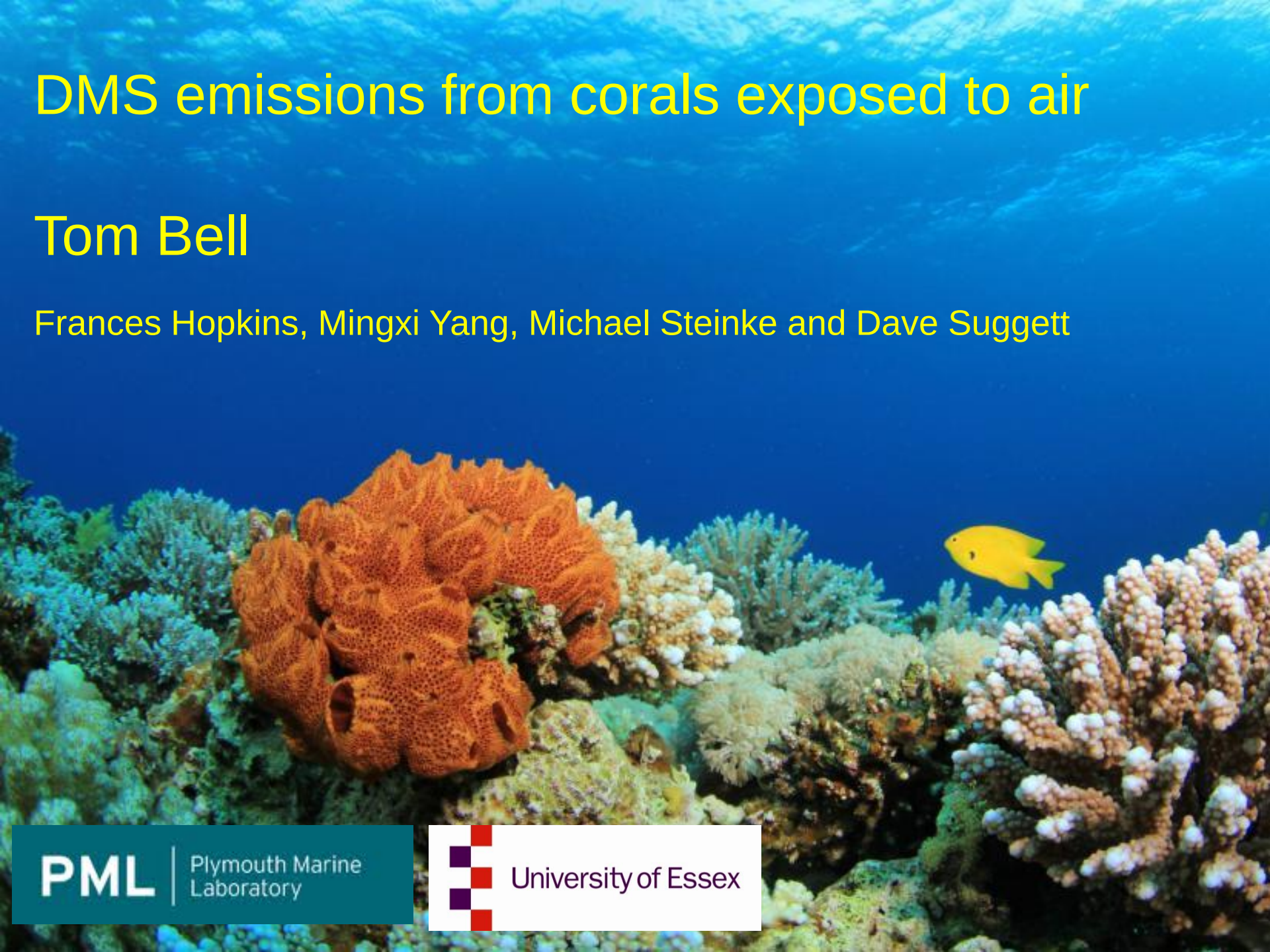
DMS emissions from corals exposed to air

Tom Bell

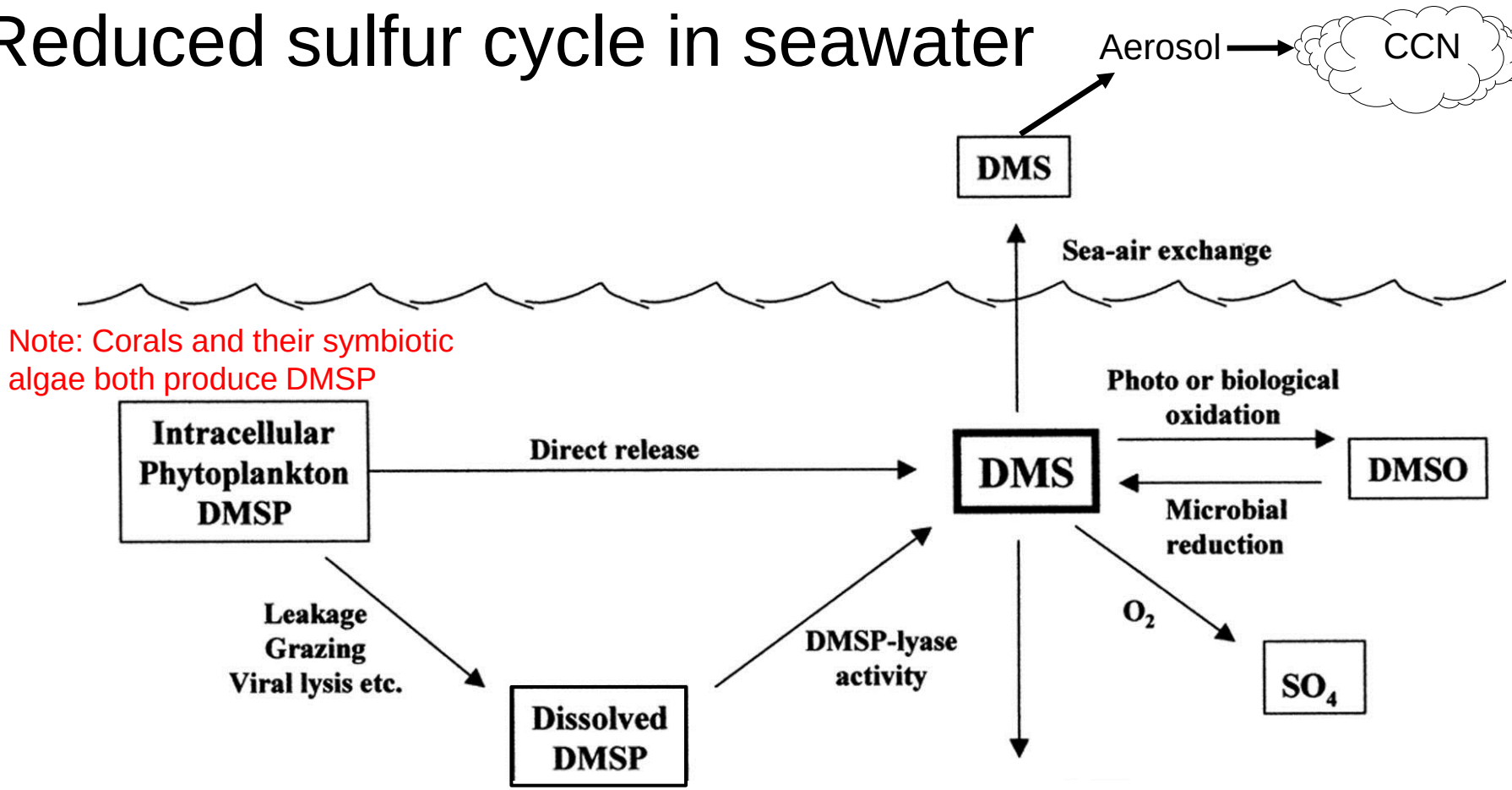
Frances Hopkins, Mingxi Yang, Michael Steinke and Dave Suggett



PML | Plymouth Marine Laboratory

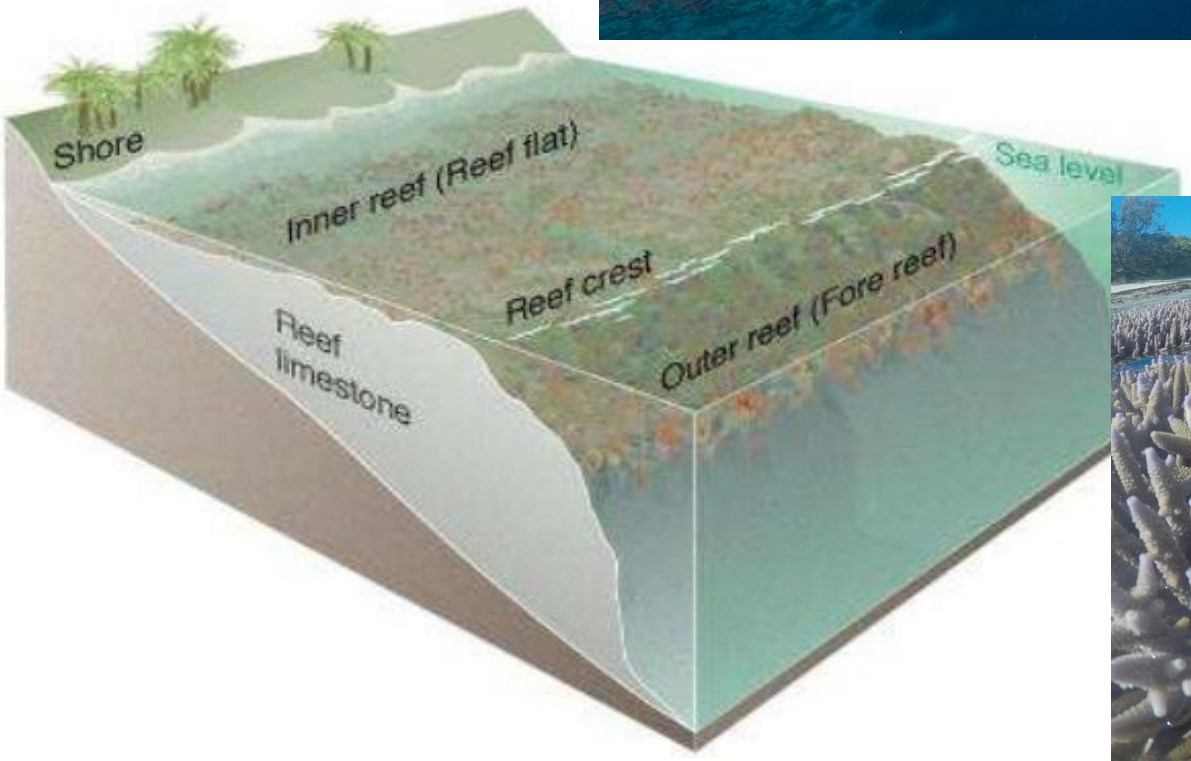
University of Essex

Reduced sulfur cycle in seawater



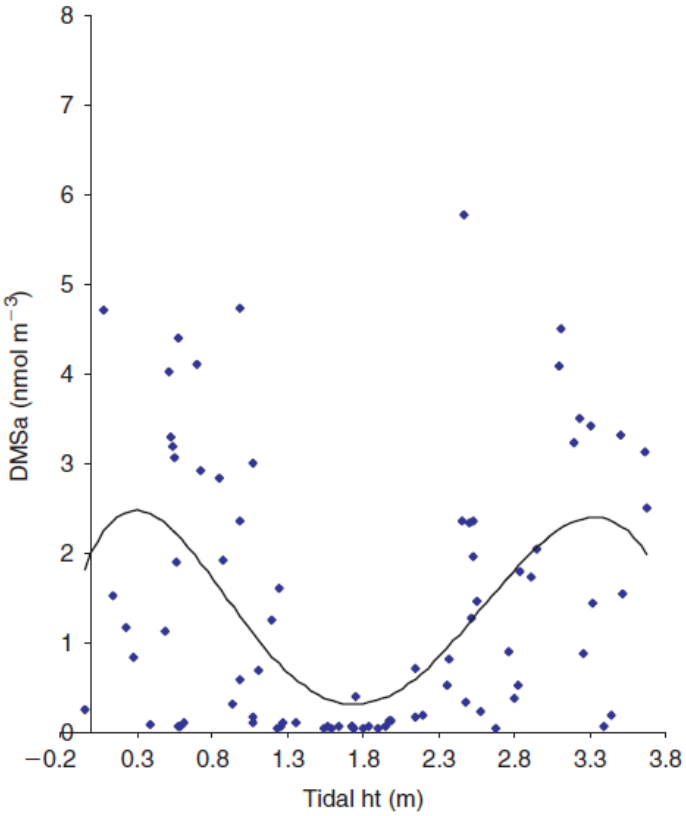
Typical marine concentrations:
Seawater DMS = 1 - 15 nM
Atmospheric DMS = 0.01 - 1 ppb

Coral reef zones and tidal exposure



Atmospheric DMS near coral reefs

- Up to 19 ppb observed downwind of a reef at low tide (Andreae et al., 1983)



Does the tidal cycle lead to higher DMS levels in the atmosphere around coral reefs?

If so:
Why?
How important is this?

Jones et al., (2007):
Lower levels (10-100 ppt) than Andreae et al (1983)
Air mass trajectories came over land

Atmospheric DMS linked to tidal height?

University of Essex Coral Reef Facility

Hopkins et al., Nature Sci. Reports, In Review

Triplicate flasks + Seawater Control

Flasks in water bath - temperature and light control

Three Indo-Pacific corals

Methods

- Seawater DMS, DMSP and DMSO analysis: Purge and trap gas chromatography

- Continuous gaseous DMS measurements: Atmospheric Pressure-Chemical Ionization Mass Spectrometry (*PML microCIMS*)

Continuous DMS monitoring

Isotopic internal standard

0.25 Hz data acquisition

Experimental Setup

Corals transferred to flasks for ~1 hr

Flasks bubbled with air

Gas in bubbles equilibrates with seawater DMS

Gaseous DMS monitored as it leaves flask

DMS, DMSP and DMSO sampled in seawater

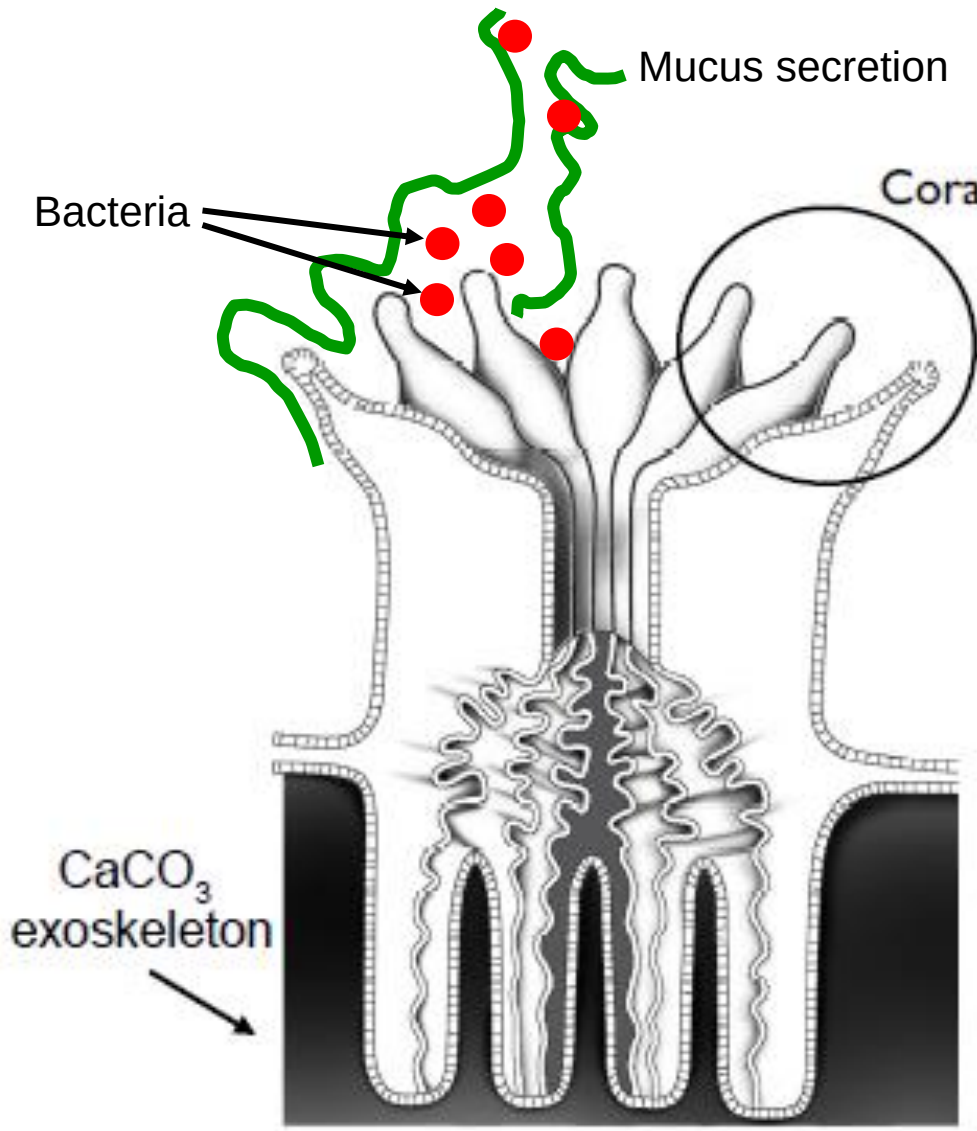
Experiment:

Stage 1 = Submersed

Stage 2 = Aerial exposure

Stage 3 = Re-submersed (same seawater)

The Coral Holobiont



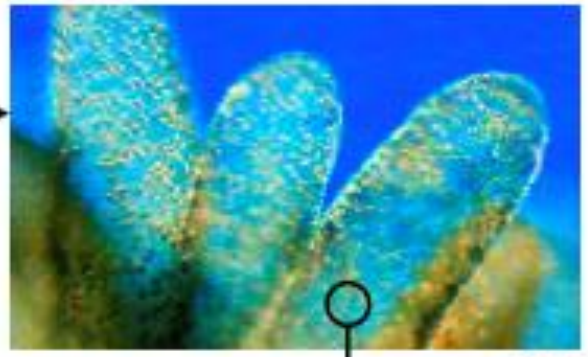


Photo: Michael ten Lohuis

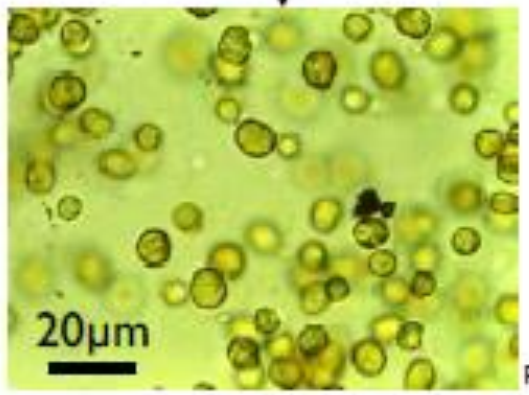
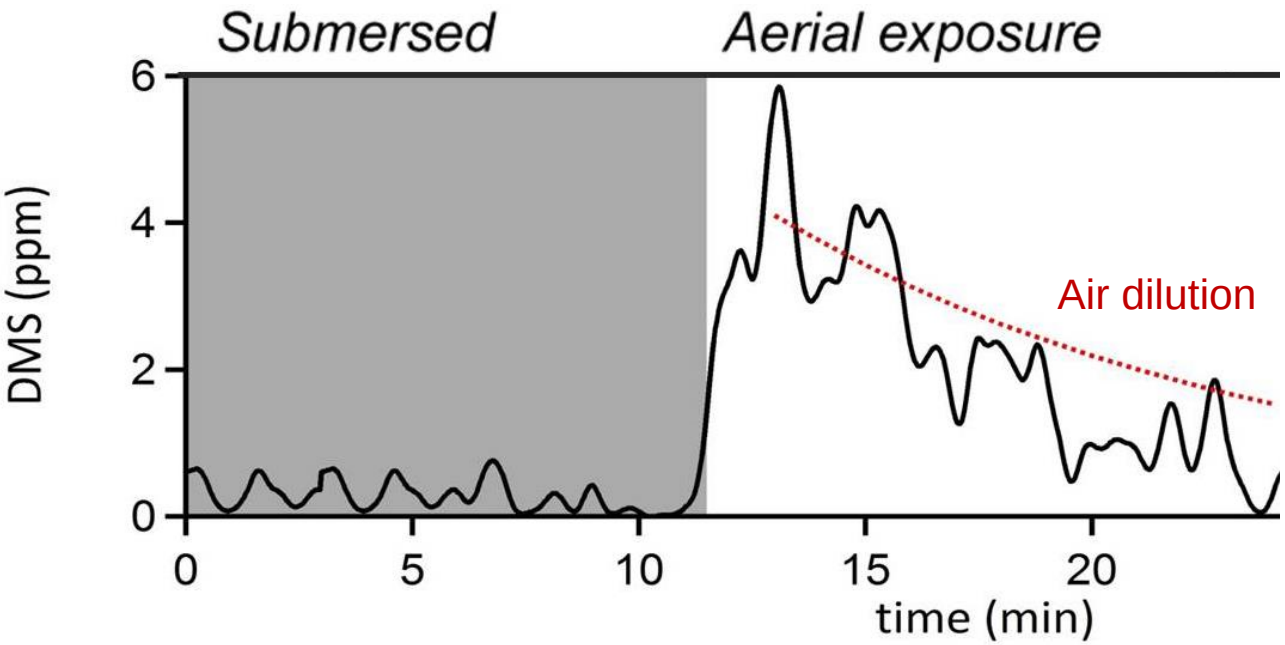


Photo: Scott Santos

Symbiodinium ('zooxanthellae')

Air exposure of *Acropora horrida*

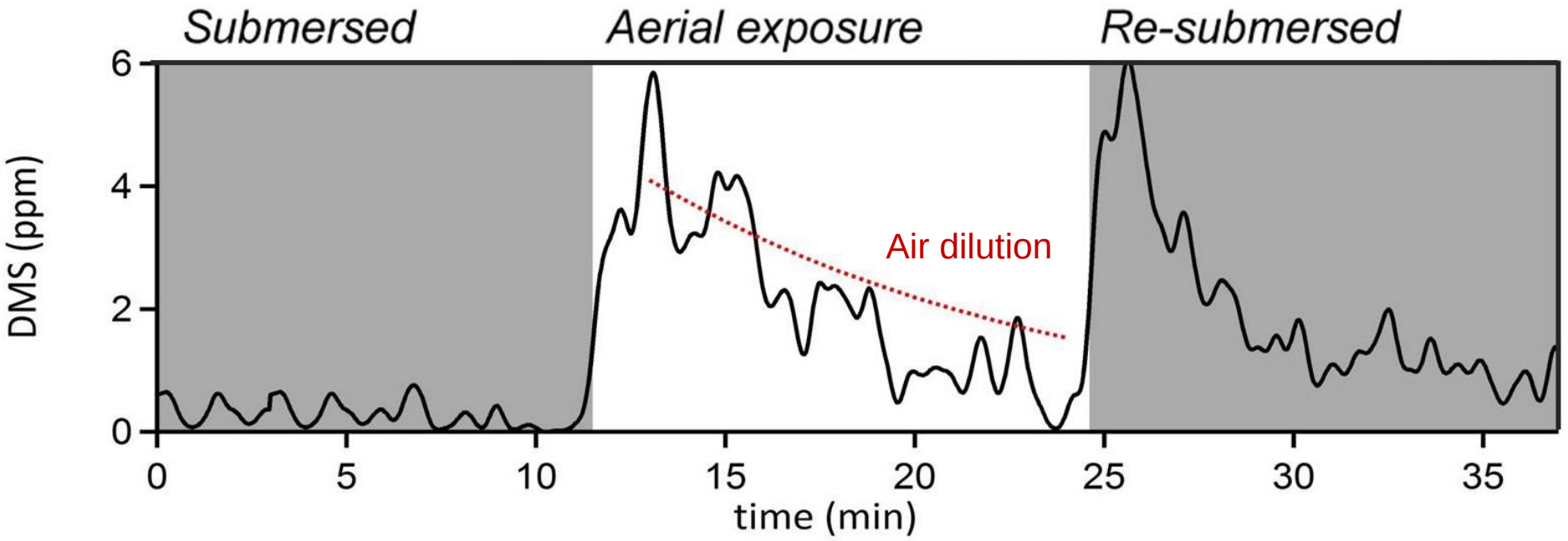


Air exposure = polyp retraction and mucus production.

Continued DMS production into air rather than water. Observed in all corals studied.

DMS trapped in mucus or production switched off?

Re-submersion of *Acropora horrida*



Dissolution of DMS trapped in mucus?

DMS in mucus ~ 500 nM

Increased DMS production due to shock of re-submersion?

Re-submersion of *Acropora horrida* - seawater sulfur cycling

Initial (first 10 mins) rates:

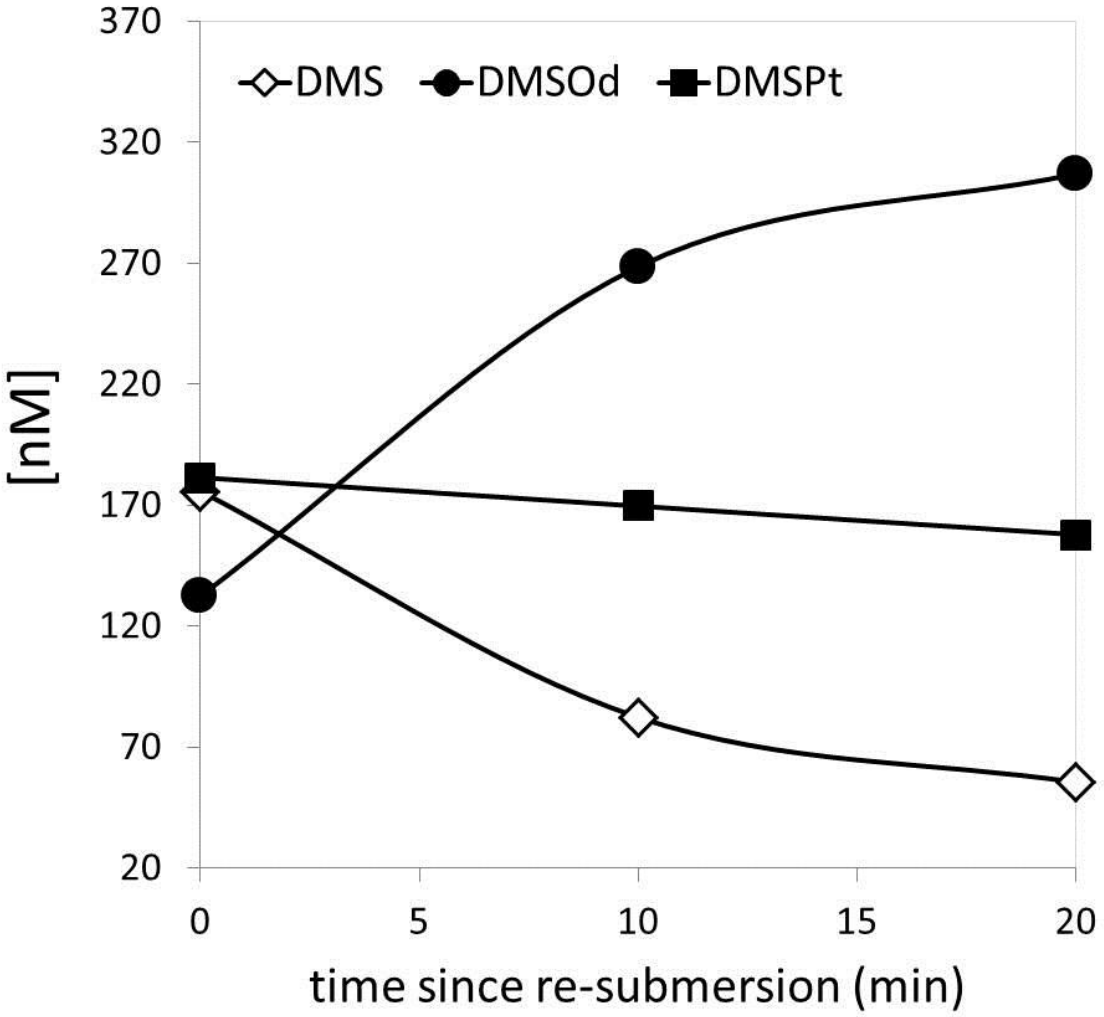
Net DMS consumption = 100 nM

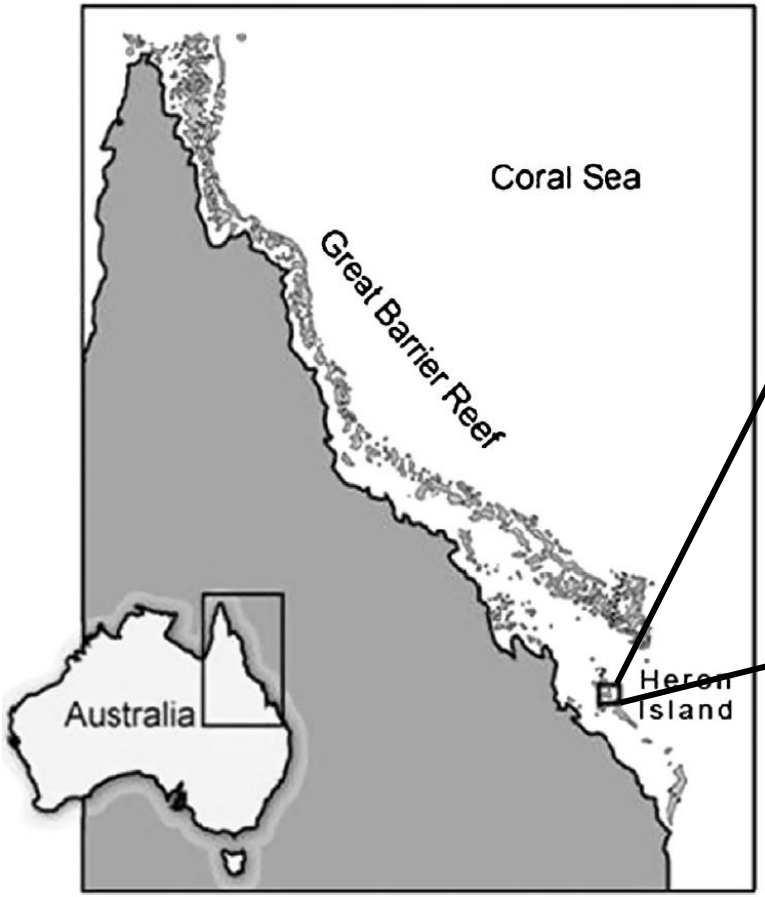
Net DMSO production = 150 nM

Minimal change in DMSP

Rapid conversion of DMS to DMSO

Active and rapid production of DMS





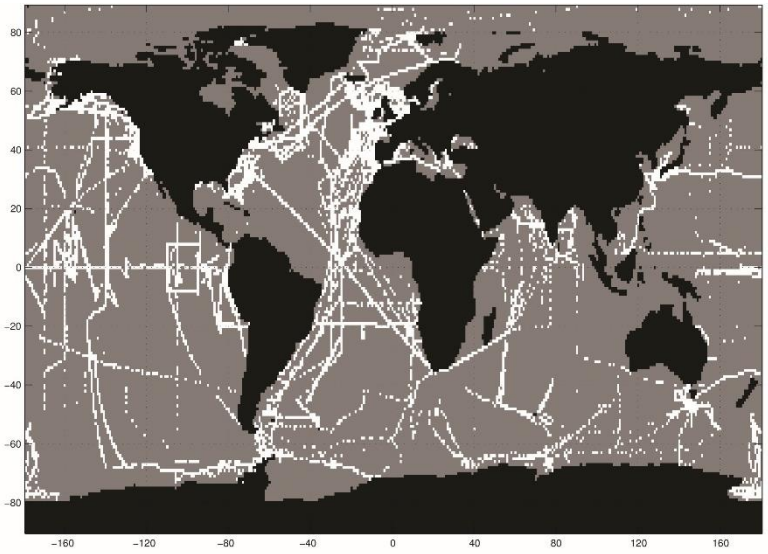
Heron Island Case Study – rough calculation:
15.8% Acropora coverage on reef crest
Exposed ~12 hrs per month

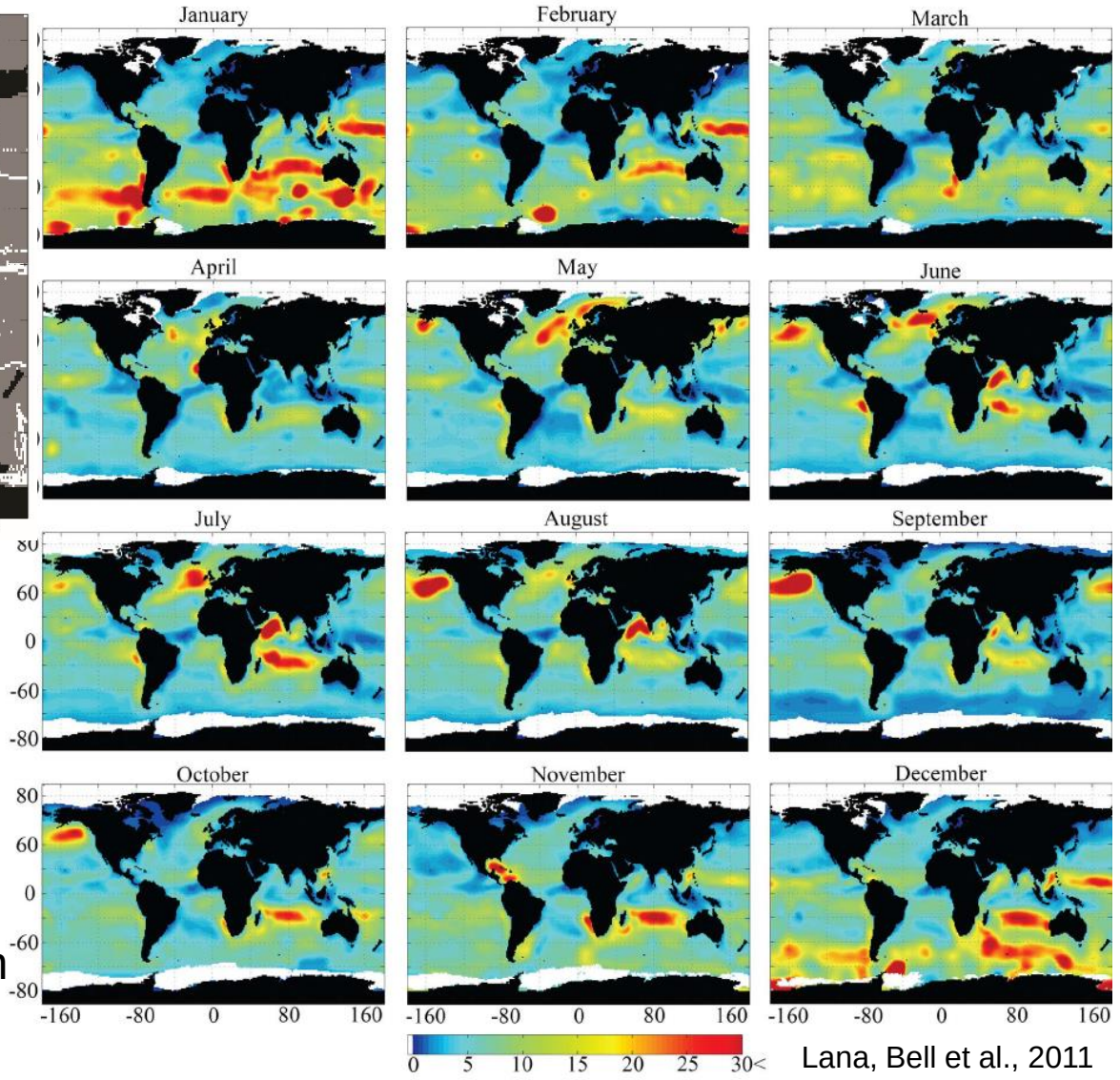
Long term average flux = 0.4 – 1.5 µmol/m^2/hr

During exposure, short pulses of 20 – 70 µmol/m^2/hr

Southern Ocean bloom with high seawater DMS (15-20 nM) = 1.3 µmol/m^2/hr

Estimating regional and global DMS fluxes





DMS database and climatology:

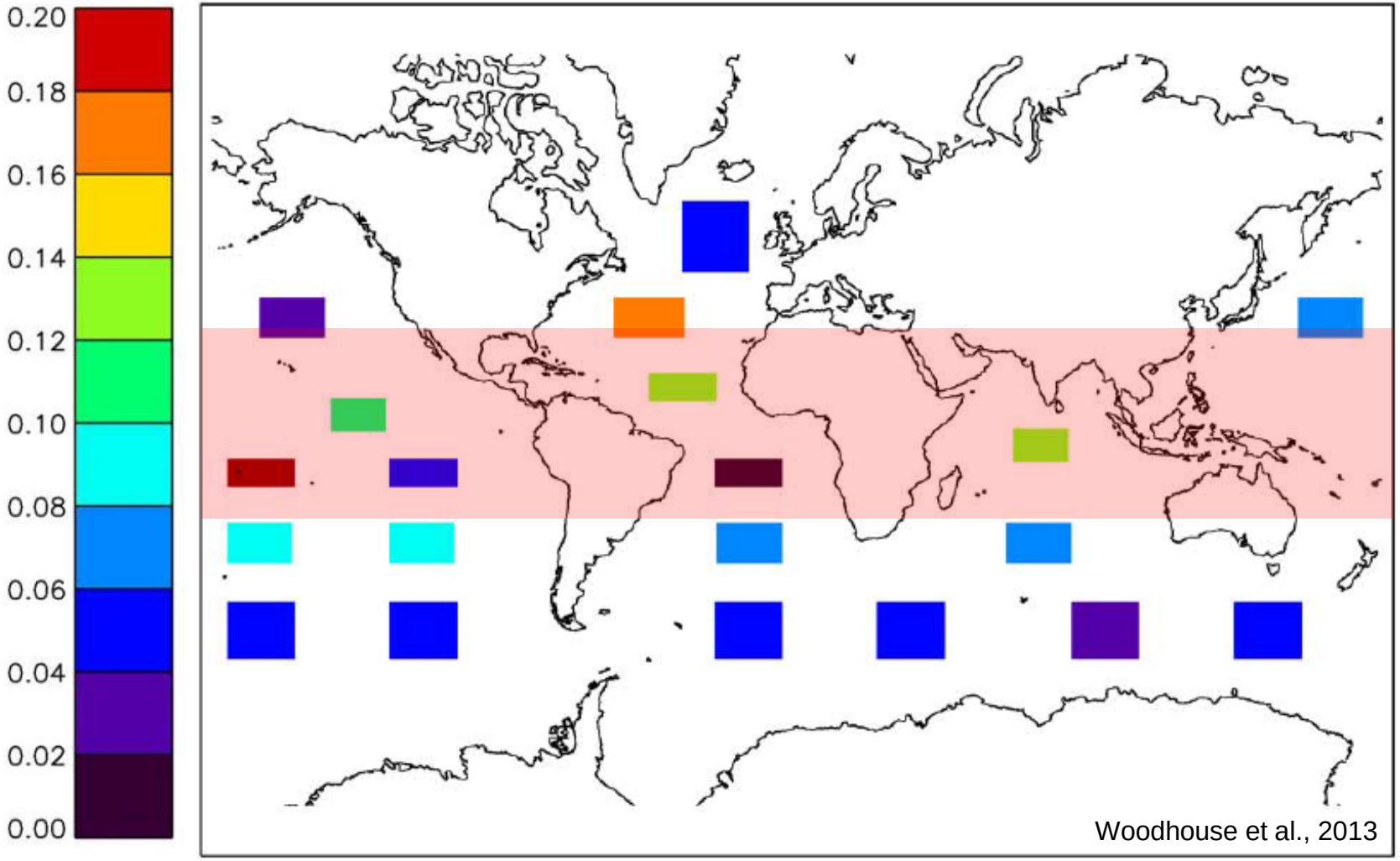
Global database of ~50,000 seawater DMS observations

Typically used to validate global model estimates of concentration and sea-to-air flux

Lana, Bell et al., 2011

Regional changes in DMS flux impacts global CCN

Relative CCN sensitivity:
% ΔFlux / % ΔCCN (global mean)



Summary

- Corals are a large but poorly understood source of sulfur in the tropics
- Corals can produce and consume reduced sulfur species at high rates
- Aerial exposure of corals may have a potentially important impact upon DMS and atmospheric chemistry in the tropics