Climate and ecosystem indicators update

Oceanic Fisheries Programme
Pacific Community (SPC)

WCPFC
22nd Regular Session
Manila, Philippines

1-5 December, 2025

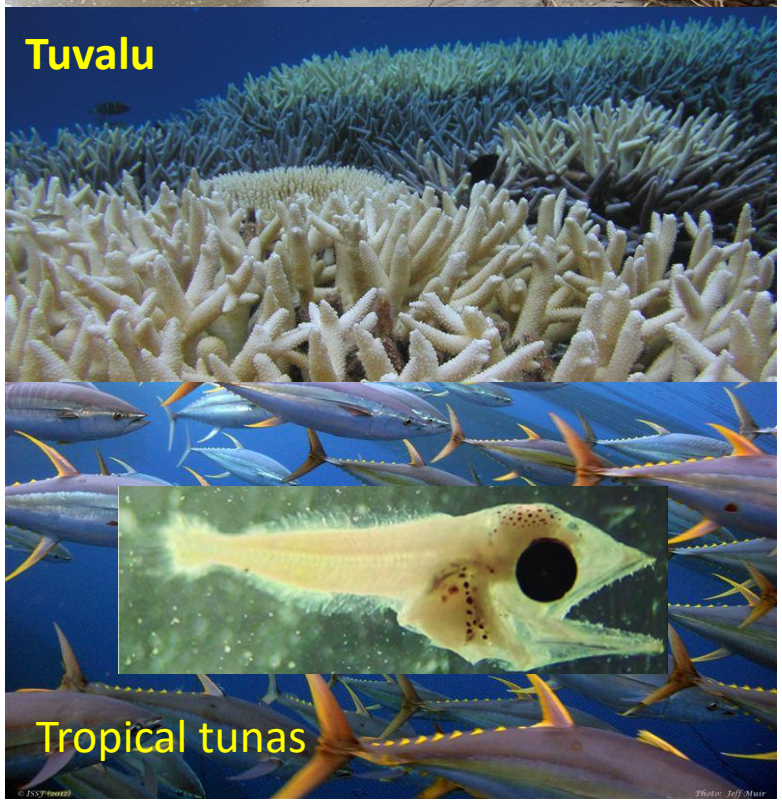
Agenda Item 10
WCPFC22-2025-16

Presented by Paul Hamer

Background

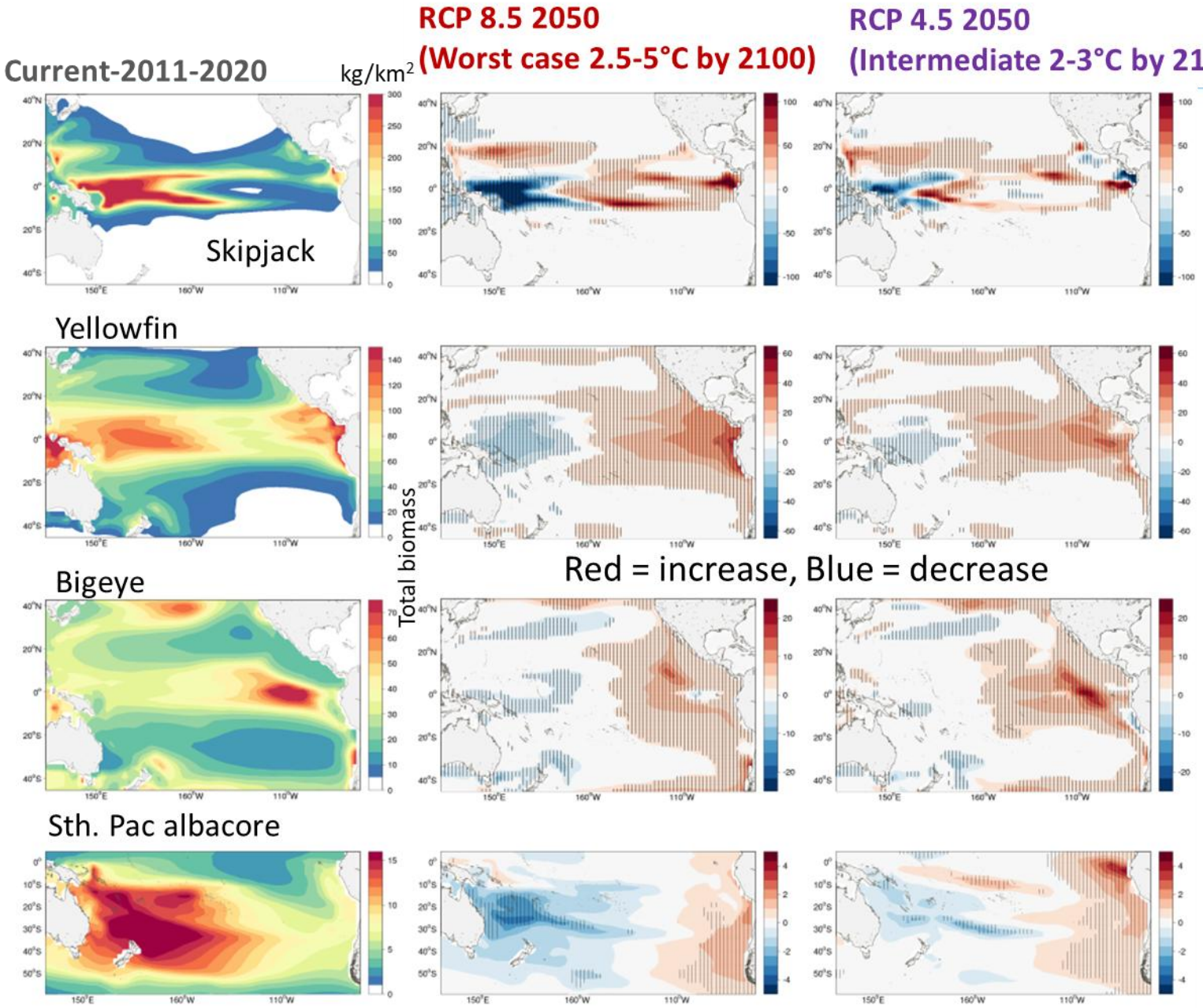
- Anthropogenic climate change caused by increased greenhouse gas emissions
- Leading to several impacts:
  - Increasing ocean temperatures (many ecosystem and climate implications)
  - Sea level rise
  - Increasing acidity of ocean

- WCPFC Resolution 2019-01 on climate change
  - Consider impacts of climate change
  - Support research
  - Consider climate change in decision making
  - Develop a set of WCPFC-CA relevant climate and ecosystem indicators for annual reporting



Projected changes in tuna abundance by 2050 (SEAPODYM)

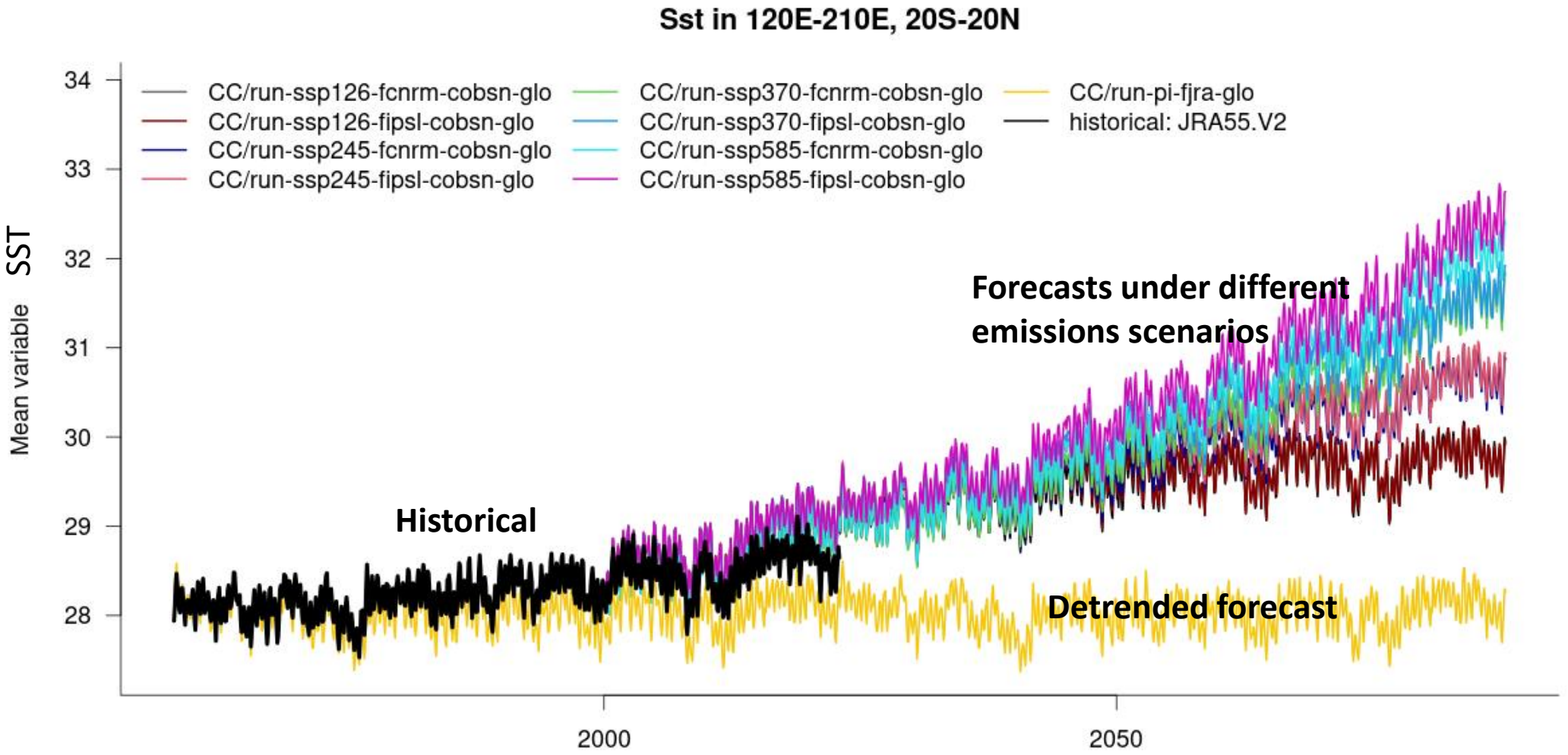
Spatial **E**cosystem **A**nd **PO**pulation **DY**namics **M**odel



- Impacts on tuna **depend on future emissions scenarios** and species
- By 2050 projected **impacts are more notable for skipjack,** but all species impacted, not 'if' but 'how much impact'…..
- Shifts in tuna distribution and biomass are linked to physical (i.e. water temperature), and biochemical/prey productivity drivers
- **Projection models have high future uncertainty** – climate and ecosystem indicators are therefore being developed to monitor variability and trends in the WCPO using **observed data**

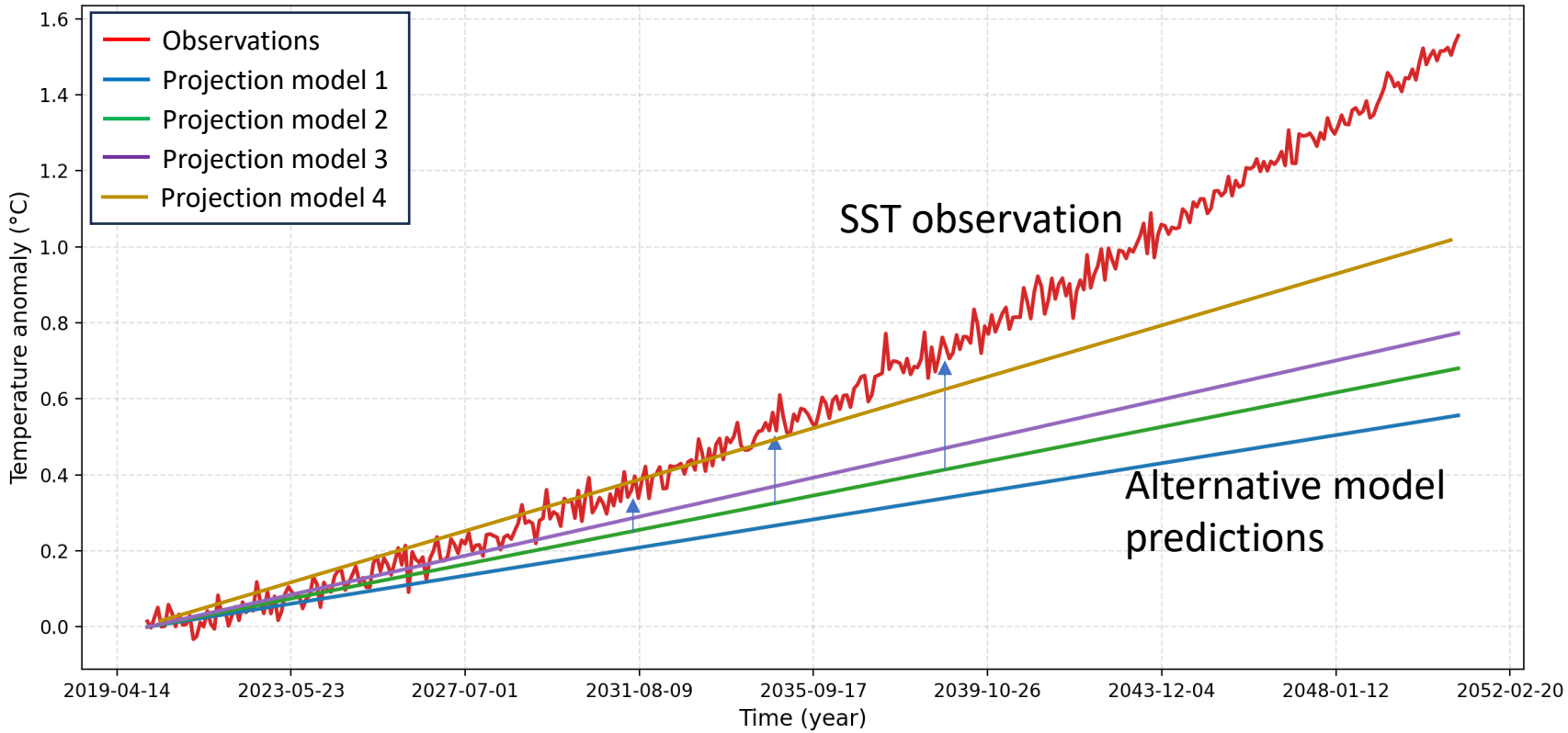
Bell et al. 2021 Nature Sustainability + SP albacore

SST forecast models in tropical WCPO



Ground truthing model forecasts

- how is the region tracking against predictions?
- are conditions changing faster/slower, tracking more/less extreme emissions scenarios?
- implications for SEAPODYM modelling, harvest strategy MSE uncertainty etc…



Hypothetical plot

Climate & ecosystem indicators – progress

- WCPFC requested development of ecosystem & climate indicators
- Completed:
  - Expert workshop held in late 2024, 29 indicators assessed
  - 2025 report produced for SC WCPFC-SC21-2025/EB-IP-01
  - Improved candidate indicators developed/ongoing

Ongoing:

- Adoption workshop (prior SC22)
- SC22 to review

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)				

Link to testing criteria - https://meetings.wcpfc.int/node/19391

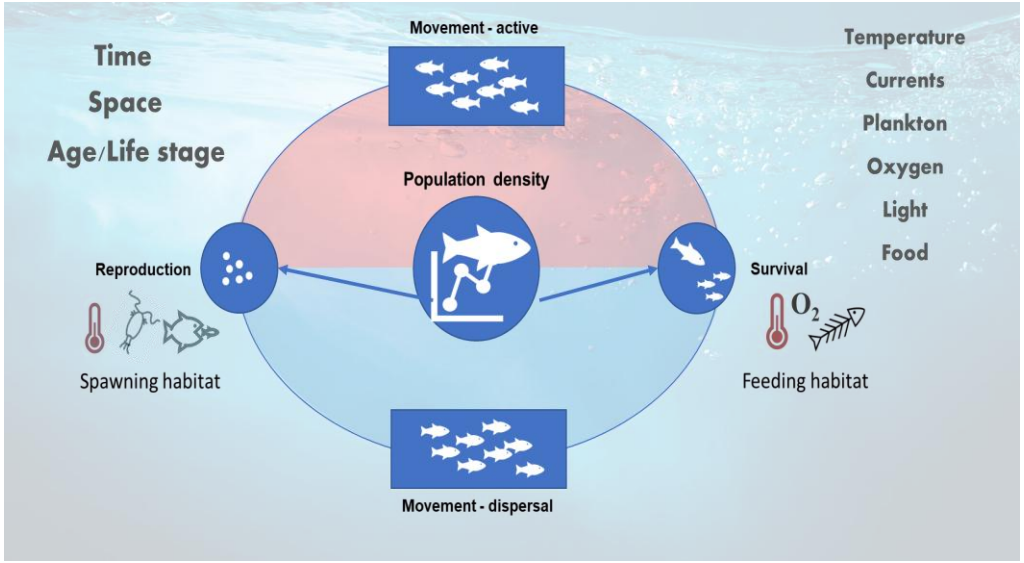
SEAPODYM update

- **Work on the enhancement of the SEAPDOYM is going full-steam**
  - Higher spatial resolution 1˚ (instead of 2˚)
  - Better ocean forcings with two improved coupled atmospheric reanalyses
  - Longer time series of ocean data 1952-2022 (previous 1979-2010)
  - Updated reference models: including updated fisheries and tagging data, incorporating early life (larval data) in the model fitting
  - General improvements in model structure, code, estimation of uncertainty and validation of reference models with longer ocean forcings data.
- **Three or four Shared Socioeconomic Pathways (SSPs)**

Tentative time frame to provide new SEAPODYM projections

- **March 2026 - Skipjack**
- **June 2026 - Yellowfin**
- **December 2026. Bigeye and south Pacific albacore.**

- Implications for PICTs will then be reassessed – similar to the previous approach



2024 WCPO climate and ecosystem indicators

Indicator categories

(1) Those that indicate change in the broad oceanography of the WCPO (i.e. climatological);

(2) Those that indicate change in key oceanographic features (i.e. warm pool); and

(3) Those that indicate direct impact on the fishery (both physical and bio-chemical) – *still being developed*.

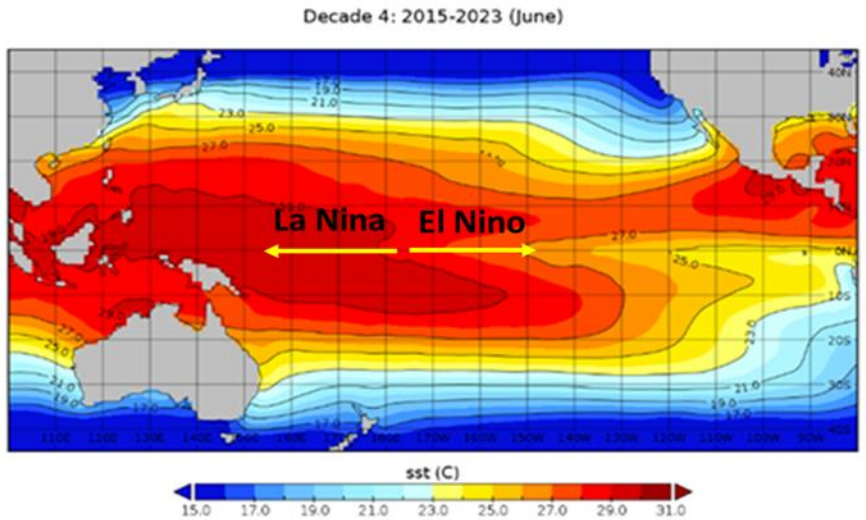
(about 30 indicators considered so far)

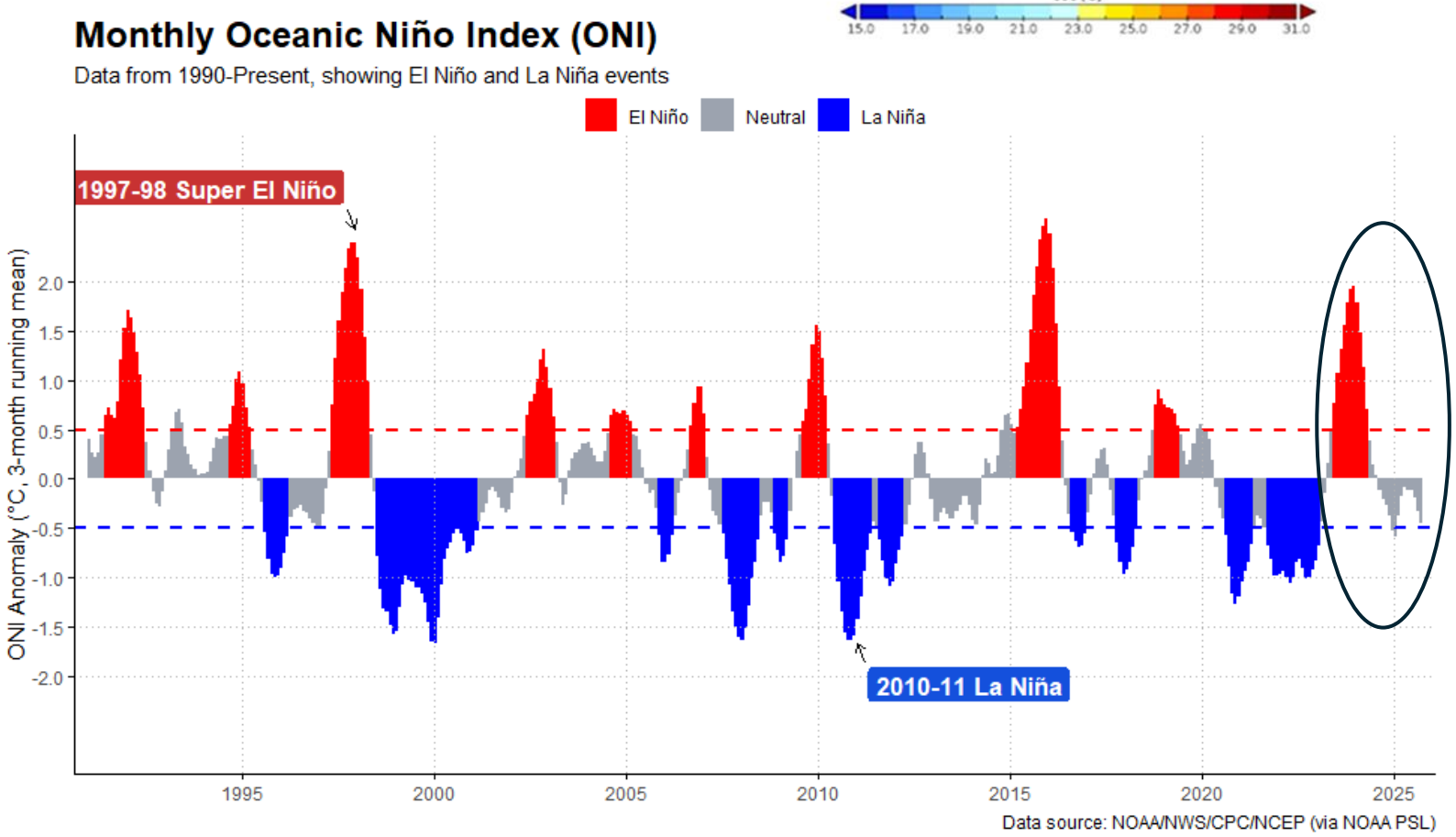
- Up-to-date climate summary for 2024

- Five indicators presented:
  1. **El Niño Southern Oscillation (ENSO)**
  2. **Sea surface temperature**
  3. **Warm pool area**
  4. **Ocean heat content**
  5. **Marine heatwaves**

1. ENSO

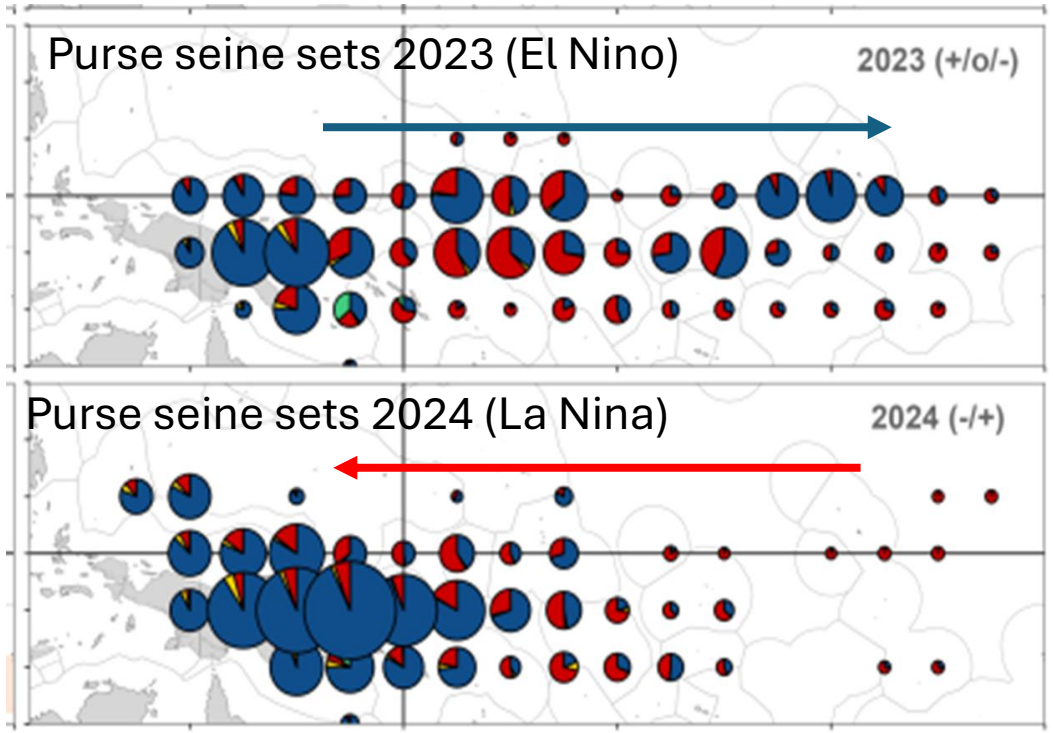
- Current conditions: neutral/slight La Niña
- 2023-24 short, but strong El Niño
- Climate implications 2024:
  - Above-average SST in western Pacific
  - Below average SST in central and eastern Pacific
  - Westerly contraction of warm pool
- Fishery implications:
  - Westerly contraction of tuna and PS effort compared to 2023





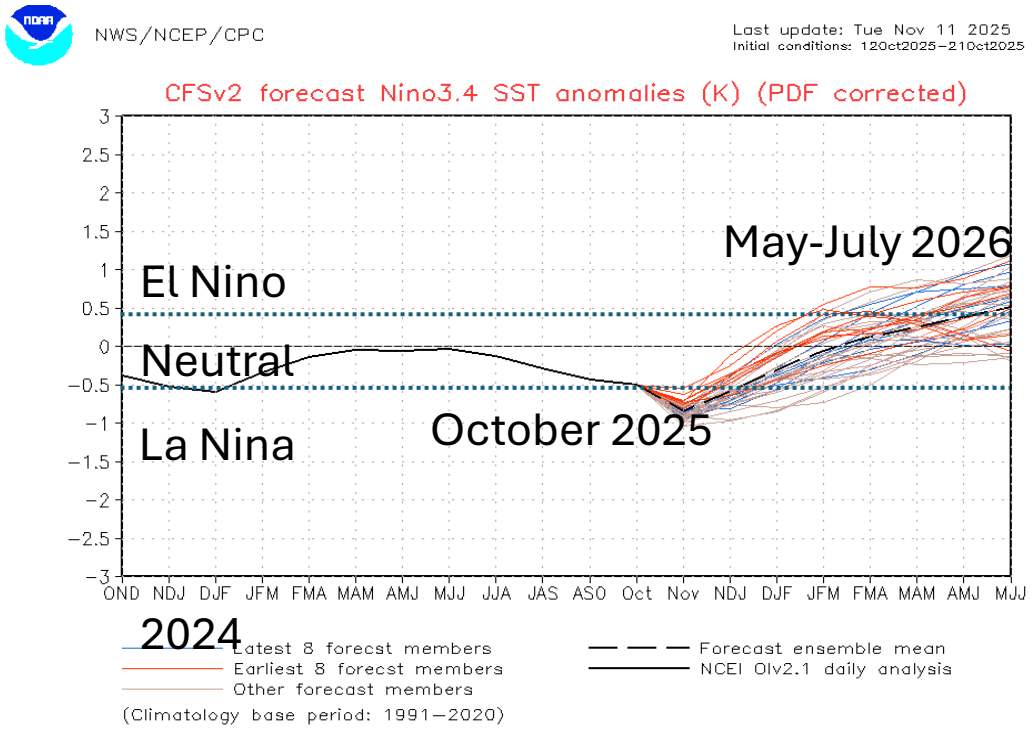
1. ENSO - outlook

- Forecast is for neutral ENSO conditions into early 2026, with weak El Niño likely forming towards the middle of 2026
- Impact on fleet distribution – bit more spread back to east, more FADs sets?? Depends on strength of El Niño.



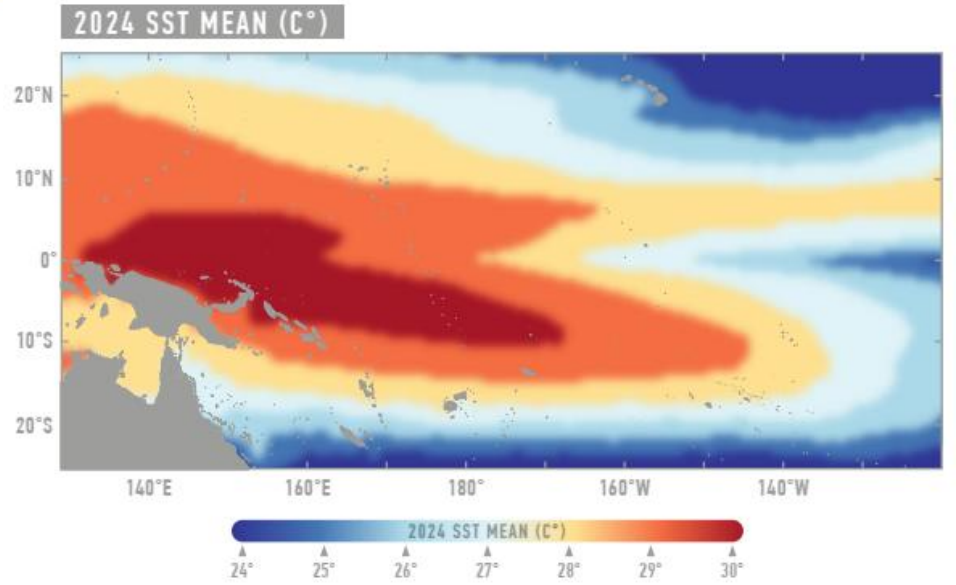
FAD sets

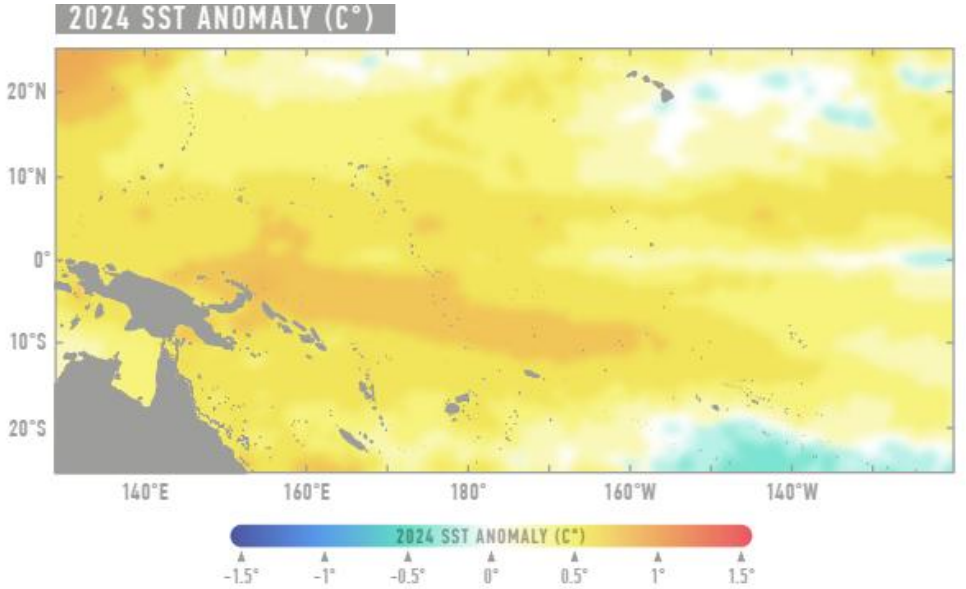
Free school



2. Sea surface temperature (SST)

- 2024 was one of the hottest years on record globally
- 2024 anomalously warm in western Pacific, closer to average in central/eastern pacific

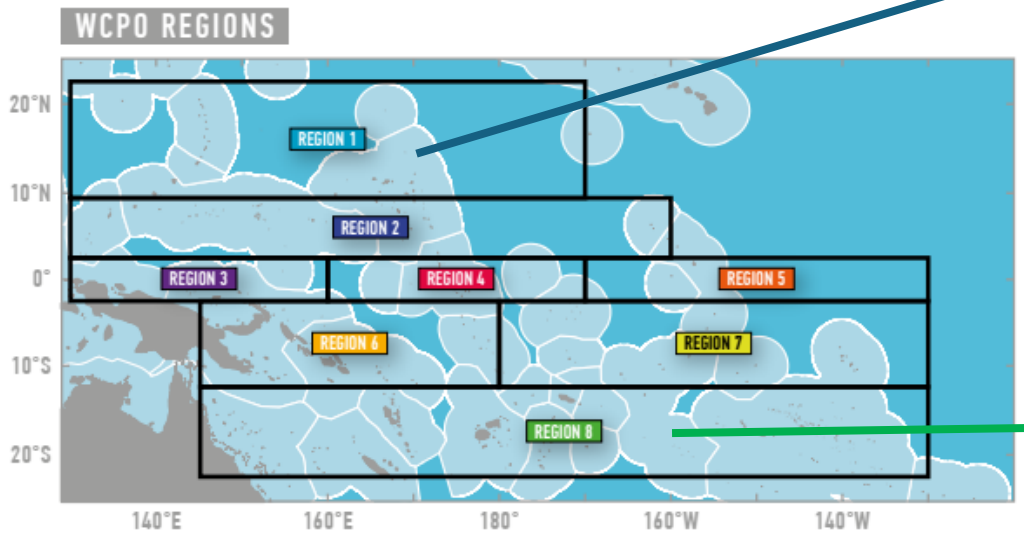




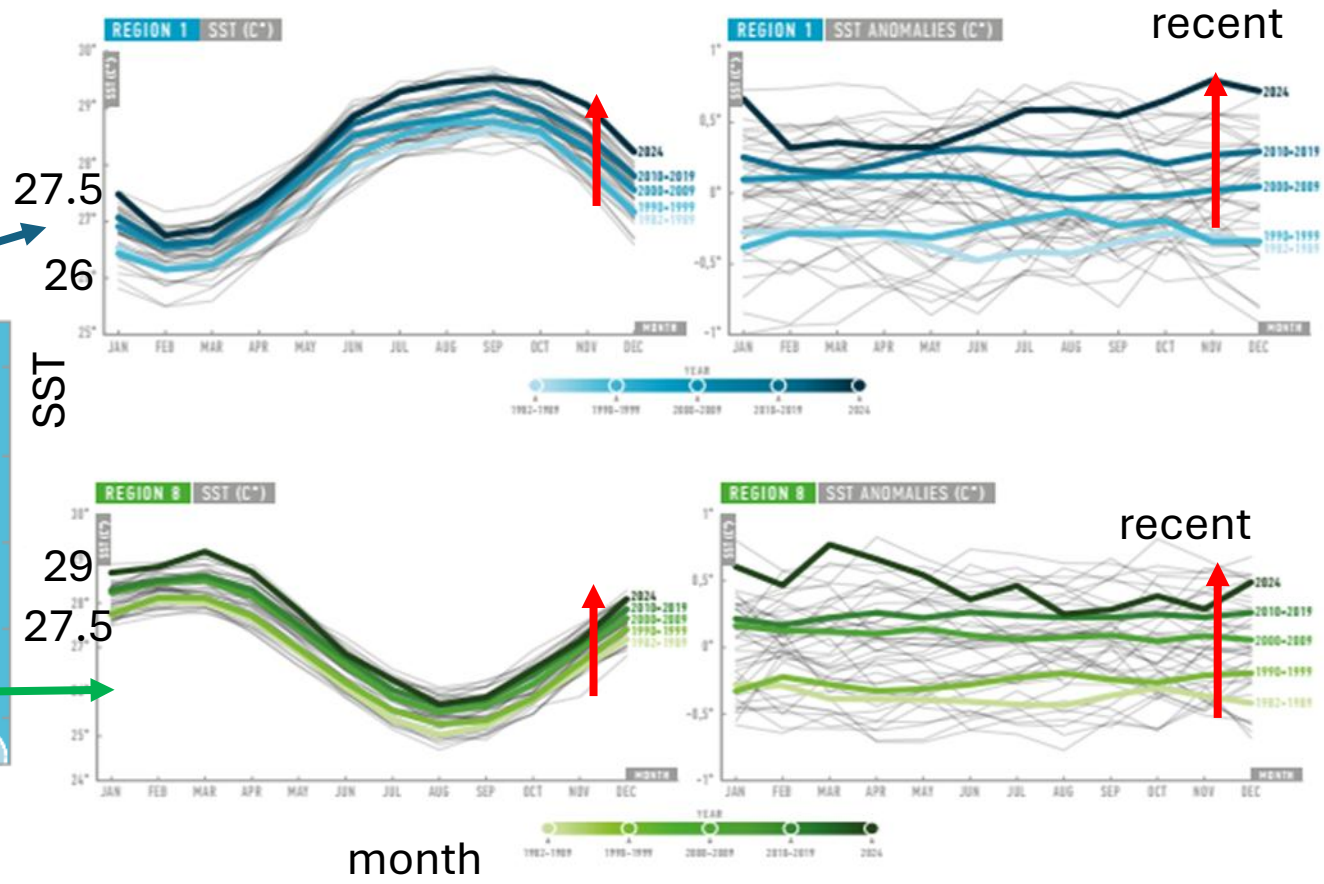
2024: +ve SST anomaly relative to average 1982-2024

2. Sea surface temperature (SST)

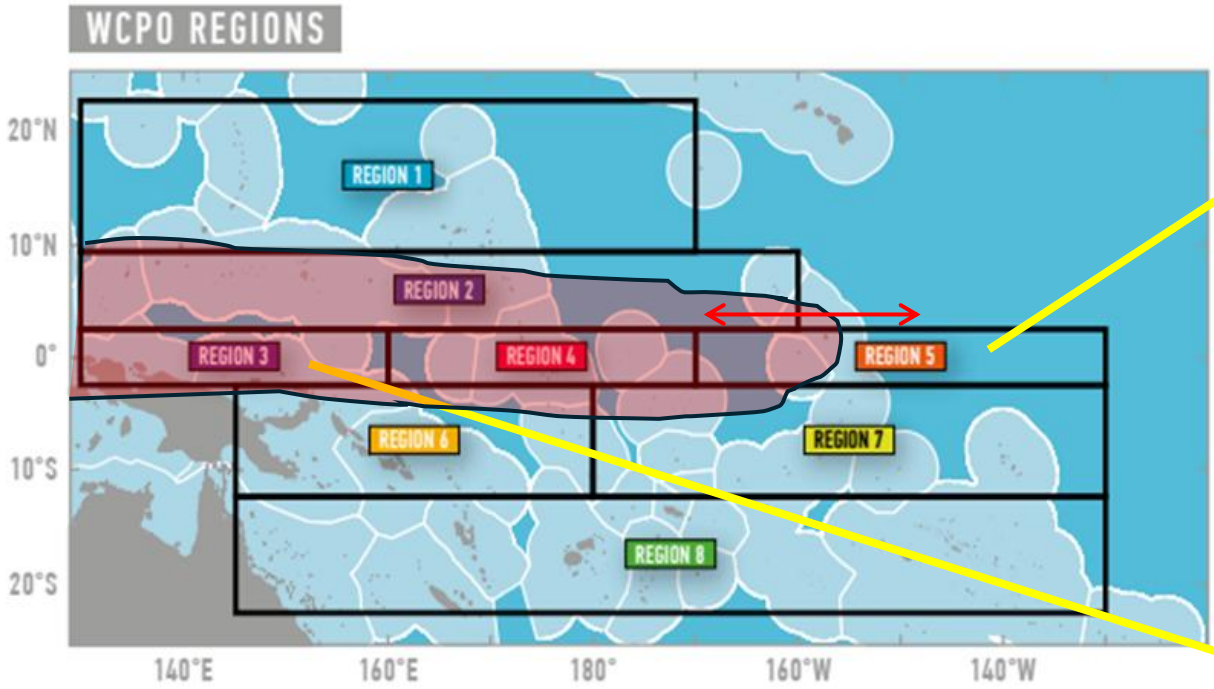
- Regional variability
  - North/South of equator → clear warming trend

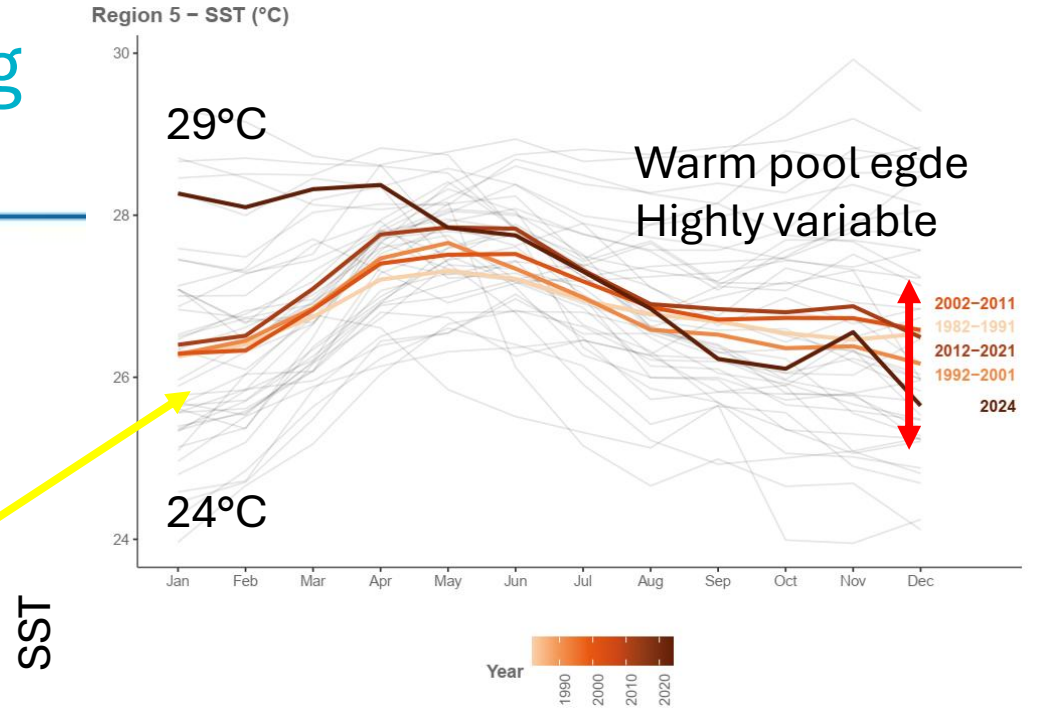


Seasonal cycles in SST compared by decade (1982 – 2024)

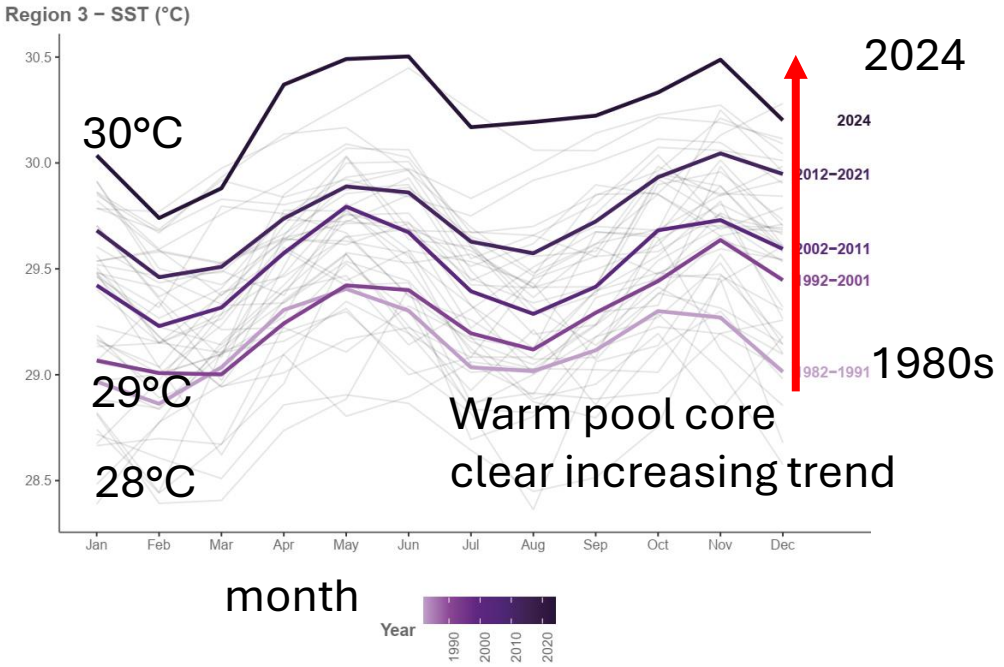


Variation and trends can differ among areas – warm pool



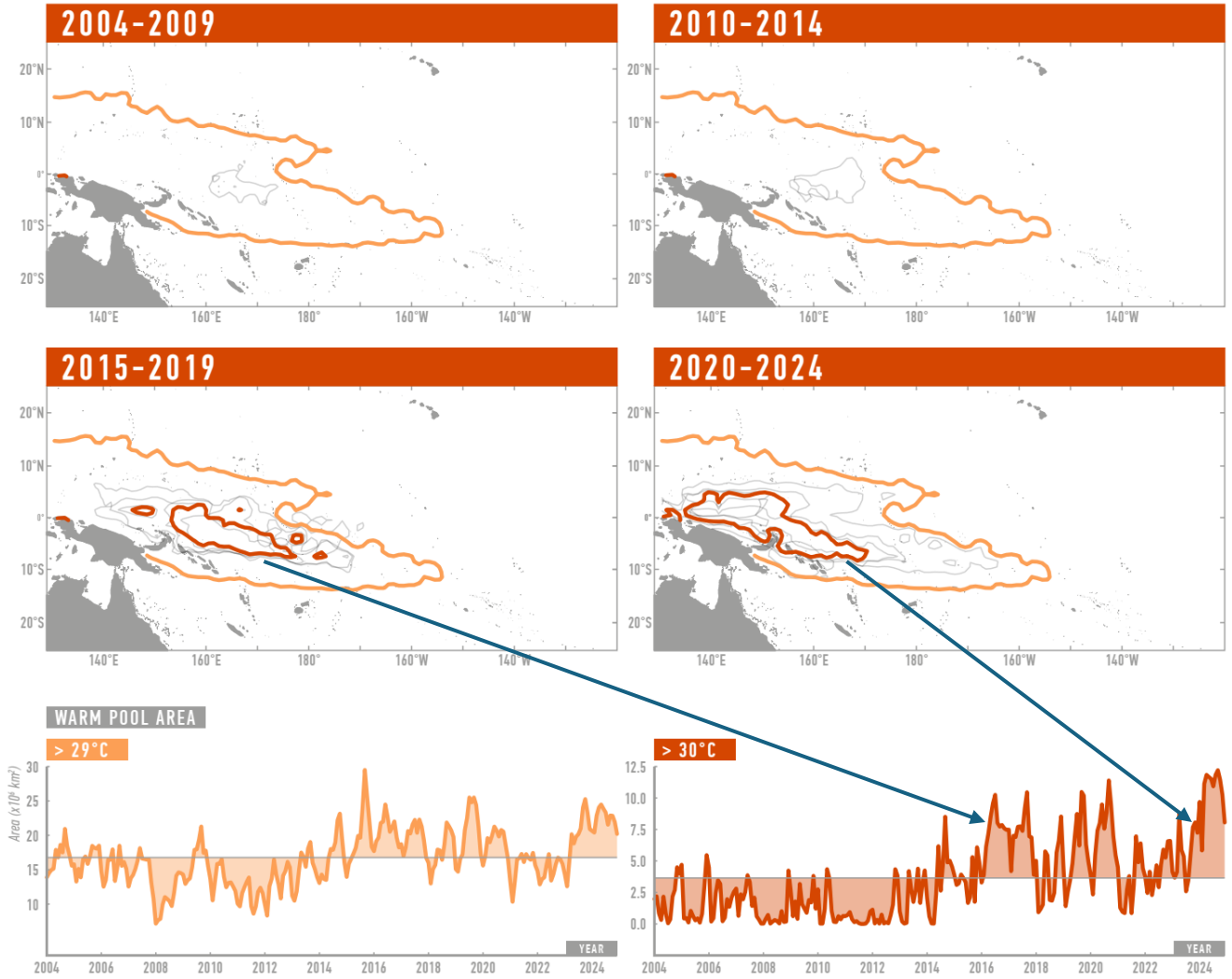


SST



3. Warm pool area

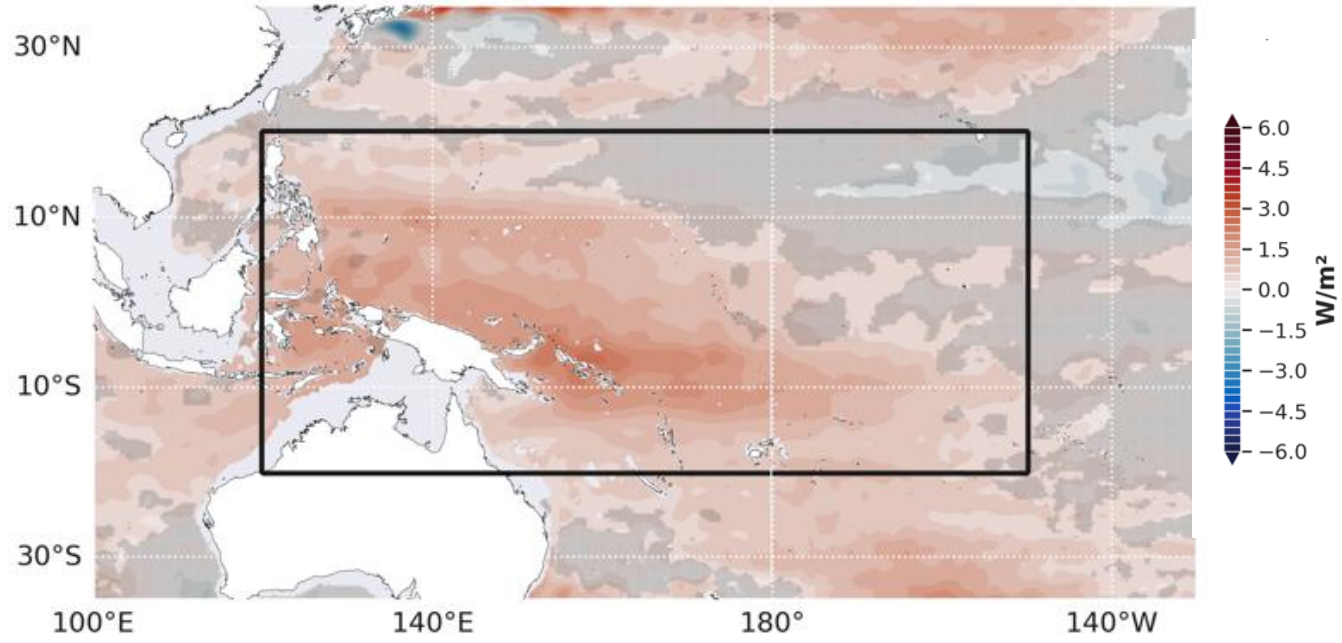
- Near average in 2024 due to neutral ENSO conditions
- Warm pool ENSO driven with less clear long-term trend apparent for 29°C from 2004-2024 (yellow line)
- BUT, there is an increasing trend in water **>30°C** from 2004-2024 within the warm pool (red line)
- Need longer observational time series, long term increase (since 1970s) in warm pool (29°C) is indicated by re-analysis models

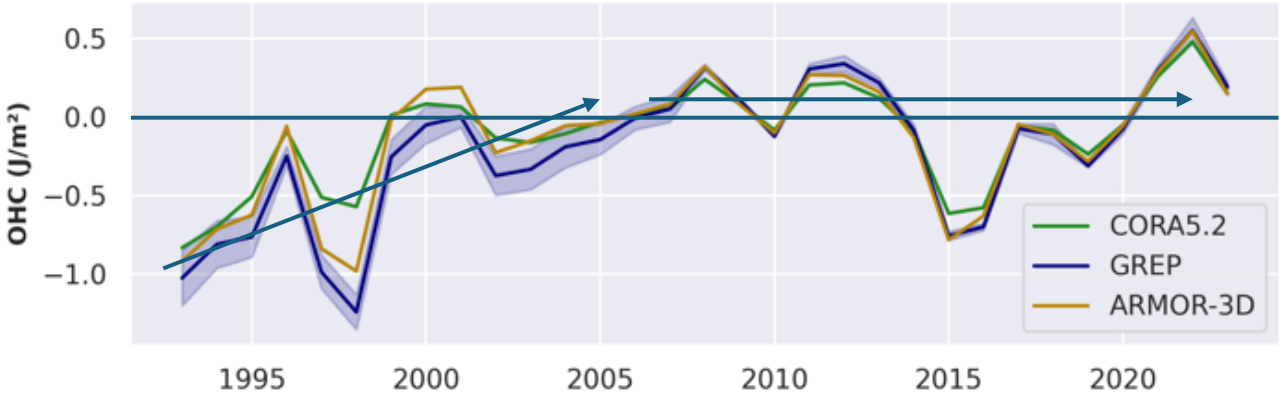


4. Ocean heat content (OHC) (0-300m)

- Ocean absorbs ~90% of excess heat from green house gases
- Heat content increasing from 1993-2023, but variable since 2000s
- Greater increase in western Pacific – linked to warm pool
- Need a longer timeseries

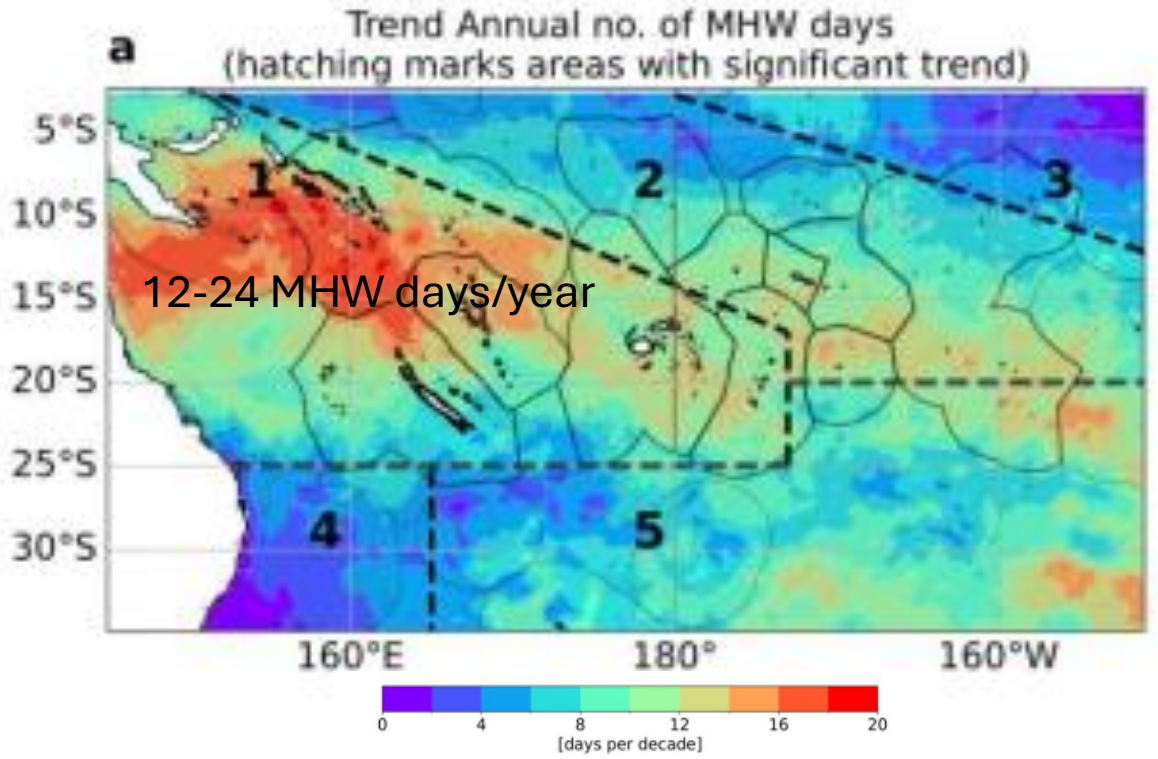
2023 anomaly relative to 1993-2023 average

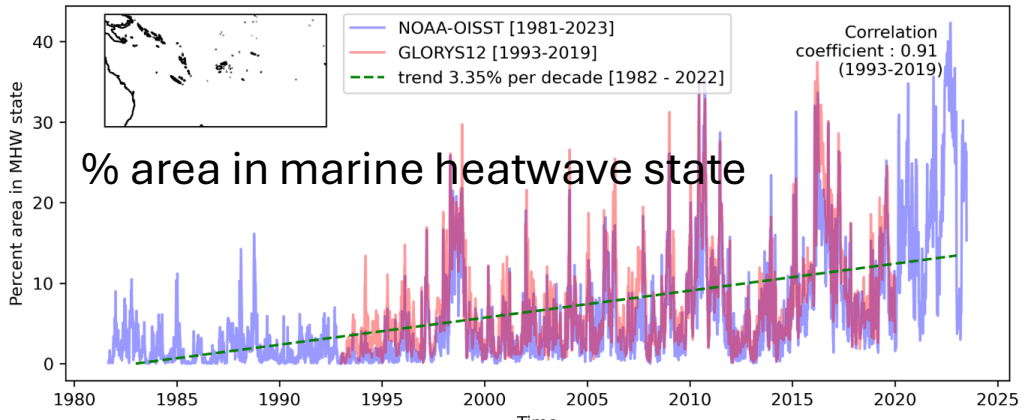




5. Marine heatwaves (MHWs)

- From 1981-2023 MHWs are:
  - Increasing in frequency (double per decade for some PICTs since 1980s)
  - Longer lasting
  - Larger in area
  - Less intense
- Mean duration of MHW has doubled each decade
- PICTs impacted differently
- From Lal et al. 2025





MHW = SST > 90%ile 1993-2019

Summary

- Up-to-date climate summary for WCPFC22
- Five indicators presented:
  1. El Nino Southern Oscillation (ENSO) → Neutral through 2025, El Nino possible for 2026
  2. Sea surface temperature → Increasing
  3. Warm pool area → Variable/increasing – more area >30˚C
  4. Ocean heat content → Increasing
  5. Marine heatwaves → Increasing

Observations are qualitatively consistent with expectations from models

NEW BOOK: Climate change implications for fisheries and aquaculture in the Pacific Islands region

"Without science and without data, it will make our jobs difficult because we will be speculating about the impacts of climate change, whereas when we have the actual science, the actual data, it provides us with the opportunity to make informed decisions."

Honourable (Mr) Tingika ELIKANA, Minister of the Crown, Minister Responsible for Foreign Affairs and Immigration, Marine Resources and Parliamentary Services. Cook Islands

LINK TO REPORT

Documents climate change projections for the region, the status of fisheries and aquaculture, and the implications of climate change for socio-ecological systems.

https://fame.spc.int/climate-change-implications-fisheries-and-aquaculture-pacific-islands-region