THE 8TH -
CHINA – JAPAN – KOREA IMBeR SYMPOSIUM

MARINE BIOGEOCHEMICAL SCIENCES FOR THE SUSTAINABILITY OF THE WEST PACIFIC BIOSPHERE

Living-resource and Ecosystem Dynamics on the Slope of the South China Sea

Vertical distribution of planktonic ciliates in the oceanic and slope areas of the western Pacific Ocean

西太平洋海区至陆坡浮游纤毛虫的垂直分布

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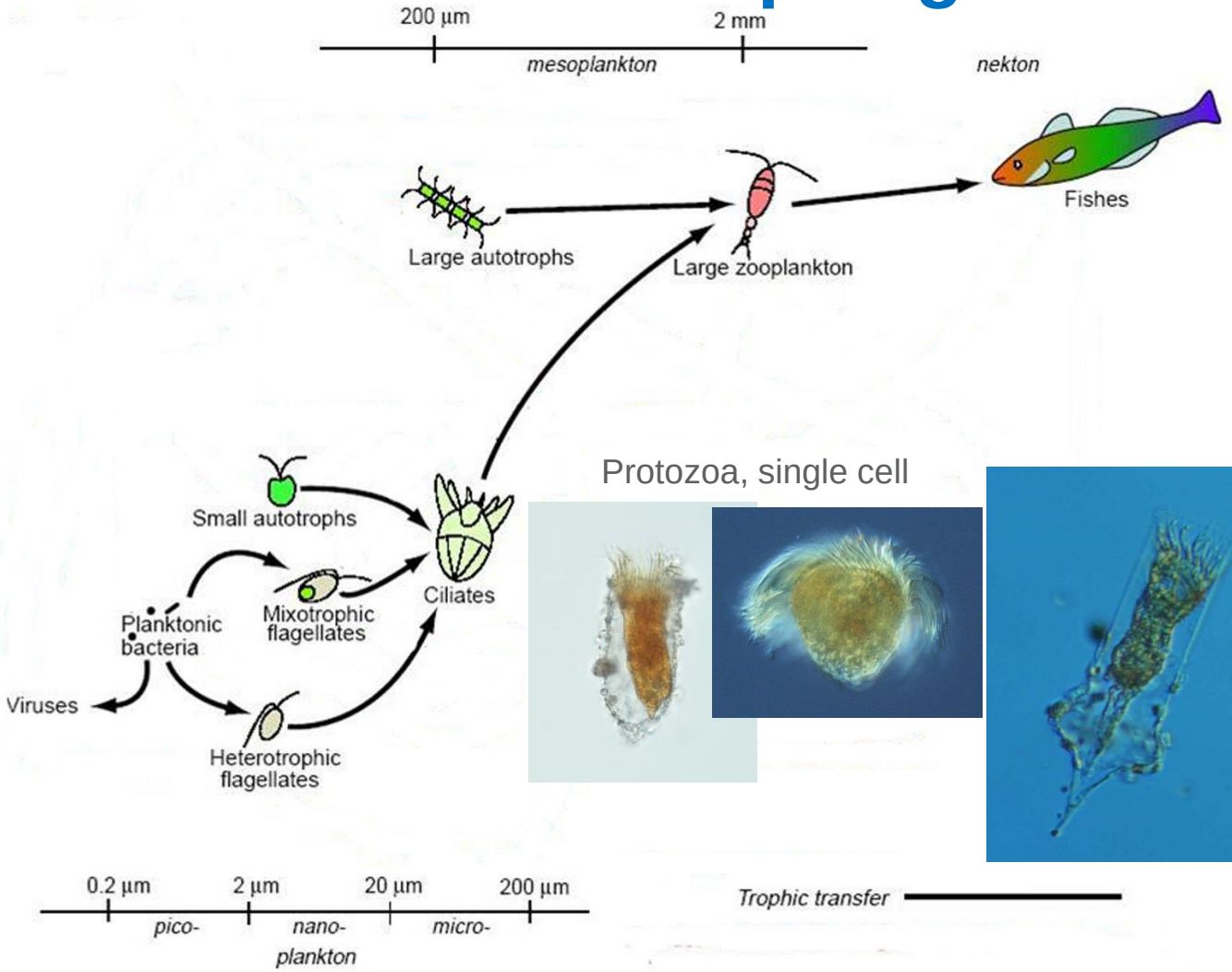
2018-9-18

中国科学院海洋研究所
INSTITUTE OF OCEANOLOGY,CHINESE ACADEMY OF SCIENCES

KLMEES

Ciliates in the marine pelagic ecosystem

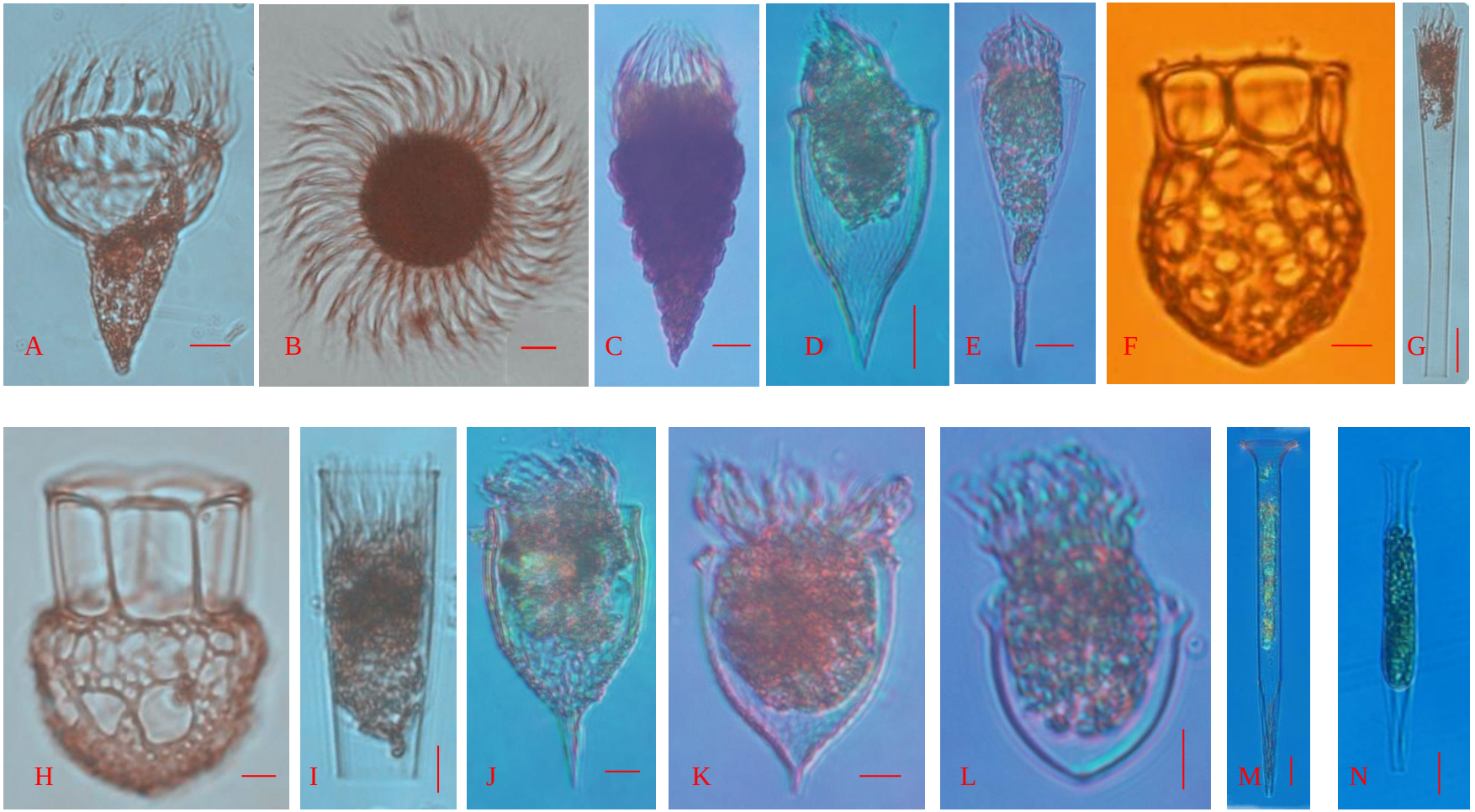


Protozoa, single cell

Stenseth, Nils. 2004. Marine Ecosystems and Climate Variation: The North Atlantic. A Comparative Perspective. OUP Oxford.

Photos of some planktonic ciliate

无壳纤毛虫和砂壳纤毛虫图片



Bar=10 μm

Taxonomy
Protozoa- heterotrophic, single cell
Ecologically-Microzooplankton

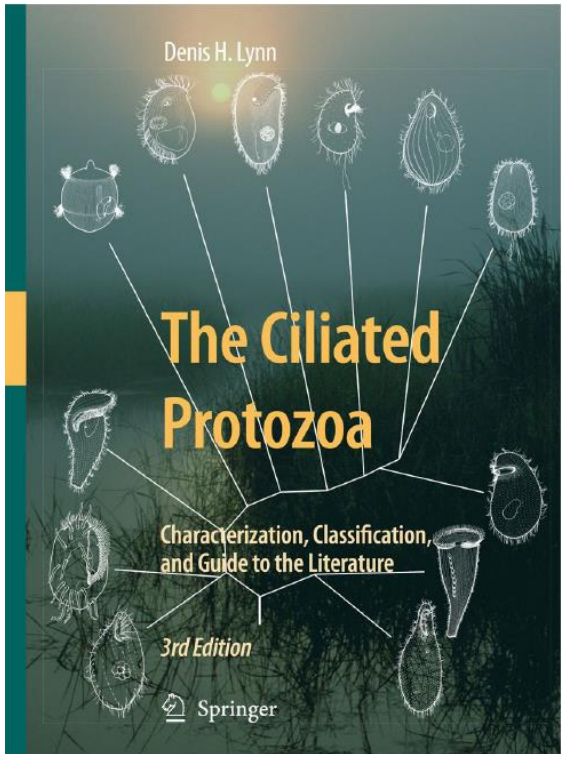
Phylum CILIOPHORA Doflein, 1901

Class **SPIROTRICHEA** Bütschli, 1889

Subclass Choreotrichia Small & Lynn, 1985
- Order Tintinnida Kofoid & Campbell, 1929
- Order Choreotrichida Small & Lynn, 1985
  - Suborder Leegaardiellina Laval-Peuto, Grain, & Deroux, 1994
  - Suborder Lohmanniellina Laval-Peuto, Grain, & Deroux, 1994
  - Suborder Strobilidiina Small & Lynn, 1985
  - Suborder Strombidinopsina Small & Lynn, 1985

Subclass Stichotrichia Small & Lynn, 1985
- Order Stichotrichida Fauré-Fremiet, 1961
- Order Sporadotrichida Fauré-Fremiet, 1961
- Order Urostylida Jankowski, 1979

Subclass Oligotrichia Bütschli, 1887/1889
- Order Strombidiida Petz & Foissner, 1992



3rd ed. 2008, XXXIII, 605 p.

Taxonomy: two groups

- **tintinnids** with shell

- **aloricate ciliate** without shell

An Illustrated Guide to

Contemporary Tintinnids in the World

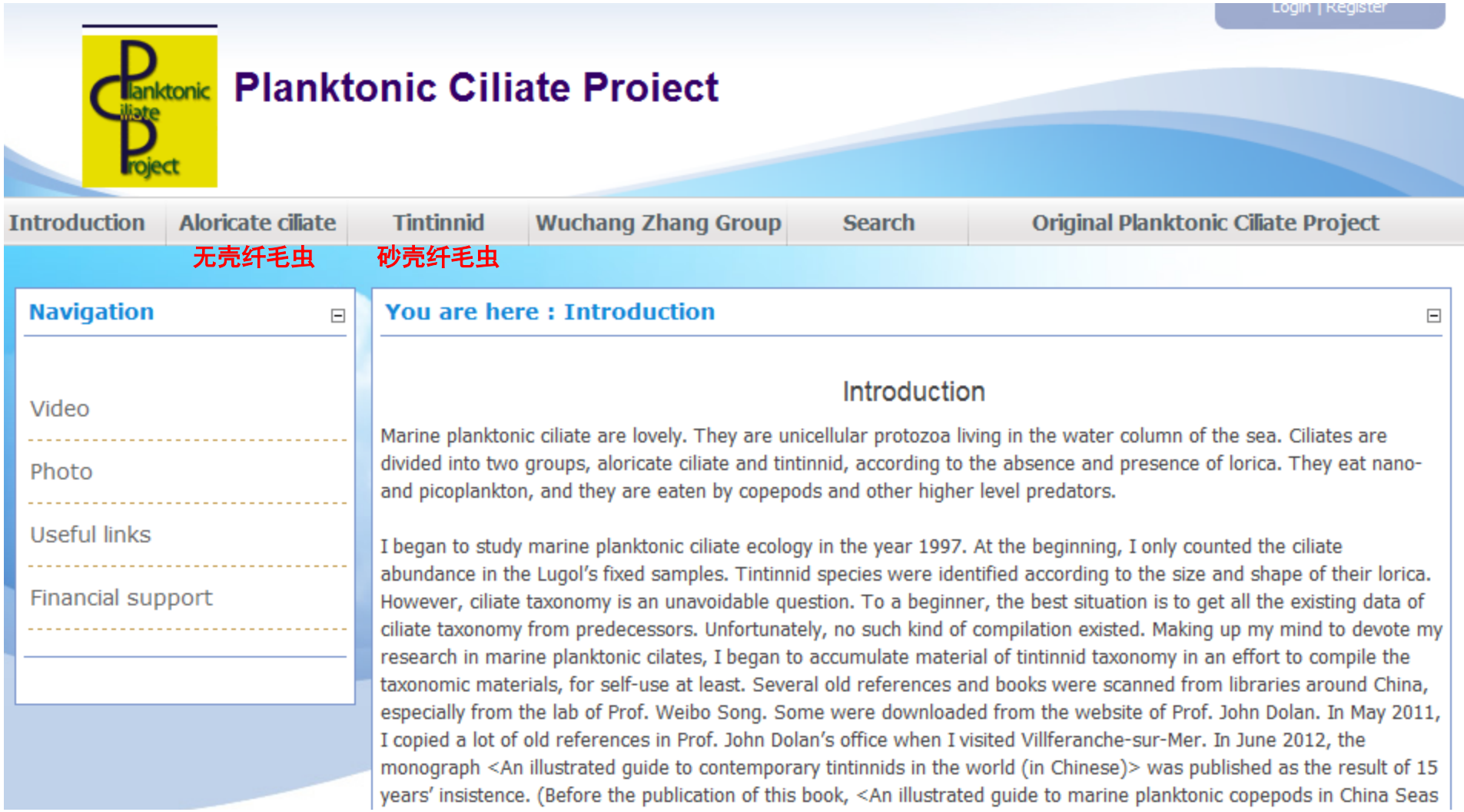
2012，930 species

An Illustrated Guide to Marine Planktonic Aloricate Oligotrich Ciliates

2015， 144 species

Planktonic Ciliate Project Website

http://www.zooplankton.cn/Default.aspx?tabid=604

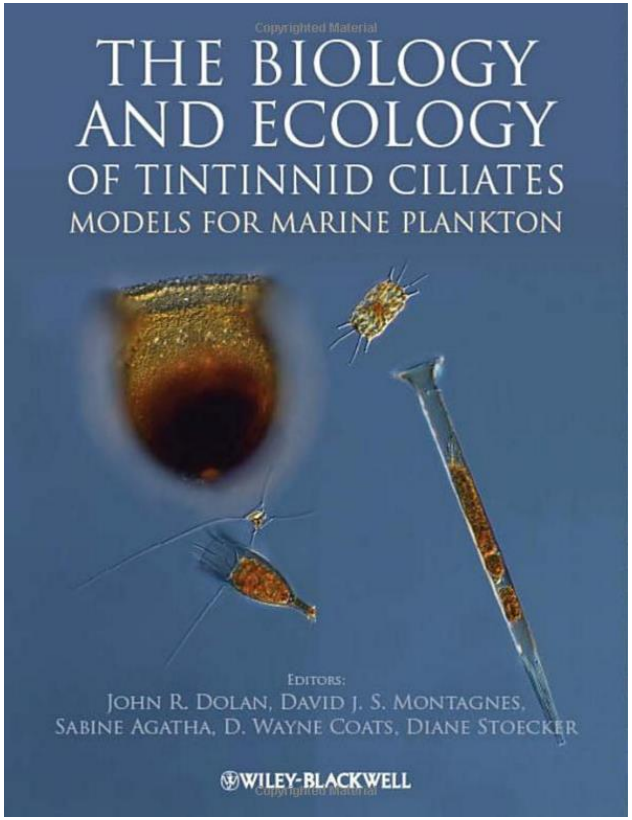


Biogeography---usually horizontal direction

- no study in aloricate ciliate
- genera level in tintinnids

Table 10.1 Biogeographic distribution patters of common tintinnid genera; genera considered were those that included species reported in at least four publications by two different authors.

Cosmopolitan	Neritic	Warm water	Boreal	Austral
Acanthostomella	*Favella*	*Amplectella*	*Parafavella*	*Cymatocylis*
Amphorellopsis	*Helicostomella*	*Ascampbelliella*	*Ptychocylis*	*Laackmanniella*
Amphorides	*Leprotintinnus*	*Brandtiella*		
Codonella	*Metacylis*	*Canthariella*		
Codonellopsis	*Stenosemella*	*Climacocylis*		
Dadayiella	*Stylicauda*	*Codonaria*		
Dictyocysta	*Tintinnidium*	*Cyttarocylis*		
Eutintinnus	*Tintinnopsis*	*Daturella*		
Parundella		*Epicancella*		
Protorhabdonella		*Epiplocylis*		
Salpingacantha		*Epiplocyloides*		
Salpingella		*Petalotricha*		
Steenstrupiella		*Poroecus*		
		Proplectella		
		Rhabdonella		
		Rhabdonellopsis		
		Undella		
		Undellopsis		
		Xystonella		
		Xystonellopsis		



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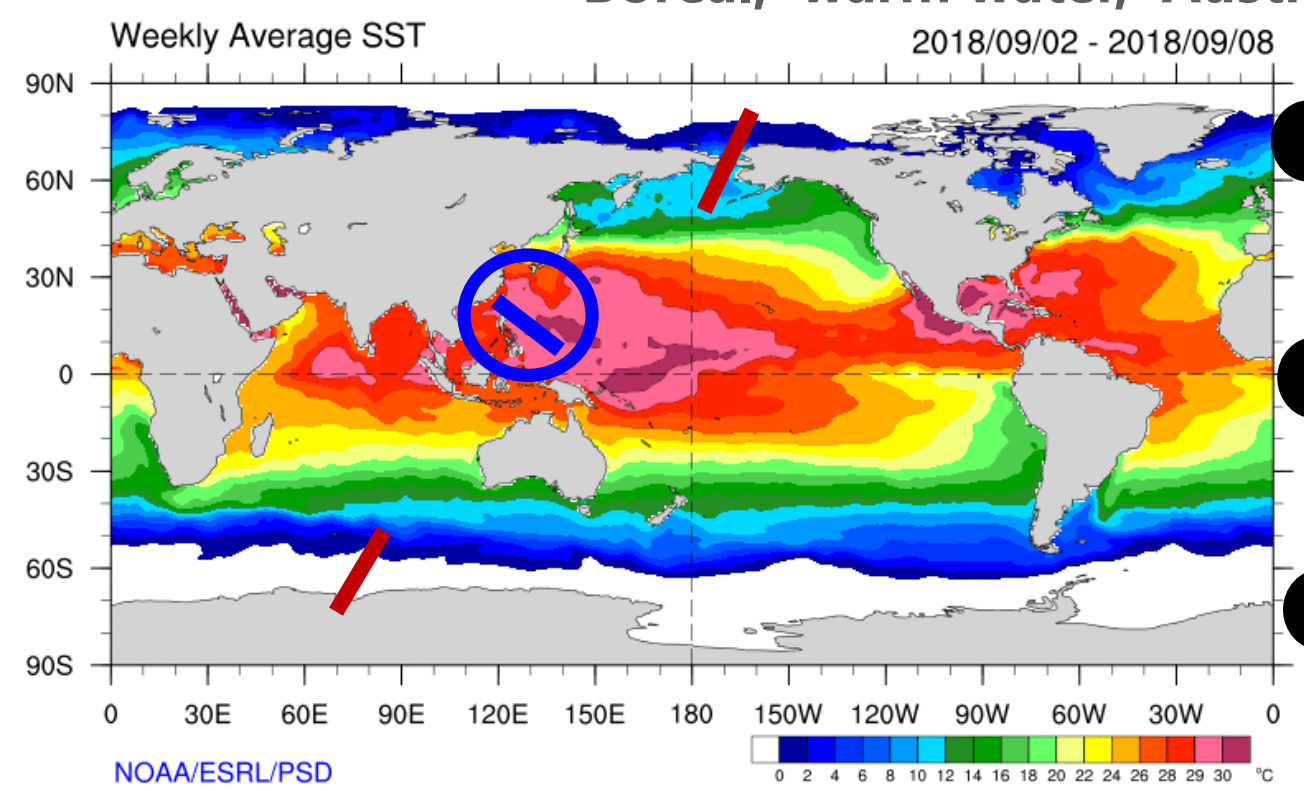
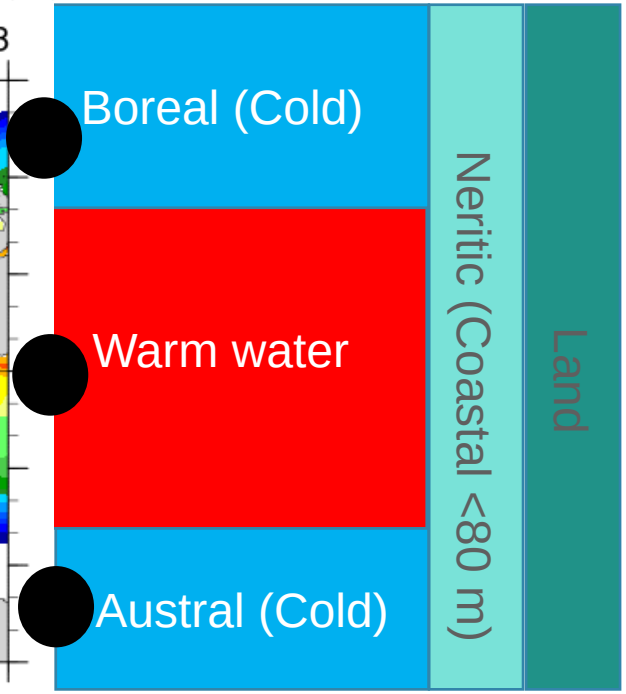
Horizontal temperature gradient vs. Tintinnid genera biogeography

How about their vertical distribution???

Boreal, warm water, Austral





https://www.ametsoc.org/amsedu/DS-Ocean/home.html

Working status

- Boreal (Arctic): **manuscript is submitted** to Polar Biology
- Warm water: **published** Wang CF, Li H, Zhao L, Zhao Y, Dong Y, Zhang WC, Xiao T. 2018. Vertical distribution of planktonic ciliates in oceanic and slope area in the tropical west Pacific. Deep Sea Rea II. DOI: https://doi.org/10.1016/j.dsr2.2018.08.002
- Austral (Antarctic): **published** Liang C, Li H, Dong Y, Zhao Y, Tao Z, Li C, Zhang W, Gregori G. Planktonic ciliates in different water masses in open waters near Prydz Bay (East Antarctic) during austral summer, with an emphasis on tintinnid assemblages. Polar Biology online

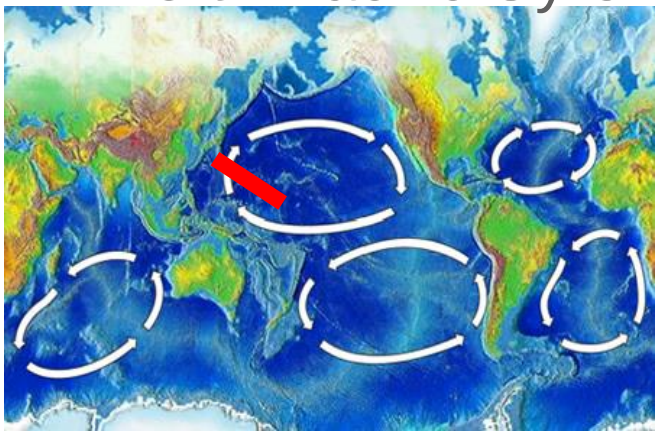
Vertical distribution of planktonic ciliates

in the oceanic and slope areas of the western Pacific Ocean

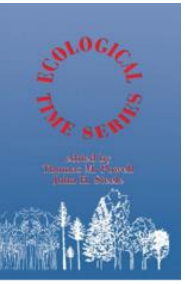
in warm water

Western Pacific Background

1 North Pacific Gyre



Five gyres in warm water



Scales of Variability in a Stable Environment / 151

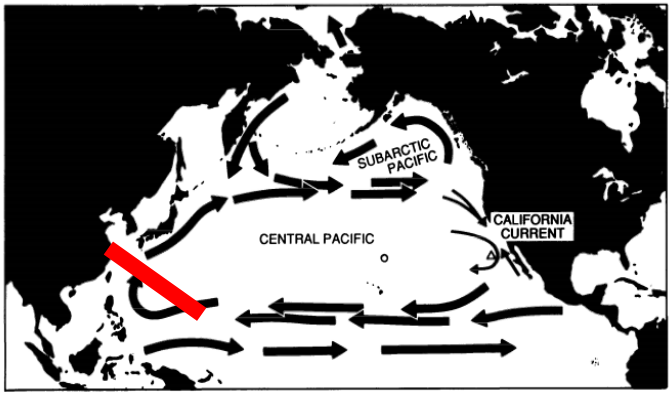
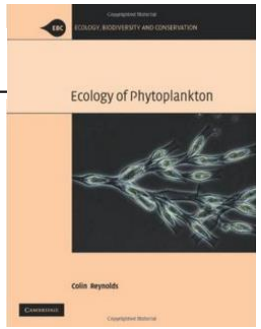


Figure 10-1. Major circulation patterns of the North Pacific. The circle marks the location of the Climax station, near the axis of the central North Pacific gyre. The triangle marks the location of the Edge station, near the eastern edge of the gyre.

2 Phytoplankton Climax

beyond. As with the other major oceanic gyres, the severe nutrient deficiencies and low supportive capacities of the surface waters of the North Pacific have long been appreciated (TN < 3 μM, TP < 0.3 μM, SRSi < 20 μM: Sverdrup *et al.*, 1942). On the other hand, the water has a high clarity (ε_{min} ~0.1 m^{-1}: Tyler and Smith, 1970, quoted by Kirk, 1994). Its low planktic biomass and weak areal production have also been accepted (Doty, 1961; Beers *et al.*, 1982; Hayward *et al.*, 1983). The supposed constancy of these conditions nurtured an idea that the system had achieved the steady state of a successional climax (Venrick, 1995). There

SPECIES COMPOSITION AND TEMPORAL CHANGE | 305



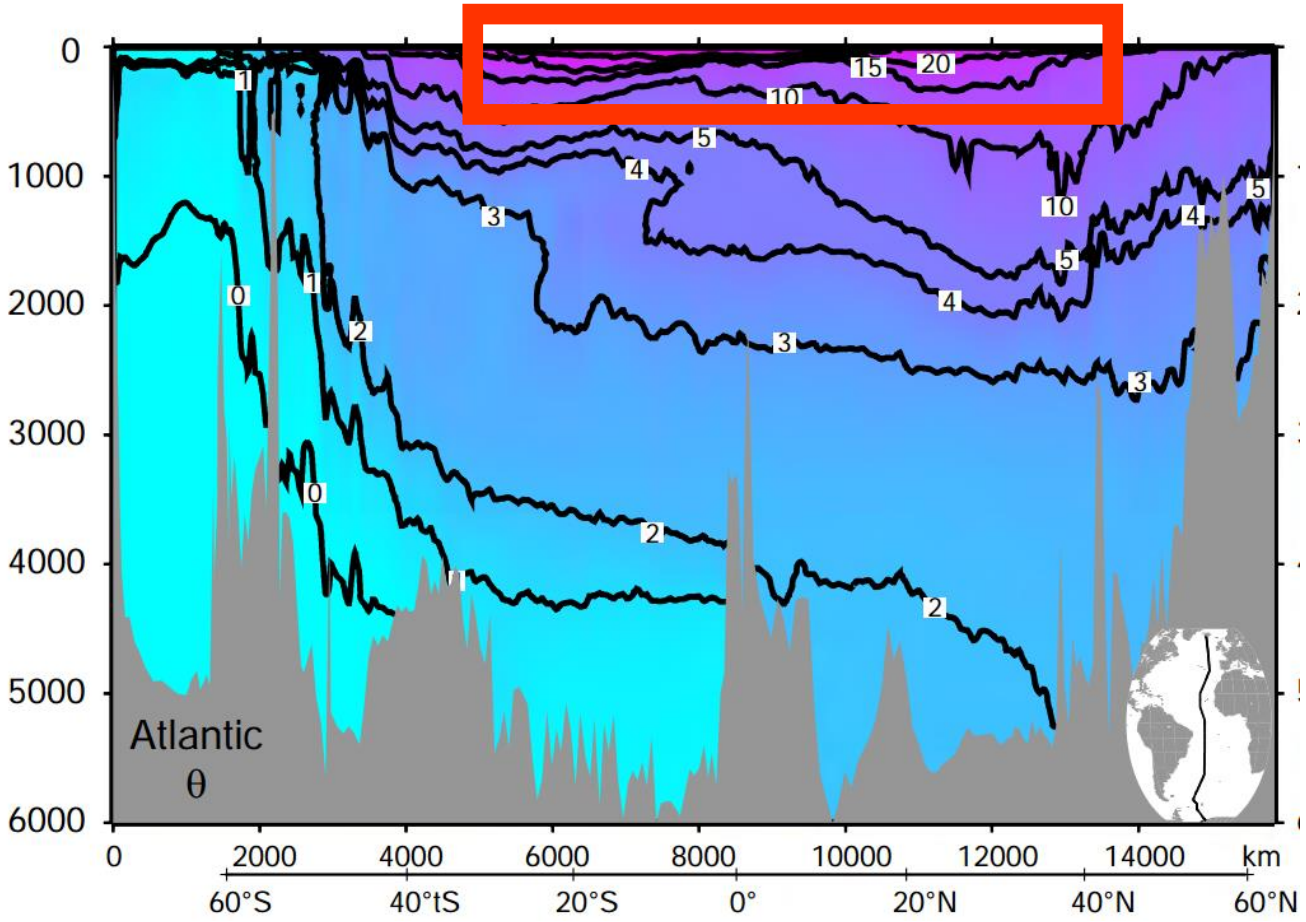
Venrick EL. 1995. Scales of variability in a stable environment: phytoplankton in the central North Pacific. In Ecological Time Series. Powell TM and Steele JH. Eds. New York: Chapman and Hall

Reynolds CS. 2006. The ecology of Phytoplankton. Cambridge University Press. Cambridge, New York, Melbourne, Madrid, Cape Town, Singapore, San Paulo.

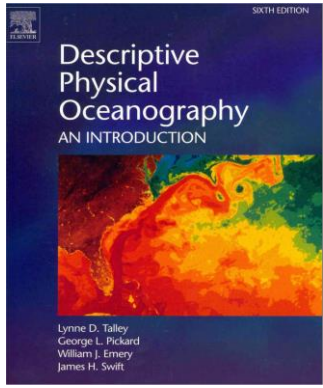
The warm water was vertically stratified

Vertical stratification
vs.
Ciliate vertical biogeography

Horizontal temperature gradient
vs.
Tintinnid genera biogeography

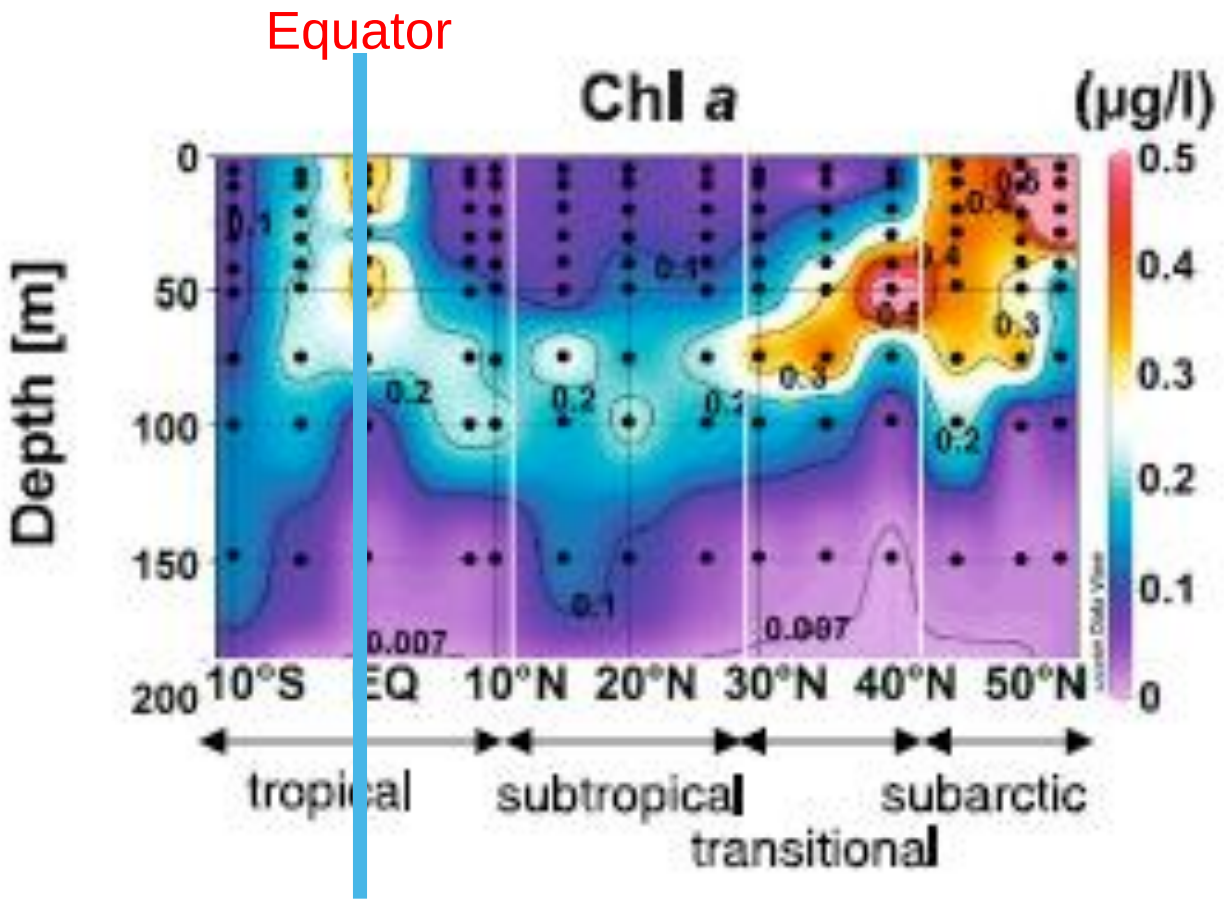


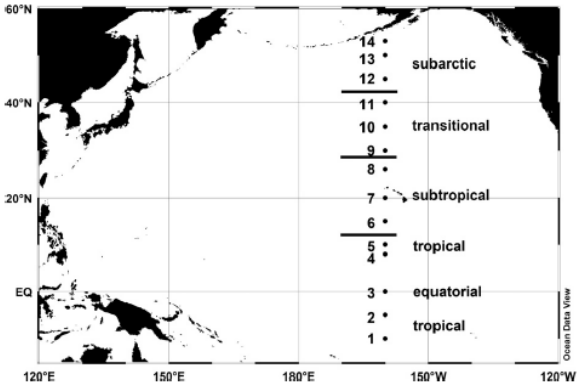
Atlantic Temperature



2011年

Deep Chlorophyll a Maximum (DCM) Layer





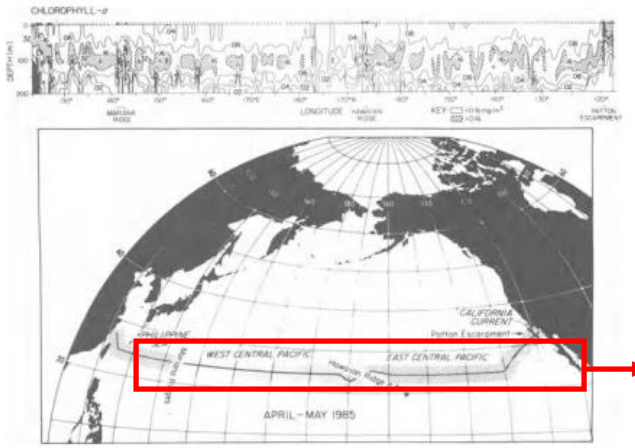
Deep-Sea Research II 57 (2010) 1537–1550
Contents lists available at ScienceDirect
Deep-Sea Research II
journal homepage: www.elsevier.com/locate/dsr2

Full-depth profiles of prokaryotes, heterotrophic nanoflagellates, and ciliates along a transect from the equatorial to the subarctic central Pacific Ocean

Rumi Sohrin [a,*], Manabu Imazawa [a], Hideki Fukuda [b], Yoshimi Suzuki [a]

Two groups of phytoplankton species according to position of abundance peak

1 Surface



Stations

Figure 10-5. Cruise track and vertical distribution of chlorophyll across the central North Pacific. (Adapted from Figs. 1 and 3, in E. L. Venrick, 1991, Mid-ocean ridges and their influence on the large-scale patterns of chlorophyll and production in the North Pacific, *Deep-Sea Research* 38, Supp. 1:S83–S109, with kind permission from Pergamon Press Ltd., Headington Hill Hall, Oxford OX3 OBW, U.K.).

2 DCM

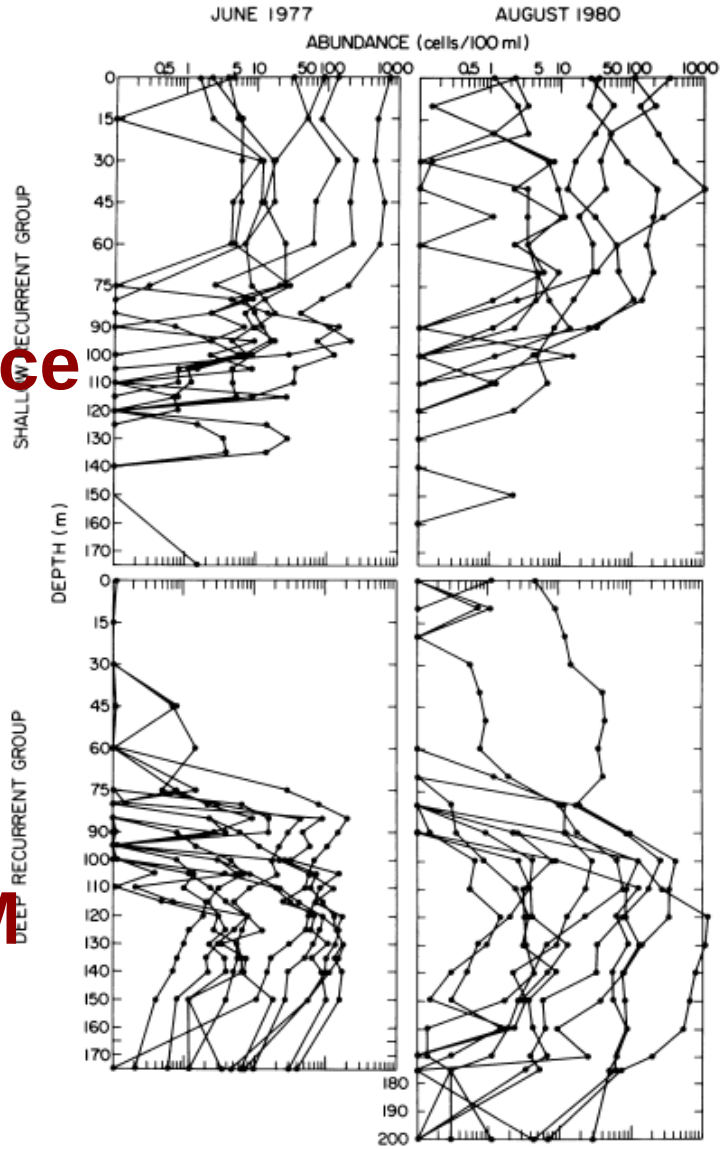


Figure 10-6. Vertical distribution of species classified into the first two recurrent groups in June 1977 and August 1980 (adapted from Fig. 2 in Venrick 1986, by permission).

Venrick EL, 1988. The vertical distributions of chlorophyll and phytoplankton species in the North Pacific central environment. J. Plankton. Res. 10(5), 987-99

Venrick EL., 1995. Scales of variability in a stable environment: phytoplankton i the central North Pacific. In Ecological Time Series. Powell TM and Steele JH. Eds. Pp. 150-180. New York: Chapman and Hall

Questions & Hypothesis

- Q1: is there depth distribution for ciliates?

  Status: no data. Only studied in Mediterranean Sea

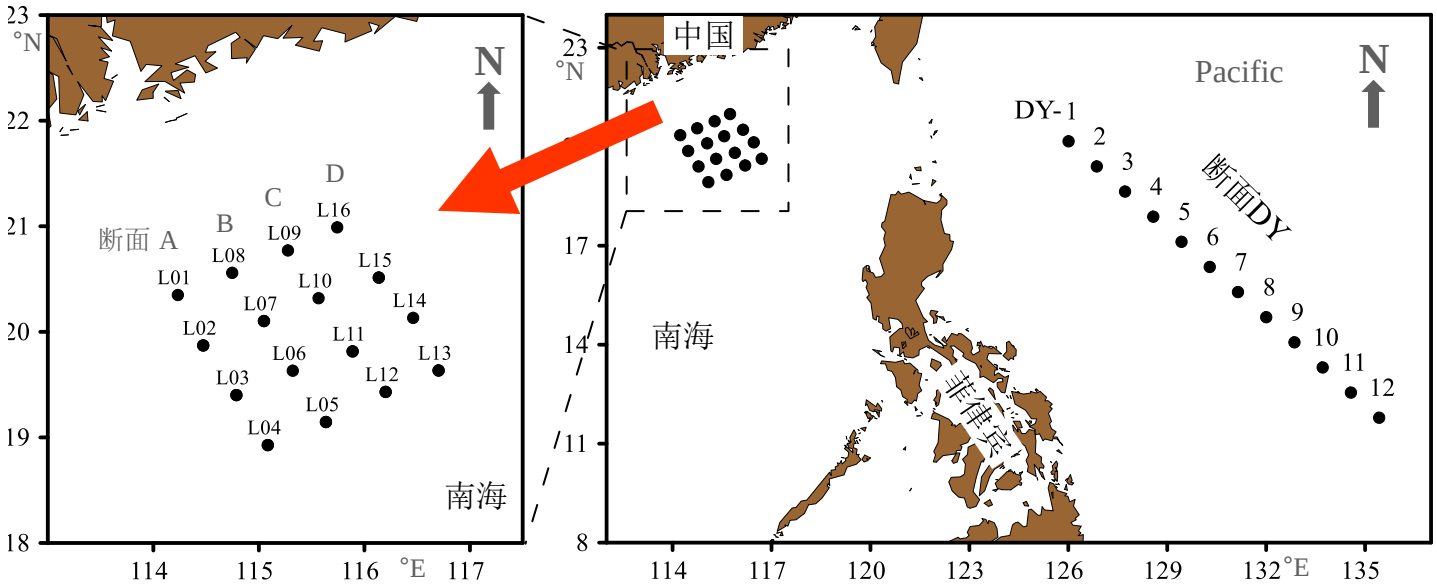
  Hypothesis: surface peak and DCM peak

- Q2: how about it in the slope (edge of the gyre)?

  Status: no data.

  Hypothesis: influence from the shelf waters

Sampling area

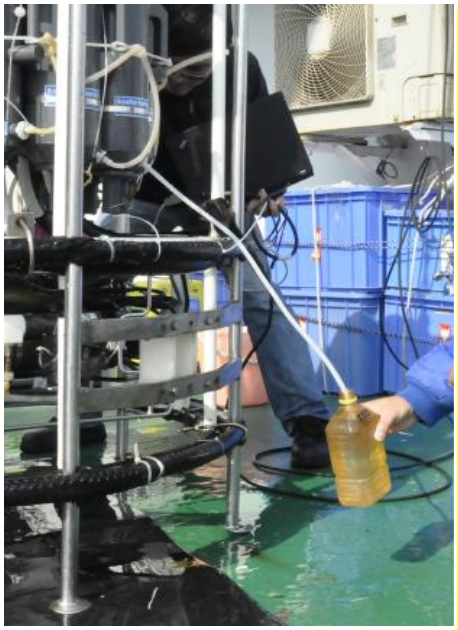


10 Jun - 1 Jul 2015

28 Nov- 31 Dec 2015

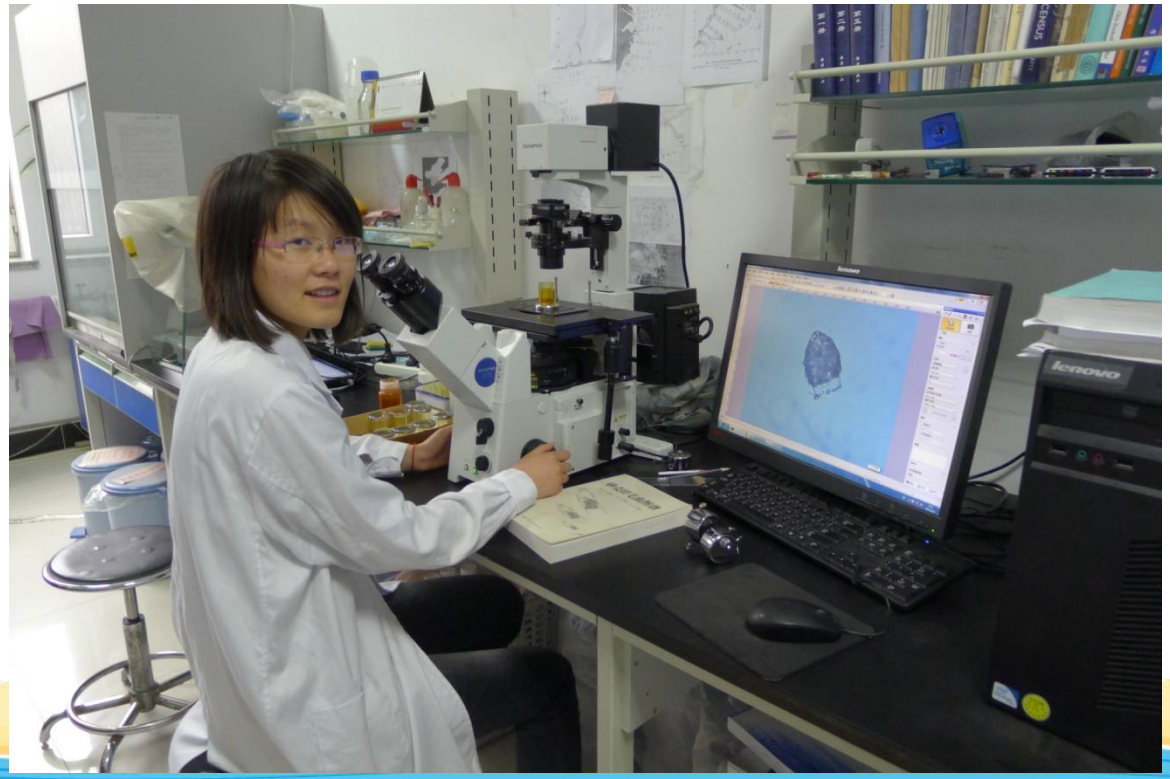
Sampling method:

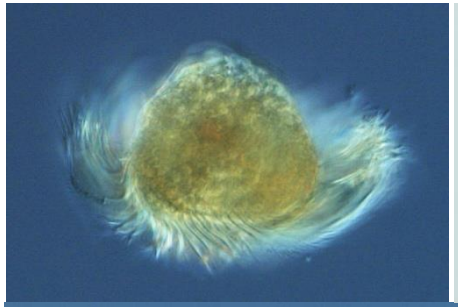
Water sample 1 L from rosette bottles
Fixed with Lugol's solution

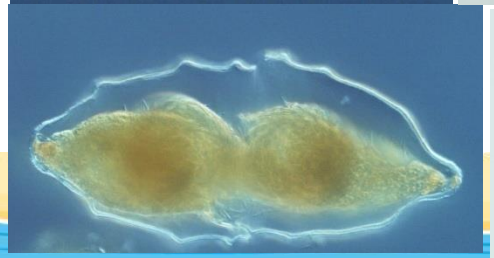




Counting in the lab

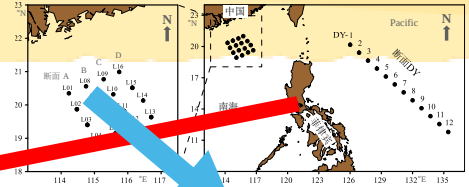
- Inverted microscope

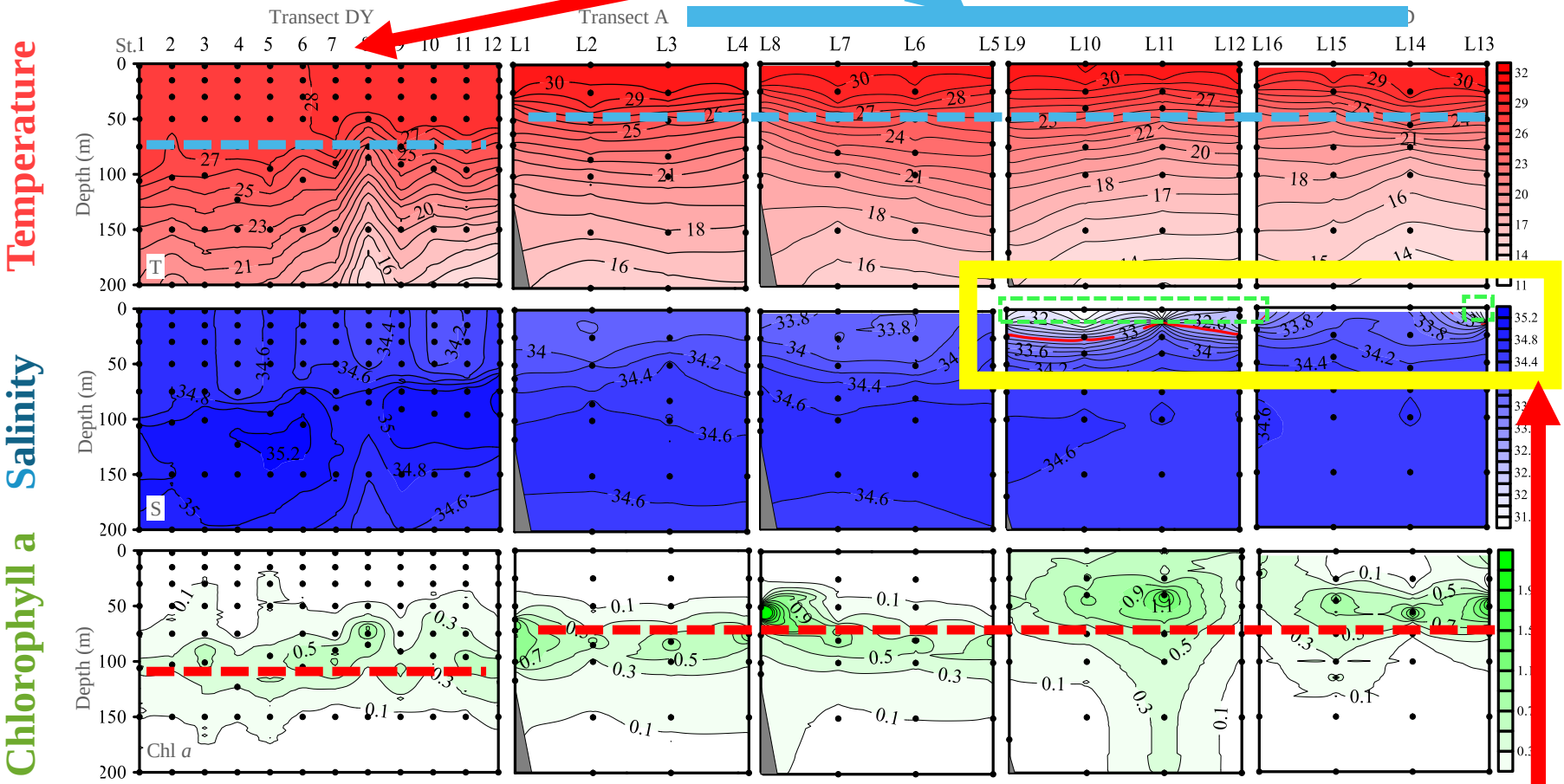






Hydrology

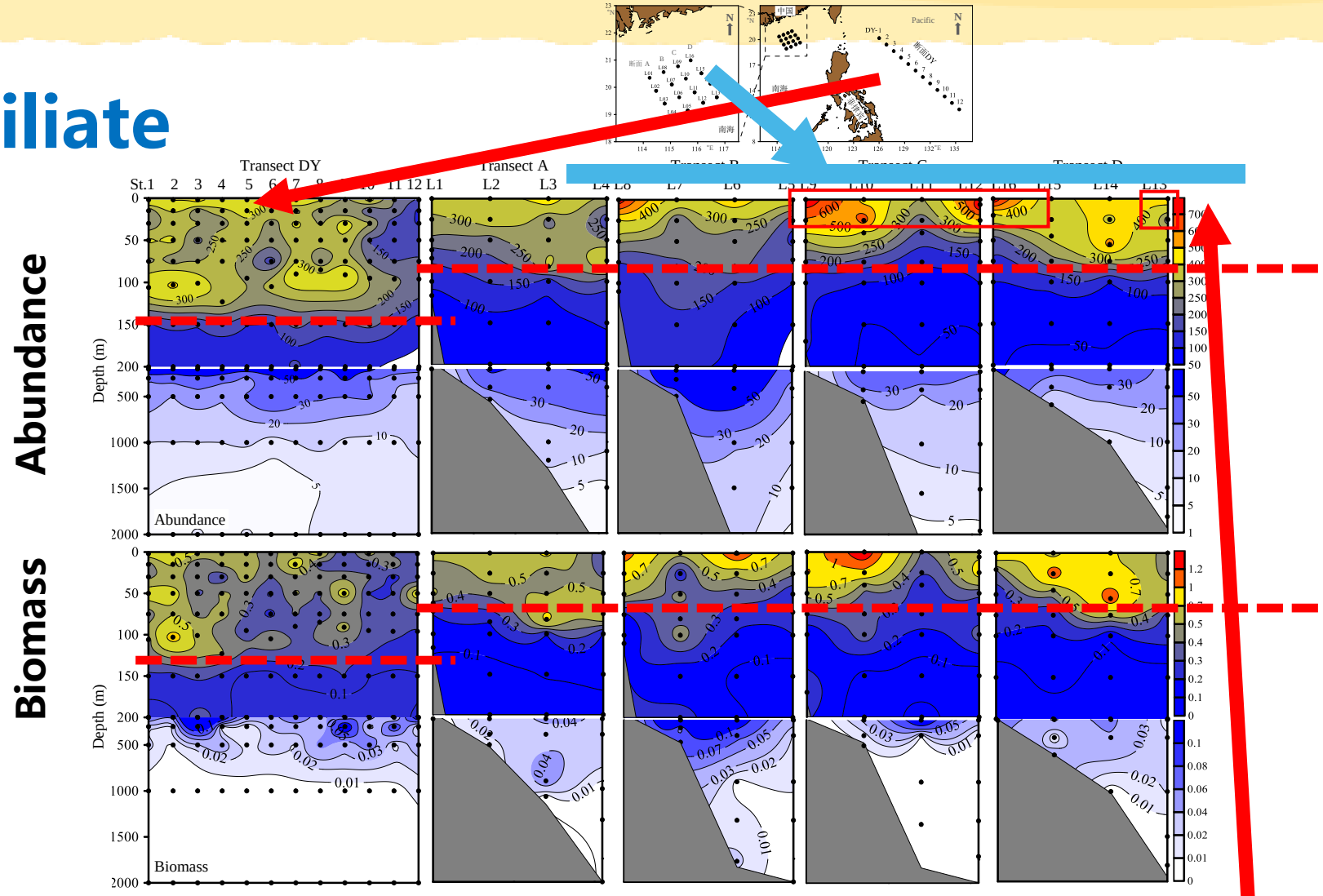




Thermocline and DCM shoaling in the slope waters

Low salinity water from shelf

Ciliate



High abundance in the mixed layer

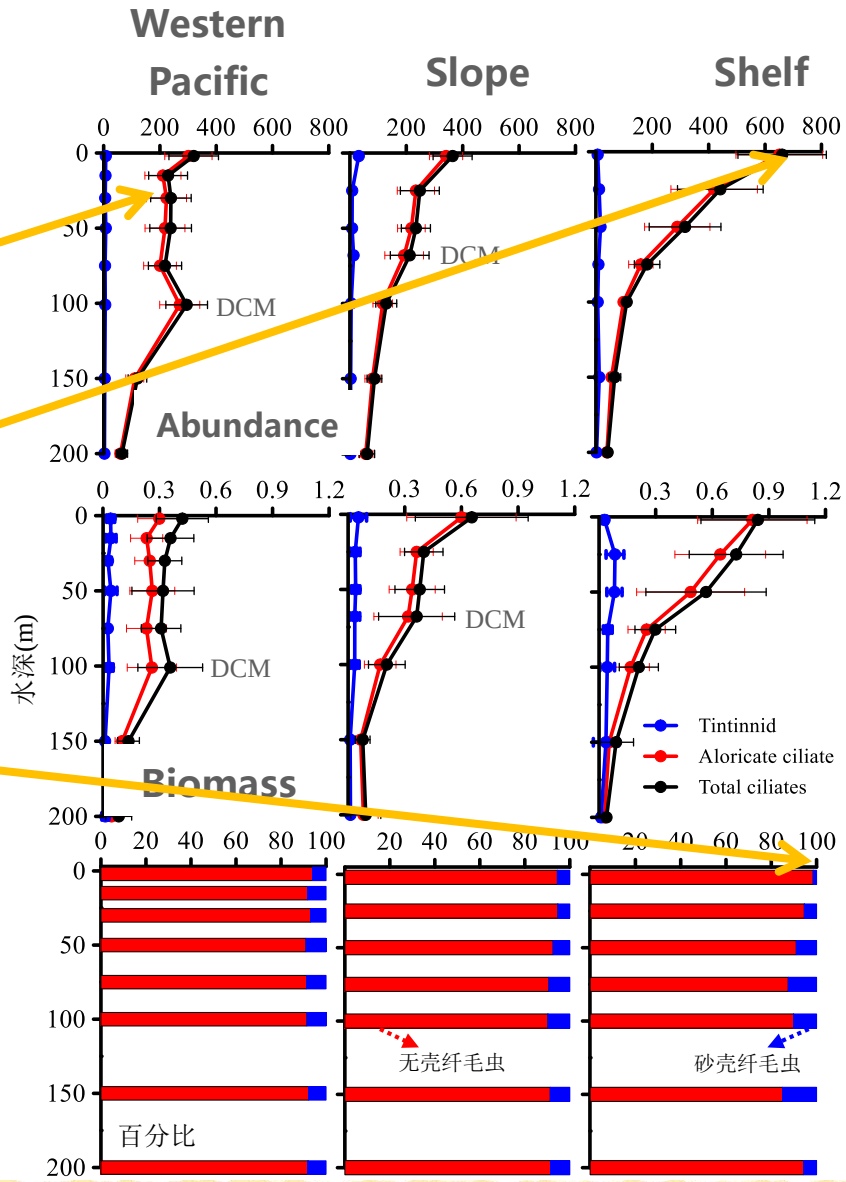
High abundance in the shelf water

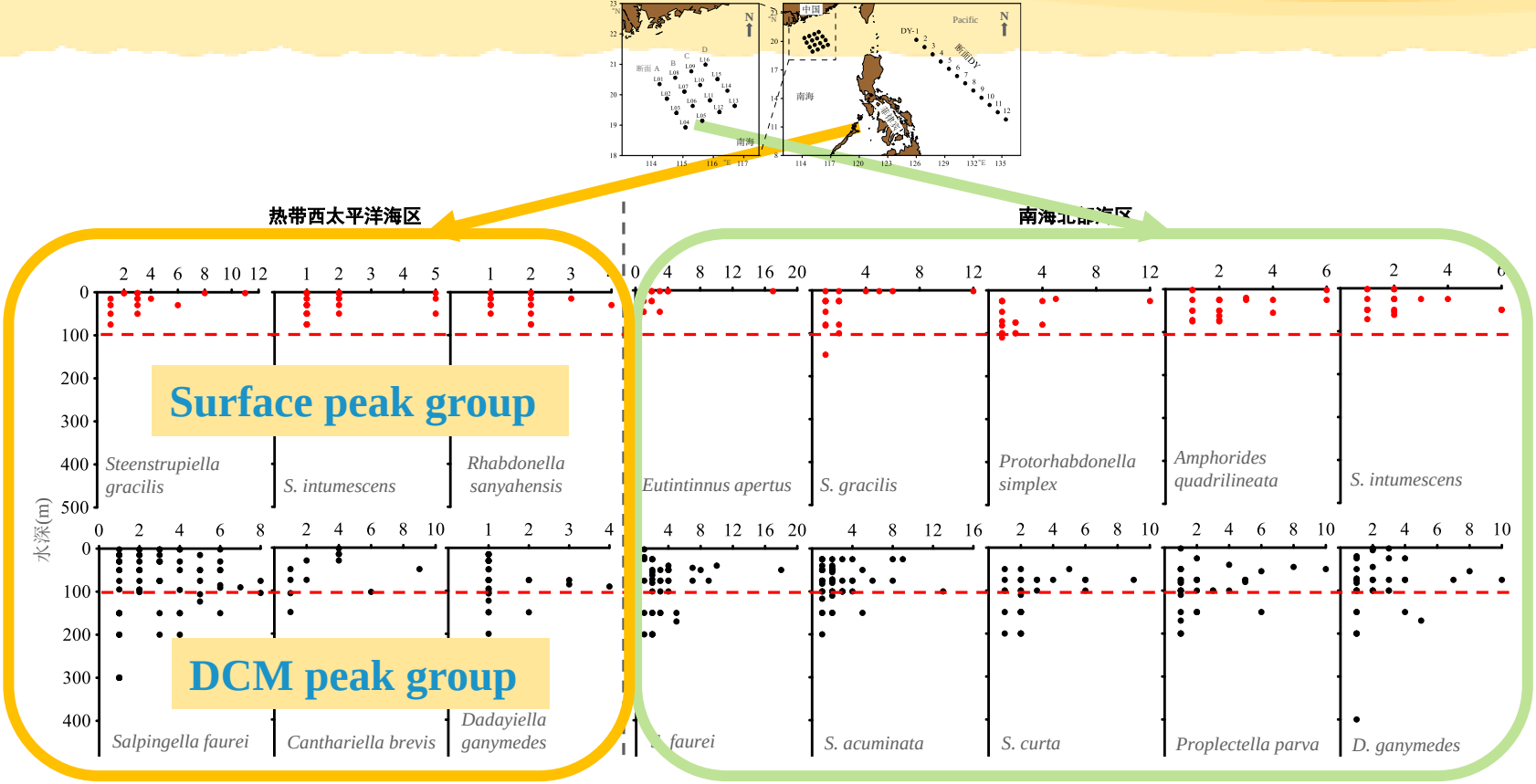
Depth distribution profiles

Bimodal in the western Pacific

Surface peak in the Shelf waters

Low tintinnid percentage in surface of Shelf waters





Tintinnids

Surface peak group and DCM peak group had different species

Questions and Answers

- **Q 1: is there depth distribution for ciliates?**

  1) Tintinnid have two groups: surface peak-DCM peak

  2) Aloricate ciliate may have similar groups.

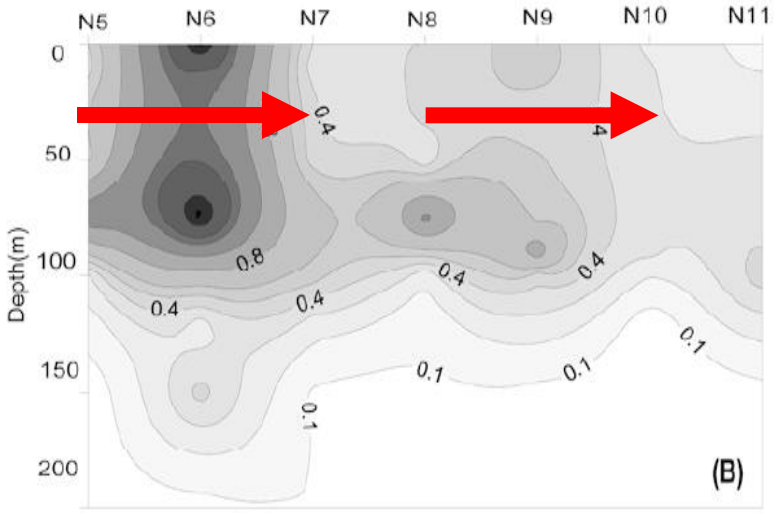
- **Q 2: how about it in the slope (edge of the gyre)?**

  1) also have two groups,

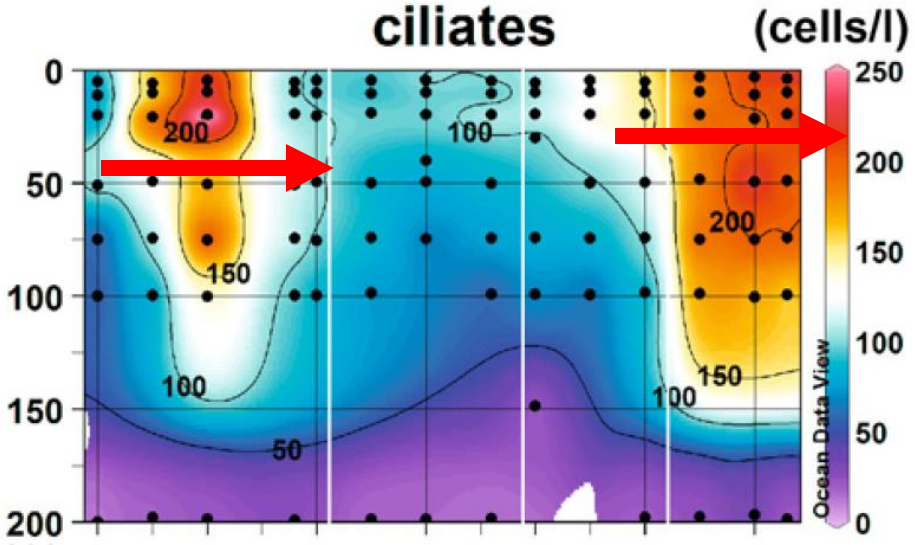
  2) showed influence of shelf waters.

Bimodal in Pacific (in other studies)

Exist but not recognized



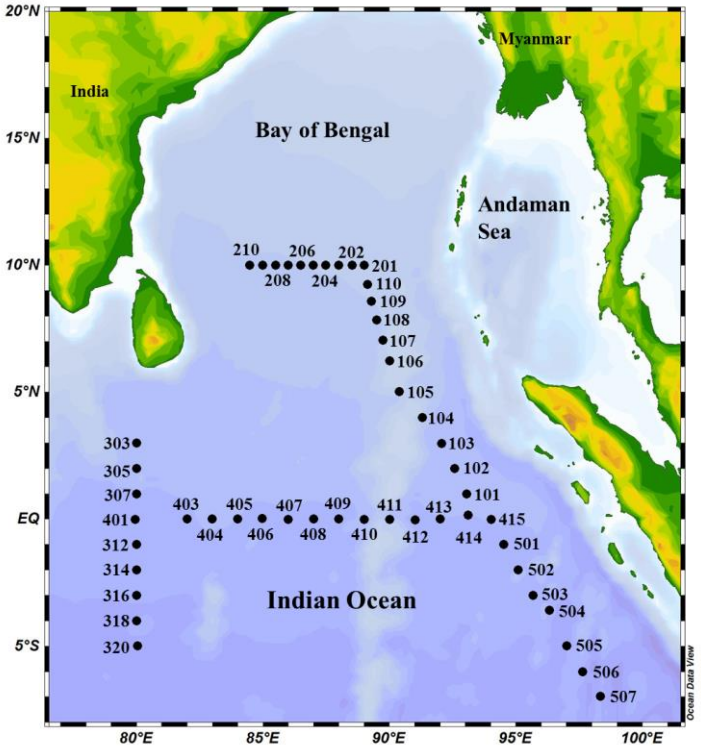
Yang et al. 2004

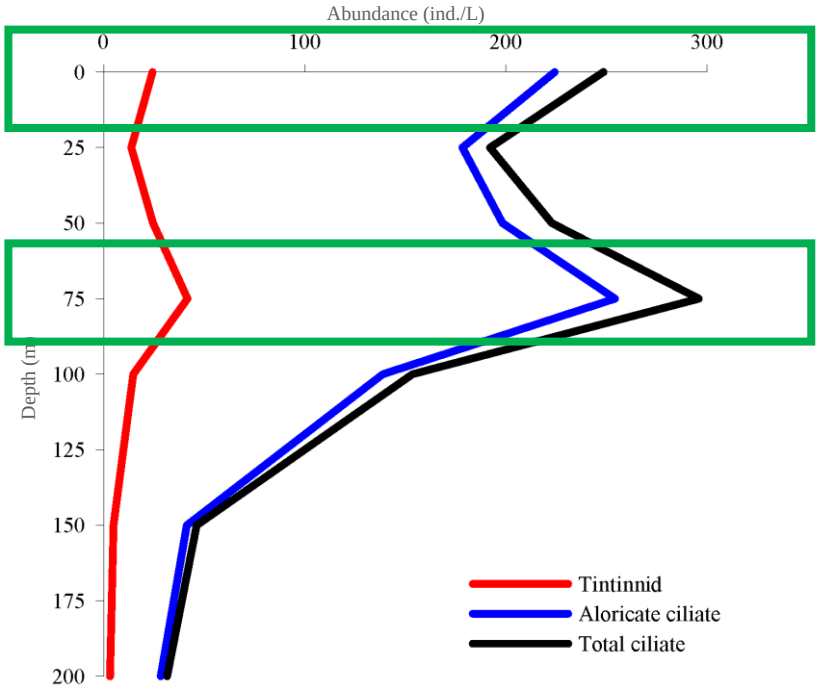


Sohrin et al. 2010

Yang, E.J., 2004. Mar. Biol. 146, 1-15.
Sohrin, R., 2010. Deep-Sea Res. II 57, 1537-1550.

Bimodal in Indian Ocean (our study)



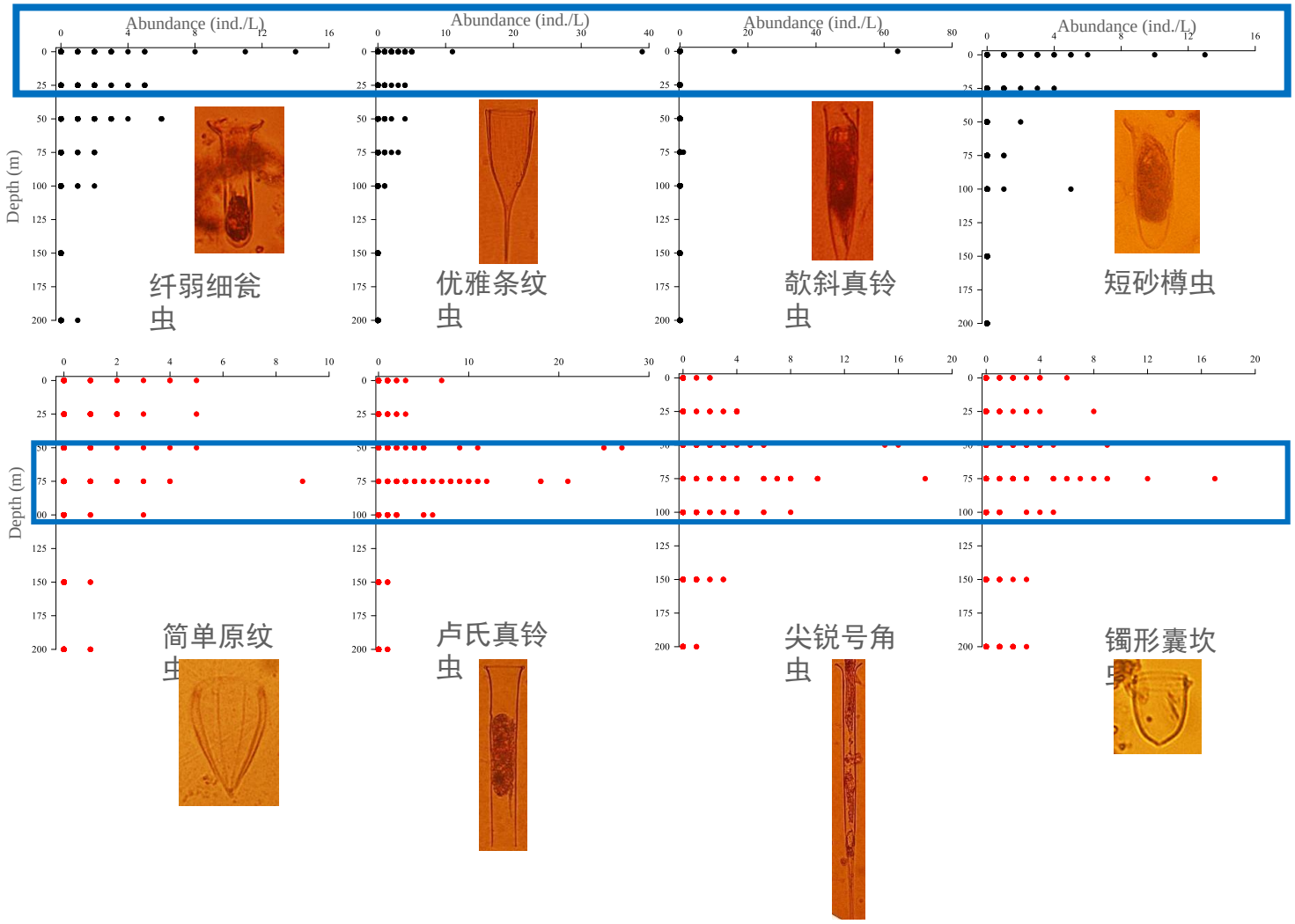


Surface

DCM

Eastern Indian Ocean in 2017 cruise

Some tintinnid species

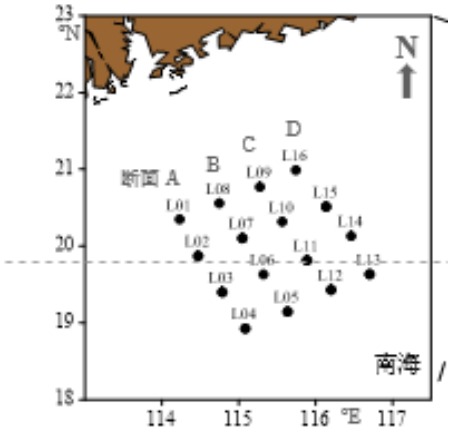


表层高

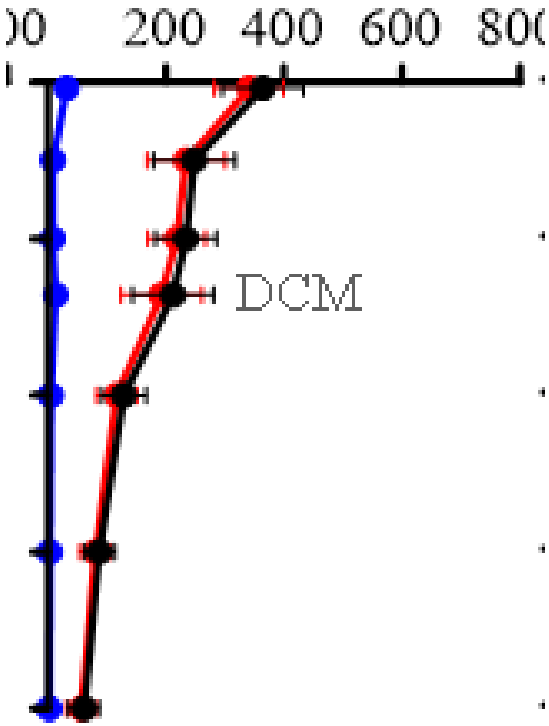
DCM层高

More story –
Seasonal variation in the slope

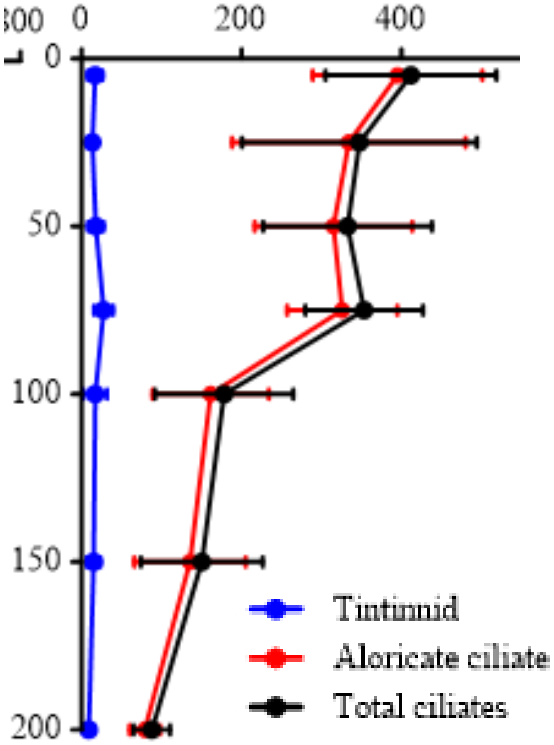
Bimodal distribution was found in slope water in March 2017
Winter-spring in slope was influenced by oceanic water?
Hydrological support?

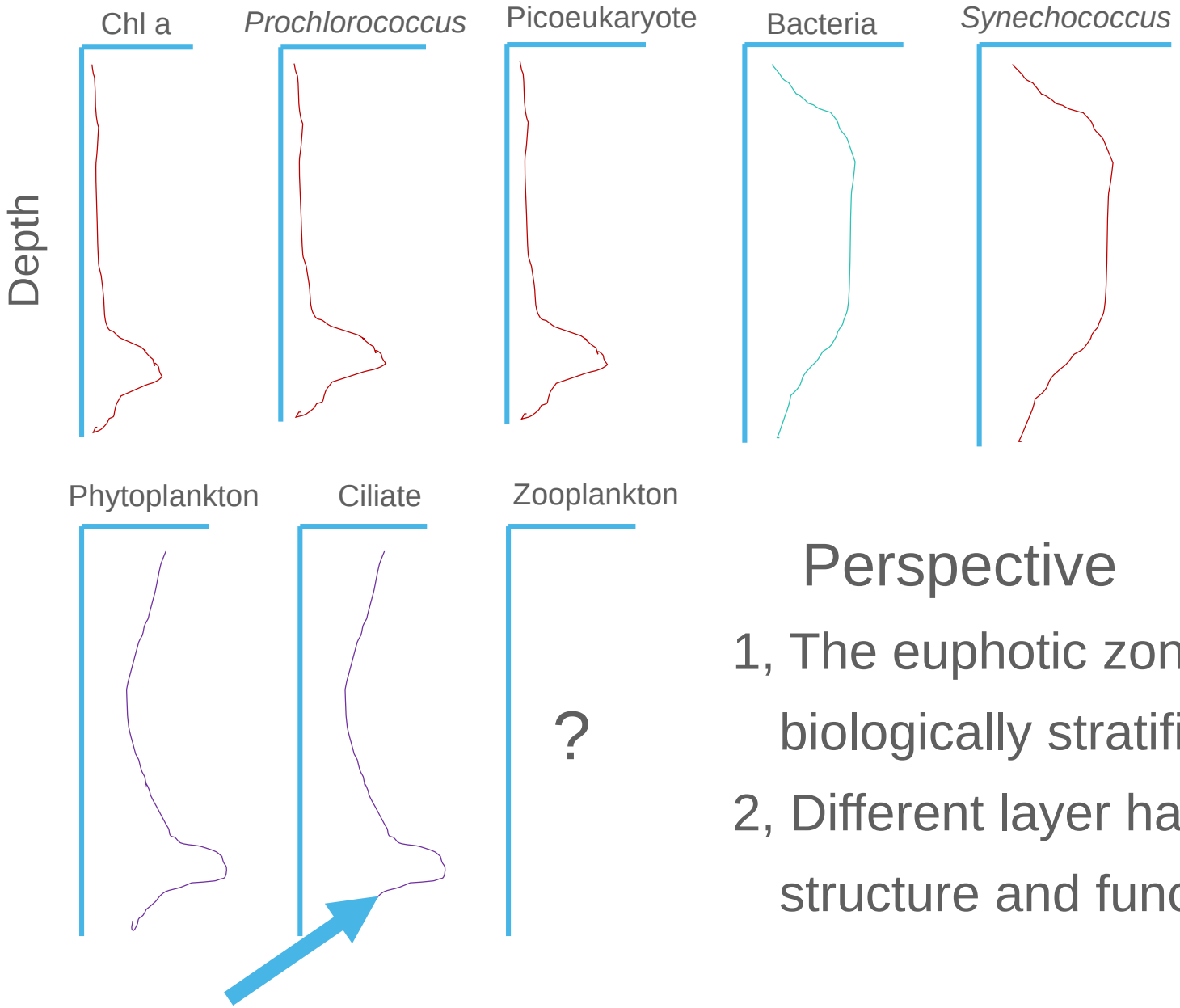


June 2015



March 2017





In each figure, different ecotype in different layer

Perspective

1, The euphotic zone is biologically stratified

2, Different layer has different structure and function

Supported by

Living-resource and Ecosystem Dynamics on the Slope of the South China Sea

国家自然科学基金委员会
National Natural Science Foundation of China

中国科学院
CHINESE ACADEMY OF SCIENCES

Planktonic Ciliate Studio

In memory of the exciting days

中国科学院海洋研究所
INSTITUTE OF OCEANOLOGY,CHINESE ACADEMY OF SCIENCES

Thank you for your attention!

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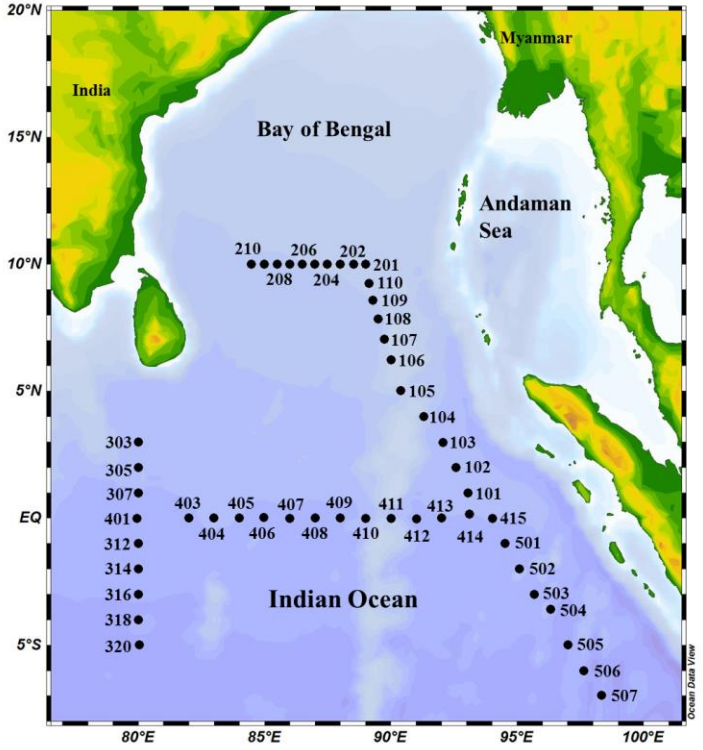
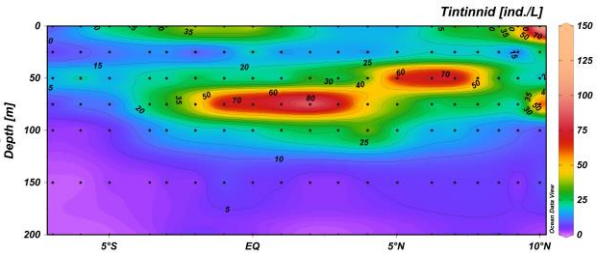
Transect distribution of tintinnids

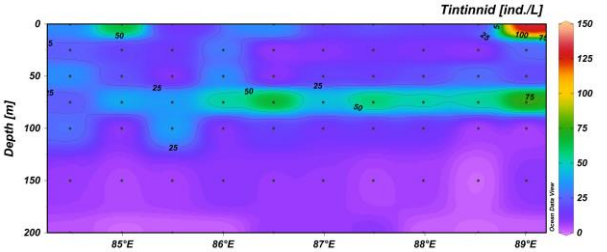


2017年3月-4月东印度洋站位

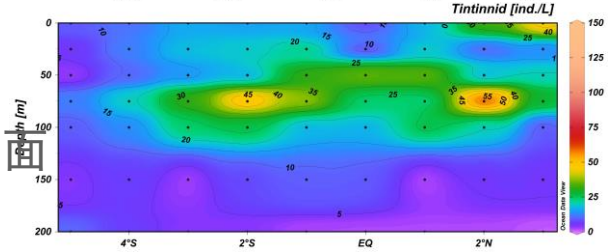
1&5断面



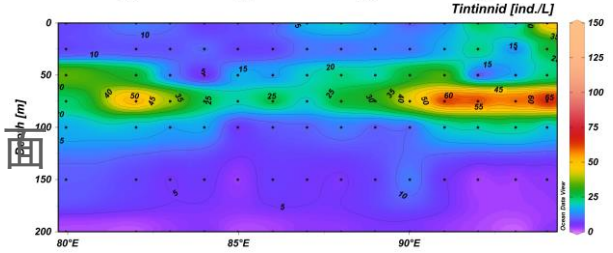
2断面



3断面



4断面



砂壳纤毛虫在表层和DCM层丰度较高，大体上呈双峰型分布。