine research and industry collaboration

1.1 Coalition Senators note that the Australian Government already plays a significant role in funding and supporting connections between industry and research organisations.

1.2 The Fisheries Research and Development Corporation, a statutory corporation, provides planning and investment advice and support in fisheries research, development and extension activities across Australian fisheries, including with respect to the impact of climate change on fishing activities.

1.3 Increased funding to support connections between the fishing industry and research organisations could help industry in meeting the challenges and opportunities of the effects of climate change on fisheries.

1.4 Any additional funding would need to be considered in the context of other budget priorities and should be outcomes focused.

Aquatic biosecurity and emergency response

1.5 Coalition Senators note that the Australian Government is currently working with state and territory governments and industry to develop a formal industry–government aquatic emergency animal disease response agreement, referred to as the 'Aquatic Deed'.

1.6 It is anticipated that the Aquatic Deed will include requirements around the distribution of information in responding to biosecurity challenges.

1.7 The development of the Aquatic Deed is expected to allow for rapid responses to emergency aquatic animal disease incidents, provide incentives for early reporting of disease occurrence and support the development of strong risk mitigation measures.

1.8 These measures would also support trade and market access.

Landcare and marine

1.9 Coalition Senators note that marine conservation in inshore waters is largely the responsibility of state and territory governments. Where the Commonwealth does invest in marine conservation, especially within the Commonwealth's jurisdiction, Coalition Senators point to the wide variety of conservation activities supported by the Australian Government. These activities include: regulatory measures aimed at safeguarding matters of national environmental significance; measures to improve onshore catchment management; marine debris clean-up; management of the Great Barrier Reef Marine Park; and management of Australia's network of Commonwealth Marine Parks.

1.10 In terms of the National Landcare Program, Coalition Senators highlight the continuing and longstanding commitment of the Australian Government to natural resource management, with more than $1 billion invested for phase two of the Program, which will be delivered from July 2017 to June 2023, as announced in the 2017–18 Budget.

1.11 The phase two investment includes:

- $450 million for the Regional Land Partnerships Program to deliver natural resource management at a regional scale;
- funding for additional biosecurity measures to support the eradication of the Red Imported Fire Ant;
- $47.4 million for the management of our treasured World Heritage sites;
- $24.7 million towards delivering the *Reef 2050 Long-Term Sustainability Plan*, in addition to the $83 million already allocated under the Program to implement the Plan from 2018–19 to 2021–22;
- $93 million for the ongoing support of existing Indigenous Protected Areas plus $15 million in new funding;
- funding for the establishment of the $20 million Centre for Invasive Species Solutions to drive research, development and extension activities to protect native ecosystems and habitats from pest animals and weeds; and
- $5 million for an environment small grants program which local community and environment groups can access (up to $50,000) for local natural resource management activities.

Engagement of Traditional Owners and Indigenous Protected Areas

1.12 Coalition Senators support appropriate and proportional consultation strategies for consulting with Indigenous fishers on relevant fisheries management matters.

1.13 Coalition Senators note that Indigenous fishing primarily occurs in state managed waters and, as such, there is limited intersection of Indigenous fishing issues with Commonwealth fisheries management, with the exception of the Torres Strait fisheries and the Northern Prawn Fishery.

1.14 Enhancing engagement between Traditional Owners, government and research agencies in relation to climate change can provided benefits toward management of the marine estate by Traditional Owners.

1.15 Consideration would need to be given to the appropriate models for engagement and resourcing requirements. Funding would need to be considered in the context of other budget priorities and should be outcomes focused.

1.16 Coalition Senators note that the rights of Indigenous fishers are already recognised in Torres Strait fisheries and are central to the management of fisheries in the Torres Strait under the Protected Zone Joint Authority. The Queensland Government also has a role in the management of fisheries under the Protected Zone Joint Authority.

Offshore Constitutional Settlement arrangements

1.17 Coalition Senators note that the Australian Government is working with jurisdictions to resolve all shared fisheries and fish stocks subject to inconsistent management arrangements through reforms to Offshore Constitutional Settlement (OCS) arrangements.

1.18 The Australian Government, in consultation with the state and Northern Territory governments, has identified priority issues that need addressing and will continue to consider inconsistent management arrangements between jurisdictions on a case-by-case basis, taking into account the costs and the net benefits of potential reforms.

1.19 Resolving some OCS matters can be very resource intensive. Priority issues are determined on the assessment of likely returns. Cross-jurisdictional cooperation is hampered by differing fisheries management objectives and approaches between jurisdictions.

1.20 Coalition Senators note that without significant efforts to harmonise or implement consistent harvest strategy regimes, including the use of output controls, such as individual transferable quota and individual transferable effort regimes, and resource allocation policies, efforts for greater cross-jurisdictional cooperation may have limited effectiveness.

State and territory recreational fisheries

1.21 Coalition Senators highlight that recreational fishing activity is not managed by the Commonwealth. Implementation of a harmonised licence is primarily a state and territory issue that would need to be driven by state and territory governments. Coalition Senators note that some jurisdictions and recreational fishers are strongly opposed to recreational fishing licences.

1.22 Coalition Senators recognise that a harmonised low-cost recreational fishing licence across all Australian jurisdictions could assist in implementing mechanisms to enhance data collection arrangements for recreational fishing and support better management of the resource for all users.

1.23 However, Coalition Senators recognise the varying licence programs implemented by states and the Northern Territory and the differing reasons for and roles these programs play.

1.24 Coalition Senators further note that the collection of national recreational fishing data requires the cooperation of state and territory governments, including financial and in-kind support, and the resolution of a range of technical issues to capture appropriate information from a highly diverse and fragmented sector.

1.25 The implementation of a comprehensive national survey was costed at $6.8 million. State and territory governments have indicated they are not in a position to co-fund a national recreational fishing survey.

1.26 The Australian Government has agreed to a national survey of recreational fishers in 2018, which will collect information on social and economic contribution.

Greenhouse trigger

1.27 Coalition Senators hold concern for the recommendation that a greenhouse trigger be considered for inclusion in the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Emissions management needs to be on a landscape scale, either national or international, rather than at a project scale. Coalition Senators regard other instruments as more appropriate mechanisms to deal with emissions than the EPBC Act.

National Oceans Commissioner

1.28 The Coalition Senators support the longstanding roles of dedicated Commonwealth agencies which manage our marine environment including, but not limited to, the Australian Institute of Marine Science, the Great Barrier Reef Marine Park Authority, Parks Australia, the Australian Fisheries Management Authority, Australian Antarctic Division and Geoscience Australia.

Marine Protected Areas

1.29 Coalition Senators support the existing regulatory arrangements that give effect to management of Commonwealth marine reserves. Within this existing regulatory framework, the Australian Government has committed to maintaining the National Representative System of Marine Protected Areas.

1.30 Coalition Senators note that an extensive consultation process, supporting a review, for Australia's network of Marine Parks in the South-west, North-west, North and Temperate East Networks and the Coral Sea was completed in September 2017.

1.31 It is intended that the draft management plans for these parks will seek to balance protecting important marine habitats and features, while providing opportunities for people to continue to use and enjoy these unique areas. The draft plans also propose a targeted approach to zoning in marine parks that would appropriately protect conservation features (like canyons, seamounts and reefs) while enabling economically important activities like fishing and tourism to continue.

1.32 Final management plans for these five regions will set out the approach Parks Australia will take in managing the marine parks over the next ten years. Provisions in the plans will protect important marine habitats and features, while providing opportunities for people to continue to enjoy these unique areas.

1.33 The Government has committed $56.1 million over four years to develop and implement these plans once finalised, including to support management, research, user engagement and industry assistance for commercial fishers directly affected.

Reef 2050 Long-Term Sustainability Plan

1.34 Coalition Senators share the commitment to protecting the Great Barrier Reef, a World Heritage site, for future generations and note that the Australian Government is doing this through sound policy, substantial direct investment, and world-class marine park management.

1.35 The Australian and Queensland governments developed the Reef 2050 Plan, a 35-year blueprint to improve the health and resilience of the Reef. Together with the Queensland Government, more than $2 billion will be invested in the health of the Reef over the coming decade.

1.36 It is acknowledged that climate change is a threat to reefs worldwide and Coalition Senators note the strong action already taken by the Australian Government to address the global threat of climate change and the ratification of the Paris Agreement. This ratification confirms Australia's ambitious and responsible target to reduce emissions by 26–28 per cent below 2005 levels by 2030 and to play its part in achieving zero net emissions in the second half of the century. Australia's target is amongst the strongest of any G20 country on a per capita basis.

1.37 The Great Barrier Reef Ministerial Forum met on 28 July 2017 and agreed to the early, immediate commencement of the Reef 2050 Plan mid-term review to identify and accelerate priority actions for managing the health of the Reef. They also charged the Independent Expert Panel with developing problem statements for an Innovation Challenge to encourage new ideas to protect the Reef. The problem statements have been prepared and the Australian and Queensland governments are now examining options for undertaking an Innovation Challenge.

Great Barrier Reef Marine Park Authority

1.38 Coalition Senators point out that the Australian Government is already fully funding the Great Barrier Reef Marine Park Authority and, alongside the Queensland Government, is investing $2 billion over the next decade to ensure the health of the Reef. Coalition Senators recognise that every effort needs to be made to mitigate the threats to the Great Barrier Reef and are committed to its long-term protection and best practice management.

1.39 Coalition Senators also note that the Australian Government announced on 20 December 2016 a $124 million funding boost to the Authority over the next ten years to augment its position as the lead Authority in Reef management.

1.40 Further, to ensure the Authority's resources are being put to the most efficient use, in March this year, the Australian Government commissioned an independent review to determine whether the current arrangements continue to be the best fit to support the Authority's important and challenging work over the coming decades.

1.41 The Australian Government has released the review's report which outlines governance recommendations to further strengthen the Authority.

1.42 Coalition Senators note that the Australian Government is currently considering these recommendations and will soon provide a response to the report.

Senator Jonathon Duniam
Deputy Chair
Senator for Tasmania

Senator Linda Reynolds CSC
Senator for Western Australia

Appendix 1

Submissions, tabled documents, answers to questions on notice and additional information

Submissions

1 Institute for Marine and Antarctic Studies, University of Tasmania
2 Fisheries Research and Development Corporation
3 OceanWatch Australia
4 EDOs of Australia
5 Australian Marine Sciences Association
6 Austral Fisheries
7 Dr Matt Landos
8 Sydney Institute of Marine Science
9 Australian Fisheries Management Authority
10 Australian Institute of Marine Science
11 WWF-Australia
12 Australian Environment Foundation
13 Australian Meteorological and Oceanographic Society
14 Queensland Government
15 Commonwealth Scientific and Industrial Research Organisation
16 Torres Strait Regional Authority
17 Northern Land Council
18 Department of Agriculture and Water Resources
19 Department of the Environment and Energy
20 Great Barrier Reef Marine Park Authority
21 Government of South Australia
22 Northern Territory Seafood Council
23 Dr Trevor Ward and Professor David Booth
24 Australian Marine Conservation Society
25 Ms Hayley Morris, Morris Group

Tabled documents

Mr Michael Baron, Eaglehawk Dive Centre – Photographs of giant kelp forest (public hearing, Hobart, 21 February 2017)

Austral Fisheries – "Climate Change and Director's Duties" Memorandum of Opinion (public hearing, Hobart, 21 February 2017)

Mr Steven Moon, Association of Marine Park Tourism Operators – Opening statement (public hearing, Cairns, 29 August 2017)

Ms Sheriden Morris, Reef and Rainforest Research Centre – Graph depicting tide movement and heating periods (public hearing, Cairns, 29 August 2017)

Mr John Rumney, Great Barrier Reef Legacy – Handout on Great Barrier Reef Legacy (public hearing, Cairns, 29 August 2017)

Dr James Findlay, Australian Fisheries Management Authority – Opening statement (public hearing, Canberra, 20 October 2017)

Answers to questions on notice

Sydney Institute of Marine Science – Answer to question taken on notice, public hearing, Sydney, 16 March 2017 (received 17 March 2017)

OceanWatch – Answers to questions taken on notice, public hearing, Sydney, 16 March 2017 (received 4 April 2017)

Commonwealth Scientific and Industrial Research Organisation – Answers to questions taken on notice, public hearing, Sydney, 17 March 2017 (received 13 April 2017)

Commonwealth Scientific and Industrial Research Organisation – Answers to questions taken on notice, public hearing, Sydney, 17 March 2017 (received 20 April 2017)

Mr Tony Fontes – Answer to question taken on notice, public hearing, Townsville, 30 August 2017 (received 3 September 2017)

Great Barrier Reef Marine Park Authority – Answer to question on notice, public hearing, Townsville, 30 August 2017 (received 28 September 2017)

Dr Andrew Hoey, ARC Centre of Excellence for Coral Reef Studies – Answers to questions taken on notice, public hearing, Townsville, 30 August 2017 (received 20 September 2017)

Additional information

Professor David Booth – Photographs and charts referred to in evidence during 16 March 2017 public hearing

OceanWatch Australia – OceanWatch Australia, draft National Marine Natural Resource Management Plan 2012-2022

OceanWatch Australia – N Duke et al (2017), 'Large-scale dieback of mangroves in Australia's Gulf of Carpentaria: a severe ecosystem response, coincidental with an unusually extreme weather event'

Ocean Watch Australia – N Duke (2017), 'Climate calamity along Australia's gulf coast'

Dr Janice Lough – Frieler et al (2012), 'Limiting global warming to 2 degrees Celcius is unlikely to save most coral reefs'

Dr Janice Lough – Gattuso et al (2015), 'Contrasting futures for ocean and society from different anthropogenic CO2 emissions scenarios'

Dr Janice Lough – Australian Institute of Marine Science, 'Long-term Reef Monitoring Program –Annual summary report on coral reef condition for 2016/17'

Appendix 2

Public hearings

Tuesday, 21 February 2017, Hobart

Institute for Marine and Antarctic Studies

Professor Gustaaf Hallegraeff, Research Scientist
Professor Stewart Frusher, Research Scientist
Dr Neville Barrett, Research Scientist

Eaglehawk Dive Centre

Mr Mick Baron, Owner

Oysters Tasmania

Mr Neil Stump, Executive Officer

Austral Fisheries

Mr Martin Exel, General Manager, Environment and Policy

Tasmanian Conservation Trust

Mr Peter McGlone, Director
Mr Jon Bryan, Marine Campaigner

Thursday, 16 March 2016, Sydney

Professor David Booth – via teleconference

EDOs of Australia

Ms Susan Higginson, Chief Executive Officer
Dr Megan Kessler, Scientific Director, Environmental Defenders Office New South Wales

Professional Fishermen's Association of NSW – via teleconference

Ms Patricia Beatty, Executive Officer

Sydney Institute of Marine Science

Professor David Andrew Raftos, Chair, Scientific Advisory Committee
Professor Iain M Suthers, Professor
Dr Adriana Verges, Senior Lecturer

World Wildlife Fund

Ms Jo-anne McCrea, Australian Fisheries and Seafood Manager

OceanWatch Australia

Ms Lowrie Pryce, Executive Officer
Mr Simon Rowe, Program Manager – Environment

New South Wales Department of Primary Industries

Dr Alan Jordan, Principal Research Scientist

Friday, 17 March 2017, Sydney

Commonwealth Scientific and Industrial Research Organisation

Dr Andreas Schiller, Acting Director, Oceans and Atmosphere
Dr David Smith, Acting Science and Deputy Director, Oceans and Atmosphere
Dr Alistair Hobday, Senior Principal Research Scientist

Tuesday, 29 August 2017, Cairns

Reef and Rainforest Research Centre

Sheriden Morris, Managing Director

Wavelength Reef Cruises

Mr John Edmondson, Owner/Director

Association of Marine Park Tourism Operators

Mr Steven Moon, OAM

Northern Escape Collection – via teleconference

Ms Hayley Morris, Executive Director, Morris Group

Great Barrier Reef Legacy

Mr John Rumney, Managing Director

Wednesday, 30 August 2017, Townsville

ARC Centre of Excellence for Coral Reef Studies, James Cook University

Dr Andrew Hoey, Reef Ecologist

Professor Damien Wayne Burrows – Private capacity

Australian Marine Conservation Society

Mr Tony Fontes, Reef Campaigner

Australian Institute of Marine Science

Dr Katharina Fabricius, Senior Principal Research Scientist
Dr Janice Lough, Senior Principal Research Scientist
Dr Michelle Heupel, Senior Research Scientist

Great Barrier Reef Marine Park Authority

Dr David Wachenfeld, Director, Reef Recovery
Mr Darren Cameron, Manager, Sustainable Fisheries
Mr Dylan Horne, Manager, Ecosystem Resilience

Friday, 20 October 2017, Canberra

Northern Land Council

Mr Matthew Salmon, Manager, Caring for Country

Australian Fisheries Management Authority

Dr James Findlay, Chief Executive Officer
Dr Nick Rayns, Executive Manager, Fisheries

Department of Agriculture and Water Resources

Mr Ian Thompson, First Assistant Secretary, Sustainable Agriculture, Fisheries and Forestry Division
Mr Gordon Neil, Assistant Secretary, Fisheries Branch
Mr Tony Harman, Director, Fisheries and Marine Environment