Modeling for Management: Predicting Coral Heat-stress Patterns for Palau's Coral Reef Ecosystem

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Overview

- MPA design
- SST variability during a bleaching event
- Modeling thermal stress patterns
- Palau model
  - Description
  - Use
- Conclusion

Designing an MPA

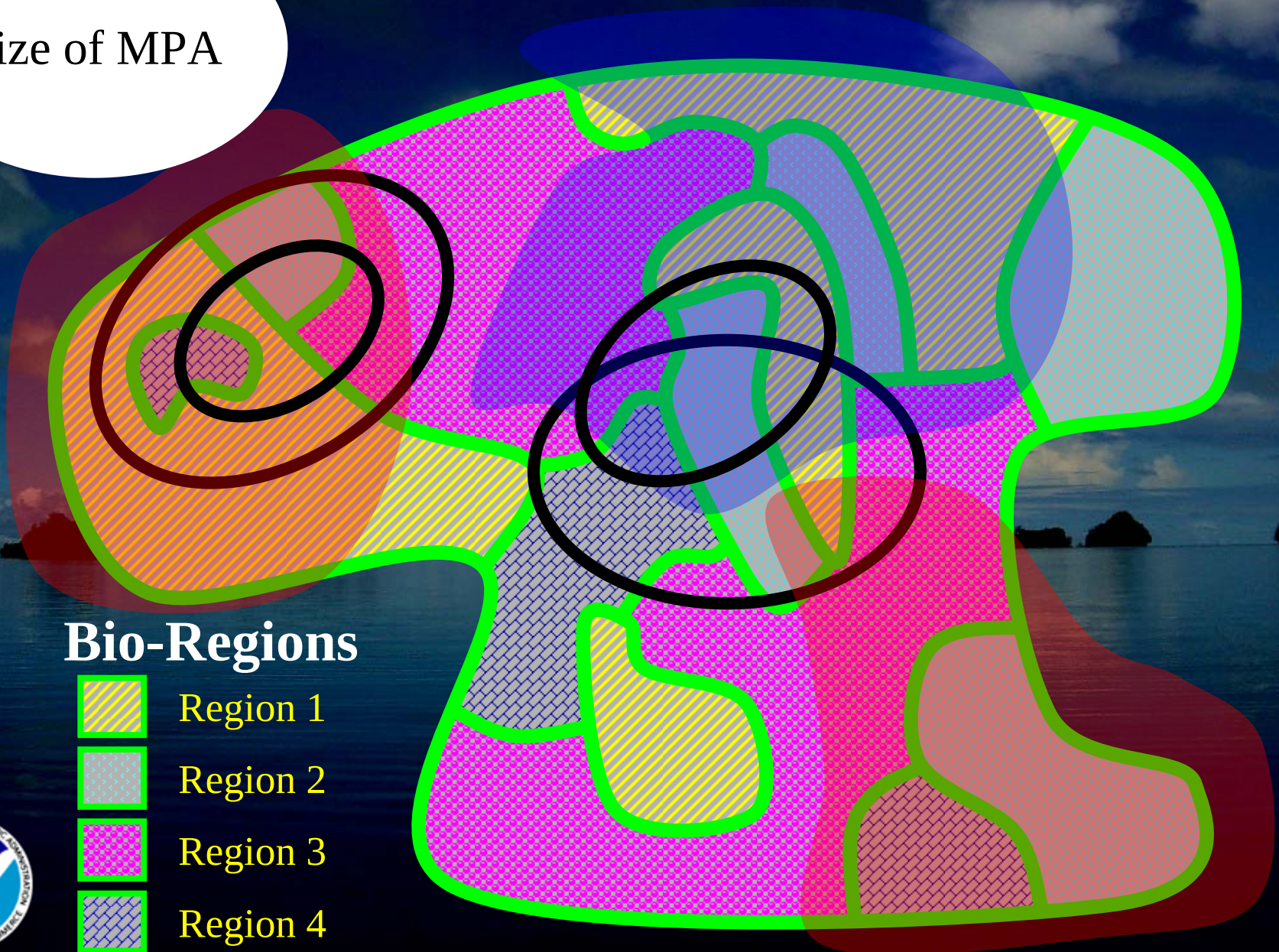
1) Determine Bioregions
2) Determine any rules for ranking
3) Divide into representative regions
4) Manual tweaking to account for socio-economic factors

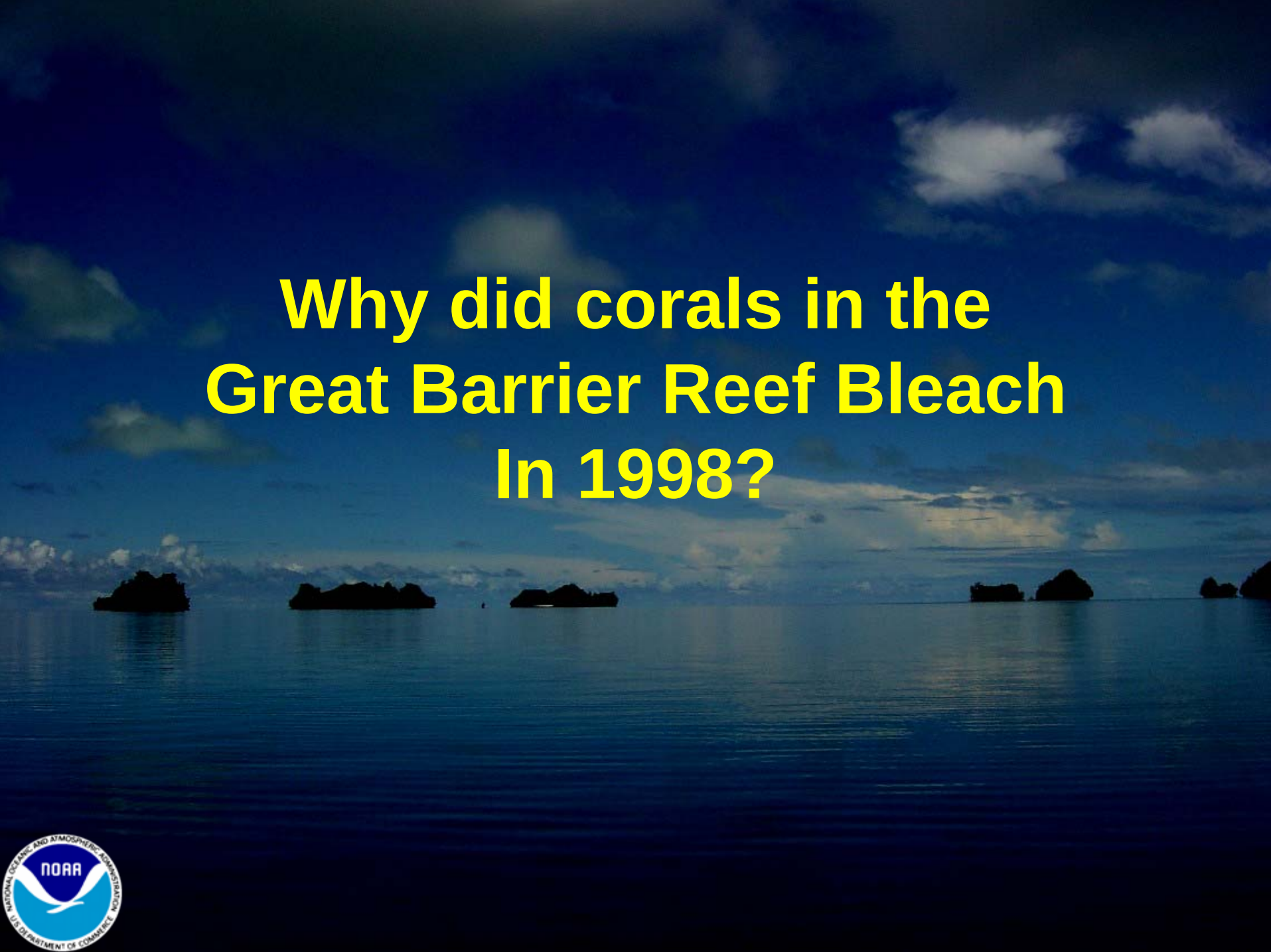
Minor consideration of the physical environment and bio-physical responses

- connectivity
- influences of light, temperature, water quality, etc
- potential effect of changing climate
- etc

Designing an MPA

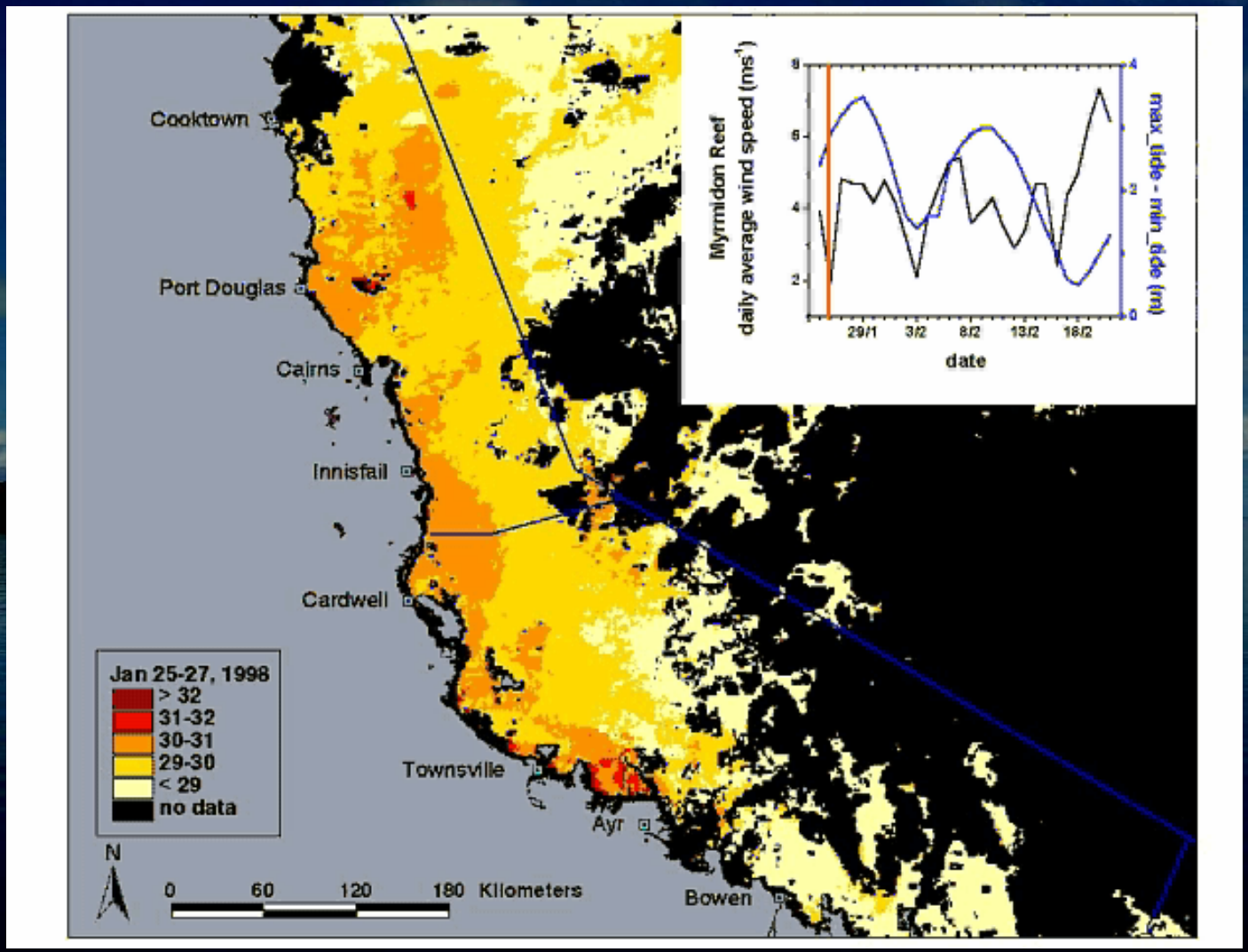
Size of MPA




Why did corals in the
Great Barrier Reef Bleach
In 1998?

Bleaching weather

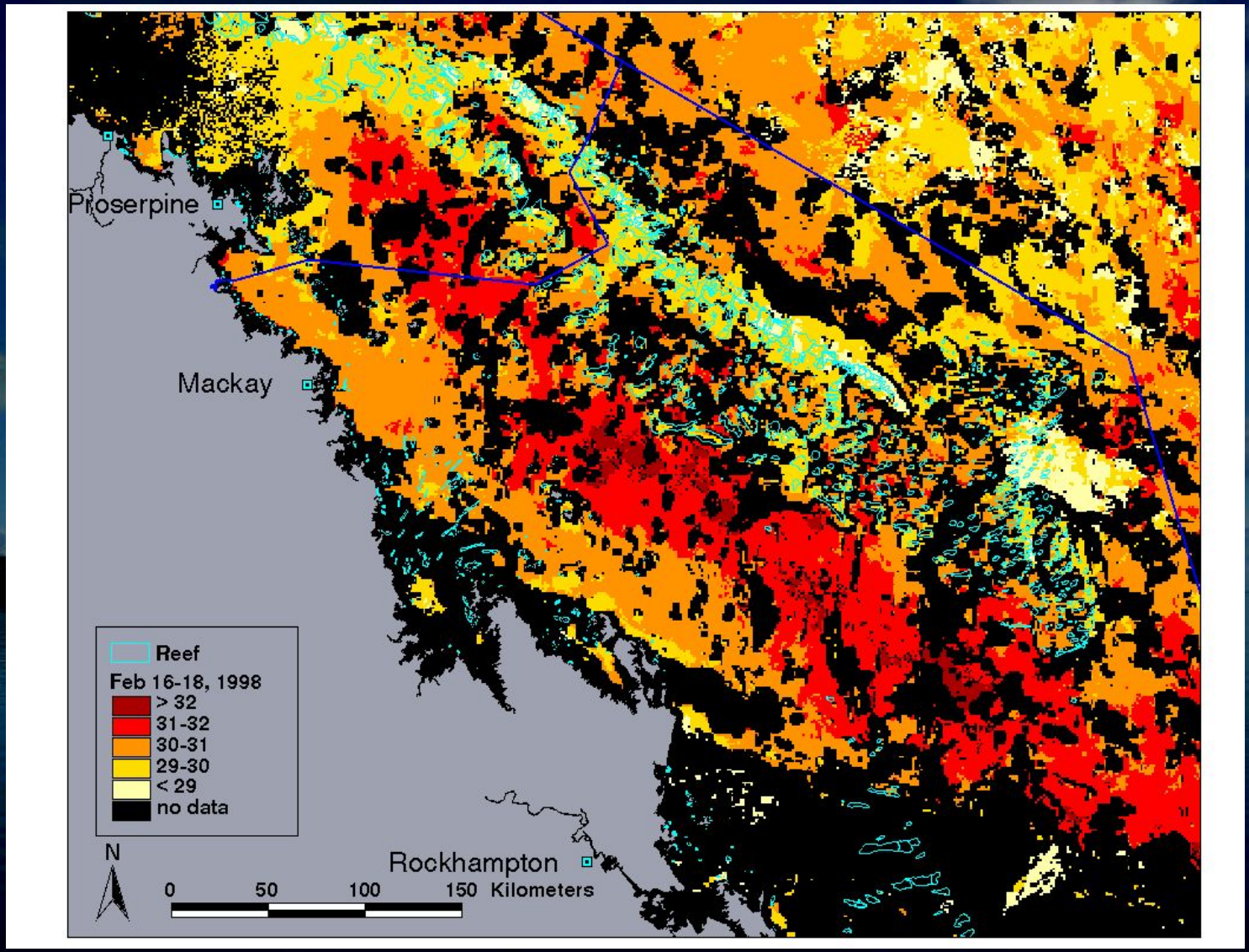
Animation of SST for 25th Jan to 21st Feb 1998



Bleaching Weather

1. Little to no wind
2. Clear sunny skies
3. Weak currents

Very patchy SST during a bleaching event



Southern GBR SST for 16th to 18th Feb 1998

MIXING

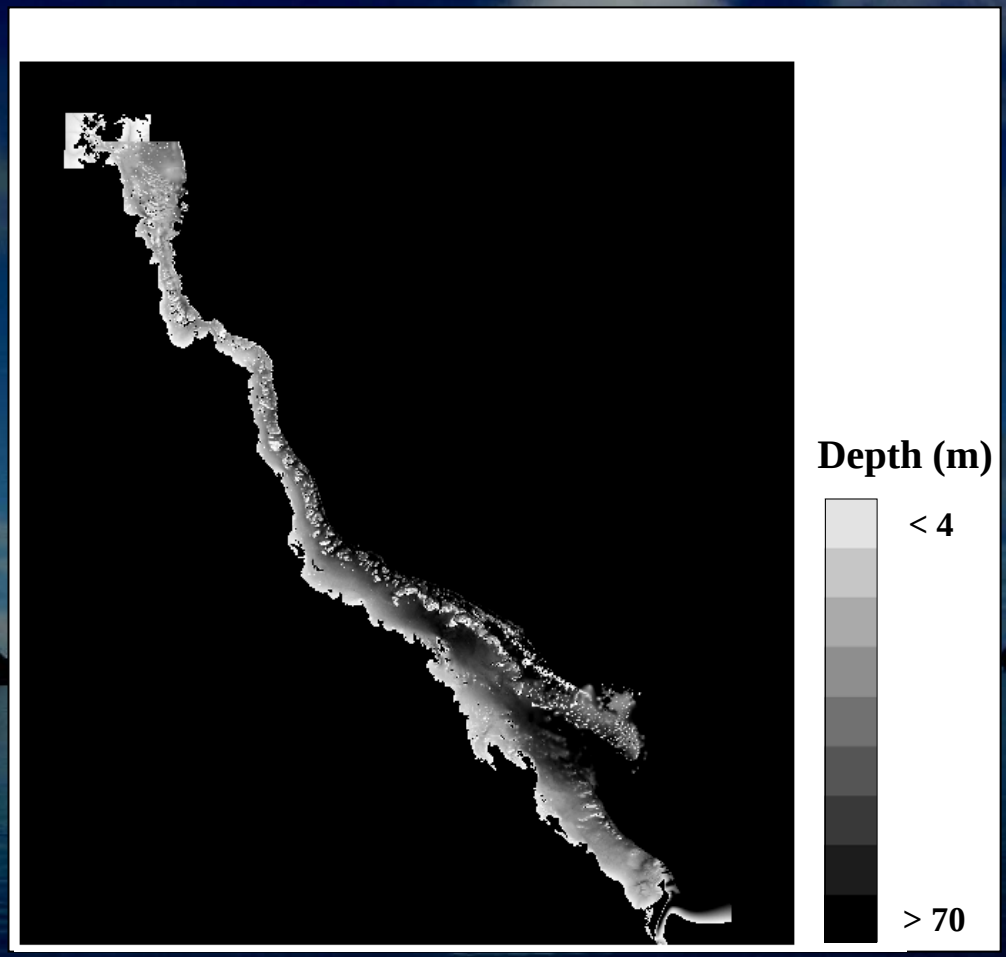
Mechanisms

- Wind
- Swell waves
- Low frequency currents
- Tidal currents

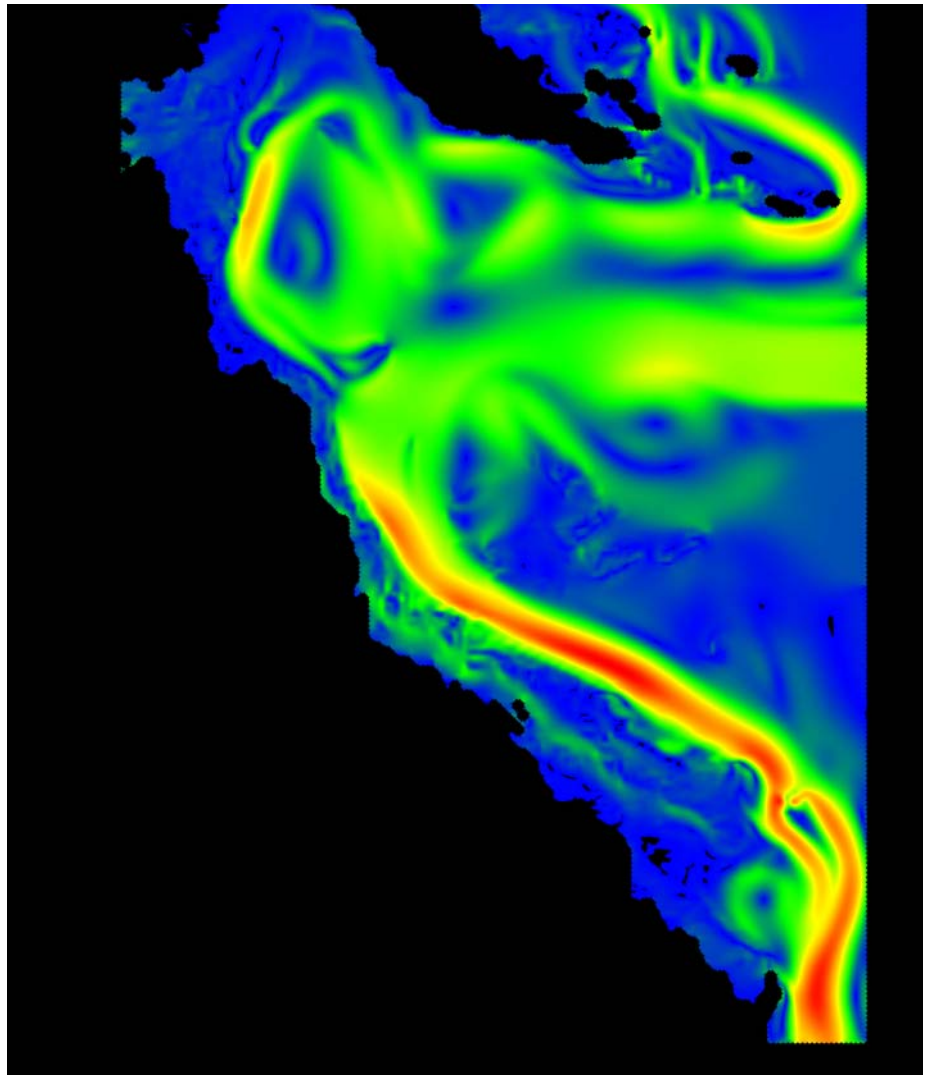
Model variables

- Bathymetry
- Currents
  - Low frequency
  - Tidal

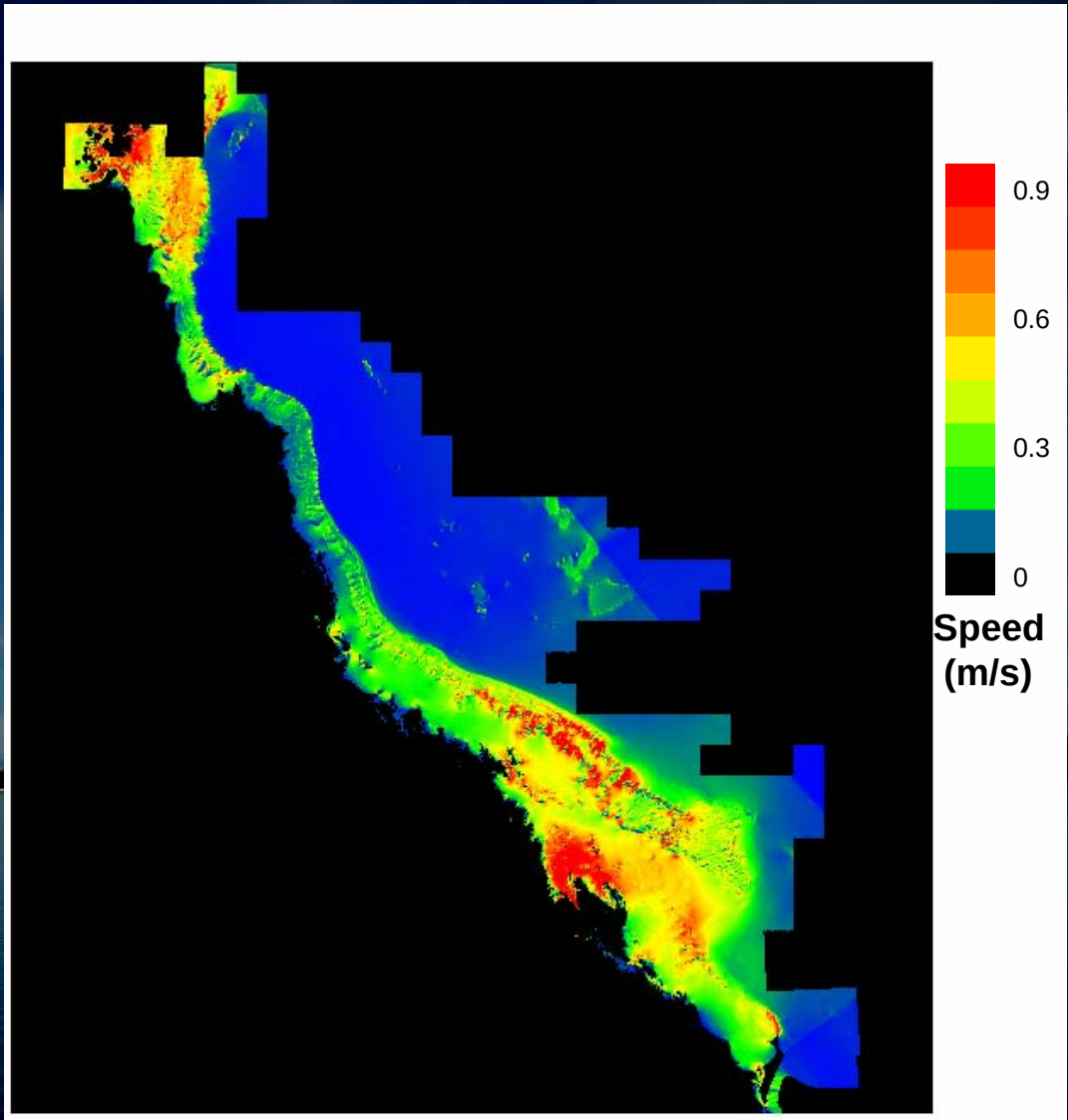
Bathymetry



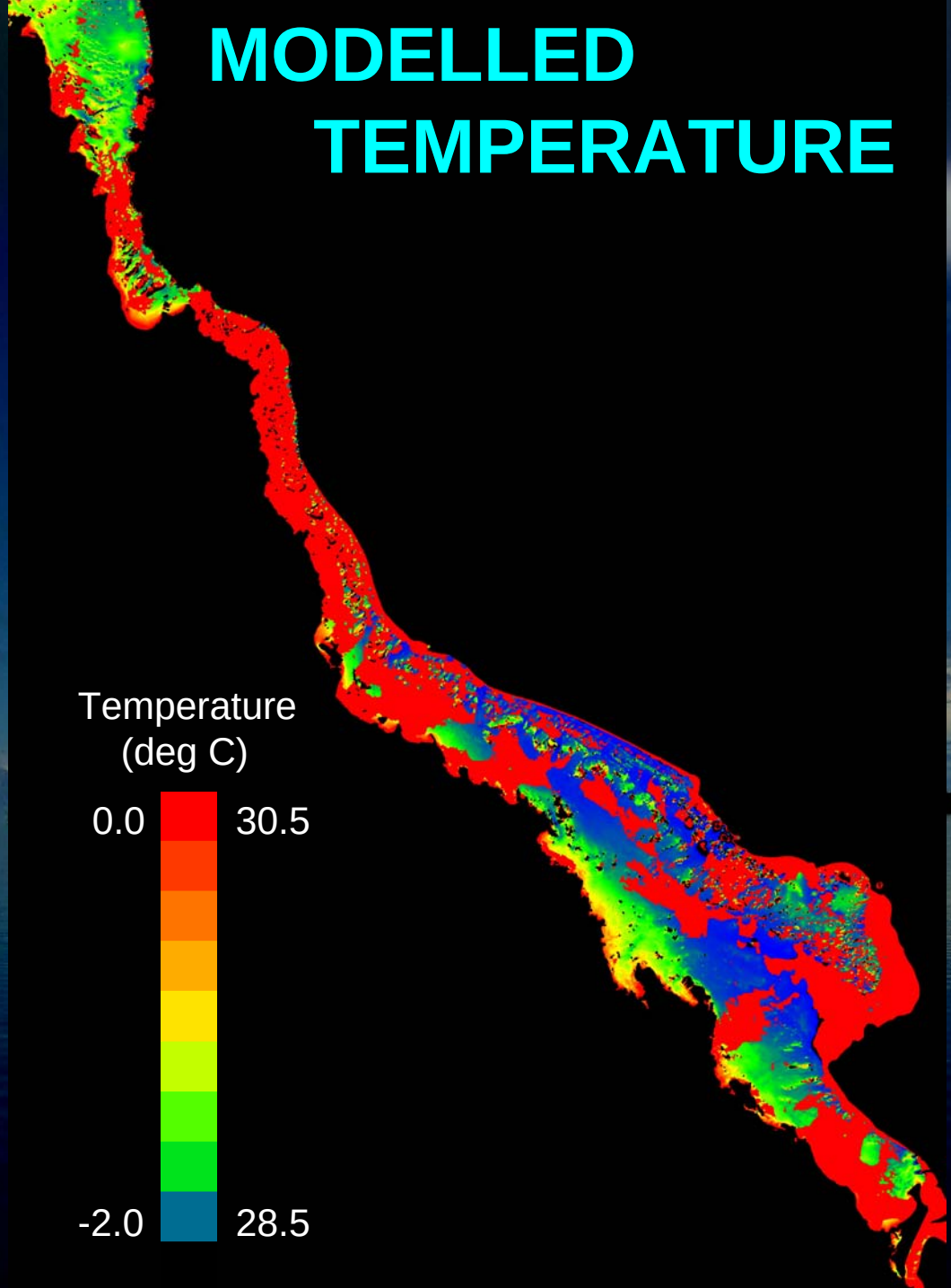
Low Frequency Currents



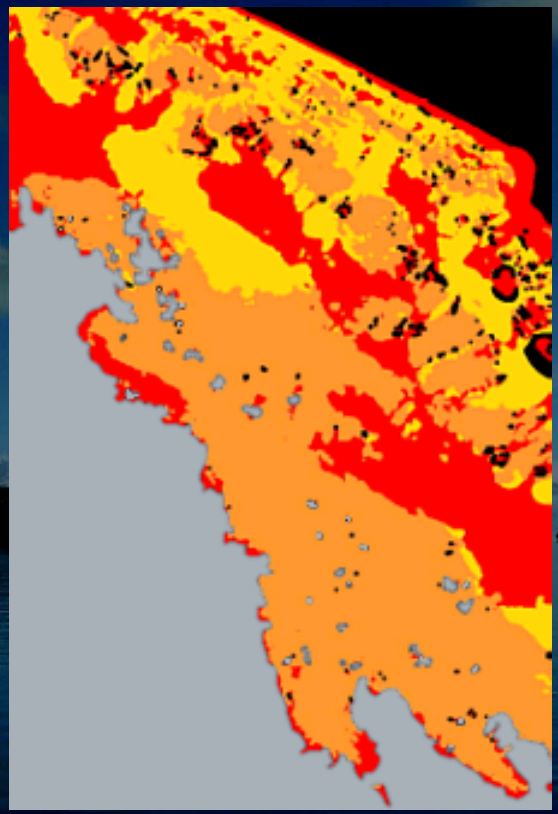
Tidal Currents



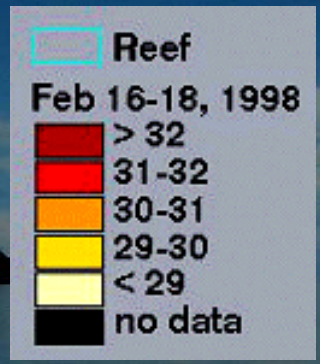
MODELLED TEMPERATURE

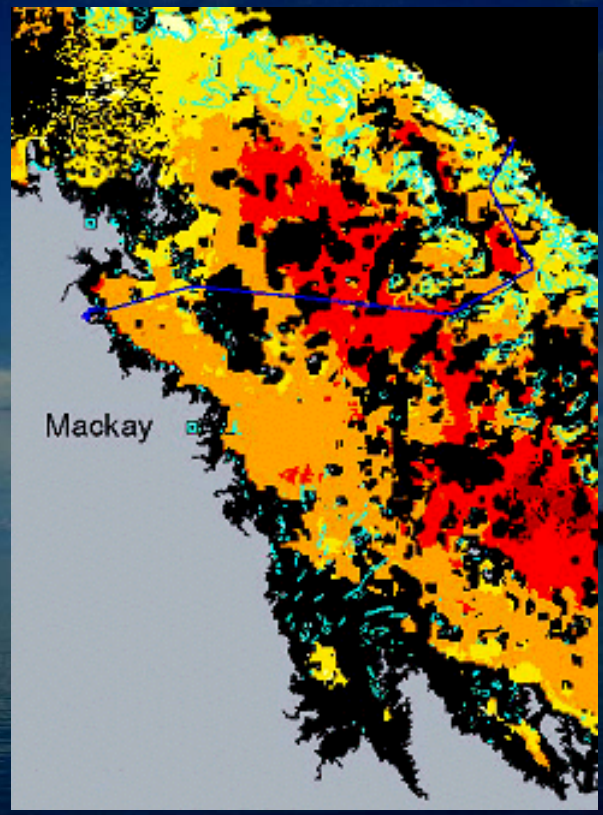


Is the Model Realistic?



Model





Satellite SST

The Palau Project

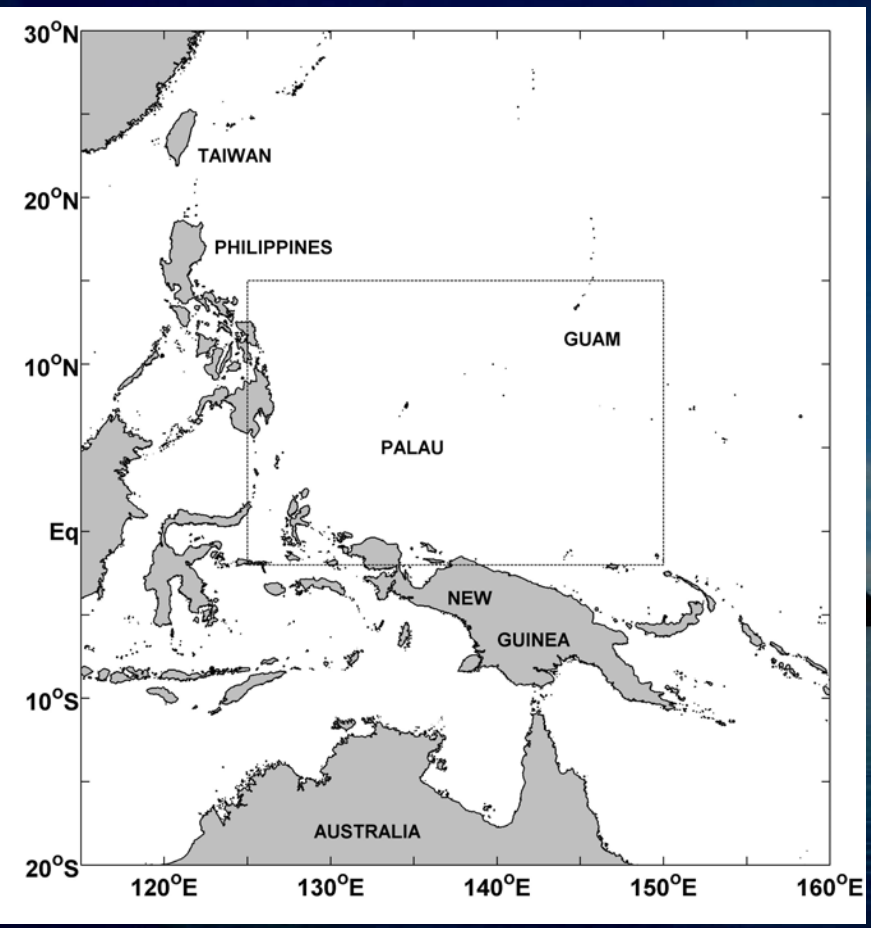
Building resilience against climate change for the Palau PAN

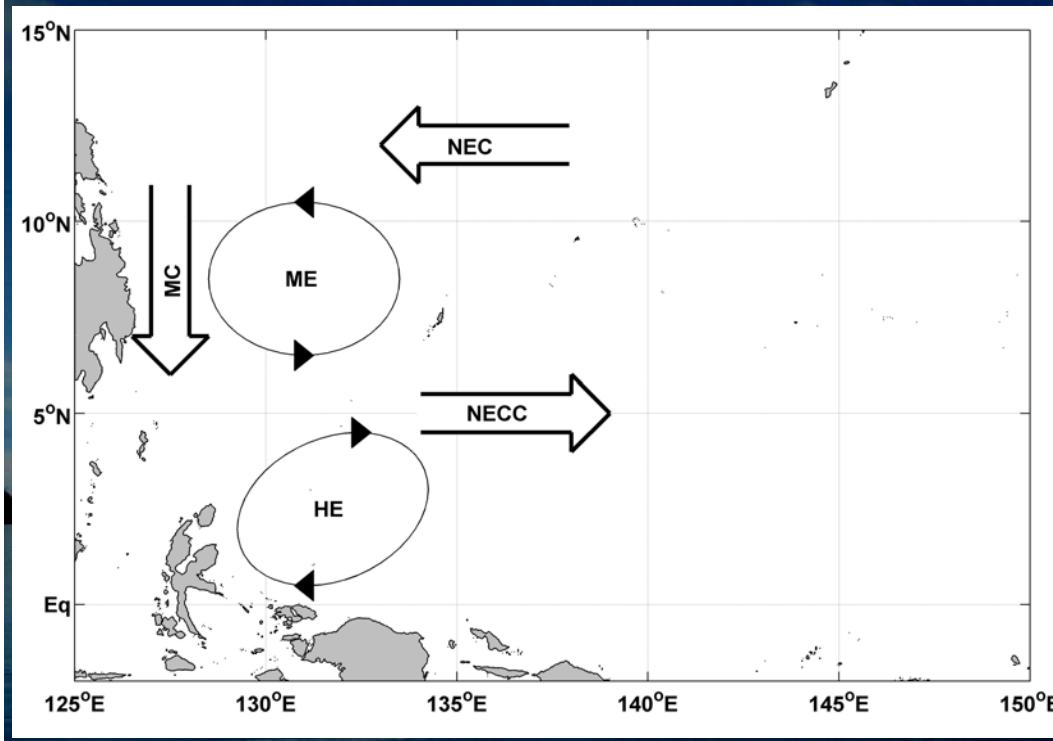
Project Requirements

- General circulation
- Bathymetry
  - Cal/Val data
  - Satellite derived bathymetry
- Hydrodynamic data
- 2D model of currents
  - Tidal forcing
  - Low frequency forcing
- Model of vertical temperature profile

Large-scale oceanography

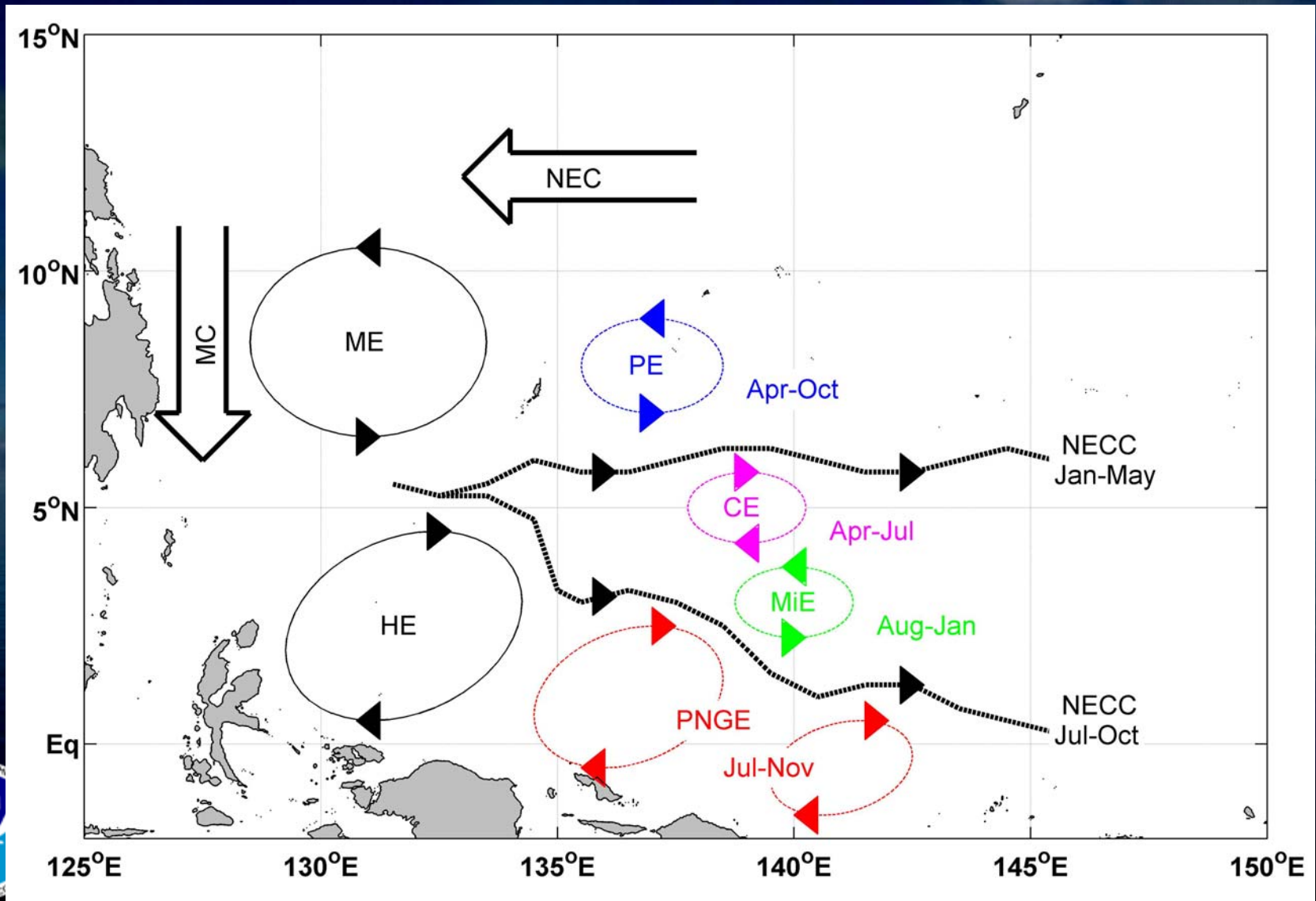
Previously known



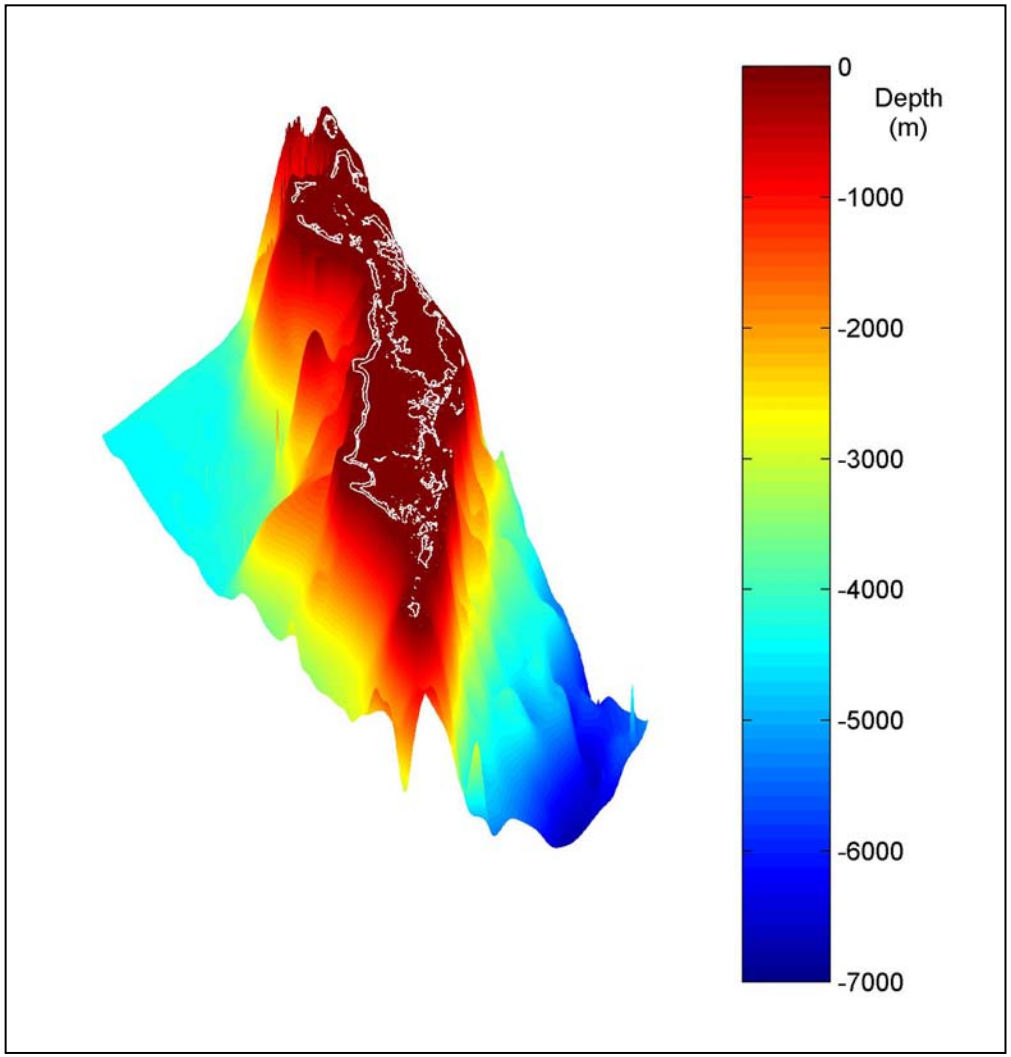


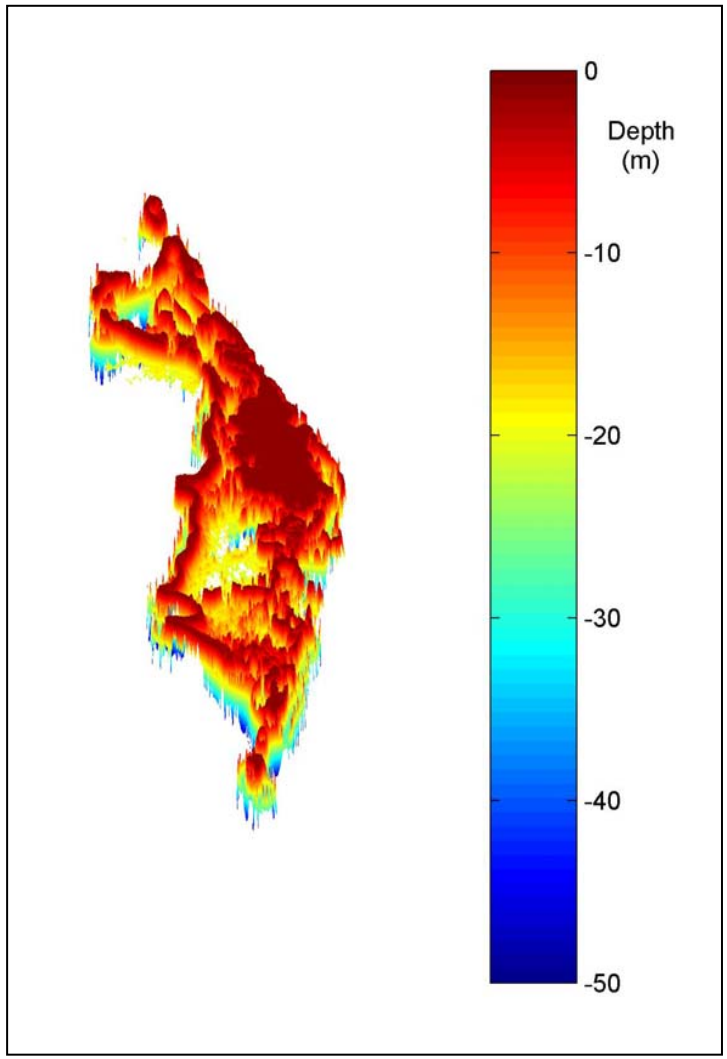
Large-scale oceanography

Contribution from this project

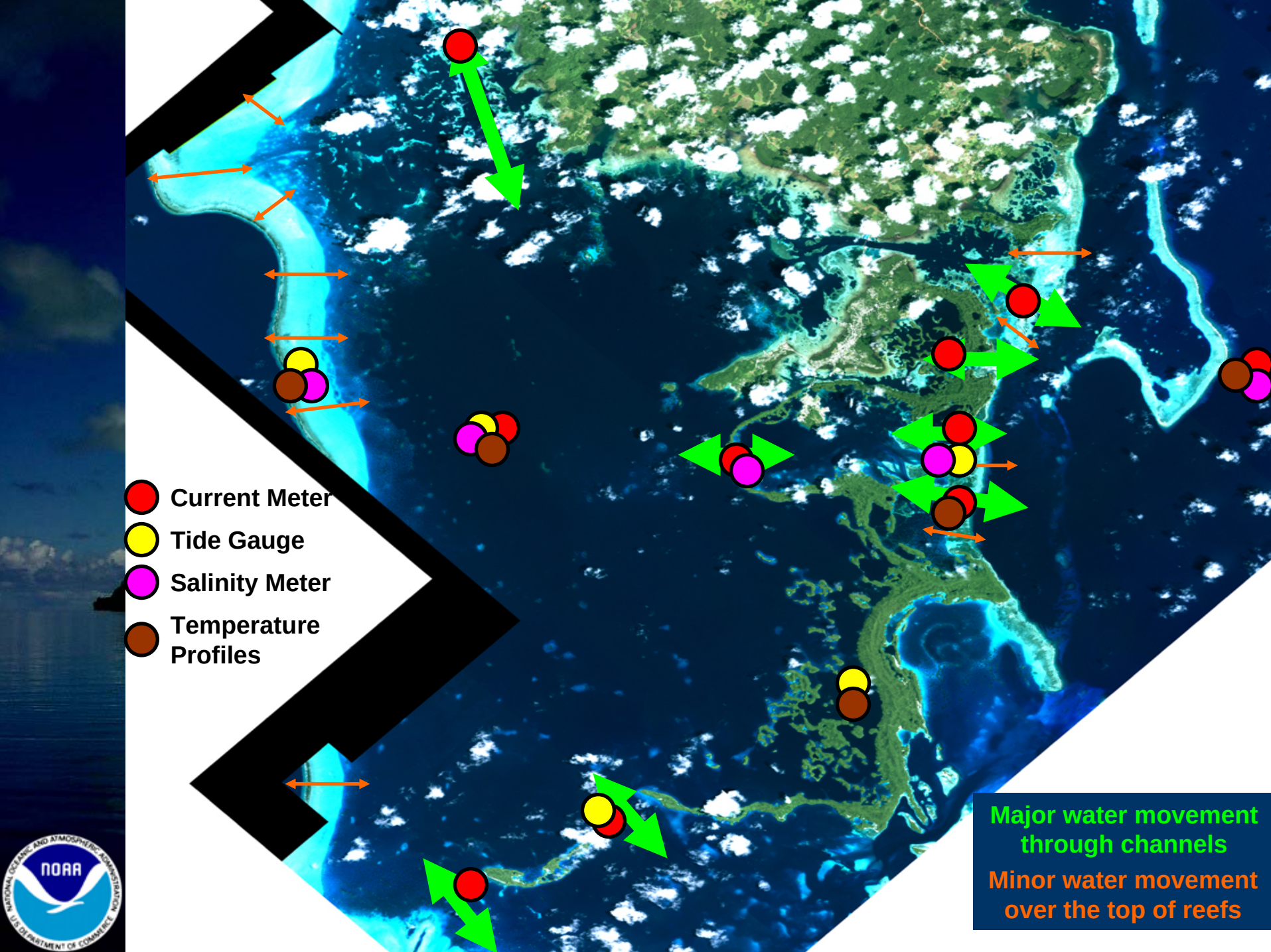


Bathymetry

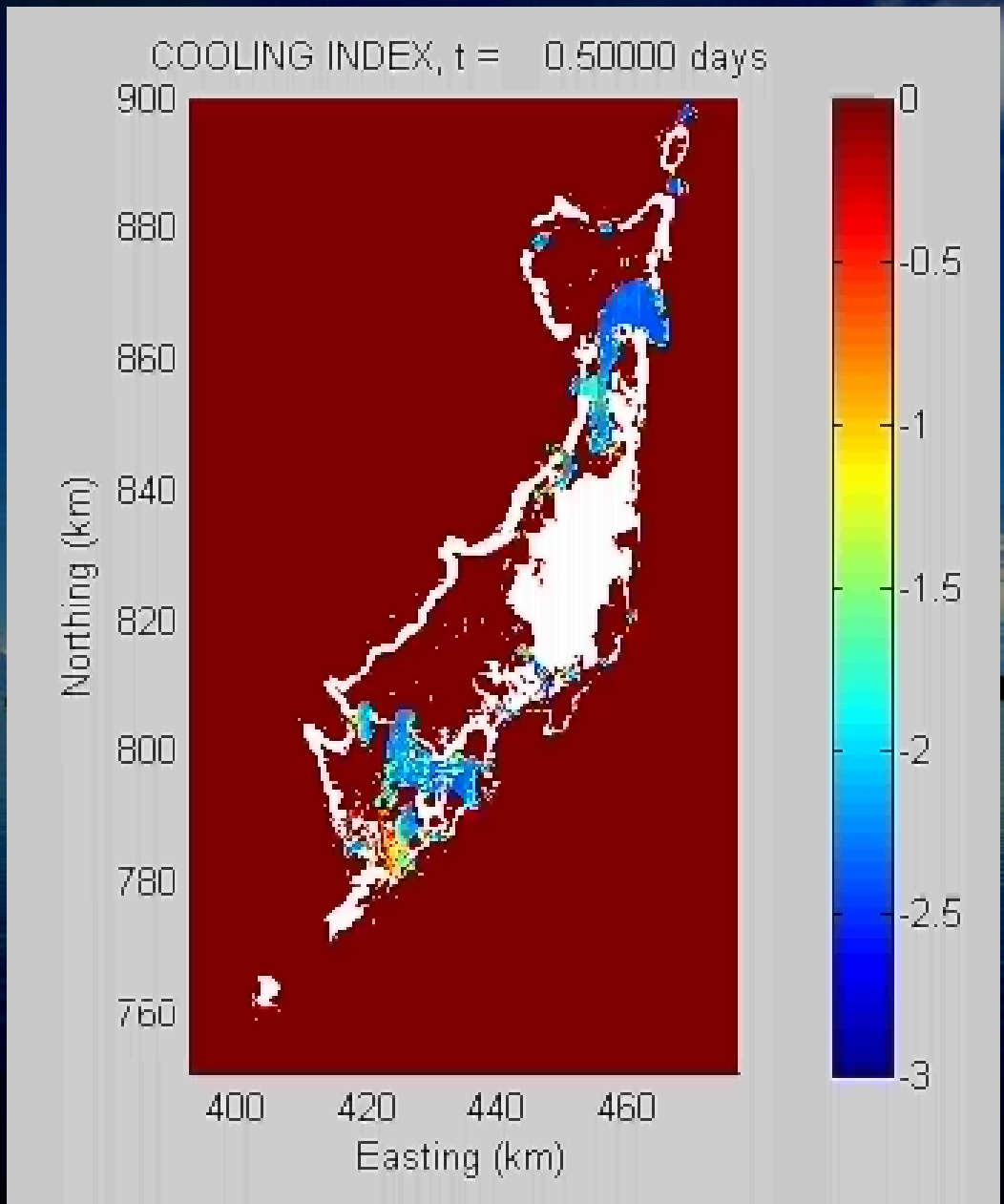

0
Depth
(m)
-1000
-2000
-3000
-4000
-5000
-6000
-7000


0
Depth
(m)
-10
-20
-30
-40
-50

Instrumentation


Current Meter
Tide Gauge
Salinity Meter
Temperature Profiles
Major water movement through channels
Minor water movement over the top of reefs

Thermal Capacitance Index



Accumulated Index

Thermal Capacitance

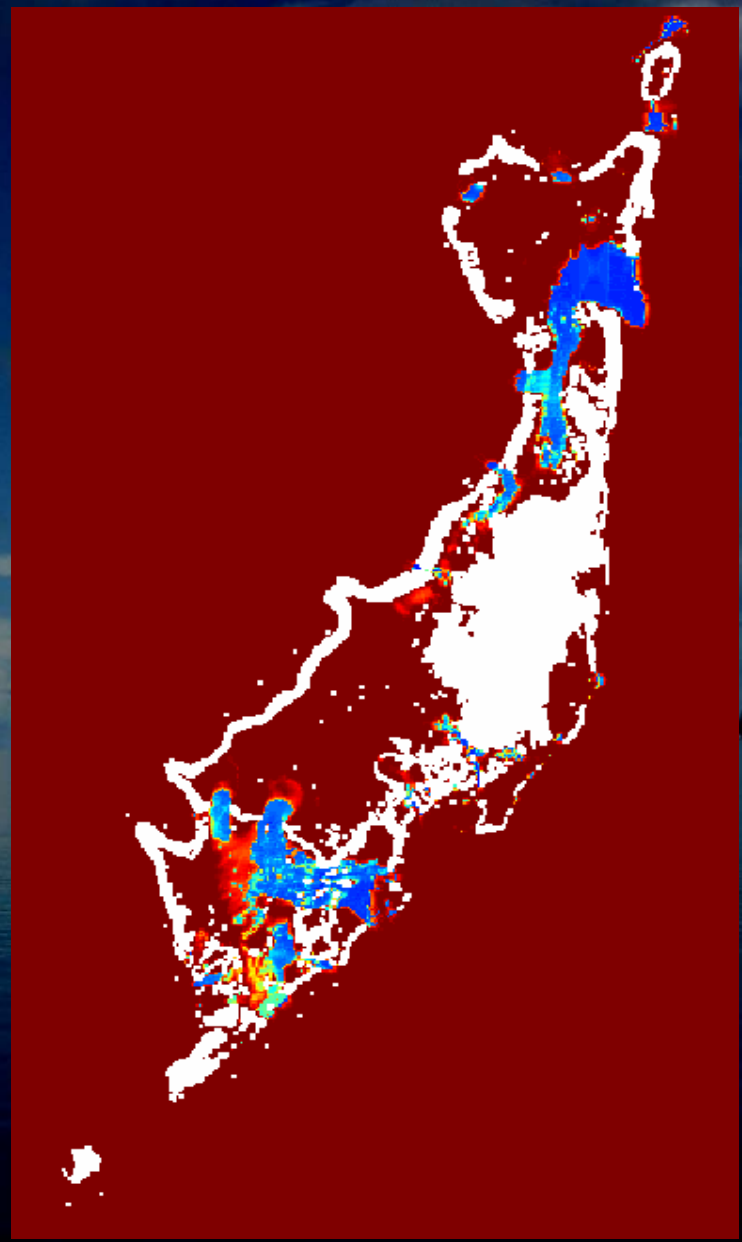
Low

High

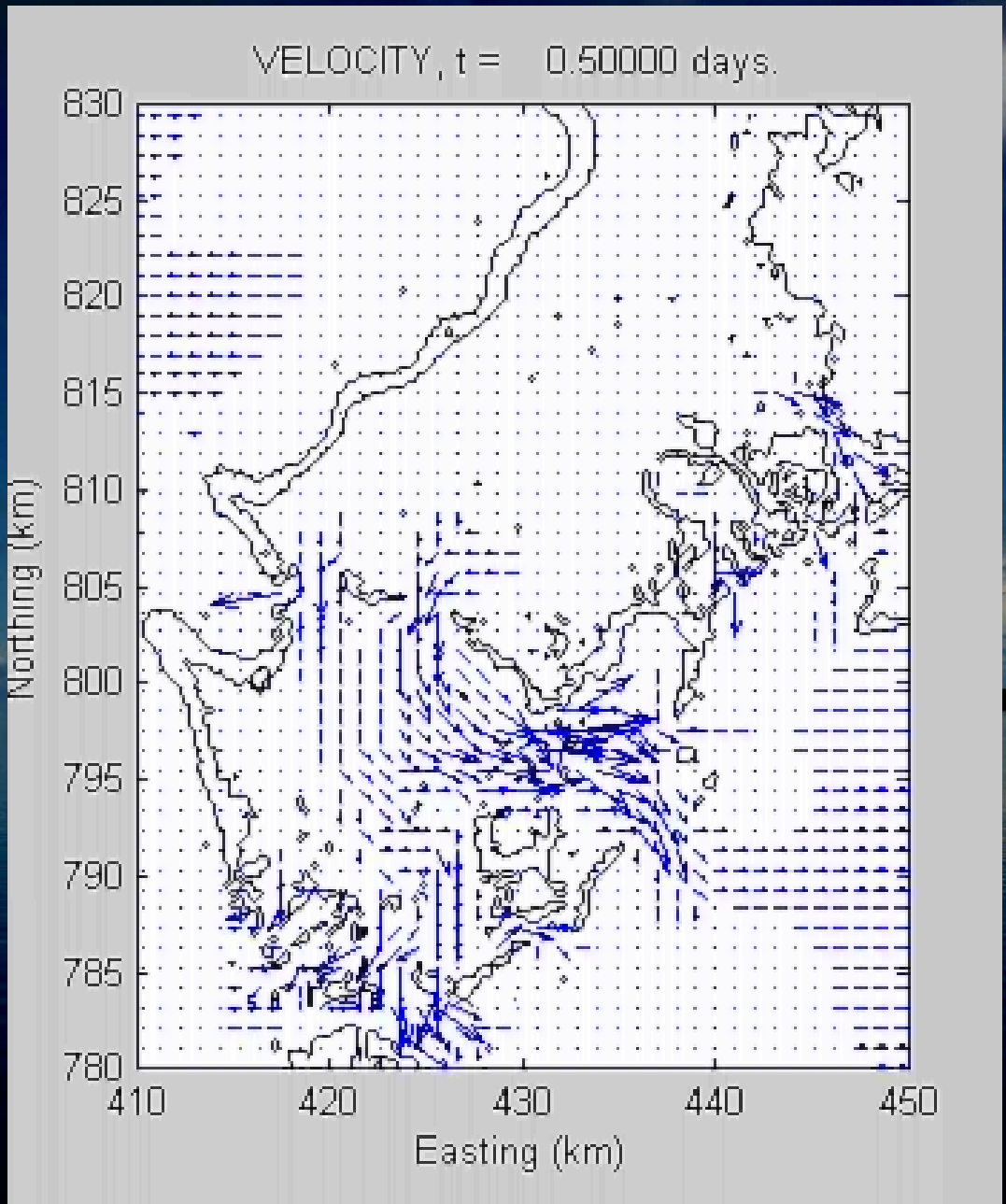
SST Variability

High

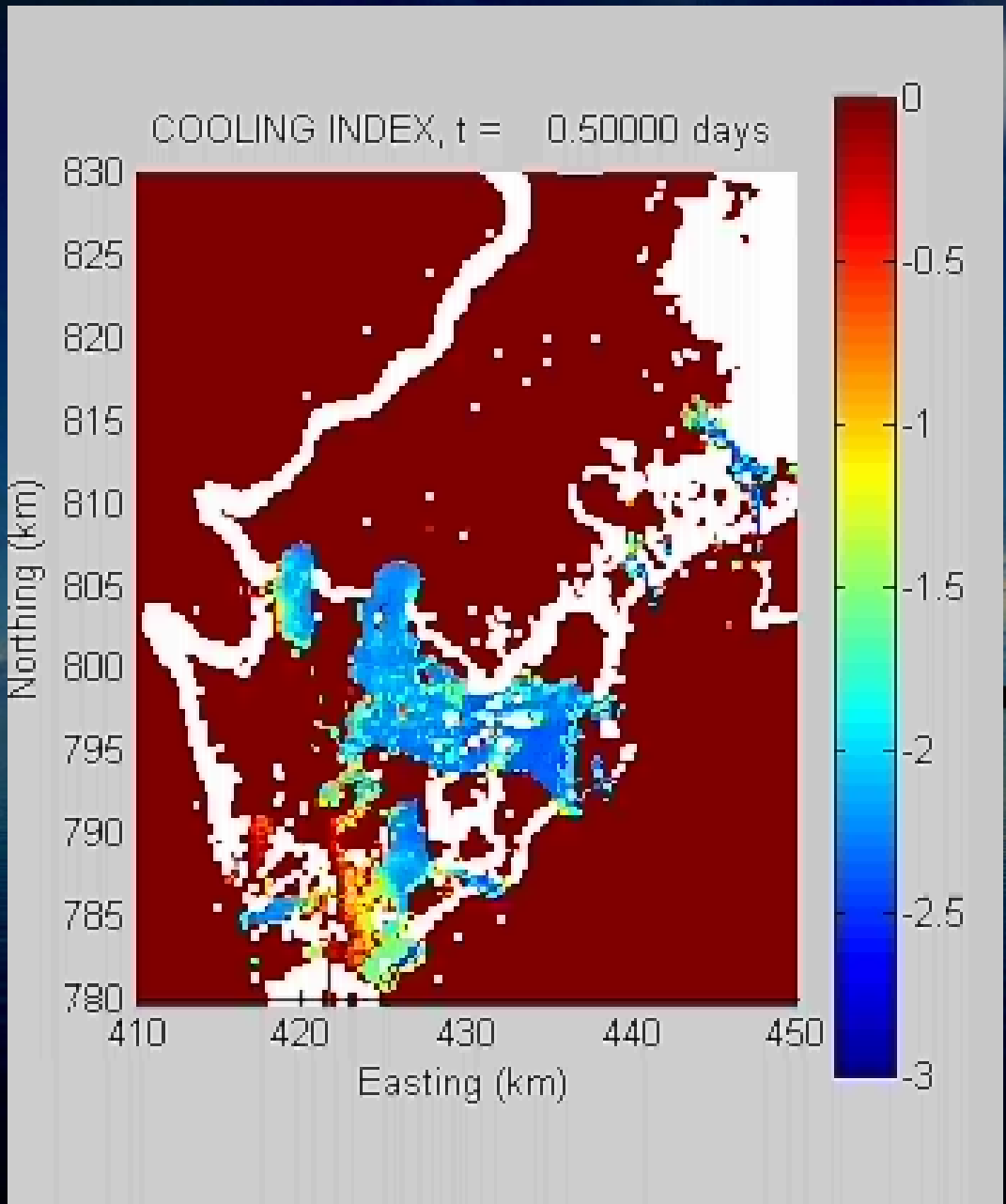
Low



Model Output

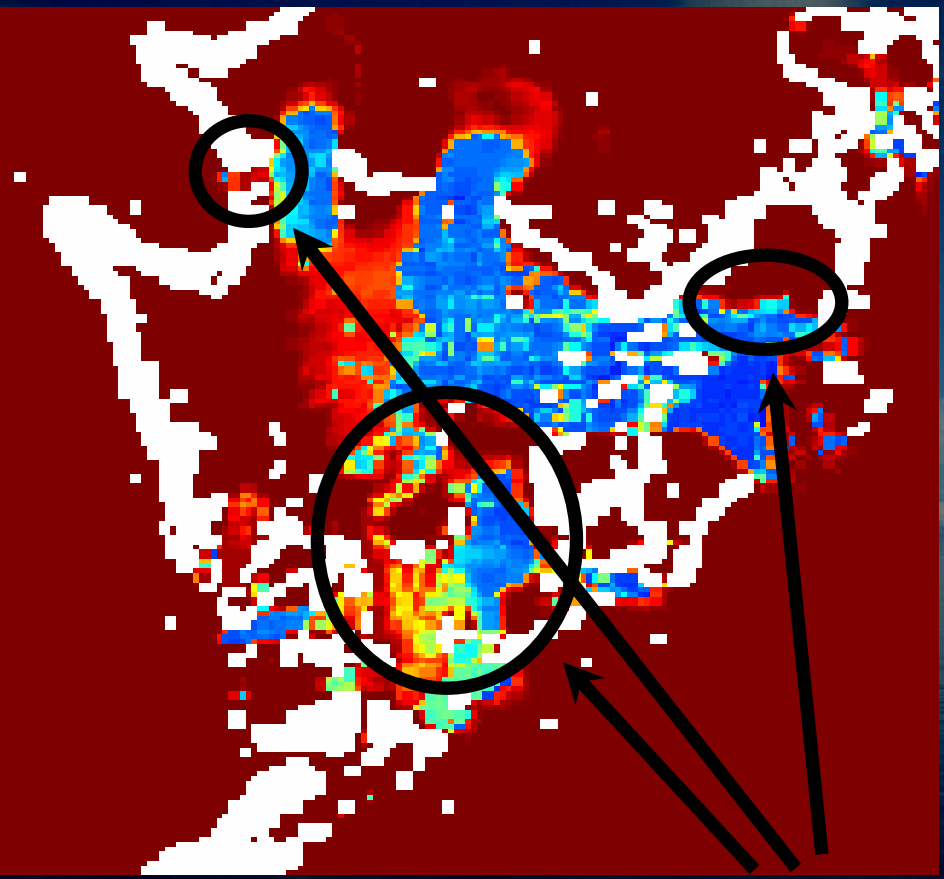


Thermal Capacitance Index

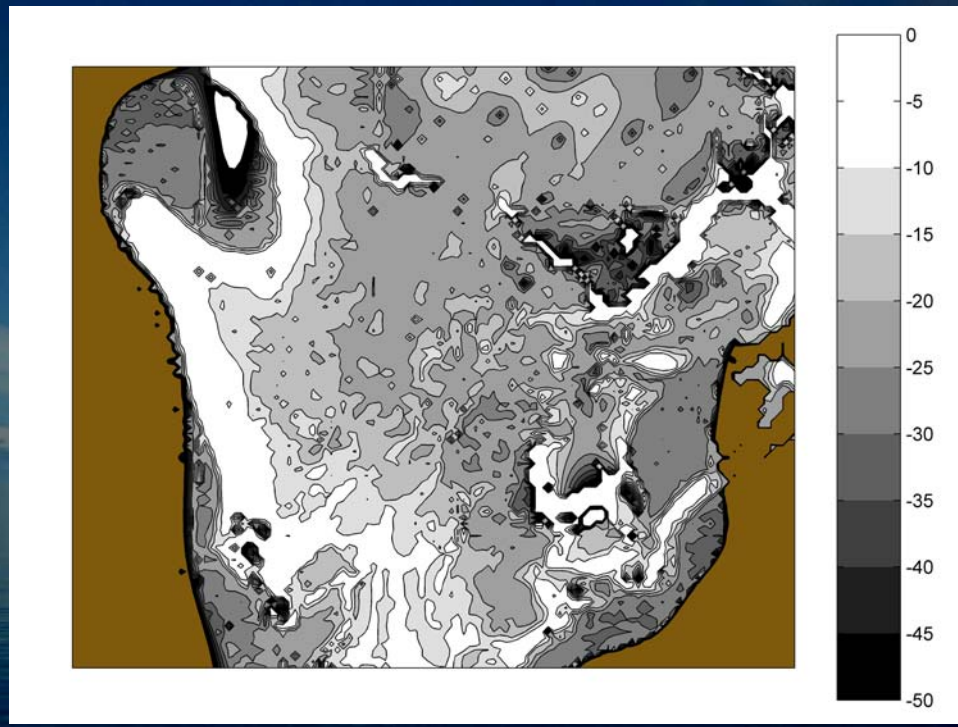


POTENTIAL SITE FOR MPA

Thermal Capacitance Index



Bathymetry



Potential area for MPA location

What did we gain from this project?

Capacity Building within Palau:

- Improved understanding of regional oceanography
- Improved bathymetry
- Hydro model
  - Connectivity (eg coral spawning, fish aggregation)
  - Water quality (eg turbidity, pollution)
  - Search and rescue
  - Coral recovery
- World Bank GEF Targeted Research Project

Project Successes

Special benefits from Palau Location:

- Helped a Freely Associated State develop the most advanced PAN in the world

- Produced beneficial techniques and scientific outcomes that were not planned

  i.e. Can now use NOS IKONOS Reef Maps of apparent depth and with a relatively small field data collection effort, can model any US Domestic reef in this manner!

CONCLUSIONS

- **Thermal stress patterns for the next bleaching event can be predicted**
- **Climatologies of water temperature can be modeled in the absence of previous data**
- **Resilience to climate change CAN be included within MPA designs**