Coral Reef Sensitivity to Physical Oceanographic Conditions: A Case Study in Mo'orea, French Polynesia

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Introduction & Background

Understanding the effects of climate change on oceanic ecosystems often requires an interdisciplinary approach. Here we downscale from a basin-wide study to local observations and ROMS modeling near the island of Mo'orea in French Polynesia to assess the effects of ocean variability on a coral reef ecosystem in Mo'orea. These islands are located between 17-18° S in the path of the South Equatorial Current, and should generally experience westward flow.

Ecological disturbance can be defined as "**any relatively discrete event in time that disrupts ecosystem, community, or population structure and changes resources, substrate availability, or the physical environment**" (*Pickett and White*, 1985). The Mo'orea coral reef ecosystem is subject to frequent disturbance events from storms and outbreaks of carnivorous crown-of-thorn starfish that eat the coral. Since the most recent starfish outbreak, a large number of new coral recruits have been observed around the island. Their distribution is very structured, with most of the recruits on the north coast of the island. We are working towards understanding the role that regional oceanography plays in this distribution.

Here we assess the physical environment of this coral reef ecosystem and the seasonal and interannual variability that the region experiences. Since we can model anticipated changes in the physical environment much more realistically than ecological changes, we are working towards defining how the physical environment controls the ecosystem.

Why does oceanography matter for coral reef ecosystems?

Coral reef ecosystems are declining worldwide as a result of human activity. The major causes of stress are pollution and overfishing. These lead to phase shifts towards an ecosystem with few predators and large fish, and much more macroalgae than coral. In addition to these direct pressures, coral reefs are sensitive to changes in the physical environment that may result from global climate change. (*Hoegh-Guldberg* 2007)

Coral reef locations are strongly controlled by **temperature**, and reefs do not grow where mean SST drops below 17°C.

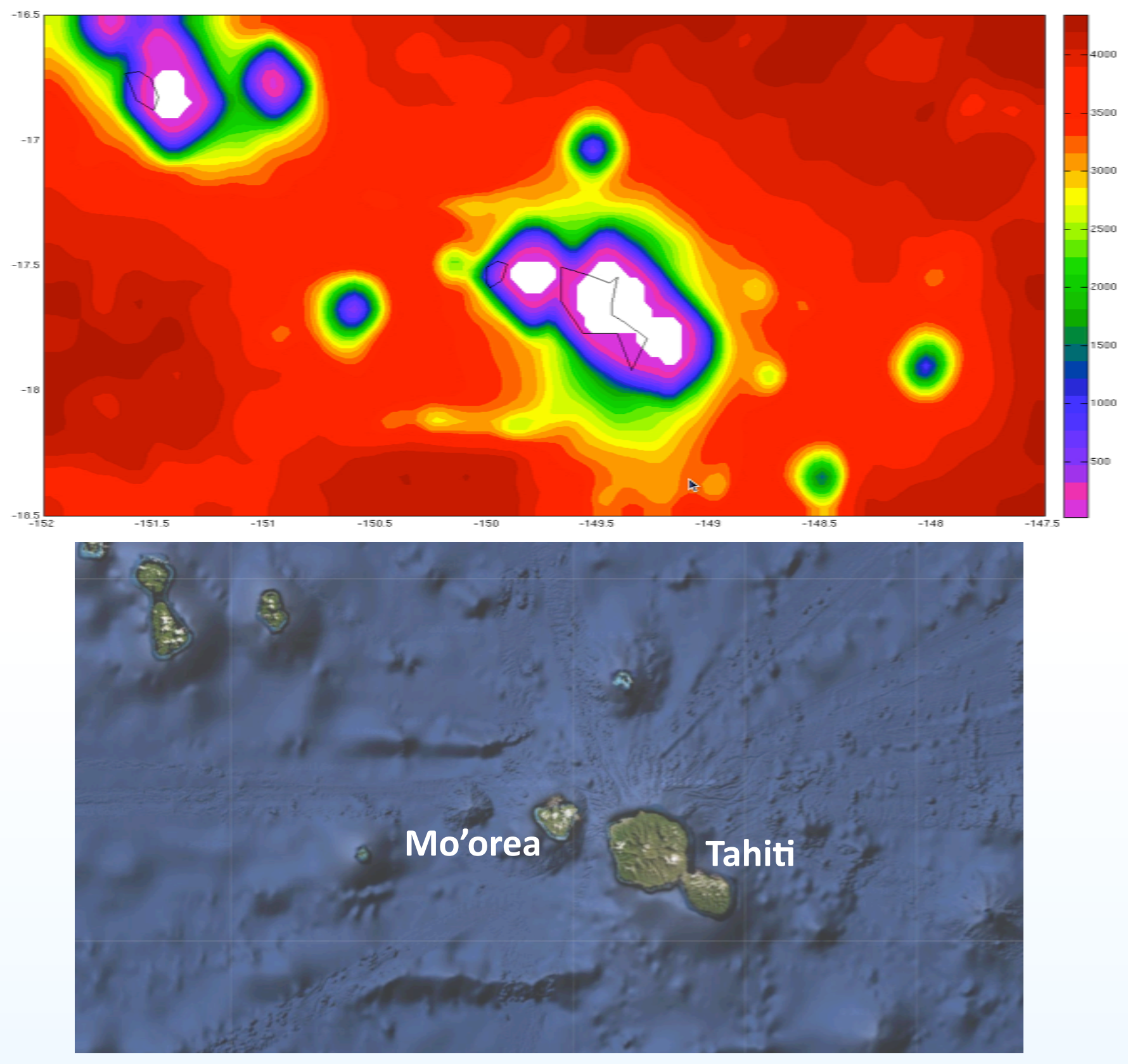
Temperature variability, in particular prolonged abnormal warm temperatures, result in coral bleaching, which often leads to mortality and subsequent reduction in coral cover (*Glynn* 1996).

Ω-aragonite is directly related to rates of coral reef calcification. Presently, most reefs grow slowly (~1 cm per year), and decreases in Ω-aragonite from increased CO_2 emissions are a serious concern for future coral reef development (*Hoegh-Guldberg* 2007).

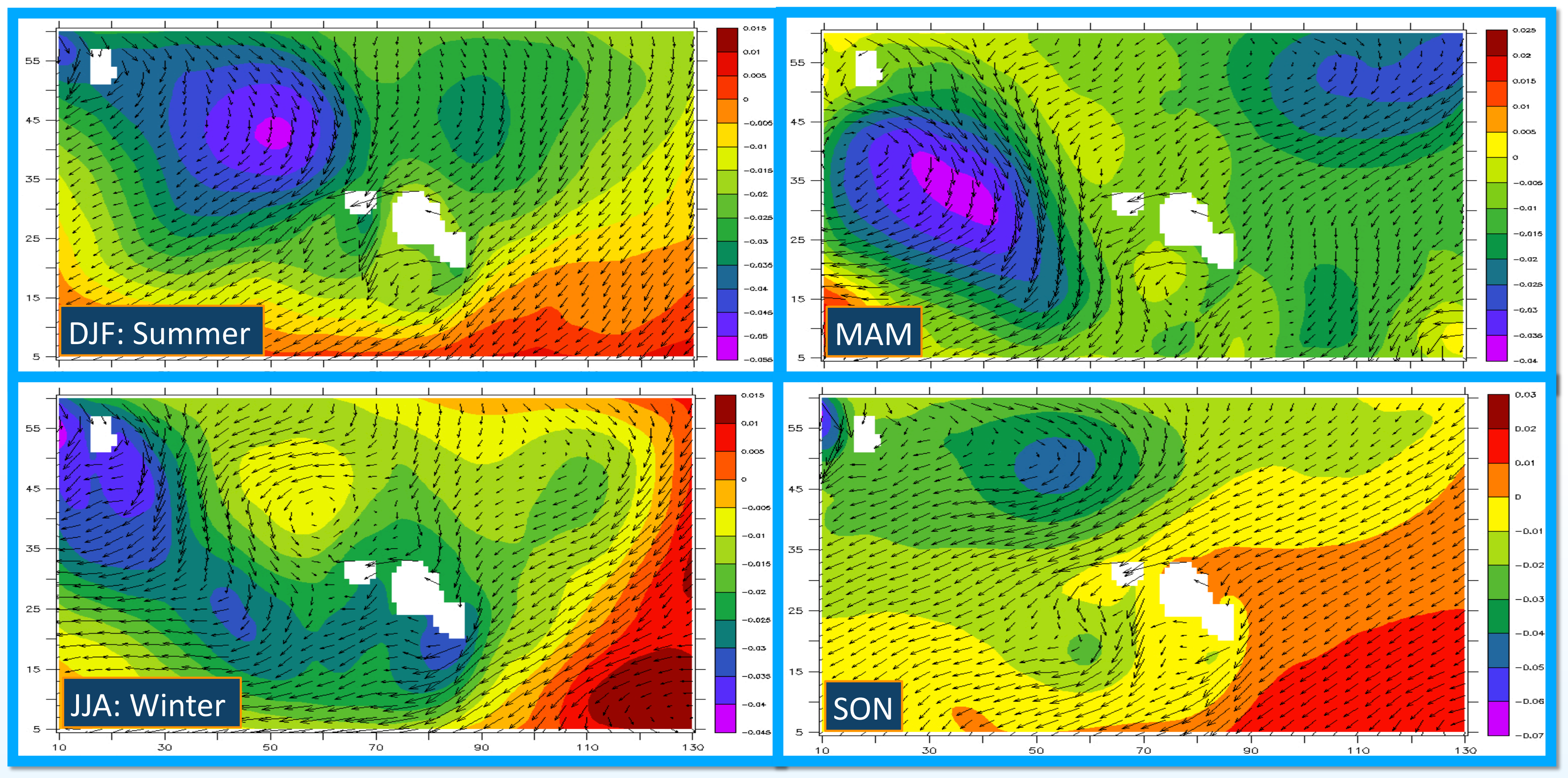
Nutrients (phosphate, nitrate, silicate) and **oxygen** are limiting factors for photosynthesis (nutrients only) and respiration (both nutrients and oxygen) and the relative concentrations of these resources will partially dictate whether ecosystems are dominated by plants or animals.

Cyclones have been documented as intermittent, severe stress events on coral reefs. Major effects on coral reefs include debris from land, increased sedimentation from land that may smother corals, and physical breaking and repositioning of coral reef structure (*Gardener et al* 2005).

Developing a Physical Oceanographic Modeling Capability with ROMS



Figures: Model domain and smoothed bathymetry from ETOPO2 (top), and Google Ocean bathymetry (bottom)



Figures: ROMS model climatology run at 3km resolution, 5 minute timestep. Second year is shown above. Each plot is a seasonal (3 month) average of sea surface height (colorbar) and surface current speeds (arrows). Average current speed is ~20 cm/s

Pacific Coral Habitats Organized by Physical Environment

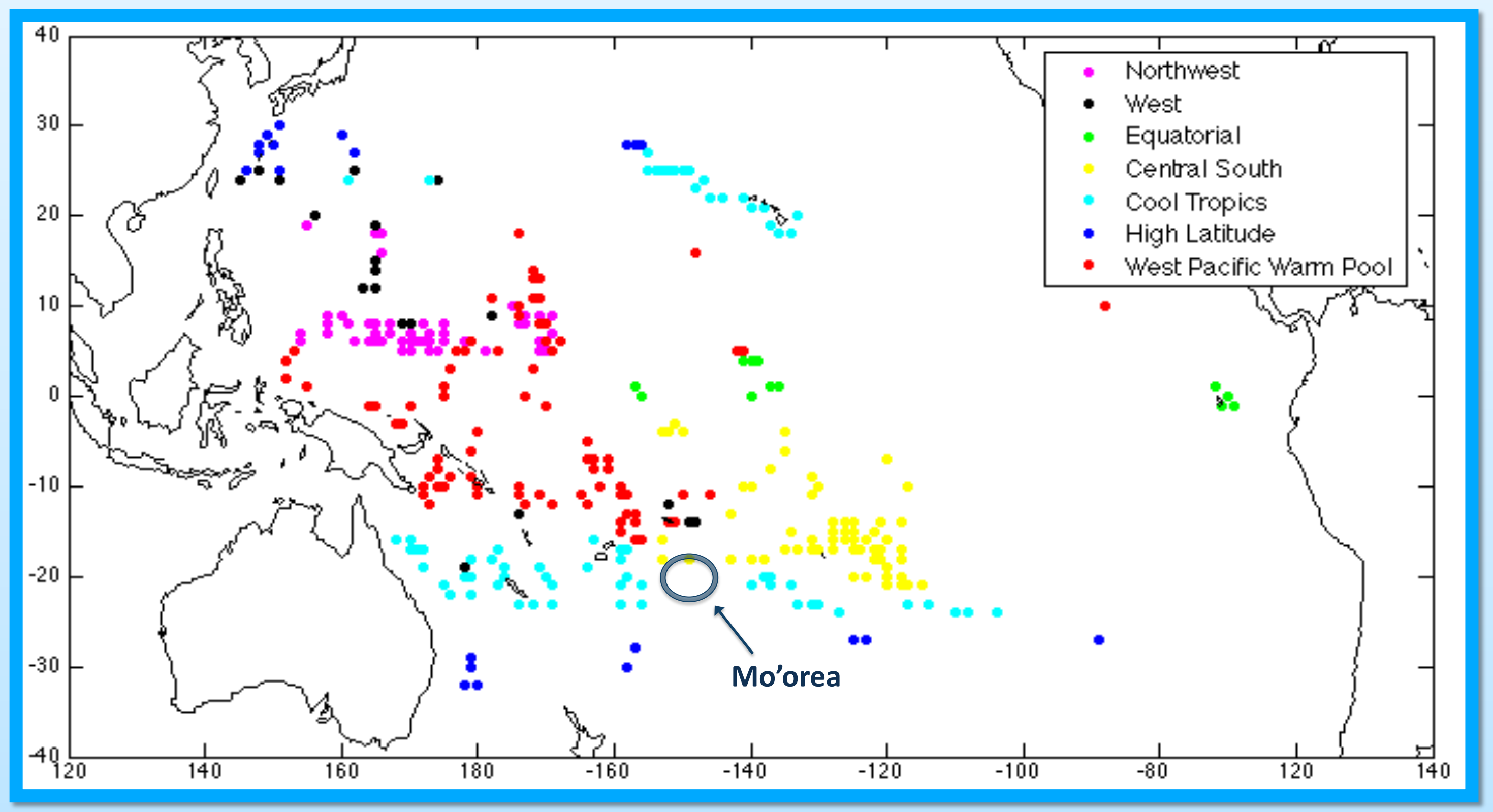


Figure: A cluster analysis is used to define coral reef "habitats" in the remote tropical Pacific. These are differentiated from one another by their oceanographic conditions (*Freeman et al* 2011). Mo'orea falls into the Central South Pacific Habitat, which is characterized by these parameters:

Cyclone Frequency	Salinity	Intense Hurricane Hits	Phosphate	Seasonal SST Range	Dissolved Oxygen	Ω-aragonite	Annual Degree Heating Weeks	Mean SST
0.04	35.84	0.00	0.29	1.78	4.63	4.15	0.17	27.63
Low	High	Low	High	Average	Average	High	Average	Average

Work Plan

Test mean flows at 3km resolution

Assess specific changes in oceanography at this location with coupled climate model outputs

Add Lagrangian floats to model to assess connectivity between and around the islands (Tahiti & Mo'orea)

Collaboration with LTER ecologists to understand bio-physical interactions and how observed coral larvae distribution relates to regional oceanography

References & Acknowledgments

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