INDEPENDENT EXPERT PANEL – ADVICE ON RESPONDING TO MASS CORAL BLEACHING OF THE GREAT BARRIER REEF

OUTCOMES FROM WORKSHOP: 5 MAY 2017

The case for urgent action

- Mass coral bleaching in reefs is primarily caused by prolonged exposure to thermal stress – the warming of the planet (particularly the oceans) caused by the continuing release of heat-trapping greenhouse gases.

- Even if anthropogenic release of greenhouse gases were stopped instantaneously, the present levels in the atmosphere would continue to warm the planet on top of the average of ~0.9°C warming above pre-industrial levels[1] that has already occurred.

- Consequently, Great Barrier Reef (the Reef) management urgently needs a revised Plan to 2050 that will build on the existing foundation but enable mitigation, adaptation and management of the Reef in the face of inexorable global warming.

Recommendations

Global emission reduction

1. Global emission reduction targets should be set to secure an average temperature increase of no more than 1.5°C above pre-industrial levels, or even less.

2. Australia should set targets appropriate to its 'fair share' of emission reduction aimed at keeping global warming to the low end of the COP21 range, or below.

3. Australia should play a prominent leading role in securing appropriate global targets and purposeful action to meet a 1.5°C target, or lower.

Revision of the Reef 2050 Plan

4. Revision of the Reef 2050 Plan is critical and should be completed as soon as practicable. The revised Plan should:

    a. accommodate possible global warming of at least 1.5°C above pre-industrial levels – managing the Reef and building capacity to adapt to present circumstances, let alone anticipated conditions, will be central to any response.

    b. focus on minimising the cumulative impacts of multiple stressors.

    c. encourage research into the differences in vulnerability between reefs to inform management of the Reef and to prioritise actions to regionally important areas.

    d. focus on the ecological functions of the Reef.

    e. be aimed at identifying and targeting the functions (e.g. herbivory, larval connectivity, reef building capacity) that are required to maintain Reef ecosystems.

[1] Collins, M. *et al.* 2013, Long-term climate change: Projections, commitments and irreversibility, in *Climate Change 2013: The Physical Science Basis*, *Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, edited by Stocker, T.F., Qin, D., Plattner, G.-K., Tignor, M. Allen, S.K., Boschung, J. Nauels, A., Xia, Y., Bex, V. and Midgley, P.M., Cambridge and New York, Cambridge University Press, pp. 1029-1136.

f. identify the key species that support the Reef's ecological processes, and target interventions to support those species.

g. emphasise actions that can be implemented at scale, according to priority and with urgency.

h. continue to be built around themes and the interplay between them (e.g. ecosystem health and social and community benefits).

Immediate strategies

5. Accelerate adoption of better land management practices to improve quality of water to the Reef;

6. Increase efforts to reduce nutrient and pesticide run-off, and reduce sediment concentrations, all at appropriate scale.

7. Identify the highest priority areas of the Reef for focused action in the short to medium term.

8. Establish rapid semi-autonomous survey systems for assessing change in the marine environment, to help identify pressures on ecosystem resilience (e.g. pests and diseases, decline of Reef communities).

Communities

9. Traditional Owners, local people, communities and local authorities should be supported better to deliver on-ground action that will benefit the Reef. Communities need to:

    a. be involved locally and regionally in ecologically and culturally relevant actions, particularly those that can be scaled for greater impact.

    b. be eligible for financial support for activities consistent with the revised Plan.

    c. have a role working with scientists to ensure knowledge exchange to support the ecosystem services provided by the Reef.

Innovative solutions to adaptation and management

10. An Open Innovation Challenge should be developed to draw from a wide range of expertise and technologies to seek out solutions to that will improve Reef health and resilience.

Statement

At the request of the Great Barrier Reef Ministerial Forum, the Reef 2050 Plan Independent Expert Panel met in Brisbane on 5 May 2017 to develop advice on protection and restoration of the Reef considering the widespread coral bleaching in both 2016 and 2017.

The key outcomes of the workshop are described in this report.

This report builds on the Panel's earlier *Advice on coral bleaching and climate change (2016)* which is available at http://environment.gov.au/marine/gbr/reef2050/advisory-bodies.

State of the Reef today

- The mass coral bleaching events of 2016 and 2017 resulted in significant coral decline and habitat loss in the Reef.
- The highest mortality of shallow water corals occurred in the northern region in 2016, and in the central region in 2017, with a predicted combined mortality of close to 50% averaged across the whole Reef. In both years, mortality of corals was negligible in the southern third of the Reef.
- Tropical Cyclone Debbie crossed the Reef near the southern boundary of bleaching in 2017 and made landfall on March 28th. In the Whitsundays, the Cyclone physically destroyed coral and caused major sediment and nutrient run-off into the Reef from flooded catchments.
- The full effects of the events in 2016/2017 will become clearer in coming months.
- The central region of the Reef is also being affected by the fourth outbreak of coral-eating crown-of-thorns starfish recorded since the late 1960s. Crown-of-thorns starfish reduce the opportunity for recovery.
- Cumulative impacts (including run-off of sediments, nutrients and pesticides, decreasing ocean pH, crown-of-thorns starfish, over-harvesting of predatory fish and especially climate change) are potential game changers for the future state of the Reef, its biodiversity, management and the Reef's connection to Traditional Owners and local communities.
- Consecutive coral bleaching events and the impact of other stressors have fundamentally changed the character of the Reef. Corals are relatively slow growing and will have too little time to recover between events or to evolve genetically.
- The diversity of any surviving reefs will therefore be different from their historical state.
- Given the extent of damage already experienced in recent years, and trajectories for future temperature and climate, reef health can be expected to worsen if urgent action is not taken.

Unprecedented bleaching events

- Large-scale coral bleaching in the Reef (and globally) is a recent phenomenon. There are no scientific reports of mass bleaching events in the Reef before 1998, while minor bleaching dates back only to the 1970s.

- The 2016 and 2017 bleaching events may be unprecedented in human history, but they are in line with predictions[2] [3].
- Coral bleaching is a global phenomenon with observations of bleaching in the world's coral reefs increasing from 236 in the 1980s to 5094 in the 2000s[4].
- The rapidity of the predicted changes in climate indicates a major problem for tropical marine ecosystems and suggests that unrestrained warming will force the loss, degradation and change of coral reefs world-wide[5].
- Coral bleaching and mortality is a visible and obvious sign of heat stress, but the effect of climate change extends well beyond corals to the entire ecosystem.

The primary cause of coral bleaching and mortality

- Mass coral bleaching is primarily caused by prolonged exposure to thermal stress[6]. The stress is expressed as degree heating weeks (DHWs) which combines into a single metric the number of weeks and the measured temperature above the long-term average sea surface temperature.
- When sea surface temperatures are high for long enough, bleaching may be followed by mortality.

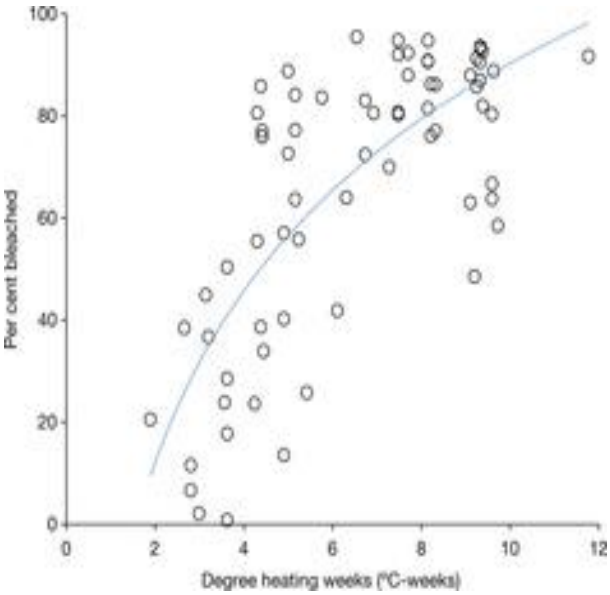

Figure 1: The relationship between heat exposure (satellite-based DHWs in 2016) and the amount of bleaching measured underwater (percentage of coral bleached) in March/April. Each data point represents an individual reef (n=69)[7].

[2] Glynn, PW 1984, Widespread coral mortality and the 1982-83 El Niño warming event Environmental Conservation, Cambridge University Press.
[3] Glynn, P.W., 1991. Coral reef bleaching in the 1980s and possible connections with global warming. *Trends in Ecology & Evolution*, *6*(6), pp.175-179.
[4] Donner, SD, Rickbell, GJM and Heron, SF 2017, A new, high-resolution global mass coral bleaching database. *PLOS ONE 12(4):* e0175490 https://doi.org/10.1371/journal.pone.0175490
[5] Hoegh-Goldberg, O 1999, Climate Change, coral bleaching and the future of the world's coral reefs. *Marine and Freshwater Research, 50(8),* 839-866).
[6] National Oceanic and Atmospheric Administration (NOAA) 2017, Daily 5-km Satellite Coral Bleaching Heat Stress Alert Area Product, https://coralreefwatch.noaa.gov/satellite/bleaching5km/index_5km_baa_max_r07d.php
[7] Hughes, T. et al. 2017, Global warming and recurrent mass bleaching of corals. *Nature* 543: 373-377.

- February to June 2016 recorded the highest sea surface water temperatures on the Reef since record keeping began in 1900[8]. Globally the year 2016 was also the hottest year on record[9].

Cause of elevated sea temperatures

- Greenhouse gases reduce the radiation of heat back into space. The trapping of heat causes oceans, land and the atmosphere to warm[10].

- The oceans are a heat sink and absorb more than 90% of the additional heat trapped by the extra greenhouse gases. Average global ocean surface temperature is now ~0.9°C above its pre-industrial average[11].

Consequences of the continuing release of greenhouse gases

- Present carbon dioxide concentrations in the atmosphere, along with other greenhouse gases, have already locked the Planet into continuing global warming over and above the present ~0.9°C above the pre-industrial average[12].

- Even if greenhouse gas emissions were stopped instantaneously, the present global average temperature of ~0.9°C (or even higher) would be maintained for centuries[13].

- Greenhouse gas emissions will not be stopped instantaneously; oceans will continue to warm as ever more emissions are released into the atmosphere and trap more heat.

- Higher average temperatures are accompanied by a greater frequency of high-temperature extremes, including record-breaking temperatures.

- Increases in global average temperature and extreme weather events add to the stresses faced by all ecosystems - including those in the ocean[14].

- Higher average temperatures and more frequent extremes combine to put the Reef (all reefs) at greater risk.

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[8] Australian Government Bureau of Meteorology 2017, Australian climate variability & change, http://www.bom.gov.au/cgi-bin/climate/change/timeseries.cgi?graph=sst&area=GBR&season=05&ave_yr=0

[9] https://public.wmo.int/en/media/press-release/wmo-confirms-2016-hottest-year-record-about-1.1°C -above-pre-industrial-era

[10] IPCC 2013, Summary for Policymakers. In: Stocker TF, Qin D, Plattner G-K, Tignor M, Allen SK, Boschung J, et al., editors. Climate Change 2013: The Physical Science Basis Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press. p. 1–30.

[11] Huang, B. et al. 2015, Further Exploring and Quantifying Uncertainties for Extended Reconstructed Sea Surface Temperature. Version 4. *Journal of Climate,* 29, 3119–3142

[12] Zickfeld, K., Eby, M., Weaver, A.J., Alexander, K., Crespin, E., Edwards, N.R., Eliseev, A.V., Feulner, G., Fichefet, T., Forest, C.E. and Friedlingstein, P., 2013. Long-term climate change commitment and reversibility: an EMIC intercomparison. *Journal of Climate*, *26*(16), pp.5782-5809.

[13] Zickfeld, K., Eby, M., Weaver, A.J., Alexander, K., Crespin, E., Edwards, N.R., Eliseev, A.V., Feulner, G., Fichefet, T., Forest, C.E. and Friedlingstein, P., 2013. Long-term climate change commitment and reversibility: an EMIC intercomparison. *Journal of Climate*, *26*(16), pp.5782-5809.

[14] Hoegh-Goldberg, O 1999. Climate Change, coral bleaching and the future of the world's coral reefs. *Marine and Freshwater Research, 50(8),* 839-866)

- Global warming will therefore increase the frequency and intensity of mass coral bleaching on the Reef and coral reefs globally[15] [16].

- The presently observed changes are consistent with modelling of how sea surface temperatures are likely to change under various climate change scenarios[17].

Climate Change

- As the planet warms, a different climate will evolve, including changes to predominant weather patterns across the globe[18].

- A higher proportion of weather events will most likely be at the more extreme end of the spectrum. In particular, global warming will lead to more intense heavy rainfall and more intense and longer heatwaves and droughts. The proportion of tropical cyclones with the highest wind speeds is also expected to increase.

- Anomalously warm February and March sea surface temperatures over the Reef have become more frequent over the past century.

- The frequency of heat events, such as those experienced in 2016 and 2017 in Queensland, is expected to increase.

- Global warming must therefore change the way the Reef is managed.

- The Reef 2050 Plan will need a substantial revision including nominating priority actions to promote resilience and reduce stresses on recovering bleached corals. The revised Plan should promote urgency, and actions at the scale needed to enhance resilience and adaptation of the Reef ecosystem.

Implications for communities

- Communities, especially those along the Queensland coast, are learning about the phenomenon of mass bleaching and damage to the ecosystem together, with no long historical guide to assist in developing a response.

- Managing adaptation is critical because social and economic feedbacks could exacerbate the problem[19] [20].

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[15] Hoegh-Goldberg, O 1999. Climate Change, coral bleaching and the future of the world's coral reefs. *Marine and Freshwater Research, 50(8),* 839-866)

[16] Hoegh-Guldberg O, Cai R, Poloczanska ES, Brewer PG, Sundby S, Hilmi K, et al. 2014, Chapter 30. The Ocean. In: Barros VR, Field CB, Dokken DJ, Mastrandrea MD, Mach KJ, Bilir TE, et al., editors. 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. Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press; p. 1655-731.

[17] Cowtan, K., Z. Hausfather, E. Hawkins, P. Jacobs, M. E. Mann, S. K. Miller, B. A. Steinman, M. B. Stolpe, and R. G. Way 2015, Robust comparison of climate models with observations using blended land air and ocean sea surface temperatures, Geophys. Res. Lett., 42(15), 6526-6534, doi:10.1002/2015GL064888

[18] CSIRO and BoM 2016, State of the Climate 2016. CSIRO and Bureau of Meteorology, Melbourne, pp.22 http://www.bom.gov.au/state-of-the-climate/

[19] Barnett, J. and O'neill, S.J., 2012. Islands, resettlement and adaptation. *Nature Climate Change*, *2*(1), pp.8-10.

[20] Cinner, J.E., Folke, C., Daw, T. and Hicks, C.C., 2011. Responding to change: using scenarios to understand how socioeconomic factors may influence amplifying or dampening exploitation feedbacks among Tanzanian fishers. *Global Environmental Change*, *21*(1), pp.7-12.

- The benefits of ecosystem services[21] provided by the Great Barrier Reef are substantial – tourism, fishing and research/management contribute around $5.7 billion to the Australian economy with the employment of just under 69,000 people[22]. Other cultural values have been estimated at an additional $8 billion[23]

- Enhancing community capacity builds 'social capital', which is critical to successful natural resource management[24].

Conclusion

The Panel concludes:

- The cumulative impact of elevated ocean temperatures and climate-related 'events' will change reefs profoundly.

- This is a pressure affecting reefs worldwide – a truly global issue.

- The Outstanding Universal Value of the Reef, and all reefs globally, will be compromised – through loss of geomorphic features, natural habitats, biological diversity, cultural impact and its beauty.

- The objective of the Reef 2050 Plan aimed at preserving the Outstanding Universal Value of the Reef, or restoring it to its historical state, may no longer be achievable.

- Notwithstanding these effects, coral reefs including the Reef will survive if the agreed targets from COP21 are achieved, or bettered; but they will continue to be challenged if sea surface temperatures are not stabilised cooler than the present national commitments to greenhouse gas emission reduction imply.

- The Reef 2050 Plan will need to be revised specifically to emphasise and manage the effect of global warming along with other stressors.

- Extreme weather events will increase in intensity and/or duration, and adaptive management strategies must account for this.

- The revised plan should lead to identified priority actions to promote resilience and reduce stresses affecting the recovery of bleached corals and other organisms.

- Future actions must seek to develop the ecosystem services that are likely to be delivered by a different reef.

- The Reef is highly significant for sustaining cultural and community well-being for over 70 Traditional Owner groups[25].

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[21] Defined as the benefits provided to humans through the transformations of resources (or environmental assets, including land, water, vegetation and atmosphere) into essential goods and services e.g. clean air, water, and food. See Costanza, R. et al. 1997. The value of the world's ecosystem services and natural capital. *Nature* 387.

[22] Economics, Deloitte Access 2013, Economic contribution to the Great Barrier Reef

[23] Jarvis, D., Stoeckl, N., Lui, H. (2017), "'New methods for valuing, and for identifying spatial variations, in cultural services: A case study of the Great Barrier Reef", Ecosystem Services, 24:58-67.

[24] Pretty, J., & Ward, H. (2001) Social capital and the environment. *World Development*, (29) 209-277

[25] Indigenous Reef Advisory Committee 2017, Indigenous Reef Advisory Committee statement, http://downloads.gbrmpa.gov.au/files/ff0pmghcln

- There is a place for greater emphasis on empowering Traditional Owners, local people, communities and local authorities to deliver on-ground action that will benefit the Reef for all.

Response

Long term impact

- It is critical that global warming be stabilised and that the increase in average temperature above pre-industrial levels be kept as low as possible.
- Global agreement reached in Paris (COP21) aimed to hold the increase in global average temperature to well below 2°C above pre-industrial levels, and to pursue efforts to limit the temperature increase to 1.5°C.
- After Paris, non-binding nationally determined contributions to greenhouse gas emission reduction were declared by each country.
- Projections indicate that even if the currently proposed national commitments are achieved, global surface temperatures will increase between 2.1°C and 3.7°C above pre-industrial levels by the end of this century[26] – well outside the aspiration of COP21.
- The present level of greenhouse gases in the atmosphere has already locked in a further increase in temperature over and above the present ~0.9°C above the pre-industrial average[27].
- In the interests of the Reef and other reefs and their ecosystems, greenhouse gas emissions should be reduced to a level that gives some realistic chance to keep the average global surface temperature increase to well below 2°C – possibly even lower than 1.5°C.
- National targets for emission reductions, including Australia's, are not adequate to meet the aspiration of COP21.
- Australia should be prominent lead the international movement to set realistic emissions targets to at least meet the COP21 goals.
- It should be noted:
    - COP21 temperature targets are too high for sea surface temperatures to be kept within safe limits for tropical reefs.
    - To protect current reef biodiversity global average temperature rise would need to be limited to ~1.2°C [28] [29] lower than even the ~1.5 °C that is the low end of the COP21 aspiration.

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[26] Rogelj, J., M. den Elzen, N. Höhne, T. Fransen, H. Fekete, H. Winkler, R. Schaeffer, F. Sha, K. Riahi, and M. Meinshausen 2016, Paris Agreement climate proposals need a boost to keep warming well below 2 °C, *Nature*, *534*(7609), 631-639, doi:10.1038/nature18307.

[27] Zickfeld, K., Eby, M., Weaver, A.J., Alexander, K., Crespin, E., Edwards, N.R., Eliseev, A.V., Feulner, G., Fichefet, T., Forest, C.E. and Friedlingstein, P., 2013. Long-term climate change commitment and reversibility: an EMIC intercomparison. *Journal of Climate*, *26*(16), pp.5782-5809.

[28] Hoegh-Guldberg, O., Mumby, P.J., Hooten, A.J., Steneck, R.S., Greenfield, P., Gomez, E., Harvell, C.D., Sale, P.F., Edwards, A.J., Caldeira, K. and Knowlton, N., 2007. Coral reefs under rapid climate change and ocean acidification. *science*, *318*(5857), pp.1737-1742.

[29] Frieler, K., Meinshausen, M., Golly, A., Mengel, M., Lebek, K., Donner, S.D. and Hoegh-Guldberg, O., 2013. Limiting global warming to 2°C is unlikely to save most coral reefs. *Nature Climate Change*, *3*(2), pp.165-170.

- Areas where corals have adapted should be identified and actively managed to protect their biodiversity in the face of future stresses.

Immediate to short-term impact

- The Reef 2050 Plan is a strong foundation for future action. The mid-term review of the Reef 2050 Plan provides an opportunity to strengthen and revise the Plan to support the management of a fundamentally different Reef.

- The Plan's objective of maintaining, enhancing and restoring the Reef's historical values may no longer be achievable[30].

- A revised Plan will need to be forward looking given that the restoration of the Reef to its past configuration is no longer an option.

- Managing the adaptation of the Reef and mitigating the worst impacts of stressors, including global warming, sediment, nutrient and chemical run-off, crown-of-thorns starfish and decreasing ocean pH, will be critical.

- The Plan should focus more on actions to support the ecological functions of the Reef, specifically regarding the cumulative impacts of multiple pressures, including climate change.

- Actions within the Plan should be implemented at an appropriate scale and with urgency to ensure sustainable ecological functions for the Reef and the people and communities that rely on it.

Ecological Function

- Shifting focus to ensuring 'ecological function' will be key to identifying the most meaningful long term strategies to focus a revised Reef 2050 Plan.

- Coral reefs are particularly vulnerable to the loss of important species[31] [32]. Management of fish species that are the only species performing a specific ecological function are critically important. For example, a global analysis of tropical reefs has estimated that about one-third of ecological functions are performed by only one species of fish – there is no redundancy to protect against loss of that species[33].

- The primary focus of the Reef 2050 Plan needs to shift to identifying and targeting the functions (e.g. herbivory, larval connectivity, reef-building capacity) that are required to maintain reef ecosystems.

- Reducing the nutrient and sediment run-off entering the Reef is important to reduce initiation and development of crown-of-thorns starfish and maximising light penetration for corals and seagrasses.

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[30] Hughes, T.P., Barnes, M.L., Bellwood, D.R., Cinner, J.E., Cumming, G.S., Jackson, J.B., Kleypas, J., van de Leemput, I.A., Lough, J.M., Morrison, T.H. and Palumbi, S.R., 2017. Coral reefs in the Anthropocene. *Nature*, *546*(7656), pp.82-90.

[31] Bellwood, D.R., Hughes, T.P., Folke, C. and Nyström, M., 2004. Confronting the coral reef crisis. *Nature*, *429*(6994), pp.827-833.

[32] Mora, C., Graham, N.A. and Nyström, M., 2016. Ecological limitations to the resilience of coral reefs. *Coral Reefs*, *35*(4), pp.1271-1280.

[33] Mouillot, D., Villéger, S., Parravicini, V., Kulbicki, M., Arias-González, J.E., Bender, M., Chabanet, P., Floeter, S.R., Friedlander, A., Vigliola, L. and Bellwood, D.R., 2014. Functional over-redundancy and high functional vulnerability in global fish faunas on tropical reefs. *Proceedings of the National Academy of Sciences*, *111*(38), pp.13757-13762.

- It should also seek to understand differences in vulnerability and resilience between reefs to inform management and target actions to regionally important areas of the Reef.
- Identifying and supporting the groups of species that most support these key functions and the ecosystems they maintain should be the focus of future funding interventions.

Mix of tools and scale

- The Panel acknowledges that there are a range of scales, tools and interventions that need to be applied when exploring options for Reef research, management and policy.
- Small scale, local actions are important but they must be nested in larger scale solutions and strategies (for example, crown-of-thorns starfish control).
- Localised interventions can have a range of benefits - for example, cultural values, community, fisheries, tourism and ecological refugia. The protection of high value tourism sites is of critical importance to local communities and state and national economies.
- The Reef 2050 Plan is built around themes and the interplay between these themes (e.g. ecosystem health and social and community benefits) must continue in the revised Plan.

Enhancing community engagement

- Traditional Owners, local people, communities and local authorities will be important partners in the management of the Reef.
- Capacity building in communities and across diverse community groups (for example, recreational fishers, local business councils) is critical to strong local understanding of the impacts of bleaching and to prepare for what is predicted to be more regular bleaching events.
- Communities:
    - must be assisted to adjust to the new circumstances – a different Reef.
    - be involved locally and regionally in ecologically relevant actions, particularly those that can be scaled for greater impact.
    - should have a role working with scientists and operational reef managers to ensure knowledge is acquired and used to support the ecosystem services provided by the Reef.

Innovation

- The transforming Reef requires new approaches to problem solving be explored.
- The Panel suggests that a process that opens opportunities for the involvement of the wider community is desirable.
- Opening the search for innovative solutions broadly across sectors, industries and communities could see the benefit of innovations in one sector or industry being applied to the Reef.
- The Panel cautions against depending on ‘gimmicks’ or quick fixes. The Panel will be identifying mechanisms that could be the basis for an Innovation Challenge at its next meeting.