Climate and ecosystem indicators update

SPC, Oceanic Fisheries Program

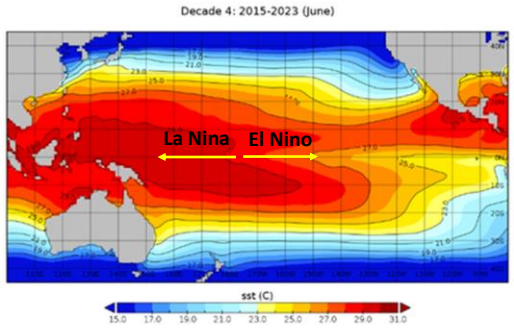
WCPFC – 21st Regular Session of the Commission

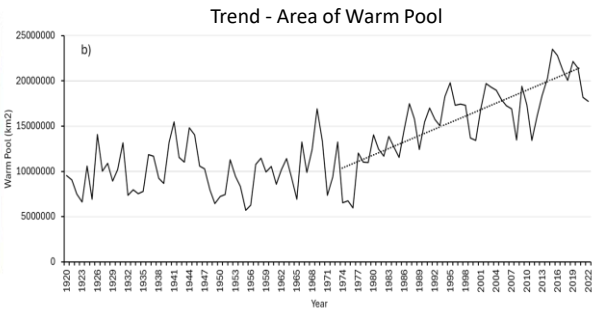
Suva, Fiji, 28th Nov – 3rd Dec 2024.

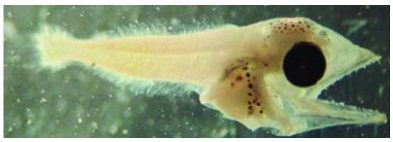
Background and context

- Primary driver of climate change is increased greenhouse gas emissions, mainly carbon dioxide
- Major areas of concern:
  - Ocean warming and sea-level rise occurring much faster than previously forecast
  - Rate of Antarctic ice loss has tripled in the last decade
  - Ocean is now more acidic than at any time in the past 2 million years
  - Ocean circulation is changing affecting heat transport
  - Oxygen depletion in the ocean has increased dramatically since the 1950s

E.g. The Western Pacific Warm Pool







While the key drivers and impacts of global warming are generally known to most by now. A very tangible change in the equatorial Pacific relates to the Western Pacific Warm Pool, a region of warm surface waters in the western and central equatorial Pacific. The warm pool is home of the tropical tuna and especially skipjack and yellowfin. Long-term monitoring clearly shows the expanding trend of the warm pool since the early 1970s, which is thought to be driven by anthropogenic forcings (greenhouse gas driven global warming), while decadal dynamics in warm pool surface area and depth is interrelated with the Pacific Decadal Oscillation. This is just a case in point of the quite big changes to the habitat of tropical tunas that have already happened over the last 50 years.

Another feature of the warm pool is that its interannual dynamics are linked to ENSO which has a major impact on fishing patterns by the purse seine fleet, as discussed in later slides.

Ecosystem & climate indicators

- WCPFC requested development of ecosystem & climate indicators
- Routine reporting for consideration of climate change impacts on tuna and impacts of tuna fisheries on the broader pelagic ecosystem
- Proposed indicators in 3 categories
  - Environment
  - Target species catch and effort
  - Biology and bycatch
- "Report Card" on the state of the WCPO ecosystem and climate

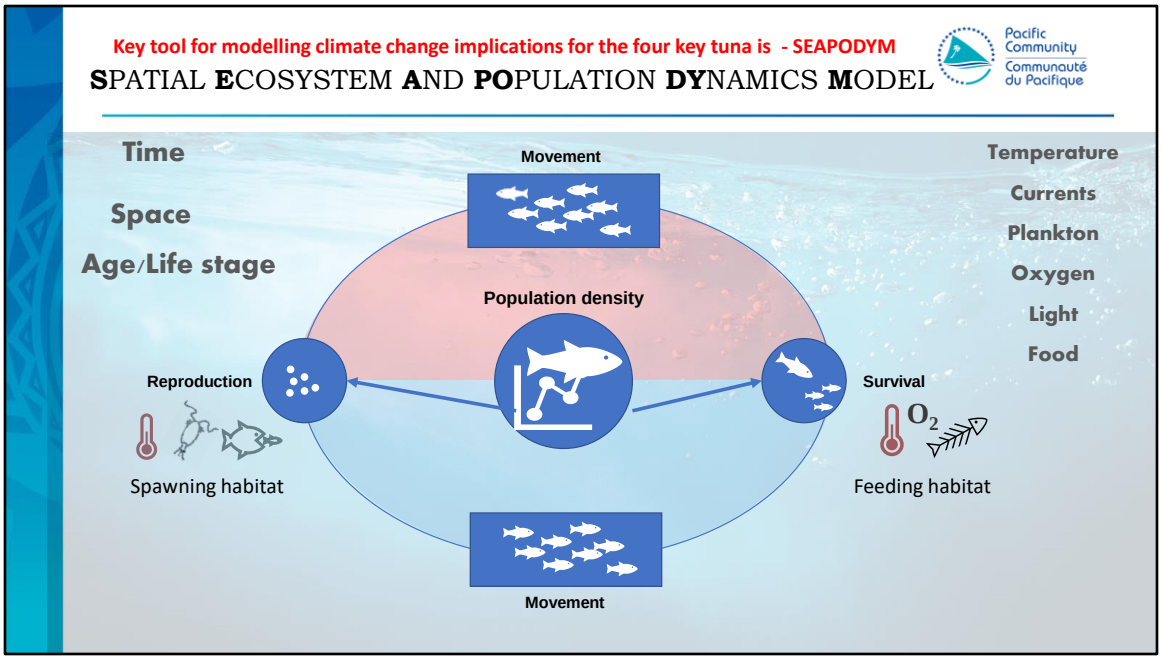
- **Recent external workshop in Suva - progress the testing criteria for the indicators**
- **SC21 - presentation of criteria for endorsement**
- **Validation of indicators – workshop Nov 2025.**

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 (see https://fame1.spc.int/resources/documents/tuna-fisheries-assessment-report)				

SPC is in the process of developing and testing climate and ecosystem indicators to be presented to SC as an indicators paper or "report card" each year to provide a climate/ecosystem synopsis for management advice to WCPFC. The indicators are being explored and have not been fully tested yet, but we expect to present a tested set of indicators to SC21 for consideration.

For this presentation I will be initially providing a longer term context on climate change implications for tuna fisheries in the Pacific, based on projection modelling using the SEAPODYM modelling framework.

Then I will discuss the recent climate status – and near term projections for the El Nino-La Nina status based on the Multivariate El Nino-Southern Oscillation Index, and implications for the purse seine fishery in particular.



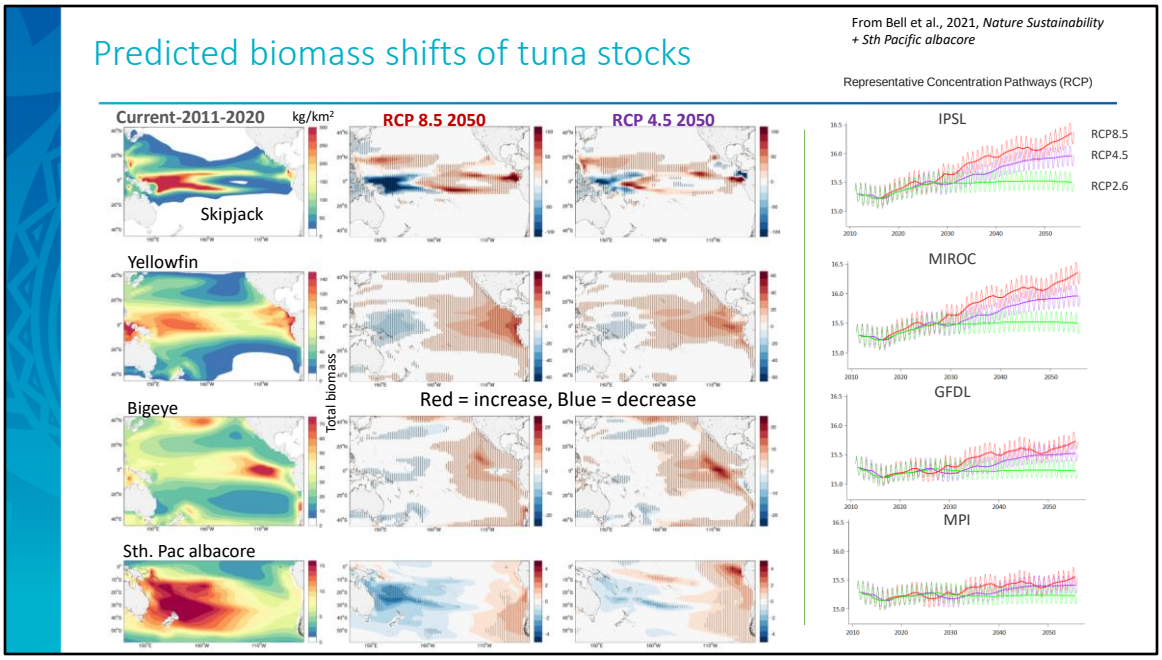
The SEAPODYM modelling framework is continually being developed and improved by a team at SPC, with the goal of being able to model and predict the dynamics of tuna populations, in space and time and for different life-stages, and at finer spatial resolutions. The key feature of the framework is that is an ecosystem/biophysical modelling approach that uses environment variables (or forcing variables), and sub-models of tuna prey dynamics and biological relationships to force the production and dispersal/movement of tuna throughout the ocean. It has been very useful in exploring climate change implications for tuna productivity and distribution.

The spatial resolution is improving, and this will be helped further by obtaining finer scale vertical data on the ocean conditions, and prey populations, in the tropical region – i.e. the ships of opportunity project.

SEAPODYM models have been developed for all four of the target tuna, and climate projections of biomass trends and distributions have now been conducted for each species. The next few slides will focus on the results of the SEAPODYM projections. This will provide some insights into the future spatial dynamics of the four species under climate change scenarios.

Long-term predictions from SEAPODYM

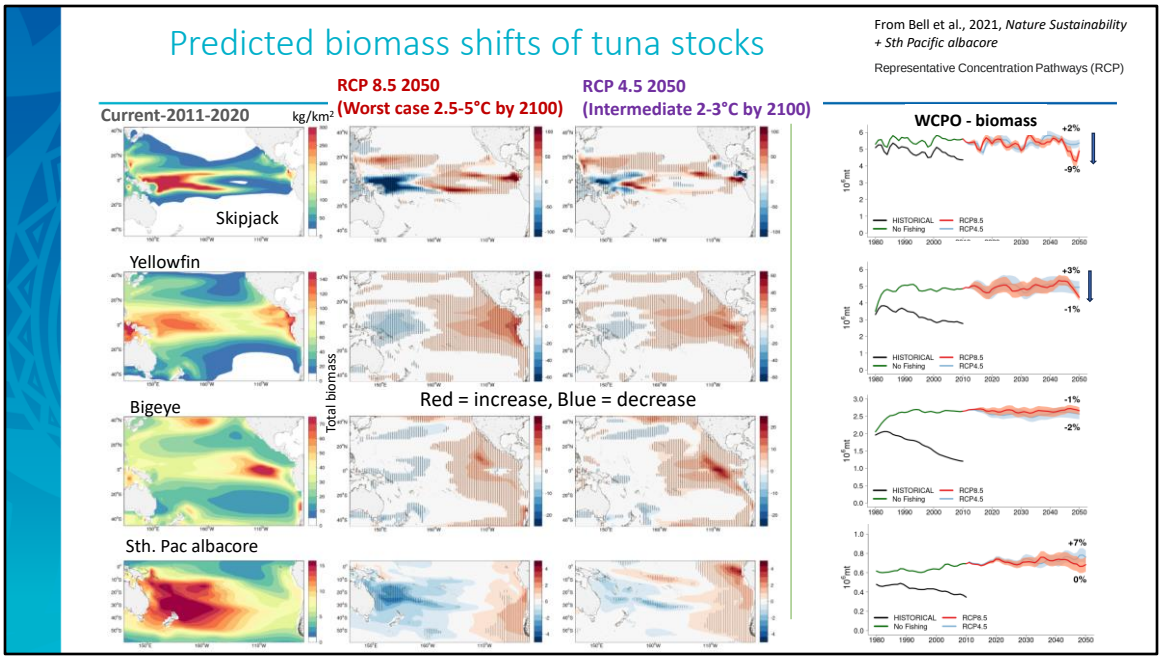
The next section of the presentation discusses longer-term predictions of the impacts of climate change on Pacific tuna derived from the SEAPODYM modelling framework.



This slide shows projections of changes in total spatial biomass levels by 2050 across the Pacific under two representative greenhouse gas concentration pathways, RCP 8.5 – an extreme/worst case scenario where emissions continue unabated for the rest of the century and global ave temperatures rise by up 4-5˚C by 2100. RCP 4.5 a more moderate scenario where emissions start declining by approximately 2045 and reach roughly half of the levels of 2050 by 2100, as fossil fuel reserves are exhausted, with a global ave temperatures rise of 2- 3˚C by 2100.

The panel on the far left shows the biomass levels for each tuna species estimated for the recent decade, and the two panels to the immediate right show the predicted changes in biomass; red indicates increase in biomass, blue indicates decrease in biomass.

The panel to the far right shows the predict global mean temperature increases under different RCPs for different global climate projection models. The projections of tuna biomass used all of these models, and the hatched areas in the projections indicate where all climate models were consistent in the predicted direction of biomass changes.



The figures on the far left show the current SEAPODYM model predictions of biomass distributions for each species, warmer colors are higher biomass. To the right of these we see the predicted changes in tuna biomass by 2050 under two representative greenhouse gas concentration pathways or RCPs. Red indicates increase in biomass, blue indicates decrease in biomass.
RCP 8.5 – an extreme/worst case scenario where emissions continue unabated for the rest of the century and global ave temperatures rise by up to 4- 5˚C by 2100. RCP 4.5 - a more moderate scenario where emissions start declining by approximately 2045 and reach roughly half of the levels of 2050 by 2100, as fossil fuel reserves are exhausted, with a global ave temperatures rise of 2- 3˚C by 2100.
On the far right are the estimated biomass trajectories in the WCPO region for the situation that assumes no fishing (top of each figure) , which is a better isolation of the impacts due to the climate change, and the recent tends with fishing (the purple lines).

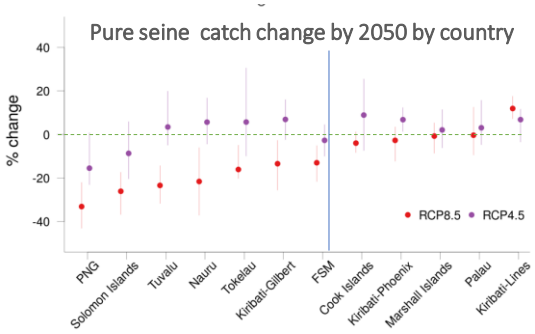
While albacore is predicted to have stable biomass out to 2050, the other three species start to decline in the mid-late 2040s, the models indicated this relates to reduced production of critical nektonic food sources in the tropical region.

Predicted spatial biomass and catch changes

From: Bell et al., 2021

Biomass changes by 2050

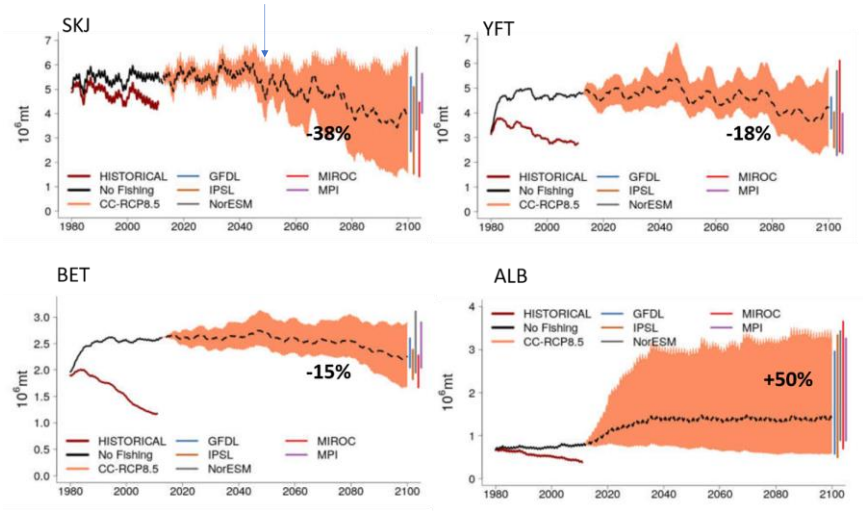
	RCP 8.5	RCP 4.5
10 SIDS	-13%	-1%
EPO	+23%	+18%



This figure shows the predicted impacts at the EEZ levels for the purse seine fishery. It shows that some countries might experience minimal change in average biomass and catch out to 2050, whereas others will see greater impacts – particularly those at the equatorial western edge of the warm pool, like PNG, and Solomons.

Broadening out a bit – the EPO appears to benefit from the shifts in biomass and the PNA EEZs might see lower available biomass and catches, but this really depends on the emissions scenario – the impact is really dependent on the greenhouse gas emissions.

Beyond 2050



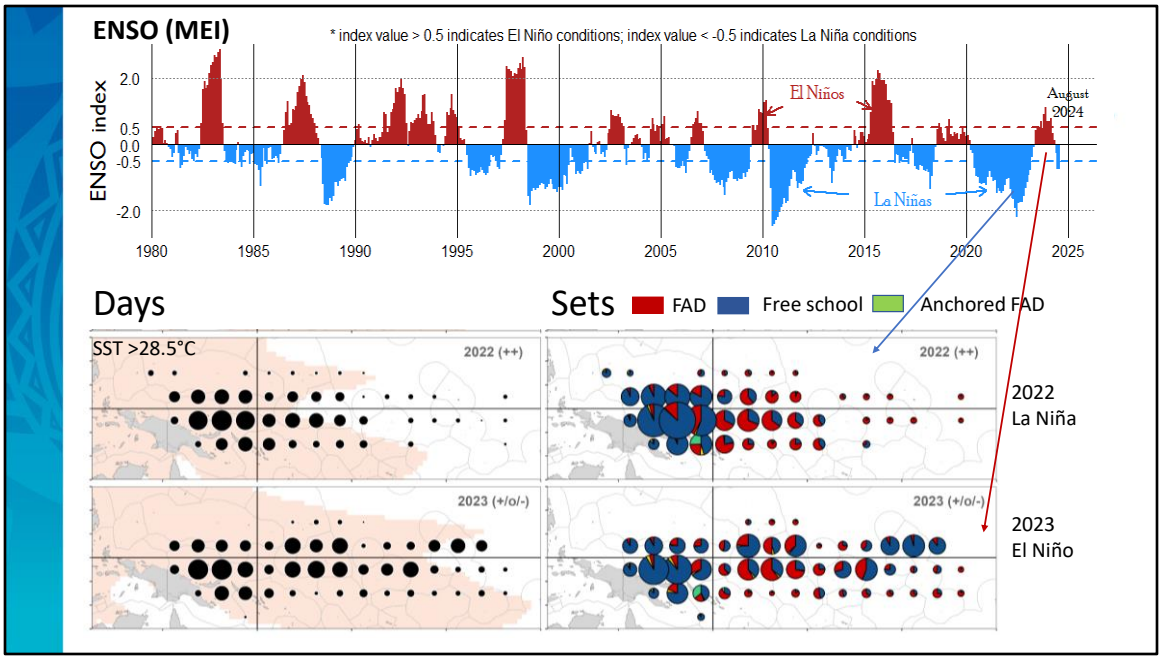
Looking further into the future – predictions get considerably more uncertain, but the declining trends in WCPO tropical tuna biomass from 2050 are predicted continue for SKJ, YFT and BET, whereas albacore is stable. SKJ biomass in the WCPO is predicted to reduce the most.

Key points

- Despite the uncertainties, agreement between different models on distributional shifts suggests that it's not a question of 'IF' the tuna biomass will shift due to climate change from the Pacific SIDS EEZs, but 'WHEN' and 'TO WHAT EXTENT'.
- Moderate redistributions of tuna under a lower-emissions scenario suggest that reductions in greenhouse gas emissions, in line with the Paris Agreement (i.e. <2°C global temperature rise by 2100), could provide a pathway to sustainability for tuna-dependent Pacific Island economies.
- Distributional shifts expected to be the most impactful responses to climate change over the next 20-30 years.
- Beyond 2045, biomass trends are predicted to be negative, except for south Pacific albacore.
- SEAPODYM ongoing development: **new climate projections for skipjack will be available next year!!**

Key points – as read.

Recent patterns and near-term forecast

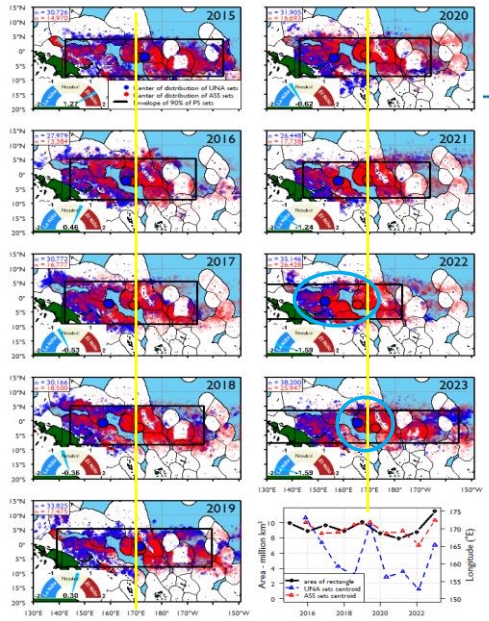


The top plot shows the Multivariate ENSO Index (MEI). The most recent data indicates the Pacific is now back into an La Nina phase, after a recent short-lived El Nino, which came off the back of a relatively strong and prolonged (3 year) La Nina from 2020 through 2022.

Remembering that in El Nino – the warm pool expands to the to east and tropical surface tuna species – skipjack and yellow – increase in abundance in the central pacific, in La Nina – the warm pool gets pushed to the west and deepens, tropical tuna biomass increases in western equatorial Pacific.

The bottom plot show how the purse seine fishing effort changes from La Nina to El Nino. The most notable change is for free school fishing which really contracts to the west in La Nina conditions.

MEI combines five variables are: sea-level pressure (P), zonal (U) and meridional (V) components of the surface wind, sea surface temperature (S), and outgoing longwave radiation (OLR).

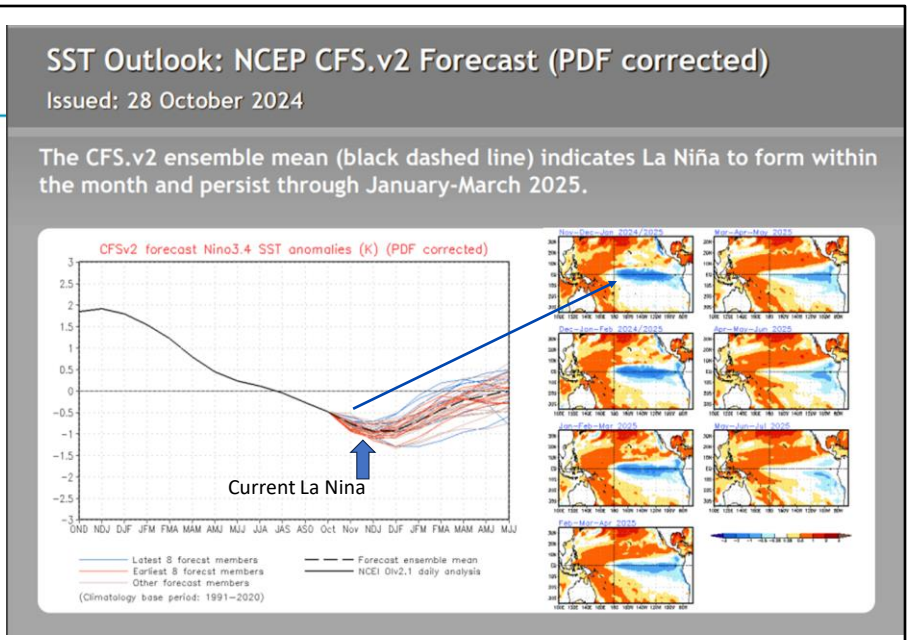


- Centre of distribution of FAD sets (red) consistently around 170°E

- Centre of distribution of free school sets (blue) moves west in La Niña and back towards 170°E in El Niño

These figure further show how the free school fishery moves east or west depending on the ENSO. Whereas the FAD set fishery tend to stay centred at around 170E.

Near term forecast



This figure show the near team forecast for ENSO – we are currently in La Nina and this is predicted to continue through to early next year when more ENSO neutral conditions a predicted to prevail.

La Nina means cooler surface waters in the central Pacific and pooling of warm water to the western Pacific, the implication is more purse seine activity expected in the west due to increased free school fishing.

Climate change and harvest strategies

- Climate variability and longer-term change may influence stock productivity (i.e. reproduction, growth, mortality) and/or distributions.
- Management procedures (MPs) can be tested for their performance under plausible or more extreme alternative productivity/distributional scenarios.
- Testing the robustness of MPs to these climate driven scenarios is conducted using alternative models of the stock/fishery dynamics – referred to as Operating Models (OMs) within a Management Strategy Evaluation (MSE) simulation framework.
- SEAPODYM modelling suggests that distributional changes are likely to be the most notable impacts of climate change and variability for the next several decades, after which reduced biological productivity could become increasingly important.
- The SSP is exploring options for developing OMs that assume alternative future spatial distributions (informed from SEAPODYM model projections) and empirical recruitment levels/dynamics (i.e. SP albacore), and to build these into MP evaluations using MSE.
- Testing MP robustness to possible future changes due to climate change is often done as 'robustness' tests.

To finish - some discussion on climate change and harvest strategies.
First dot points provided some refresher points on MPs and MSE.

Predictions out to 2050 - which is about as far out as we run the MSE evaluations of MPs are indicating biomass distribution changes are more important than stock productivity changes. So, the MPs as currently tested might do ok in terms of managing overall fishing levels. However, will be more important is how fishing effort can be transferred or allocated fairly across EEZs to compensate for average distributional changes. The PNA VDS could deal with that for EEZs, but what about high seas, and the EPO. Any WCPFC allocation discussions need to have an eye to the future.

We are currently exploring new OMs that factor alternative future scenarios, and more extreme changes – to kind of climate stress test MPs – but these more appropriately sit in what we call 'robustness' testing – rather than in the core set of models used to evaluate MPs.

Thanks

Transhipment, Guadalcanal, Honiara October 25th

Recent photo of Guadalcanal, near Honiara, Solomons showing build-up of transhipment activities – already a significant move of PS fishing effort to the west as La Nina is established.

Extras

WCPFC Resolution 2019-01 on Climate Change

1. Consider the potential impacts of climate change on HMS in the Convention Area and any related impacts on the economies of CCMs and food security and livelihoods of their people, in particular SIDS.
2. Support further development of science on the relationship between climate change and target stocks, non-target species, and species belonging to the same ecosystem or dependent on or associated with the target stocks, as well as interrelationships with other factors that affect these stocks and species, and estimates of the associated uncertainties.
3. Take into account in its deliberations, including in the development of CMMs, scientific information available from SC on the potential impacts of climate change on target stocks, non-target species, and species belonging to the same ecosystem or dependent on or associated with the target stocks.
4. Consider how climate change and fishing activities may be related and address any potential impacts in a manner consistent with the Convention.
5. Consider options to reduce the environmental impacts of the Commission related to headquarters operation and meetings of the Commission and its subsidiary bodies.

Operationalising the Resolution

- One way would be similar to CMM 2013-06 for any new management action considered by the Commission
- E.g. proponents of a new management action could be required to report, perhaps against a checklist, things like:
  - Impact of the proposed action on GHG emissions by the fishery
  - Expected fishery impacts on target and non-target stocks under climate change scenarios, i.e. including in MSE evaluations of management procedures
  - Impacts of the proposed action on ecosystem structure and function under current and future expected conditions related to climate change
  - etc