Australian Government
Department of the Environment, Water, Heritage and the Arts

Marine and Tropical Sciences Research Facility Milestone Report, 10 June 2009

Program 5(i): **Climate Change: Great Barrier Reef**

Project 2.5i.2(d): **Early warning and assessment system for thermal stress on the Great Barrier Reef – Extention (d) *Vulnerability of high trophic levels on the Great Barrier Reef (e.g. seabirds) to climate change***

Project Leader: **Dr Brad Congdon, James Cook University (JCU)**

Summary

Research findings in ARP2[1] and ARP3[2]

Pelagic tern breeding participation in the northern Great Barrier Reef (GBR) was found to be directly, and independently, related to changes in both surface chlorophyll concentration and thermocline depth that occur well in advance of El Niño generated sea-surface temperature (SST) anomalies. In contrast, breeding in an inshore foraging tern species was not correlated with any environmental/biological parameter investigated. These findings demonstrate that El Niño related phenomena do not affect seabird prey dynamics solely via productivity shifts at seasonal scales, nor in similar ways across different seabird foraging guilds. Our results also suggest that population declines observed in the western tropical Pacific over the study period may be directly related to the frequency and intensity of El Niño anomalies.

Self-provisioning adult shearwaters breeding in the southern GBR access high productivity foraging locations in the Coral Sea and to the south of Fraser Island that have specific and identifiable oceanographic characteristics. As a consequence, breeding success in the southern GBR is likely to be totally dependent on continued productivity at these 'at-distance' locations. Sample sizes on which these results are based are currently small and so further validation is required.

Shearwaters breeding in the southern GBR use local prey resources from the Capricorn-Bunker and Swain reefs regions to provision chicks. Prey are obtained primarily from surface waters with generally cooler than average SSTs and these patches of 'favourable' habitat are spatially and temporally restricted. Data continue to suggest that the quantity of food provided to chicks can be directly related to SST. Sample sizes on which these results are based are currently small and so further validation is required.

Similar to shearwaters, provisioning rates in black noddies were shown to be directly related with day-to-day variation in SST. Black noddies expressed limited plasticity of adult provisioning behaviour or offspring development during periods of low food availability. This means they have a restricted capacity to resist environmental variation associated with

[1] Research conducted in 2007/2008 as per Annual Research Plan for 2007/2008 (ARP2).
[2] Research conducted in 2008/2009 as per Annual Research Plan for 2008/2009 (ARP3).

climate change, with responses to future changes in sea-surface temperature and other environmental variation likely dependant on evolutionary responses via natural selection.

Project Objectives and Agreed Milestones

Seabird foraging and reproductive success is explicitly linked to both local and large-scale oceanographic variation. We will investigate the relationships between prey availability and accessibility and specific physiochemical oceanographic parameters at different scales. These data will be combined with satellite and hydrodynamic information on meso-scale oceanographic variability to better predict how seabirds will respond to projected increases in both SST and other ENSO associated phenomena. Further, we will aim to assess both behavioural and developmental plasticity in multiple seabird species under fluctuating resource availability. These project components will allow determination of the likely range of oceanographic and climatic conditions within which seabird reproduction on the GBR will remain viable.

Project 2.5i.2(d) Milestone
Report 2 submission Progress report covering: • Overlays of satellite telemetry foraging data on meso-scale oceanographic information to further identify and confirm critical 'at-distance' foraging locations and associated oceanographic features. • Preliminary analysis of oceanographic phenomena used by local foraging shearwaters in the southern Great Barrier Reef during chick rearing based on one season's data.

Project Results

Progress report: Overlays of satellite telemetry foraging data on meso-scale oceanographic information to further identify and confirm critical 'at-distance' foraging locations and associated oceanographic features (Dr B. Congdon, JCU and Dr S. Weeks, UQ)

- A preliminary analysis combining satellite foraging position data, bathymetry data and meso-scale oceanographic information for the East Australian coast and Coral Sea region is complete. A manuscript incorporating this analysis, in part, is in final preparation:

  Weeks, S. J., Bakun, A., Congdon, B. C. and Steinberg, C. (In prep.) Mesoscale ocean eddy dynamics and seabird foraging ecology in the southern Great Barrier Reef: Observations during the 2005-06 coral bleaching event. *Ecology Letters*.
- Confirmation of these findings requires at least another season's tracking data to become statistically robust. A new PTT harness system for longer-term deployment of satellite telemetry equipment on foraging shearwaters was successfully trialled using dummy loggers during the 2009 breeding season for deployment in 2010.

Progress report: Preliminary analysis of oceanographic phenomena used by local foraging shearwaters in the southern GBR during chick rearing based on one seasons data (Dr B. Congdon, JCU)

- The analysis examining the effects of large-scale and long-term among-season, oceanographic variation in SST, thermocline depth and productivity

(chlorophyll *a*) on breeding participation in three species breeding at Michealmas Cay in the northern GBR is complete. A manuscript arising from this work has been published:

Devney, C. A., Short, M. and Congdon, B. C. (2009) Sensitivity of tropical seabirds to El Niño precursors. *Ecology* 90: 1175-1183.

This work is continuing so as to further refine the functional relationships identified in this analysis.

- A preliminary analysis combining foraging success data with satellite and hydrodynamic information at local inter-reef scales in the Capricorn-Bunker Island group based on one season's data is complete. A manuscript from this work is in final preparation (see Weeks *et al.* In prep. above).
- In conjunction with this work, temperature and depth logging equipment was successfully deployed on local foraging shearwaters during the 2009 breeding season and a preliminary analysis of SST foraging preferences in wedge-tailed shearwaters has been undertaken. When provisioning chicks, shearwaters feed primarily in surface waters and appear to target water that is at temperatures below mean background levels. This preferred foraging habitat has a restricted spatial and temporal distribution likely linked to reef bathymetry. Confirmation of these findings requires further incorporation of samples from 2009 and at least a further season's data.
- In addition, an analysis of levels of adult behavioural and chick developmental plasticity has been completed for one off-shore foraging species – the black noddy (*Anous minutus*) and a manuscript arising from this work is currently in review:

Devney, C. A., Caley, M. J. and Congdon, B. C. (In review) Flexibility of responses by parent and offspring noddies to sea-surface temperature anomalies. *Marine Ecology Progress Series*.

Communications, major activities and events

Over the 2007-2009 (ARP2 and ARP3) period the seabird sub-project and associated researchers have produced a total of three international refereed journal articles, with a further manuscript in review and one in final preparation. The team has also produced:

- Two refereed book chapters that synthesise seabird/climate research outcomes;
- Two management reports summarising the current status of GBR seabirds;
- One international and two national workshop presentations on the impacts of climate variation on seabirds and other upper level predators;
- Two professional reviews of workshop outcomes; and
- Three international, one national and one invited conference presentation (summarised below).

Refereed manuscripts

Devney, C. A., Caley, M. J. and Congdon, B. C. (In review) Flexibility of responses by parent and offspring noddies to sea-surface temperature anomalies. *Marine Ecology Progress Series*.

Devney, C. A., Short, M. and Congdon, B. C. (2009) Sensitivity of tropical seabirds to El Niño precursors. *Ecology* 90: 1175-1183.

Devney C.A., Short, M. and Congdon, B. C. (2009) Cyclonic and anthropogenic influences on tern populations. *Wildlife Research* 36: 368-378.

Erwin, C.A. and Congdon, B. C. (2007) Day-to-day variation in sea-surface temperature reduces sooty tern (*Sterna fuscata*) foraging success on the Great Barrier Reef, Australia. *Marine Ecology Progress Series* 331: 255-266.

Weeks, S. J., Bakun, A., Congdon, B. C. and Steinberg, C. (In prep.) Mesoscale ocean eddy dynamics and seabird foraging ecology in the southern Great Barrier Reef: Observations during the 2005-06 coral bleaching event. *Ecology Letters*.

Book chapters

Congdon, B. C. (2008) Seabirds of the Great Barrier Reef. In: Hutchins, P., Kingsford, M. and Hoegh-Guldberg O. (eds.) *The Great Barrier Reef: Biology, Environment and Management* CSIRO Publishing, Australia.

Congdon B. C., Erwin, C. A., Peck, D. R., Baker, G. B., Double, M. C. and O'Neill, P. (2007) Vulnerability of seabirds on the Great Barrier Reef to climate change. In: Johnson, J. and Marshall, P. (eds.) *Climate change and the Great Barrier Reef: A Vulnerability Assessment*. Great Barrier Reef Marine Park Authority, Canberra [Access chapters online]

Management reports/articles

Chambers, L. E., Congdon, B. C., Dunlop, N., Dann, P. and Devney, C. (2009) *Seabirds.* In: *Marine Climate Change Impacts and Adaptation Report Card for Australia*. Climate Adaptation Flagship, CSIRO [Access Report Card online]

(Erwin) Devney C. A. and Congdon, B. C. (2007) Demographic and reproductive impacts on seabirds? In. Olsen, P. (ed.) *The state of Australia's birds 2007 – Birds in a changing climate.* Birds Australia [Access report online]

Management workshops

Congdon, B. C. (2008) Seabirds of GBR: Current status. *Coastal Seabird Atlas Workshop*, Great Barrier Reef Marine Park Authority (GBRMPA), Townsville, Australia.

Congdon, B. C. (2008) Climate change and the seabirds of Raine Island. *Raine Island Workshop: A climate change risk assessment*. Great Barrier Reef Marine Park Authority (GBRMPA), Townsville, Australia.

Congdon, B. C. (2007) Assessing the upper trophic level impacts of climate variation in tropical marine ecosystems. In: *Seabirds as bio-indicators in the tropical Indian Ocean*. WIOMSA/Ecomar International Workshop, Victoria, Mahe, Seychelles.

Conference abstracts / Invited presentations

Congdon, B. C. (2009) *Climate change impacts on top marine predators of the Great Barrier Reef.* Heron Island Research Station – Opening ceremony. Heron Island, Australia.

Congdon, B. C., Erwin, C. A., Peck, D. R., Krockenberger, A. K., Weeks, S. and Short, M. (2008) Seabirds in hot water: Climate variation and upper tropic level dynamics on the GBR. In: Taylor, R. and Long, S. (eds.) Proceedings of the 2008 Marine and Tropical Sciences Research Facility Annual Conference, 28 April – 1 May 2008. Reef and Rainforest Research Centre Ltd, Cairns [Access Proceedings online]

Devney, C., Short, M. and Congdon, B. C. (2007) Climate change on the Great Barrier Reef: A tern for the worse? Fourth Biennial Australasian Ornithological Conference, 3-5 December 2007, Perth, Australia [Access book of abstracts online]

Devney, C., Caley, J. and Congdon, B. C. (2007) Measuring seabird resistance to climate change on the Great Barrier Reef. Fourth Biennial Australasian Ornithological Conference, 3-5 December 2007, Perth, Australia [Access book of abstracts online]

Hashmi, D. and Congdon, B. C. (2007) Diversity-dependent selection: a generally applicable scheme. *Verhandlungen der Gesellschaft für Oekologie* 37: 531 (Munich, Germany)

Professional reviews

GBRMPA Raine Island Workshop Report 2008

GBRMPA Seabird Atlas Workshop Report 2008