NCCARF
National
Climate Change Adaptation
Research Facility
Adaptation Research Network
MARINE BIODIVERSITY AND RESOURCES

School of Geography and Environmental Studies University of Tasmania
Private Bag 76, Hobart TAS 7001, Australia
Phone: 03 6226 2134 Fax: 03 6226 7628
arnmbr@arnmbr.org
www.nccarf.edu.au/marine/

Information Sheet prepared by
Peat Leith[1,2] and Marcus Haward[1,3]
1. Adaptation Research Network Marine Biodiversity and Resources
2. School of Geography and Environmental Studies, University of Tasmania
3. School of Government, University of Tasmania

Potential climate change impacts and adaptation pathways for the Australian edible oyster industry

Human induced climate change does not only mean a gradual warming of atmospheric temperature. We are seeing changes in ocean currents, in rainfall patterns, in seasonal conditions and in the frequency of extreme events. Some of these changes are expected to continue or intensify as greenhouse gas concentrations increase. In our bays and estuaries where oyster aquaculture takes place, the changes may well substantial, especially if climate change is viewed in the context of changing population pressures on waterways, land use and the growing sea-change phenomena that affects much of the eastern seaboard of Australia.

In the three major oyster producing states of Australia – New South Wales (NSW), South Australia (SA) and Tasmania (TAS) – oysters occupy a unique geographical position in bays and estuaries. The large majority of oysters grown in Australia are introduced Pacific oysters (POs) and, in NSW, Sydney rock oysters (SROs). As filter feeders, all oysters are susceptible to changes in water chemistry, temperature, and the availability of algae and other food.

The largely estuarine based industry in NSW and TAS is affected by upstream human action that can alter environmental flows and water quality. Changes in bacterial matter, turbidity, salinity, water temperature and a variety of other factors can lead to loss of condition and make oysters vulnerable to disease. In SA, oyster aquaculture mainly occurs in oceanic bays, in which terrestrial impacts are generally negligible. The TAS and SA industries are wholly dependent on hatchery reared juvenile oysters (spat). There has been a concerted and relatively successful effort to breed SROs for resistance to their two main diseases, QX and Winter Mortality. Breeding programs gained substantial support following QX outbreaks which destroyed the industry in two of the most important estuaries in 1994 (Georges River) and 2004 (Hawkesbury River). In NSW it is not uncommon for large-scale SROs kills following heatwave conditions, especially in the north. Biotoxins from harmful algal blooms (HABs) can contaminate oysters in all areas making them harmful to humans, and in some cases lethal. Some areas are much more susceptible to HABs than others.

Impacts, adaptive capacity and vulnerability are related terms. There are often feedbacks between them making vulnerability very complicated, even locally. Vulnerability is perhaps best thought of as a process within a particular place or sector, rather than a trait of an individual, locality or industry (Fig. 1.1).

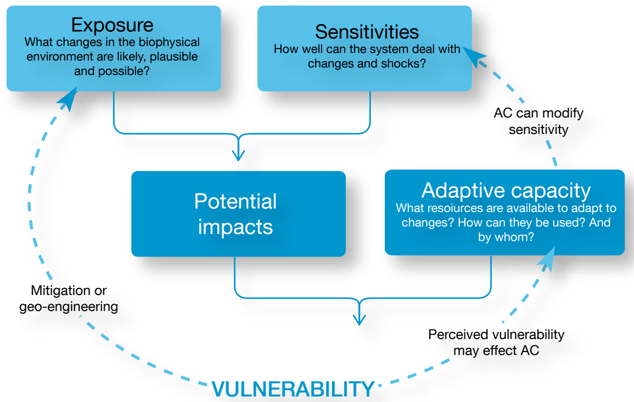

Figure 1.1: Defining vulnerability as process, rather than outcome highlights the potential feedbacks in social-ecological systems, adapted from Allen Consulting (2005)

This information sheet is based on a synthesis of the latest science on climate impacts and oyster sensitivities and a series of workshops and discussions with oyster growers, scientists, policy-makers, and other stakeholders across the three main oyster producing states of Australia (NSW, SA and TAS). More information about this project and opportunities to continue this discussion about adaptation are available at: www.arnmbr.org The process for the project involved four sequential stages, each informing the next (Fig. 1.2).

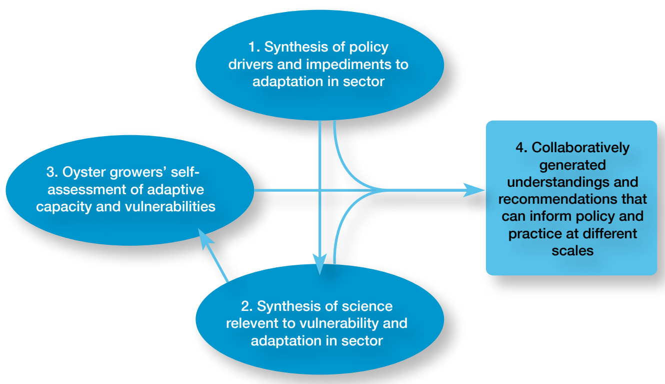

Figure 1.2: Schematic of approach to stages of RCVA applied in this project.

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Potential Impacts

Potential impacts vary with locality and there is variable confidence and uncertainty associated with different exposures and impacts. Nevertheless, modelling studies and observation consistently point to specific exposures and impacts. It will be useful for growers, industry bodies and government agencies to think through issues that will plausibly affect the oyster industry over coming years and decades. These projected exposures and potential impacts (outlined briefly in table) should therefore be considered as plausible scenarios for the purpose of planning and decision-making.

Adaptive capacity and adaptation pathways

Adaptation will require diverse strategies and linkages across the public and private sector. In the workshops across NSW, SA and TAS, oyster growers and other stakeholders identified a range of issues that are crucial to their adaptive capacity.

These ranged from technological and research-based approaches to more social and economic measures to strengthen the resilience of the industry and individual growers.

Technological approaches include development of new infrastructure or breeding lines of oysters that are less susceptible to disease and emerging conditions, such as acidification (Parker et al., 2009). More scientific effort is required to under-

	Projected exposures to climate changes			Potential impacts (positive and negative)		
	NSW	TAS	SA	NSW	TAS	SA
Average rainfall	Projections of mean annual rainfall indicate increases in the NE and a decline in the SE of the state ((Hennessy et al, 2007)). In the SE projected declines in run-off are up to 20% (Hennessy et al., 2007).	Over the 21st century rainfall on the east coast is projected to increase in summer and autumn and decrease in winter and spring (Grose et al, In Press).	Low average rainfall and low runoff into most oyster growing area mean that the effects of rainfall are small or negligible in SA.	Reduced rainfall could lead to reduced estuarine productivity and carrying capacity of lease sites. The abundance of flatworm in estuarine regions appears to be coupled with prolonged drought (Li and Clarke, 2010).		N/A
Extreme rainfall	Rainfall is projected to become more sporadic with more intense downpours and longer dry periods. Frequency of tropical cyclones is projected to increase by 22% by 2050* (Hennessy et al., 2007).	Projected increasing intensity of summer rainfall due to blocking high in Tasman Sea (Grose et al., In Press).	See above	High bacterial, nutrient and pollution loads, increasing frequency and duration of farm closures. High water temperature, increased rainfall, and reduced wind stress are key variables influencing bloom frequency and severity of a harmful algal species, which causes shellfish toxicity, in Tasmanian waters (Hallegraeff, 1992).		N/A
Air & Water temperature	Sea-surface temperatures increasing with southern excursion of the East Australian Current (EAC) coupled with background warming. Projections indicate 1°C by 2030 and 2.5°C by 2100 in NSW (Lough, 2009). 0.6 - 1.5°C increase in mean air temperature by 2030, with increasing frequency of heatwaves		Projections vary. The complexity of upwelling off the coast in SA creates substantial uncertainty. Upwelling events can result in a 2-3°C drop in SST (Kämpf et al, 2004).	Increased growth window for algal species, potentially increasing period of food availability. However, increases opportunity for HABs to occur (see above). May increase likelihood of QX disease and winter mortality in SRO, however, relationship is unclear. Temperature is also linked with summer mortality in POs, but in combination with many other factors. May disrupt timing of the reproductive cycle and impact reproductive success and larval development. Opportunistic pathogens infect oysters weakened by a combination of stress (ie. due to elevate temperature) and reproductive activity. Oyster growth rates may increase.		
Acidification	Projected acidification is poorly specified for coastal zone and estuaries: pCO2 of 490-1250 are possible given the range of SRES (Hennessy et al. 2007). Oceanic pH is projected to decline by 0.2 units over the course of the century (Hobday et al, 2008).			Calcification rate in POs has been shown to decline linearly with increasing pCO2 (Gazeau et al, 2007). International studies show that growth and healthy larval development is inhibited at elevated pCO2 levels (Gazeau et al., 2007). Australian studies on POs and SROs show that the combined effects of increasing temperature and acidification effects growth and reproduction (Parker et al, 2009).		
Sea-level rise	Up to, and potentially exceeding 0.8 metre increase by 2100 (Church et al, 2008).			Loss of suitable farming sites may occur over time. POs can be farmed sub-tidally, but practices are not well developed in Australia (Li and Clarke, 2010). Small changes in emersion time can dramatically effect oyster survival.		
Storm surge	Storm surges are expected to increase four-fold in frequency, leading to increased erosion and inundation of coastal areas.			Increases in storms will reduce the number of suitable work hours for farmers and increase levels of mechanical damage to infrastructure.		
Wind speed	Increases in wind speed of 0-1 m/s by 2070 are projected (CSIRO and Australian Bureau of Meteorology, 2007).			Increases in wind speed and associated waves may reduce the time farmers can access leases and increase levels of mechanical damage to infrastructure. Excessive water movement can effect oyster growth. May reduce frequency of HABs (see Tas example under 'Rainfall')		
Upwelling	Upwelling is an important source of nutrients in some coastal systems. Effects of climate change on upwelling systems are poorly understood.			Impacts unknown.		
Ocean currents	The East Australian and Leeuwin currents are expected to continue to intensify (Oulton, 2009), bringing warm nutrient-poor waters further south.			Nutrient-poor waters may have a negative impact on oyster productivity, and could affect the spread of harmful algal species.		
Salinity	Increasing evaporation and reduced rainfall in inlets in southern NSW will lead to higher salinity levels. Increased rainfall in northern NSW will lead to reduced salinity	Increasing evaporation rates may lead to higher salinity levels in low rainfall periods, and vice versa.	Increasing evaporation rates in gulfs and bays will lead to higher salinity levels on average.	In SROs, reduced salinity may exacerbate QX disease, and elevated salinity may exacerbate winter mortality, but these issues remain the subject of research (Butt et al, 2006)		Salinity is linked with summer mortality in POs, but in combination with many other factors. High salinity levels can reduce growth rates.

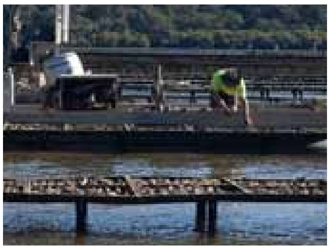
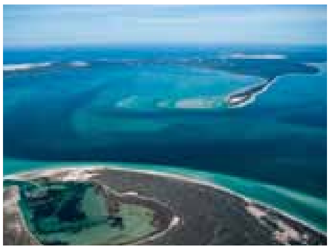
* Projections are based on Hennessy et al. high emissions (A1F1) scenario and drawn from Hennessy et al. (2007)

Image courtesy Oysters Tasmania

stand environmental conditions which make oyster susceptible to diseases (Li et al, 2007; Nell, 2007). Yet such understanding is unlikely to help inform policy or practice unless moves are made to develop cost-effective monitoring programs for estuaries and bays across oyster growing areas. As well as providing useful information to oyster growers, such programs could produce substantial public goods, through for example, providing baseline data for estuary health, evaluating upstream NRM and pollution mitigation strategies, and monitoring the changes of ecological function within our estuaries. Improving monitoring will require robust partnerships among, for example, industry bodies, growers, regional NRM authorities, local councils, schools and state government agencies. They will also require support of major national initiatives to improve water management.

The effectiveness of research initiatives, such as monitoring programs, is as dependent on social networks and institutions as they are on equipment and funding. In workshops growers articulated the need for improved networks of communication, decision-making and knowledge-production. Much of the time, especially where oysters are grown in estuaries, the best way to minimise the effects of climate impacts is to reduce non-climate stressors, such as those caused by pollution, acid sulphate soils or altered environmental flows. These sorts of issues require good natural resource governance, strong relationships between the industry and the broader community, and effective policy instruments to protect water quality and ensure that oyster aquaculture is treated as a priority use. Together, such processes, structures and networks can create a long-lasting 'social license to operate' for oyster aquaculture and will lay the foundations for an adaptive industry which can continue to develop and flourish in a changing climate.

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