DMS emissions from corals exposed to air

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Reduced sulfur cycle in seawater

Note: Corals and their symbiotic algae both produce DMSP

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?
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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

Mucus secretion

Bacteria

Coral polyps

CaCO₃ exoskeleton

Symbiodinium (‘zooxanthellae’)

Photo: Michael ten Lohuis

20µm

Photo: Scott Santos
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 $\sim 500$ 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/m²/hr

During exposure, short pulses of 20 – 70 μmol/m²/hr

Southern Ocean bloom with high seawater DMS (15-20 nM) = 1.3 μmol/m²/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)

Woodhouse et al., 2013

Warm water coral habitat range
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.