Nov. 14, 2016

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

RE: AMSA Submission to the inquiry on "Current and future impacts of climate change on marine fisheries and biodiversity"

Dear Committee Secretary,

The Australian Marine Science Committee is pleased to provide a submission to the Inquiry on "Current and future impacts of climate change on marine fisheries and biodiversity". AMSA is a professional society of over 800 members nationwide, committed to promoting marine sciences. Our members are from universities and government agencies and have expertise spanning all disciplines related to marine science. As many but not all of our members are also part of the Sydney Institute of Marine Science (SIMS) our submission shares the same views and certainly discussion of science for the various terms of reference. The SIMS submission has done an excellent job of summarising issues especially pertinent to the East coast of Australia. In consideration of the committee's time, we do not repeat these points here but ask that they be considered as also representative of AMSA's view. Below we expand on these points where necessary to provide an Australian-wide context.

General comments

The topic of this inquiry is very large and there is a broad body of scientific literature that addresses it. There is unequivocal evidence that ocean conditions around Australia are changing at a rate that is amongst the fastest in the world due to climate change. There is also an ever-expanding body of work that documents the effects of these changes, including changes to species distributions and the makeup of entire assemblages. While we have made an attempt at summarizing the relevant part of this literature below (and in the SIMS submission), AMSA would suggest that a truly exhaustive analysis of this body of work within the Australian context is beyond the scope of a single submission. AMSA would strongly encourage the Senate to commission an independent scientific study to compile the required information.

Kind regards,

Associate Professor Will Figueira
President, Australian Marine Sciences Association

Comments on Terms of Reference (in addition to those from the SIMS submission)

a. recent and projected changes in ocean temperatures, currents and chemistry associated with climate change

While rates of increase in ocean temperature do seem to be greatest in SE Australia (Lough and Hobday 2011), there are also notable increases throughout tropical Australia as well as along the West and South coast's (García Molinos et al. 2015) driven by increases in Leeuwin current strength. Recent heat waves on WA (2011) and the Great Barrier Reef (2016) which lead to widespread death of key habitat forming organisms (kelp and corals respectively) are indicative of the future predicted warming for Australian waters of 1-3° C by the end of the century.

b. recent and projected changes in fish stocks, marine biodiversity and marine ecosystems associated with climate change

Recent scientific studies on the effects of climate change on fisheries indicate that extreme weather events, changes in ocean temperatures, currents and acidity will, and already are, changing the distribution and resilience of fish stocks (Munday et al. 2009, Gillanders et al. 2011, Meynecke and Lee 2011). The area of greatest warming (SE Australia) also supplies approximately 50% of Australia's fish production and has seen warming related distributional shifts in species from about 30% of inshore fish families (see summary in Hobday and Pecl 2013). These shifts are especially noteworthy for Tasmanian waters 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. It is also important to acknowledge that impacts of climate change are likely to be cumulative, although initially they may be non-lethal [e.g., reduced reproduction, changes in timing of reproduction and reduced rates of calcification in some species (Przeslawski et al. 2008)]. Severe impacts from climate change on fishing communities are expected and, in some places, are already in occurring due to increased abundance of invasive species and rising temperatures (Ling et al. 2009).

Changes in biodiversity and flow-on effects on fish stocks are likely to vary geographically and especially latitudinally given the variable intensities of climate change factors such as temperature across this gradient and the existence of appropriate refuge habitat into which organisms can move. Modelling based on climate velocities and current species distributions has suggested that Northern Australia and Papua New Guinea will experience the highest drops in species richness (number of species) of anywhere on the planet (García Molinos et al. 2015). For Australia as a whole a modest increase is actually expected (as tropical species not currently present move poleward into temperate Australian waters) though the makeup of the species assemblage is quite likely to be changed considerably in any given location. The East and West coasts are likely to experience overall net homogenization of assemblages over the rest of the century due to poleward range shifts and species invasions (García Molinos et al. 2015). Recent analyses of range shifts which are occurring along the east coast of Australia suggests that organisms which have high dispersive capacity and are ecological generalist in some way (diet, habitat preference) will be best able to keep pace with climate change by moving (Sunday et al. 2015).

The marine heat wave off Western Australia in 2011, which saw water temperatures of more than 3° C above long-term monthly averages, provides some suggestions of what changes long-term warming in the region may bring. In this case the event was followed by an extensive "tropicalisation" of the fish community which, 5 years on, seems to be persistent, and a die off of kelp from which the system has yet to fully recover (Wernberg et al. 2016).

There is an urgent need for scientific documentation of changes experienced so that management of fisheries can incorporate climate change impacts on fish stocks. An example of an ongoing

scientific initiative to document range extensions of fishes is 'Redmap' which includes fishers registering unusual sightings of marine species along the coast of Tasmania (www.redmap.org.au). This project has been used to identify the range extension of 8 different fish species so far (Robinson et al. 2015).

c. recent and projected changes in marine pest and diseases associated with climate change

In addition to the important links between climate change and disease highlighted in the SIM submission, it is important also to note that invasive species originating from warmer waters could find more favourable conditions with ocean warming, and gain a competitive advantage over native species (Robinson et al. 2015).

d. the impact of these changes on commercial fishing and aquaculture, including associated business activity and employment

As summarised in the SIMS submission, the flow on effects to fisheries are difficult to assess given the added complexity of the fishery response to changes in the geography or dynamics of target species. The marine heat wave off West Australia led to massive mortality (99%) of Roe's abalone in northern regions and this lucrative fishery has been closed indefinitely (Caputi et al. 2015). This event also impacted short-lived species such as crabs and scallops in specific regions where fisheries were completely closed in 2012 (Caputi et al. 2014).

e. the impact of these changes on recreational fishing

The impacts of climate change on recreational fisheries will depend upon the mobility and target specificity of the fisheries. As indicated in the SIMS submission, this can make recreational fishers particularly vulnerable to climate change. We are already seeing shifts in the distribution of many of the target species. Where anglers are happy to move they may be able to continue to access desired catch. But this movement will come at a cost of course and thus is likely to affect the economics of fishing for individual participants. Where fishers are flexible about their target, they may experience lower impacts. But where fishers are targeting something specific, there are likely to be larger impacts. For instance, in the Roe's abalone fishery described above, about 40% of the catch was historically recreational. The closure of this fishery in certain northern regions would have had a large impact on fishers.

f. the adequacy of current quota-setting and access rights provisions and processes given current and projected climate change impacts

The key challenge to management of access and harvest imposed by climate change is the rapid changes to stock sizes that are likely to occur in any given area. Good stock management relies upon accurate estimates of the stock size as well as the effort imposed upon it. Management systems must be set up to collect information on both these aspects and be flexible to alterations in access and quota allocations over time as the species composition of specific geographic areas changes.

g. the adequacy of current and proposed marine biodiversity protections given current and projected climate change impacts

One of the primary management techniques used currently in Australia (and worldwide) for the management and protection of biodiversity is spatial closures or marine parks. As we've outlined in our position statement (https://www.amsa.asn.au/sites/default/files/AMSA_MPA_PositionStatement_June2012_final.pdf) and several previous submissions to government on this matter (https://www.amsa.asn.au/submissions), no-take zones are a cornerstone for complete biodiversity protection. For spatial management systems to be robust to climate change, they must therefore

include multiple no-take areas which represent the various habitat to be protected at an adequate level, but there must also be a network of such zones spread geographically. This will afford the management and conservation benefit to as wide a variety of organisms as possible, even as changes occur to the assemblage locally. Based on our recent review of the proposed changes to the commonwealth marine reserve network it would appear that this goal is generally not met as there are relatively few no-take zones within the various bioregions. The aim suggested by the scientific panel for the review, to have at least one no-take zone per management area, was not achieved, especially in the climate change sensitive temperate-east bioregion.

h. the adequacy of biosecurity measures and monitoring systems given current and projected climate change impacts

As highlighted in the SIMS submission, while biosecurity measures in Australia are relatively advanced, the appearance of Pacific Oyster Mortality Syndrome from overseas is an indication that they could be better.

i. any other related matters.

The information presented here is largely a snapshot of a variety of active research in this area. It is clear climate change is affecting oceanic properties at a very fast rate in Australia and that we are already observing these affects in the biota. There is general scientific consensus that such changes will increase and effects on fisheries are beginning to be seen. However understanding the long-term effects requires long-term planning and thinking. There is a need for on-going data series as well experimental investigations into the effects of climate change on food web structure in order to fully understand the changes occurring in the marine ecosystems and how they affect human use of living marine resources.

Literature Cited

Caputi, N., M. Feng, A. F. Pearce, J. Benthuysen, A. Denham, Y. Hetzel, R. Matear, G. Jackson, B. W. Molony, L. Joll, and A. Chandrapavan. 2015. Management implications of climate change effect on fisheries in Western Australia, Part 2: Case studies. . FRDC Project No. 2010/535. Fisheries Research Report No. 261. Department of Fisheries, Western Australia. 156pp.

Caputi, N., G. Jackson, and A. F. Pearce. 2014. The marine heat wave off Western Australia during the summer of 2010/11 – 2 years on. Fisheries Research Report No. 250. Department of Fisheries, Western Australia. 40pp. **2014**.

García Molinos, J., Benjamin S. Halpern, David S. Schoeman, Christopher J. Brown, W. Kiessling, Pippa J. Moore, John M. Pandolfi, Elvira S. Poloczanska, Anthony J. Richardson, and Michael T. Burrows. 2015. Climate velocity and the future global redistribution of marine biodiversity. Nature Climate Change **6**:83-88.

Gillanders, B. M., T. S. Elsdon, I. A. Halliday, G. P. Jenkins, J. B. Robins, and F. J. Valesini. 2011. Potential effects of climate change on Australian estuaries and fish utilising estuaries: a review. Marine and Freshwater Research **62**:1115-1131.

Hobday, A. J., and G. T. Pecl. 2013. Identification of global marine hotspots: sentinels for change and vanguards for adaptation action. Reviews in Fish Biology and Fisheries **24**:415-425.

Ling, S. D., C. R. Johnson, S. D. Frusher, and K. R. Ridgway. 2009. Overfishing reduces resilience of kelp beds to climate-driven catastrophic phase shift. Proceedings of the National Academy of Sciences of the United States of America **106**:22341-22345.

Lough, J. M., and A. J. Hobday. 2011. Observed climate change in Australian marine and freshwater environments. Marine and Freshwater Research **62**:984-999.

Meynecke, J.-O., and S. Y. Lee. 2011. Climate-coastal fisheries relationships and their spatial variation in Queensland, Australia. Fisheries Research **110**:365-376.

Munday, P. L., J. M. Leis, J. M. Lough, C. B. Paris, M. J. Kingsford, M. L. Berumen, and J. Lambrechts. 2009. Climate change and coral reef connectivity. Coral reefs.

Przeslawski, R., S. Ahyong, M. Byrne, G. WÖRheide, and P. A. T. Hutchings. 2008. Beyond corals and fish: the effects of climate change on noncoral benthic invertebrates of tropical reefs. Global Change Biology **14**:2773-2795.

Robinson, L. M., D. C. Gledhill, N. A. Moltschaniwskyj, A. J. Hobday, S. Frusher, N.Barrett, J. Stuart-Smith, and G. T. Pecl. 2015. Rapid assessment of an ocean warming hotspot reveals “high” confidence in potential species’ range extensions. Global Environmental Change **31**:28-37.

Sunday, J. M., G. T. Pecl, S. Frusher, A. J. Hobday, N. Hill, N. J. Holbrook, G. J. Edgar, R. Stuart-Smith, N. Barrett, T. Wernberg, R. A. Watson, D. A. Smale, E. A. Fulton, D. Slawinski, M. Feng, B. T. Radford, P. A. Thompson, and A. E. Bates. 2015. Species traits and climate velocity explain geographic range shifts in an ocean-warming hotspot. Ecology Letters **18**:944-953.

Wernberg, T., S. Bennett, R. C. Babcock, T. de Bettignies, K. Cure, M. Depczynski, F. Dufois, J. Fromont, C. J. Fulton, R. K. Hovey, E. S. Harvey, T. H. Holmes, G. A. Kendrick, B. Radford, J. Santana-Garcon, B. J. Saunders, D. A. Smale, M. S. Thomsen, C. A. Tuckett, F. Tuya, M. A. Vanderklift, and S. Wilson. 2016. Climate-driven regime shift of a temperate marine ecosystem. Science **353**:169-172.