Small organisms with a large climate footprint:
the production of DMS by phytoplankton and bacteria

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Dimethylsulfide (DMS)
DMS is an important source of sulfate aerosols.

- 18-42% sulfate aerosol mass
- 80-90% marine biogenic sulfur

Woodhouse et al. 2010
Model predictions ranges from:

14% increase in DMS (11% offset in warming)

Gabric et al 2004
Model predictions ranges from:

10% decrease in DMS (17% increase in warming)

Kloster et al. 2007
HOW is DMS produced?

DMS$_{aq}$ → sulfate aerosols → CCN

Changes in surface temperature and UV radiation

DMSP → DMS

Chemical structures for DMSP and DMS.
HOW is DMS produced?

**Diagram Explanation:**

- **DMSO + ?**
  - **DMS\textsubscript{aq}**
  - **DMS\textsubscript{g}**
  - **sulfate aerosols**
  - **CCN**
  - **Changes in surface temperature and UV radiation**
  - **Changes in albedo**
  - **reflection**
  - **ventilation**

**Pathways:**

- **Phytoplankton**
  - **DMSP\textsubscript{p}**
  - **grazing**
  - **viral lysis**
  - **cell lysis**
  - **senescence**

**Bacterial Processes:**

- **bacterial consumption photolysis**
- **bacterial demethylation (DMS excluding)**
- **phytoplankton DMS production**
- **DMS production**

**Other Processes:**

- **amino acids**

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This diagram illustrates the various pathways and processes involved in the production of DMS (Dimethyl Sulfide) in aquatic environments.
WHEN and WHY is DMS produced?
Interdisciplinary Approach

- How much? (concentration)
- How fast? (rate)
Interdisciplinary Approach

Who’s there? DNA
Who’s active? RNA
Biogeochem active? Enzyme

biological physical
Interdisciplinary Approach

- chemical
- biological
- physical

- What conditions? (mixing, light...)
Bermuda Atlantic
Time-series Study (BATS) site
Bermuda Atlantic Time-series Study (BATS) site

Concentration

Gene Abundance & Expression

Enzyme Activity

Consumption Rate
Bermuda Atlantic Time-series Study (BATS) site

- Temp
- Light (14 λ)
- DMS
- DMSPd
- DMSPp
- TOC
- TOC:DMSP
- NO₃
- Si
- PO₄
- Bact Abund
- C demand
- dDMS/dt
- dDMSP/dt
- Season, Depth...
Seasonal Variations in DMS

Toole et al. in prep
Seasonal Variations in DMS

Toole et al. in prep
WHEN and WHY is DMS produced?

- **DMS\textsubscript{aq}**
  - **DMSPp**
    - **phytoplankton DMS production**
    - **bacterial DMS production**
  - **DMSPd**
    - **bacterial demethylation (DMS excluding)**
DMS Excluding Gene Expression

\[ dmdA \text{ expression: Copies per L} \]

Levine et al. submitted
DMS Excluding Gene Expression

Gene expression: Copies per L

UV-A light Dose (W/m²/day)

Levine et al. submitted
UV-A intolerant
(86% under low UV-A dose)

Levine et al. submitted
WHEN and WHY is DMS produced?
DMS Production

Phytoplankton DMS Producing Enzyme Activity

Bacterial DMS Producing Enzyme Activity

□ = DMS producing gene expression

Levine et al. submitted
Bacterial DMS Production

UV-A tolerant
(33% under high UV-A dose)

Levine et al. submitted
Phytoplankton DMSP lyase activity is UV-A dependent (88% under high UV-A dose) according to Levine et al. submitted.
Estimating DMS Production

BATS 20m depth

- DMS concentration
- Phytoplankton DMS prod. (DLA)
- Bacterial DMS prod (DLA × DMSPd)

DMS concentration (nM)

Month

Levine et al. submitted
Estimating DMS Production

\[ \text{DMS}_{\text{predicted}} = \text{Production} - \text{Loss} \]

Production = \( a \times \text{DMS}_{\text{phytoplankton}} \) + \( b \times \text{DMS}_{\text{bacteria}} \)

Loss = \( c \times \text{DMS}_{\text{consumption}} \) + \( d \times \text{DMS}_{\text{photolysis}} \)

Levine et al. submitted
Estimating DMS Production

BATS 20m depth

- DMS concentration
- Phytoplankton DMS prod. (DLA)
- Bacterial DMS prod (DLA x DMSPd)
- Predicted DMS concentration

Month: F M A M J J A S O N

DMS concentration (nM)

DMS production

Levine et al. submitted
Estimating DMS Production

Levine et al. submitted
Interdisciplinary Insight
WHEN and WHY is DMS produced?
Interdisciplinary Insight
Both phytoplankton and bacteria contribute to DMS production.
Light (UV-A dose) plays an important role in DMSP degradation and DMS production.
Interdisciplinary Challenges

- oxidation
- remineralization
- consumption
- isotope
- flux
- tracer
- rate
- cycling
- primer
- transcription
- water mass
- circulation
- amplification
- qPCR
- degenerate
- gene transcription
- non-specific clone
- Gene
- lateral attenuation
- vertical dose
- sink
- transformation
- deep-water
- advection
Communicating with non-scientists
Communicating with non-scientists

- Water
- Surface levels
- Ocean
- Small
- Marine
- Life
- Atmosphere
- Climate
- Much
- Higher
- Carbon dioxide
- May