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Progressing adaptation to climate variability and change in Western and Central Pacific Ocean tuna fisheries

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Progressing adaptation to climate variability and change in Western and Central Pacific Ocean tuna fisheries.

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Abstract

A multi-agency collaboration is proposed that will (1) enhance national and international policy advice and technical support to maintain a healthy Pacific Ocean that sustains catches of tuna in the Western and Central Pacific Ocean under climate variation and longer-term change; and (2) build capacity for prioritising and implementing adaptations to maintain the socio-economic benefits of Pacific Ocean tuna fisheries to Pacific Island communities.

Objective

To provide evidence-based policy advice and technical support to enhance the capacity of Pacific Island Countries and Territories (PICTs) and regional organisations to identify the most appropriate adaptation strategies to (1) minimise the socio-economic and environmental impacts of climate variability and longer term climate change on tuna fisheries in the Pacific Ocean and (2) maximise opportunities.

Deliverables

1. Improved climate change risk profiles for inclusion in Regional and National Tuna Resource management plans via the provision of benchmarks on the influence of short-term climate variability and longer-term climate change on tuna fisheries.
2. Improved regional and national projections under a range of climate change and socio-economic scenarios, to inform appropriate national and regional management strategies for sustainable use of tuna resources of the region.
3. Tools that allow PICTs and regional organisations to prioritise and optimise adaptation strategies for effective development of climate policies for national, regional and international negotiations.
4. Enhanced capacity for PICT fishery resource managers to participate in regional and national negotiations on climate change adaptations relating to tuna fisheries.

Background and need

Tropical tuna fisheries provide a vital contribution to the development goals of PICTs, with many depending heavily on the benefits derived from these fisheries. License fees from distant water fishing nations operating in the region contribute as much as 40% of government revenue and domestic tuna fishing fleets and local fish processing can account for up to 20% of national gross domestic product. Tuna resources provide 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 throughout the Pacific region. There are active plans to domesticate more of the potential benefits available from tuna resource, increasing job opportunities for local populations.

In more than half of all PICTs, fish consumption is at least 2 – 4 times greater than the global average, often making up 50 − 90% of dietary animal protein. Tuna already substantially contribute to fish consumption throughout the region, and will need to continue to provide continuing contributions to dietary animal protein into the future (Bell et al. 2011).

The benefits associated with tuna resources for PICTs depend on maintaining healthy stocks of tuna. Considerable investments have already been made to improve the understanding of how tuna populations respond to fishing and environmental variability at the scale of the Western and Central Pacific Ocean (WCPO). The Secretariat of the Pacific Community (SPC) presented the results of the first comprehensive vulnerability assessment of tuna fisheries to climate change, supported by AusAID, to the members of the Pacific Community at the SPC Conference in 2011. The results of this assessment are currently being used to guide the provision of technical assistance to SPC members through the International Climate Change Adaptation Initiative (ICCAI) climate change support programme, particularly in the areas of:

i. implications of alterations to the contributions of tuna fisheries to economic development, government revenue, food security and livelihoods in PICTs;
ii. adaptations, policies and investments needed to reduce the threats of climate change to the sector and capitalise on the opportunities;
iii. research required to reduce uncertainty and fill the remaining gaps in knowledge needed to improve the success of adaptations.

The results of this assessment are included in SPC's Climate Change Engagement Strategy and its implementation is currently assisting PICTs with preparing adaptations for the industries relying on tuna through:

i. modification of strategic plans for the fisheries and aquaculture sector and National Adaptation Programmes of Action on Climate Change (NAPAs);
ii. development of tuna fisheries resource models at higher and more appropriate resolutions to provide reliable information PICTs require on the impacts of climate change on tuna, bycatch species, biodiversity and oceanic ecosystems within their waters.
iii. increasing capacity in PICT fishery managers to develop and articulate climate change adaptations at the sectoral and national planning levels.

The most mature modeling framework developed for characterising the interaction between climate and tuna stocks currently available is SEAPODYM (Lehodey et al. 2008). This

framework integrates biological and ecological knowledge of tuna species (and other large oceanic predators) within a comprehensive description of the pelagic ecosystem (Lehodey et al. 2010).

An important conclusion of the climate change vulnerability assessment was that there is still considerable uncertainty in projecting the influences of short to medium-term environmental variability and longer-term change on tuna populations (Lehodey et al. 2011). This uncertainty limits the ability to provide robust projections of tuna catches. Improved models and, in association, improved forecasts and projections of tuna stocks, are required by regional fisheries management organisations and agencies (including Western and Central Fisheries Commission, Fisheries forum Agency, Parties to the Nauru Agreement, Te Vaka Moana) to assess the socio-economic implications of changes in tuna catches and adjust preliminary recommended adaptations to minimise any risks and maximise opportunities (Bell et al. 2011).

To reduce uncertainty and improve projected sustainable harvests from tuna populations, improved knowledge is needed in four key areas.

1. modeling of the climate system, particularly in relation to future projections of El Niño/Southern Oscillation (ENSO) patterns (including the position of the convergence zone between the Warm Pool and the Pacific Equatorial Divergence Province), seasonal and decadal forecasting and the limitations posed by ongoing model biases.
2. physiology, biology and ecology of tunas, particularly in relation to thermal, oxygen and pH preferences and thresholds, spatial and temporal (age) variability in preferences and thresholds and potential non-linear interactions and feedbacks (e.g. density dependence).
3. describing food webs in the WCPO, particularly in relation to estimating relative abundance of key functional groups, transfer of energy from nutrients-plankton-zooplankton-nekton (N-P-Z-K) and any spatial and temporal variability in N-P-Z-K distributions.
4. improving the quality and spatial resolution of fisheries catch data and developing a better understanding of the behaviour of fishing fleets.

The uncertainties in these four key areas and the requirement for further research to improve current models was recently highlighted at a joint SPC-FAO workshop on 'Priority Adaptations to Climate Change for Pacific Fisheries and Aquaculture' held in Noumea, New Caledonia in June 2012. Further, the Australian Government's Pacific Climate Change Science Program[6] has highlighted the need for further studies of the climate features in the WCPO and patterns of variability in the climate to advance climate science.

The opportunity to significantly advance knowledge in these four areas is immediately achievable. Tuna fisheries in the Pacific Ocean are in the fortuitous position of access to over 50 years of fisheries logbook data, complemented more recently by fishery observer data and fishery independent datasets including bio-logging and conventional tagging and dietary and trophic datasets. Interrogation of these datasets to estimate the functional and numerical relationships between tuna and climate has only been undertaken superficially to date, and so provides a foundation upon which this project can achieve its aims. Opportunities also exist associated with the latest generation of ocean models that will be used to inform the

[6] www.pacificclimatechangecience.org

upcoming Intergovernmental Panel on Climate Change (IPCC) fifth assessment report and provide improved estimates of oceanographic environments for the past 40 years. These models represent a significant step forward for understanding physical and biogeochemical ocean environments. In addition to providing improved long-term climate projections, experiments involving these new generation models provide the potential for more accurate near-term (decadal) projections. Furthermore, the development of high-resolution ocean models such as the BLUElink model[7] provide the opportunity to explore the role of small scale features (such as eddies and upwelling) on marine ecosystems.

Strategy

The overall aim of this project is to increase national capacity in understanding future projections of regional tropical tuna stocks. This project aims to address the uncertainties associated with the four key research areas by progressively 'filling the gaps' in our current understanding of ocean variability and the responses of tropical tuna stocks. The resulting improved understanding of variability in tuna resources will equip PICTs and regional fisheries management agencies and organisations with the tools required for (i) better decision making in the management of regional stocks; and (ii) development and implementation of adaptation strategies required to maintain the contributions tuna make to economic development, food security and livelihoods (Figure 1).

The project is designed in two phases.

Phase 1

The first phase will involve (i) improving our understanding of current ocean state and developing tools and techniques for seasonal and decadal forecasting; (ii) a RV Investigator cruise aimed at providing information for better describing ocean systems and food webs within the western equatorial area of the Pacific; (iii) characterisation of thermal and physiological responses of tropical tuna populations and (iv) investigation of the potential for the description and implementation of fishing fleet behaviour into SEAPODYM.

Phase 2

The second phase will involve (i) incorporation of improved physical and biological parameters into SEAPODYM (ii) development of ocean scenarios relating to short-term variability and longer-term change and then testing those scenarios within the framework of SEAPODYM and potentially alternative models to evaluate the uncertainties associated with climate scenarios; (iii) evaluating a range of management strategies that might be suggested in response to the scenarios and (iv) identifying socio-economic impacts and improved adaptation strategies required.

Results from the project will be communicated to national and regional fisheries managers across the Pacific region throughout both phases of the project via presentations and papers to relevant management meetings and a regional workshop associated with each phase. The project will build upon a wide range of existing data, knowledge, information and modeling techniques

[7] www.bom.gov.au/bluelink/

developed across CSIRO, SPC, Collecte Localisation Satellites (CLS), the University of New South Wales (UNSW) and Institut de recherche pour le développement (IRD). It will identify and address current limitations in the understanding the ocean and climate, fish and fishery behavior, and requirements for integrating variability in fish distributions and biomass into fisheries management structures and national adaptation strategies.

Capacity building

Capacity building will be an integral component to the project and will be incorporated into the project in various forms. Information resulting from this project will be made available to national and regional fisheries management agencies and organisations to help guide the development of fisheries management and adaptation plans. The project team will work closely with fisheries stock assessment researchers at the SPC to ensure scenarios used in management strategy evaluations are relevant to fisheries management in the region. Regular submissions will be made in the form of papers and presentations to the Western and Central Pacific Fisheries Commission Scientific Committee and to relevant workshops.

Two 'hands-on' regional workshops, one towards the end of each phase, involving national and regional fisheries managers will be held following up from the Heads of Fisheries workshop on Priority Adaptations to Climate Change for Pacific Fisheries and Aquaculture held in Noumea, New Caledonia in June 2012. These workshops will provide fisheries managers with updates on most recent research outcomes from the project and also with the technical assistance required to ensure that the results of the project are integrated into adaptation strategies and fisheries policies. At the educational level, joint PhDs and post-doctoral placements supported by exchange programs will be developed between CSIRO, SPC, UNSW and the University of the South Pacific (USP). The potential for short courses and webinars to add to current under-graduate courses run by USP will also be explored.

Indicative budget

Phase 1: $5M over 3 years

Understanding of tropical climate and development of forecasting tools	2.1M
Physiological responses of tuna and fisher behaviour	1M
Ecosystem characterisation (incl. RV Investigator cruise)	1.8M
Information transfer and implementation	0.1M

Phase 2: $4.5M over 3 years

Implementation of newly available ocean environments for the current climate as well as forecasting tools and development of climate scenarios	1.5M
Incorporation of improved parameters into SEAPODYM and scenario testing	1.5M
Management strategy evaluation	0.7M
Identification of impacts and adaptation strategies	0.7M
Information transfer and implementation	0.1M

Organisations and Capability

CSIRO: CSIRO's Wealth from Oceans National Flagship aims to provide enduring social, environmental and economic wealth from the oceans. As leaders in the understanding of ocean systems, processes and technologies the Flagship's research concentrates on:

- innovative ocean modelling and observing technologies (including world standard ocean and biogeochemical models for both seasonal and climate change time scales such as ACCESS[8], POAMA[9] and BLUElink);
- understanding of the role of oceans in climate change and variability;
- understanding whole of ecosystem processes;
- marine biodiversity assessment and conservation;
- sustainable fisheries management including development of robust modelling; frameworks for fisheries management;
- multiple-use management strategies for marine and coastal ecosystems.

The Wealth from Ocean Flagships draws on scientific capability from eight of CSIRO Divisions including the Division for Marine and Atmospheric Research, the Division for Mathematics, Informatics and Statistics, the Division for Ecosystem Sciences, the Information and Communication Technologies Centre and the joint CSIRO – Bureau of Meteorology Centre for Australian Weather and Climate Research. With access to high-performance computing, advanced ocean technologies and links to international remote sensing programs, scientists from the Wealth from Oceans Flagship push the boundaries of ocean-based research, delivering science and technology that benefits both Australia and the greater region.

SPC: SPC's Division of Fisheries, Aquaculture and Marine Ecosystems (FAME) main work is concentrated on providing SPC's member countries and territories with the information they need to make informed decisions on the management and development of their aquatic resources, and help to provide the tools and strengthen the capacity needed to implement these decisions.

The Oceanic Fisheries Programme (OFP) within FAME is the Pacific Community's regional centre for tuna fisheries research, fishery monitoring, stock assessment and data management. It was established by the 1980 South Pacific Conference (as the Tuna and Billfish Assessment Programme) to continue and expand the work initiated by its predecessor project, the Skipjack Survey and Assessment Programme. The OFP's key clients are the fisheries administrations of SPC members as well as the FFA, PNA and TVM. The OFP provides data management and stock assessment services and advice to WCPFC under an annual service agreement. Services carried out by OFP include:

- processing and management of data from commercial tuna fishing fleets (both domestic and foreign licensed),
- provision of assistance in the development and implementation of effective fishery monitoring programmes,

[8] http://www.accessimulator.org.au/

[9] http://poama.bom.gov.au/

- provision of advice on the status of tuna and other affected pelagic fish stocks,
- evaluation of species- and ecosystem-based management options,
- conducting research on the biology and ecology of the pelagic ecosystem, and
- provision training and other capacity building in these areas.

The OFP provides data products, scientific analyses and advice to assist these groups with the assessment and development of fisheries management measures.

CLS: CLS was created in 1990 as a subsidiary of the French Space Agency CNES and the French Research Institute for Exploration of the Sea (IFREMER) and operates the ARGOS data collection and location system. Through its large Space Oceanography Direction (SOD), CLS develops (i) ground processing systems for various satellite oceanography missions and (ii) operational ocean models through its contribution to the French operational oceanography program Mercator-Ocean and the European project "MyOcean". The MyOcean project is aimed at setting up a new European service to monitor and forecast the oceans. CLS is responsible for cross-cutting system engineering, data management and information systems and maintains real-time chain of production of SST, SSH, Ocean Colour and derived parameters (Chlorophyll-a, Euphotic depth, total suspended matter and primary production).

CLS/SOD includes a Marine Ecosystem Department, the main goal of which is to contribute to a better understanding of how marine ecosystems function under the pressure of human activities and climate/environmental variability. The department aims to develop useful tools for ecosystem-based management and sustainable exploitation of marine resources, and has developed the Spatial Ecosystem And Population Dynamics Model (SEAPODYM). This modeling framework combines several functional groups of the food web and detailed descriptions of the population dynamics of exploited or protected species under the influence of fishing, natural climate variability and the release of greenhouse gases. It uses rigorous parameter optimization methods allowing estimation of major key indicators (e.g. total or spawning biomass, fishing mortality, recruitment) used to manage exploited species. SEAPODYM can also be used to analyse responses of species to fisheries management or species conservation programmes (e.g. protected marine areas). The model was developed initially for tuna and their fisheries, but can also be adapted for other pelagic fish species ranging from small pelagic species such as anchovy to larger species such as swordfish.

UNSW/CCRC: The Climate Change Research Centre (CCRC) at the University of New South Wales is the largest university based climate research organisation in Australia. CCRC houses research expertise in three key areas of Earth's climate processes: atmospheric, oceanic and terrestrial. The CCRC applies basic scientific principles to pressing questions on climate dynamics, global climate change, and extremes of weather and climate. The CCRC is the lead institution in the newly formed ARC Centre of Excellence for Climate System Science, a multi-university initiative to advance fundamental climate sciences in Australia.

The CCRC's expertise lies in a number of key areas:

- the use and analysis of global climate models that underlie ecosystem models;
- understanding of the role of oceans in climate change and variability;
- individual based modeling, a complementary framework to SEAPODYM for understanding changes in tuna populations;

- high performance computing capability.

IRD: IRD is a French research organisation that, together with its partners, addresses international development issues by aiming to improve sanitary conditions, understand the evolution of society and preserve the environment and resources with a view to achieving millenium development objectives. As a French science and technology establishment, the IRD is jointly supervised by the Ministries of Research and Foreign Affairs. IRD operates internationally from its headquarters in Marseille, and two metropolitan centres in Montpellier and Bondy. Collaborative activities in research, education and innovation operate in more than fifty countries around the world including the Mediterranean, Africa, Asia and Latin America. Inter-disciplinary projects carried out by IRD jointly handle issues crucial for the South Pacific: tropical diseases and civilisation, relationships between health and environment, climate change, water resources, food security, ecosystems, natural hazards, poverty, vulnerability and social inequality, migration and changes in the labour market.

IRD's expertise in the understanding of ocean ecosystems and climate change includes:

- understanding of the role of oceans in climate change and variability;
- high resolution regional (ROMS) and global ocean modelling (NEMO) and their coupling to biogeochemical models (PISCES);
- sea experiments dedicated to the understanding of the relationships between tuna species and their oceanographic and food web environments.

Core collaboration: CSIRO and SPC have a well-established history of collaboration, particularly in relation to tropical tuna population dynamics, ecosystem studies, fisheries stock assessments and climate change vulnerability assessments. Well-established collaborations also exist between the CLS Marine Ecosystem Department and SPC, particularly in relation to the on-going development of the SEAPODYM model and between IRD and SPC, particularly in relation to modeling the marine ecosystems and understanding of tuna prey dynamics via joint sea-experiments. CSIRO, UNSW and IRD are all currently involved in regional climate change programs including the Southwest Pacific Ocean Circulation and Climate Experiment (SPICE) and Climate Variability and Predictability (CLIVAR), and within these programs collaborate on a number of initiatives. This project will build on the strategic regional position of SPC as the science provider for regional fisheries management agencies and expands the technical capacity of the organisations involved and their research partners. These benefits will come from the innovative collaboration required to integrate the complex areas of climate science and fisheries oceanography to improve our understanding of the likely responses of tuna to global warming and ocean acidification.

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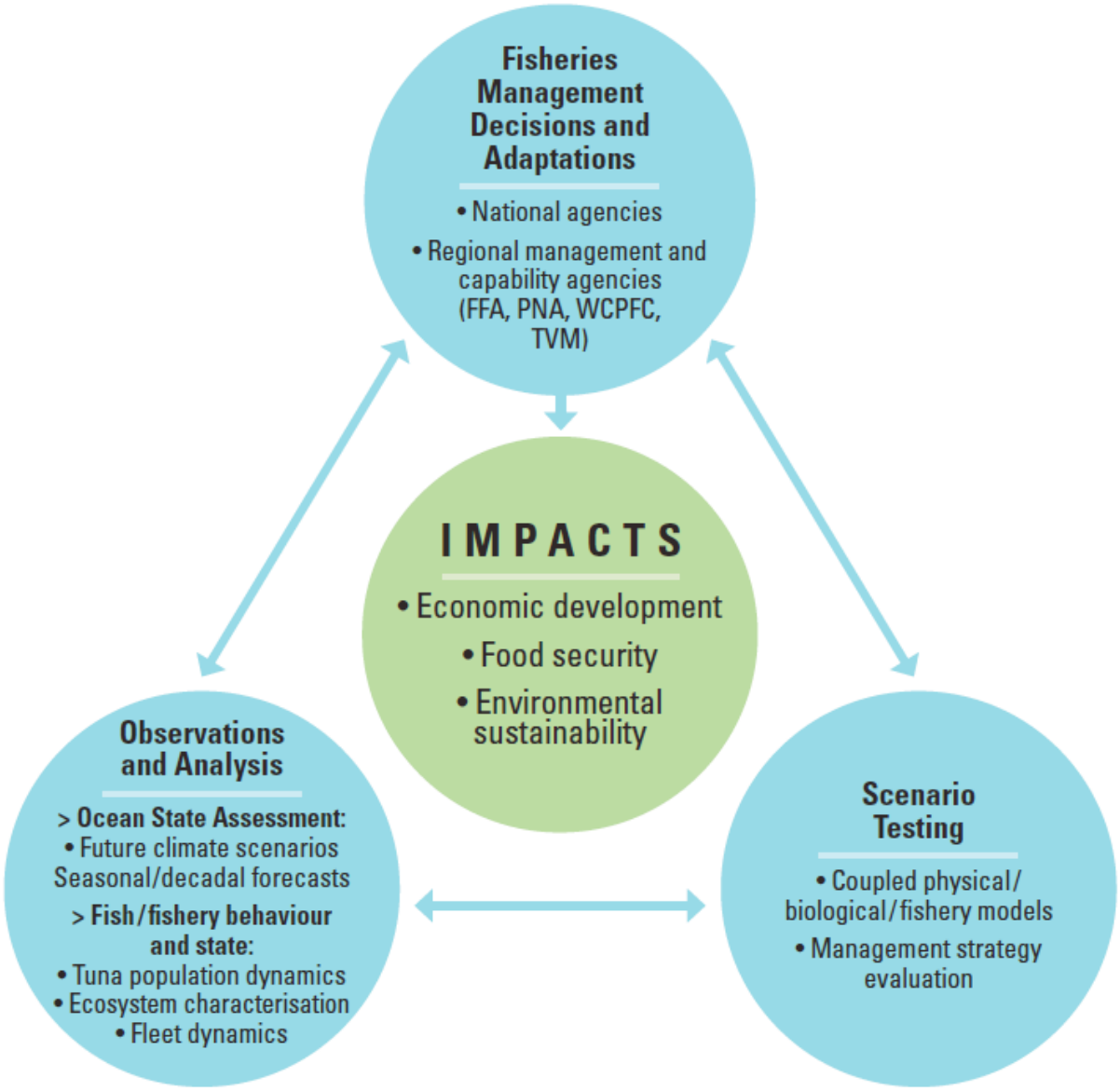

Figure 1. Project strategy and linkages.