



**SCIENTIFIC COMMITTEE  
TWENTIETH REGULAR SESSION**

Manila, Philippines  
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**ECOSYSTEM AND CLIMATE INDICATORS**

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**WCPFC-SC20-2024/EB-WP-01  
1<sup>st</sup> August 2024**

**SPC-OFP<sup>1</sup>**

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<sup>1</sup> Oceanic Fisheries Programme of the Pacific Community

## **Executive summary**

This Working Paper updates SC20 on progress regarding development of the candidate ecosystem and climate indicators for the Western and Central Pacific Ocean (WCPO). Significant progress has been made to improve the methods applied to remove biases in Earth System Models (ESM) that overly influence the projections of future climate state in the WCPO. The removal of these biases improves the robustness of these models for generating climate change indicators that are relevant for tuna fisheries management, in addition to providing more realistic environmental forcings for the next generation of climate change projections on tuna stocks. In addition, the bias corrected versions of ESM have been detrended for climate change trend facilitating the commencement of analyses that can attribute current impacts of greenhouse gas emissions.

The terms of reference for a workshop to develop a specific set of criteria/process for selecting, testing and adopting candidate indicators is provided in the working paper.

## **Recommendations**

SC20 is invited to:

- note the progress towards implementing the SC19 endorsed Ecosystem and Climate Indicators Workplan.
- note the delay in the first expert workshop due to travel disruptions associated with the civil disturbances through May-July in New Caledonia.

## Background

The Scientific Committee has been considering the application of ecosystem indicators to assist with advice generation on the impacts of fisheries targeting tuna and tuna-like species on the broader pelagic ecosystem since SC11 in 2015. The rationale for and potential design and testing criteria for ecosystem indicators were agreed at SC12 and candidate indicators have subsequently been presented to the Science Committee since SC15. Once adopted, key ecosystem and climate indicators will provide the Scientific Committee with the capability to report on ecosystem and climate change impacts in its annual reporting to WCPFC.

## Ecosystem and Climate Indicators Workplan

SC19 endorsed the following project workplan

Task	Activity	Schedule			
		SC20	SC21	SC22	SC23
Initial screening of candidate indicators	Apply criteria endorsed at SC12 to candidate indicators that are relevant for monitoring impacts on purse seine and long-line fisheries and tuna species productivity				
Test candidate indicators	Fully develop methodology for developing and testing candidate indicators				
	Test candidate indicators				
	Expert Workshop				
	Adoption Workshop				
Indicator validation	SC review and evaluation that adopted				
Communication tools	Report cards				
	Dashboards				
	TFAR				

## Workplan Progress

### Initial screening of candidate indicators

The SSP completed a first screening of a subset of candidate indicators and presented these to SC19. Based on this experience the SSP recommended to SC19 that the criteria identified at SC12 are appropriate for the initial screening of candidate indicators however a more specific criteria/process is needed for testing and adoption.

SC12 endorsed screening criteria are:

- science and data based;

- characterize the states and trends of WCPFC marine ecosystems with respect to fishing activity and/or climate (including reference levels and baselines);
- reflect well-defined processes underlying fishing activity and fishery responses to climate;
- responsive to changes attributable to fishing pressure and climate (ie. minimal time-lags and capability to provide early warning);
- estimable on a routine basis with a historical data time-series available;
- cost-effectiveness;
- scalable across national, sub-regional and regional scales;
- linked to existing WCPFC models and decision-making processes (for inclusion in MSE scenarios, validation of predictions and testing of model assumptions);
- can be routinely estimated by members without reliance of the Science Service Provider.

### Test candidate indicators

Expert workshops proposed for June and August 2024 to develop the criteria for testing and adopting indicators have been postponed to November 2024 due to the travel restrictions associated with the current civil unrest in New Caledonia that prevented participation by the SSP and collaborating organization personnel. The revised schedule for the workshops means it will be held in conjunction with an ocean monitoring meeting of regional practitioners in the week prior to WCPFC21 in Suva, Fiji. Not only does this provide an opportunity for cost savings associated with travel by relevant experts but also provides opportunity for WCPFC members to participate as part of their travel arrangements for WCPFC21. The draft Terms of Reference for this meeting is attached as Annex 1 to this working paper.

In preparation for the expert workshop the SSP in collaboration with partner organisations (Mercator Oceans International, IRD and CSIRO) has prepared the climate forcings necessary for evaluating the sensitivity of candidate climate and ecosystem indicators. These include: (1) bias corrected simulations covering the period of WCPO fisheries that reproduce the long-term variability of the ocean dynamics in the Pacific Ocean (i.e. a bias corrected reference to the historical conditions); (2) a bias corrected reference ensemble to future WCPO ocean states; and (3) historical simulations with the removal of greenhouse gas emissions for the period 1900-2010 (i.e. a simulation to attribute current impacts of greenhouse gas emissions). All simulations have been coupled to the SEAPODYM\_LMTL (Lower and Mid Trophic Level model) to include estimates of ecosystem structure. Simulations are produced at 1° resolution.

#### Bias Corrected historical simulation

- Two historical simulation using different atmospheric reanalysis have been prepared. The first is a global 1° resolution ERA5-NEMO-PISCES-SEAPODYM\_LMTL simulation covering the period 1959-2022 and interpolated onto a regular grid. It has been intercompared and validated against various observational datasets and operational models, in order to assess its capacity to reproduce the long-term variability of the dynamics in the global ocean and more particularly in the Pacific Ocean. The coarse resolution of the simulations does not allow the reproduction of the mesoscale activity, which induces a less dynamic circulation than observed (mean bias of 0.1 m s<sup>-1</sup>). In terms of temperature, it is in good agreement with observations, at the surface and at depth. We note a positive anomaly in the Kuroshio extension (> 2°C), associated with an anomaly in the mixed layer depth (too deep by 50m). This is explained by the coarse resolution which does not fully resolve the intensity and activity of the boundary currents. The biogeochemical component also reproduces the regional patterns correctly. The surface chlorophyll shows a negative anomaly in the

Indonesia region and a positive anomaly in the Kuroshio extension and eastern Peru-equatorial upwelling. The vertically integrated primary production has a positive bias. The oxygen minimum zones along the equator and the Indian Ocean are correctly reproduced. The simulation captures the large basin scale changes in temperature circulation and productivity linked to El Niño southern oscillation (ENSO).

The second is a global 1° resolution JRA55-NEMO-PISCES-SEAPODYM\_LMTL simulation covering the period 1958-2022 and interpolated onto a regular grid. As with the ERA5 simulation described above the coarse resolution of the simulation does not allow the reproduction of the mesoscale activity. The simulation is currently undergoing intercomparison and validation against various observational datasets and operational models, in order to assess its capacity to reproduce the long-term variability of the dynamics in the Pacific Ocean. Initial results indicate good performance.

#### Ensemble of future climate scenarios

- In addition to providing the baseline variability for the historical period of the WCPO fisheries the ERA5 and JRA55 simulations provide the baseline variability for preparing climate projections, following various climate model trends and Shared Socioeconomic Pathways (SSP) scenarios. Simulations have been prepared for three scenarios of climate change, SSP1-2.6, SSP2-4.5 and SSP5-8.5 and two CMIP6 models (IPSL-CM6A-LR and CNRM-ESM2-1). Two methods have been applied to mitigate the influence of present-day biases in these Earth System Models (ESMs) on future regional ocean physical and biogeochemical projections. The first approach applies the trend of the ensemble of various climate models to the interannual variability of a detrended version of the atmospheric reanalysis (i.e. this approach is a correction to the atmospheric variables of the ESM in the bulk formulae). The second approach applies the correction directly to the atmospheric fluxes by splitting the fluxes into components that are climate change dependent and independent. The bias corrections demonstrate that present-day biases in ESMs can significantly compromise the reliability of regional projections. For instance, the strong cold-tongue bias in the IPSL-CM6A-LR model leads to greater warming and chlorophyll decrease in the western equatorial Pacific compared to the eastern region, whereas our bias-corrected simulation simulates opposite patterns. Climate simulations for all scenarios extend to 2085. Detrended versions of each ESM can be used as a baseline for evaluating future impacts of climate change.

#### GHG removed historical simulation

- This is a global 1° resolution ERA20C-NEMO-PISCES-SEAPODYM\_LMTL simulation covering the period 1900-2010 and interpolated onto a regular grid. It has been detrended to remove the historical impact of greenhouse gas emissions to provide a reference to the potential magnitude of change already observable in the Western and Central Pacific Ocean due to climate change.

#### WCPFC member workshop on indicators

The FAO administered and GEF funded Common Oceans II project has agreed to provide resources for a WCPFC member workshop to refine indicators. Scheduling of this workshop is tentatively for 2026.

#### Development of tools for communication to WCPFC and wider stakeholders

An example report card format has been provided to the SC in WCPFC-SC19-2024/EB-WP-01 and potential dashboard format is available on this link (<https://ofp-sam.shinyapps.io/ofp-FEMA-climate->

[dashboard/](#)). Participants at SC19 were invited to explore these styles of communication and provide feedback to the SSP (either formally or informally) on options for improvement. No responses have been received as yet.

## Recommendations

SC20 is invited to:

- note the progress towards implementing the SC19 endorsed Ecosystem and Climate Indicators Workplan.
- note the delay in the first expert workshop due to travel disruptions associated with the civil disturbances through May-July in New Caledonia.

## Annex 1 Terms of Reference: Indicators Expert workshop

### *Purpose:*

To develop a specific set of criteria/process for selecting, testing and adopting candidate indicators for consideration by the WCPFC Scientific Committee.

### *Location and timing*

SPC Nabua Campus, Suva Fiji, 20-22 November 2024

### *Participant Background*

Participants with backgrounds in physical and fisheries oceanography, climate and ecosystem science and ocean-science based service providers with experience in developing ocean-climate services are invited to consider participation. Expected participation includes SPC, FFA, Copernicus Marine Services, CSIRO, NIWA, Pacific Meteorological Desk, WCPFC members with a background in climate and ecosystem science.

### *Expected Outcomes*

- Development of discussion paper and recommendations for the WCPFC-SC that details the criteria and process for testing and adopting climate and ecosystem indicators.
- Fully worked examples of the proposed criteria.
- Recommendations for further work areas.
- Identification of opportunities for broader collaboration with other RFMOs and institutions developing ecosystem and climate indicators.

### *Nominations*

This will be an open workshop however attendance will need to be provided to the SSP by 1 October 2024 (via the WCPFC Secretariat) to allow appropriate facilities to be reserved for the workshop. Invited participants will be partially supported through travel assistance. General participants will be expected to fund their own participation.