

Prey-dependent retention of
Dimethylsulfoniopropionate (DMSP)
by mixitrophic dinoflagellates

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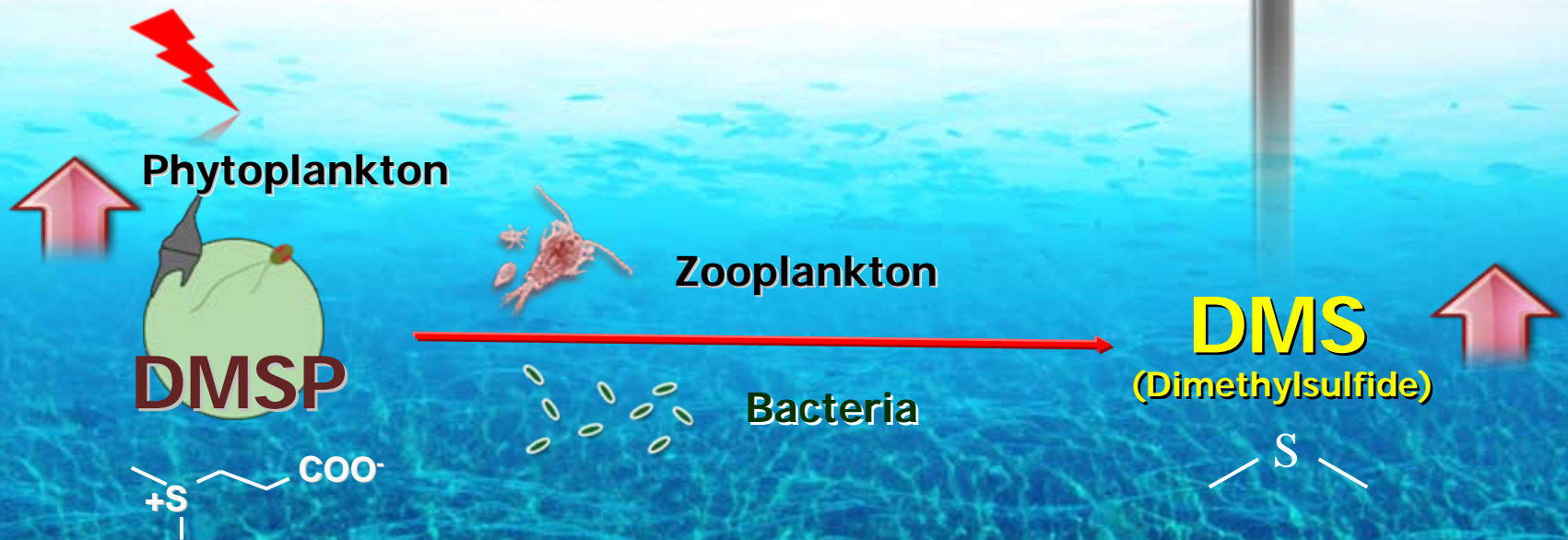
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[†] equal contribution

CLAW hypothesis

(Charlson et al., Nature 1987)

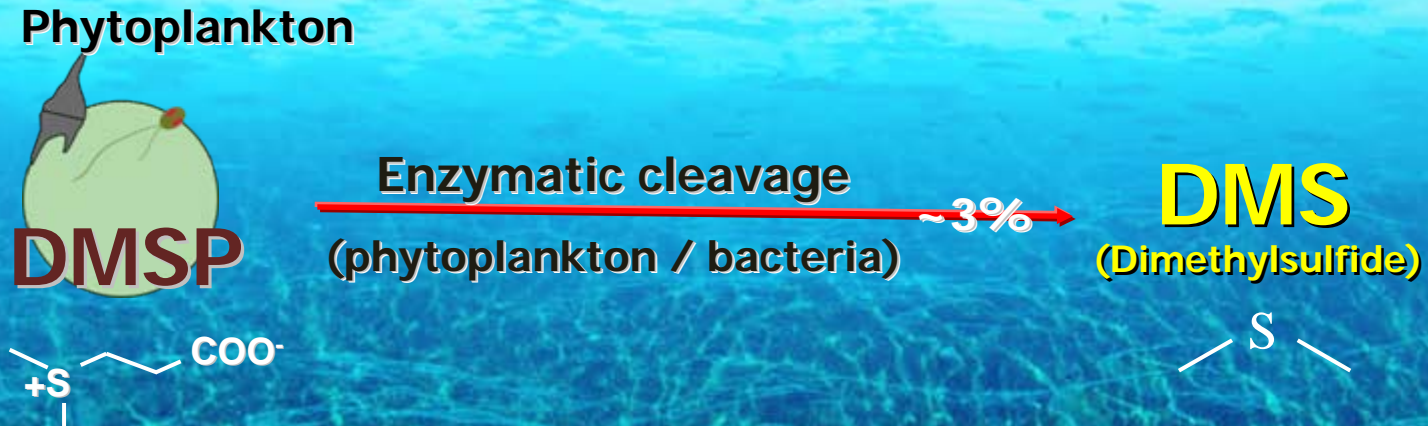
Ocean warms



Dimethylsulfoniopropionate (DMSP)

; compatible solutes synthesized by marine algae

- ▶ Osmolyte, Cryoprotectant (*Dickson & Kirst 1987, Kirst 1990*)
- ▶ Anti-oxidant mechanism (*Sunda et al. 2002*)
- ▶ Grazing deterrent, Chemo-attraction (*Wolfe et al. 1997, Seymour et al. 2010*)

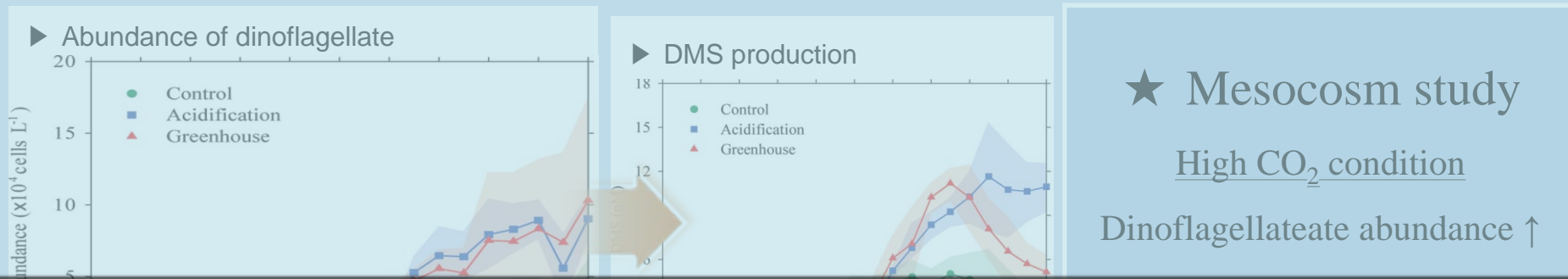


DMSP content of species groups

Species Group	DMSP(C)-Carbon (%)	DMSP chl-a ⁻¹ (mmol g ⁻¹)	No. of tested species
Dinoflagellates	11.1 ± 15.8	111 ± 168	32
Haptophytes	5.3 ± 3.7	52 ± 37	32
Prasinophytes	2.5 ± 3.4	25 ± 34	18
Diatoms	0.4 ± 0.6	4 ± 6	22
Prochlorophytes	~ 0.0	~ 0	17

Dinoflagellate : Dominant DMS and DMSP producer in Coastal water

Dinoflagellate : Response to climate change



★ Mesocosm study

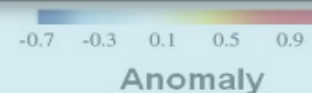
High CO₂ condition

Dinoflagellate abundance ↑

★ Dinoflagellate population seems to be affected by the changing climate

★ Roles of dinoflagellate on DMS/DMSP production??

★ Field observation
bloom frequency ↑
over 40yrs in NE Atlantic
(*Edwards et al.*, 2006)



▶ Difference between long-term mean (1960-1989) and post 1990s (1990-2002)

★ Lab. Study : Growth rate of *P. min* and *P. mic* ↑ under future condition (*Peperzak*, 2003)

Dinoflagellate : Mixotrophic nature

★ Mixotrophic behavior

: capable of both
photosynthesis and
ingestion of prey

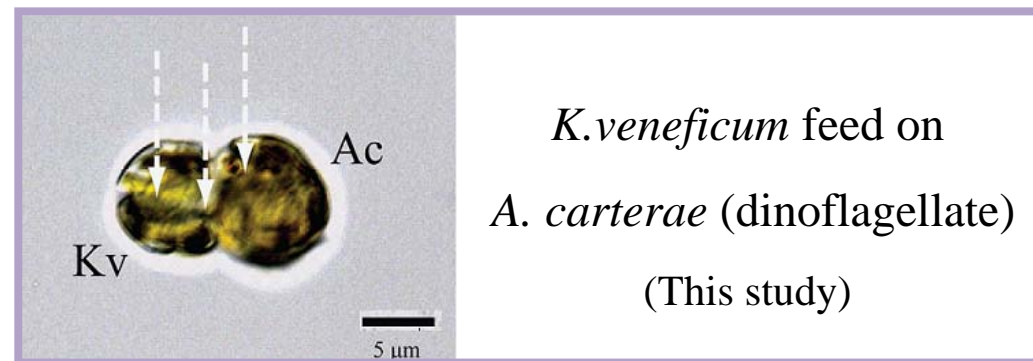
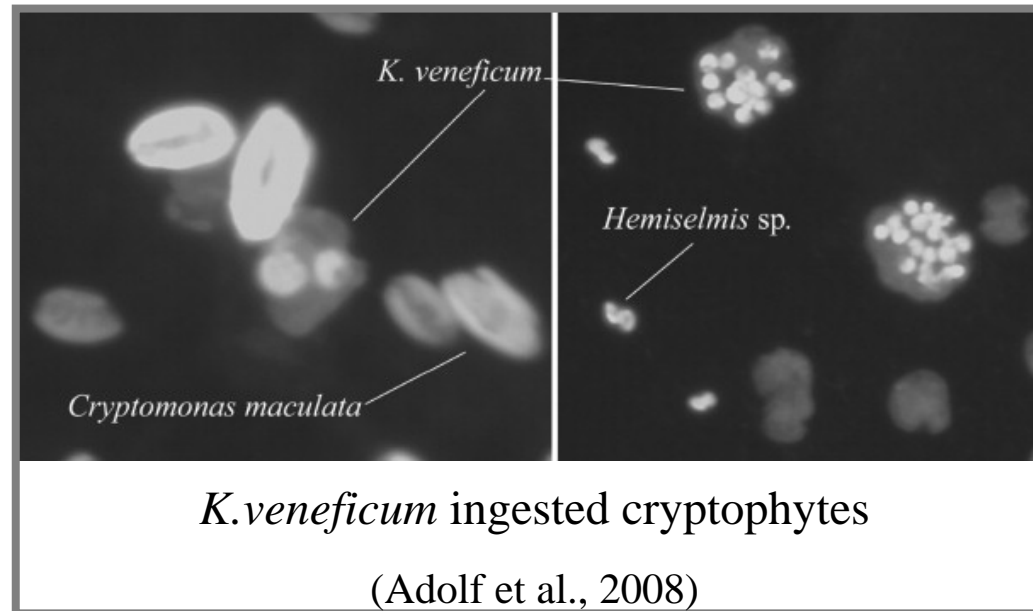
Predator

(Mixotrophic growth)

► *Karlodinium veneficum* (*K.v*)

: Dinoflagellate

- 0.94 ± 0.19 pg DMSP cell⁻¹
(1.30 ± 0.26 fg DMSP μm^{-3})



Effect of Mixotrophic nature of dinoflagellate on DMS/DMSP cycle

Q1. DMSP content of mixotrophic dinoflagellate

DMSP production is related to photosynthesis.

Then What is happening to the DMSP content of mixotrophic dinoflagellates

when they graze different prey?

Q2. The fate of grazed DMSP

Retained DMSP / transfer to other compounds/ Conversion into DMS ??

Q1. DMSP content of mixotrophic dinoflagellate

Predator

(Mixotrophic growth)

- ▶ *Karlodinium veneficum*
(*K.v*)
: Dinoflagellate

- 1.30 ± 0.26 fg DMSP μm^{-3}
- 0.94 ± 0.19 pg DMSP cell⁻¹

Prey

(Autotrophic growth only)

- ▶ *Teleaulax sp (Te)*
: Cryptophytes

- 0.34 ± 0.11 fg DMSP μm^{-3}
- 0.03 ± 0.03 pg DMSP cell⁻¹

DMSP-poor

- ▶ *Amphidinium carterae*
(*A.c*)
: Dinoflagellate

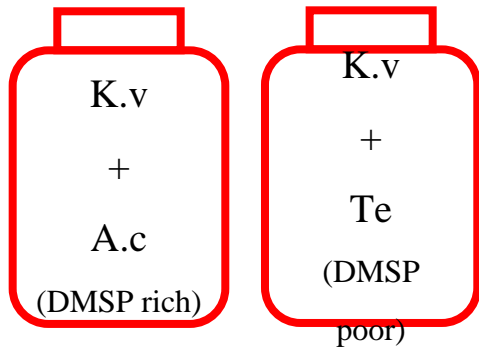
- 37.3 ± 4.5 fg DMSP μm^{-3}
- 19.7 ± 2.3 pg DMSP cell⁻¹
- DMSP cleavage enzyme

DMSP-rich

How the mixotrophic nature of *K. veneficum* affects its cellular content of DMSP when it co-occurs with DMSP-rich (*A.c*) or DMSP-poor (*Te*) prey.....

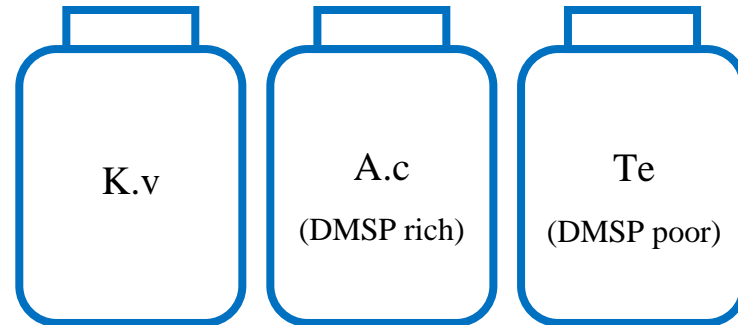
Q1. DMSP content of mixotrophic dinoflagellate

Experiment



Prey + Predator

Control

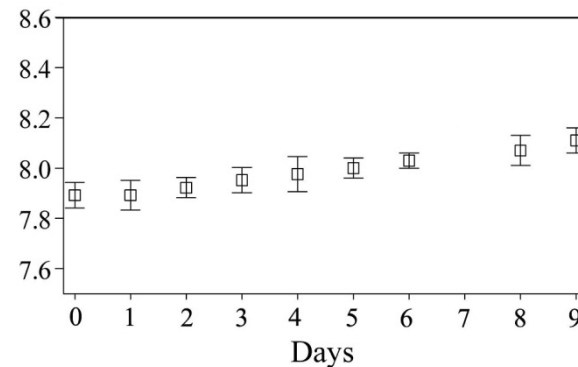


Predator
only

Prey only

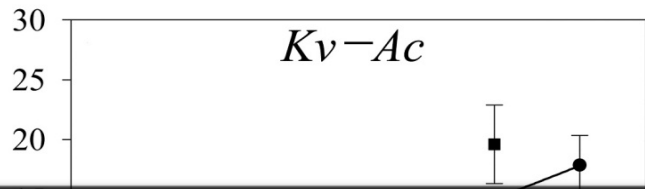
■ Culture condition

- 7~10 days culture
- 20°C, 12:12 Light/Dark cycle
- ~400 ppmv CO₂ gas aeration
- Sufficient Nutrient supply (f/4)

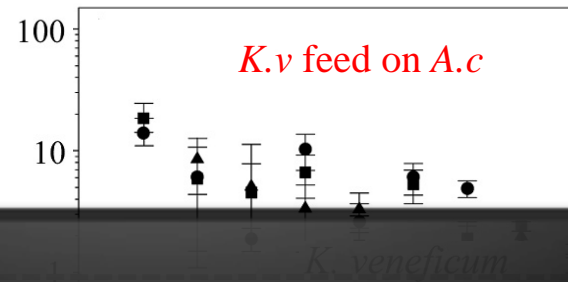


Q1. DMSP content of mixotrophic dinoflagellate

DMSP content of *K.v*
vs ingestion rate



Experiment

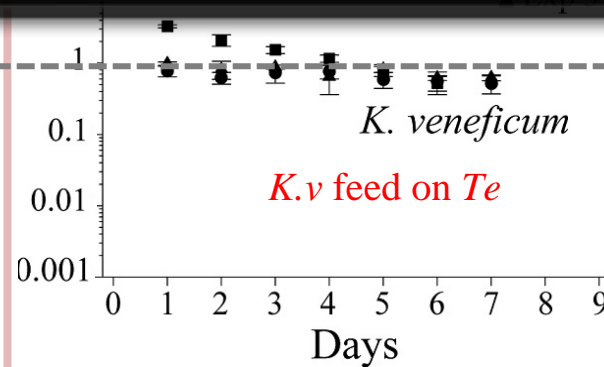
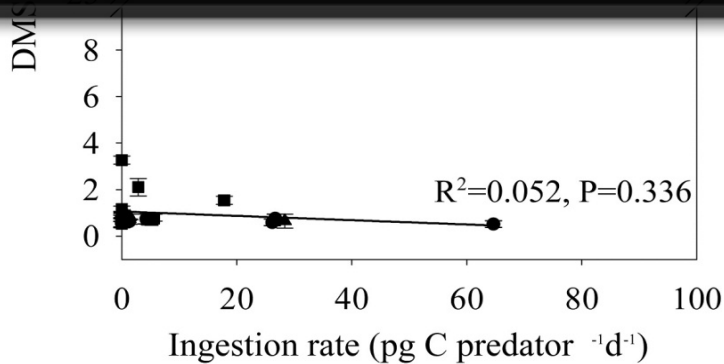


Kv-Ac (DMSP rich)

DMSP content of *K.v*

0.94-19.6 pg cell⁻¹

★ DMSP content of prey affects temporal variation
in the DMSP content of *K.v*



DMSP content of *K.v*
was comparable to control

Q2. The fate of grazed DMSP

Dilution experiment

- ▶ Prey (DMSP-rich)

Amphidinium carterae (A.c)

- ▶ Predator (Mixotrophic growth)

Karlodinium veneficum (K.v)

- 24 hrs incubation -



Retained DMSP

Grazing mediated DMS production

Net dissolved DMSP production

Q2. The fate of grazed DMSP

Mean \pm SD (%)

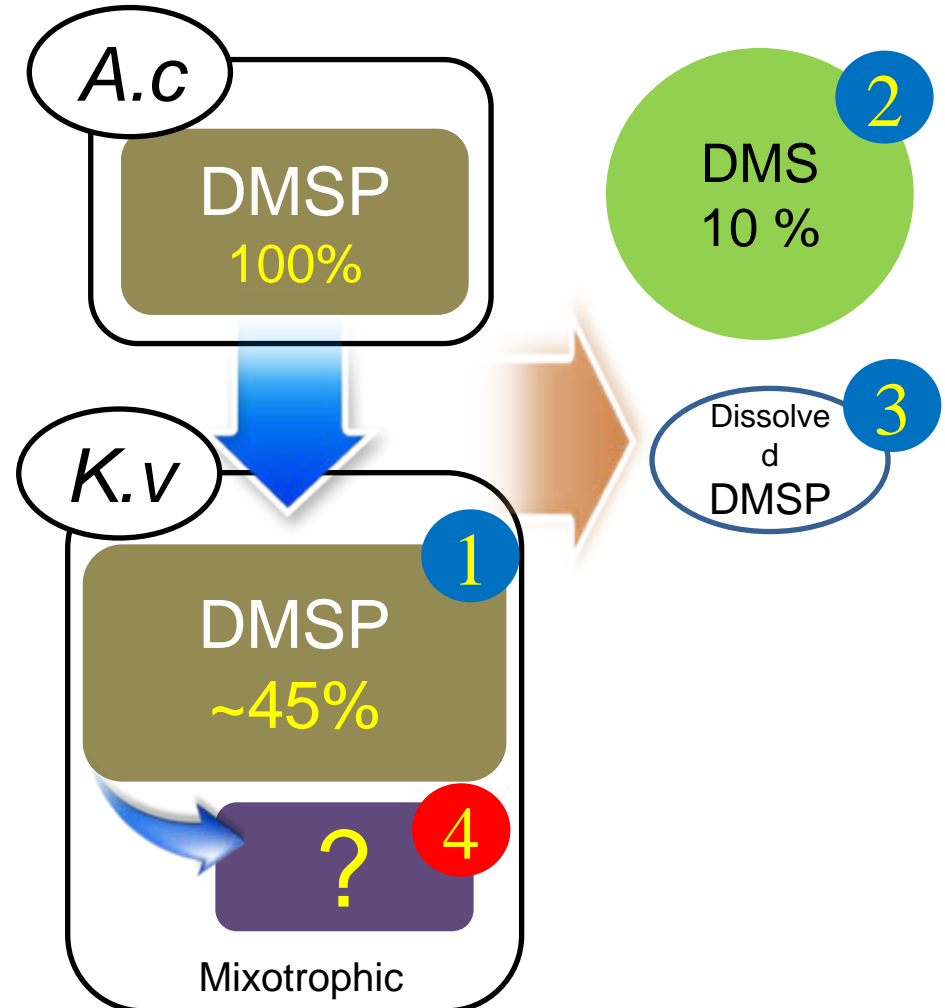
Grazing mediated DMS production	76.1 \pm 10.1
DMS production other than grazing	24 \pm 17.0

24 hrs dilution Exp.

Mean \pm SD (%)

	Grazed DMSP	100.0
1	Retained DMSP	44.8 \pm 8.7
2	Grazing mediated DMS production	10.1 \pm 3.4
3	Net dissolved DMSP production	< 1.8 \pm 0.6
4	Other compound	~ 43.3 \pm 10.6

- measured / calculated
- estimated



Conclusion

Q1. DMSP content of mixotrophic dinoflagellate

- ▶ DMSP content of prey affects temporal variation in the cellular DMSP content of mixotrophic dinoflagellate

Q2. Fate of grazed DMSP

- ▶ Nearly an half of grazed DMSP remained in predator (for 24 hrs)
- ▶ Mixotrophic dinoflagellate produce DMS through grazing on DMSP-rich preys.

If Dnoflagellate population increase under future ocean condition..

the mixotrophic nature of dinoflagellate could enhance DMS production in future ocean.

Thank you.

