Earth Systems and Climate Change Hub

National Environmental Science Programme

TSRA

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WORKSHOP REPORT

Climate change in the Torres Strait

Implications for fisheries and marine ecosystems

June 2018

Earth Systems and Climate Change Hub Report No. 4

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AT A GLANCE

Key messages from the workshop

The climate is changing in the Torres Strait. Research shows that it is changing, communities see it on country (land and sea) and fishers see it in the changing state of natural resources.

Marine impacts from climate change in the Western and Central Torres Strait will include coastal erosion and declines in reef health and diversity, loss of critical inshore habitat, increased sea temperatures and sea levels and changes to currents and water quality; all of which will have a variety of direct and indirect impacts on fish stocks and marine ecosystems. Climate change will affect fisheries productivity, species distributions and seasonality, so subsistence and commercial fishery practices will need to be able to adapt to shifting circumstances.

It is important that all relevant parties are engaged in conversations about what climate change means for fisheries and marine ecosystems in order to prepare for the changes. Local traditional knowledge and scientific knowledge from the research community are important tools which can and should be integrated to help understand and prepare for future changes.

Torres Strait fisheries and marine ecosystems

- Torres Strait has diverse, productive and commercially, ecologically and culturally valuable fisheries and marine resources.
- There are complex traditional and regulatory management and resource sharing arrangements.
- Marine resources are likely to constitute a large proportion of protein for local communities.
- Traditional values of marine resources are very important to Torres Strait communities.

Climate change and impacts

- Being island based and heavily dependent on their marine resources, Torres Strait communities have certain inherent vulnerabilities in relation to climate change impacts compared to other parts of Australia.
- Climate change will strongly impact the Torres Strait marine environments and fisheries due to increased frequency and intensity of extreme events such as marine heatwaves, sea-level rise and changes to ocean oxygen content and ocean pH.
- Possible changes to ocean circulation and currents could have major ramifications fisheries and marine ecosystems.

Managing impacts

- Traditional fishers already practice many of the approaches needed to help ensure they can adjust to some of the likely impacts of climate change, such as providing

spatial flexibility in fishing effort by observing Traditional boundaries between each community's sea country.

- Community values have an important role to play in determining management and adaptive responses to the impacts of climate change.
- Traditional cultural spatial management of resources between Australia and Papua New Guinea, while effective when observed and well supported, could contribute to conflict between the haves and the have-nots as climate change impacts increase.

Information to support management and adaptation

- There are already many climate projections data and information products available for the region, ranging from relatively large spatial scale (e.g. global and regional climate projections located at www.climatechangeinaustralia.gov.au) to smaller scale (e.g. downscaled CCAM projections for some parts of northern Australia and Papua New Guinea) and some regional ocean and fisheries modelling, but it is not necessarily accessible.
- Global model projections have limited value for the Torres Strait Islands because of the geography (small size and limited topography) of the islands and the poor resolution of El Niño–Southern Oscillation/Pacific Decadal Oscillation influences. Instead, higher resolution modelling (including ocean modelling and fisheries modelling) is needed to provide information at the appropriate spatial scale.
- Tidal dynamics need to be further taken into account to improve the climate downscaling in the Torres Strait region.
- Important oceanographic and environmental data are intermittent and/or absent, and there is a need for dedicated Torres Strait modelling across a range of applications related to fisheries.
- Although a lot of climate information is being continually generated, very little targeted information at required intervals is available to Torres Strait fishers to inform their seasonal fishing practices.
- Provision of regular climate, adaptation and management information via an annual forum or other updates may be useful.
- Managers seeking to adapt to climate/climate change issues in Torres Strait can glean valuable information from relevant projects around Australia and in the Pacific.
- Researchers need to have due diligence to present information appropriately for local communities so useful information can be placed in the hands of the local decision makers who are the traditional custodians of the resource.
- Communities in the Torres Strait are keen to be involved in discussions about how a changing climate affects fisheries.
- There is enough information now from studies in Torres Strait and adjacent areas (as proxies and examples) to make management decisions in the short term. Filling some key knowledge gaps and downscaling climate change projections will provide information to refine actions, but we don't need to wait for this information to act now.
- Consultation and engagement with traditional owners and fishers is paramount to appropriately target actions for key fisheries and vulnerabilities.

Background

The National Environmental Science Program (NESP) Earth Systems and Climate Change (ESCC) Hub and Torres Strait Regional Authority (TSRA) jointly convened a workshop in December 2017 to bring together key researchers and managers to review the current state of relevant scientific knowledge about climate change impacts on communities of the Torres Strait Islands, with a particular emphasis on inshore fisheries and marine ecosystems. This is the first time that climate and fisheries researchers and managers working in the Torres Strait have come together in this way.

The workshop is the first in a series of engagements that aim to:

- build relationships and raise awareness and understanding of key stakeholders (including traditional owners/local fishers, natural resource managers, other local communities of interest and scientists)
- identify data and information gaps and needs where appropriate
- develop options for the delivery of relevant science-based products and services to target end-users to inform policy development, management/adaptation planning and associated decision-making.

The objectives of this workshop are to:

1. Assess current state of knowledge and understanding on climate projections and impacts as they relate to the marine environment in the Torres Strait.
2. Capture knowledge of any observed or reported shifts in environmental variables
3. Identify key data and knowledge gaps and assess priority areas and issues from a scientific and managerial perspective and make recommendations for further focus or investigation
4. Determine communication products that should be developed to increase awareness and understanding of key stakeholders of climate change impacts on Torres Strait marine fisheries and ecosystems
5. Improve coordination and collaboration across relevant agencies and stakeholders and scope next steps in the proposed series of engagements.
6. Determine the nature of ongoing engagement with traditional owners on this issue. In practice, it will likely be facilitated through the TSRA and the fisheries working groups/management forums.

The workshop program and participant list are included in the appendices of this report.

This report, which provides a brief synthesis of the workshop presentations and key discussion points, is the primary workshop output.

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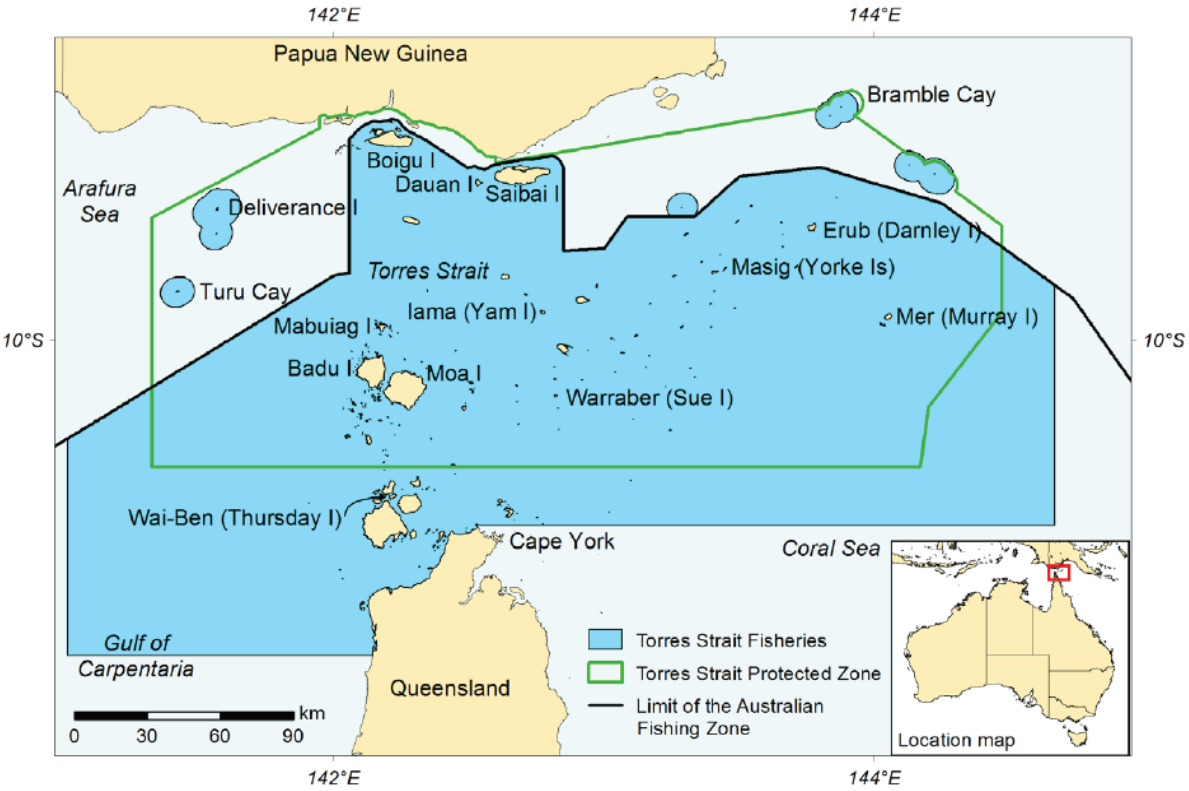
Fisheries in Torres Strait

Ian Butler, AFMA

- Torres Strait fisheries have complex arrangements for resource sharing.
- Torres Strait fisheries cover a diverse range of species.
- Historical catch data have been difficult to obtain, but improvements are being made (fish receiver data).

Region



The Torres Strait Protected Zone (TSPZ) is jointly managed by Australia and Papua New Guinea (PNG) through bilateral discussions. Within Australian waters in the TSPZ, traditional and commercial fishing are managed by the Protected Zone Joint Authority.

The fisheries in this region are shared between traditional inhabitant commercial fisheries, traditional artisanal fisheries, PNG fisheries and recreational fishers. Formal catch arrangements between Australian and PNG fishers are established under the Treaty.

The fisheries have commercial, cultural and lifestyle value.

Key fisheries

Torres Strait Finfish Fishery	Spanish mackerel but some other species	Trolling lure	2016 catch: 86.9 t Value: n/a (total finfish $1.2 m)
Torres Strait Finfish Reef Line Fishery	Mostly coral trout but also other groupers, snapper, emperor, barramundi and trevally	Hook and line, spear, nets and traps	2016 catch: 38.7 t Value: n/a (total finfish $1.2 m)
Torres Strait Tropical Rock Lobster Fishery	Tropical rock lobster	Hand diving (surface air supply, free diving); 306 commercial licenses (294 traditional inhabitants); artisanal; shared resource with PNG	2015–16 catch: 445 t Value: $14.3 m
Torres Prawn Fishery	Brown tiger prawns, blue endeavour prawns, also other prawn species, bugs, octopus and squid	Caught at night using demersal otter trawl	2016 catch: 412 t Value: $8.9 m
Torres Strait Beche-de-Mer Fishery	Sea cucumber (e.g. black teatfish, prickly redfish, sandfish, white teatfish, surf redfish)	Collected by hand free diving or on reef flats; scuba and hookah banned; traditional inhabitant and artisanal fishers only	2016 catch: 14.9 t Value: not assessed Illegal fishing from other countries
Trochus	Trochus	Collected by hand free diving or on reef flats; scuba and hookah banned; traditional inhabitant and artisanal fishers only	Catch: 0 t Illegal fishing from other countries
Pearl shell	Gold-lipped and black-lipped pearl shells	By hand for use in farming (Qld); traditional inhabitants only (with PNG)	Catch: limited to small amounts
Torres Strait Crab Fishery	Mostly mud crabs, some blue swimmer	Hand or scoop net; traditional inhabitants and artisanal fishers	Value: unknown
Turtle		Traditional artisanal fishers	Culturally important for food
Dugong		Traditional artisanal fishers	Culturally important for food

Understanding Torres Strait stakeholders

Charles David, TSRA

- The Torres Strait economy benefits significantly from the ocean. Jobs etc. often stem from the health of and access to fisheries – traditional fishing is commercial fishing.
- Climate change impacts shift movement patterns of fish and directly affect the health of coral and other less mobile aquatic resources.
- Wild stocks, in some cases, are at lower levels than recently observed and others are not recovering from past overfishing. To what degree these are attributed to or compounded by the impacts of climate change is unknown. Employment opportunities for Islanders could reduce as a consequence of continued decline in stocks.
- There are implications for ownership and management arrangements, aspiration and the current status of the fishery.
- Traditional knowledge considerations are important for management of Torres Strait Island fisheries.
- A summation of climate change in Torres Strait and what to expect in a given timeframe needs to be delivered to traditional owners and/or full-time commercial and community fishermen.

The Torres Strait Treaty and *Torres Strait Fisheries Act 1984* (Commonwealth) are in place to acknowledge and protect the traditional way of life in the Torres Strait and the traditional inhabitants.

The Protected Zone Joint Authority (PZJA) is responsible for management of commercial and traditional fishing in the Australian area of the Torres Strait Protected Zone (TSPZ) and designated adjacent Torres Strait waters.

The PZJA is comprised of the Commonwealth and Queensland Ministers with responsibility for fisheries and the Chairperson of the TSRA. The PZJA is advised by a framework of management advisory committees made up of Torres Strait Islander fishers, commercial fishers, fishery managers and scientists. Recreational fishing is managed under Queensland law.

The Torres Strait fisheries management structure does not exist anywhere else in the country. The structure can make it seem difficult to get things done; however, this is not the case – you just have to have the traditional owners at the table.

There are five cluster groups in the Torres Strait. Traditionally you seek permission to go into someone else's sea country, but commercial fishing licences are for the whole zone so there's a disconnect between the two systems.

Roadmap to 100% fisheries ownership

The TSRA is working with key regional stakeholders and traditional inhabitants to achieve 100% ownership of the region's fisheries for traditional inhabitants. Both the finfish and bêche-de-mer fisheries are 100% owned by traditional inhabitants. The tropical rock lobster

fishery is 66.18% owned by traditional inhabitants (at 20 November 2017, as reported on the TSRA website).

Traditional management of Torres Strait fisheries

Traditional areas and boundaries are important to traditional owners and their maintenance can be advantageous both culturally and for sustainability. Traditional owners want traditional boundaries and management to be recognised (which is why bringing traditional owners to the table is important).

Torres Strait Islanders have seen the changes, especially in fish stocks – and believe this is a strong reason why returning to traditional management (because it's more sustainable) is crucial. Turtle and dugong are success stories for traditional management.

Things in the past have resulted in some distrust of the science and 'westerners'; this is being overcome slowly.

The climate context: variability, extremes, change and risk relevant to impacts on marine systems in the Torres Strait

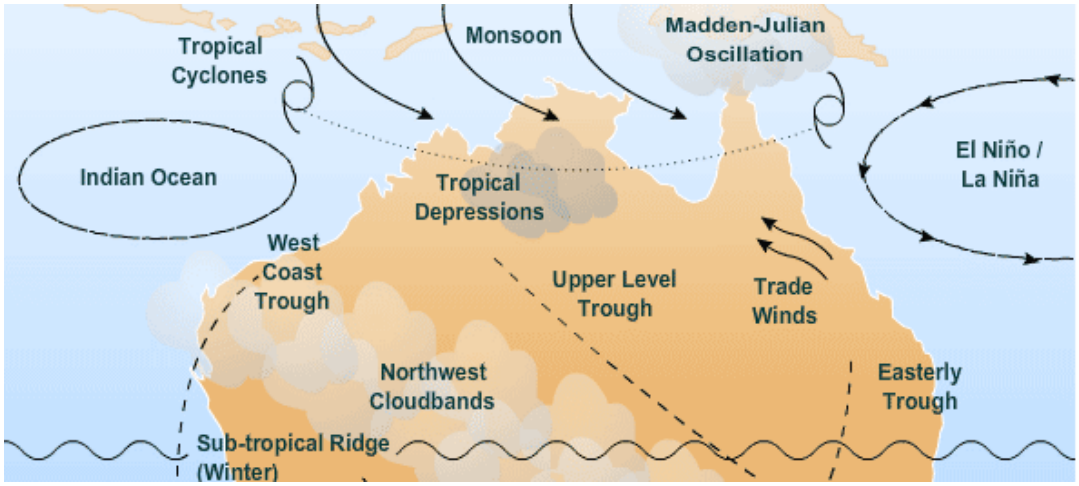
Neil Holbrook, ESCC Hub

- Torres Strait Islands are subjected to considerable ocean and climate variability (dominated by the monsoon and El Niño–Southern Oscillation) and extremes (including sea-level extremes, marine heatwaves, tropical cyclones and storms – and the associated winds, waves and storm surges – and extreme rainfall.
- Impacts of long-term changes in ocean temperatures (surface and deep), sea level and storminess will be both physical (e.g. inundation, erosion, coral damage) and ecological (affecting habitats, communities and species).
- Ocean acidification (reduction of ocean pH) affects calcifying organisms.

Variability

The climate of the Torres Strait is characterised by the monsoon wet season (December–April) with north-westerly winds and the dry season (May–November) with south-easterly winds.

The El Niño–Southern Oscillation (ENSO) contributes to year-to-year variability. During El Niño events, northern Australia is drier than normal, while during La Niña events it is wetter than normal. ENSO also plays a strong role in year to year variability of sea level.



(Source: Commonwealth of Australia 2010, Bureau of Meteorology. http://www.bom.gov.au/climate/about/)

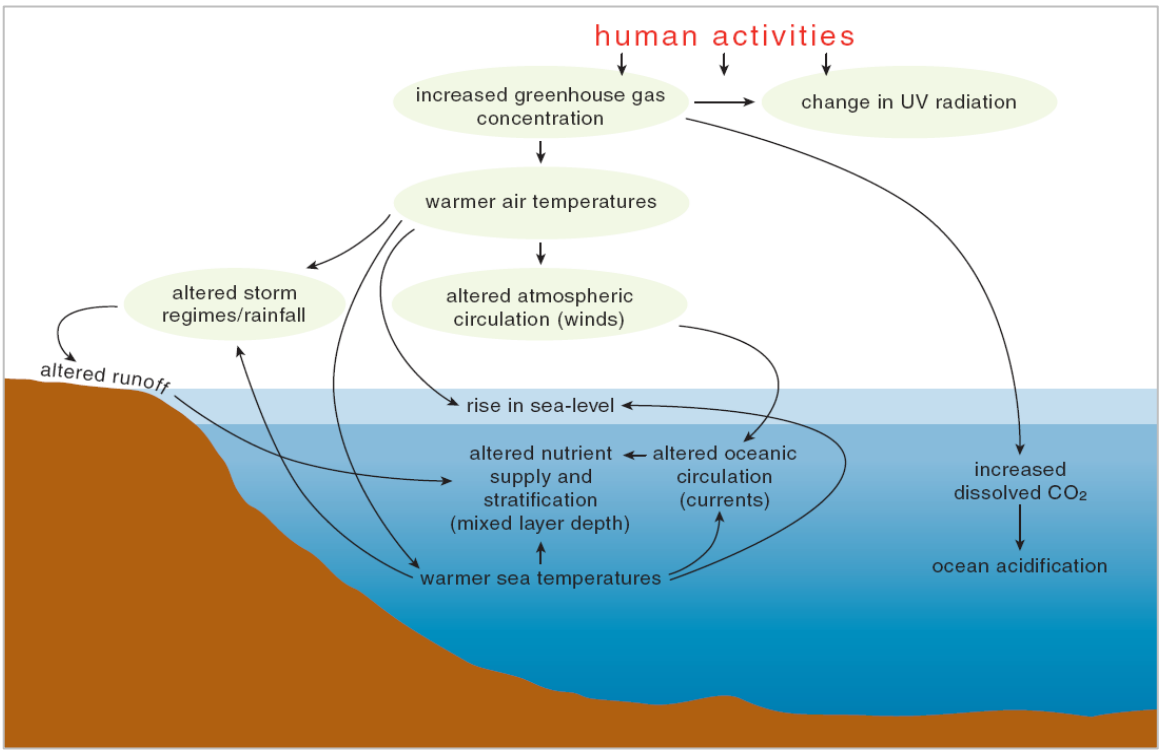
Extremes

By definition, extremes are rare and intense. They include tropical cyclones, storm surge, heatwaves (including marine heatwaves) and heavy rainfall.

Climate change, sea level rise and extremes

The impacts of sea-level rise will be felt most profoundly during extreme sea-level events. Increased sea level will increase the frequency of these events and the frequency of coastal inundation and erosion. Extreme sea levels may also change due to changes in storms (their frequency and intensity may change).

Climate change will also increase the frequency of extreme El Niño and La Niña events.



Physical and chemical changes in atmosphere and oceans due to climate change (Source: Poloczanska *et al*. 2007)

Implications

Coastal systems are particularly sensitive to sea-level rise, warming oceans and ocean acidification. The Intergovernmental Panel on Climate Change Working Group 2 contribution to the fifth assessment report gives examples of key risks.

Table 29-4 | Selected key risks and potential for adaptation for small islands from the present day to the long term.

Climate-related drivers of impacts								Level of risk & potential for adaptation
Warming trend	Extreme temperature	Drying trend	Extreme precipitation	Damaging cyclone	Sea level	Ocean acidification	Sea surface temperature	Potential for additional adaptation to reduce risk; Risk level with **high** adaptation; Risk level with **current** adaptation

Key risk	Adaptation issues & prospects	Climatic drivers	Timeframe	Risk & potential for adaptation (Very low – Medium – Very high)
Loss of livelihoods, coastal settlements, infrastructure, ecosystem services, and economic stability (*high confidence*) [29.6, 29.8, Figure 29-4]	• Significant potential exists for adaptation in islands, but additional external resources and technologies will enhance response. • Maintenance and enhancement of ecosystem functions and services and of water and food security • Efficacy of traditional community coping strategies is expected to be substantially reduced in the future.		Present Near term (2030–2040) Long term (2080–2100) 2°C 4°C	
Decline and possible loss of coral reef ecosystems in small islands through thermal stress (*high confidence*) [29.3.1.2]	Limited coral reef adaptation responses; however, minimizing the negative impact of anthrogopenic stresses (ie: water quality change, destructive fishing practices) may increase resilience.		Present Near term (2030–2040) Long term (2080–2100) 2°C 4°C	
The interaction of rising global mean sea level in the 21st century with high-water-level events will threaten low-lying coastal areas (*high confidence*) [29.4, Table 29-1; WGI AR5 13.5, Table 13.5]	• High ratio of coastal area to land mass will make adaptation a significant financial and resource challenge for islands. • Adaptation options include maintenance and restoration of coastal landforms and ecosystems, improved management of soils and freshwater resources, and appropriate building codes and settlement patterns.		Present Near term (2030–2040) Long term (2080–2100) 2°C 4°C	

(Source: Table 29-4 in Nurse et al. 2014)

References/more information

- Nurse LA, McLean RF, Agard J, Briguglio LP, Duvat-Magnan V, Pelesikoti N, Tompkins E, Webb A (2014) Small islands. In: *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [VR Barros, CB Field, DJ Dokken, MD Mastrandrea, KJ Mach, TE Bilir, M Chatterjee, KL Ebi, YO Estrada, RC Genova, B Girma, ES Kissel, AN Levy, S MacCracken, PR Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1613–1654.
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Climate trends and projections for the Torres Strait Islands

Josephine Brown, ESCC Hub

- There is an observed warming trend in both air and sea-surface temperatures in the Torres Strait.
- Rainfall is highly variable, with a strong influence from the El Niño–Southern Oscillation. A trend due to global warming cannot be identified in the observations.
- Regional projections for the Torres Strait include warmer sea-surface temperatures and higher sea level. Rainfall will become more variable with more intense extreme events.

Climate projections

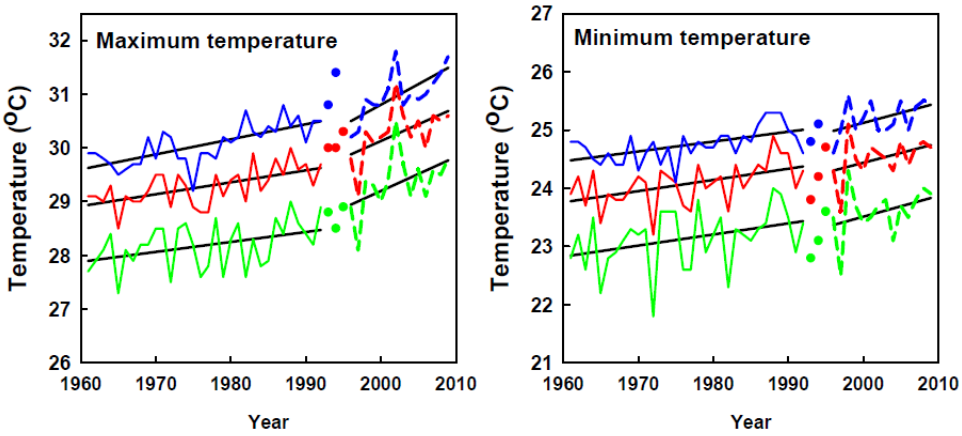
Projections based on global climate models generally cannot resolve the details of islands, topography or ocean currents in the Torres Strait. Global model information can be useful for some applications, while higher resolution (downscaled) model output may be needed for other applications. It is also important to evaluate whether the model can reproduce the observed present-day climate of the variable of interest (e.g. rainfall, temperature), and to consider the influence of model biases and errors on the climate of the Torres Strait.

Climate drivers

Climate in the Torres Strait is heavily influenced by the monsoon and the El Niño–Southern Oscillation (ENSO). In the future, monsoon rainfall is likely to be more variable than it is now and the influence of ENSO on rainfall will be greater.

Temperature

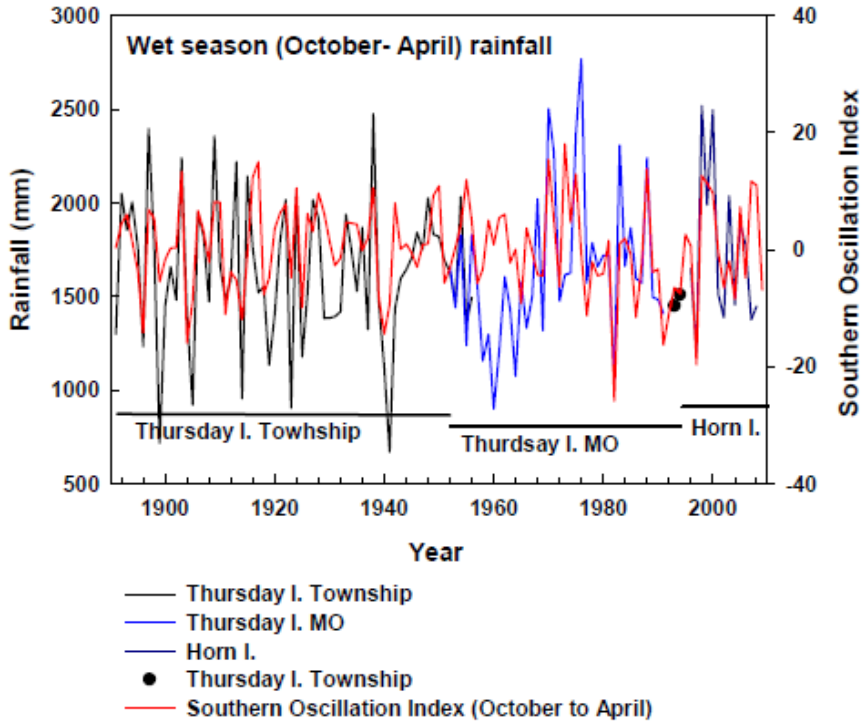
Mean temperature currently ranges annually from about 22–25 °C (min) to 28–32 °C (max). Temperatures have increased over the past century, with the rate of warming higher since 1960. Average temperatures will continue to increase in all seasons as a result of long term climate change, and there will be more hot days and warm spells.



Observed temperatures. Solid lines are records taken at Thursday Island MO. The observation site changed to Horn Island (dotted lines).

Rainfall

Rainfall has a strong seasonal cycle due to the influence of the monsoon. ENSO also influences rainfall, with drier years during El Niño events and wetter years during La Niña events. Changes to rainfall as a result of climate change are possible but unclear, but intensity of extreme daily rainfall events will increase.



Sea-surface temperature

The oceans around Australia have warmed. In the Torres Strait, this warming has occurred at 0.08–0.12 °C per decade since 1950. Sea-surface temperature will continue to increase as a result of climate change.

Ocean acidification

The pH of waters around Australia is decreasing (i.e. becoming more acidic). In the Torres Strait, the pH has dropped by 0.085–0.095 between 1880–89 and 2000–09, and ocean acidification will continue as a result of climate change.

Tropical cyclones

Tropical cyclones are generally located south of Torres Strait, but six have tracked through Torres Strait since1906 and many more over Cape York. Since the 1970s there has been an overall trend for fewer tropical cyclones in the Australian region, and it is expected that there will be fewer but more intense tropical cyclones in the future as a result of climate change.

Sea level

In the period 1993–2015, sea level has increased in the Torres Strait by 6–7 mm per year. Mean sea level will continue to rise as a result of climate change, and height of extreme sea-level events will also increase.

References/more information

- Climate Change in Australia https://www.climatechangeinaustralia.gov.au/en/
- State of the Climate 2016 http://www.bom.gov.au/state-of-the-climate/index.shtml
- CoastAdapt https://coastadapt.com.au/
- Pacific Climate Futures https:/www.pacificclimatefutures.net

Vulnerability of Torres Strait fisheries to climate change

Johanna Johnson, Tropical Water Quality Hub

- Torres Strait fishers already operate under climate variability and practice flexible approaches that will help with adaptation to future climate change impacts.
- There is enough information now from studies in Torres Strait and adjacent areas (as proxies and examples) to make management decisions immediately. Filling some key knowledge gaps and downscaling climate change projections will provide information to refine actions, but we don't need to wait for this information to act now.
- Consultation and engagement with traditional owners and fishers is important to target appropriate actions to key fisheries and vulnerabilities (and within the local/cultural context)

Potential climate change impacts on species

Species	Key potential impacts of climate change (2030)
Coral trout – common/barcheek/ passionfruit	• Reduced catchability after intense storms • Reduced survival/development of early life stages due to increased sea-surface temperature (SST+) • Adult movements into deeper waters due to SST+ • Impacts on coral reef habitat may affect juvenile survival

Dugong	• Declines in seagrass negatively impact dugong due to:
	  ○ primary food source
	  ○ preferred habitat
	• Increased stranding mortality due to intense storms

Blue endeavour prawn & brown tiger prawn	• Impacts on seagrass may decrease juvenile growth and survival • Compromised growth and survival due to SST+ (near northern limit)
Turtle	• Female biased populations due to higher air temperatures during egg incubation • Decrease in available nesting sites/disrupt successful nesting due to sea-level rise (SLR), more intense storms and extremes in rainfall • Increased stranding mortality due to intense storms • Impacts on seagrass may decrease growth and survival
Trochus	• Unknown and previously assessed as minor
Sandfish	• Generally unknown
Black teatfish	• Reproductive success may be compromised (winter spawner) with SST+

Species	Key potential impacts of climate change (2030)
Tropical rock lobster	• Faster growth and higher larval supply, but decreased juvenile survival due to SST+. Net result reduced spawning biomass • Adult movement into deeper water due to SST+ • Settlement areas and recruitment rates may change due to altered north-west Coral Sea currents
Mud crab	• Higher catch rates due to SST+ • Possible population increases due to increases in rainfall
Spanish mackerel	• Possible links between SST and larval survival but generally unknown
Gold-lipped pearl oyster	• Reduced larval growth due to increased rainfall/lower salinity
Black-lipped pearl oyster	• Lower abundance due to upper thermal limits of ~32 °C for adults and reduced larval growth >29 °C

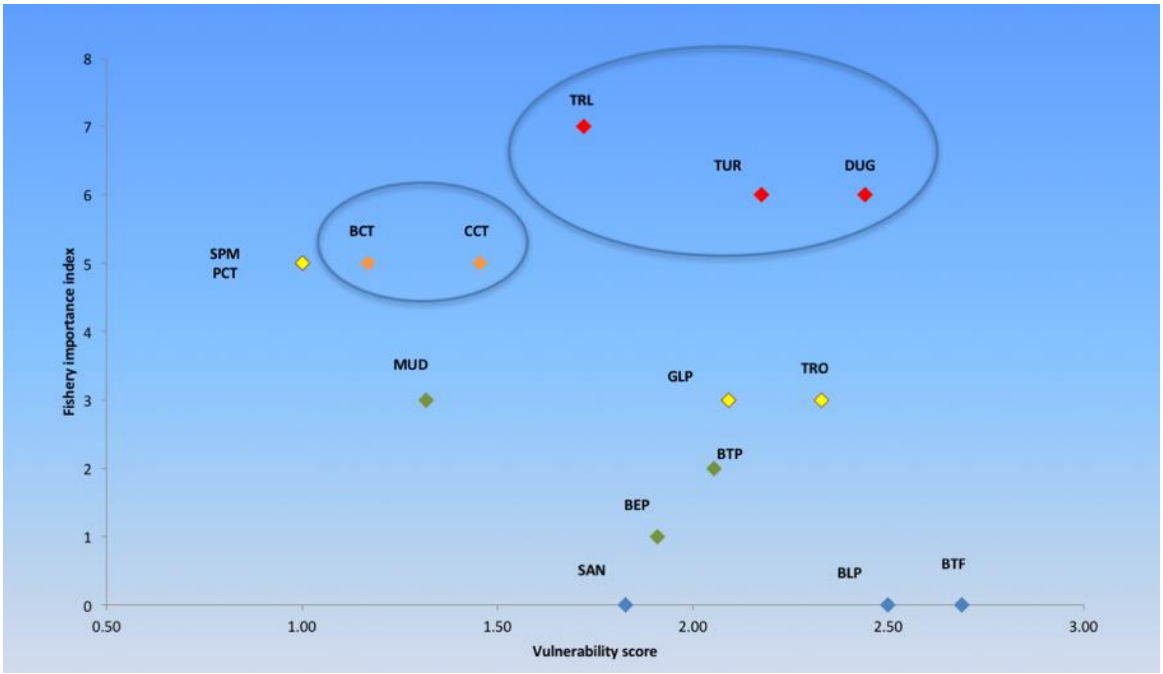
Vulnerability of supporting habitats

	SST	Rainfall/ river flow	Sea level	Cyclones & storms	Ocean pH	Solar radiation	Productivity /circulation
Coastal wetlands	very low	moderate	high – very high	moderate	very low	low	moderate
Seagrass	high	moderate	moderate	high	very low	high	moderate
Coral reefs	very high	high	low	high	very high	low	moderate

Prioritising species for management

Fisheries were ranked according to vulnerability and an 'importance' index that considered cultural and economic value. This process identified three species as management priorities – dugong, turtle and tropical rock lobster (red diamonds on the following figure). Second order priorities were coral trout (common and barcheek; orange diamonds on the following figure).

Importantly, any changes to fishing effort and therefore the pressure and value of fisheries could change the management priorities. For example, the reopening of the *bêche-de-mer* (specifically black teatfish) fishery since the assessment was conducted is likely to have increased the management priority of the main target species, and therefore requires a review and possible adaptations.



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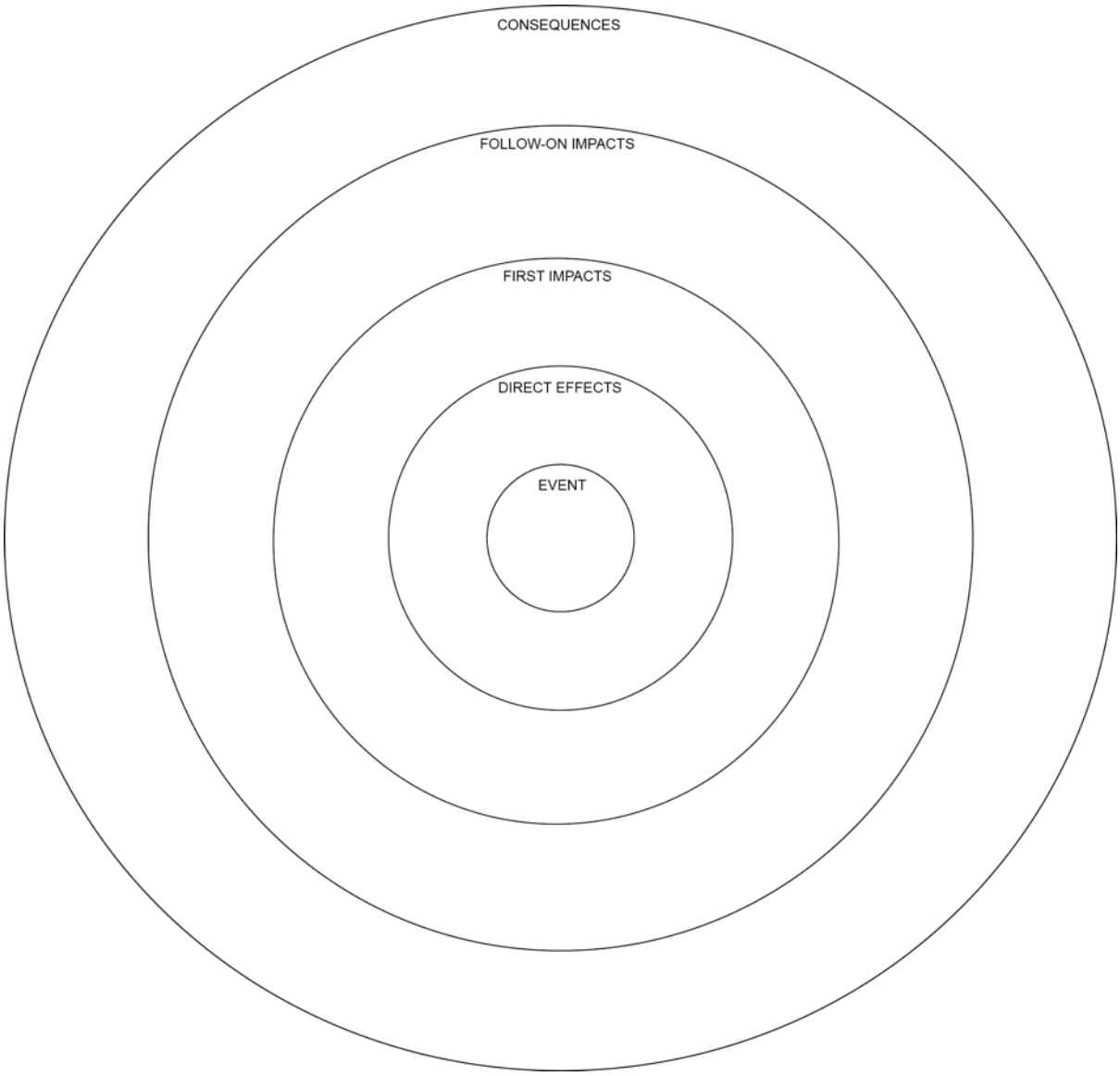
Cascading consequences

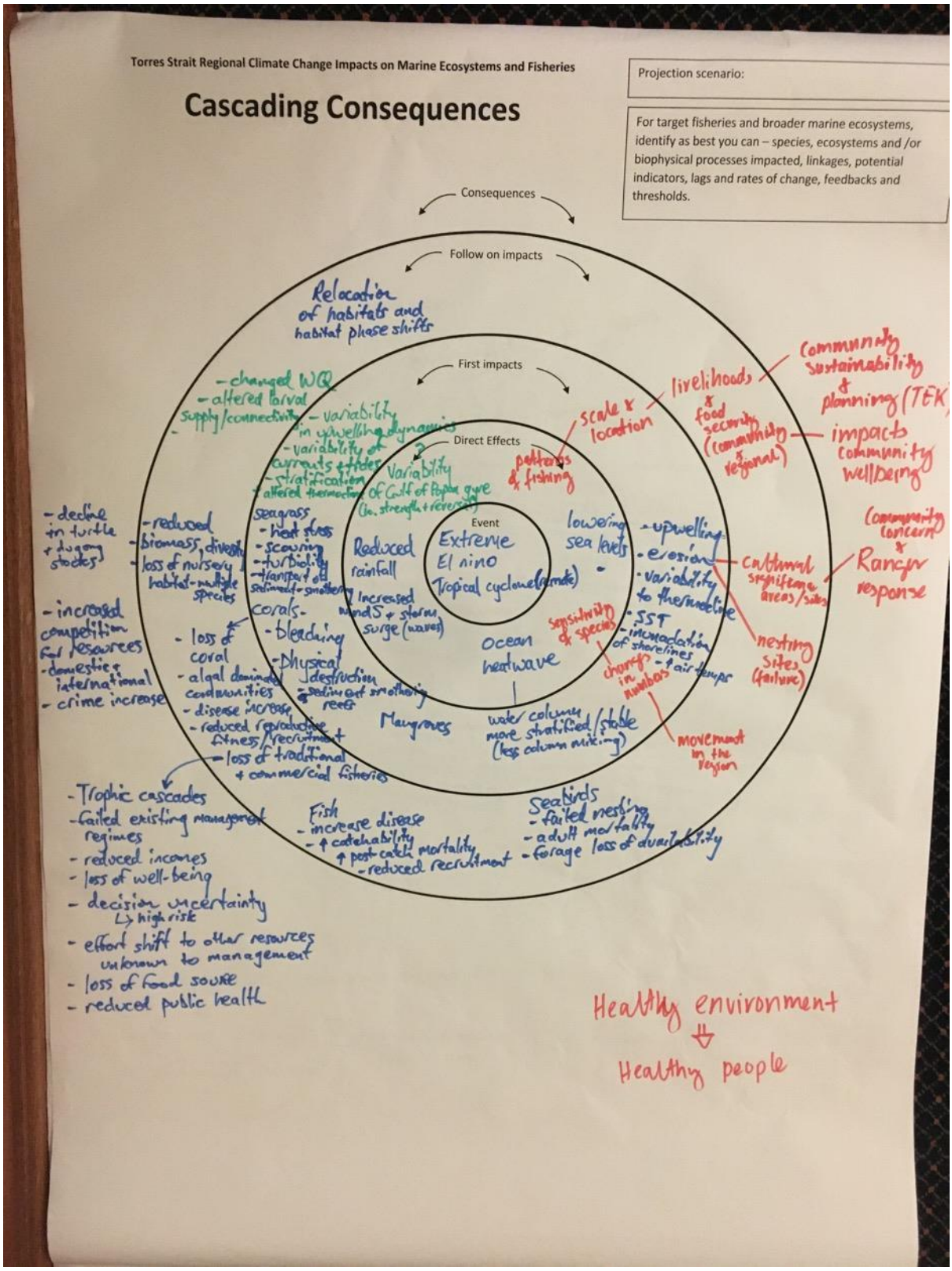
The impacts of climate change in the Torres Strait are not limited to the direct impact of climate events, and the 'ripples' or flow-on effects can be more significant than the primary impacts – particularly when considering co-incident climate events or impacts.

The consequences of two climate scenarios were explored in a 'cascading consequences' exercise, where workshop participants split into groups to map the impacts and consequences of climate change on Torres Strait fisheries and marine ecosystems. The following template was used.

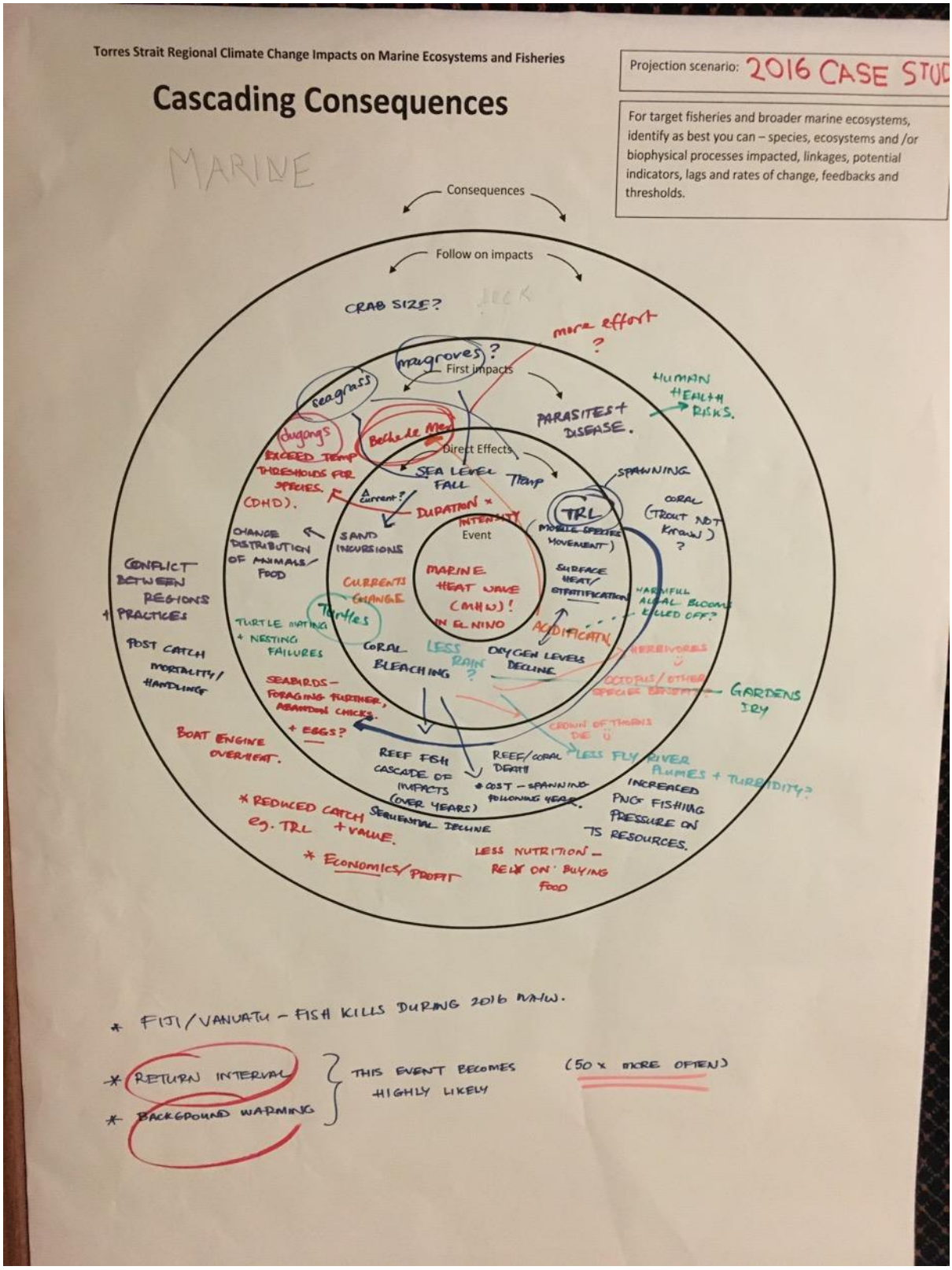
(This template is also a useful community engagement tool and can serve as the basis of insightful discussions when communities think about the consequences of climate events in their context.)



SCENARIO 1: Tropical cyclone occurring during an extreme El Niño event



SCENARIO 2: Marine heatwave during an El Niño event



This example was based on an event examined in this paper: Oliver ECJ, Perkins-Kirkpatrick SE, Holbrook NJ, Bindoff NL (2017) Anthropogenic and natural influences on record 2016 marine heat waves. *Bulletin of the American Meteorological Society*, 98(12), S44-S48, DOI:10.1175/BAMS-D-17-0118.1 (and 10.1175/BAMS-D-17-0118.2).

Adapting to a changing environment: learning with the Torres Strait community to understand future impacts on wellbeing

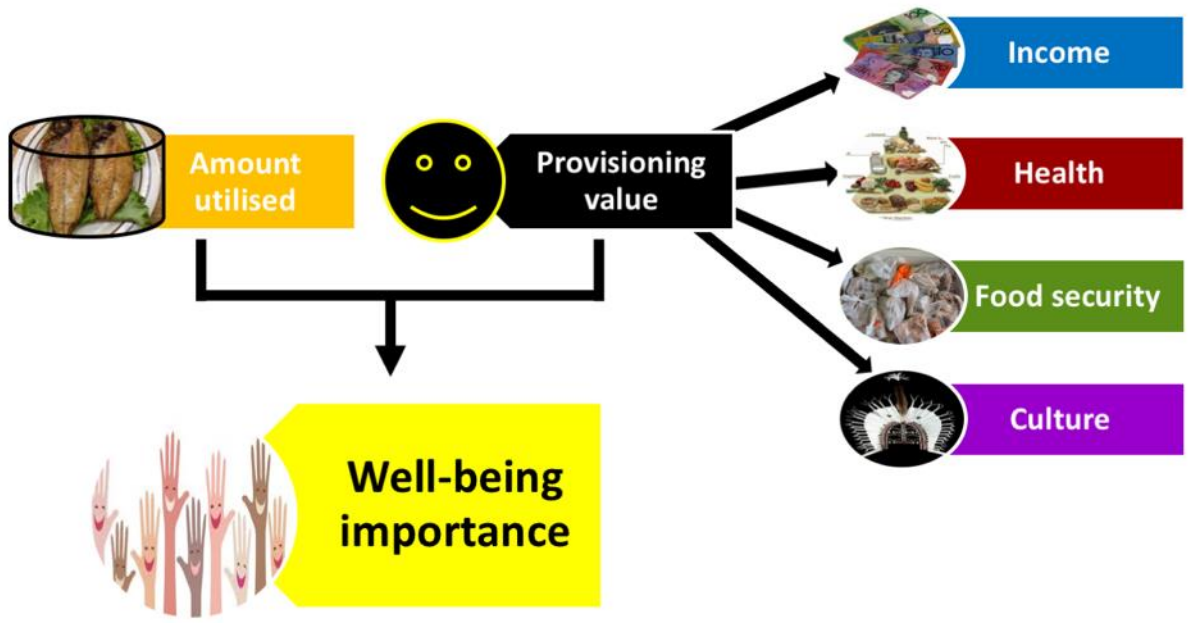
Cass Hunter, CSIRO

- Our science engagement and information needs to be relevant to communities by incorporating local views into the discussions
- Turning community visions about adaptation into reality involves being prepared to work across multiple sectors and the TSRA Climate Program
- Getting the right narrative for adaptation to climate change is about more than just our precision with science predictions.

Understanding impacts

- What are the drivers of change for livelihoods?
- What are the desired possible futures?
- What impact will the 'business as usual' (climate) future have on well-being?
- What is the resilience of the community today?
- What are the priority adaptation strategies to build resilience?

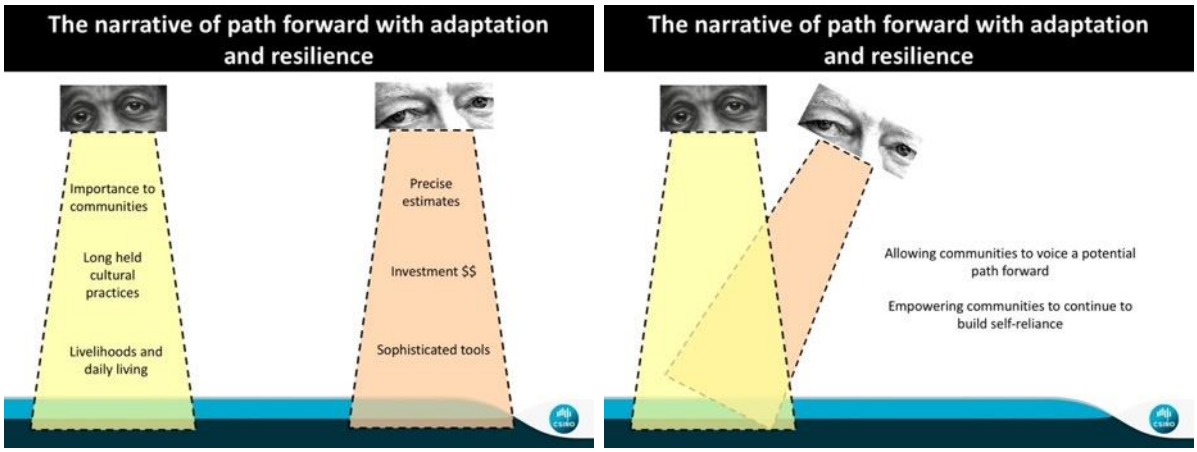
Understanding the importance of ecosystem goods and services



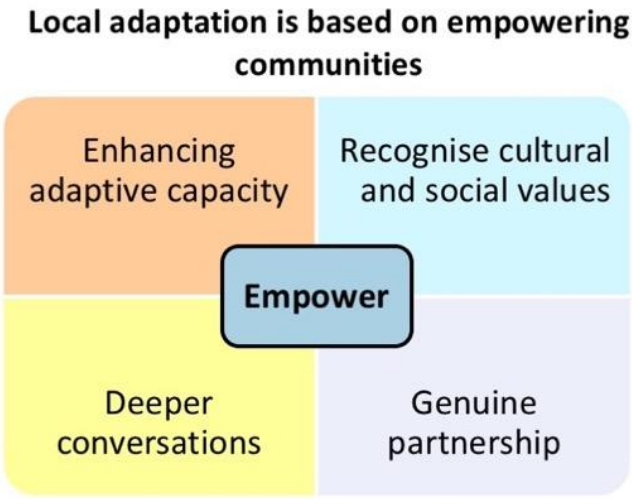
Adaptation strategies

Make it relevant – communities want to see their views and importance factored into climate conversations.

Culture is key – keeping culture strong helps the community to be sustainable and self-reliant.



Need collaborative partnerships to advance forward – to turn visions into reality (conversations into actions) we need to work across sectors (e.g. land use planners, renewables, sustainable housing, employment)



Lessons from the Pacific

Johanna Johnson, TWQ Hub and Mandy Hopkins, ESCC Hub

The Torres Strait is more like the Pacific than Australia – islands are geographically remote with decentralised and dispersed populations, and communities are critically dependent on marine resources for food and income.

In addition to the direct impacts, climate change is affecting habitats, which in turn affects fisheries, which in turn affects livelihoods and income, food security and economic development. It follows that Pacific Islands are highly exposed and vulnerable to climate change.

So, it is useful to consider how communities in the Pacific are using projections science to drive risk assessments, and how this informs adaptation planning and associated decision-making and on-ground actions.

Case studies

Food security

Pacific per capita fish consumption (98–147 kg/person/year) is 3–5 times the global average. Projected climate-related habitat declines (loss of coral cover, reduced seagrass, reduced mangrove area) will affect fisheries. Some Pacific nations are better placed than others to deal with this.

Vanuatu has undertaken a number of adaptation activities in response, including:

- Structured monitoring of coastal fish habitats (reefs, seagrass, mangroves) commenced in 2015/16
- National Fisheries Policy 2016–2031 (ecosystem-based approach to coastal fisheries management)
- Trial of solar dryers for improved post-harvest fish preservation in north Efate and Santo
- New freshwater pond aquaculture for tilapia in villages
- Transfer fishing effort to target nearshore pelagic species using fish attracting devices (FADs); mostly local 'Vatuika' ('Fish and Wealth') design; 30 FADS installed/replaced since 2014

Papua New Guinea Treaty Villages

There are 13 Treaty Villages in the South Fly District of Papua New Guinea, where the low human development index is second only to the Congo. These villages are only 4 km from the northern Torres Strait Islands (Saibai and Boigu), and are highly exposed to climate variability and change.

Challenges for Treaty Villages include: water contamination, salinity intrusion, lack of sanitation, increasing demand/competition for natural resources (due to population growth), flooding and inundation during extreme sea level events, declining fisheries due to fish poaching, habitat loss and overfishing, high human disease prevalence (TB, malaria, cholera), isolation and lack of income opportunities – all serious cross-cutting issues that cannot be dealt with in isolation of climate change or each other.

A Community Ranger program is building a resilience platform for these villages with community-based and community-led activities to improve food security, water, health, livelihoods and well-being.

Outreach

The Pacific-Australia Climate Change Science and Adaptation Planning (PACCSAP) program developed *The Pacific Adventures of the Climate Crab*, an animation and communication resource toolkit to raise awareness of the science and impacts of El Niño and La Niña to encourage Pacific Islanders to take early action in preparing for these extreme climate events.

The resource was developed in close consultation with in-country stakeholders, and its success as a community-level information tool demonstrates the importance of getting in the room and talking to people when developing content to facilitate outreach of the science.

The animation and toolkit are available on the Pacific Climate Change Science website at www.pacificclimatechangescience.org.

References/more information

- Johnson JE, Basel B (2017) Vulnerability Assessment & Local Early Action Planning (VA-LEAP): Community-based Assessments on Rendova Island, Solomon Islands. Report to the Pacific-American Climate Fund (PACAM), USAID Program, March 2017.
- Johnson JE, Waterhouse J, Devlin, MJ, Hooper E (2016) Marine Ecosystem Assessment: North Efate, Vanuatu. Report to the Pacific Community (SPC), Noumea, New Caledonia, and Agence Francaise de Developpement, Paris, France. Vanuatu RESCCUE project.
- Johnson, JE, Welch DJ (2016) Climate change impacts and adaptation actions in North Efate, Vanuatu. Report to the Pacific Community (SPC), Noumea, New Caledonia, and Agence Francaise de Developpement, Paris, France. Vanuatu RESCCUE project.
- Pacific Climate Change Science – www.pacificclimatechangescience.org

Work being done in or relevant to Torres Strait fisheries and climate change

Australian Fisheries Management Authority

Ian Butler

AFMA's has a three-phase approach for adapting Commonwealth fisheries management to climate change.

1. Now

Industry perspectives – AFMA recently completed a survey of fishers in south-eastern Australia (Lakes Entrance) and found that climate change was not perceived as a major issue, even though the region is a climate change 'hot spot'. More important issues were economics, quotas, fishing costs and competition.

Non-recovering undercaught species – a collaboration between AFMA, Fishwell Consulting, CSIRO, the South East Trawl Fishing Industry Association and the Department of Agriculture and Water Resources is investigating the causes of undercaught total allowable catches (TACs) and non-recovering species in the Southern and Eastern Scalefish and Shark Fisheries.

Updated modelling – a CSIRO-led project involving AFMA, the University of Tasmania, the University of British Columbia and the Fisheries Research and Development Corporation is underway to update existing models to account for decadal and regional variation. The project will provide analyses of species sensitivity to climate change impacts and provide a set of recommendations based on findings.

2. 2018–20: Adaptation project

The objectives of AFMA's adaptation project are to:

- Determine how well the existing Commonwealth fisheries management framework copes with climate change impacts (i.e. risk assessment)
- Develop methodology and approach for AFMA (and other fisheries) to adapt the regulatory environment to climate change impacts.
- Develop strategies and priorities to account for the effects of climate change in management of fisheries.

This project does not directly apply to Torres Strait, but can fit in with some effort.

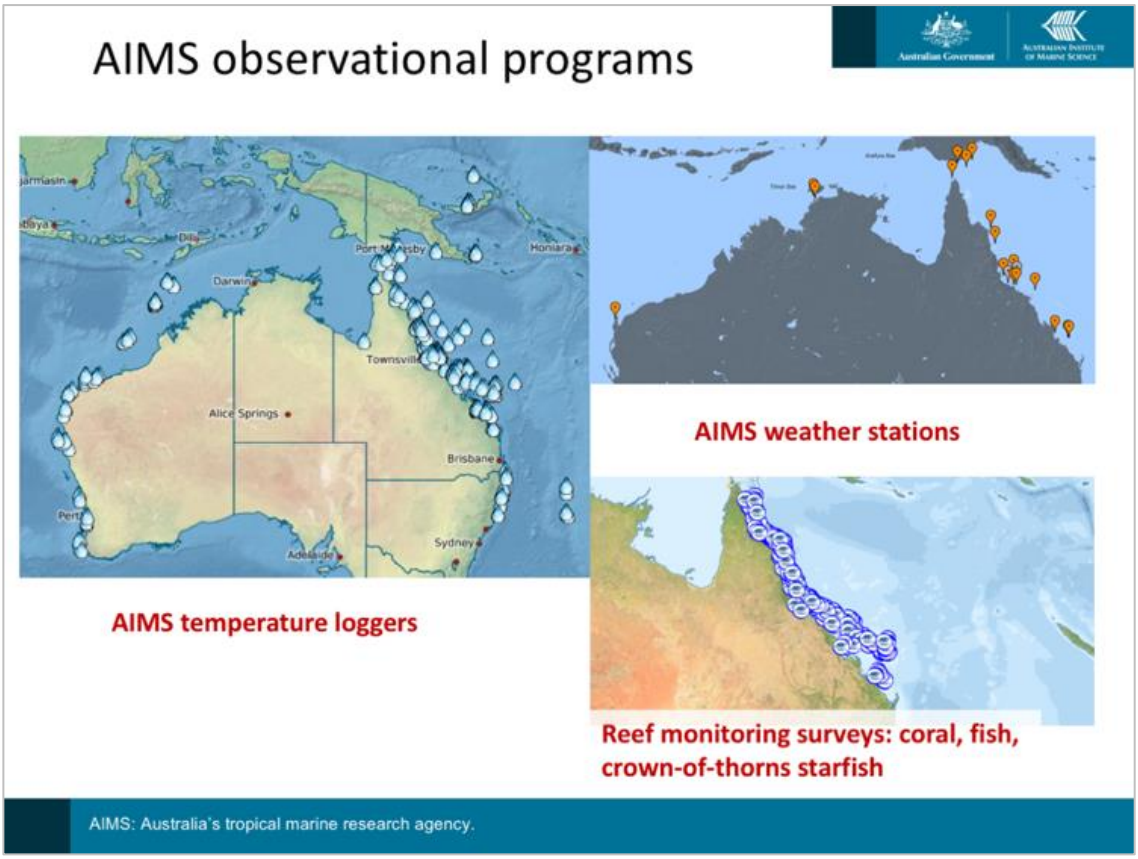
3. 2020+: Implementation

Flexible management is likely to be a key for future fisheries management with features such as a one-fishery approach (flexible management techniques with fewer boundaries) and mobile boundaries (e.g. Southern Bluefin tuna). Another feature is integration of forecasting of optimal fishing conditions.

Australian Institute of Marine Science

Craig Steinberg

One of AIMS's strengths is in its observational programs, which includes temperature loggers, weather stations and surveys of coral, fish and crown-of-thorns starfish.



Modelling currents, sea surface temperatures and sea-level anomalies allows analysis of marine heatwaves and coral bleaching events. Some results to come out of this work:

- The 2016 bleaching event on the Great Barrier Reef was the most severe on record and heat anomalies persisted to the following winter
- Micro-climates created by small scale upwelling can create persistent thermal refugia for coral from a variety of oceanographic processes
- The Gulf of Papua current can reverse, and the current is predicted to intensify in winter in the future. The fate of larvae will be dependent on these changes.

An environmental data gateway has been developed to bring together existing near-realtime data from many sources – IMOS, eReefs, NOAA, AIMS – into one location. The gateway is at http://eatlas.org.au/gbr-gateway-temp.

CSIRO

Eva Plaganyi

There is a long history of fisheries research in Torres Strait and several long time series of fisheries and habitat information collected as part of scientific surveys.

CSIRO has worked closely with traditional owners in the region for several decades in advancing fisheries science and management in the region, and there is a reasonably good two-way flow of information via workshops and meetings.

Torres Strait tropical rock lobster	• Biological and climate data (CSIRO/AFMA surveys since 1989) • Mapping climate impacts on life history stages (2010 study) • Use of management strategy evaluation (2010–13) • Changes in oceanic currents and larval advection (current Environmental Influences project co-funded by AFMA & CSIRO) • Model projections under future climate change (current project that links also with AFMA decadal projections project)
Bêche de mer	• Mapping climate impacts on life history stages (2011 study) • Examples of the use of management strategy evaluation to test the performance of alternative marine monitoring and management strategies to detect and respond to ecological changes caused by climate change (2009–11, part of RUSS project)

There are gaps in some of the physical and oceanographic models that are needed to couple with the biological population dynamics for species of interest in order to reliably make predictions of impacts under climate change for fisheries and ecosystems (e.g. need to resolve tides in the region).

Management strategy evaluation as a risk management tool

Climate-smart strategies build resilience to multiple stresses. Management strategy evaluation (MSE) has been and continues to be used as one effective risk assessment method for road-testing the ‘climate-smartness’ of management strategies. This involves:

- Using climate risk assessment as an input to dynamic models
- Using a reference set of models (ensemble rather than single model) to capture key uncertainties
- Demonstration of use of MSE to test the performance (and adaptability),especially in the face of uncertainty, of alternative harvest strategies in meeting fishery management objectives, such as ensuring:
    - low risk of stock depletion (overall and local)
    - high probability of good catch / average profits
    - low risk of changing the multi-species community composition
    - high probability of managing through climate variability and change.

Torres Strait Regional Authority

Andrew Simmonds

Climate change is impacting vulnerable species and habitats in the Torres Strait and Great Barrier Reef.

Seagrass meadows to date have not shown a negative response to climate change as trends in biomass and species diversity remain consistently high across the region. Seagrass could be vulnerable to climate extremes in the future and this would then impact the Torres Strait **dugong** population – currently low risk. Aerial surveys indicate the population is stable. There is a need to maintain five-yearly survey effort.

Isolated locations of **mangroves** on Torres Strait islands have shown local-scale dieback from coastal erosion/sea-level rise.

Hawksbill turtle nesting population in Torres Strait is in severe decline mostly due anthropogenic impacts of overharvest in neighbouring nations and potential overharvest of eggs in Torres Strait and in neighbouring nations.

Northern Great Barrier Reef stock of **green turtles** is likely heading for a steep decline as a result of failing hatchling production at key index sites at Raine Island and Moulter Cay. Targeting of adult females for harvest and overharvest of eggs in some locations in PNG, Solomons and Torres Strait are also primary contributors. Climate change is drastically skewing the sex of marine turtle hatchlings (all species nesting in Torres Strait) to female via the effects of increased temperatures on incubating eggs. This may lead to negative population outcomes once current hatchling cohorts reach maturity. Funding to support ongoing monitoring of vulnerable marine turtle species in Torres Strait is at risk. If monitoring of key nesting index sites were to cease, this would be a bad outcome for these stock as community-based management would cease to have access to population trends.

Impacts on **coral reefs** from broad-scale severe bleaching will likely have an impact on supporting habitat for commercial fish species. A fisheries management response may be necessary in the future if harvest levels decline. However, there is a lack of information in Torres Strait fisheries regarding amount and value of catches which limits certainty in accurate management responses. There may be refugia for corals at the north-eastern corner of the Torres Strait where waters remain cooler and this may need special management arrangements for future conservation.

Certain low-lying islands in Torres Strait are experiencing **sea-level-related coastal erosion**, which TSRA LSMU is monitoring. There are real concerns in these communities.

There is ongoing **water quality** research into the implications of sediment-related pollution originating from the Fly River. Saibai, Dauan and Boigu are most affected, though results are currently inconclusive. Working with JCU TropWater. Future directions may include investigation of common food sources for metal contamination as well as work to determine historical levels of metals in sediment and corals.

NESP Tropical Water Quality Hub

Johanna Johnson

Previous water quality research

- Torres Strait baseline study (1993) – survey of trace metals in marine seafood, seagrass and sediments
- Apte & Day (1998) – first accurate data on trace metal concentrations in waters (Cu, Cd and Ni only)
- Haynes & Kwan (2002) – 28 sediment samples collected in 2000 and analysed for metals
- NERP WQ hazards (2011–13) – hydrodynamic modelling, predictions of water flow, hazard assessment based on previous data

Current relevant Tropical Water Quality Hub projects

Influence of the Fly River on the Torres Strait region (Projects 2.2.1 and 2.2.2)

Runoff from the Fly River in Papua New Guinea influences water quality conditions in the Torres Strait region; however, the extent and frequency of this influence, and the potential ecological impacts, are not well understood. This project builds on previous efforts to determine the spatial extent, temporal patterns and constituent pollutants of Fly River discharge, and assess the vulnerability of ecosystems in the Torres Strait exposed to the discharge.

A related project is using state of the art procedures to determine trace metal concentrations in marine waters and sediments at locations across the Torres Strait. Chemical signatures of mine pollution are being measured in Torres Strait waters and sediments and hotspots of contamination identified. The water quality data generated will allow informed management decisions to be made on how to best address trans-boundary mining related pollution and potential ecological impacts.

Connectivity and inter-dependencies of values in the northeast Australia seascape: Great Barrier Reef, Torres Strait, Coral Sea, Great Sandy (Project 3.3.3)

This project is identifying and assessing the ecological, cultural, social and economic values of four marine jurisdictions – Great Barrier Reef, Torres Strait, Coral Sea, Great Sandy Straits – and characterising the processes and attributes that influence the values and their connectivity at a regional scale. In doing so, the project will deliver a resource that can inform cross-jurisdictional planning and management.

References/more information

- NESP Tropical Water Quality Hub – www.nesptropical.edu.au

Science, data and research priorities

Workshop participants identified six priority areas for research that will help inform fisheries and marine ecosystem management in Torres Strait (and thereby to inform science-based adaptation response).

The following table summarises initial thoughts with regards to these priority areas. It is anticipated that ideas in this table will further refined over time.

Biological understanding	• Limited understanding of species responses to combinations of changing environmental variables (e.g. bêche-de-mer) (lab, desktop, field) • Seagrass sensitivities
Monitoring	• Tidal gauges – to analyse and add • Drifters – inform on complexity • Integrated Marine Observing System • Moorings (upwellings) – strings of loggers • Himawari satellite information – 1 picture/10 minutes • Turbidity using Secchi discs (cheap and easy)
Population modelling	• Coupling with high-resolution current/climate • Follow similar approaches to those used for corals, crown-of-thorns starfish • Additional models for species (e.g. turtles, dugongs) at appropriate spatial scales • Coral trout correlations with coral abundance or habitat
Climate modelling	• Downscaling of projections for Torres Strait and in particular, tides • Produce regional rainfall projections from CMIP5 models selected for skill/low biases (and maybe CCAM model runs)
Adaptation responses/ communities	• Communication • Community consultation regarding adaptation • Industry and traditional owner advice/experience with regard to fishing behaviour • Management of fisheries – parallel AFMA projects, fishery by fishery; adaptation
Fly River	• Plume prediction • Metals/health risks

Science-based information products and services

Existing information and tools

While additional science will help inform management decisions in the Torres Strait, there is a great deal of information and a number of communication products and decision support tools currently available.

Data collected in the region	• AIMS – in-situ collection (water temperature, weather) – online gateway • BoM – heatwave mapping • AMSA – tide gauges • AFMA – fisheries data • Climate Change in Australia – climate projections • PACCSAP – climate projections for Papua New Guinea and various technical and non-technical climate change communication products and resources • TSRA – reef monitoring, crown-of-thorns starfish monitoring, bleaching, beach profiling • TropWater (James Cook University) – in-situ seagrass surveys • CSIRO – annual habitat surveys (including numbers of pearl oyster, crown-of-thorns starfish and holothurians, and percent cover of standard substratum and biota (including seagrass and algae species) categories
Tools/ programs that make use of the information	• ADWIM (impacts and wellbeing) –> CSIRO • Torres Strait vulnerability assessment • NESP ESCC Hub (www.nespclimate.com.au)

The challenge lies in identifying which information is most useful and delivering it to the people that need it in ways that they can use it.

Communication and outreach ideas

It was agreed that a useful communication and outreach model is needed to develop information resources for the communities and stakeholder groups to provide information that can be easily understood and delivered to stakeholders. A number of ideas for ways this might occur were identified at the workshop.

As is the case with the ideas for science, data and research priorities, it is anticipated that these ideas will be refined over time as follow-up to the workshop.

Support	• Outreach specialist in climate supporting TSRA in disseminating information
Engagement/ outreach activities	• TSRA staff discussing the outcomes of this workshop in fisheries working group meetings and canvasing interest in engagement • More targeted outreach effort to discuss key climate change messages in Torres Strait communities • Building local climate change capacity -> drive local adaptation plans -> climate champion -> who wants to be involved in the communities • Annual event (pre-season gathering of key stakeholders) to provide timely climate information relevant to local communities/the fishery sector
Communication/ knowledge brokering products	• Workshop report • Climate change themed ‘comic book’ as a communication resource for local communities • Video – explain the science and communicate traditional knowledge (communities explain what they see)

Appendix 1: Workshop agenda

Technical workshop

CLIMATE CHANGE IN THE TORRES STRAIT: IMPLICATIONS FOR FISHERIES AND MARINE ECOSYSTEMS

Pullman Cairns International, 17 Abbott Street, Cairns
7–8 December 2017

DAY 1: THU 7/12/17 13:00–17:30

Time	Agenda item	Who	Session purpose
13:00	**LUNCH**		
Introduction			
14:00	Welcome	Geoff Gooley (ESCC Hub)	
14:05	Welcome to country	Gudju Gudju	
14:10	Introduction	Geoff Gooley (ESCC Hub)	
Setting the context			
14:20	Overview: Climate change impacts on oceans, fisheries and marine systems	Neil Holbrook (ESCC Hub)	To ensure all workshop participants understand what aspects of climate change impact oceans and marine systems and what the impacts could be (starting with the global 'big picture' and including all aspects of climate change relevant to TS including SLR, coastal hazards, ocean temp extremes, acidification, extreme events, coral bleaching risk)
14:50	Overview: Torres Strait fisheries and marine ecosystems	TSRA/AFMA	To ensure all workshop participants understand the nature and extent of TS fisheries and marine ecosystems, including and key features and related considerations (e.g. social, political, economic).
Current and future climate in the Torres Strait			
15:20	Climate trends and projections for Torres Strait Islands	Jo Brown (ESCC Hub)	To provide an overview of the current climate of the TS, how it has changed and how it could change in the future, drawing on the latest climate change science. This information will provide an important basis for later discussions in the workshop.

Time	Agenda item	Who	Session purpose
15:50	Climate change impacts on key TS resources – ADWIM model	Cass Hunter (CSIRO)	To share outputs from the CSIRO ecosystem goods and services model to show how climate change is likely to impact key marine resources for TS communities.
16:20	Vulnerability of fisheries to climate change – report summary	Jo Johnson (TWQ Hub)	To provide an overview of climate change hazards, vulnerability and risk specific to fisheries and marine ecosystems in the TS.
16:50	Day 1 wrap-up	Geoff Gooley (ESCC Hub)	
17:00	**Close Day 1**		

DAY 2: FRI 8/12/17 9:00–16:30

Time	Agenda item	Who	Session purpose
Snapshots: Understanding climate change and impacts in the Torres Strait			
9:00	Issues and impacts Including: • impacts of the last coral bleaching event • decadal scale projection of changes in fisheries stocks under climate change • adaptation of fisheries to climate change	Craig Steinberg (AIMS) Eva Plaganyi (CSIRO) Ian Butler (AFMA) John Rainbird and Andrew Simmonds (TSRA) Jo Johnson (TWQ Hub)	To provide a brief overview of current projects and monitoring activities that are helping us to understand climate change and impacts in the TS, as well as discussion of current issues and impacts. Each presenter will have 15 mins to talk about work from their respective organisations, with time for discussion at the end. Outcomes/findings reported here will feed into the following discussions.
10:40	**Morning tea**		
Looking ahead: what does the future hold for TS fisheries and marine ecosystems?			
11:00	Understanding TS stakeholders	Charles David (TSRA)	To identify TS stakeholder groups and their needs
11:30	Activity: Cascading consequences	Facilitator: John Rainbird (TSRA)	To identify possible consequences of climate change and coincident events in TS. Participants will break into two groups for this activity.
12:30	Discussion: Cascading consequences activity	Facilitator: John Rainbird (TSRA)	To discuss the outcomes of the previous activity. As well as being included in the workshop report, responses will inform post-workshop technical meeting discussions.
13:00	**Lunch**		
Preparing for the future			
13:30	Lessons from the Pacific	Jo Johnson (TWQ Hub) and Mandy Hopkins (ESCC Hub)	To share how communities in the Pacific are using projections/science to drive risk assessments, and how

Time	Agenda item	Who	Session purpose
			this feeds into adaptation planning and associated decision-making
14:00	Identified knowledge gaps and prioritised needs	Facilitator: Geoff Gooley (ESCC Hub)	To learn about some knowledge gaps and needs that have already been identified and prioritised. These will inform the following discussion.
14:20	Small group discussions: Knowledge gaps and knowledge products	Facilitator: Mariana Nahas (TSRA)	To identify knowledge gaps and needs in light of what has been presented at the workshop, and how they may be able to be addressed. What [information] resources/ knowledge products are needed to convey the learnings from this workshop to TS stakeholders (including TOs/local fishers, natural resource managers, other local communities of interest and scientists) and what information do we need from TOs?
15:00	Report back – Knowledge gaps and knowledge products	Facilitator: Mariana Nahas (TSRA)	To record ideas for management responses and information needs. As well as being included in the workshop report, responses will inform post-workshop technical meeting discussions.
15:30	Group discussion: Options for further engagement including priority actions and responsibilities	Facilitators: Geoff Gooley (ESCC Hub), John Rainbird (TSRA)	Emphasis on options for further strategic engagement, collaborative partnerships and delivery
Workshop wrap-up			
16:15	Closing remarks (including next steps)	Geoff Gooley (ESCC Hub), John Rainbird (TSRA)	To provide a brief recap of what has been covered and why, and what the next steps will be.
16:30	**Workshop close**		

Appendix 2: Workshop participants

- Shaun BARCLAY, TSRA (Day 2 only)
- Josephine BROWN, ESCC Hub
- Ian BUTLER, AFMA
- Charles DAVID, TSRA
- Geoff GOOLEY, ESCC Hub
- Rohan HAMDEN, Consultant (Day 1 only)
- Neil HOLBROOK, ESCC Hub
- Mandy HOPKINS, ESCC Hub
- Cass HUNTER, CSIRO
- Johanna JOHNSON, TWQ Hub
- Phil LAYCOCK, GBRMPA
- Mariana NAHAS, TSRA
- Karen PEARCE, ESCC Hub (Day 2 only)
- Eva PLAGANYI, CSIRO
- John RAINBIRD, TSRA
- Andrew SIMMONDS, TSRA
- Selina SOUTE, AFMA (Day 2 only)
- Craig STEINBERG, AIMS

Earth Systems and Climate Change Hub

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