CLIMATE CHANGE, MARINE BIODIVERSITY AND THE FISHING AND AQUACULTURE INDUSTRIES

Climate change — we will experience a changing climate through increasing climate variability

Fishing and aquaculture — substantial opportunities to improve practices and management arrangements

Mitigation — reducing greenhouse gases is smart business sense

Adaptation — responding to a more variable and changing climate is essential for long term profitability

Research — part of boosting knowledge on marine biodiversity and fostering a smarter and more profitable fishing and aquaculture sector

Climate change

Weather is what we experience on a daily basis — sunshine, rain, wind. It is today and tomorrow and what a fisher looks at when deciding what they will do that day.

Climate variability is what you expect to experience over a longer period of time — more rainfall and floods or less rainfall and drought — with the resulting flow-on impacts on the environment and fish stocks.

Climate change is a shift in the baseline pattern of climate variability. The projections for increasing global air and ocean temperatures are well documented.

This *Climate change, marine biodiversity and the fishing and aquaculture industries* fact sheet has been prepared by the Fisheries Research and Development Corporation (FRDC).

FRDC has been investing in climate related research for 15 years to provide answers for its stakeholders.


WKNIGHT94


CORRES


ALPHA DU CENTAURE

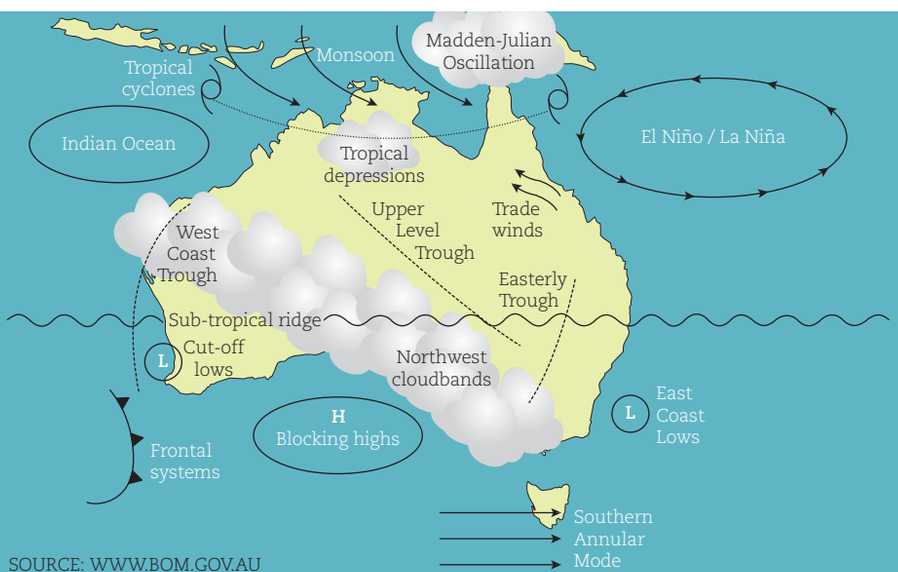

XENODREAM

AXEL ROUVIN

Climate drivers across Australia

There are a number of climate drivers that influence weather patterns in Australia (and rest of the world). For example:

- El Niño/La Niña Southern Oscillation — the temperature range that occurs in the Pacific over a number of years. This system influences climate and generally leads to wetter or drier conditions across most of eastern Australia depending on the cycle.
- Indian Ocean Dipole — the temperature range that occurs over a time scale of months to years in the Indian Ocean. This system influences the climate across western Australia.
- Southern Annular Mode — the temperature and pressure ranges associated with the Southern Ocean, with varied time scales (both short and long term). This system generally brings rain to southern Australia when it is in its northernmost phases.
- Cloud bands — these start in mid north west Australia and move south east. They bring high and low pressure changes and determine available moisture.
- Frontal changes — these start in the south west moving towards the south east and Southern Indian Ocean. They bring rain and wind.
- Madden-Julian Oscillation — the system pulses in waves with eight distinct phases. The system moves across the Indian Ocean towards the Pacific Ocean.
- The monsoon — this moves between the northern and southern hemisphere across the equator on an annual basis. This accounts for a large part of driving the 'wet season' in northern Australia.



SOURCE: WWW.BOM.GOV.AU

These climate drivers all operate at differing time and spatial scales and have differing levels of impact across Australia. It is not only the strength of each climate driver, but the combination and interaction between them that dictates our weather and the level of climate variability we see. There are multiple permutations of these interactions that make forecasting climate a complex and difficult task. More accurate forecasting is becoming achievable through the array of satellites and ocean buoys that have been placed worldwide and the data received being coupled with high powered computer driven climate models.

Human activity has impacted on climate.

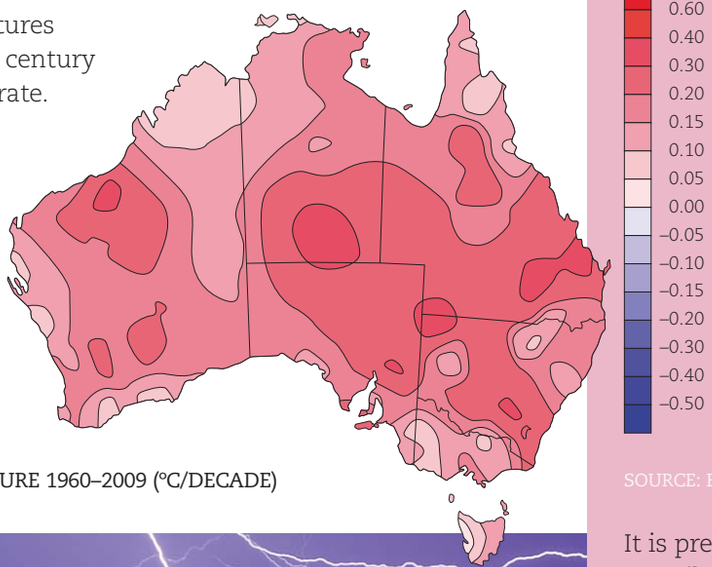
TARO TAYLOR

Overlying this complex pattern of climate variability is climate change. The world's climate continues to change — just as it has for millions of years (with ice ages and hot cycles). We now understand global climate systems enough to make a distinction between what is natural climate change and what can be attributed to human impacts.

Industrialisation, burning fossil fuels, land clearing and the loss of wetlands are some of the factors that lead to increased greenhouse gas pollution and have affected the dynamics of the planet and its atmosphere — or put simply how the earth naturally heats and cools. Increased production of greenhouse gases, such as carbon dioxide and nitrous oxide, when released into the atmosphere act like a blanket, trapping more radiation from the sun, heating up the planet and causing what is termed as the greenhouse effect.

DEMOKRAATTI

Global average temperatures have risen over the past century — and at an increasing rate. As the baseline earth temperature increases, the climate will become more variable. For example, we will still get hot and dry years, but they will occur with greater frequency and are likely to include extreme heat waves.

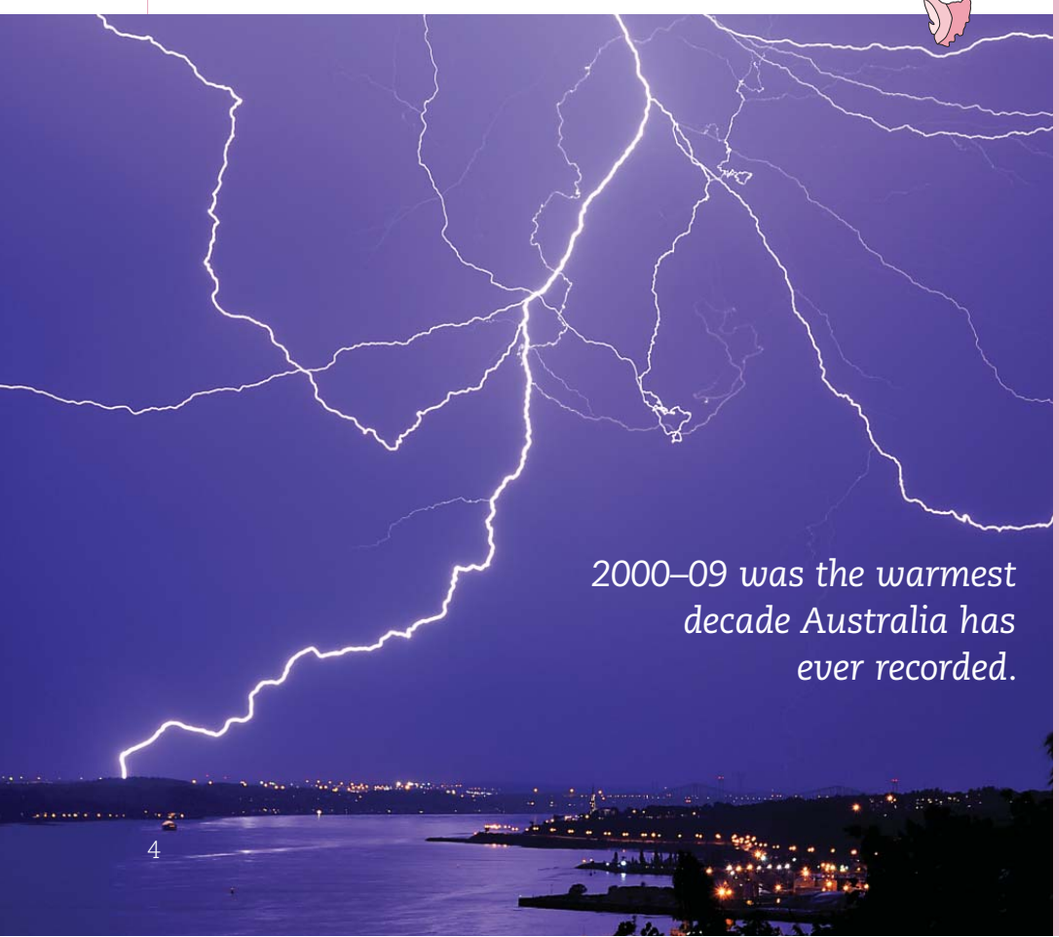


TREND IN MEAN TEMPERATURE 1960–2009 (°C/DECADE)

SOURCE: BUREAU OF METEOROLOGY 2010

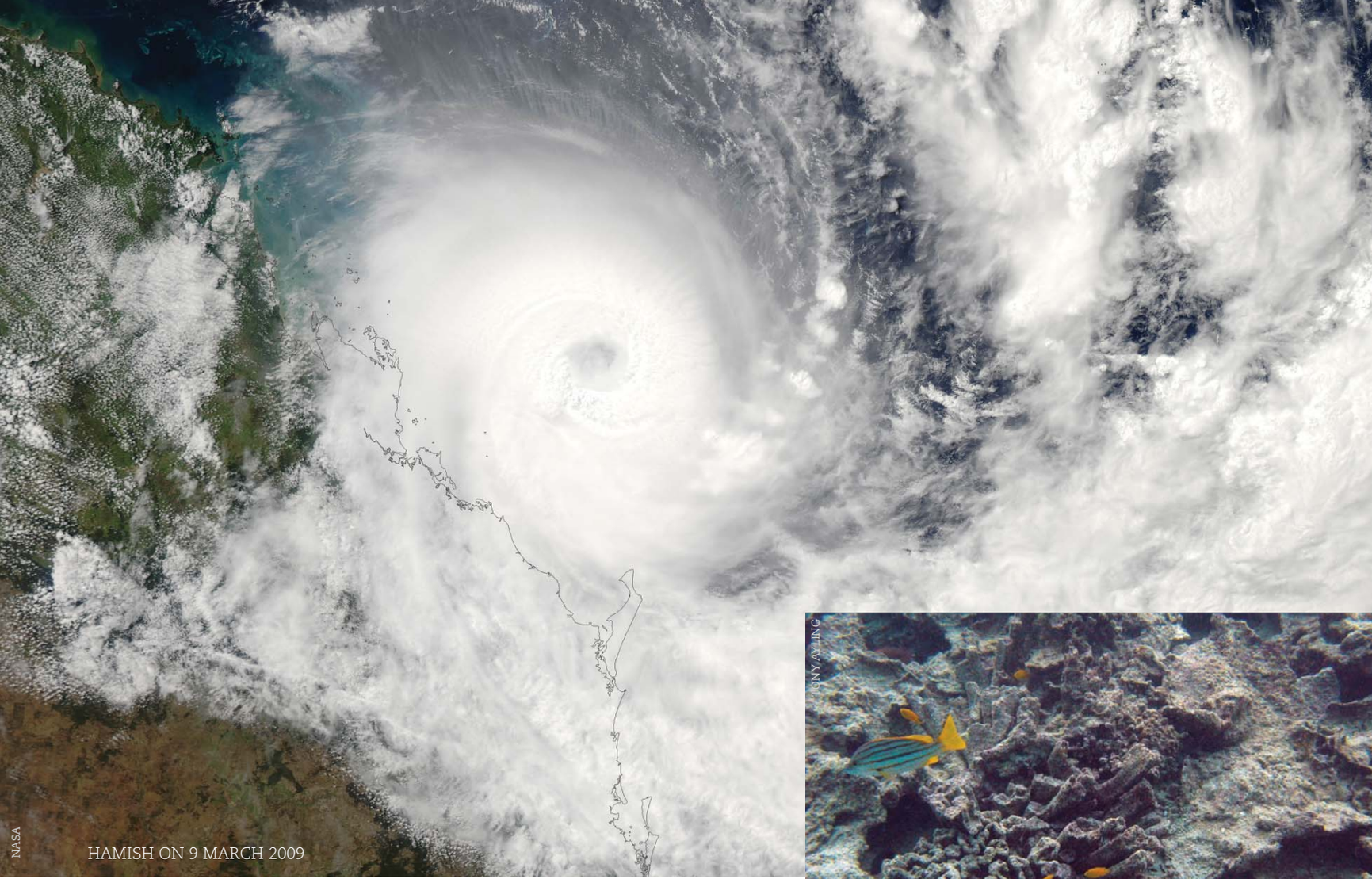
It is predicted that climate change will contribute to more extreme weather events (e.g. drought, severe storms, high sea levels).

Australia will continue to see tropical cyclones build in northern Australia. However, while it is projected these cyclones will be of similar frequency, they will become more intense. Australian fisheries have already seen and know what to expect after tropical cyclone Hamish swept across the Great Barrier Reef in March 2009 — see case study on the opposite page. It surpassed all previous storms in intensity, duration and track length over coral reef structure.



2000–09 was the warmest decade Australia has ever recorded.

JP MARQUIS



NASA

HAMISH ON 9 MARCH 2009

ANYA LING

Tropical cyclone impacts

The influence of tropical cyclones on the performance of the Coral Reef Fin Fish Fishery is an annual event, though mostly restricted to the loss of potential fishing days due to the inclement and unpredictable weather. The 'average' cyclone that impacts the Great Barrier Reef World Heritage Area, within which the fishery operates, is generally short lived and crosses the reef structure rapidly in an east to west direction. Most of the tropical cyclones in the past two decades have been low intensity systems (category 1 or 2).

In March 2009, tropical cyclone Hamish (category 5) changed that and was the most severe storm system to impact the Reef in recent decades. Commercial fishers were the first to witness, and verbally document, the widespread structural damage caused by Hamish. The destruction, scouring and displacement of reef habitat were significant and widespread covering 3 degrees of latitude (19 to 21 degrees inclusive). In addition to the structural reef damage, commercial fishers were also quick to report lower catch rates (up to 30 per cent) of all species throughout the directly impacted areas.

Research has shown that catch rates can be significantly affected by some cyclone events. Understanding the biophysical drivers of these changed catch rates is difficult because of the variable and unique nature of each cyclone event. However, it is the negative effects of a cyclone that may, depending on its intensity and duration, significantly alter catch rates and these effects may linger for at least 12 months after the event.

Following Hamish and its effects on fish and their habitat, the commercial sector had to adapt by moving locations. Research confirms the actions of the fishers and clearly identifies the need for adaptation and resilience planning.

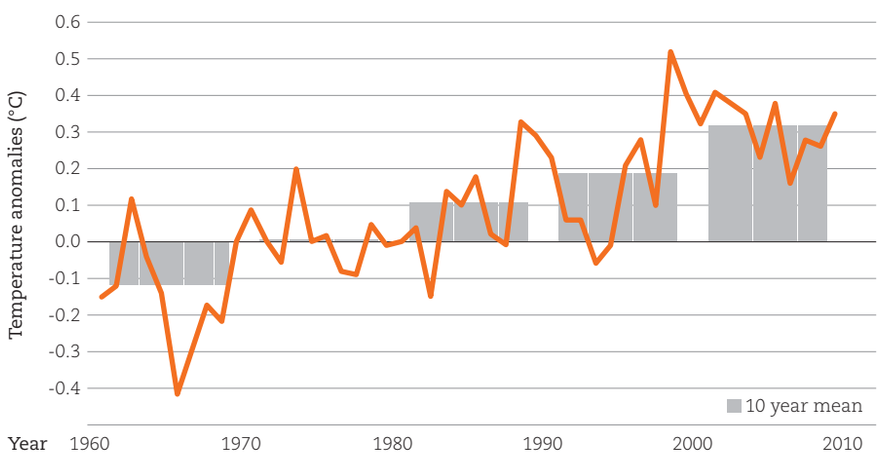
Major implications for marine biodiversity, fisheries and aquaculture

A changing climate will impact on the water and food sources that support aquatic life.

The *Marine Climate Change Impacts and Adaptation Report Card for Australia* provides a guide for industry, scientists, government and the community on the observed and projected impacts of climate change on marine ecosystems. The report card was developed by leading marine scientists from across Australia. Some of the key findings include:

- Australian ocean temperatures are likely to be 1 degree warmer by 2030 and 2.5 degrees warmer by the end of the century.
- There has been a 30 per cent increase in hydrogen ion (acid) concentration in oceans since 1750 and this is associated with the amount of carbon dioxide absorbed.
- The southward flow of the East Australian Current has strengthened so that warmer, saltier water is now found 350 kilometres further south compared with 60 years ago.
- Global sea levels increased by 20 centimetres between 1870 and 2004.
- Declines of over 10 per cent in growth rates of massive corals on the Great Barrier Reef are likely due to ocean acidification and thermal stress.
- Loss of algal habitat off eastern Tasmania associated with a southward range expansion of a sea urchin has been assisted by the strengthening of the East Australian Current and warmer temperatures.
- Expansion of sub-tropical species, into south-eastern waters is driven by warming and a strengthening of the East Australian Current.

ANNUAL AND 10 YEAR MEAN SEA SURFACE TEMPERATURE FOR THE AUSTRALIAN REGION. SOURCE: BUREAU OF METEOROLOGY 2010.



Resource managers need to appreciate change is here and they need to put in place adaptive strategies to deal with it.

GUILLAUME BLANCHARD

Ocean acidification and increased thermal stress are the likely causes of slower growth rates of corals and this may mean greater susceptibility to storm disturbance and loss of diversity. Sea level rises will also disrupt the ecosystem causing an expected expansion of mangrove areas and a decline in sea grasses in some areas. Upstream movement of water into estuaries will affect juvenile stages of many species, including prawns, while changing areas suited to oyster culture.

These issues show that fishing and aquaculture activities, management and planning will need to be flexible because of changes to habitats, populations, movement, feeding opportunities, aggregations and breeding cycles.

Mitigating climate change

For the global average temperature to rise no more than 2 degrees above pre-industrial levels by 2050, the world will need to produce less than half the amount of additional greenhouse gases that it does now.

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (IPCC)
FOURTH ASSESSMENT REPORT 2007 — www.ipcc.ch/

As noted in the *National Climate Change Action Plan for Fisheries and Aquaculture*, Australian fisheries operations are not a major source of greenhouse gas emissions. Nevertheless, there are smart business reasons to be more fuel efficient and therefore participate in reducing greenhouse gas pollution.

Certain fishing activities rely upon and use a lot of fossil fuel — for example, all large vessels and aquaculture systems that rely on pumping and circulating water. Fuel costs in some commercial wild catch fisheries can be 40 per cent of all input costs, so there is a large incentive to transition to systems that use less fuel.

Some of the measures available for improving fuel efficiency include:

- fuel efficient modern diesel engines
- minimising the drag of trawl gear
- use of fuel flow meters to determine optimal operating speeds
- engine and hull maintenance
- efficient hull designs
- optimising engine and propulsion systems
- fuel efficient pumping gear and farm layout
- solar or wind driven pumping systems.

As Kim Mundy, skipper for Australian Fishing Enterprises explains, "It is hard to say that a lot of us see climate change as an issue for our day to day operations, but we see it as important and something that we have to have in our minds."

Technologies that enhance catch efficiency and keep fuel use in check will be beneficial. "It has been about efficiency and getting value, particularly when fuel costs are so high."

"What will help us cope with future developments is operational efficiency plus our awareness of the interactions which can affect fish stocks."

In processing plants, an energy audit that looks for points of over-use and opportunities for savings is a good starting point. Simple modifications to lighting, water use and refrigeration can make large impacts — reducing costs and improving efficiency.

Mitigation is smart business sense.

Oceans, and particularly the estuaries and wetlands associated with them, play an important part in capturing, or sequestering, carbon. Along with vegetation and soil they are part of what is known as the global carbon cycle. About 55 per cent of all biological carbon capture is 'blue', that is in the world's ocean ecosystems. Repairing and redeveloping wetlands could play a major role in sequestering carbon, far more so than planted forests, as well as increasing fish production for an increasingly hungry world.

UNITED NATIONS ENVIRONMENT PROGRAMME — http://www.unep.org/climatechange/

Using less, means saving money and the environment.

Adaptation options for fishing sectors

Fishing and aquaculture is subject to uncertainty caused by the effects of climate change. Flow-on effects include the abundance and productivity of species and how they are affected by weather patterns and by fluctuations in operating conditions and markets.

Around Australia, fishing businesses are re-thinking their plans. In southern states, for example, industries involved in Atlantic salmon, abalone and rocklobster know they are going to be affected by rising ocean water temperatures. The Tasmanian Atlantic Salmon industry has initiated a research program to examine how to farm fish in warmer waters. This includes selective breeding of heat tolerant fish or farming fish in cooler waters offshore. Similarly, northern fisheries reliant on Barramundi and prawns understand they will need to contend with a more variable climate and the effects of more variable rainfall patterns on populations.

More variable freshwater flows to estuaries and tidal interchanges will influence habitats and this will alter the distribution of wetland plants and aquatic organisms. Estuarine areas suitable for oyster culture and habitats for crustaceans and juvenile stages of finfish are expected to vary accordingly.

Adaptation is about reducing vulnerability to the effects of climate change.

Research will boost knowledge and assist adaptation

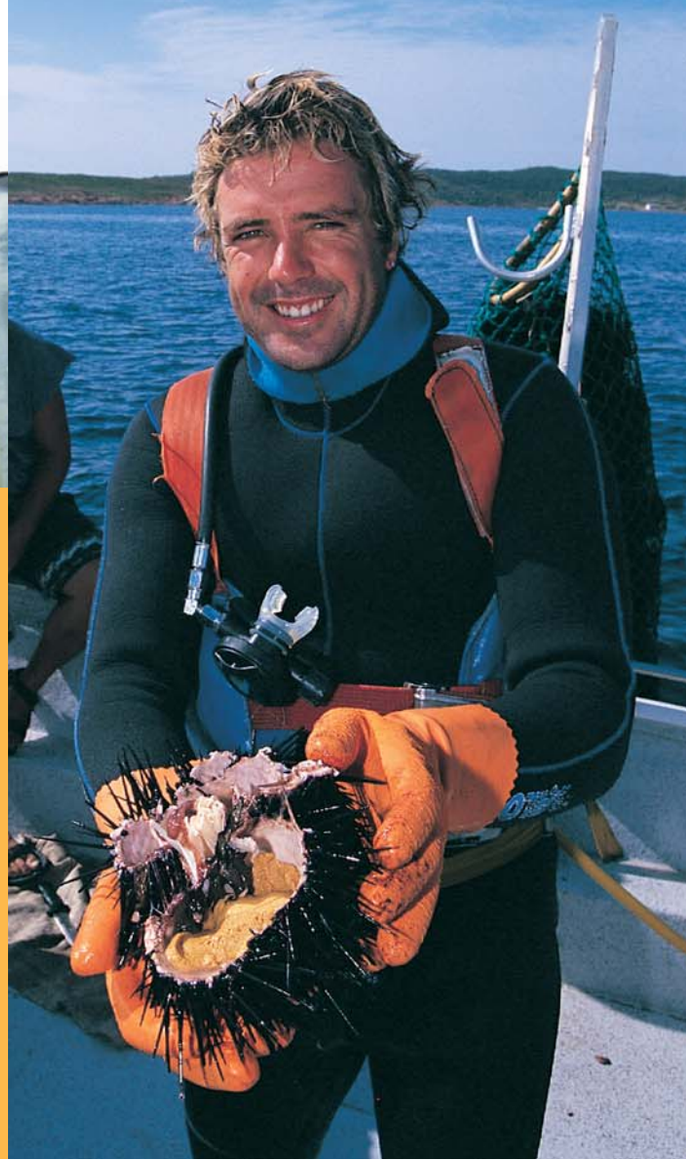
Marine biodiversity and fisheries climate change adaptation research coordinated by the Fisheries Research and Development Corporation in partnership with the Department of Climate Change and Energy Efficiency are focused on improving knowledge and assisting sectors to adapt to change. They include vulnerability assessments, examining the biophysical implications, and incorporating social and economic factors into changed management regimes.

Adaptation can mean improved management arrangements and regulations.

The march south by sea urchins

Sea urchins are voracious. Feeding on macro algae they can clear whole sections of reefs and rocky platforms. Add to this the fact they are expanding their range with the assistance of changing currents and warmer sea temperatures.

Recently the Victorian Department of Primary Industries and the Eastern Zone Abalone Industry Association joined forces for a three year project to help recover the biodiversity of sections of reefs identified as being in decline under the influence of urchins. One of the first steps will be to reduce the urchin biomass. Working together a better knowledge of populations of both species and their interactions with the marine environment will result. Eventually Victoria hopes to claim improved sustainability of the valuable abalone fishery and better quality urchin roe among remaining urchins.



FRDC climate projects

FRDC and the Department of Climate Change and Energy Efficiency partnership projects

These research projects focus on adaption and respond to the priority issues identified in the *National Climate Change Adaption Research Plan* and the *National Climate Change Action Plan for Fisheries and Aquaculture*.

- Project 2010/565 — *Management implications of climate change impacts on fisheries resources of tropical Australia*. The climate change effects on tropical Australia marine environments will be used to assess the vulnerability of high value fisheries species and identify improved fisheries management strategies.
- Project 2010/564 — *Pre-adapting a Tasmanian coastal ecosystem to ongoing climate change through reintroduction of a locally extinct species*. Using highly valued species, including blue groper, the potential for translocating fish as an adaptation policy will be investigated.
- Project 2010/554 — *Effects of climate change on reproduction, larval development and population growth of coral trout*. Climate change effects on the biology and ecology of the highly valued coral trout will be determined, providing valuable information for those involved in fishing and management. Wild fishery and aquaculture implications and adaption strategies will be developed.
- Project 2010/542 — *A climate change adaptation blueprint for coastal regional communities*. Adaptation options will be trialled in three coastal communities with results synthesised so that an adaptation blueprint can be developed. Extension activities will ensure findings from the program can be communicated to Australia's coastal communities.
- Project 2010/536 — *Beach and surf tourism and recreation in Australia: vulnerability and adaptation*. This project is about the relationship between climate change, coastal communities, beach infrastructure and marine resources.
- Project 2010/535 — *Management implications of climate change effects on fisheries in Western Australia*. This project is assessing Western Australian marine environments with particular attention being given to the vulnerability of high value fish species and will identify improved fisheries management strategies.
- Project 2010/534 — *Ensuring that the Australian oyster industry adapts to a changing climate: a natural resource and industry spatial information portal for knowledge action and informed adaptation frameworks*. This project will make available to the oyster industry, information that will assist planning for changes which will affect management and production.
- Project 2010/533 — *Human adaptation options to increase resilience of conservation-dependent seabirds and marine mammals impacted by climate change*. This work will provide an insight into the effects of climate change on a number of species and will help with the monitoring of marine biodiversity.

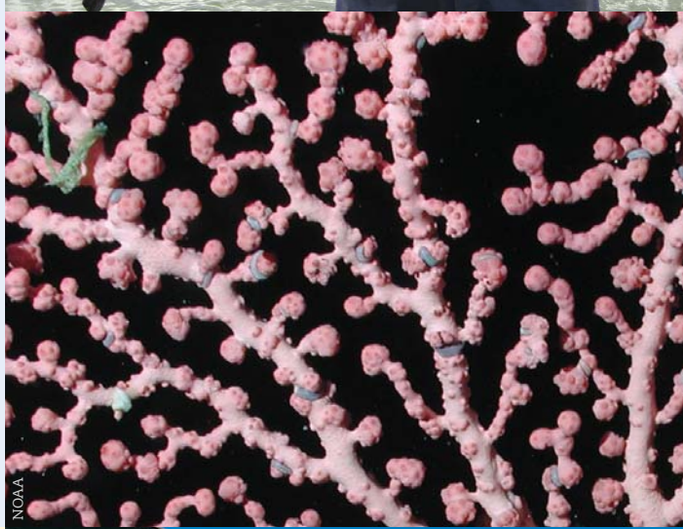

RICHARD LING


MARTIN BOWERMAN

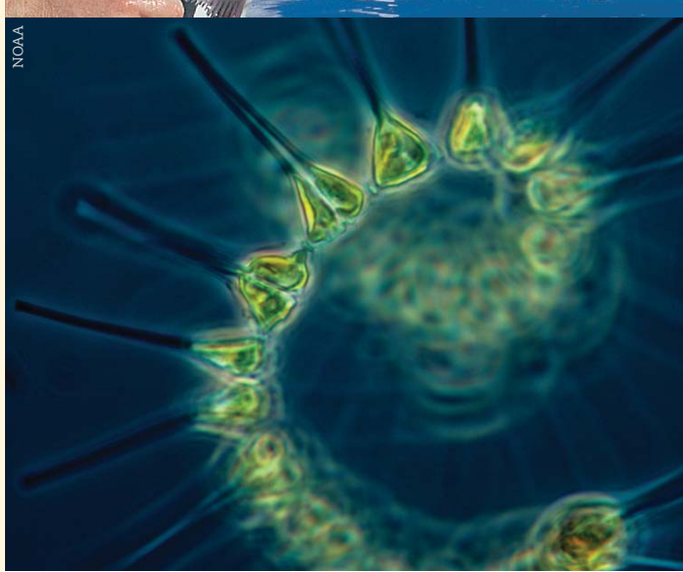

NOODLE SNACKS


REBECCA THYER

- Project 2010/532 — *Changing currents in marine biodiversity governance and management responding to climate change*. Marine biodiversity management will be informed by this project which is identifying the critical influences of climate change on habitats and species.
- Project 2010/524 — *Identification of climate-driven species shifts and adaptation options for recreational fishers: learning general lessons from a data rich case*. Using spear fishing club records for rocky reef fish in eastern Australia any changes in distribution over the last 40 years that may be attributed to climate change will be determined and used to suggest adaptation strategies for recreational management.
- Project 2010/521 — *Vulnerability of an iconic Australian finfish (Barramundi,* Lates calcarifer*) and related industries to altered climate across tropical Australia*. By determining thermal tolerances and associated consequences of thermal adaptation in Barramundi stocks across tropical Australia, this project will guide adaptation strategies.
- Project 2010/510 — *Adapting to the effects of climate change on Australia's deep marine reserves*. A model to predict the effects of ocean acidification and climate change on the distribution of deep reef corals and biota will be the outcome of this project.
- Project 2010/506 — *Adaptive management of temperate reefs to minimise effects of climate change: developing effective approaches for ecological monitoring and predictive modelling*. This work builds on data from past surveys to determine shifts in distribution and abundance of species. It will suggest strategies for fishery and marine park managers.



NOAA

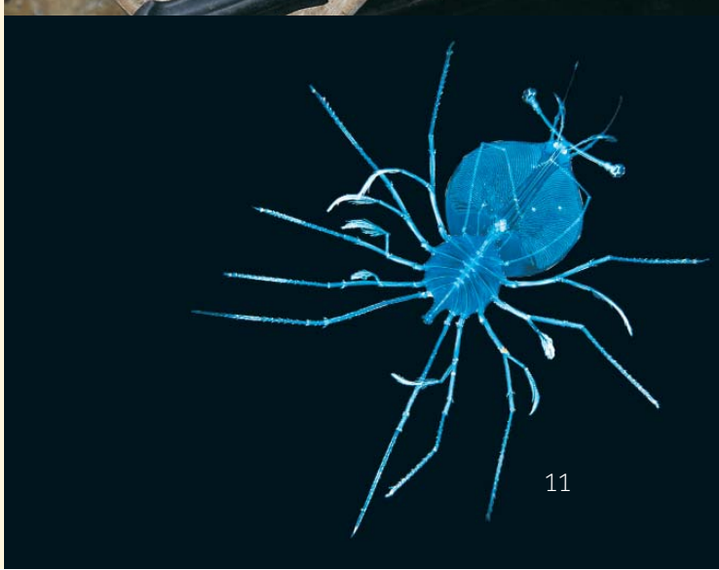


NOAA

Recent FRDC projects with a climate focus

PROJECT NO.	TITLE
2010/217	Atlantic Salmon Aquaculture Subprogram: forecasting ocean temperatures for salmon at the farm site
2010/023 and 2010/023.02	El Nemo South East: quantitative testing of fisheries management arrangements under climate change using Atlantis
2009/085	Atlantic Salmon Aquaculture Subprogram: mitigation of climate change effects on salmon brood stock: effects of oestrogen therapy
2009/073	El Nemo South East: social and economic risk assessment of the fishing and aquaculture sectors in the south eastern Australia region due to climate change
2009/070	El Nemo South East: risk assessment of impacts of climate change for key species in south eastern Australia
2009/067	Tactical Research Fund: nutrient and phytoplankton data from Storm Bay to support sustainable resource planning
2009/056	El Nemo South East: understanding the biophysical implications of climate change — project 1 and 2
2009/055	El Nemo South East: adaptation of fishing and aquaculture sectors and fisheries management to climate change in South Eastern Australia Work Area 4, Project 1 Development and testing of a national integrated climate change adaptation assessment framework
2009/053	Tactical Research Fund: spreading the risk — management strategies for multi-method inshore fisheries in a changing climate

PROJECT NO.	TITLE
2009/018	Identifying factors affecting the low western rocklobster puerulus settlement in recent years
2008/023	The trophodynamics of small pelagic fishes in the southern Australian ecosystem and the implications for ecosystem modelling of southern temperate fisheries
2008/012	Evaluating the environmental drivers of mud crab (*Scylla serrata*) catches in Australia
2007/068	National Climate Change Research Strategy for Primary Industries (CCRSPI)
2007/054	Climate Change and Fisheries Status Report
2007/045	Rebuilding ecosystem resilience: assessment of management options to minimise formation of 'barrens' habitat by the long-spined sea urchin (*Centrostephanus rodgersii*) in Tasmania
2007/003	Flow and fisheries: theme — river flow impacts on estuarine prawns in the Gulf of Carpentaria
2007/002	Flow impacts on estuarine finfish fisheries of the Gulf of Carpentaria
2006/046	Effects of environmental variability on recruitment to fisheries in South Australia
2006/045	Flow related fish and fisheries ecology in the Coorong, South Australia
2006/040	Understanding the ecological role of abalone in the reef ecosystem of Victoria
2005/063	Development of an ecosystem approach to the monitoring and management of Western Australian fisheries
2005/006	The influence of environmental factors on recruitment and availability of fish stocks in south east Australia
2004/078	Development and evaluation of community based monitoring programs for coastal ecosystems and fisheries habitats
2004/013	Towards integrated multi-species management of Australia's south east reef fisheries: a Tasmanian example
2003/061	Evaluation of alternative strategies for management of Commonwealth fisheries in south eastern Australia
2003/050	Linking habitat mapping with fisheries assessment in key commercial fishing grounds
2002/028	Trophic dynamics of the eastern shelf and slope of the South East Fishery: impacts of, and on, the fishery
2002/007	Larval transport and recruitment processes of southern rocklobster
2001/044	Establishment of the long-spined sea urchin (*Centrostephanus rodgersii*) in Tasmania: a first assessment of the threat to abalone and rocklobster fisheries



IMAGES ARE FROM FRDC UNLESS CREDITED OTHERWISE.
IMAGES SOURCED FROM WIKIMEDIA COMMONS ARE USED UNDER VARIOUS LICENCES.

PRINTED ON .

DESIGN BY ANGEL INK. PRINTED BY BLUE STAR

To find out more about fishing and climate change

www.frdc.com.au

The FRDC invests in a range of research projects on behalf of the fishing industry. Information on projects concerning climate change is available on the Corporation's website and in their *FISH* magazine.

www.climatechange.gov.au

A comprehensive assessment of how climate change will affect fishing is provided in the Australian Government Department of Climate Change and Energy Efficiency report *Implications of Climate Change for Australian Fisheries and Aquaculture*.

www.nccarf.edu.au and **www.arnmbr.org**

The Australian Government's National Climate Change Adaptation Research Facility is a body working across all industries to help generate reliable information needed by decision makers to manage climate change risks and inform adaptation. The network fosters interaction between researchers, managers and the community.

www.climatekelpie.com.au

Summarises climate drivers and Australia's climate variability, provides links to key climate forecasting websites internationally, links to key climate risk management decision support tools and provides stories on how Australian primary industries are adapting to a changing climate.

www.csiro.au

A major climate change research provider is CSIRO, particularly through its Climate Change Adaptation Flagship.

www.daff.gov.au

The Climate Change Division of the Department of Agriculture, Fisheries and Forestry manages Australian Government policies and programs to help primary industries and producers make choices and decisions to adapt and respond to climate change.

FOR MORE INFORMATION

Colin Creighton

Climate Change Adaptation R&D
Marine Biodiversity, Resources and Fisheries
colin.creighton@frdc.com.au

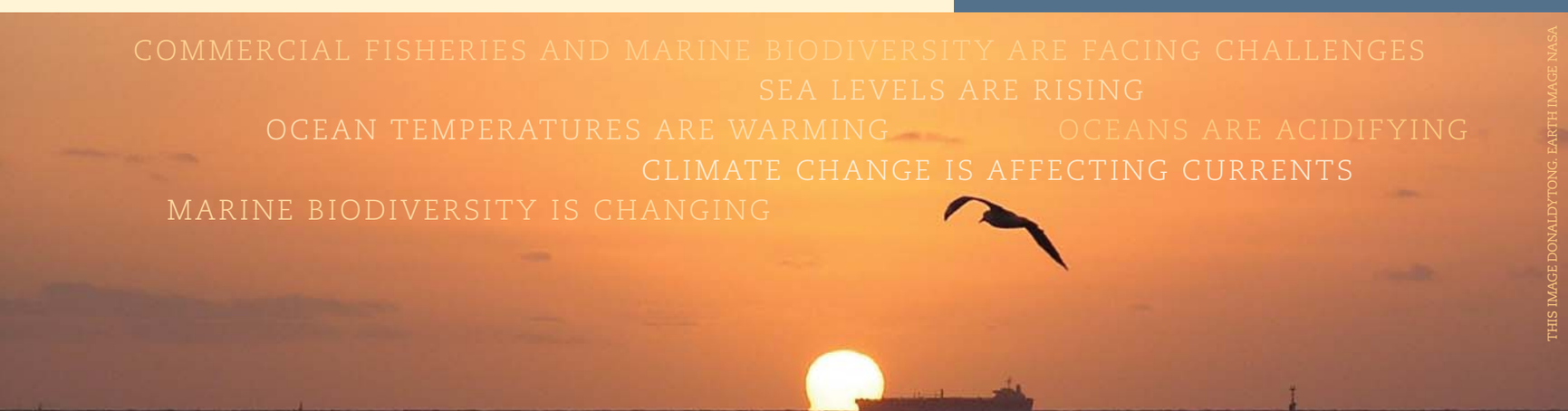
Post: Locked Bag 222
Deakin West ACT 2600

Telephone: 02 6285 0400
Facsimile: 02 6285 4421
E-mail: frdc@frdc.com.au
Web: www.frdc.com.au

YOU HAVE SOME VERY SIMPLE DECISIONS TO MAKE

1. Given the choice would you **waste energy** [or water, food, resources etc.]?
2. Given the choice would you **pollute the atmosphere** [or water, land]?

If no… then mitigate — it's smart business sense; and adapt — it's part of business risk management.



THIS IMAGE DONALDYTONG, EARTH IMAGE NASA

RESEARCHERS IN PARTNERSHIP WITH THE FISHING INDUSTRY ARE SEEKING A BETTER UNDERSTANDING OF THE EFFECTS OF CLIMATE CHANGE TO HELP MANAGE RISKS AND ADAPT.