Dynamics of Marine Heat Wave and Its Impact on Iloilo City

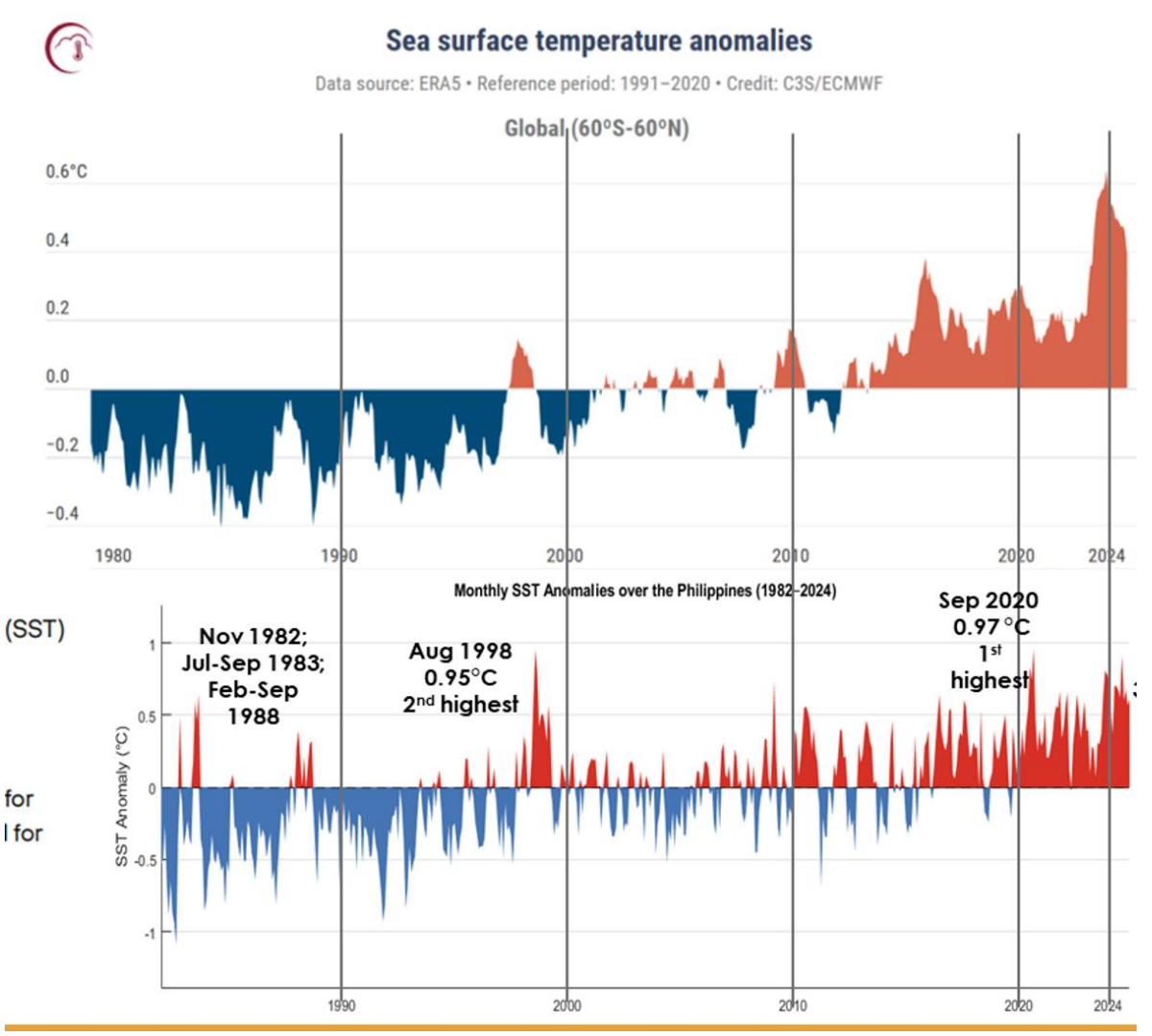
Charina Lyn Amedo-Repollo, Rachel Francisco-Barce, Stephen Luces,
Gwyneth Keena Gaviola,
Cristan Dave Zablan, Rhea Mae Luciano, Lowell Jay Tupaz, and Maria Vanessa Baria-Rodriguez
email:crepollo@msi.upd.edu.ph
Marine Science Institute, University of the Philippines in Diliman
Quezon City 1101 Philippines

Monthly sea surface temperature (SST) anomalies

GLOBAL SST

Vs.

PHILIPPINE SST

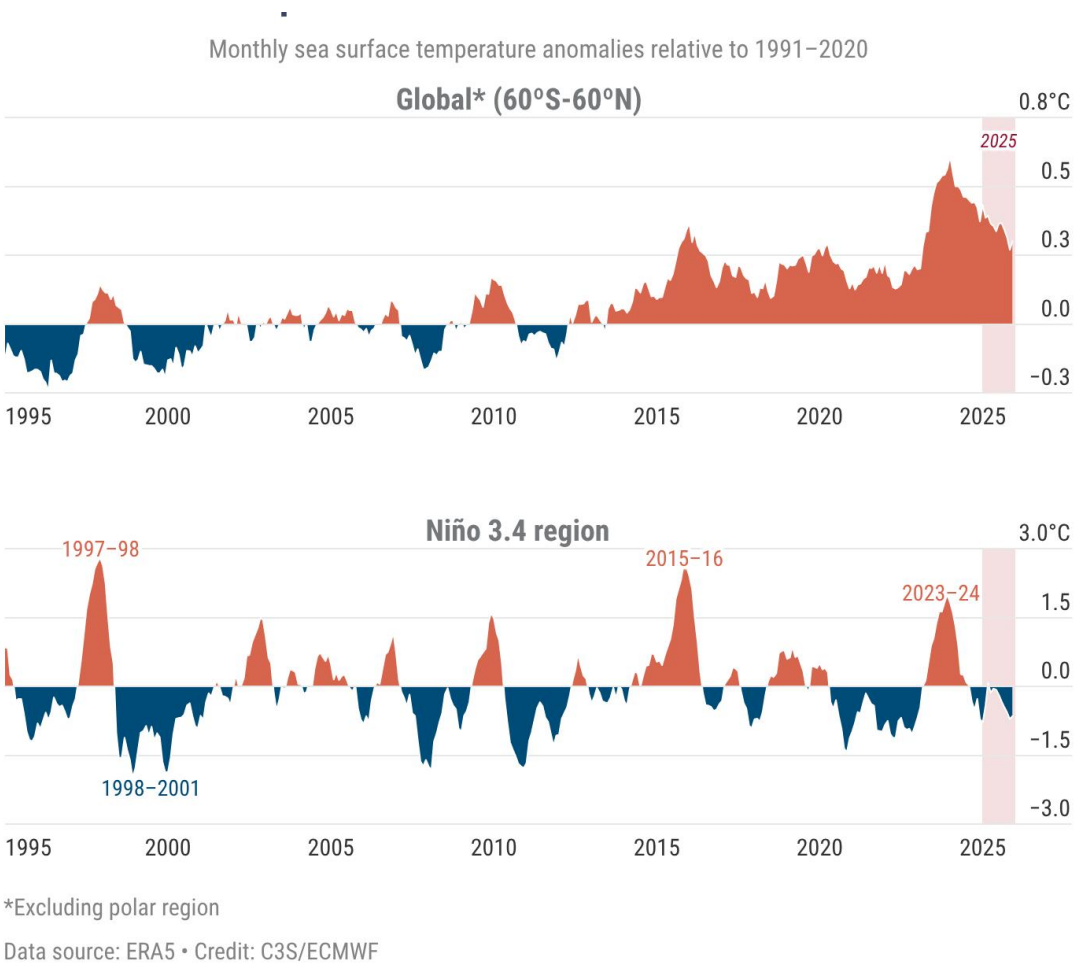


Monthly sea surface temperature (SST) anomalies

Historically high SST throughout 2025, despite the absence of El Niño conditions

WMO/PAGASA, El Niño

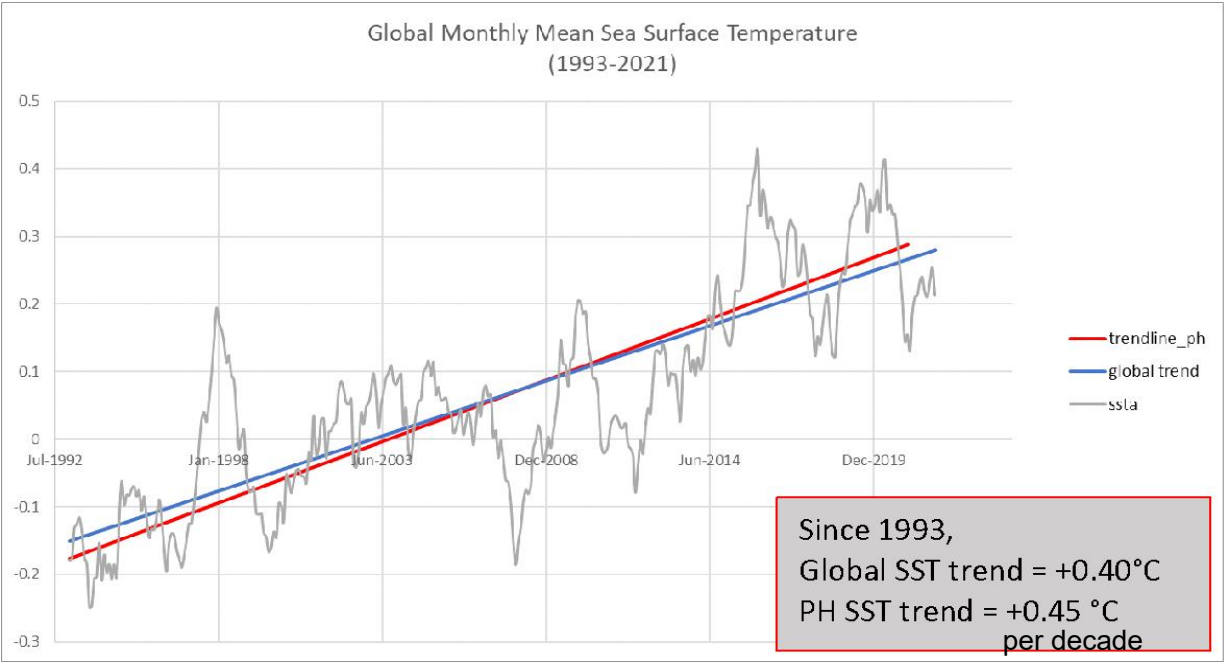
Start – Jun 2023
Peak – Dec 2023 – Jan 2024
End – May 2024



PROGRAMME OF THE EUROPEAN UNION
opernicus
Climate Change Service
IMPLEMENTED BY ECMWF

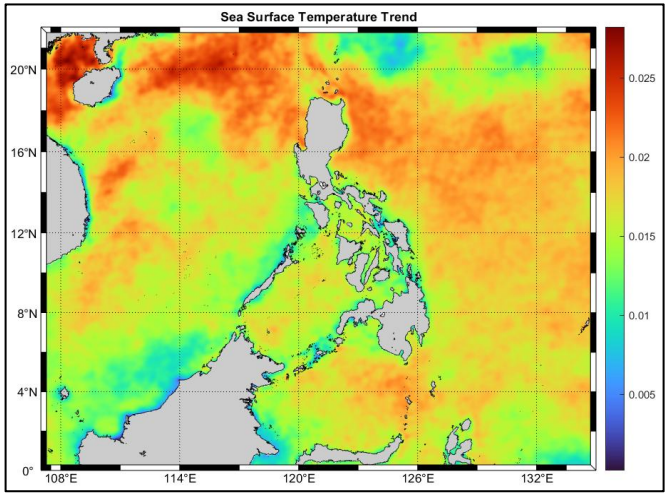
Sea surface temperature trend

Global SST Trend vs. Philippine SST Trend



Since 1993,
Global SST trend = +0.40°C
PH SST trend = +0.45 °C per decade

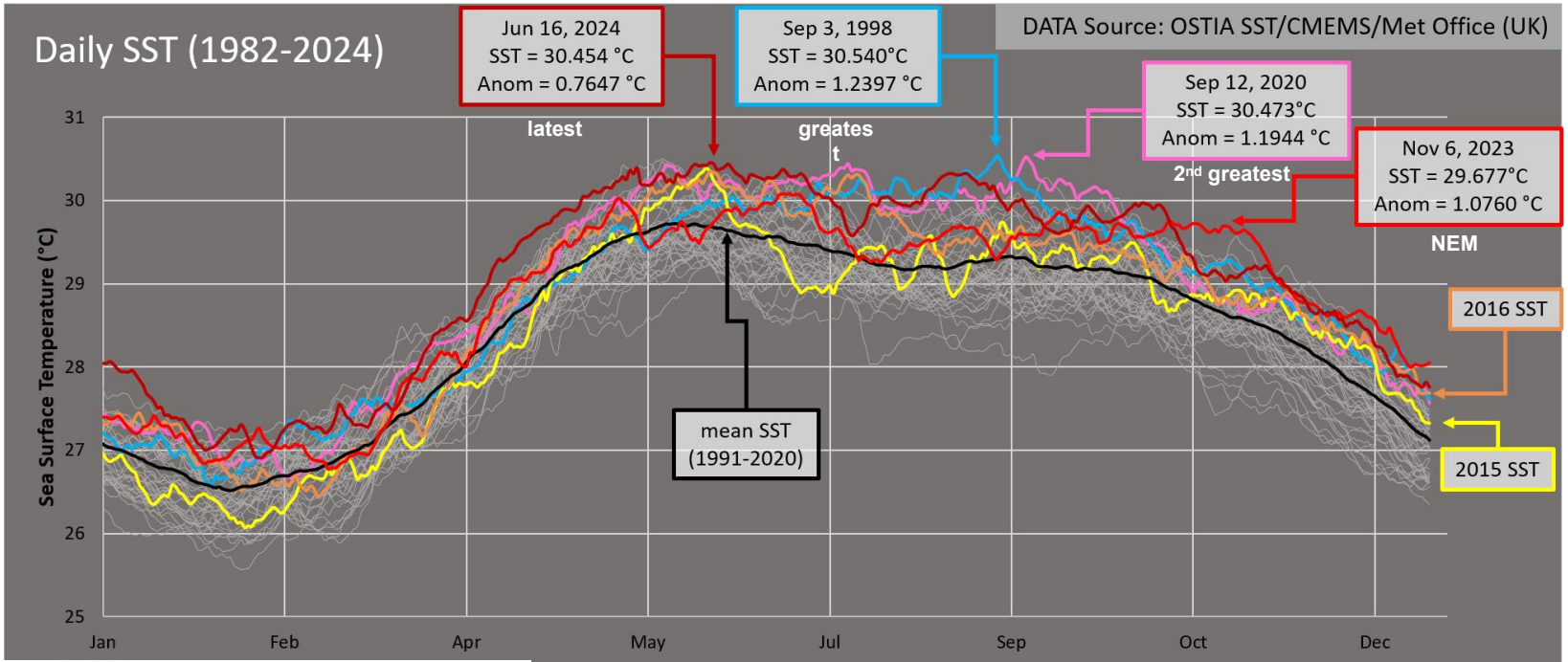
Data Source: ECMWF/CMEMS



Spatial variation of SST trend

Daily sea surface temperature

Record-breaking Philippine Daily Sea Surface Temperature



PAPER • OPEN ACCESS

Evolution of Marine Heatwave in the Philippines During and After the 2023/24 El Niño

Rachel Francisco, Charina Lyn Amedo-Repollo, Chloie Mae Libatog and Maria Vanessa Baria-Rodriguez

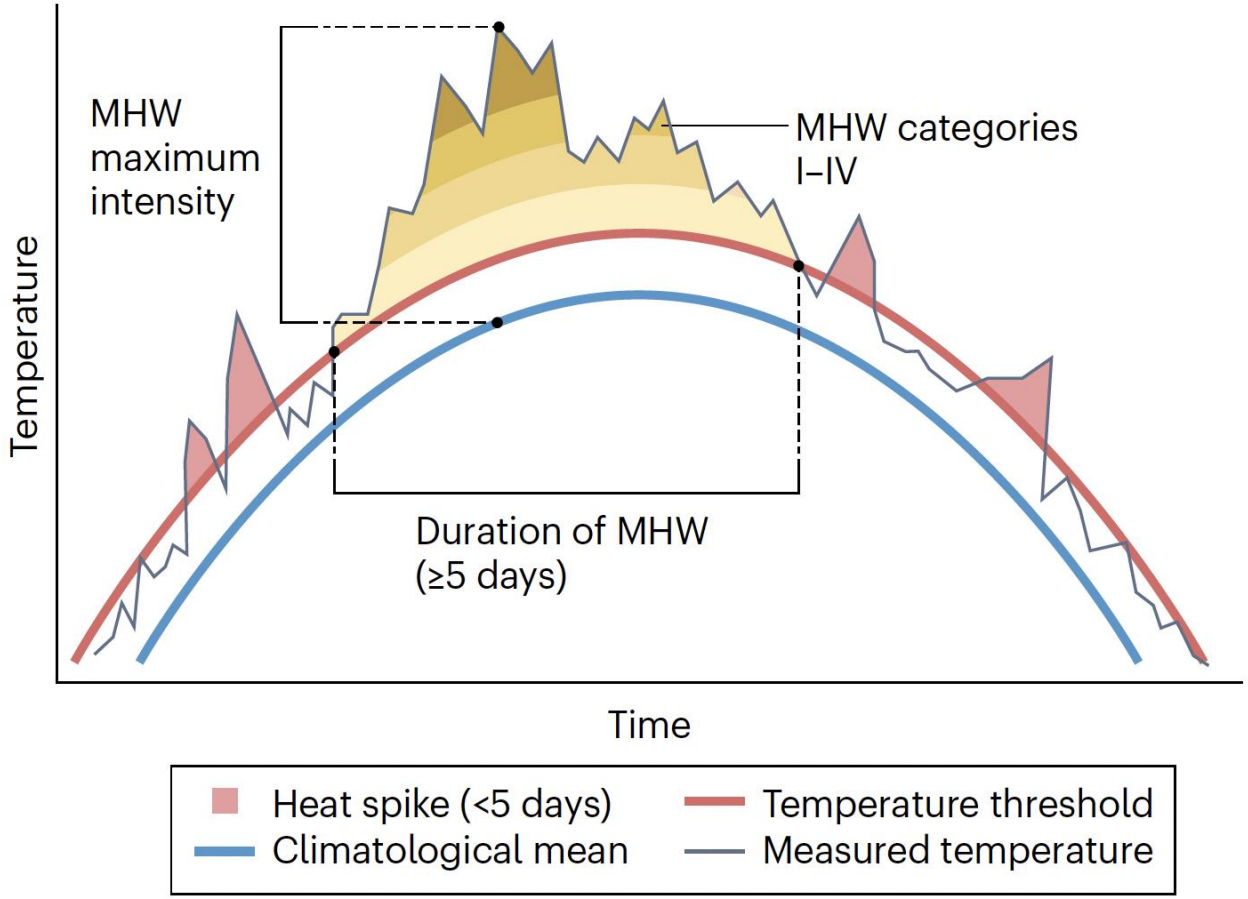
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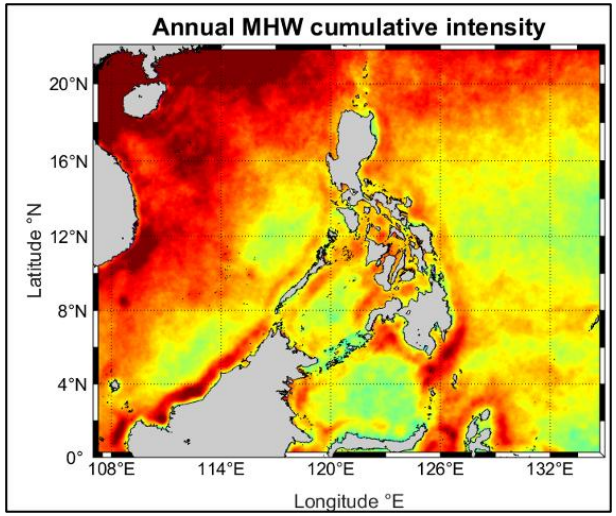
IOP Conference Series: Earth and Environmental Science, Volume 1496, 8th International Conference on Tropical Coastal Region Eco-Development (ICTCRED 2024) 24/09/2024 - 25/09/2024 Semarang, Indonesia

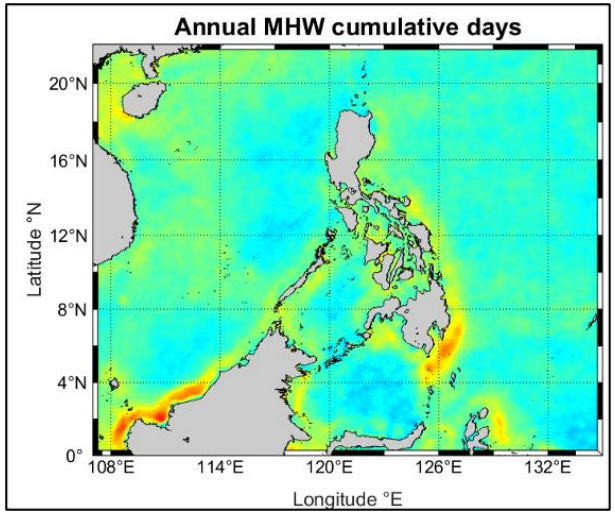
Citation Rachel Francisco *et al 2025 IOP Conf. Ser.: Earth Environ. Sci.* **1496** 012028

DOI 10.1088/1755-1315/1496/1/012028

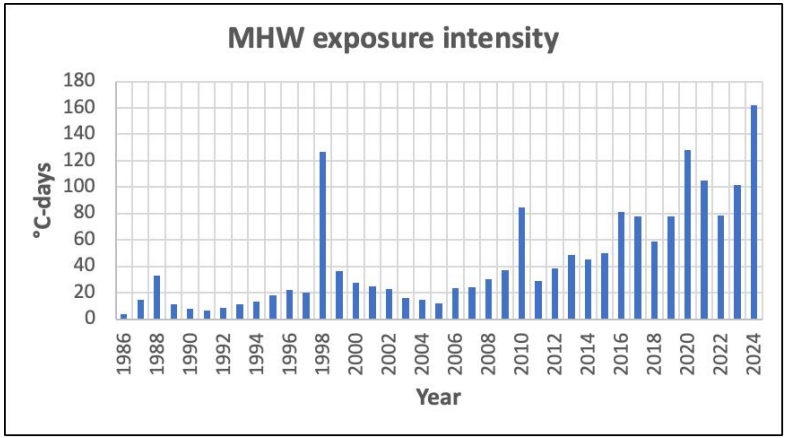
Francisco et al., 2025 (IOP Conference Series: Earth and Environmental Science)

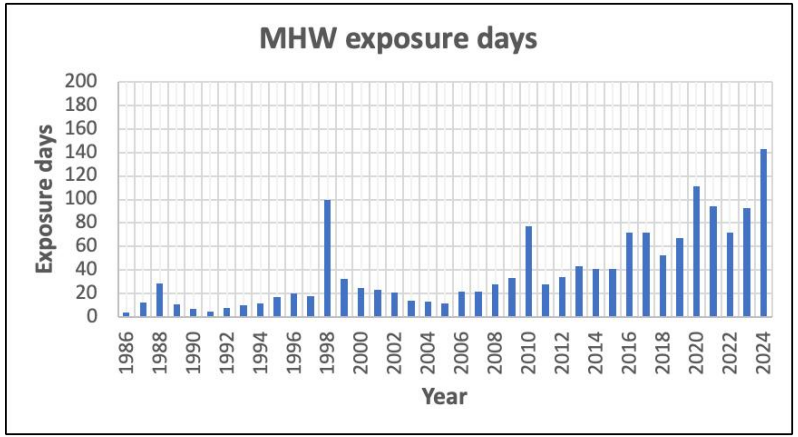

MHW
maximum
intensity
MHW categories
I–IV
Temperature
Duration of MHW
(≥5 days)
Time
Heat spike (<5 days)
Climatological mean
Temperature threshold
Measured temperature





Rank	Year
1	2024
2	2020
3	1998
4	2021
5	2023





Sea surface temperature (SST) during 2023-2024 El Nino Event

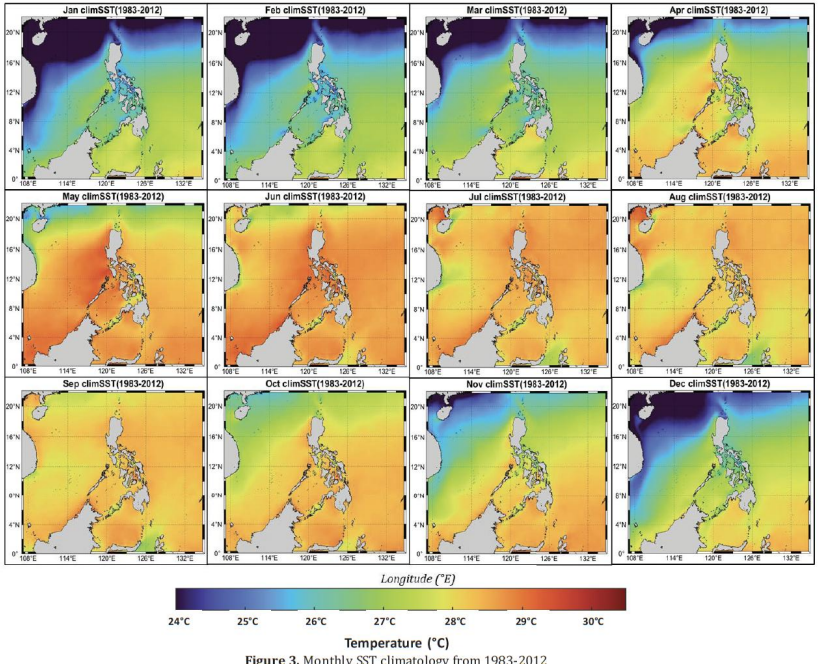
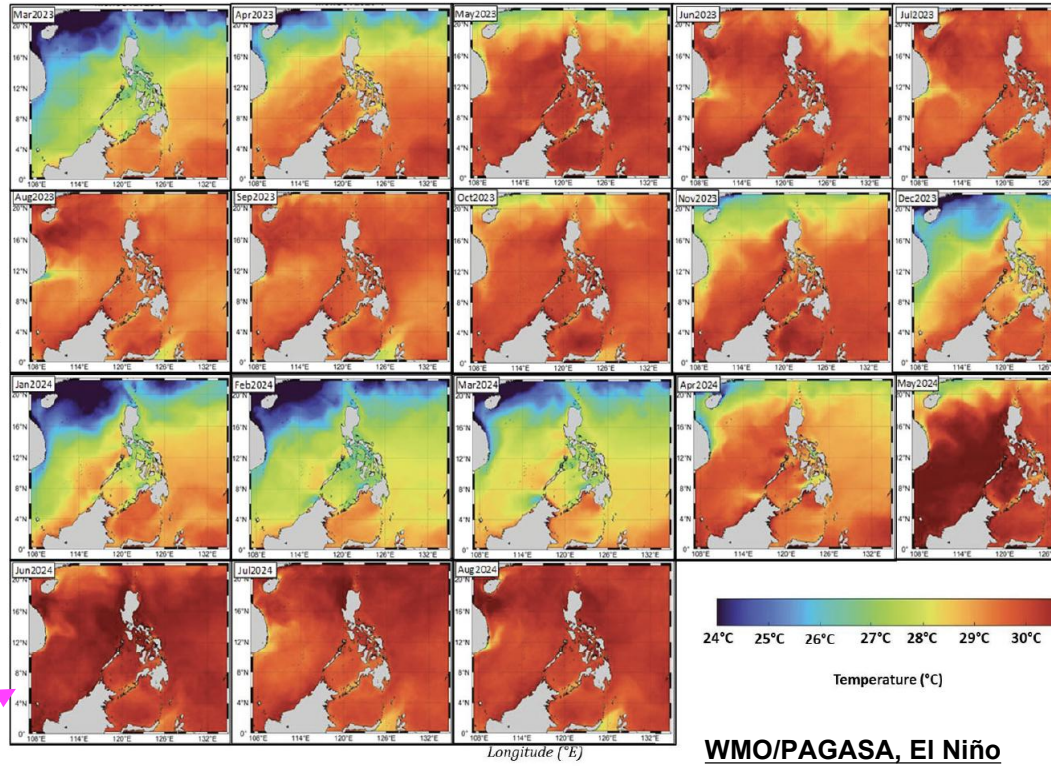


Figure 3. Monthly SST climatology from 1983-2012

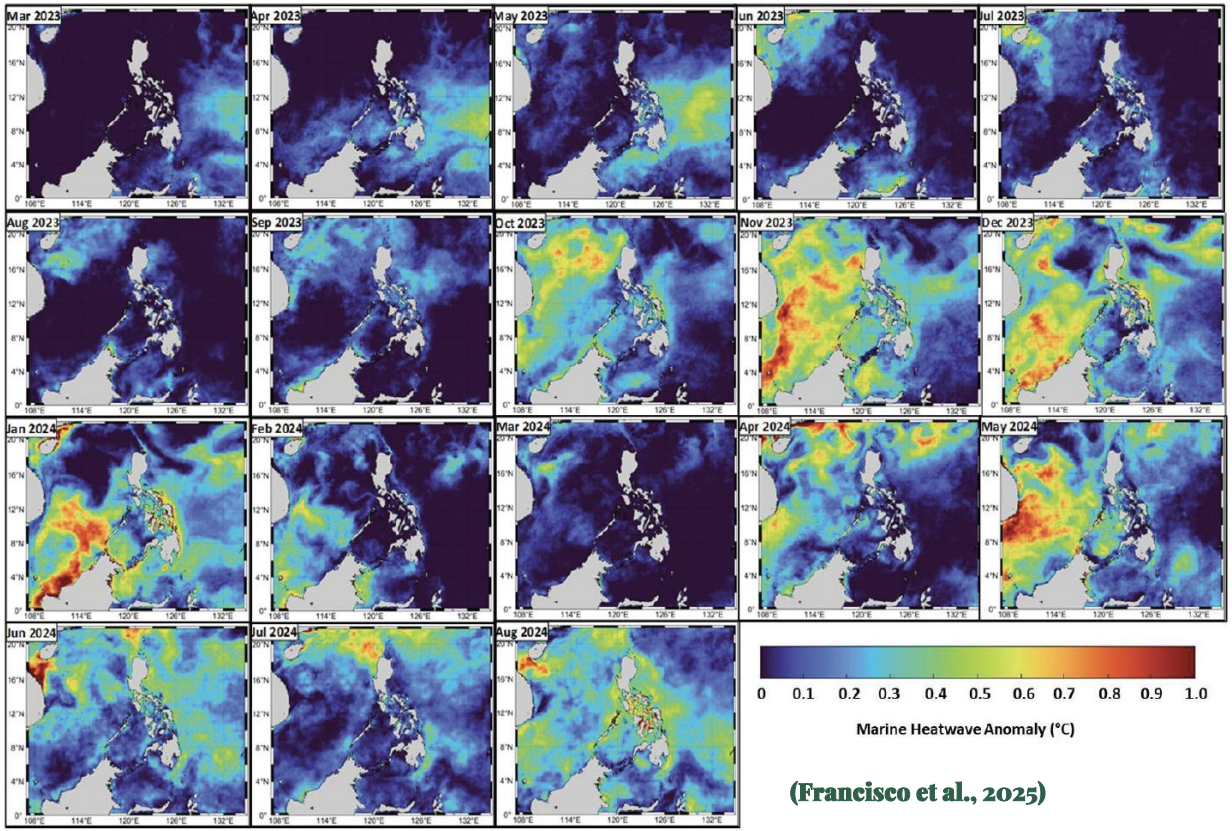


Record-high SSTs during the 2023–2024 El Niño reached **in June 2024**, which **surpassed previous El Niño SSTs** (e.g., 2015–2016) and posed a heightened risk to temperature-sensitive marine ecosystems.

(Francisco et al., 2025)

WMO/PAGASA, El Niño
Start – Jun 2023
Peak – Dec 2023 – Jan 2024
End – May 2024

What happened during 2023-2024 El Nino Event



(Francisco et al., 2025)

Figure 6. Monthly MHW anomaly during the 2023-2024 El Niño event (March 2023-August 2024)

MHW anomalies persisted beyond the official end of El Niño

Two distinct MHW anomaly phases were identified:

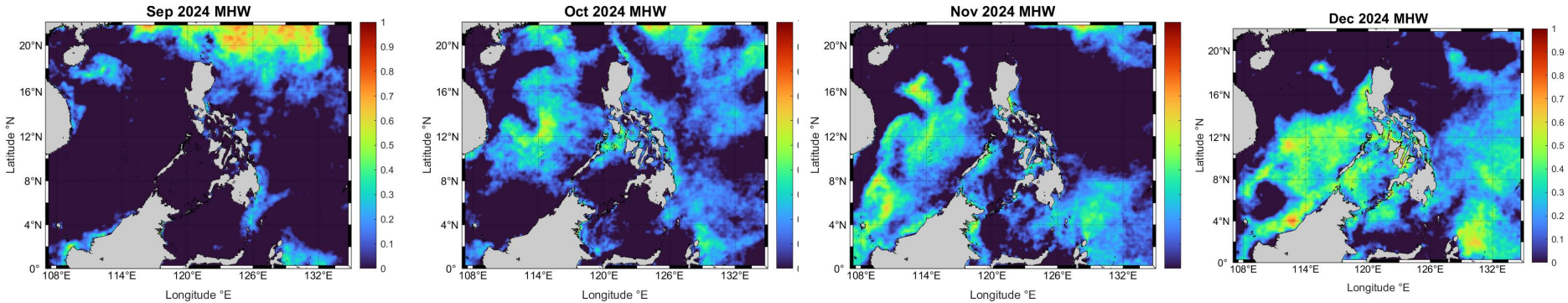
(1) **November 2023–January 2024** — during the **northeast monsoon**, despite lower SSTs; and

(2) **April–August 2024** — post-El Niño, with **stronger and more extensive MHW anomalies**, especially west and northeast of the Philippines.

WMO/PAGASA, El Niño
Start – Jun 2023
Peak – Dec 2023 – Jan 2024
End – May 2024

Marine heatwave anomaly during 2023-2024 El Nino Event

(Francisco et al., 2025)

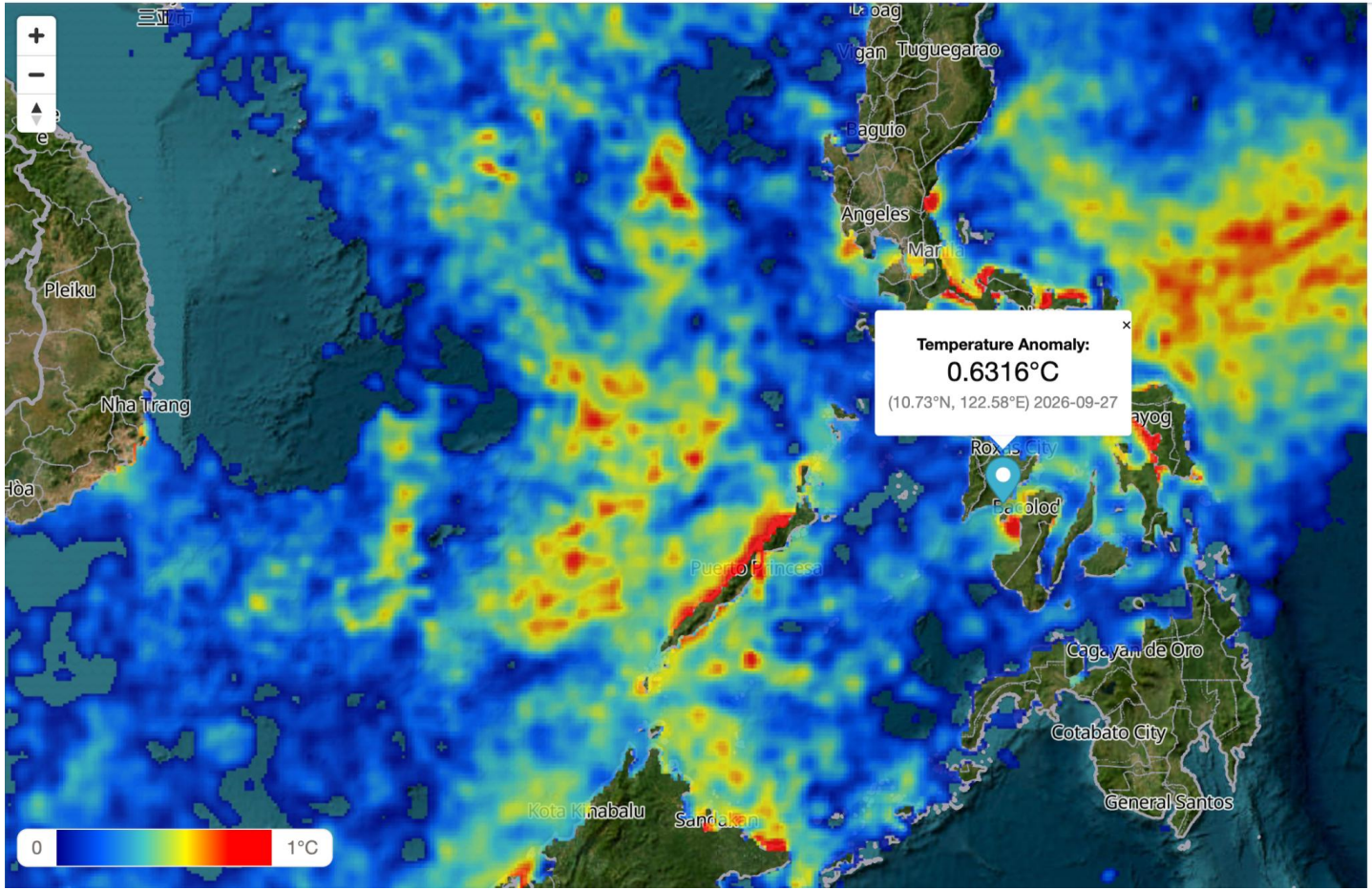


- **Alarmingly, this extreme warming occurred at the end of the El Niño phase**, suggesting that marine heat persists longer than expected— due to the combined effects of **El Niño**, **monsoon dynamics**, and l**ong-term climate change**. (Francisco et al.,2025)

(Francisco et al., 2025)

MARINE HEATWAVES TRACKER

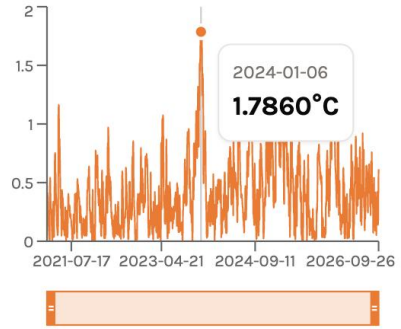
Sep 27, 2026



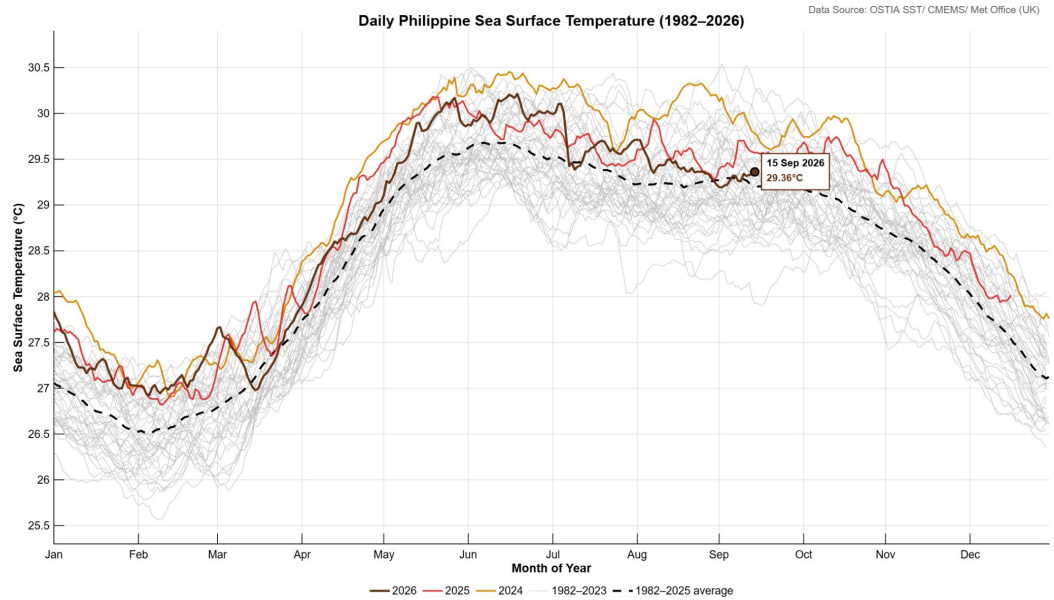
Trend

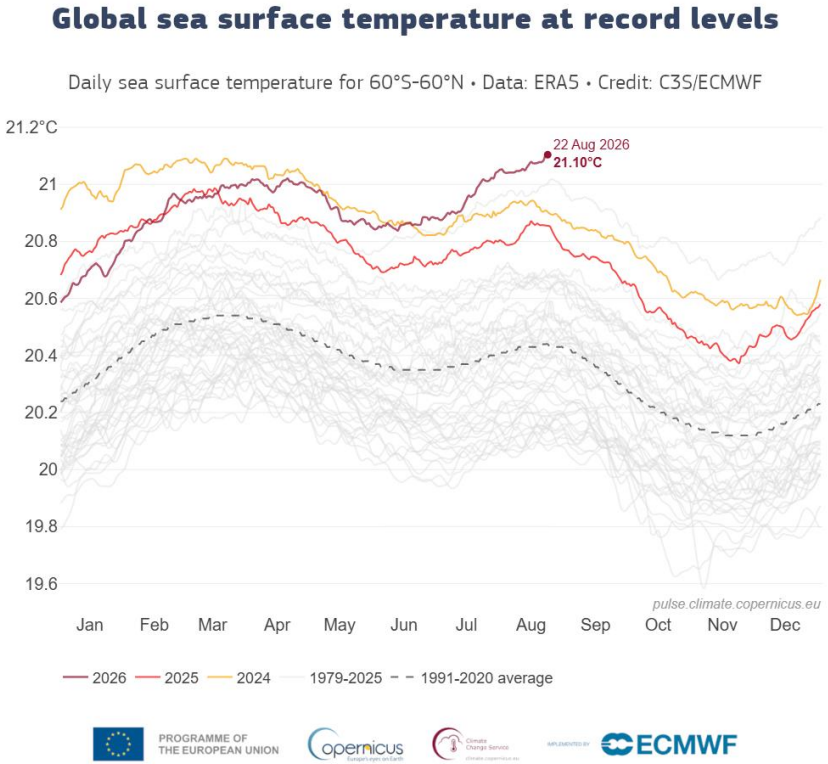
for 10.73°N, 122.58°E

Jan 01, 2021 - Sep 27, 2026



Current status

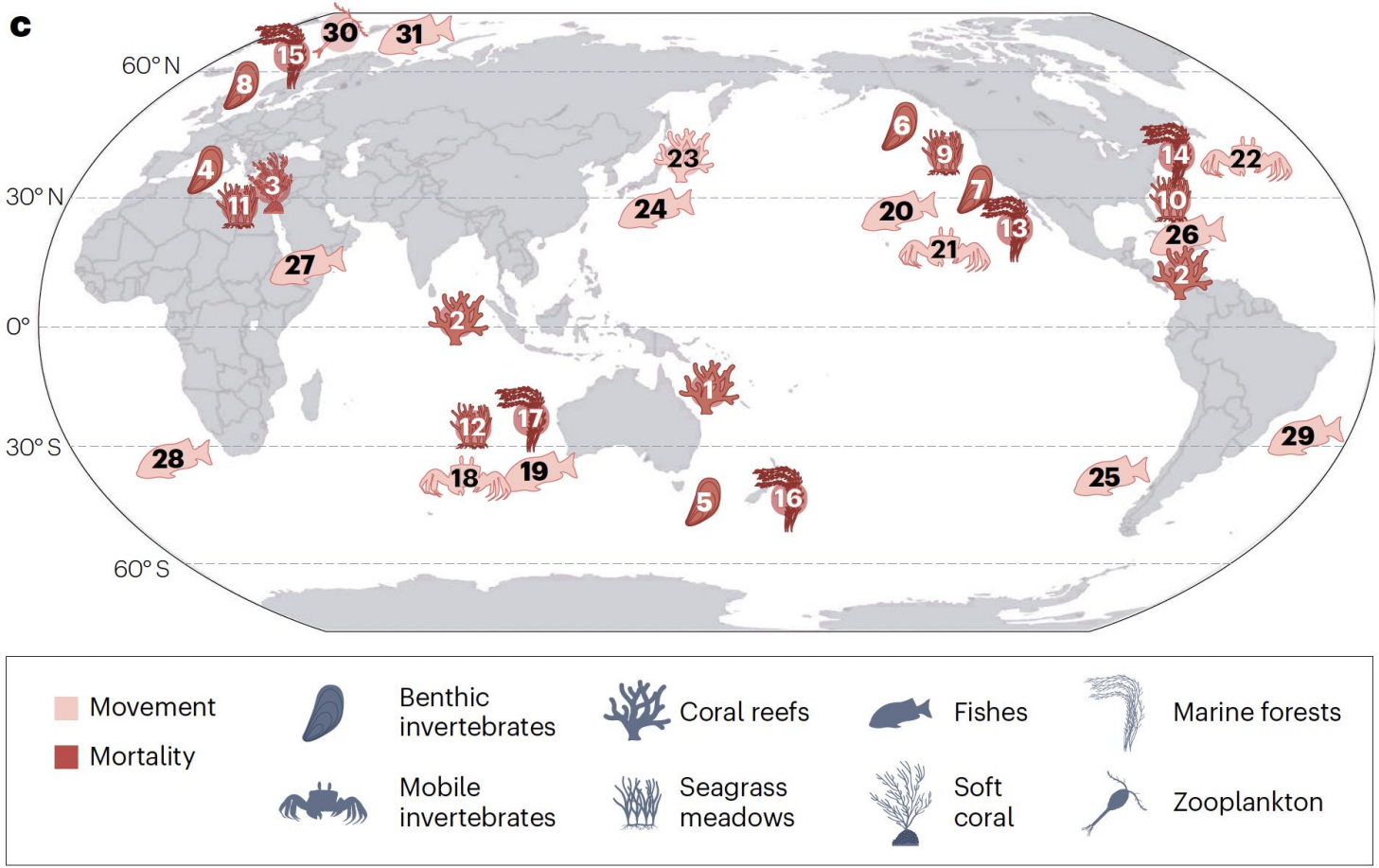




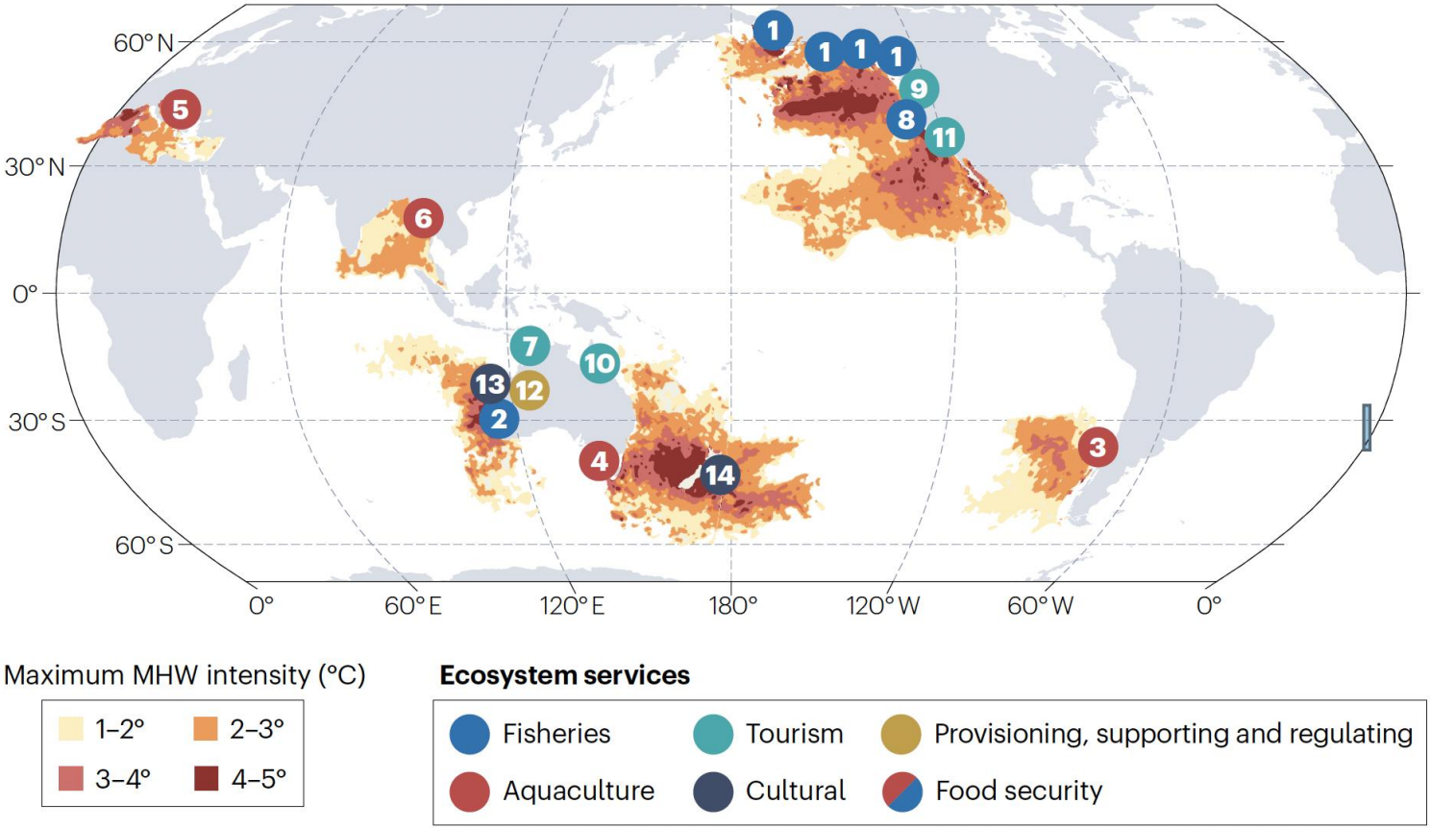
Current (2026–2027) El Niño started:
NOAA – June 11
WMO – June 2
PAGASA – June 9

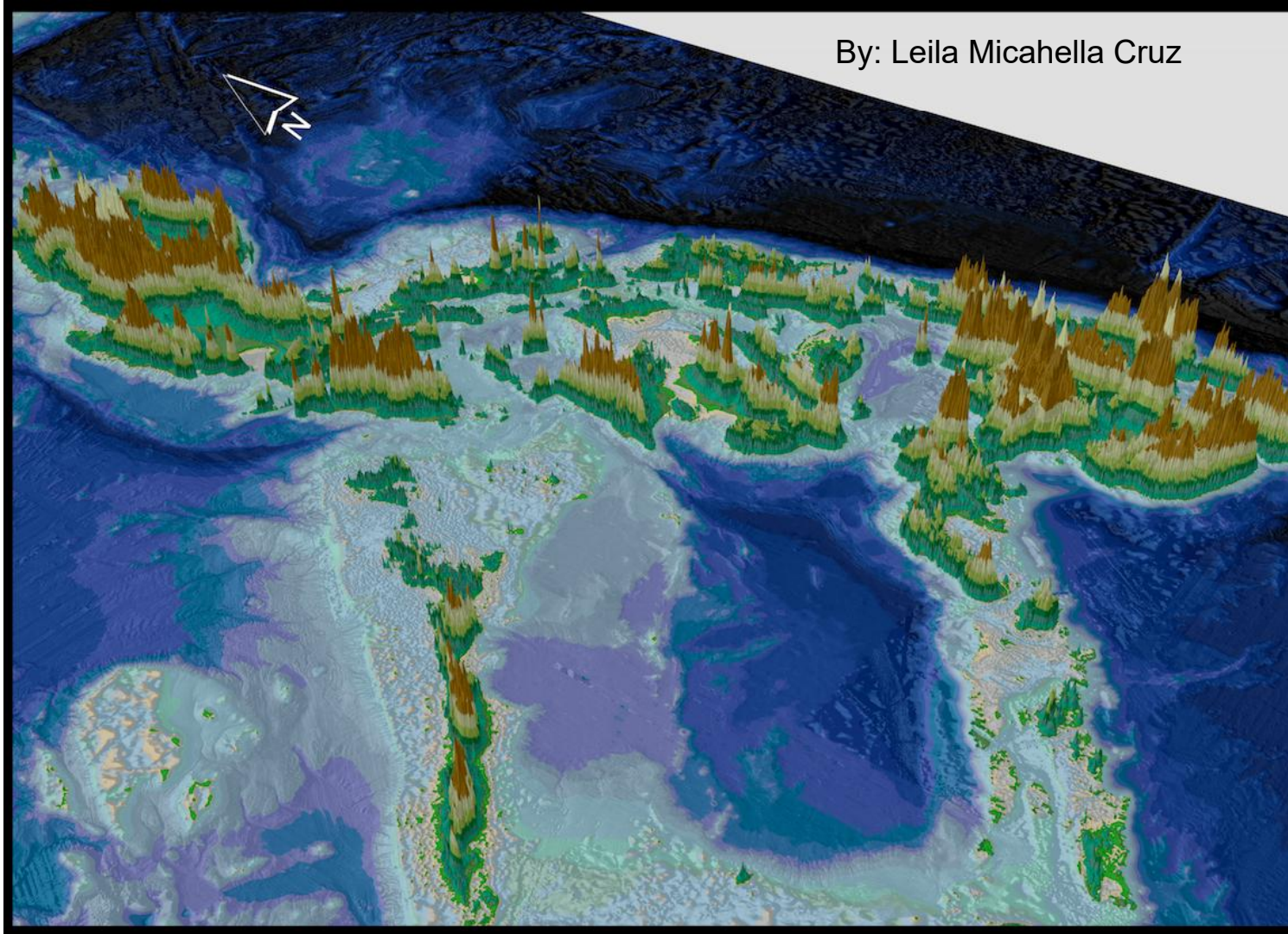
Previous (2023-2024) El Niño
Start – Jun 2023
Peak – Dec 2023 – Jan 2024
End – May 2024

Marine heatwave causes rapid mortality and distribution shifts



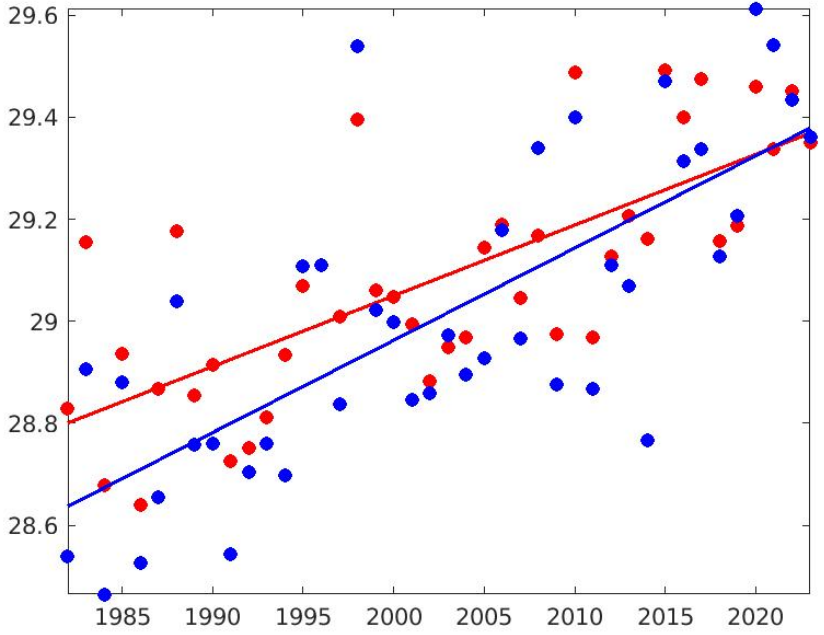
Marine heatwave impacts to ecosystem services



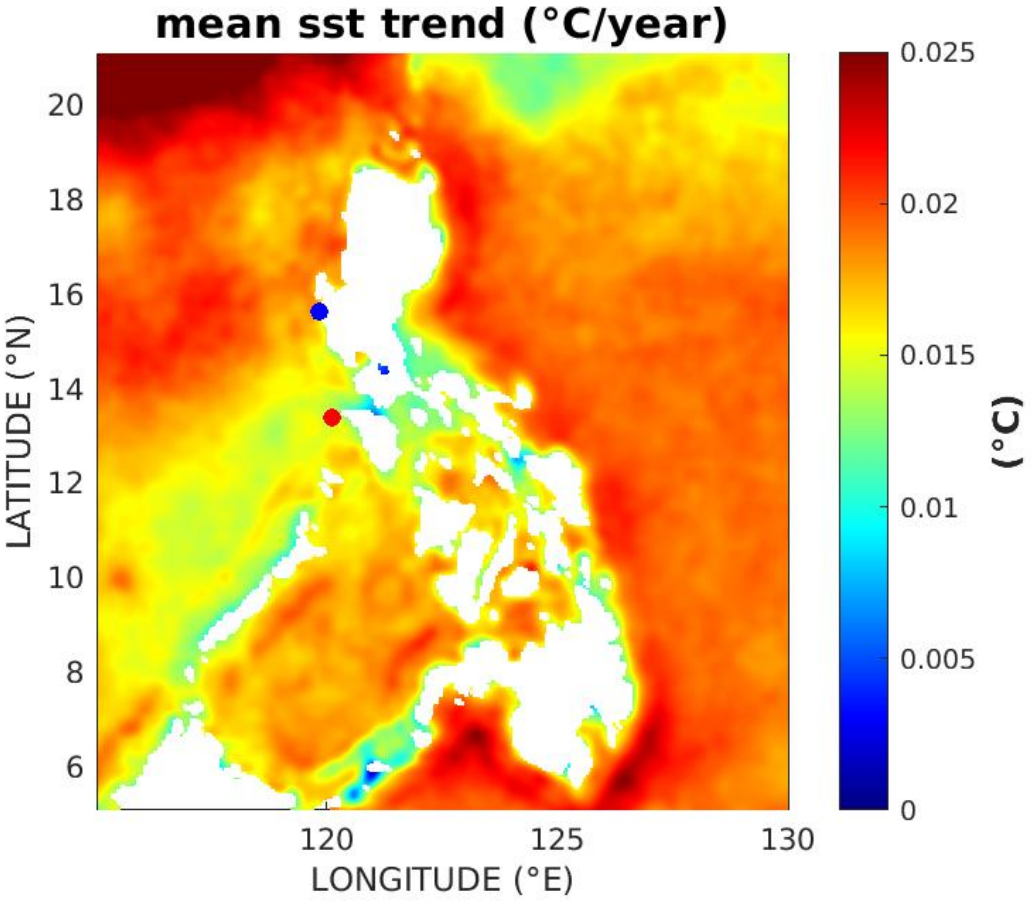


By: Leila Micahella Cruz

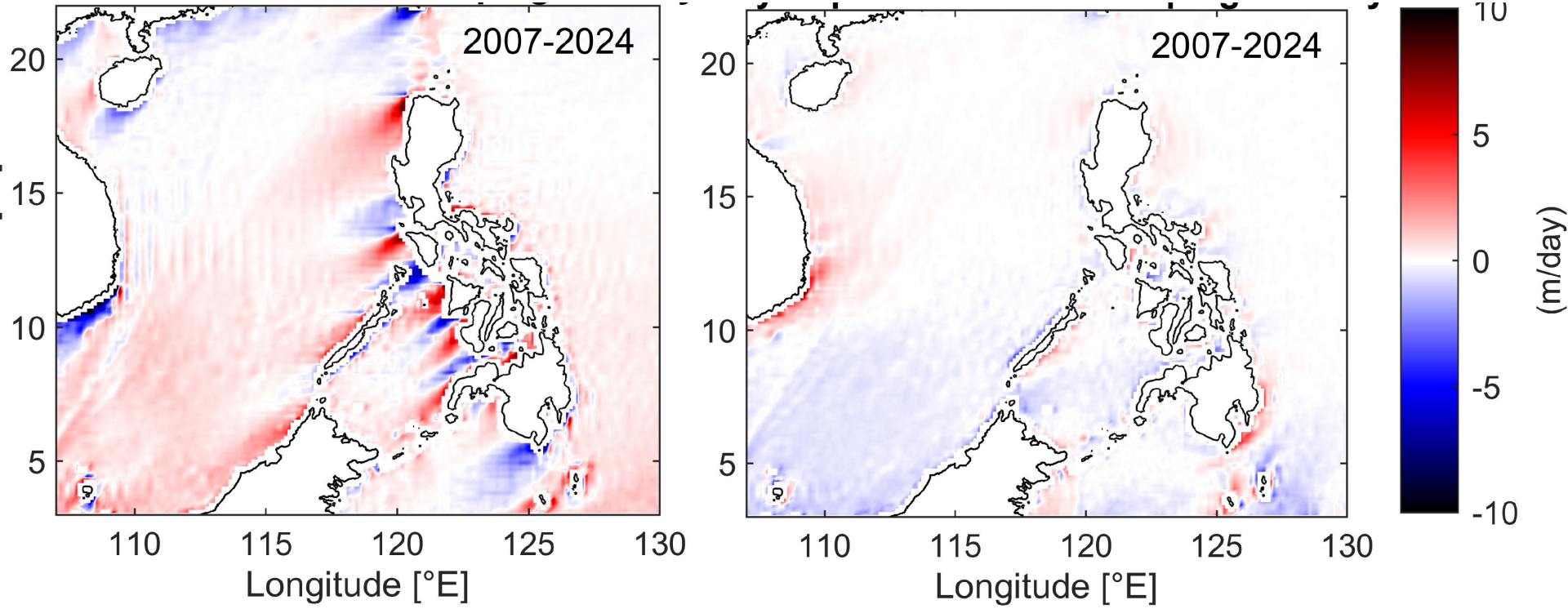
Operational Sea Surface Temperature and Ice Analysis (OSTIA) (Oct 1981 - Aug 2024)



Upwelling/Downwelling



Upwelling/Downwelling

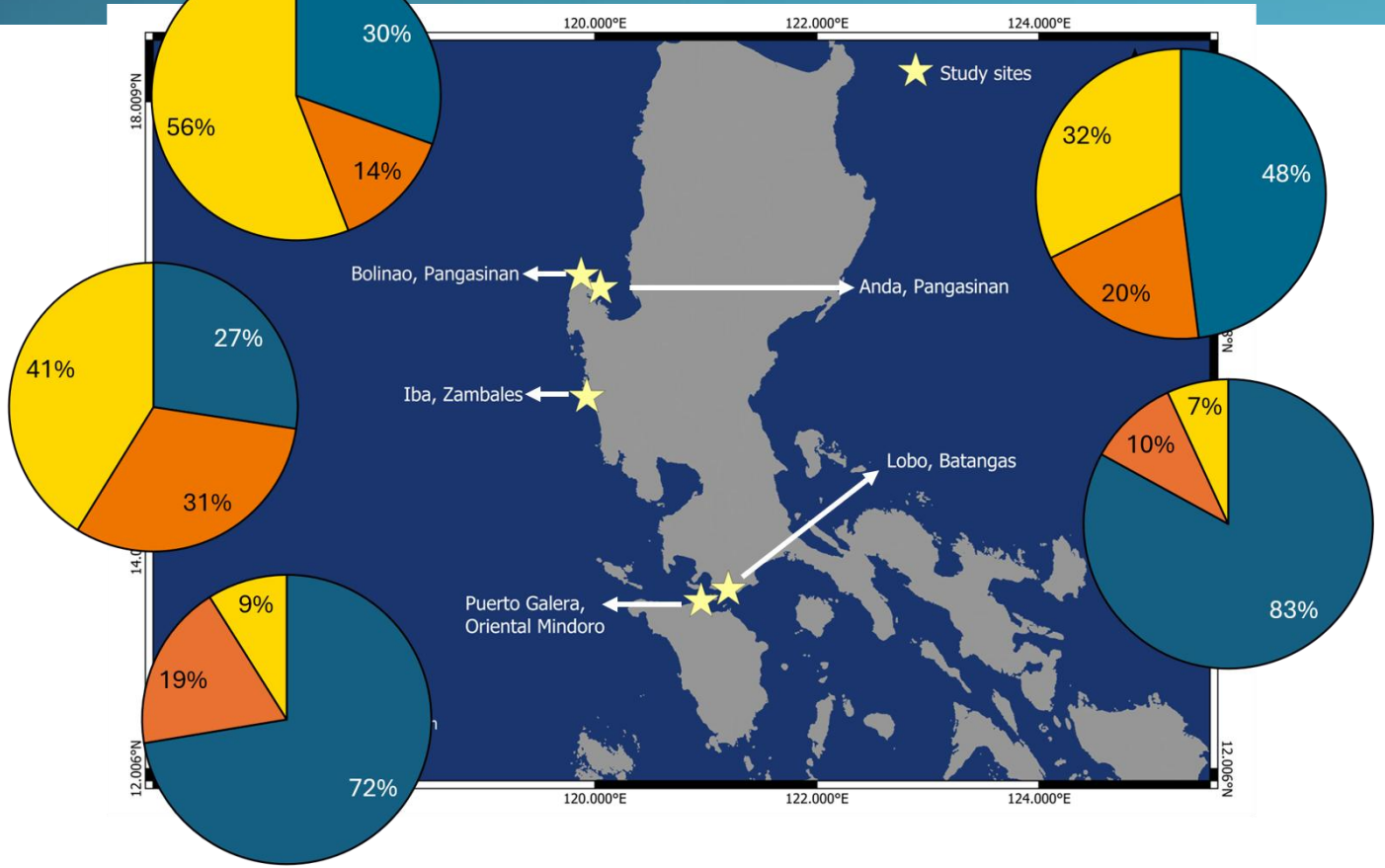


Amedo-Repollo et al., 2026

Proportion of bleaching status per location

> 50% of corals bleached (Moderate + Severe) in Iba, Bolinao, Anda

< 28% corals bleached (Moderate + Severe) in Lobo and Puerto Galera



No bleaching

Moderately bleached

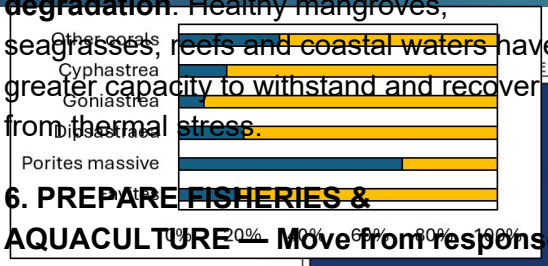
Severely bleached

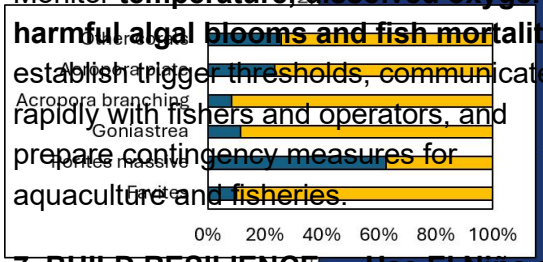
Proportion of non-bleached and bleached top coral taxa per location

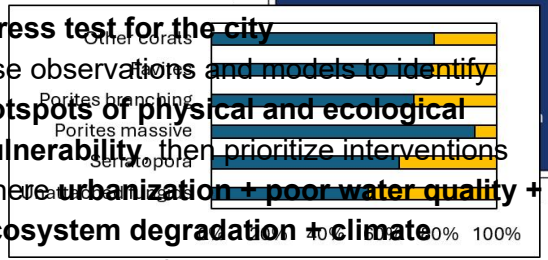
5. PROTECT THE COAST — Reduce non-climate stressors before the MHW peaks
Reduce **pollution, nutrient loading, sedimentation, overfishing and habitat degradation**. Healthy mangroves, seagrasses, reefs and coastal waters have greater capacity to withstand and recover from thermal stress.

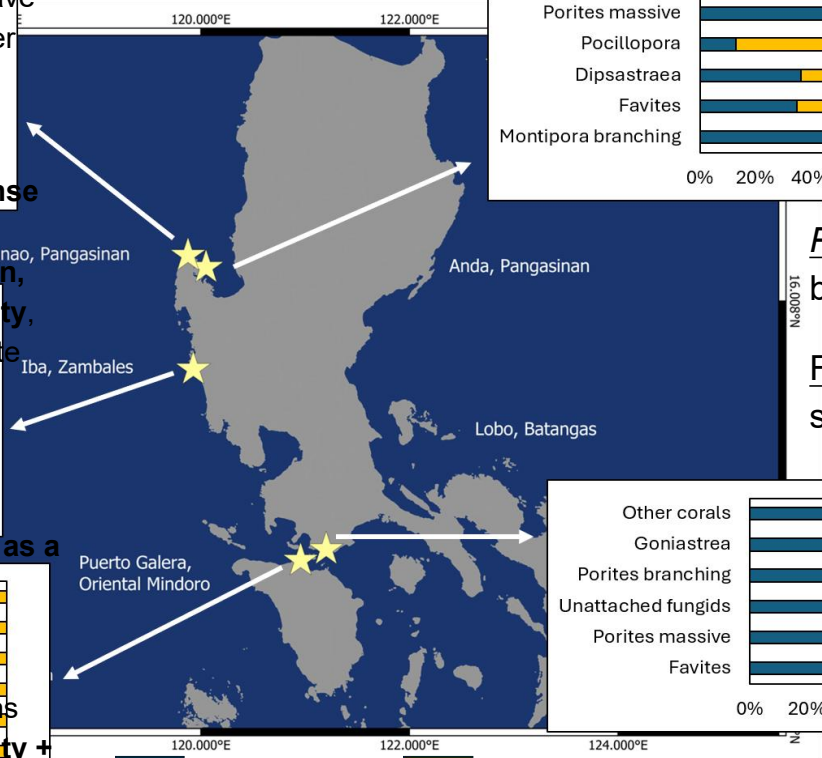
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Monitor **temperature, dissolved oxygen, harmful algal blooms and fish mortality**, establish trigger thresholds, communicate rapidly with fishers and operators, and prepare contingency measures for aquaculture and fisheries.

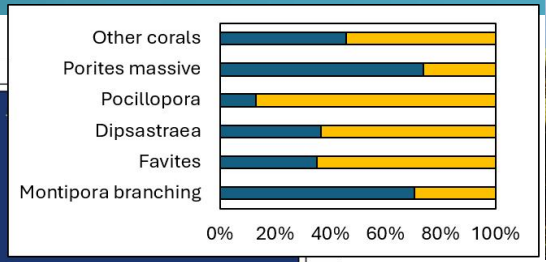
7. BUILD RESILIENCE — Use El Niño as a stress test for the city
Use observations and models to identify **hotspots of physical and ecological vulnerability**, then prioritize interventions where **urbanization + poor water quality + ecosystem degradation + climate extremes** overlap.

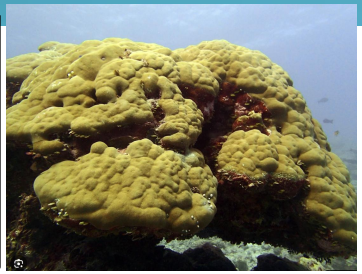






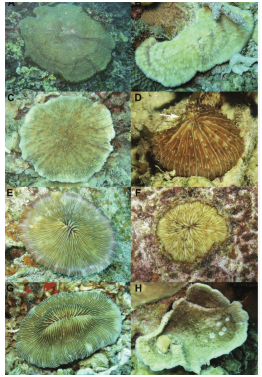






Porites - least susceptible to bleaching (Anda, Bolinao, Iba).

Fungids - highest bleaching susceptibility (Puerto Galera, Lobo).



CLIMATE IMPACT DRIVERS

Large-scale and atmospheric–oceanic processes that shape ocean conditions and can generate or intensify marine heatwaves

Anthropogenic climate change

- Long-term ocean warming
- Raises background ocean temperature
- Makes marine heatwaves more frequent, intense and longer lasting

El Niño–Southern Oscillation (ENSO)

- Alters winds, circulation, mixing and upwelling
- Favors warmer ocean conditions, especially during El Niño

Other climate modes

- Pacific Decadal Oscillation (PDO/IPO)
- North Atlantic Oscillation (NAO)
- Madden–Julian Oscillation (MJO)
- Modify regional atmospheric and ocean conditions

Persistent high-pressure systems

- Clear skies and weak winds
- Reduced heat loss to the atmosphere
- Can persist for weeks to months

Reduced cloud cover / enhanced solar heating

- More shortwave radiation reaches the ocean surface
- Increases surface heating

Weak winds / reduced evaporative cooling

- Less heat loss to the atmosphere
- Can reduce vertical mixing and promote a shallow mixed layer

NON-CLIMATE IMPACT DRIVERS

Local oceanographic processes and human activities that influence local heat retention, exposure, vulnerability and impacts

Reduced vertical mixing / stronger stratification

- Shallow mixed layer concentrates heat in surface waters
- Less mixing with cooler subsurface water

Suppressed coastal upwelling

- Less delivery of cold subsurface water to the surface
- Allows coastal waters to warm more quickly

Warm-water advection & boundary currents

- Transport of anomalously warm water into the region
- Changes in strength or position of boundary currents

Mesoscale eddies and fronts

- Warm-core eddies can retain or transport heat
- Fronts and planetary waves can enhance or prolong MHWs

Coastal development and reclamation

- Alters coastal circulation and water exchange
- Can reduce flushing and increase heat retention in coastal waters

Pollution / nutrient loading

- Contaminants and excess nutrients increase stress on marine organisms
- Can lead to algal blooms and lower oxygen, compounding MHW impacts

Overfishing / fishing pressure

- Reduces population resilience
- Alters food webs
- Makes ecosystems less able to recover from MHW impacts

Habitat degradation and loss

- Loss of corals, mangroves and seagrass reduces natural buffers
- Decreases ecosystem resilience

Upper-Ocean Thermal Structure (XBT)

Philippine Sea: Open-ocean heating produces the warmest and most uniform upper layer

Celebes Sea: Throughflow-driven mixing leads to slightly cooler surface waters

Sulu Sea: Semi-enclosed basin with strong mixing causes cooler and more variable upper layers

Strong surface–deep temperature contrast in the Philippine Sea meets OTEC requirements, indicating high potential for continuous baseload renewable energy, desalination, and cooling.

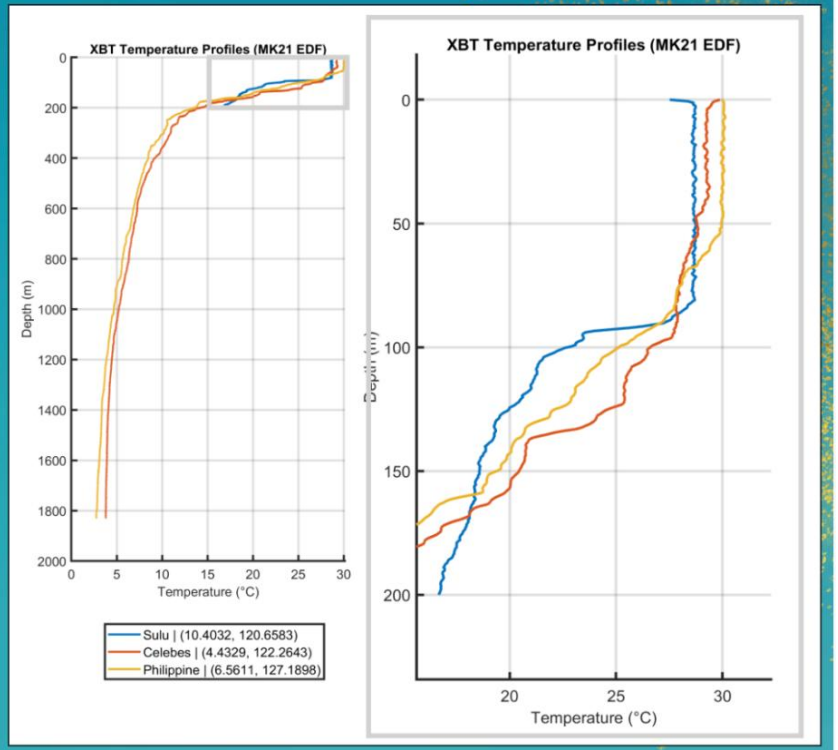
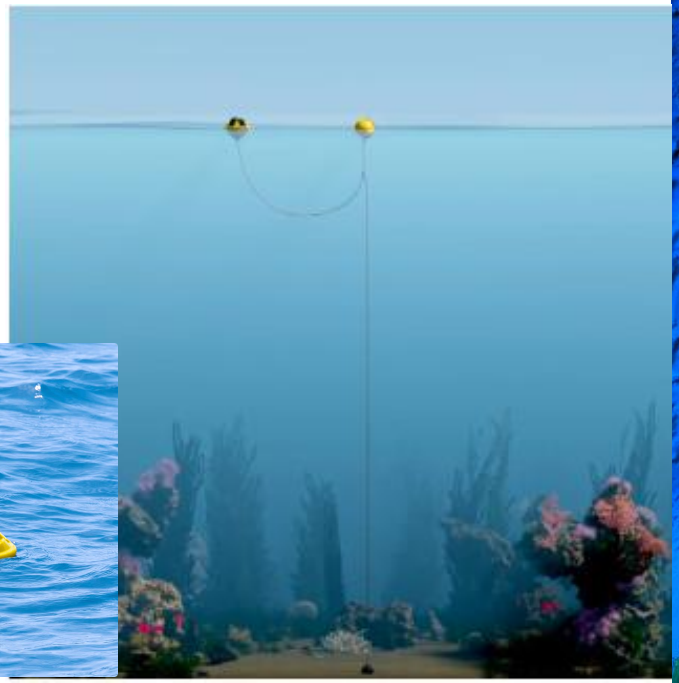


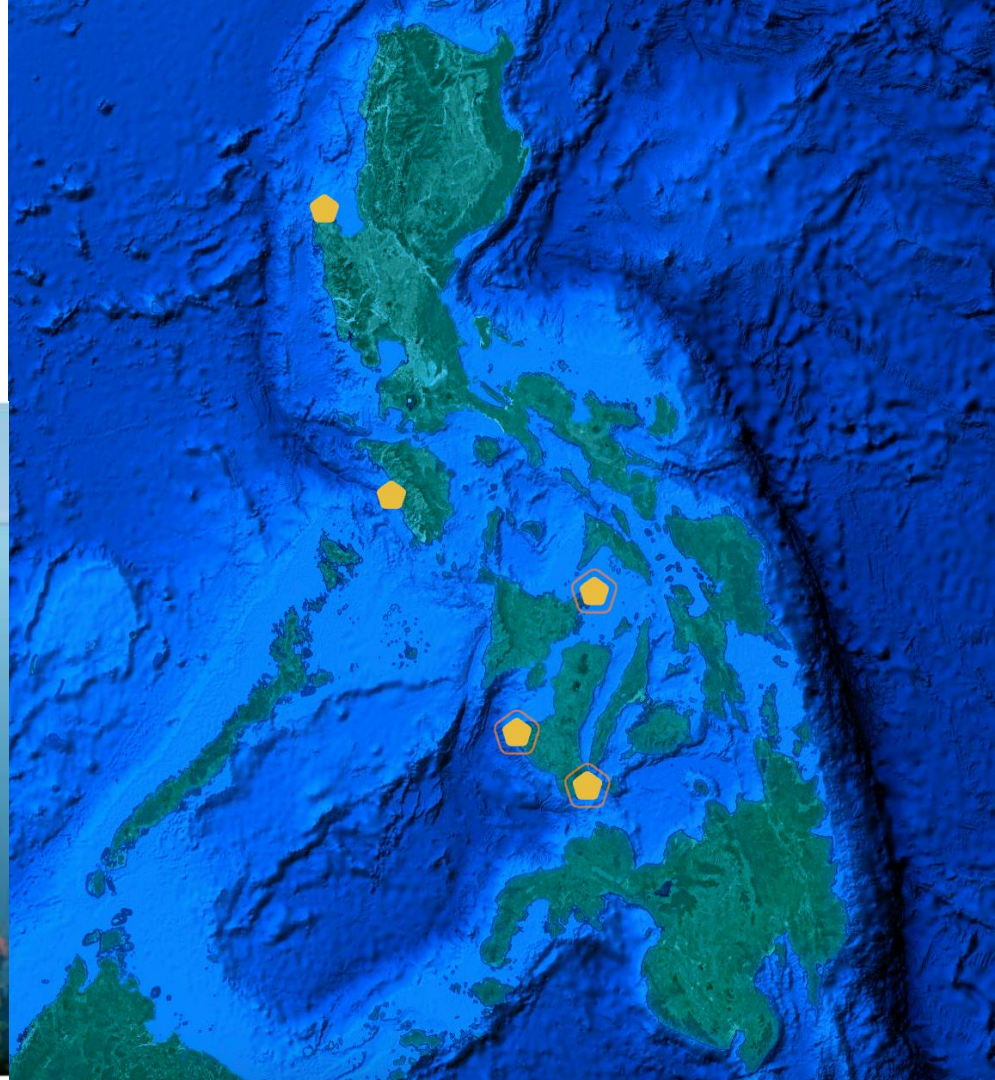
Figure 7. XBT-derived temperature profiles (MK21 EDF) from the Sulu Sea, Celebes Sea, and Philippine Sea. The full-depth profiles (left) and a zoomed view of the upper 200 m (right) highlight differences in upper-ocean thermal structure.

Spotter Buoy (8)

- delivers real-time wave, wind, temperature, and barometric pressure data







Key TakeawayS

1. MONITOR — Know what is coming
Integrate **PAGASA ENSO forecasts + rainfall + air temperature + SST + Marine Heatwave (MHW) + Degree Heating Weeks (DHW)** into one early-warning dashboard. Monitor not only *how hot*, but **how long and how extensive** the ocean warming becomes.

2. ANTICIPATE — Prepare for compound hazards
Plan for **heat + drought/water shortage + MHW**, but retain preparedness for **extreme rainfall, flooding and storm surge**. El Niño does not mean “no floods”; PAGASA notes that Habagat and tropical cyclones can still produce heavy rainfall in western Philippines.

3. PROTECT WATER — Treat water security as a priority
Conserve and diversify water supplies, protect watersheds and groundwater, reduce leakage, and prepare contingency supplies for prolonged dry periods. Iloilo City's own climate-risk assessment identifies drought and limited water access as important vulnerabilities.

4. PROTECT PEOPLE — Prepare for extreme heat
Strengthen **heat-health alerts**, cooling/shaded public spaces, drinking-water access, adjusted outdoor work/school activities, and targeted support for vulnerable populations. Urban heat can amplify rising temperatures in Iloilo's built-up areas.

5. PROTECT THE COAST — Reduce non-climate stressors before the MHW peaks
Reduce **pollution, nutrient loading, sedimentation, overfishing and habitat degradation**. Healthy mangroves, seagrasses, reefs and coastal waters have greater capacity to withstand and recover from thermal stress.

6. PREPARE FISHERIES & AQUACULTURE — Move from response to early action
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7. BUILD RESILIENCE — Use El Niño as a stress test for the city
Use observations and models to identify **hotspots of physical and ecological vulnerability**, then prioritize interventions where **urbanization + poor water quality + ecosystem degradation + climate extremes** overlap.

We cannot prevent El Niño or a marine heatwave, but we can prevent climate hazards from becoming disasters by anticipating them, reducing local stressors, and acting before thresholds are crossed."

Thank you!

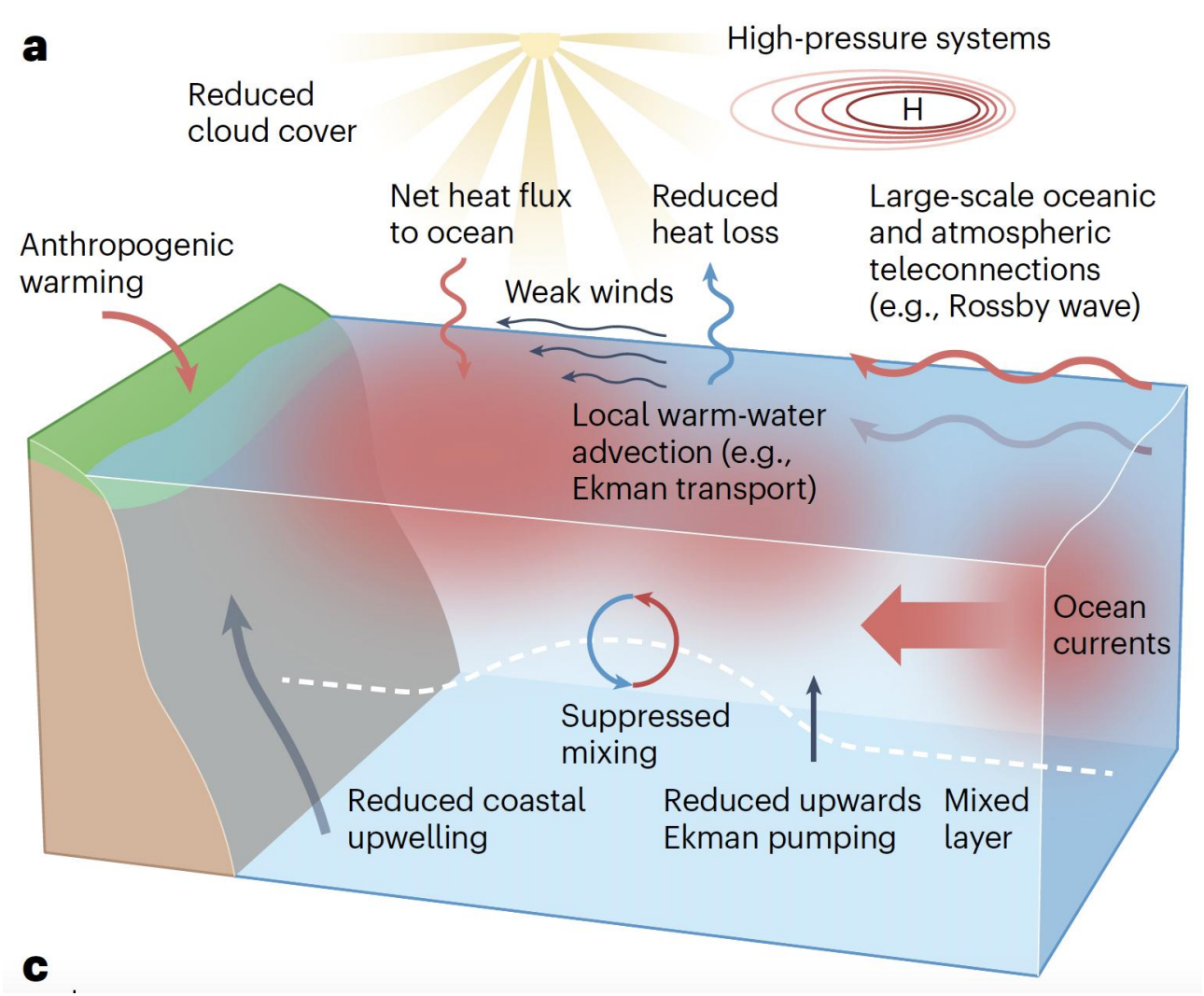
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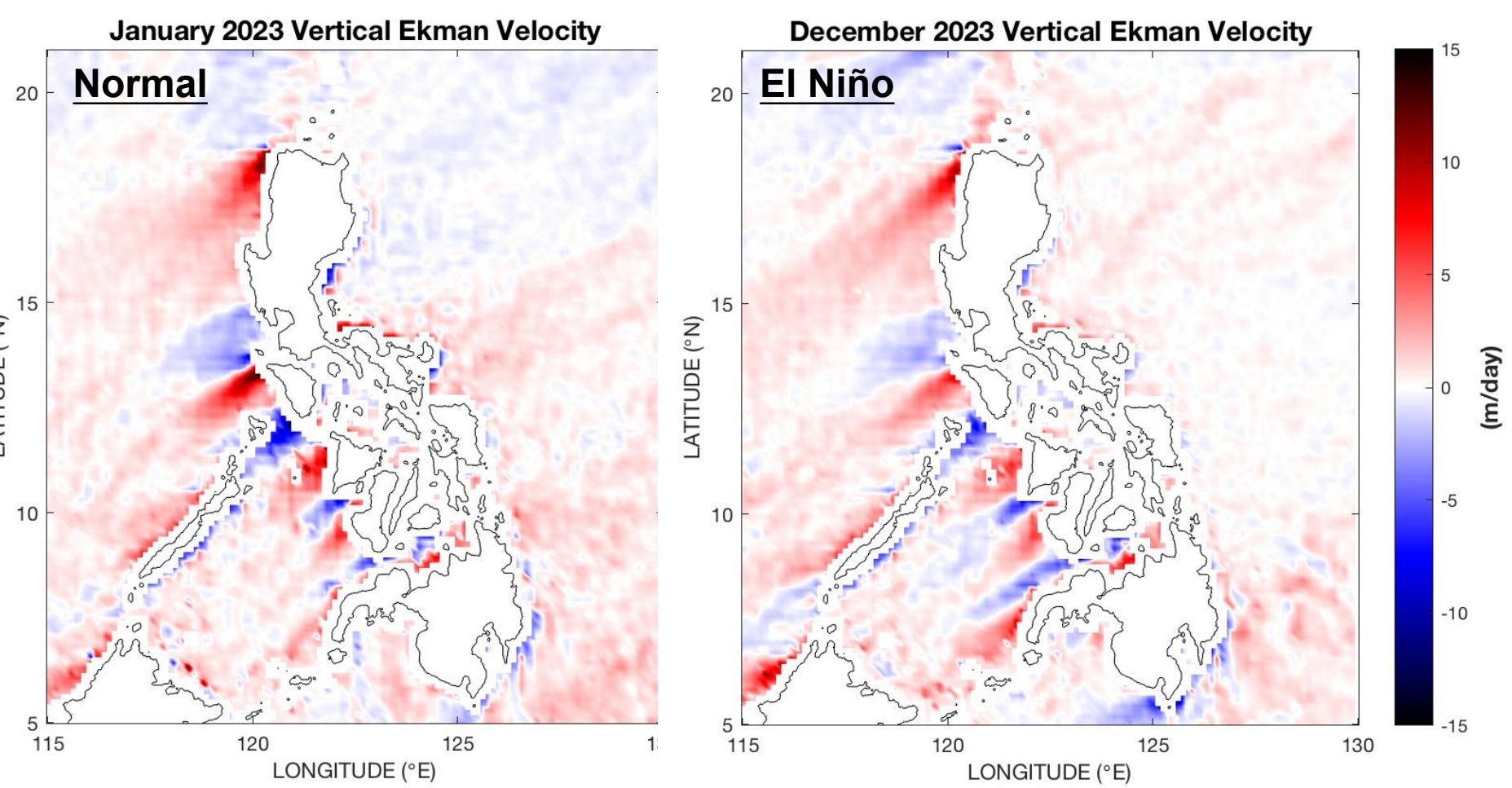
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@up.msi

Drivers of MHWs





Weakening of upwelling due to El Niño

Monthly productivity of the WPS during El Niño 2015-16

Arceo etal., 2024

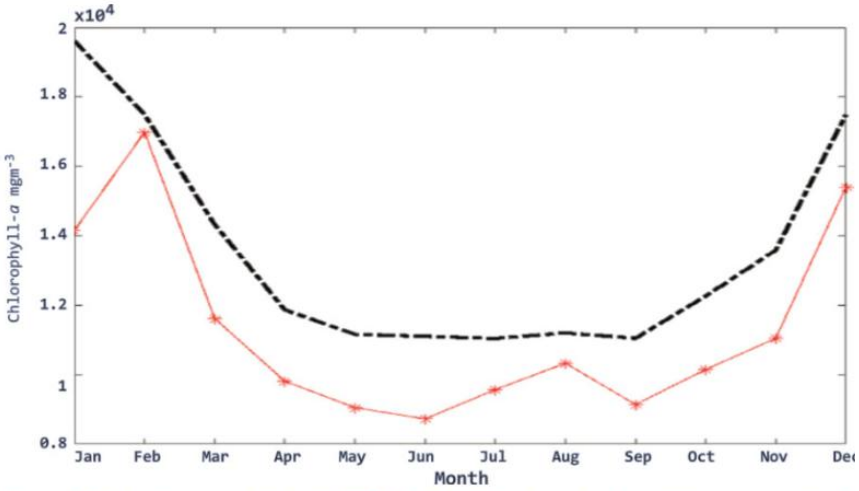


Figure 1.3-3. Monthly productivity in the WPS. Black dash line shows the climatological mean productivi while the red line represents the decreased productivity during the 2015 El Niño.

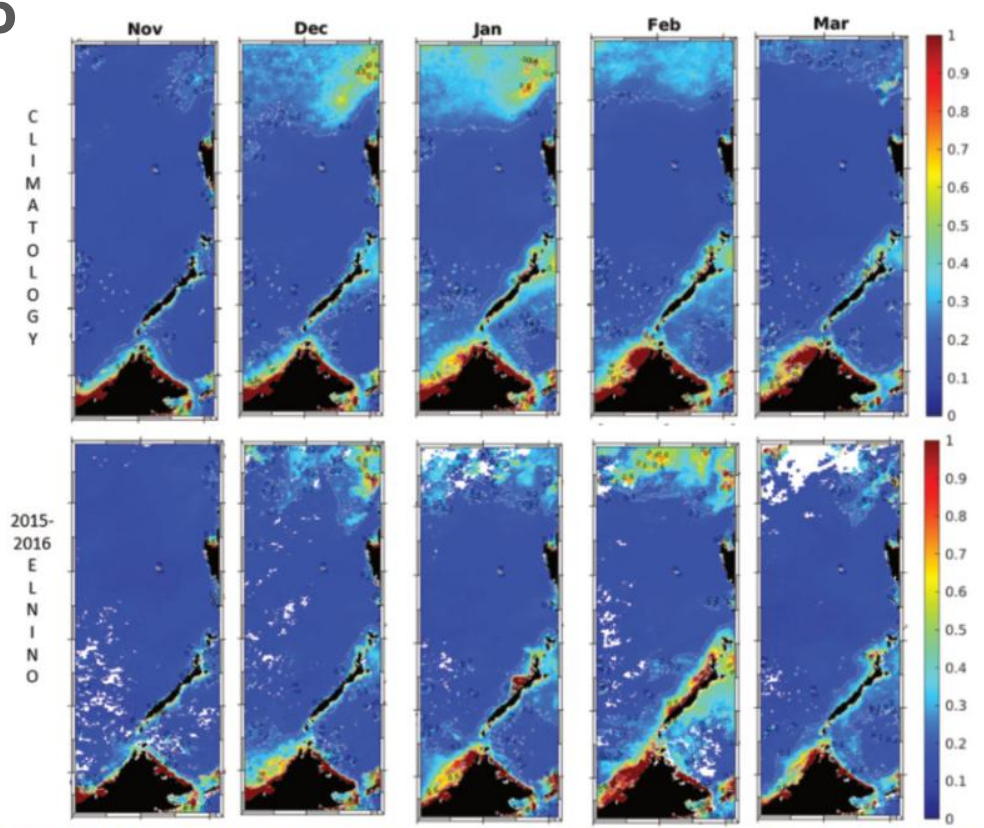
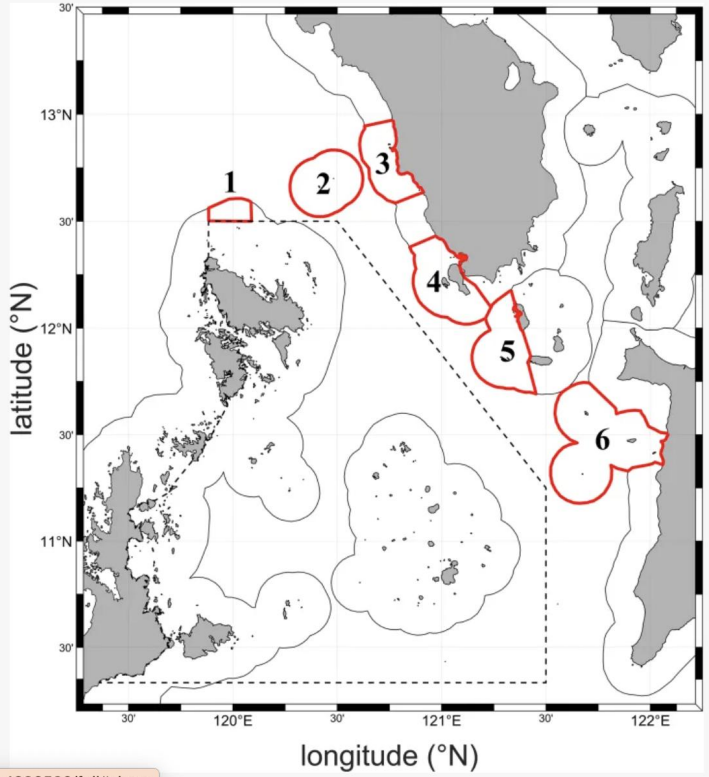


Figure 1.3-4. Chlorophyll-*a* climatology and corresponding productivity in the WPS during El Niño 2015-2016 (Nov-March)

Suggested Marine Protected Areas (MPAs) for round scads

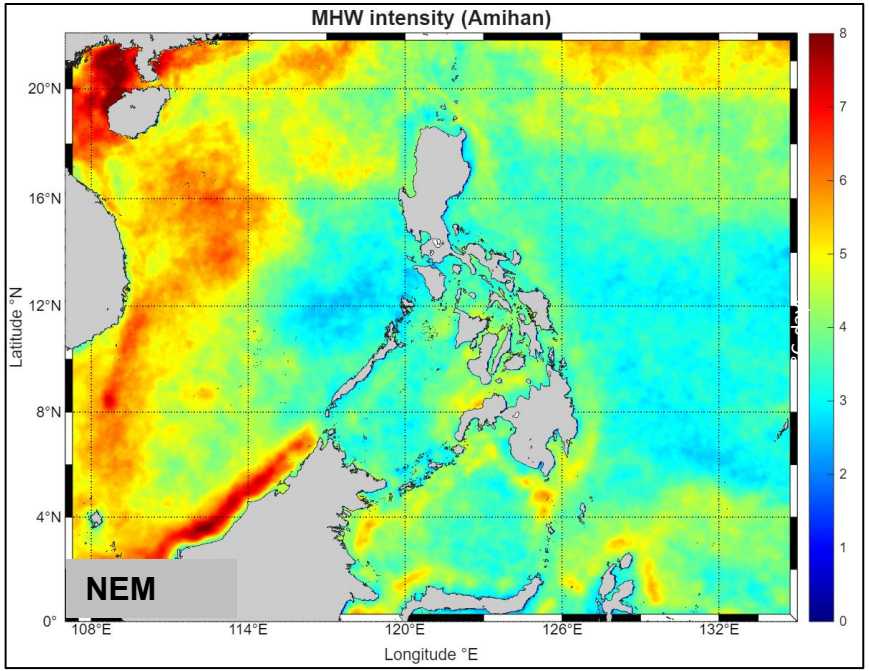


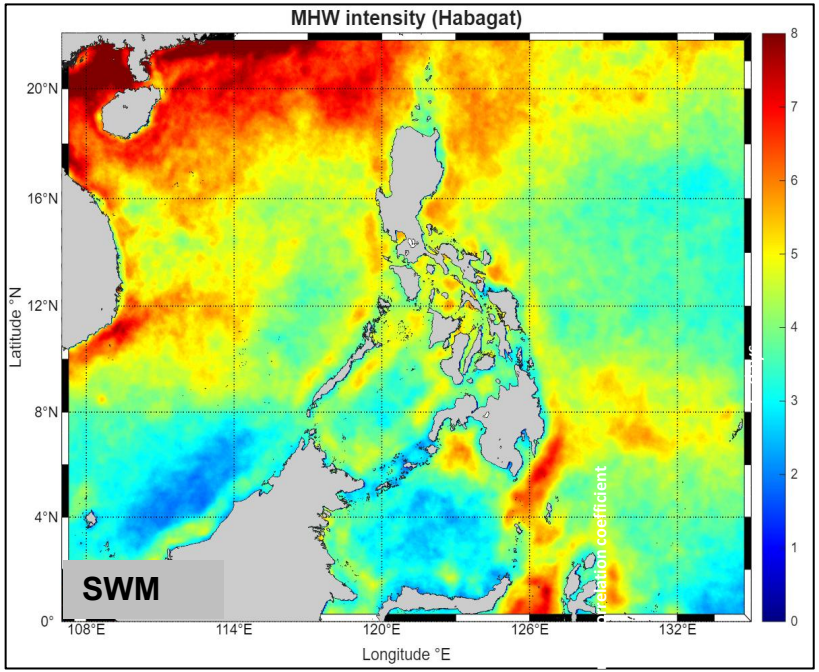
Sudaria ER and Amedo-Repollo CL (2026)

ENSO phase	Key findings	Potential MPAs
Overall patterns	Relatively high transport success and self-seeding rate in Palawan. Presence of Mindoro-Panay Strait dispersal corridor.	(1) North of Calauit island (2) Apo Reef Natural Park (3) Sablayan, Occidental Mindoro (4) Ilin island, Occidental Mindoro (5) Western Caluya (6) Maniguin, Batbatan, and Seco islands
La Niña	Maniguin, Batbatan, and Seco islands of Panay as dispersal sinks.	
Neutral	Relatively high transport success and self-seeding rate in Cuyo. Cuyo as particle source for Palawan.	
El Niño	Generally high transport success and selfseeding rate in Palawan but substantially decreased compared to La Nina˜ and neutral phases. Particle migration from Palawan to Mindoro and Appo. Increased transport success and particle settlement in Mindoro and Apo. Relatively high closed-season area particle losses.	

Seasonal THERMAL EXPOSURE characteristics

- MHWs occur for both seasons but with different spatial patterns





Department of Primary Industries
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Marine Heatwave Response Plan 2023/24

To guide the actions required at each stage of the marine heatwave cycle

November 2023

- .formal strategies used by governments and industries to predict, prepare for, and manage extreme ocean temperature events

Structure of the Plan

The plan will have four components that will provide for a robust and strategic approach to assessing the threat of and responding to marine heatwaves in the NSW Marine Estate.

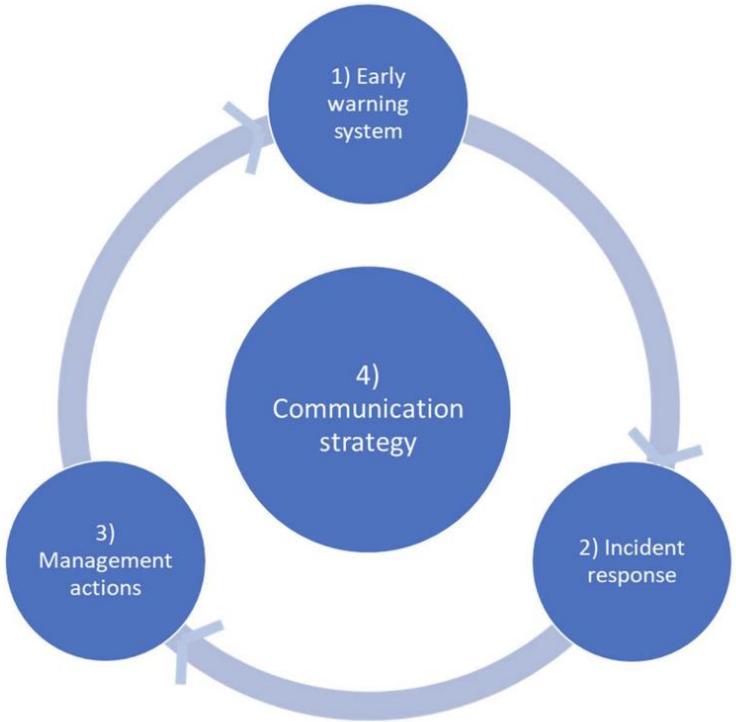


Figure 1: Four key components to the NSW Marine Heatwave Response Pan