



Climate change effects on the marine environment and fisheries: Western Australia

Leeuwin Current effect on marine environment

Along the coastline of Western Australia (WA) the Leeuwin Current has a significant effect on the marine environment and fisheries. The current flows southwards carrying warm, low-nutrient waters along the west and south coast of Australia¹. It has the highest eddy energy among all eastern boundary current systems in the world². This current is weaker during summer when there are strong opposing winds, and stronger during winter when the opposing winds cease. In late autumn/early winter, the current accelerates and rounds Cape Leeuwin off the southwest of WA and continues as an eastward shelf current along the southern coast of Australia. The strength of the current is influenced by El Niño - Southern Oscillation (ENSO) events being strong during La Niña events and weaker during El Niño events.

Environmental changes

The Leeuwin Current is driven by the variations and changes of the Pacific equatorial easterly winds. During the past two decades the current experienced a strengthening trend, which has almost reversed the weakening trend from the 1960s to the early 1990's³. Currently, most climate models project a weakening trend of the Pacific trade winds and a reduction of the Leeuwin Current strength in response to greenhouse gas forcing.

Some key environmental trends that may be affecting fish stocks of WA include:

- (a) changing frequency of ENSO events that affects the strength of the Leeuwin Current;
- (b) increase in water temperature off the lower west coast of WA, particularly in autumn-winter;
- (c) increase in salinity with large annual fluctuations;
- (d) change in frequency and location of storms (and rainfall) affecting the lower west coast of WA;
- (e) change in frequency of cyclones (and summer rainfall) affecting the north-west of WA; and
- (f) increase in sea level along the coast.

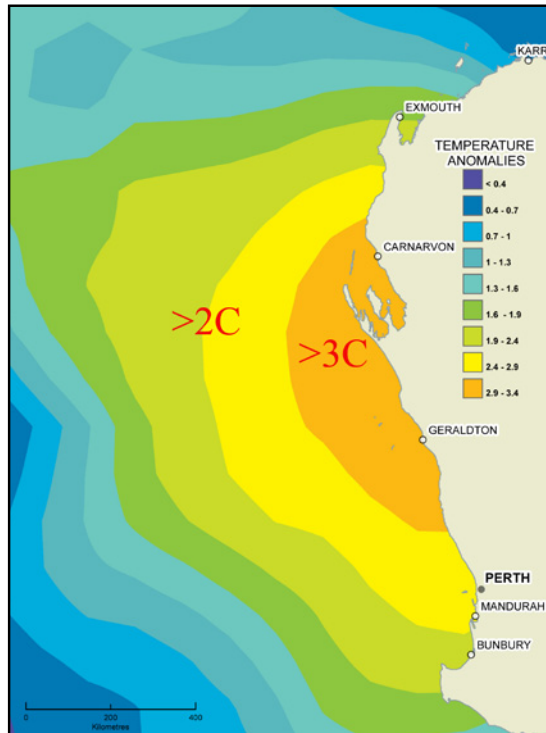
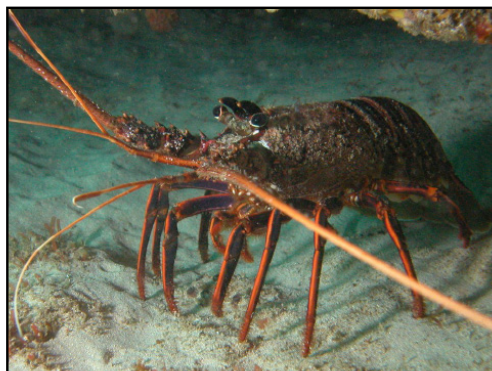


Figure 1: SST anomaly associated with the very strong La Niña during February 2011.

Marine heat wave

During the summer of 2010/11, the waters off WA experienced an unprecedented warming with some regions showing 3-4.5°C above average seasonal temperature, particularly through the mid-west and Gascoyne region (Figure 1). This “marine heat wave” event coincided with an extremely strong La Niña event and a record strength Leeuwin Current creating a major temperature anomaly superimposed on the underlying long-term ocean-warming trend⁴. The elevated water temperatures produced sub-lethal effects and mortalities of several fish species, as well as coral bleaching. Range extensions and changes to recruitment of some species were also noted. Dead fish, abalone and lobsters *Panulirus cygnus*, were reported along the mid-west coast and the Abrolhos Islands.

For example, Roe’s abalone *Haliotis roei*, near Kalbarri, suffered 99% mortality. These mortalities appear to have been caused by elevated water temperatures and calm conditions that probably resulted in deoxygenation.



Western rock lobster, *Panulirus cygnus*. Photo courtesy of WA Department of Fisheries

Whilst the longer-term biological consequences of the heat wave are still being understood, recreational fishers observed tropical fish species had extended further south, such as Spanish Mackerel *Scomberomus commerson*. The heat wave was also responsible for some spikes in recruitment such as commercial prawn species in Exmouth Gulf and Shark Bay and of tropical fish species at Rottnest Island. Both the Shark Bay saucer scallop *Amusium balloti* and blue swimmer crab *Portunus armatus*

stocks have suffered a severe recruitment failure, and a high mortality of adults in the months following the heat wave.

Fisheries management has been focused on protecting the remaining spawning stock with ongoing stock surveys to monitor the recovery process. Stock enhancement operations are also underway for Roe’s abalone in an attempt to restore the fishery. This extreme marine event has brought into focus the need for monitoring of pre-recruits and the development

of management tools to deal with increased climate extremes projected for the future⁴.

Effect on invertebrate fisheries

Climate change effects such as increasing water temperatures may have resulted in a decrease in size at maturity and the size of migrating lobsters from shallow to deep water⁵. The western rock lobster fishery is one of the best candidates to study climate change effects on a fishery in Australia as it has about 40 years of data in a number of biological variables such as *puerulus* (post-larval stage) abundance.

The poor lobster *puerulus* settlement and the 2010/11 marine heat wave effects on abalone, scallops and crab stocks have provided case studies for dealing with extreme climatic changes on fisheries. These case studies have highlighted the value of having a reliable pre-recruit abundance for an appropriate management adaptation response. The pre-recruit information enables early detection of changes in abundance that allows for proper assessment and early management intervention before fishing takes place on the poor year classes. The lag between the timing of the pre-recruit estimate and the fishery is 3-4 years for the western rock lobsters whereas for scallops and crabs the lag is only 3-6 months. These pre-recruit abundances also enable early planning by the fishing industry on the level of fishing (and catch) that is likely to occur in the coming season.

Effects on finfish fisheries

Long-term catch and effort data are available for most finfish fisheries. However, long-term data on biological variables that enable climate change effects to be examined historically are not available for WA finfish fisheries. From the modelled consequences of climate change⁶, the WA coast is expected to experience a 'tropicalisation' of the marine community in the future, with increasing dominance of warmer-water species. Available empirical data supports this view that the incidence of tropical species in temperate regions of the state is increasing. Conversely, the northern extent of a number of temperate species along the west coast appears to have

decreased. A longer time series of empirical records, such as stock abundance and recruitment, are needed to confirm the modelling. The advent of short-term heat wave events (summer 2010/11 and to lesser extent 2011/12) tend to confound the effects of longer-term climate change, i.e. the trend in water



Beached Australian salmon and Australian herring on a beach near Albany. Photo courtesy of WA Department of Fisheries

temperatures. Earlier work^{7,8} has confirmed links between the strength and timing of the Leeuwin Current, and the abundance of key scalefish species harvested by commercial fisheries off the WA coast. The primary focus has been on temperate species such as dhufish *Glaucosoma herbraicum*, Australian herring (family *Arripidae*), Australian salmon, tailor *Pomatomus saltatrix* and whitebait. Refinement of these relationships is continuing as results of ongoing monitoring become available.

References

1. Cresswell GR and Golding TJ (1980) Observations of a southward flowing current in the south-eastern Indian Ocean. *Deep-Sea Research* 27A: 449-466.
2. Feng M, Wijffels S, Godfrey S and Meyers G (2005) Do eddies play a role in the momentum balance of the Leeuwin Current? *Journal of Physical Oceanography* 35: 964-975.
3. Feng, M, Caputi N and Pearce A (2012) Leeuwin Current. In: *A Marine Climate Change Impacts and Adaptation Report Card for Australia 2012* (Eds. E.S. Poloczanska, A.J. Hobday and A.J. Richardson).
4. Pearce A, Lenanton R, Jackson G, et al. (2011) The "marine heat-wave" off Western Australia during the summer of 2010/11. *Fisheries Research Report No.222*. Department of Fisheries, Western Australia. 40 pp.
5. Caputi N, Melville-Smith R, de Lestang S, et al. (2010): The effect of climate change on the western rock lobster (*Panulirus cygnus*) fishery of Western Australia, *Canadian Journal of Fisheries & Aquatic Sciences*, 67, 85-96.
6. Cheung WW, Meeuwig JJ, Feng M, et al. (2012) Climate-change induced tropicalisation of marine communities in Western Australia. *Marine and Freshwater Research*, 2012, 63, 415-427.
7. Lenanton RC, Caputi N, Kangas M, et al. (2009) The ongoing influence of the Leeuwin Current on economically important fish and invertebrates off temperate Western Australia – has it changed? *Journal of the Royal Society of Western Australia*. 92:111-127.
8. Caputi N, Pearce A and Lenanton R (2010) Fisheries-dependent indicators of climate change in Western Australia WAMSI Sub-project 4.2.3. *Fisheries Research Report No. 213*. Department of Fisheries, Western Australia. 36pp.



Baldchin groper, *Choerodon rubescens*. Photo courtesy of WA Department of Fisheries

For further information regarding this article please contact: Nick.Caputi@fish.wa.gov.au or Arani.Chandrapavan@fish.wa.gov.au

About the Marine Adaptation Network

The Adaptation Research Network for Marine Biodiversity and Resources (a.k.a. the Marine Adaptation Network) is hosted by the University of Tasmania and convened by Assoc Prof Neil Holbrook. The Network is supported by 14 partner institutions nation-wide. It comprises a holistic framework of interconnecting marine themes that cross-cuts climate change risk, marine biodiversity and resources, socio-economics and policy. This interdisciplinary network aims to build adaptive capacity and adaptive response strategies for the effective management of marine biodiversity and living marine resources under climate change. For more information on the Marine Adaptation Network, or to subscribe to become a member of the Network, please visit www.nccarf.edu.au/marine/.