A contribution to

An analysis of medium to long-term impacts on the Australian Oceans

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1.1 Ecosystem Services

Marine ecosystem services are the direct benefits which people obtain from marine ecosystems including tourism, fishing, boating, fisheries, aquaculture, energy, medicine, water (desalination plants). Ecosystem services are also indirect e.g. climate regulation, nutrient cycling, coastal protection (Costanza et al., 2014).

The Great Barrier Reef (GBR) is the world's largest coral reef ecosystem and its ecosystem services was estimated to add AU$ 6.4 billion to Australian economy and provide 64,000 jobs in 2011/12 (O'Mahony, 2017). Australia's Great Barrier Reef surveys suggested that reef trips by divers and snorkelers could fall by up to 80% under scenarios of climate-induced reef quality decline principally coral degradation and fish decrease, resulting in lost tourism expenditures in the Cairns area of AUD103 million per year (Kragt, Roebeling, & Ruijs, 2009).
GBR will be 2°C to 6°C warmer than today by 2100, coral cover will decrease to less than 5% and will be replaced by seaweed and blue green algae (O. H.-G. Hoegh-Guldberg, H., 2008). The resulting loss to Queensland communities will be up to $8 billion by 2020. To minimise the damage to coral developed countries will need to reduce the emissions by 80% based on 1990 levels by 2050 and by 2100 to close to zero. Queensland government must manage fishery sustainably and trawling needs to be phased out and marine sanctuaries established. Reef Water Quality Protection Plan needs to be implemented.

Coastal tourism is projected to be highly affected by climate change by 2070 with tropical North Queensland, Townsville, South West and Gascoyne being most threatened scoring 25 and above (highest score of assessed vulnerability in terms of climate change) and Sydney, Great Ocean Road, Phillip Island/Gippsland, Fraser Coast, South East and Pilbara least threatened (score of 15-19) (H. Hoegh-Guldberg, 2008).

The following scenarios explore how climate change and global and Australian development impact GBR ecosystem services (Bohensky et al., 2011). Scenario Trashing the Commons (by 2100 global warming exceeds 3.5°C, sea level rises by 1 m, cyclones increase in intensity, marine waters are more acidic (pH 7.7), rainfall is more erratic, the population in catchments adjacent to GBR reaches 3 million and economy grows including irrigation and extractive industries) predicts that coral cover will disappear and reefs will be irreversibly dominated by algae. The international tourism shifts from reef to beaches and shopping. Scenario Free Riders (temperature stabilizes by 2100 to <2°C and CO_2 concentrations stabilizes at 350 ppm, seawater pH is 8.0, storm intensity and rainfall patterns do not change much and sea level does not rise more than 0.3 m, irrigated agriculture persists, economic growth is based on extractive industry and GBR catchments population increases by 2.5 million) predicts that coral cover will decline to 20% by 2050 and fish biomass by 70%. Scenario Best of Both Worlds (global climate change is managed and mitigated through regional scale development with CO_2 returning to 350 ppm, temperature stabilizes at 2 °C above pre-industrial level, sea level rises by 0.3 m, Australian economy is based on global faire trade and population increases to 2 million coral cover will remain similar to present, tourism industry remains the primary industry followed by low level agriculture and aquaculture and renewable energy.

(Bell et al., 2018) predicts a shift toward sponge dominance on reefs if sponges exhibit high environmental resilience in face of climate change. Sponge dominated system will result in in reduction of habitat complexity reducing fish abundance and diversity, and make fish more vulnerable to predation. Under global change and fishing pressure changes to the function of coral reefs are predicted (Fig. 1). Mitigation options include marine protected areas, artificial reefs, coral restoration, fish aggregation devices and management of herbivores ((Rogers et al., 2015).

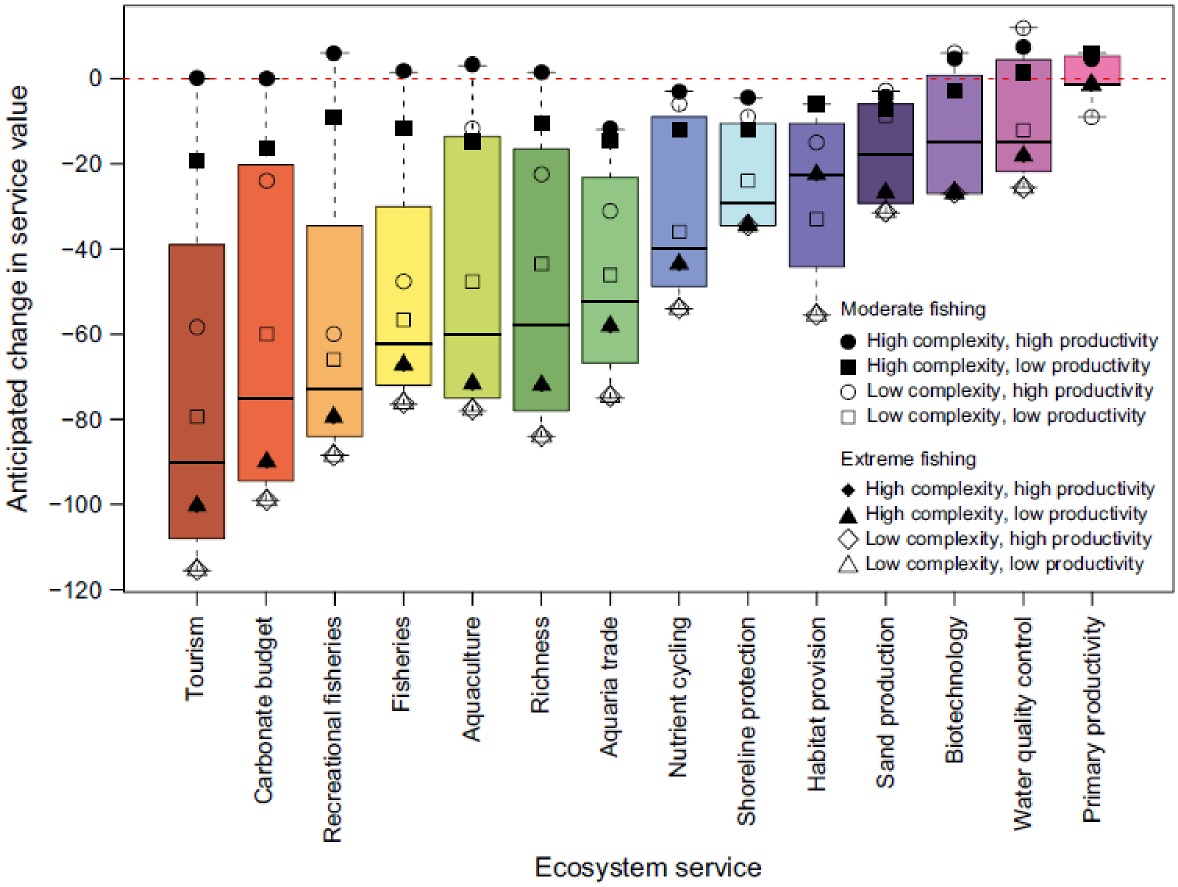

Fig. 1 Anticipated losses in the value of ecosystem services under projected decline in coral due to climate change and moderate or extreme overfishing ((Rogers et al., 2015).

Great Southern Reef (GSR) is Australia's spatially connected temperate reef system dominated by kelp forest covering 71,000 km^2 and generating AU$10 billion $year^{-1}$ (Bennett et al., 2016). The services provided by GSR is under threat due to global warming causing losses of kelp forests. The losses are predicted to increase over the next century due to localised pollution from nitrogen enrichment as the human population is projected to double by 2060. Management of local stressors by federal and state governments can mitigate kelp loss. In an unfished ocean due to climate change under RCP8.5 projected changes in total animal biomass was projected to reach ~19% around Australia from 1990s to 2100 and the change in biomass was projected to be uniform across all size classes (Bryndum-Buchholz et al., 2019). Climate change mitigation in line with RCP2.6 projected biomass declines of ~ 5%. Such changes will have socio-economic and food security impacts. Shifts towards warmer climate is projected to cause an increase in the probability of occurrence of marine heat waves (MHW) such as the 2011 Western Australia MHW that caused reduction in habitat forming kelp and subsequent shift in community structure and southward migration in tropical fish community (Frölicher & Laufkötter, 2018). Ocean acidification and deoxygenation exacerbate the stress caused by MHW. The Queensland commercial wild and aquaculture fisheries dominated by calcifying crustaceans and molluscs is projected to be vulnerable to the effects of ocean acidification with wild populations being more vulnerable (Richards et al., 2015). The resilience of wild prawns is predicted to be greater than scallops. If no mitigation is undertaken local extinctions are forecast. Suggested mitigation include increased research of effects of acidification and modelling of water quality, inclusion of acidification in risk assessment and capacity to modify the quality of seawater in aquaculture.

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