Ecological Functions of Thraustochytrids in the Ocean Carbon Cycling

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Oceanography-2014
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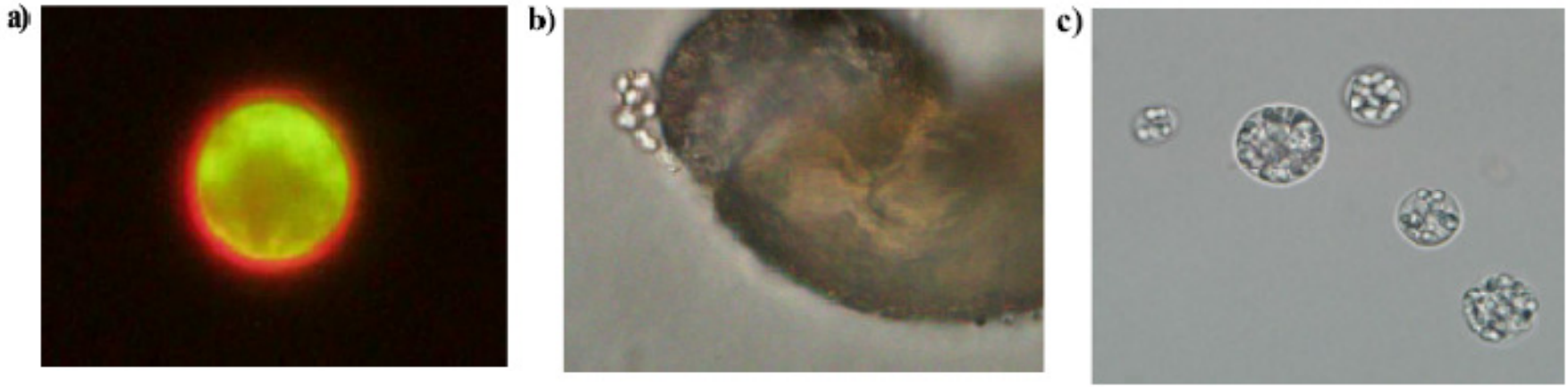
TJU Center for Marine Environmental Ecology



Labyrinthulomycetes

- Heterotrophic fungoid (fungal-like) protists
- Unicellular eukaryotic organisms & ubiquitous in marine environment;
- Producing various enzymes through them, and functioning as remineralizers in the ocean;
- Classified into 3 groups: labyrinthulids, thraustochytrids and aplanochytrids;
- Occasionally found in high numbers in the water column and microbial carbon biomass of proportions equaling that of bacterioplankton;
- Potential important function in microbial food web.

Thraustochytrids (cont'd)



a Epifluorescence micrograph of acriflavine-stained cell. b Cells attached to the surface of single pine pollen (marked with arrow). c Phase contrast photomicrograph of Aurantiochytrium sp. (Singh & Wang, 2014)

No. of cells (l^{-1})	Habitat	Reference
56×10^3	Coastal oceanic waters off Japan	Naganuma et al. (1998)
50×10^3	Coastal oceanic waters off Japan	Kimura et al. (1999)
21.4×10^3	Coastal oceanic waters off Japan	Kimura et al. (2001)
130×10^3	Arabian Sea	Raghukumar et al. (2001)
42.3×10^3	Sandy shores of Mediterranean Sea	Bongiorni et al. (2004)
230×10^3	Greenland and Norwegian seas	Naganuma et al. (2006)
674×10^3	Equatorial Indian Ocean	Damare and Raghukumar (2008)
630×10^3	North Pacific subtropical ocean off Hawaii	Li et al. (unpublished data) } 2014
320×10^3	Coastal oceanic waters of Pearl River Delta	Liu et al. (unpublished data) } 2014

Abundance by direct counting (Singh et al., 2014)

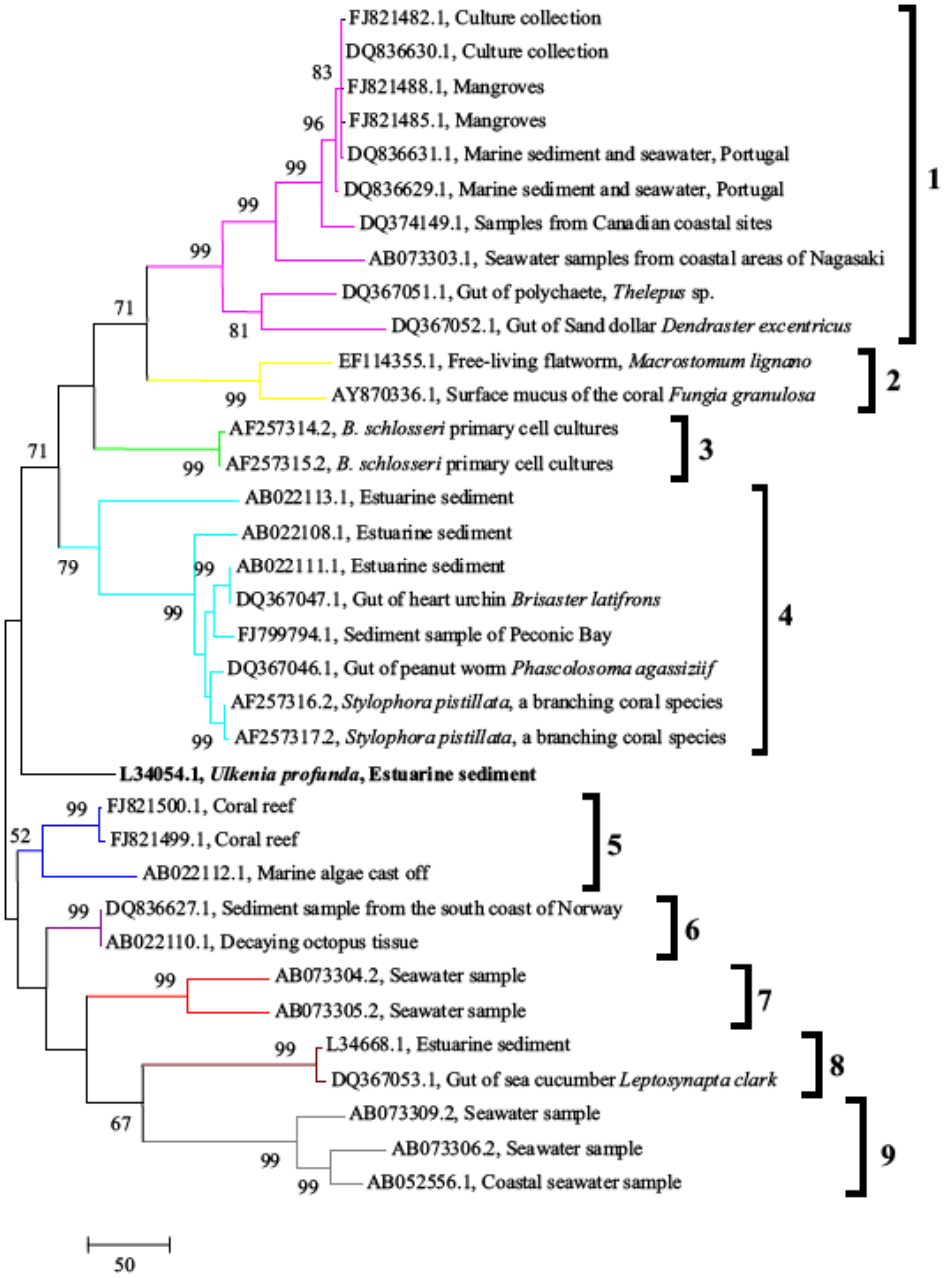
Thraustochytrids (cont'd)

Table 2 Particulars regarding representative 18S rRNA gene sequences (used for construction of phylogenetic tree in Fig. 2) of thraustochytrid isolates from different habitats

GenBank accession numbers of the 18S sequences	Phylogenetic identification	Probable function of the isolate	Reference
L34054.1	*Ulkenia profunda*	DHA production	Cavalier-Smith et al. (1994)
AB022108.1	*Schizochytrium minutum*	Source of PUFAs and extracellular enzymes	Honda et al. (1999)
AB022110.1	*Thraustochytrium aureum*		
AB022111.1	*Thraustochytrium multirudimentale*		
AB022112.1	*Thraustochytrium striatum*		
AB022113.1	*Thraustochytrium pachydermum*		
L34668.1 and AB022109.1	*Thraustochytrium kinnei*		
AB052556.1	*Thraustochytrium* sp. KK17-3	DHA production	Huang et al. (2001)
AF257314.2, AF257315.2, AF257316.2, and AF257317.2	*Thraustochytriidae* sp.	DHA production	Mo et al. (2002)
AB073303.1, AB073304.2, AB073305.2, AB073306.2, and AB073309.2	*Thraustochytriidae* sp.	DHA production	Huang et al. (2003)
DQ374149.1	*Thraustochytrium* sp. ONC-T18	DHA and carotenoid production	Burja et al. (2006)
DQ836627.1, DQ836629.1, DQ836630.1, and DQ836631.1	*Thraustochytriidae* sp.	Production of osmolytes such as protoquercitol and glycine betaine	Jakobsen et al. (2007)
EF114355.1	*Thraustochytrium caudivorum*	Parasites of marine free living flat worms	Schärer et al. (2007)
DQ367046.1, DQ367047.1, DQ367051.1, and DQ367052.1	*Thraustochytriidae* sp.	Source of PUFAs and extracellular enzymes	Tsui et al. (2009)
DQ367053.1	*T. kinnei*		
FJ821482.1, FJ821485.1, FJ821488.1, FJ821499.1, and FJ821500.1	*Thraustochytrium* sp.	DHA production	Yang et al. (2010)
FJ799794.1	*Oblongichytrium* sp. PBS05	Not known	Collado-Mercado et al. (2010)

Singh et al., 2014

Thraustochytrids (cont'd)



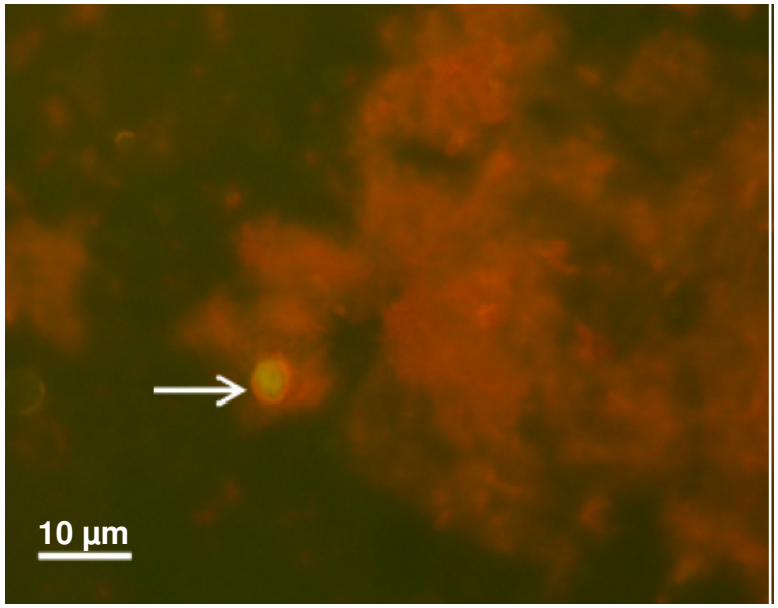
Singh et al., 2014

Marine *Labyrinthulomycetes*

Labyrinthulomycetes
(mainly marine)

- *Labyrinthulids*
- *Thraustochytrids*

$\frac{20.6 \times 10^{-12} \text{ g carbon/cell}}{3.02 \times 10^{-15} \text{ g carbon/cell (Bac)}}$ **=682**



Photomicrograph of an acriflavine-stained thraustochytrid cell (marked by arrow) from a natural sample on a black filter membrane (Demare, 2008)

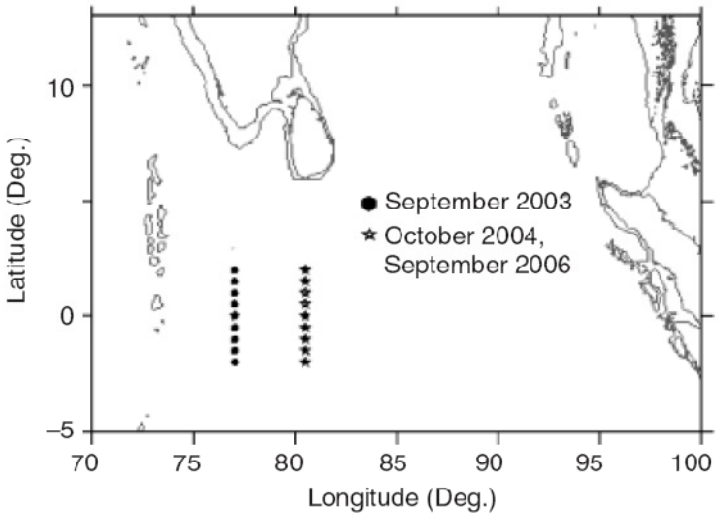
Biomass of thraustochytrids in some marine habitats

Substrate	Parameter
Brown alga *Sargassum cinereum*; 21 days of decomposition; coastal waters of Goa, India	0.0007 g C per g detritus
Decaying mangrove leaves	0.0015–043% of detrital dry weight
Phytoplankton detritus; North Sea	0.111 mg C g^{-1} detritus, at 20.6 pg C per 5 µm cell (based on Kimura et al. 1999)
Faecal pellets of the salp, *Pegea confoederata*; Arabian Sea	12 mg C g^{-1} dry wt. faecal pellet, at 20.6 pg C per 5 µm cell (based on Kimura et al. 1999)
Coastal waters of the Japan Sea 2.6 µg C/ml	0.0026 mg C L^{-1} seawater (at 165 pg C per 10 µm cell, Kimura et al. 1999)
Water column of the Arabian Sea 27 µg C/ml	Up to 0.027 mg C L^{-1} seawater (at 20.6 pg C per 5 µm cell (based on Kimura et al. 1999)

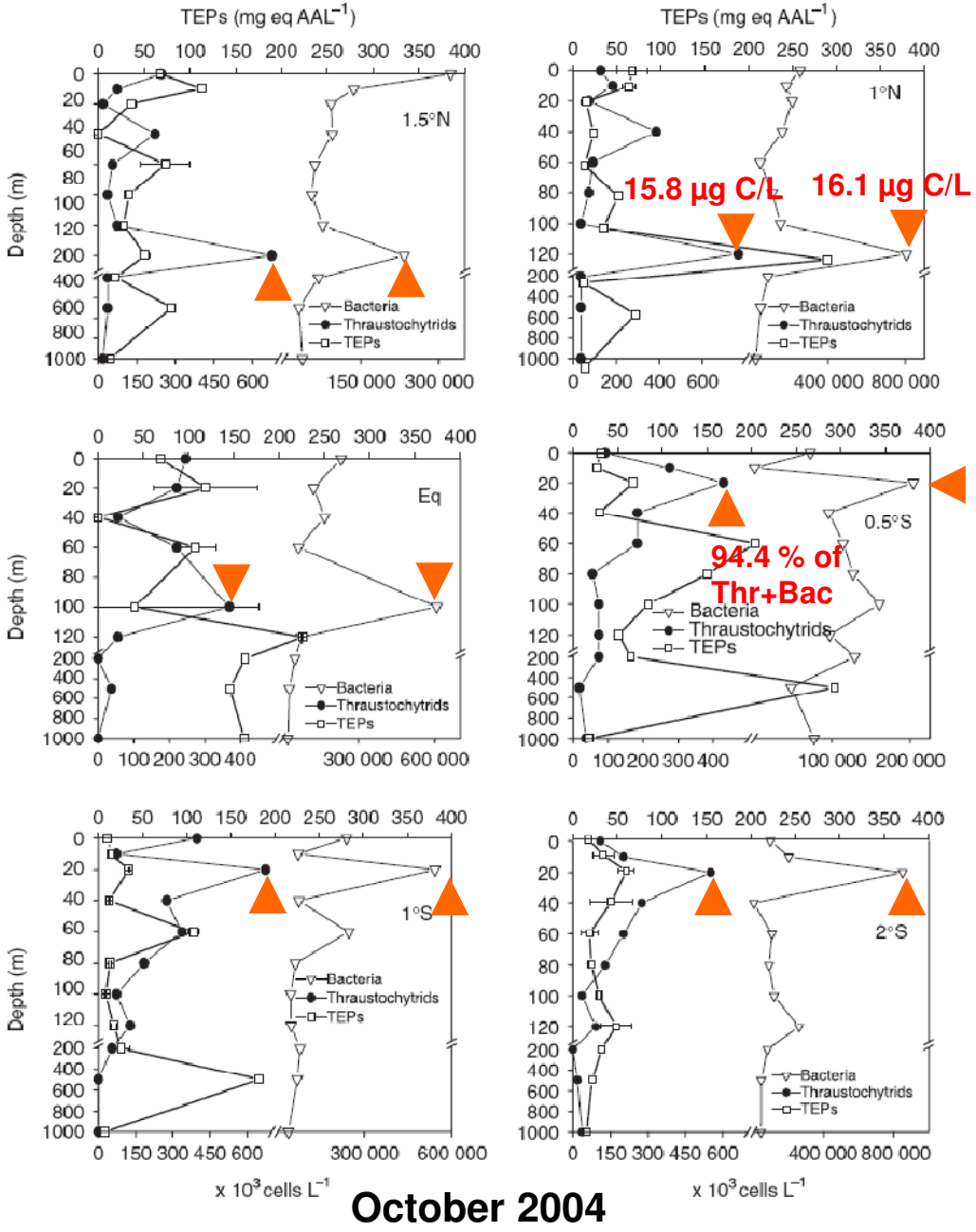
Raghukumar, 2002

Thraustochytrids (cont'd)

Abundance in the equatorial Indian Ocean



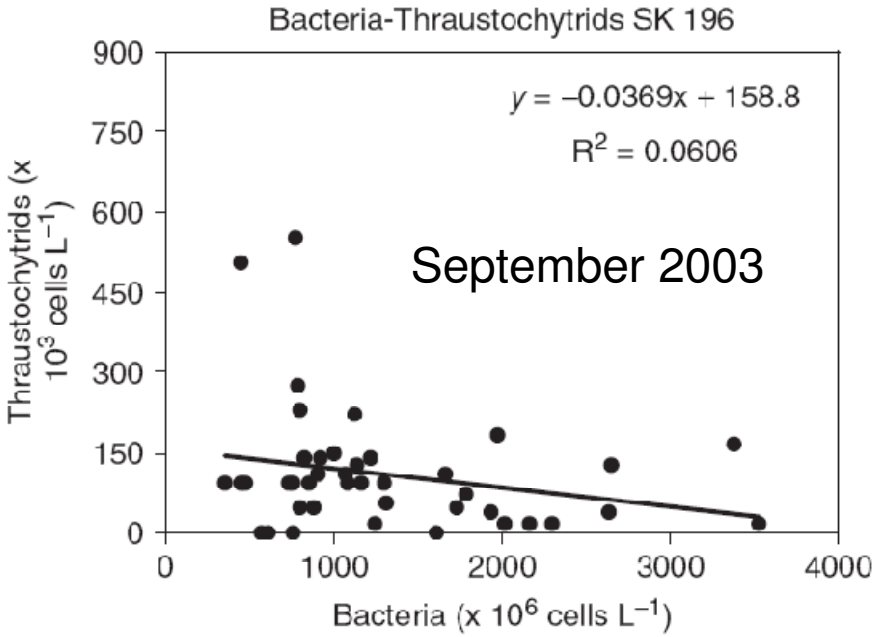
CTD stations in the equatorial Indian Ocean during the cruise of ORV Sagar Kanya.

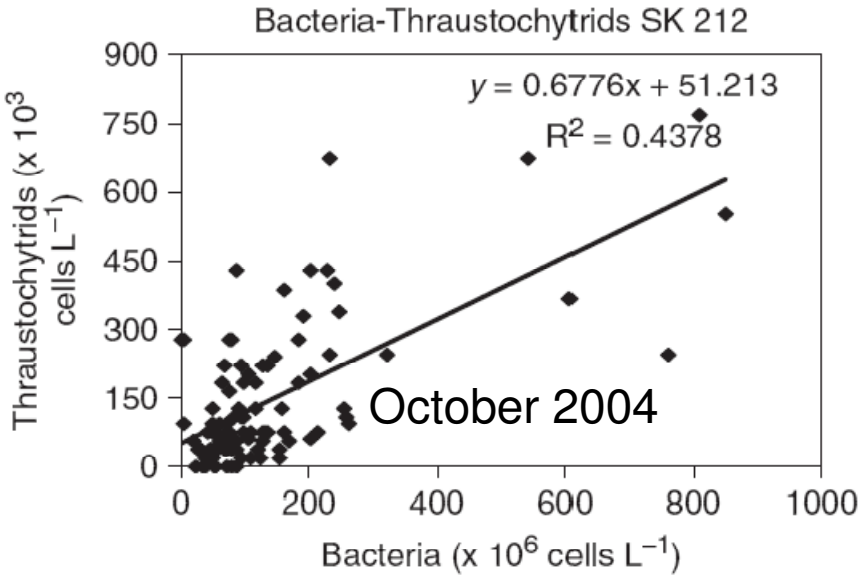


October 2004

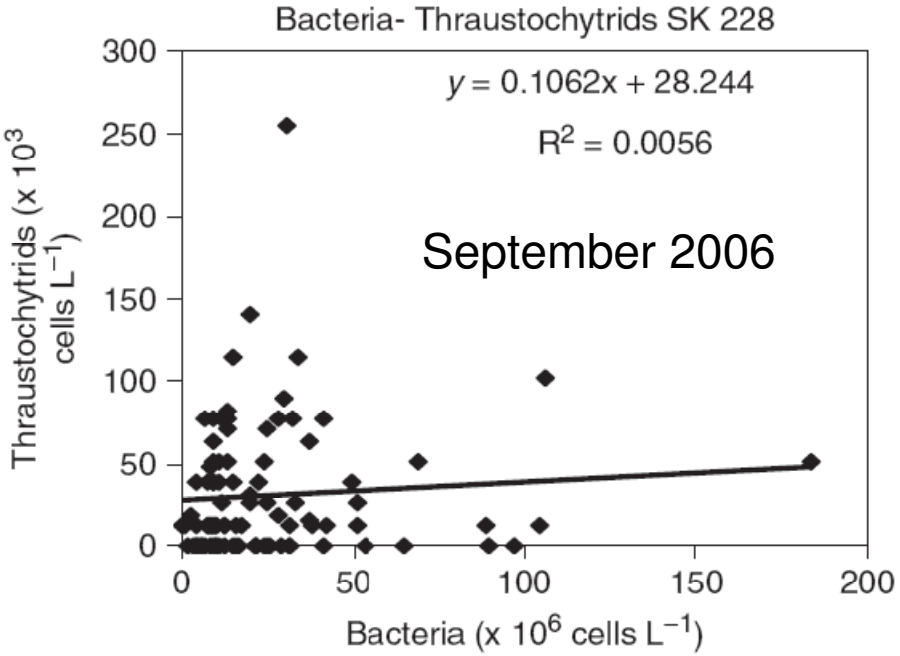
Damare & Raghukumar, 2008

Thraustochytrids (cont'd)

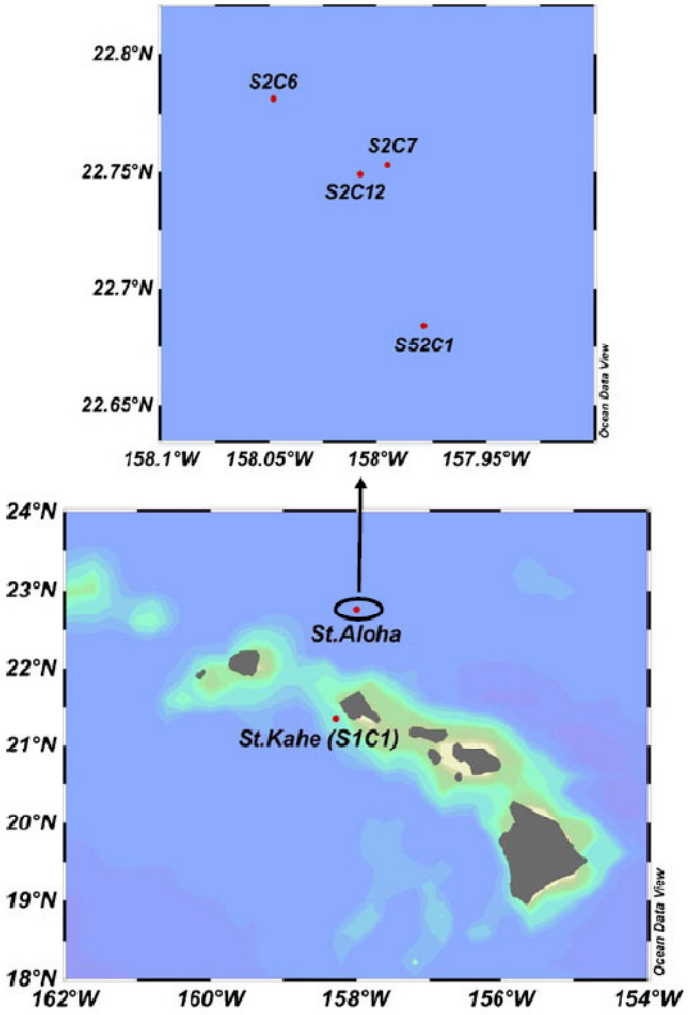




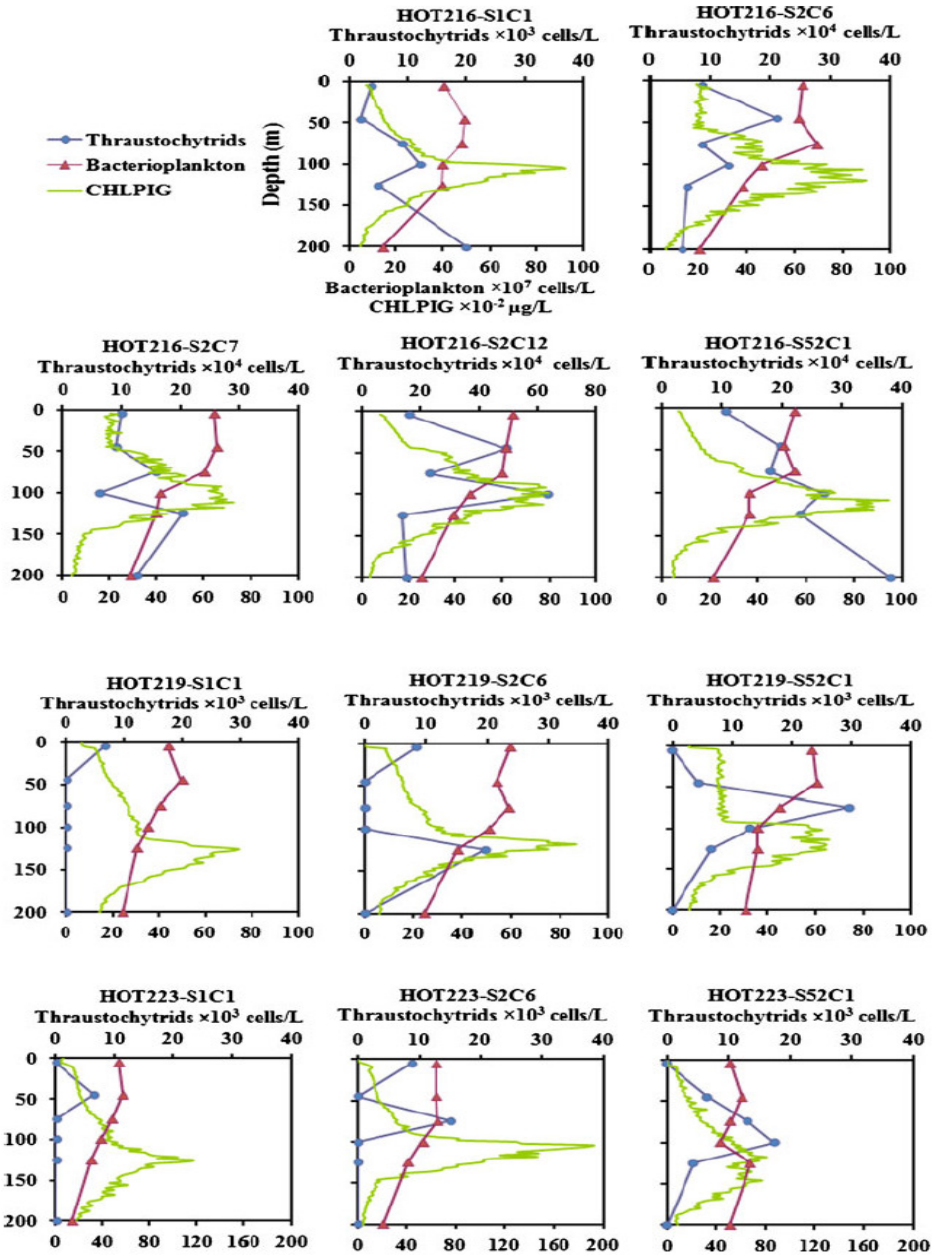
- **Relationship between thraustochytrids and bacteria varied with sampling time.**
- **Biotic and abiotic factors, which affect the abundance of thraustrochytrids, remain unknow.**



Thraustochytrids (cont'd)



Vertical distribution of thraustochytrids in Hawaiian waters (Li et al, 2013)

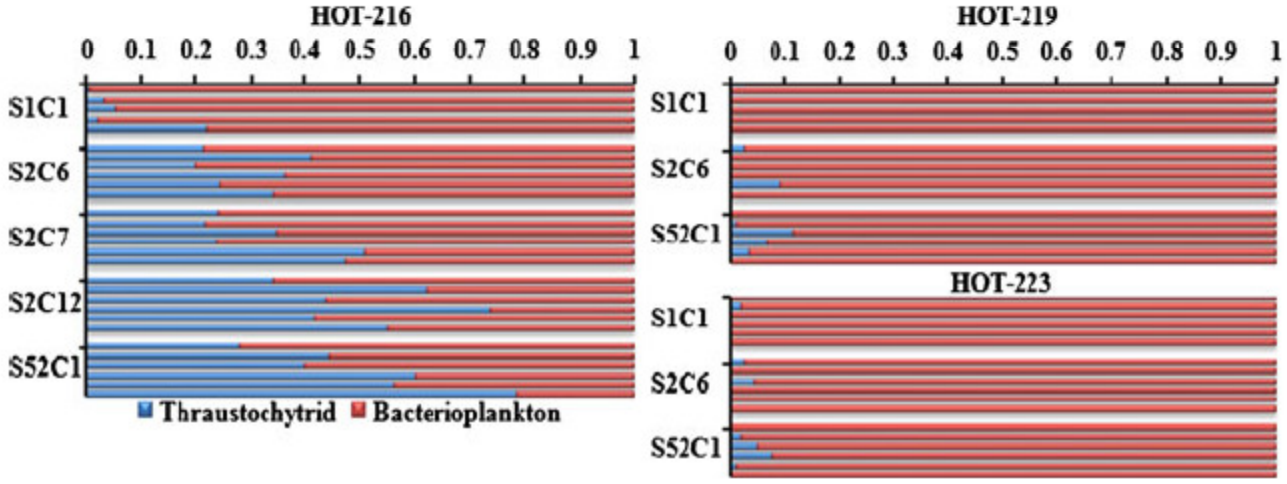


Thraustochytrids (cont'd)

Table 1 Extreme values occurrence of thraustochytrids abundance and biomass percentage during all three cruises (each cell displayed in value and location)

Features of Bacterioplankton and thraustochytrids	HOT-216 (November 2009)	HOT-219 (March 2010)	HOT-223 (July 2010)
Maximum thraustochytrid abundance (cells/L)	6.3×10^5, 100 m, S2C12	2.95×10^3, 75 m, S52C1	1.75×10^3, 100 m, S52C1
Minimum thraustochytrid abundance (cells/L)	1.89×10^3, 45 m, S1C1	UD	UD
Maximum bacterioplankton abundance (cells/L)	6.94×10^8, 75 m, S2C6	6.09×10^8, 45 m, S52C1	6.81×10^8, 125 m, S52C1
Minimum bacterioplankton abundance (cells/L)	1.45×10^8, 200 m, S1C1	2.41×10^8, 200 m, S1C1	1.41×10^8, 200 m, S1C1
Maximum thraustochytrid biomass percentage against bacterioplankton	365.1 %, 200 m, S52C1	13.49 %, 100 m, S2C12	8.36 %, 100 m, S2C12
Minimum thraustochytrid biomass percentage against bacterioplankton	0.79 %, 45 m, S1C1	UD	UD

UD unde[illegible]



(Li et al, 2013)

Thraustochytrids (cont'd)

Correlation analysis

Pearson Correlation	Bac	Tem	Sal	Oxy	CHLPIG	Nit
All three cruises	0.059	0.038	0.048	−0.022	0.089	*0.551*[a]
(*n*=66)	0.640	0.763	0.704	0.860	0.476	*0.000*
HOT-216	0.083	−0.063	0.069	0.124	0.157	*0.496*[b]
(*n*=30)	0.664	0.739	0.718	0.513	0.407	*0.014*
HOT-223	0.357	0.103	*0.523*[b]	*0.673*[a]	−0.091	−0.310
(*n*=18)	0.146	0.684	*0.026*	*0.002*	0.720	0.327
216-S1C1	*−0.837*[b]	*−0.872*[b]	*−0.875*[b]	−0.424	−0.016	0.792
(*n*=6)	*0.038*	*0.024*	*0.022*	0.402	0.976	0.061
216-S52C1	*−0.945*[a]	*−0.909*[b]	*−0.864*[b]	−0.398	0.084	ND
(*n*=6)	*0.005*	*0.012*	*0.027*	0.434	0.874	
223-S52C1	−0.418	0.050	*0.816*[b]	0.810	0.668	ND
(*n*=6)	0.410	0.925	*0.048*	0.051	0.147	

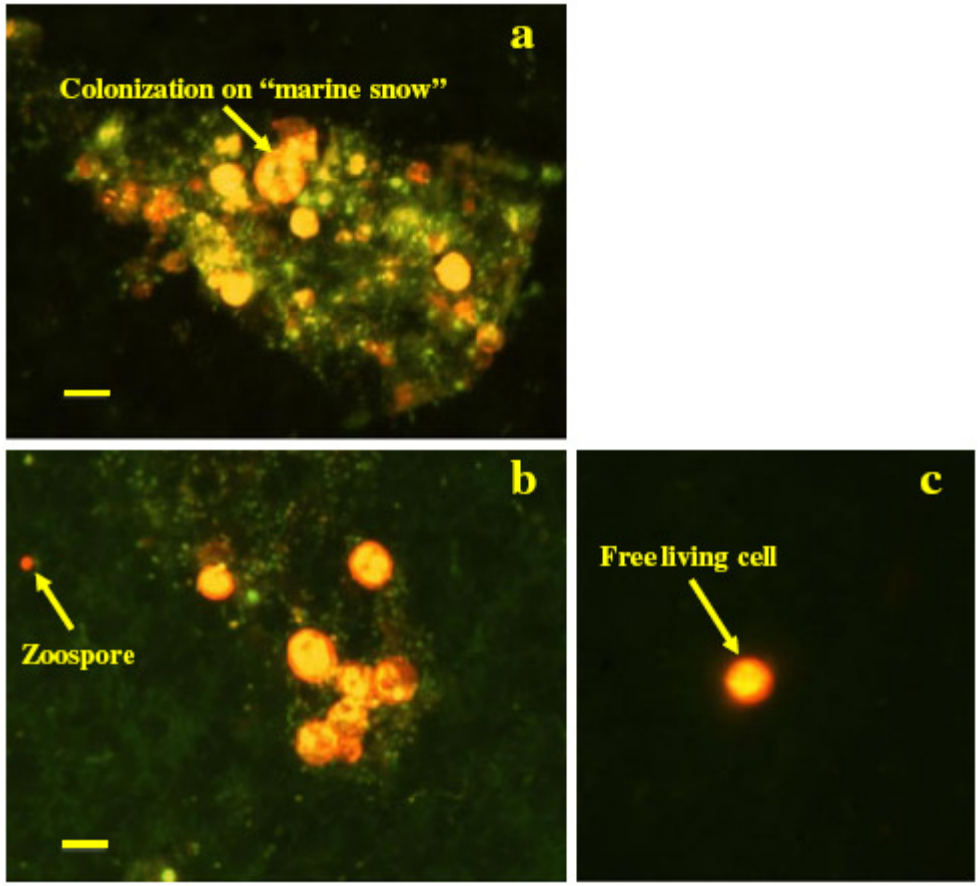
Significant values are marked in italics. The two rows at each cell represents "*r*" and "*p*" value, respectively

[a] Correlation is significant at the 0.01 (two-tailed)

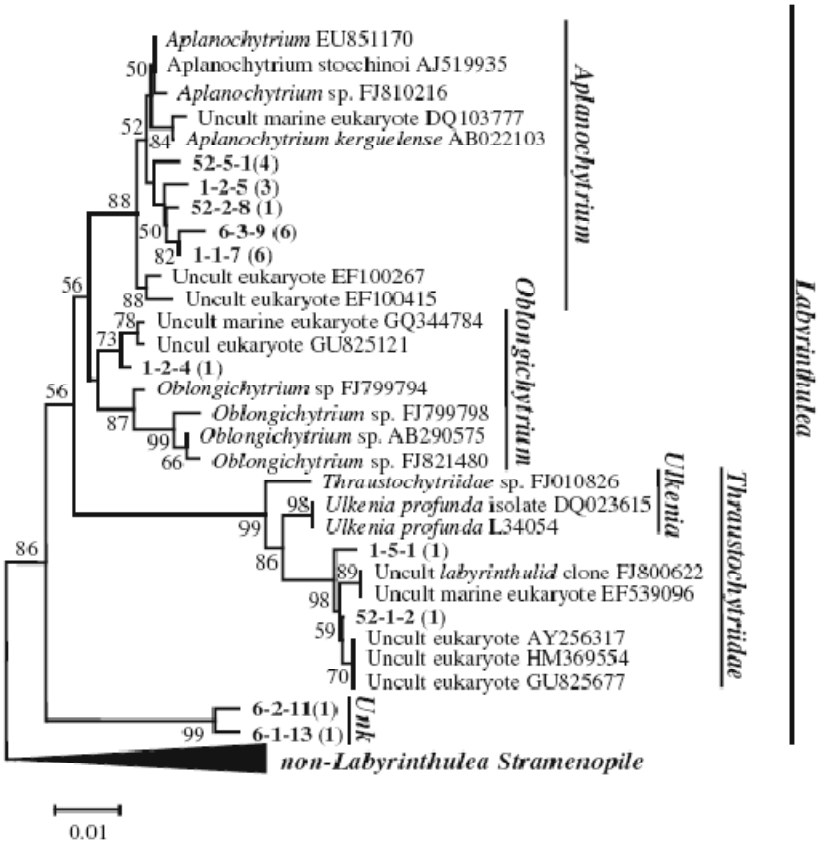
[b] Correlation is significant at the 0.05 (two-tailed)

(Li et al, 2013)

Thraustochytrids (cont'd)



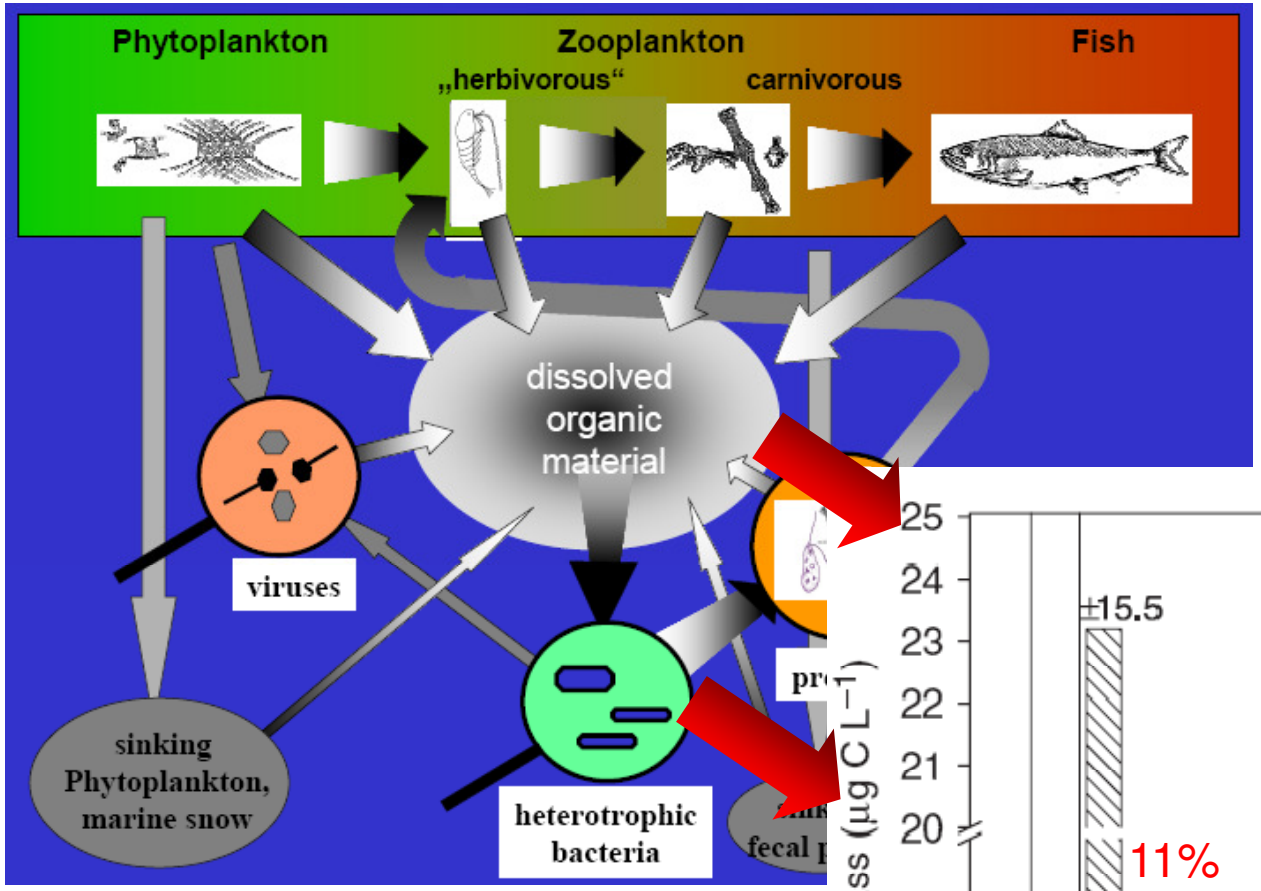
Living styles



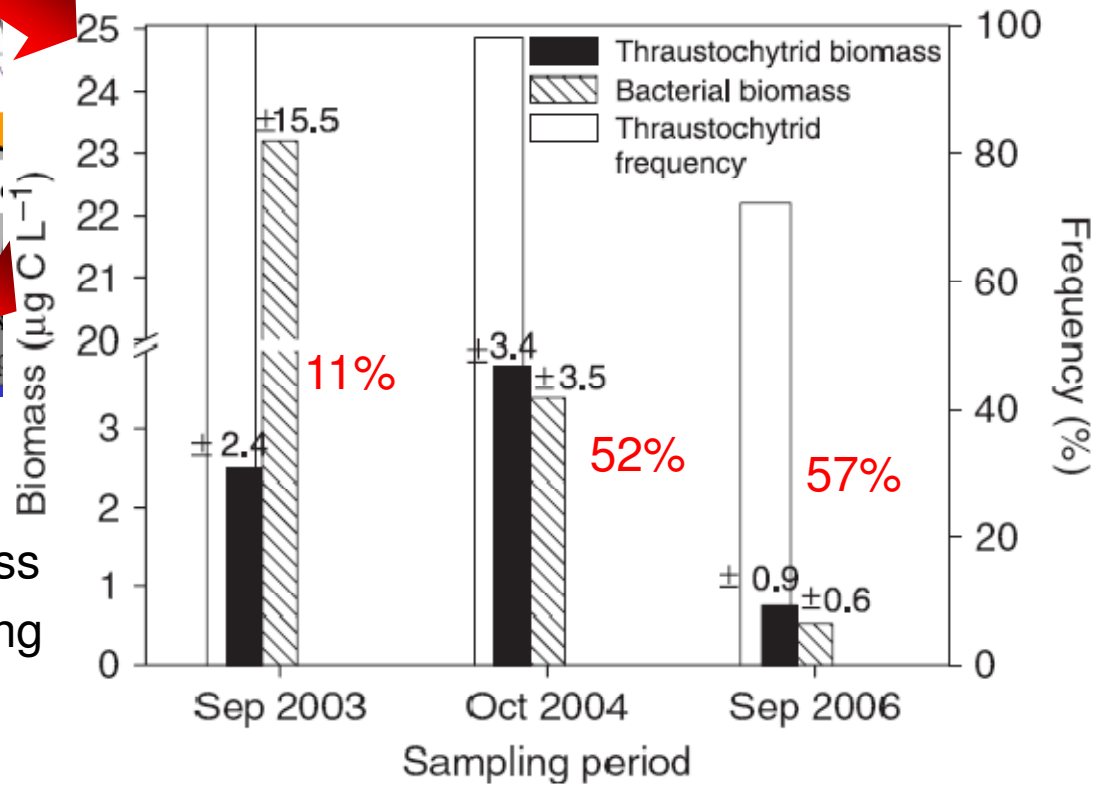
Low diversity

(Li et al, 2013)

Thraustochytrids (cont'd)

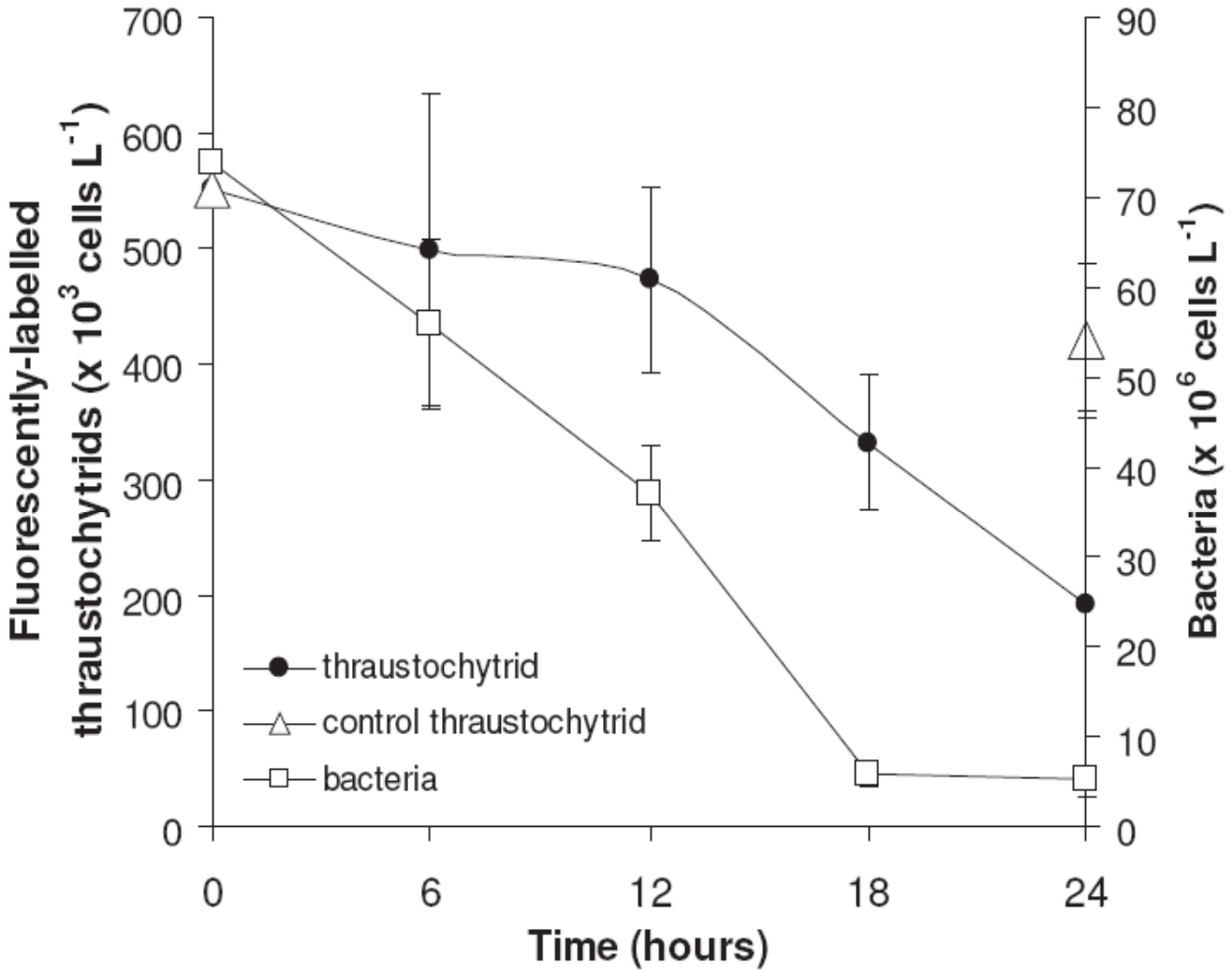


We are likely ignoring more than half of secondary production in the oceans!!!!



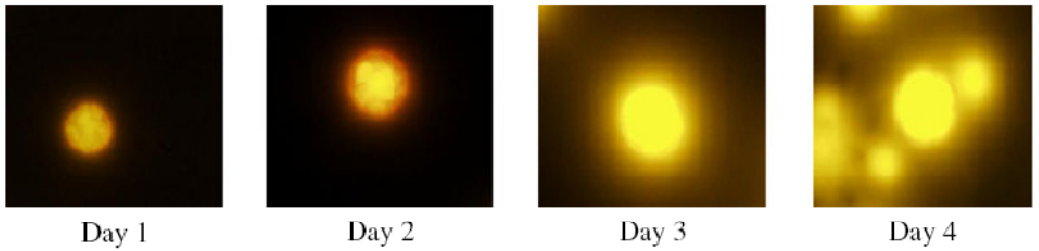
Thraustochytrid frequency and biomass with respect to bacterial biomass during three cruises (Damare 2008).

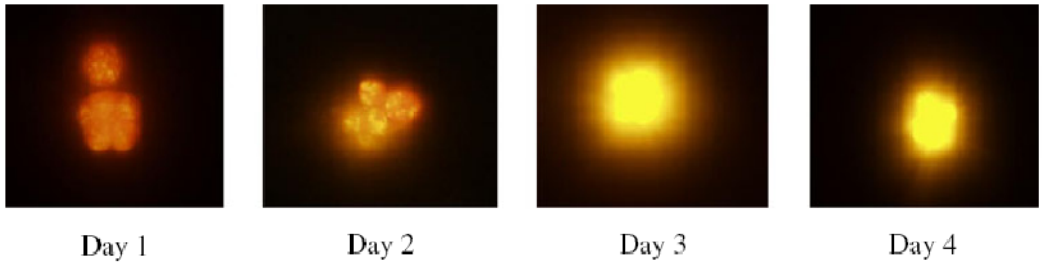
Thraustochytrids (cont'd)



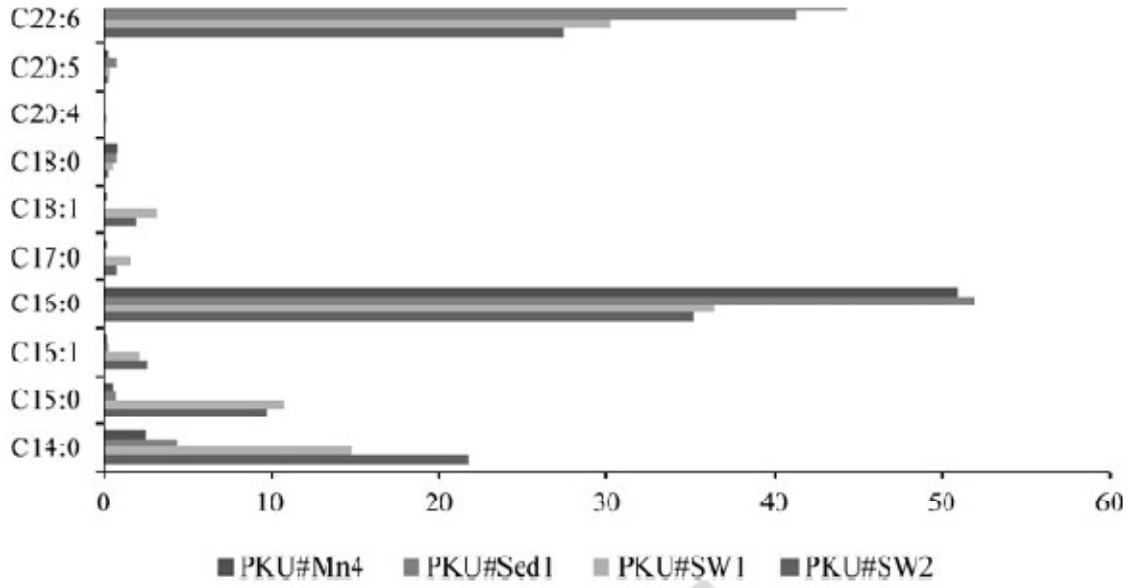
Changes in abundance of fluorescently-labeled thraustochytrids (FLT) and bacteria due to microzooplankton grazing with respect to time (Damare & Raghukumar, 2014).

Thraustochytrids (cont'd)





Nile red staining



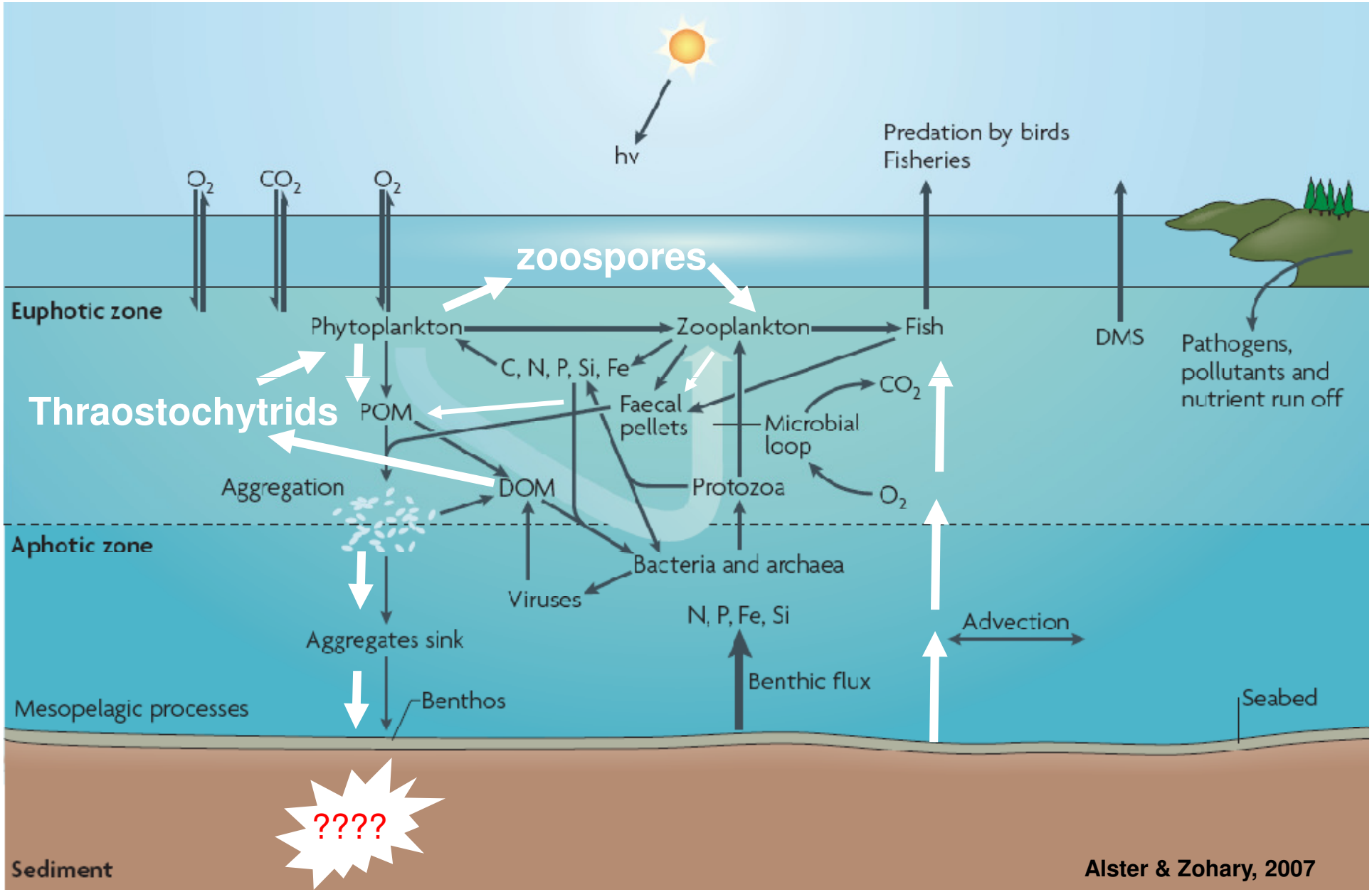
Fatty acid profile

Liu et al, 2013

Summary on Thraustochytrids

1. Significant role in ocean carbon cycling and seconday production (frequency and biomass), but with low diversity;
2. Unknown relationship with other biological environmental factor;
3. Rich in fatty acids and potential application in DHA and biodiesel production.

Mycoloop of Marine Food Web



Alster & Zohary, 2007

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