

**SECRETARIAT OF THE PACIFIC COMMUNITY****SEVENTH CONFERENCE OF THE PACIFIC COMMUNITY**

(Noumea, New Caledonia, 7–8 November 2011)

**AGENDA ITEM 4 B - ASSESSING THE VULNERABILITY OF TROPICAL PACIFIC FISHERIES
AND AQUACULTURE TO CLIMATE CHANGE**

(Presented by the Secretariat)

SUMMARY

1. The vital contributions of fisheries and aquaculture to the regional goals of economic, human and social development based on sustainable management of natural resources cannot be overemphasised. Nowhere else in the world do so many countries and territories depend as heavily on the benefits derived from fish and shellfish. The Pacific Plan recognises that these benefits are linked to the effective management of fish, and the habitats that support them. *‘Development and implementation of national and regional conservation and management measures for the sustainable use of fisheries resources’* is a priority of the Plan. *‘The Future of Pacific Island Fisheries’* study commissioned by the Forum Fisheries Agency and SPC maps out the actions needed to maintain the benefits of the sector. This study also identifies the various drivers that could affect these plans. Climate change is one of these drivers, and its influence is expected to grow in significance in the years ahead.
2. With the generous support of AusAID, SPC designed and co-ordinated a 3.5 year project to identify the risks of climate change to the fisheries and aquaculture sector, and the most useful adaptation initiatives. The results have been published by SPC in a major peer-reviewed book entitled *‘Vulnerability of Tropical Pacific Fisheries and Aquaculture to Climate Change’*. This book, the first of its kind on this subject in the region and possibly the world, will be launched at the 7th SPC Conference and submitted to the Intergovernmental Panel on Climate Change for its use in compiling the Fifth Assessment Report.

RECOMMENDATIONS

3. Conference is invited to:
 - i. Acknowledge the value of this comprehensive compilation of research on the projected impacts of climate change on Pacific Island fishery and aquaculture resources, and the implications for future food security, sustainable livelihoods and economic development;
 - ii. Convey appreciation to the authors and institutions that have been part of this historic journey, and to the Australian Government for the funding that made the work possible;
 - iii. Bring the recommended adaptation initiatives, and suggested supporting policies and investments, to the attention of national policy makers and other stakeholders in the fisheries and aquaculture sector, and their development partners.
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ASSESSING THE VULNERABILITY OF TROPICAL PACIFIC FISHERIES AND AQUACULTURE TO CLIMATE CHANGE

PURPOSE

1. This paper informs members of the publication by SPC of a major peer-reviewed book documenting the results of a comprehensive assessment of the vulnerability of fisheries and aquaculture in the region to climate change.
2. The book describes the vulnerability of the region's diverse fisheries and aquaculture activities, and the habitats that support them, to the changing climate. It also describes the implications of these projected changes for economic development, food security and livelihoods, and the adaptations, policies and investments required to reduce threats and capitalise on opportunities.
3. The paper briefly describes the rationale for the vulnerability assessment, the multi-disciplinary teamwork required to produce the assessment, and the key findings documented in the book.

BACKGROUND

4. Pacific Island countries and territories face considerable challenges in implementing their shared vision for a secure and prosperous region in the face of changes in population profiles, unstable financial markets, escalating food prices, changing terms of trade and the revolution in information technology. The rapidly growing population of the region – estimated to reach around 15 million by 2035 and 18 million by 2050 – means that new approaches will be needed to achieve the collective goals of economic, human and social development. Sustainable management of the region's natural resources will play a major role in achieving these important development outcomes.
5. The vital contributions of fisheries and aquaculture to the development goals cannot be overemphasised. Nowhere else in the world do so many countries and territories depend as heavily on the benefits derived from fish and shellfish. License fees from distant water fishing nations operating in the region contribute from 3% to 40% of government revenue for seven exclusive economic zones of Pacific Island countries and territories (PICTs). Domestic fishing fleets and local fish processing operations provide further benefits and account for 3% to 20% of gross domestic product in four PICTs¹.
6. Fish is a cornerstone of food security in the region. In more than half of all 22 PICTs fish consumption is at least 2–4 times greater than the global average. In the rural areas of most PICTs, 60–90% of this fish comes from subsistence fishing activities and fish often makes up 50-90% of dietary animal protein².
7. Fisheries and aquaculture are also an important source of jobs and opportunities to earn income. More than 12,000 people are employed in tuna canneries or processing facilities, or on tuna fishing vessels. Recent surveys in 17 PICTs show that an average of 47% of households in coastal fishing communities earn either their first or second income from fishing. In several remote atolls, pearl farming is an important source of employment and in inland Papua New Guinea there are now thousands of freshwater ponds producing fish.

¹ Gillett R. (2009) *Fisheries in the economies of Pacific Island countries and territories*. Pacific Studies Series, Asian Development Bank, Manila, Philippines.

² Bell et al. (2009) Planning the use of fish for food security in the Pacific. *Marine Policy* 33, 64-76.

8. The Pacific Plan recognises that these benefits are linked to the effective management of fish and shellfish, and the habitats that support them. *'Development and implementation of national and regional conservation and management measures for the sustainable use of fisheries resources'* is a priority of the Plan. The need for responsible and effective stewardship of our fisheries resources was also reinforced by Pacific Islands Forum Leaders in their 'Vava'u Declaration'.
9. Developing and implementing practical plans to maximise sustainable economic and social benefits from fisheries and aquaculture is a major responsibility for all stakeholders. 'The Future of Pacific Island Fisheries' study³ commissioned by the Forum Fisheries Agency and SPC maps out the management measures needed to retain the benefits of the sector. It also identifies plausible scenarios that could result in these benefits being reduced or lost. Achieving good outcomes will depend on our collective ability to respond to the various drivers likely to affect the sector.
10. One driver that is very likely to grow in significance in coming years is the increased emission of carbon dioxide and other greenhouse gases. There are serious concerns that the resulting global warming and acidification of the ocean could soon begin to affect the plans being made to optimise the social and economic benefits derived from fisheries and aquaculture. The region needs to know the vulnerability of these plans to climate change, and how best to adapt.
11. With the generous support of AusAID, SPC designed and co-ordinated a 3.5 year project to assist PICTs to understand the effects of increased greenhouse gas emissions on the fisheries and aquaculture sector, and how to adapt appropriately. The results have been published by SPC as a major peer-reviewed book entitled 'Vulnerability of Tropical Pacific Fisheries and Aquaculture to Climate Change'⁴. This book will be launched at this 7th Meeting of the Conference of the Pacific Community and submitted to the Intergovernmental Panel on Climate Change for its use in compiling the Fifth Assessment Report.

DESIGN OF THE PROJECT

12. The complex task of assessing the vulnerability of fisheries and aquaculture in the region was not one that SPC could shoulder alone. Almost 90 scientists and fisheries and aquaculture specialists from 36 institutions around the world contributed to the assessment (see Annexes 1 and 2). Together, these experts assisted SPC to produce estimates of the effects of representative low and high greenhouse gas emissions on the wide range of physical, chemical and biological processes that underpin the benefits provided by fisheries and aquaculture.
13. The approach used to make the assessment involved six steps.
 - a) Describing the observed and projected changes to atmospheric (surface) climate.
 - b) Describing the observed and projected changes to the tropical Pacific Ocean.
 - c) Assessing the way in which projected changes to the climate and ocean are likely to affect the ecosystems that support fishery resources, i.e. the food chains in the ocean, coral reefs and other important coastal habitats such as mangroves, seagrasses and intertidal sand flats, and freshwater and estuarine habitats.

³ Gillett R and Cartwright I. (2010) *The Future of Pacific Island Fisheries*. Secretariat of the Pacific Community, Noumea, New Caledonia.

⁴ Bell JD, Johnson JE and Hobday AJ (editors). (2011) *Vulnerability of Tropical Pacific Fisheries and Aquaculture to Climate Change*. Secretariat of the Pacific Community, Noumea, New Caledonia.

- d) Assessing the likely direct effects of projected changes to surface climate and oceanic conditions, and the indirect effects of projected changes to ecosystems, on the abundance and distribution of the fish and shellfish species supporting oceanic fisheries, coastal fisheries, freshwater fisheries and aquaculture.
 - e) Identifying the implications of projected changes to the nature and productivity of oceanic, coastal and freshwater fisheries, and aquaculture, for regional plans to use fisheries resources for economic growth, government revenue, food security and livelihoods.
 - f) Recommending adaptation responses, policies and investments to help communities and industries maintain the benefits of fisheries in the face of climate change. These recommendations also included the research needed to fill critical gaps in knowledge.
14. Steps c), d) and e) of this approach involved determining the vulnerability of ecosystems, fish stocks and fishing communities and industries to climate change. Vulnerability is the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity⁵.
15. To deal with the considerable uncertainty associated with steps a) – e), the vulnerability assessment was based on scenarios. Scenarios are plausible alternative pictures of how the future might unfold. The rationale for using scenarios was not only to encompass the range of possible outcomes stemming from current uncertainties but also to alert decision-makers to potential future situations. Ultimately, governments need to be ready to adapt to all scenarios. For any scenario, they need to be able to answer the question: ‘How can we best respond if these circumstances eventuate?’
16. The scenarios used in this book were based on the IPCC Special Report on Emissions Scenarios storylines B1 (low emissions) and A2 (high emissions) for 2035 and 2100⁶. To provide mid-term projections, the B1 scenario in 2100 has been used as a proxy for A2 in 2050.

KEY FINDINGS

17. The results of the vulnerability assessment are mixed – there are likely to be winners and losers. Increases in sea surface temperature and changes in the location of nutrient-rich waters are projected to change the distribution and abundance of tuna. In particular, catches are eventually expected to decrease in the western Pacific and increase in the eastern Pacific. Increasing water temperatures and ocean acidification are expected to affect the replenishment potential of coastal fisheries species and degrade coral reef habitats across the region. Such conditions are also expected to cause problems for the main forms of coastal aquaculture (pearl culture, shrimp farming and seaweed cultivation). However, warmer surface temperatures and higher rainfall are likely to enhance production from freshwater fisheries and pond aquaculture.

⁵ IPCC (2007) Summary for Policymakers. In: S Solomon, D Qin, M Manning, Z Chen, M Marquis, KB Averyt, M Tignor and HL Miller (eds) *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, Cambridge, United Kingdom, and New York, United States of America.

⁶ Nakicenovic N, Alcamo J, Davis G, De Vries B and others (2000) *Special Report on Emissions Scenarios: A Special Report of Working Group III of the Intergovernmental Panel on Climate Change*. PNNL-SA-39650, Cambridge University Press, New York, United States of America.

18. The negative effects are expected to be greatest for coastal fisheries, where production is expected to decrease by 20% in 2050 and by 20–50% in 2100 under the high emissions scenario. However, notwithstanding the need to manage catchments and coastal fish habitats and stocks to secure reliable levels of fish production, coastal communities also have the option of switching some fishing effort from fish associated with corals reefs to the tuna that often frequent coastal waters. In particular, access to tuna can be improved by adding networks of anchored inshore fish aggregating devices (FADs) to the national infrastructure for food security. The rich tuna resources of the region can also be used to provide increased access to fish for the rapidly growing urban populations of the region by providing enterprises with incentives to store and distribute small-sized tuna and bycatch landed at major ports by industrial fleets. Development of peri-urban pond aquaculture also promises to provide more fish in urban areas. Greater emphasis on the management of freshwater fisheries and development of pond aquaculture where conditions are suitable should improve access to fish in inland areas.
19. Adaptations based on increased access to tuna are likely to be favoured by climate change until 2035 across the entire region, and for the eastern part of the region until 2100. Production from freshwater fisheries and pond aquaculture is also expected to increase throughout much of Melanesia because the projected increases in rainfall and temperature are likely to enhance production of the key species.
20. The key challenges posed by climate changes for the fisheries and aquaculture sector are to:
 - a) reduce the effects of local stressors on fish habitats by legislating to restore and protect catchment vegetation and prevent direct damage to coral reefs, mangroves, seagrasses and intertidal flats caused by excess sediments, nutrients, pollution and poor management of waste;
 - b) launch adaptation initiatives favoured by climate change that will improve the supply of fish available to the rapidly growing populations in many PICTs, for example, using FADs to increase the access of coastal communities to the rich tuna resources of the region;
 - c) create flexible policy arrangements to ensure continued supply of fish to established and proposed canneries and fish processing facilities in the region as the distribution of tuna shifts to the east; and
 - d) manage coastal aquaculture enterprises producing commodities for export and local markets to optimise employment opportunities in the face of the adverse effects of rising sea surface temperatures and ocean acidification.
21. Despite the concerted, multi-disciplinary approach used to produce the vulnerability assessment, considerable uncertainty remains about the magnitude of the projected effects of climate change on the sector. This uncertainty is due partly to the coarse resolution of the global climate models used to project changes to surface climate, the tropical Pacific Ocean, and tuna stocks. Some of this uncertainty will be reduced through the development of downscaled models by Australia's Pacific Climate Change Science Programme.

FUTURE RESPONSIBILITIES

22. The effects of climate change on the region's vital fisheries and aquaculture resources, and the plans to use these resources sustainably to optimise the economic and social benefits, should be re-assessed regularly to take advantage of the improved climate models as they become available. This will allow the key adaptations needed to maintain benefits from the sector to be re-evaluated and

adjusted if necessary. The ‘Summary for Pacific Island Countries and Territories’ which accompanies the book has been designed with this need in mind. The summary can be updated every 5–7 years with the latest projected changes to surface climate, the tropical Pacific Ocean, fish habitats, and fish stocks.

24 October 2011

Annex 1

Authors of 'Vulnerability of Tropical Pacific Fisheries and Aquaculture to Climate Change'

CHAPTER 1 Pacific communities, fisheries, aquaculture and climate change: An introduction

Johann D Bell, Tim JH Adams, Johanna E Johnson, Alistair J Hobday and Alex Sen Gupta

CHAPTER 2 Observed and projected changes in surface climate of the tropical Pacific

Janice M Lough, Gerry A Meehl and M Jim Salinger

CHAPTER 3 Observed and expected changes to the tropical Pacific Ocean

Alexandre S Ganachaud, Alex Sen Gupta, James C Orr, Susan E Wijffels, Ken R Ridgway, Mark A Hemer, Christophe Maes, Craig R Steinberg, Aline D Tribollet, Bo Qiu and Jens C Kruger

CHAPTER 4 Vulnerability of open ocean food webs in the tropical Pacific to climate change

Robert Le Borgne, Valérie Allain, Shane P Griffiths, Richard J Matear, A David McKinnon, Anthony J Richardson and Jock W Young

CHAPTER 5 Vulnerability of coral reefs in the tropical Pacific to climate change

Ove Hoegh-Guldberg, Serge Andréfouët, Katharina E Fabricius, Guillermo Diaz-Pulido, Janice M Lough, Paul A Marshall and Morgan S Pratchett

CHAPTER 6 Vulnerability of mangroves, seagrasses and intertidal flats in the tropical Pacific to climate change

Michelle Waycott, Len J McKenzie, Jane E Mellors, Joanna C Ellison, Marcus T Sheaves, Catherine Collier, Anne-Maree Schwarz, Arthur Webb, Johanna E Johnson and Claude E Payri

CHAPTER 7 Vulnerability of freshwater and estuarine fish habitats in the tropical Pacific to climate change

Peter C Gehrke, Marcus J Sheaves, James P Terry, David T Boseto, Joanna C Ellison, Boga S Figa and Jacob Wani

CHAPTER 8 Vulnerability of oceanic fisheries in the tropical Pacific to climate change

Patrick Lehodey, John Hampton, Rich W Brill, Simon Nicol, Inna Senina, Beatriz Calmettes, Hans O Pörtner, Laurent Bopp, Tatiana Ilyina, Johann D Bell and John Sibert

CHAPTER 9 Vulnerability of coastal fisheries in the tropical Pacific to climate change

Morgan S Pratchett, Philip L Munday, Nicholas AJ Graham, Mecki Kronen, Silvia Pinca, Kim Friedman, Tom D Brewer, Johann D Bell, Shaun K Wilson, Joshua E Cinner, Jeff P Kinch, Rebecca J Lawton, Ashley J Williams, Lindsay Chapman, Franck Magron and Arthur Webb

CHAPTER 10 Vulnerability of freshwater and estuarine fisheries in the tropical Pacific to climate change

Peter C Gehrke, Marcus J Sheaves, David Boseto, Boga S Figa and Jacob Wani

CHAPTER 11 Vulnerability of aquaculture in the tropical Pacific to climate change

Timothy D Pickering, Ben Ponia, Cathy A Hair, Paul C Southgate, Elvira S Poloczanska, Luc Della Patrona, Antoine Teitelbaum, Chadag V Mohan, Michael J Phillips, Johann D Bell and Sena De Silva

CHAPTER 12 Implications of climate change for contributions by fisheries and aquaculture to Pacific Island economies and communities

Johann D Bell, Chris Reid, Michael J Batty, Edward H Allison, Patrick Lehodey, Len Rodwell, Timothy D Pickering, Robert Gillett, Johanna E Johnson, Alistair J Hobday and Andreas Demmke

CHAPTER 13 Adapting tropical Pacific fisheries and aquaculture to climate change: Management measures, policies and investments

Johann D Bell, Neil L Andrew, Michael J Batty, Lindsay B Chapman, Jeffrey M Dambacher, Brian Dawson, Alexandre S Ganachaud, Peter C Gehrke, John Hampton, Alistair J Hobday, Ove Hoegh-Guldberg, Johanna E Johnson, Jeff P Kinch, Robert Le Borgne, Patrick Lehodey, Janice M Lough, Timothy D Pickering, Morgan S Pratchett, Aliti Vunisea and Michelle Waycott

Annex 2

Institutions contributing to '*Vulnerability of Tropical Pacific Fisheries and Aquaculture to Climate Change*'

1. Alfred-Wegener-Institute, Bremerhaven, Germany
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4. CSIRO Marine and Atmospheric Research, Australia (Climate Adaptation Flagship, Wealth from Oceans Flagship, and Mathematics, Informatics and Statistics)
5. **Collecte Localisation Satellites, Space Oceanography Division, Ramonville, France***
6. Department of Environment and Conservation, Western Australia
7. University of Hawaii, Honolulu, USA (Department of Oceanography)
8. Forum Fisheries Agency, Honiara, Solomon Islands
9. Gillett, Preston and Associates Inc, Suva, Fiji
10. Great Barrier Reef Marine Park Authority, Townsville, Australia
11. Griffith University, Nathan, Australia (Griffith School of Environment)
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13. Institut Français de Recherche pour l'Exploitation de la Mer, Noumea, New Caledonia
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15. Laboratoire d'Études en Géophysique et Océanographie Spatiales/Observatoire Midi-Pyrénées, Toulouse, France
16. Laboratoire des Sciences du Climat et de l'Environnement/Institut Pierre Simon Laplace, Commissariat à l'Énergie Atomique, Saclay, France
17. Max Planck Institute for Meteorology, Hamburg, Germany
18. Ministry of Marine Resources Cook Islands, Rarotonga, Cook Islands
19. National Centre for Atmospheric Research, Boulder, USA
20. National Fisheries Authority, Port Moresby, Papua New Guinea
21. National Fisheries College, Kavieng, Papua New Guinea
22. National University of Singapore, Singapore
23. Nauru Fisheries and Marine Resources Authority, Nauru
24. Network of Aquaculture Centers in Asia-Pacific, Bangkok, Thailand
25. Primary Industry and Fisheries, Queensland Department of Employment, Economic Development and Innovation, Cairns, Australia
26. **Secretariat of the Pacific Community***
27. Secretariat of the Pacific Regional Environmental Programme, Apia, Samoa

28. **Snowy Mountains Engineering Corporation, Brisbane, Australia***
29. Texas A&M University, Corpus Christi, USA (College of Science and Technology)
30. The WorldFish Center, Solomon Islands and Malaysia
31. University of Auckland, Auckland, New Zealand
32. University of Hawaii, Honolulu, USA (Institute of Marine and Atmospheric Research)
33. University of New South Wales, Kensington, Australia
34. **University of Queensland, St Lucia, Australia*** (Global Change Institute and ARC Centre of Excellence for Coral Reef Studies)
35. University of Tasmania, Hobart, Australia (School of Geography and Environmental Studies)
36. Virginia Institute of Marine Science, Gloucester Point, USA (Cooperative Marine Education and Research Program)

*Institutions that provided time for senior staff to be lead authors of chapters
