ICES/PICES 7th International Zooplankton Production Symposium
Session 7: The role of microzooplankton in biogeochemical cycling and food webs

Biogeography of Tintinnid in Global Oceanic Waters: A Review

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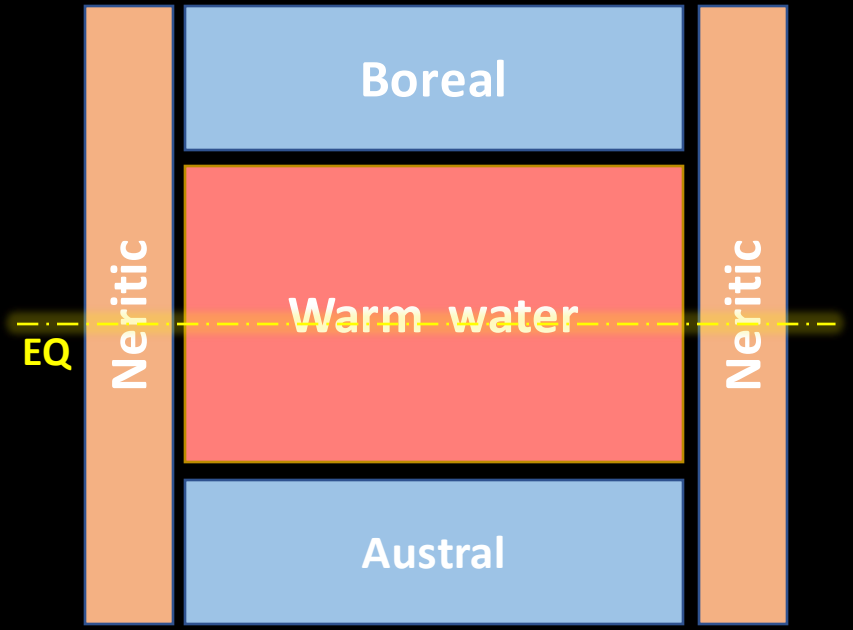
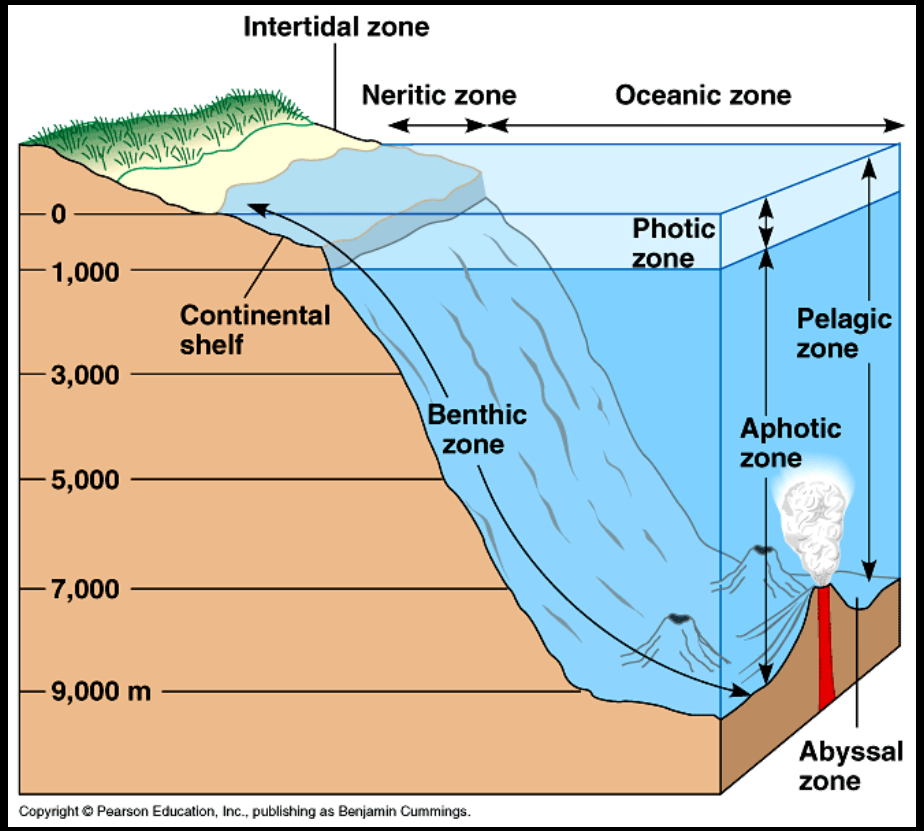
Qingdao, P. R. China

Biogeography of Marine Plankton

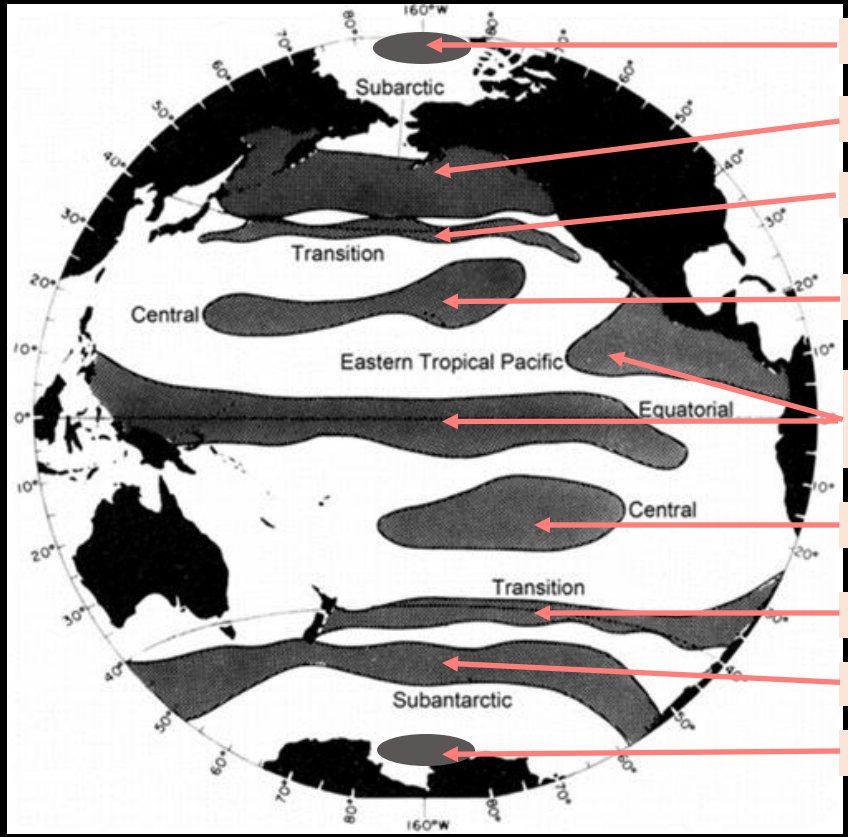
Neritic – **Oceanic** – Neritic





Oceanic Biogeography of Zooplankton

Water masses determine the biogeography (Reid 1962)



Arctic

Subarctic

Transition

Central

EQ / Eastern Tropical Pacific

Central

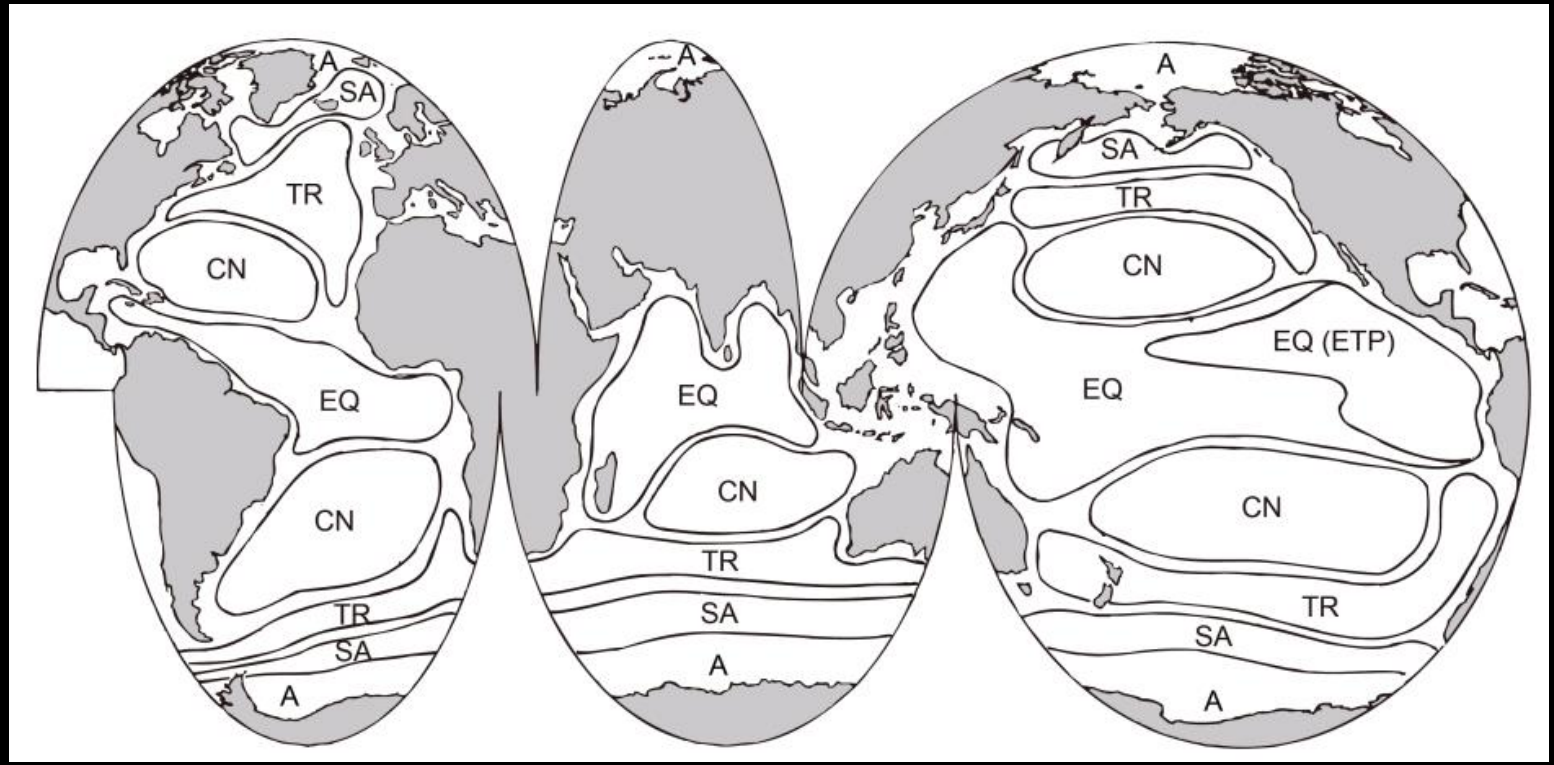
Transition

Subantarctic

Antarctic

Adapted from Fernandez-Alamo and Farber-Lorda, 2006

The Nine-belt pattern of Oceanic Zooplankton



Arctic

Subarctic

Transition

Central

EQ / Eastern Tropical Pacific

Central

Transition

Subantarctic

Antarctic

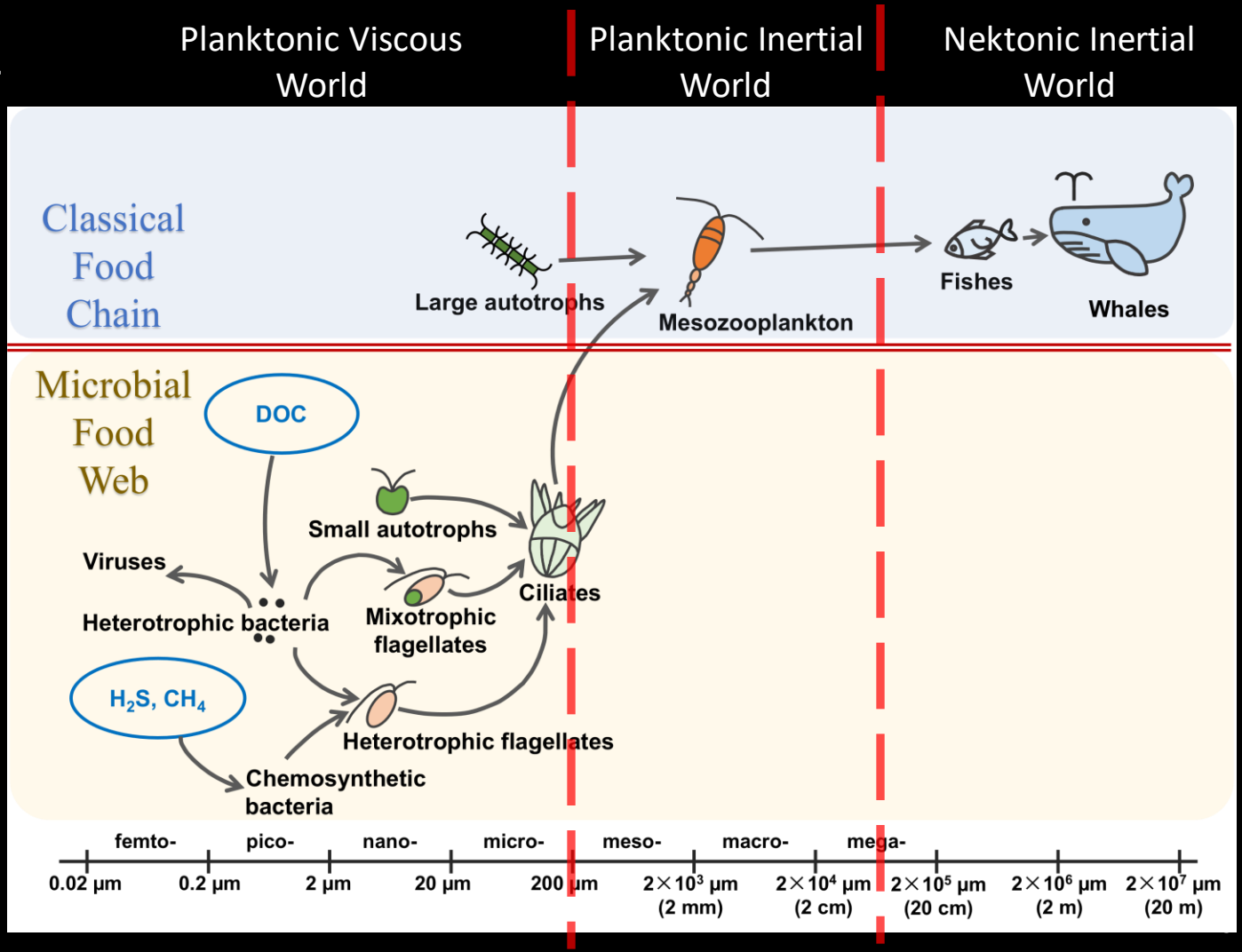
Longhurst 2011

Life in the Sea

- Marine life in three worlds
  size: $10^{-2} \sim 10^{7}$ μm
  across 9 size orders

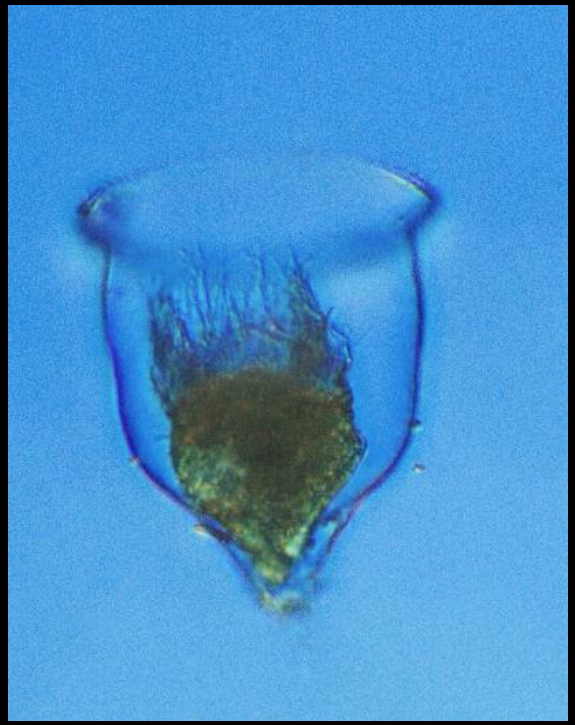
- Plankton
  live in viscous and inertial world
  size: $10^{-2} \sim 10^{4.5}$ μm
  across 6.5 size orders

- Ciliate
  dividing viscous and inertial planktonic world



Tintinnina (tintinnid)

Single cell ciliates, 10-200 μm



Ciliate vs copepod

Tintinnid in the eyes of artists

Oceanides
ART OF THE OCEAN

Fine Tintinnid pin

$245.00

Oceanides
ART OF THE OCEAN

Tintinnid Brooch 1

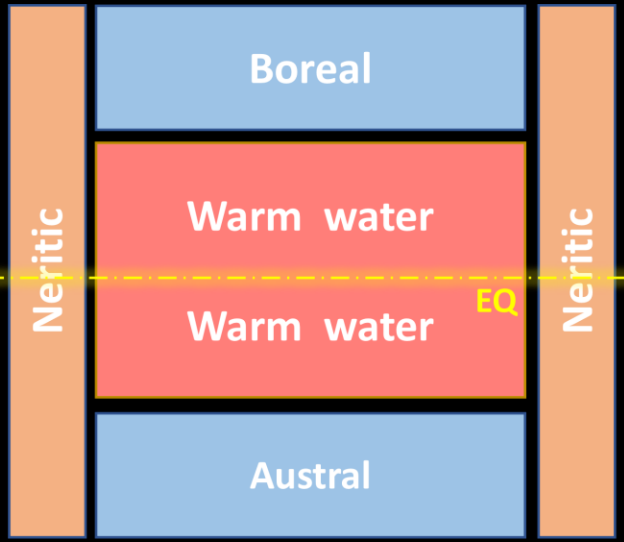
$675.00

Oceanides
ART OF THE OCEAN

Fine Tintinnid pendant

$525.00

Biogeography of Tintinnids



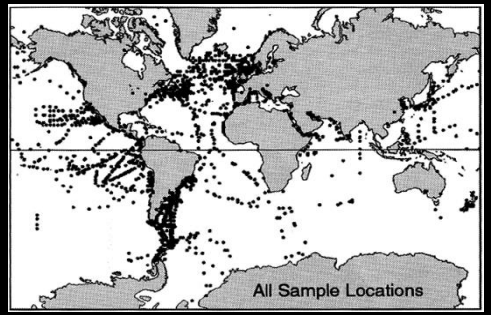
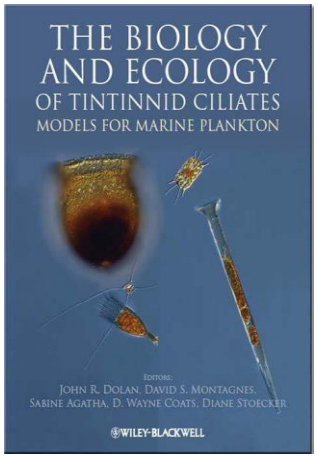


Table 10.1 Biogeographic distribution patters of common tintinnid genera; genera considered were those that included species reported in at least four publications by two dif

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		



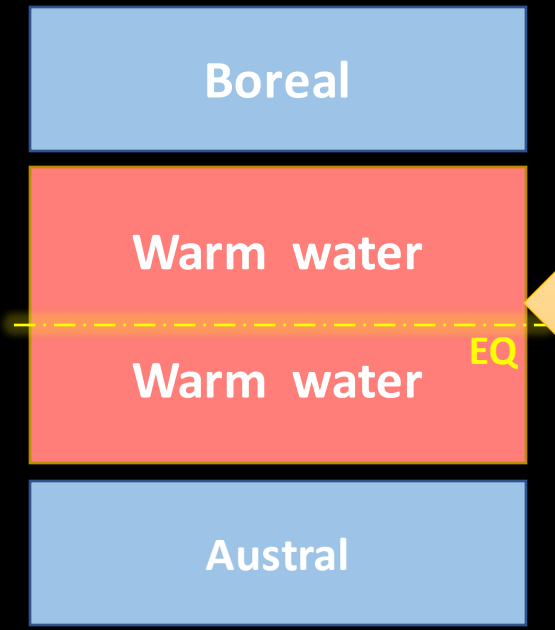
Based on data from 1800 sampling stations.

Dolan et al., 2012.

Biogeography Pattern of Oceanic Tintinnids

Oceanic Tintinnid

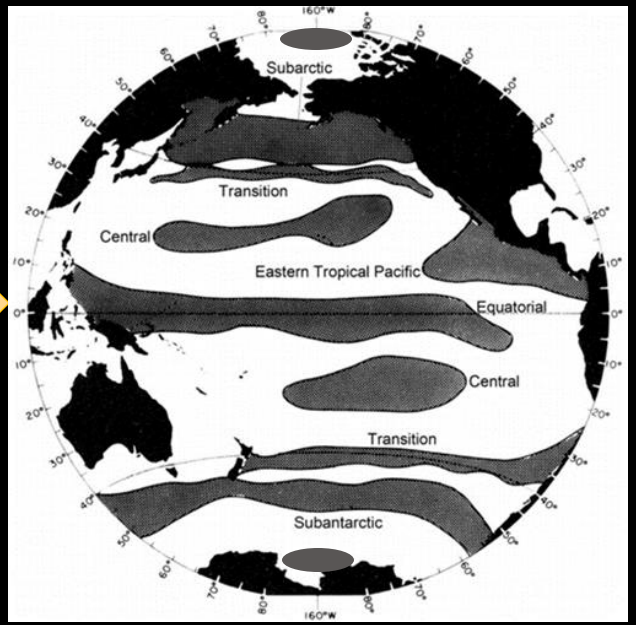
Three-belt pattern (2012)



Discrepancy

Oceanic Zooplankton

Nine-belt pattern

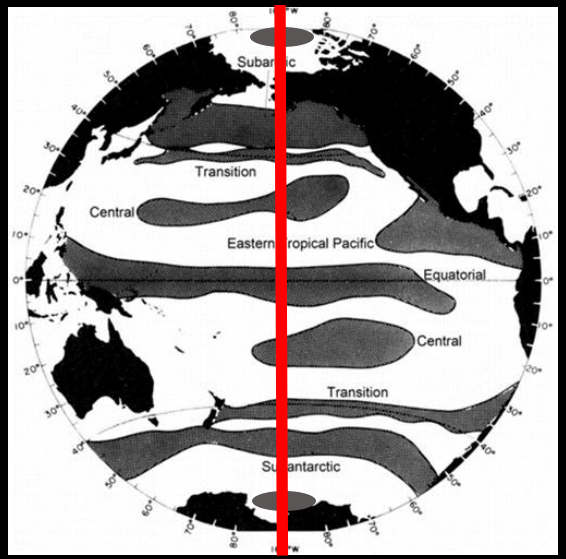


Our Research Objectives

- Refinement of the existing three-belt distribution pattern of oceanic tintinnid
- Any differences from the classical nine-belt pattern?

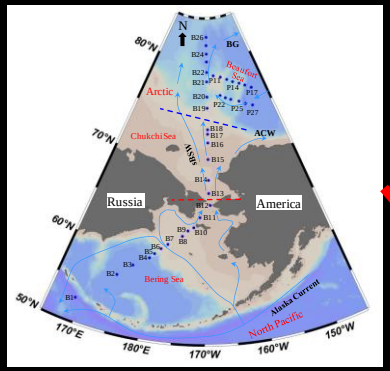
Method

- ❑ Sampling along longitudinal transects
- ❑ Sampling with vertical profile

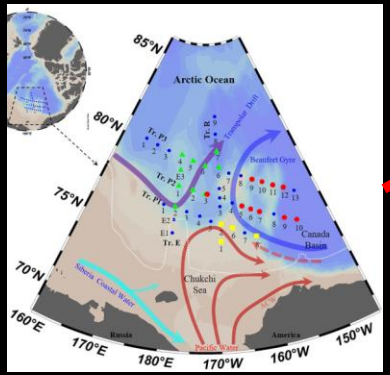


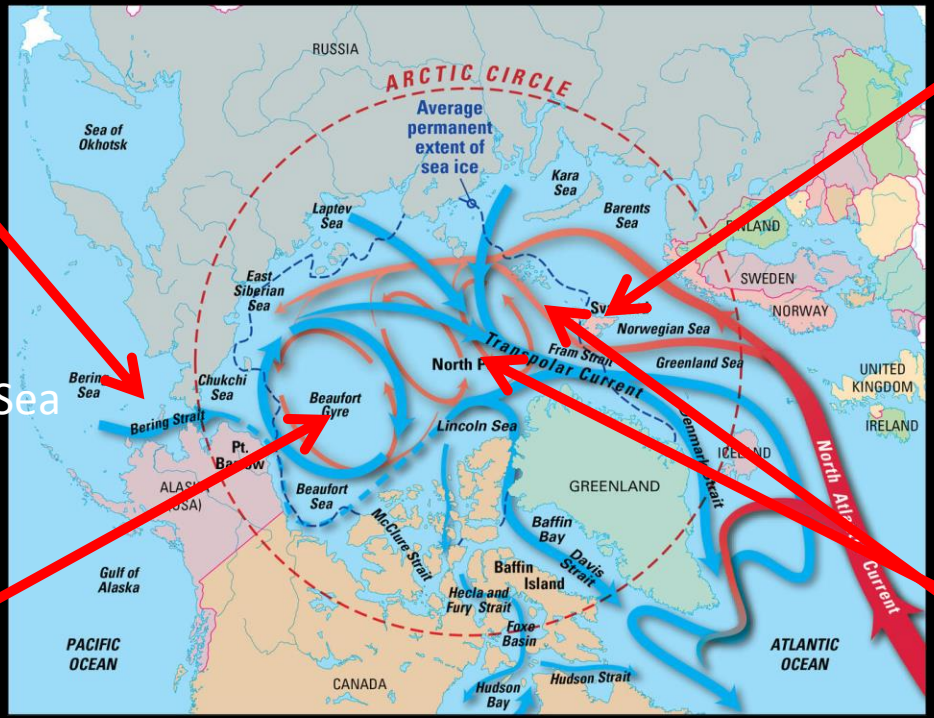
Sampling Sites in the Arctic Gyres

Subarctic gyre in Bering Sea

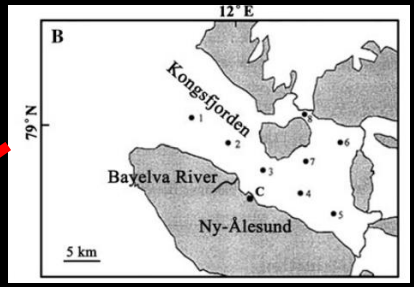


Arctic Gyre in Beaufort Sea

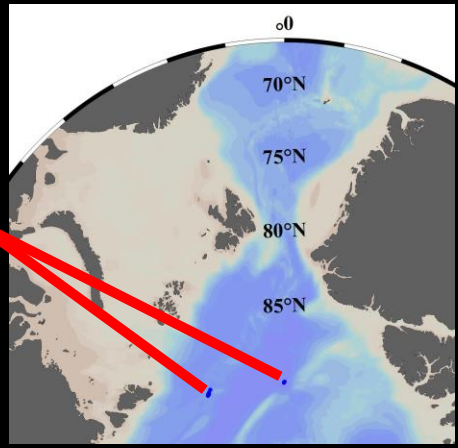




Svalbard

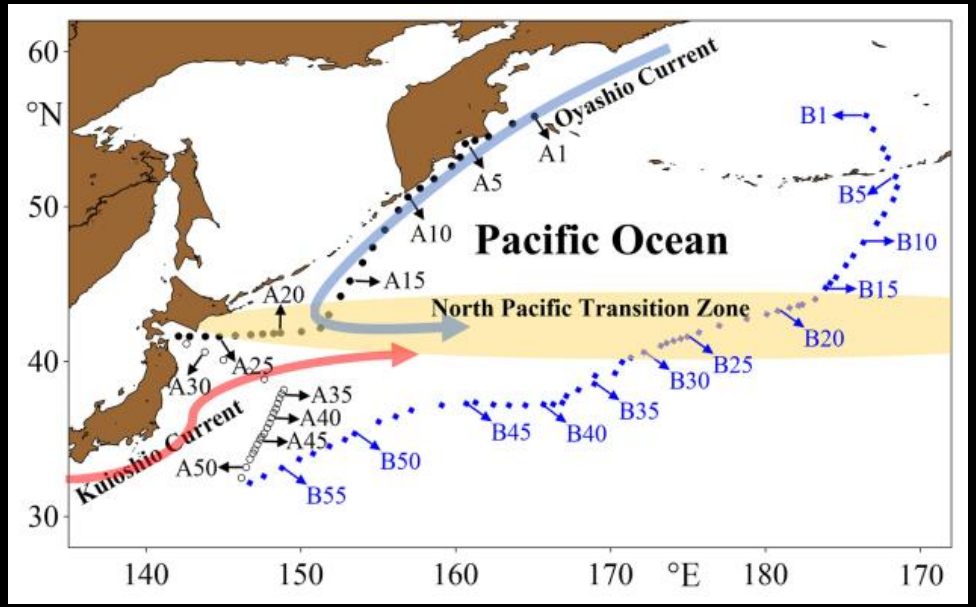


North Pole

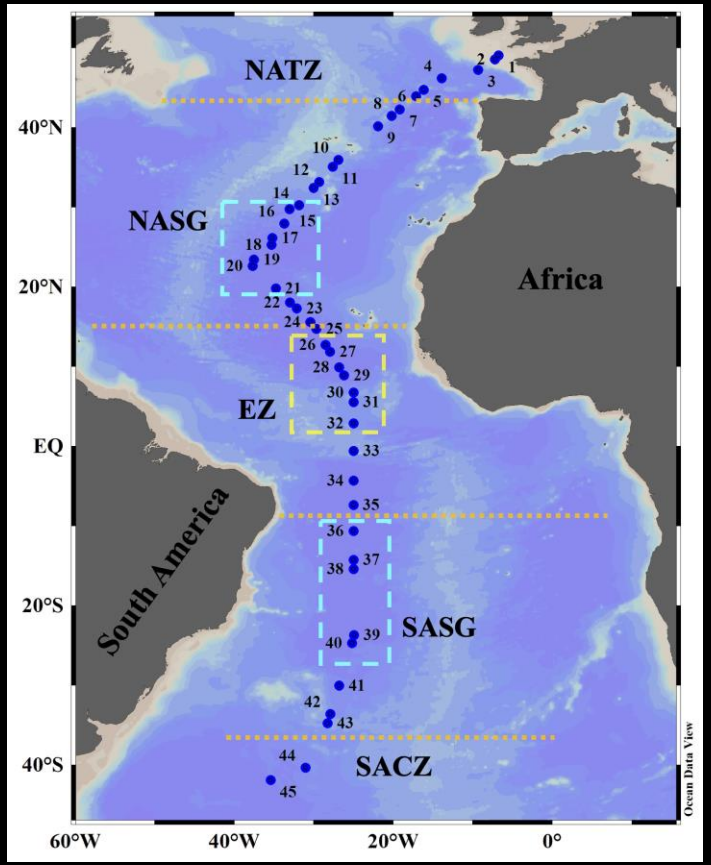


- Feng et al. 2014. Polar Biology
- Wang et al. 2019. Polar Biology
- Wang et al. 2022. Frontiers in Marine Science
- Unpublished data from Summer 2023 cruise

Sampling Sites in the Subpolar and Subtropical Gyres



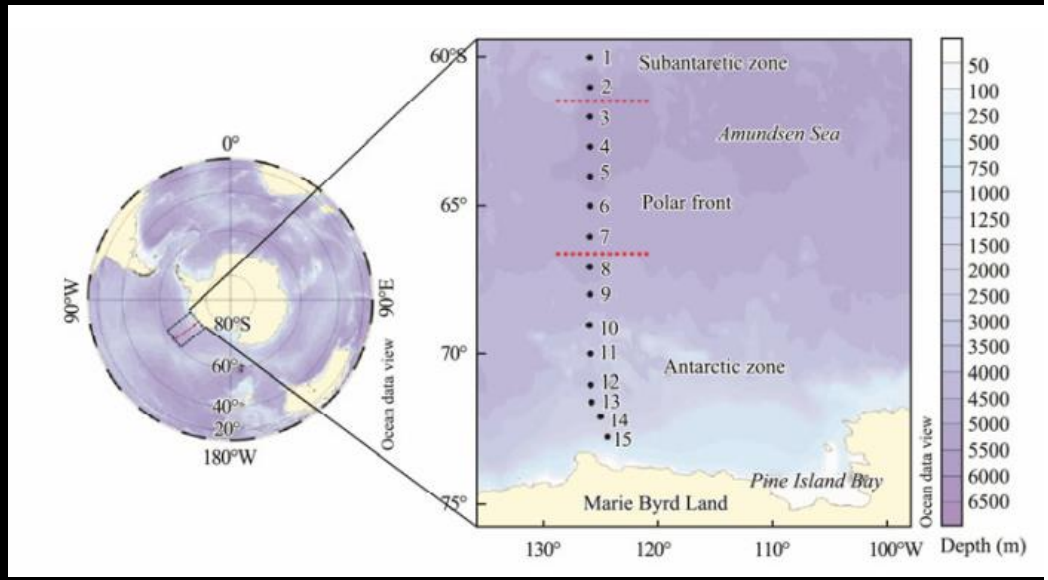
North Pacific Gyre and North Pacific Transition Zone



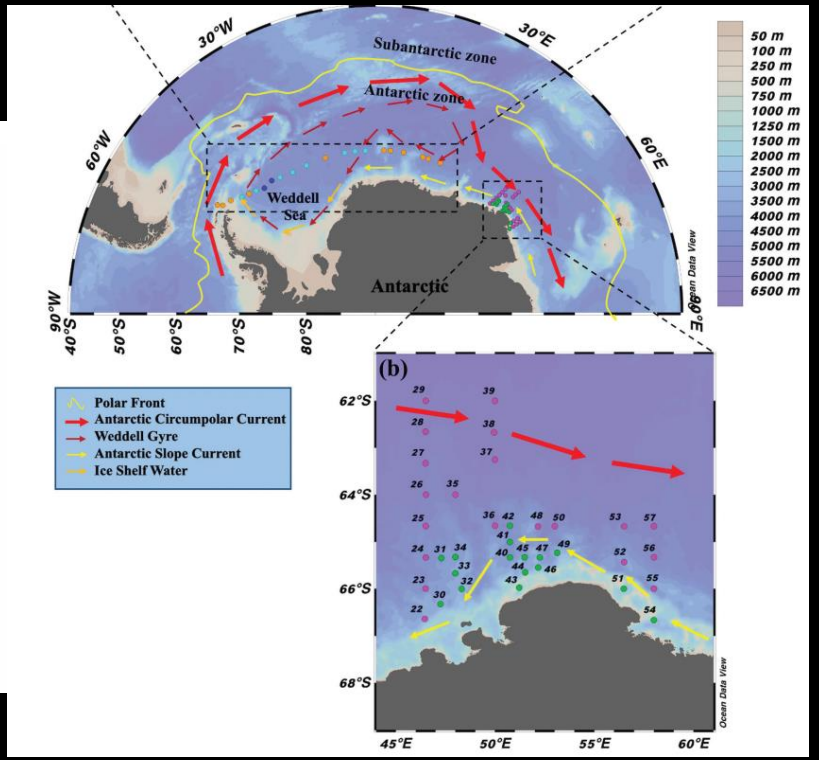
North and South Atlantic Gyre

- Li et al. 2021. Frontiers in Microbiology
- Li et al. 2023. Frontiers in Marine Science

Sampling Sites in the Antarctic Gyres



Antarctic Circumpolar Current



Antarctic Slope Current

- Liang et al. 2020. J Ocean Univ China.
- Li et al. 2023.Polar Research。

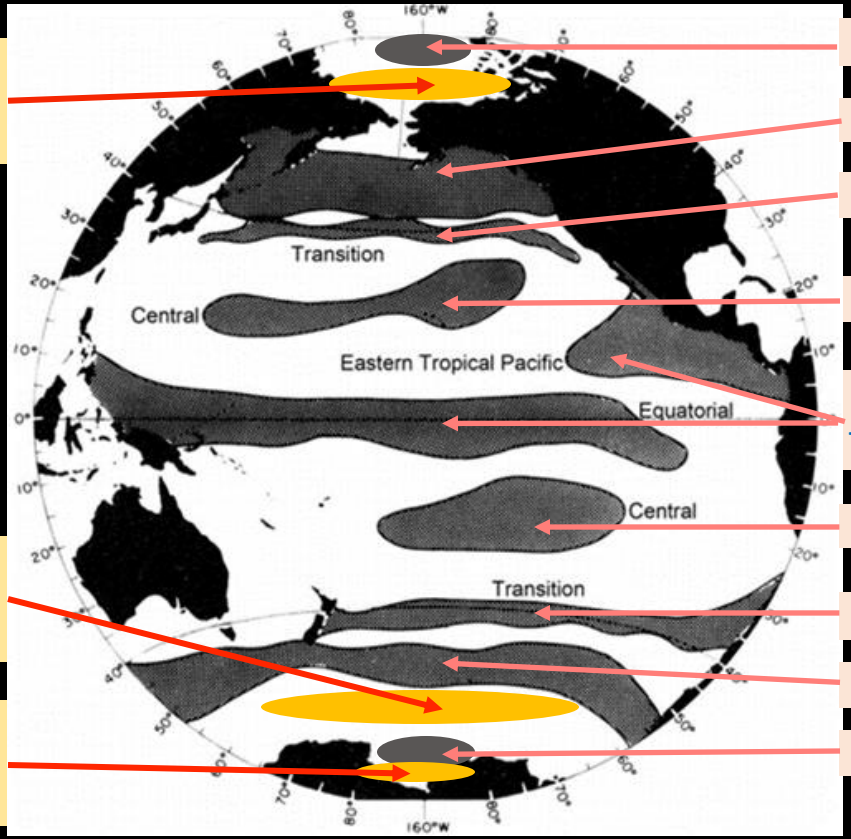
The Twelve-belt pattern of Oceanic Tintinnid

Arctic-Subarctic Transition

Three more belts

Antarctic-Subantarctic Transition

Antarctic Slope Gyre



Arctic

Subarctic

Transition

Central

EQ / Eastern Tropical Pacific

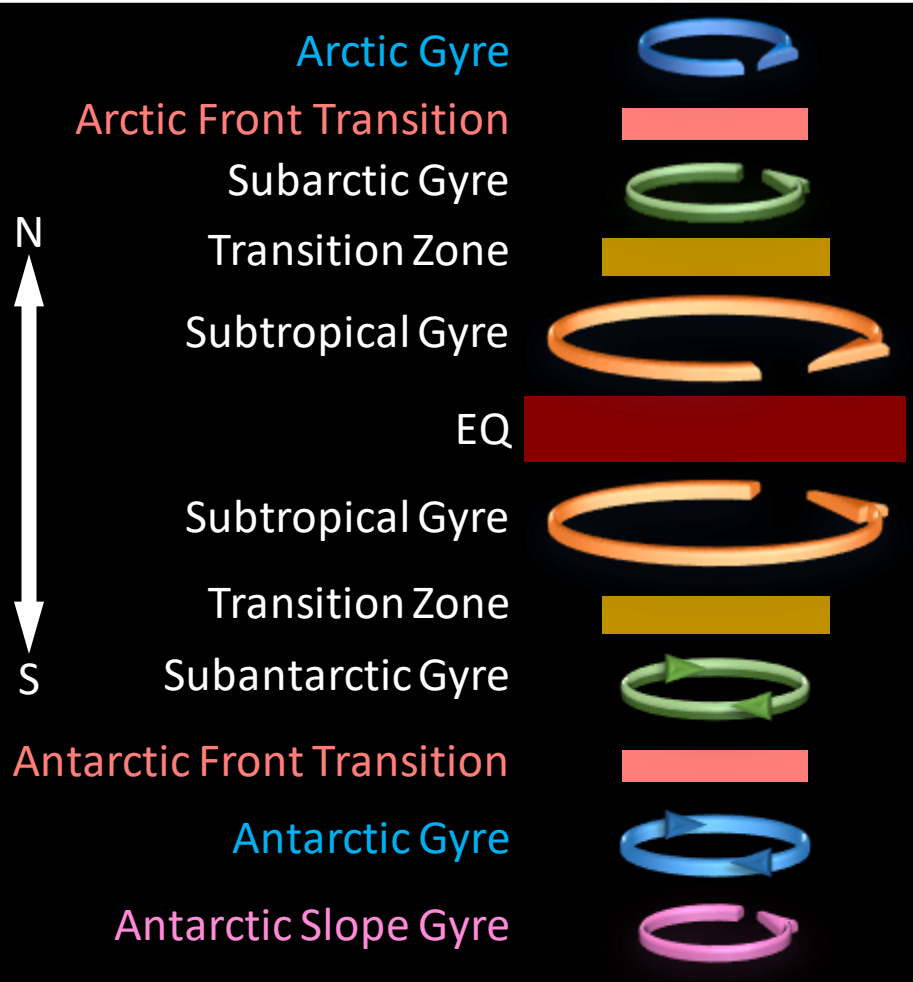
Central

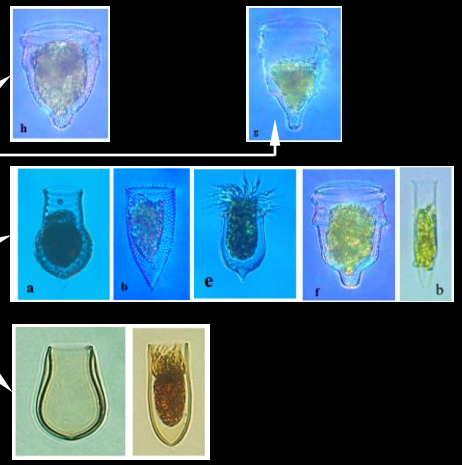
Transition

Subantarctic

Antarctic

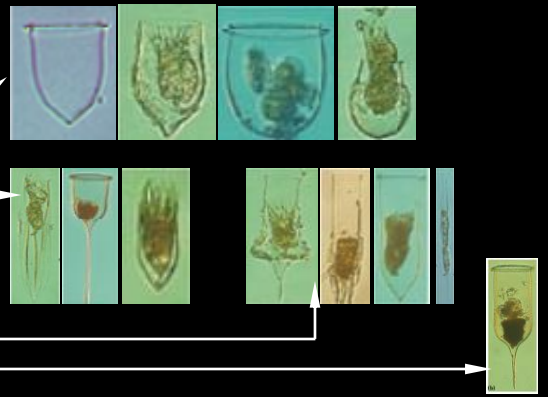
The Arctic-Antarctic Asymmetry





The Southern Ocean

- More belts
- More species

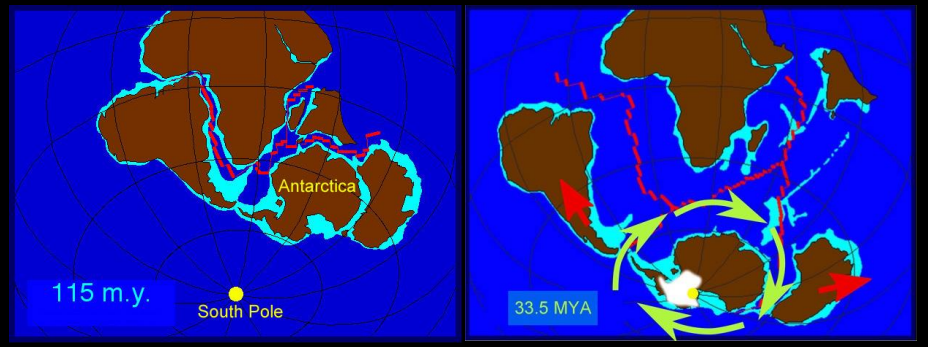


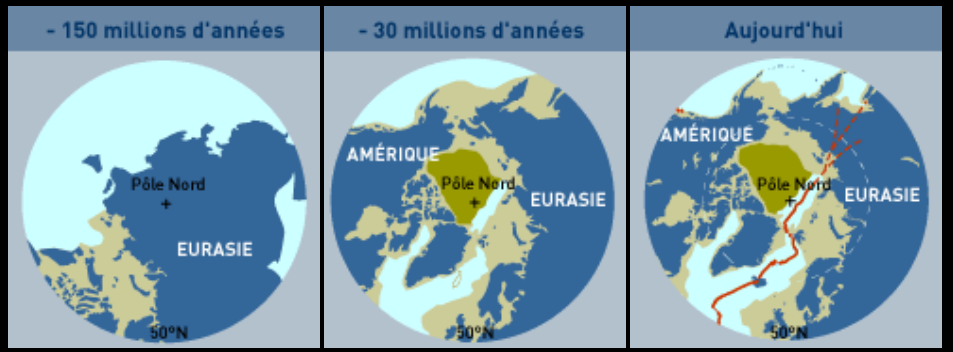
The Arctic-Antarctic Asymmetry

- **Speculation:** Early formation of the Southern Ocean probably leads to more tintinnid species

❖The Southern ocean was formed around 33.5 million years ago.

❖The Arctic Ocean formed around 18.2 million years ago when Fram Strait began to widen.

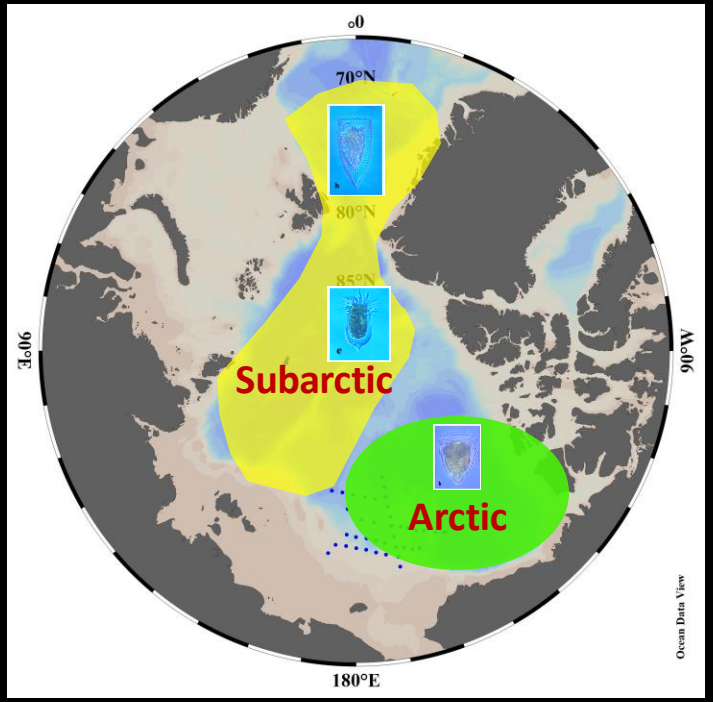




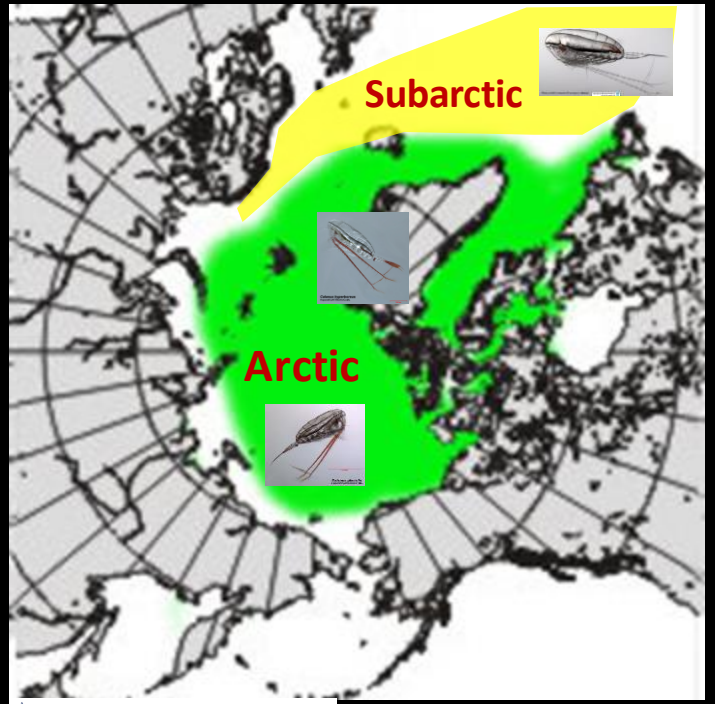
- https://www.coolantarctica.com/
- https://www.polarpod.fr/

Arctic and Subarctic Belts Defined by Tintinnid or Copepod

Tintinnid



Copepod



Calanus finmarchicus

C. hyperboreus

C. glacialis

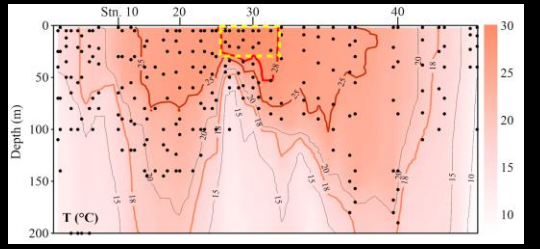
Arctic Ocean Diversity

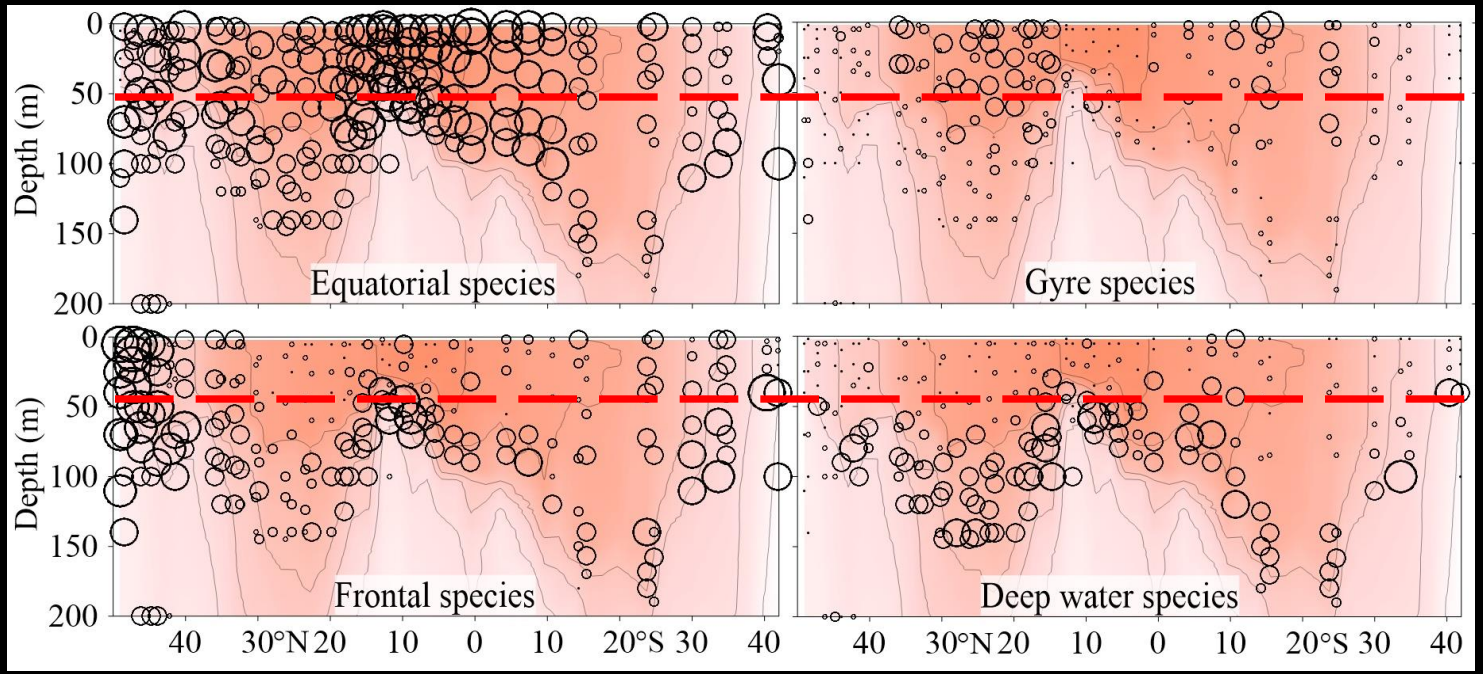
Adapted from Russ Hopcroft @ http://www.arcodiv.org/

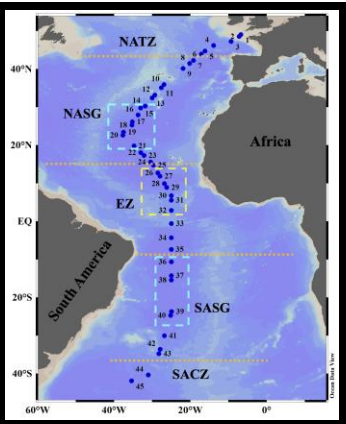
Different Vertical Profiles of Tintinnid

- the Subtropical Gyre

Tintinnid abundance peak: Above vs. below 50 m







Abundance (ind. L^{-1})
- 50 to 200
- 10 to 50
- 5 to 10
- 1 to 5
- 0.5 to 1
- 0 to 0.5
- 0

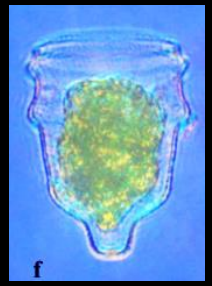
- Li et al. 2023. Frontiers in Marine Science

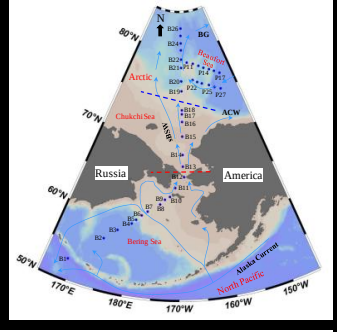
Different Vertical Profiles of Tintinnid

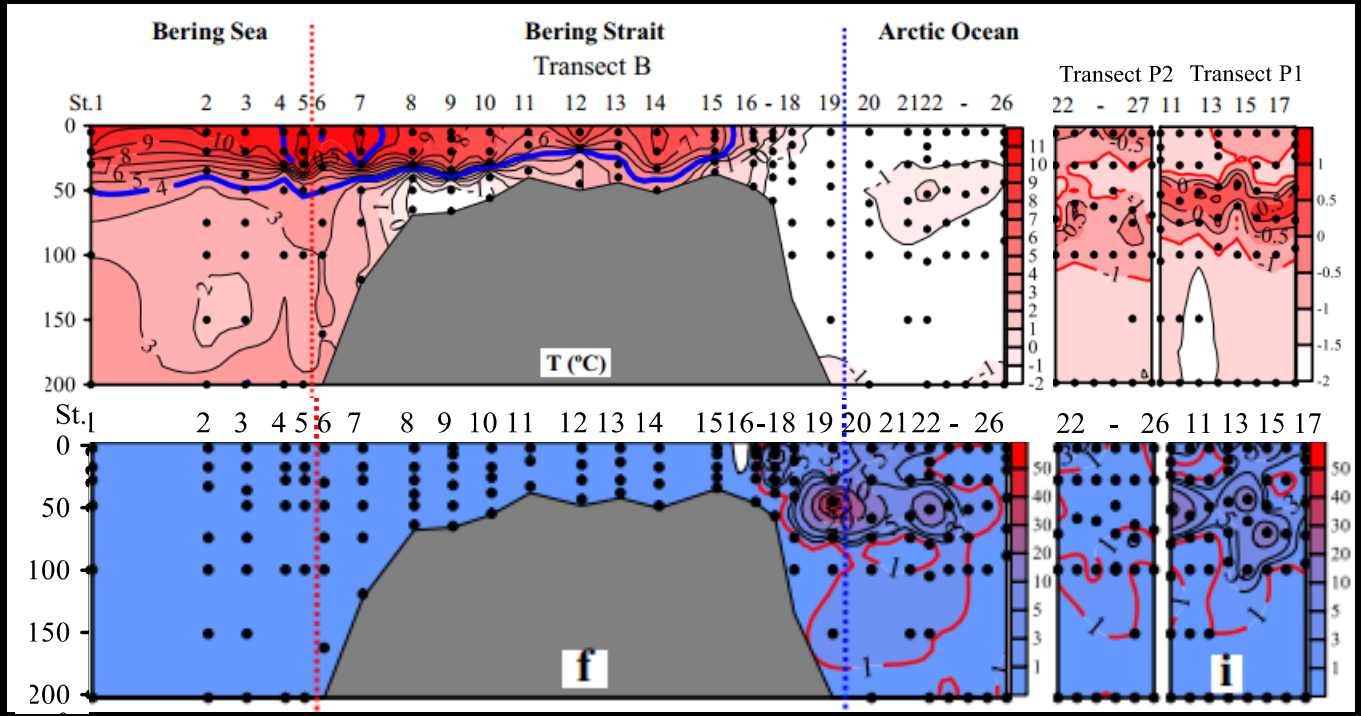
- the Arctic Gyre

Ptychocylis urnala

- Abundance peak in subsurface water during summertime
- Speculation: no difference between winter and summer



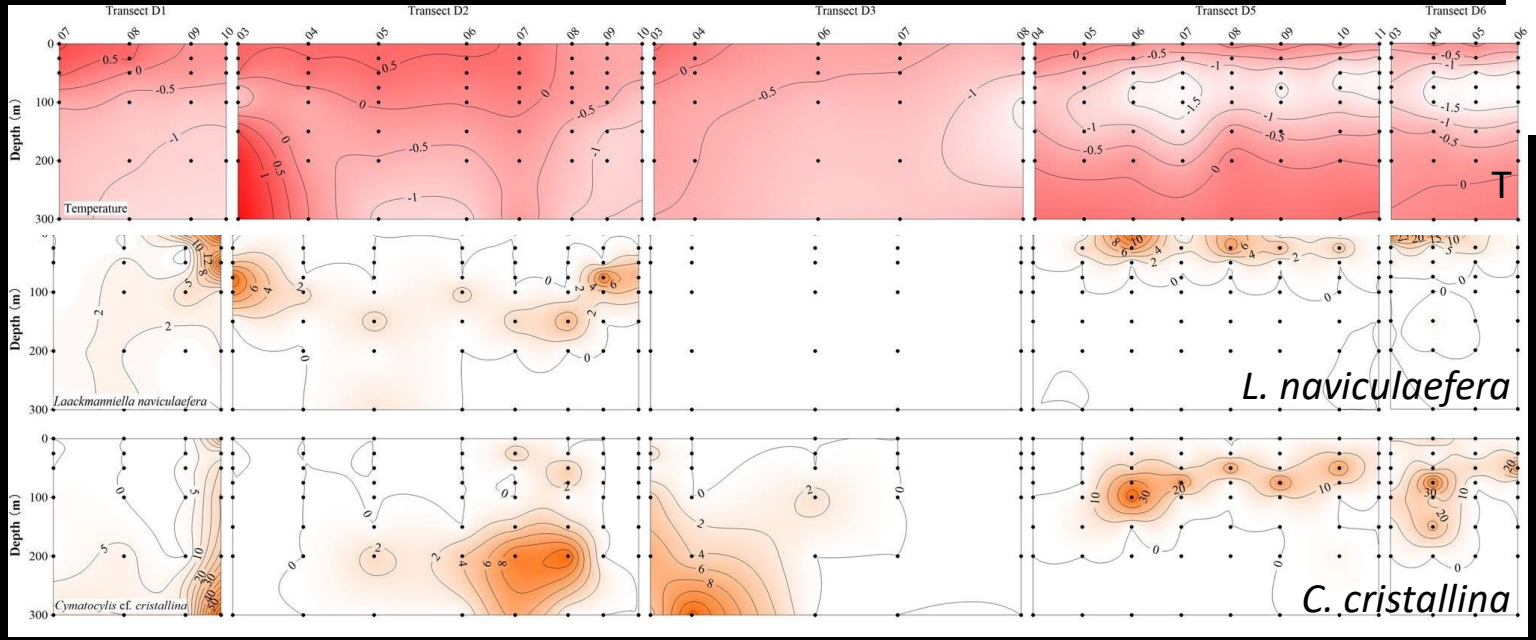


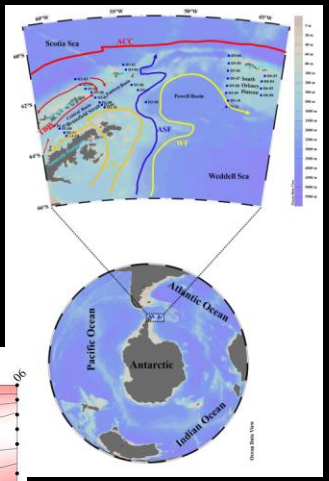


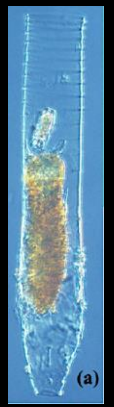
- Wang et al. 2019. Polar Biology

Different Vertical Profiles of Tintinnid

- the Antarctic Gyre
  - *Laackmanniella naviculaefera* → summer surface water
  - *Cymatocylis cristallina* → winter water





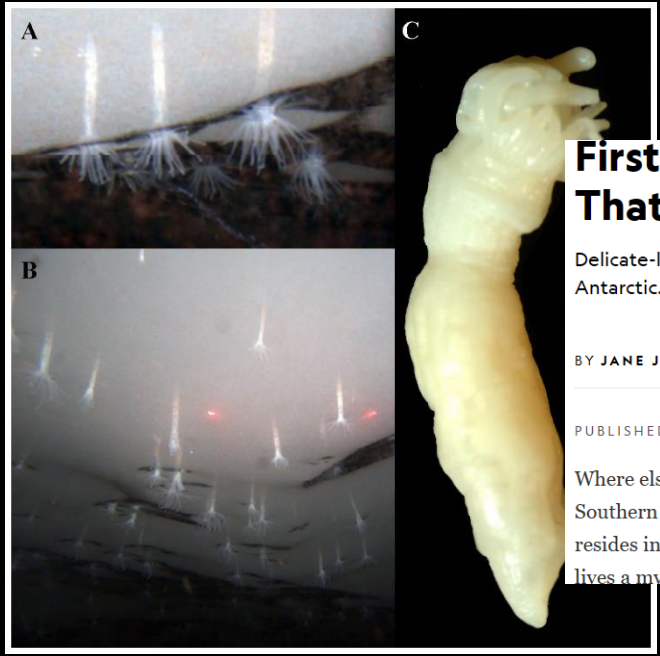


- Li et al. 2023. Polar Biology

Different Vertical Profiles of Tintinnid

Speculation:

Overwintering strategy of summer surface water Tintinnid in the Antarctic → **in the sea ice**



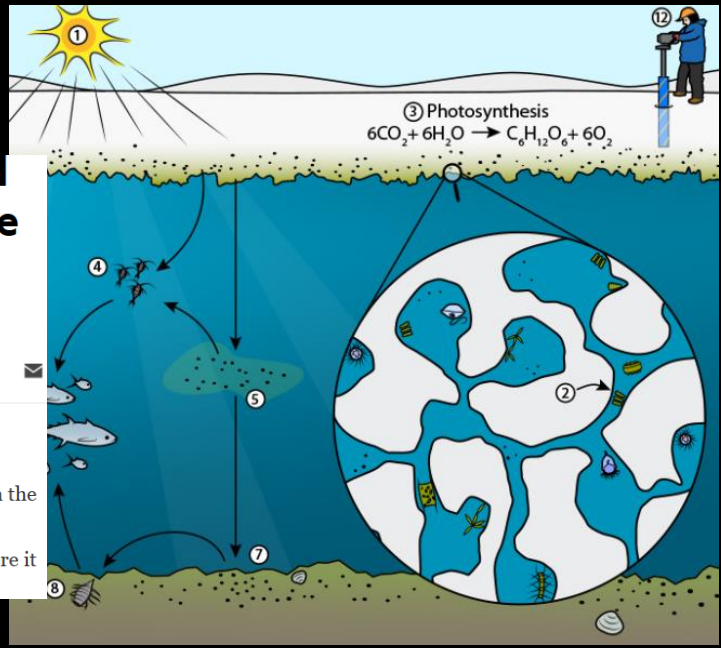
First Known Sea Anemone Found That Lives Upside Down in Sea Ice

Delicate-looking creatures burrow into the bottom of sea ice in the Antarctic.

BY JANE J. LEE, NATIONAL GEOGRAPHIC

PUBLISHED JANUARY 17, 2014 • 5 MIN READ

Where else would a species that spends its life upside down live but in the Southern Hemisphere? The newly discovered Antarctic sea anemone resides in burrows dug into the bottom of sea ice in the Ross Sea, where it lives a mysterious existence.



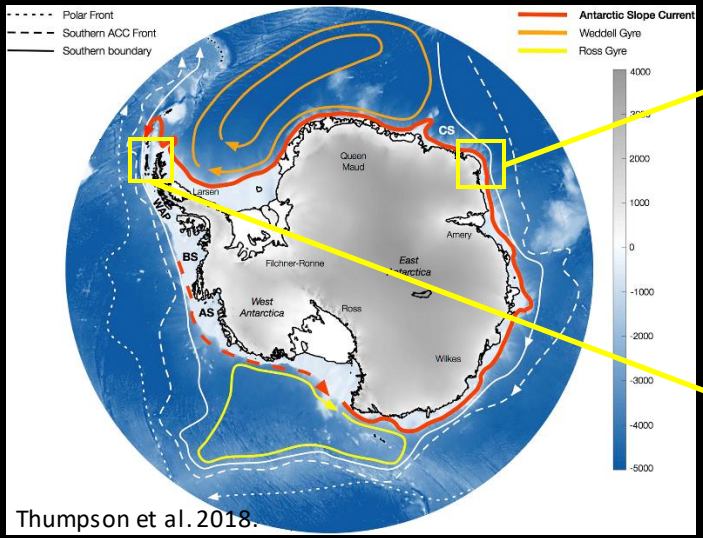
- Daly M et al. 2013. PLOS ONE
- https://www.nationalgeographic.com/science/article/140117-sea-anemone-antarctica-ice-ocean-animals-science
- https://askabiologist.asu.edu/explore/frozen-life

Different Vertical Profiles of Tintinnid

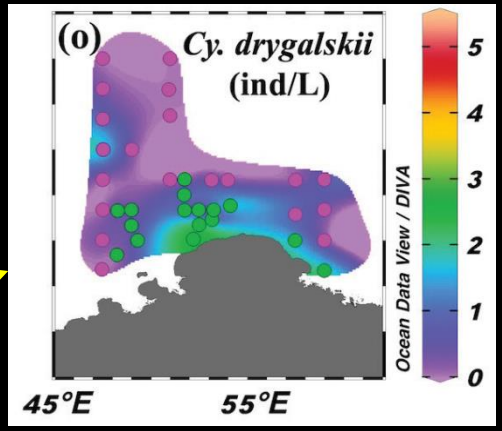
- the Arctic Slope Gyre
  - *Cymatocylis drygalskii* :

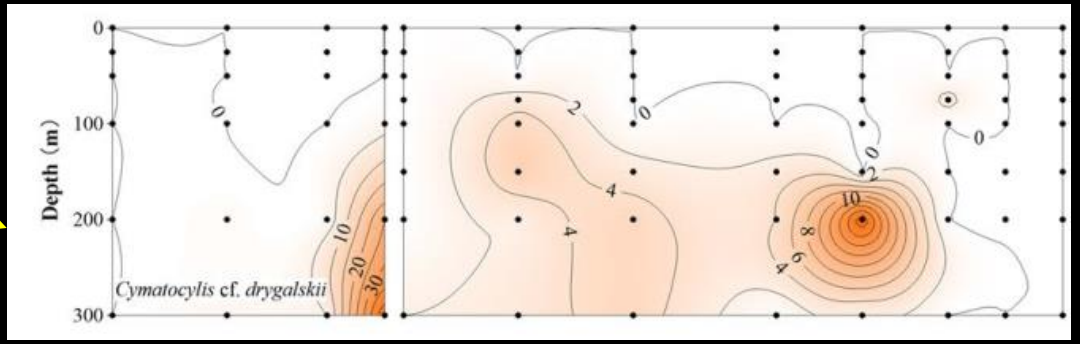
→ surface water of the Cosmonaut Sea,

→ 200~300m around *the* South Shetland Islands



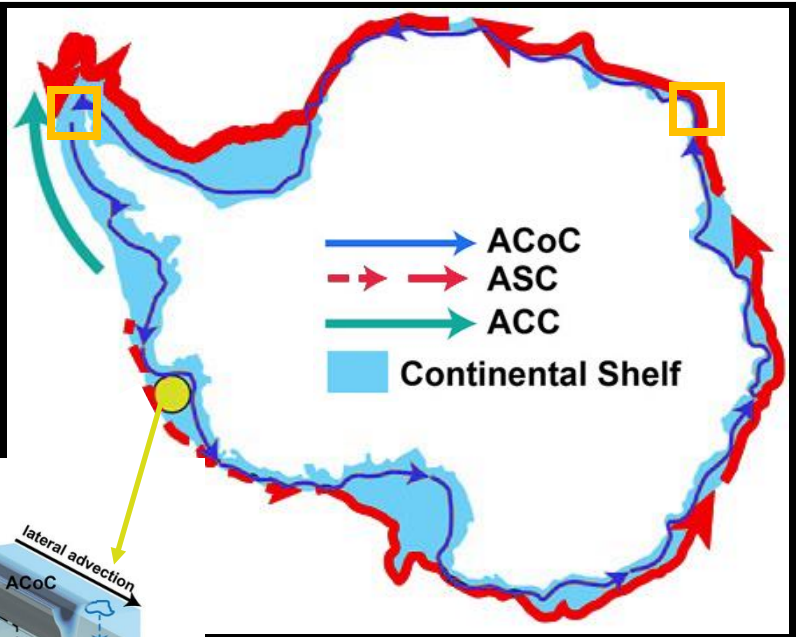
Thumpson et al. 2018.

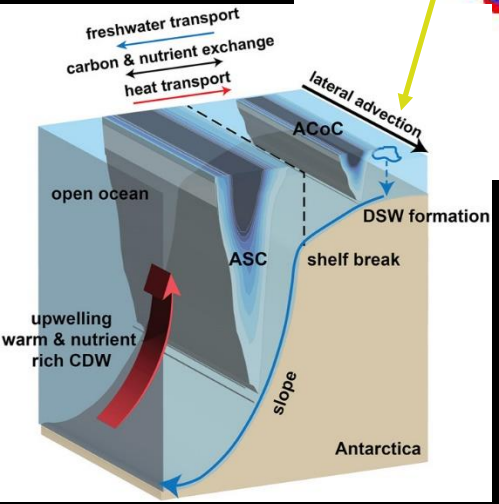




- Li et al. 2023. Polar Research.
- Li et al. 2023. Polar Biology.

Different Vertical Profiles of Tintinnid



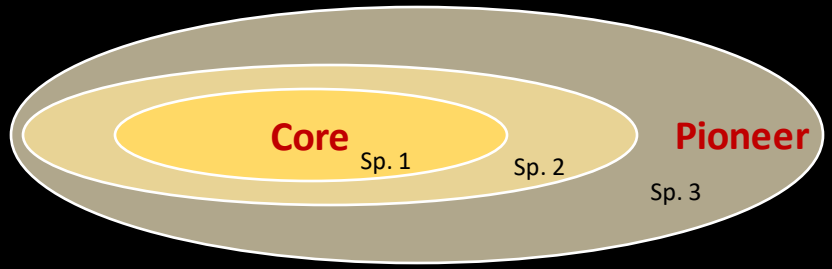


- **ASC**: a near-circumpolar, anticyclonic feature appearing at the shelf break in East Antarctica and the Weddell Sea.
- **Uncertainty regarding the initiation of the ASC** is indicated by the dashed line.
- Tintinnid -- a possible bioindicator of the initiation of ASC.

Adapted from Beadling 2023.

The Making of an Assemblage——
Superposition of Biogeographic Belts

- Different tintinnid species have varying distribution core (highest abundance) and latitudinal / longitudinal range.
- Biogeographic belts: Collective distribution pattern of species with same core and similar range.
- Assemblage: Superposition of biogeographic belts.

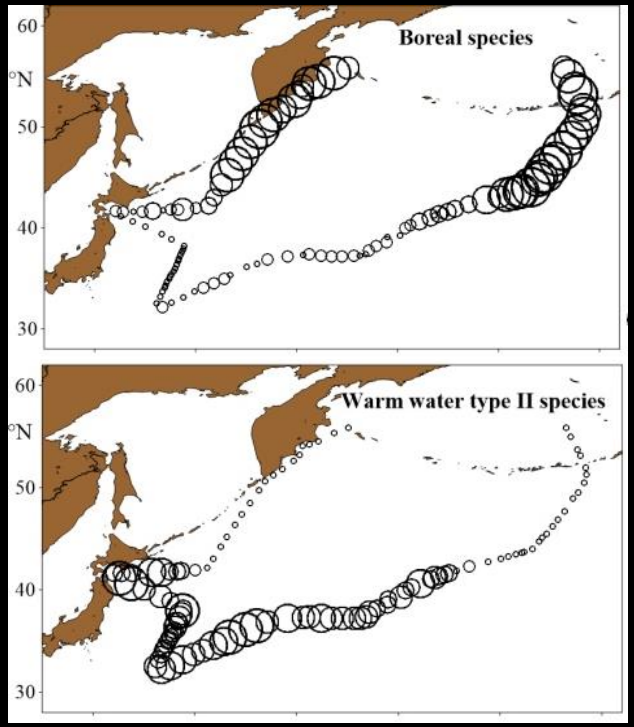


The Making of an Assemblage:
Superposition of Biogeographic Belts

- Scenario 1: Belts are adjacent but with no (or little) overlap

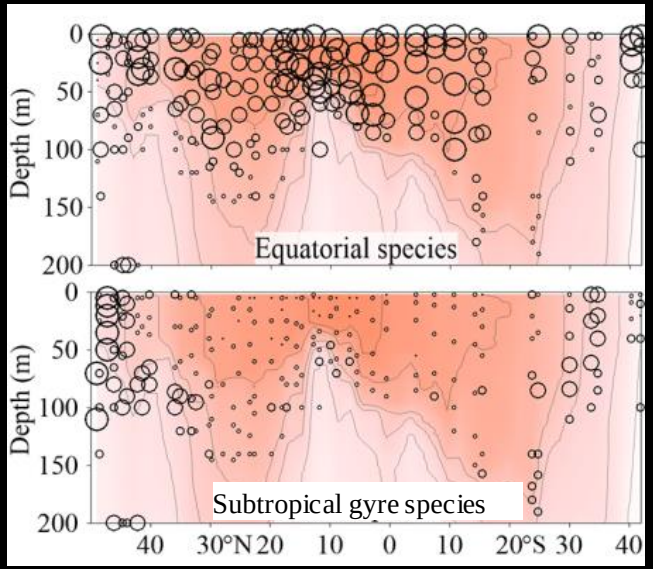
- Polar Gyre vs Subpolar Gyre
- Subpolar Gyre vs Subtropical Gyre

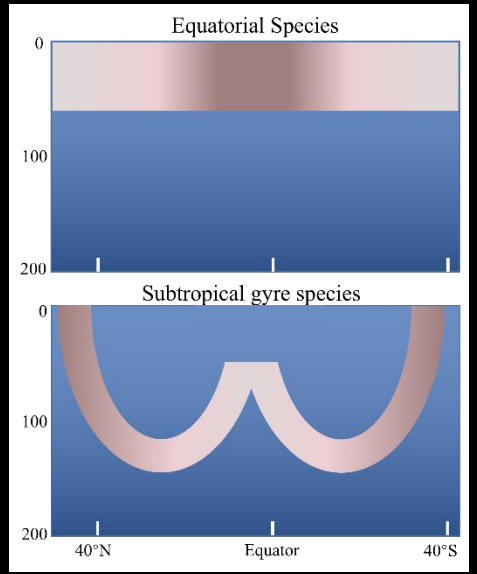
Interacting Galaxy NGC 5257and NGC 5258
Credit: NASA



The Making of an Assemblage:
Superposition of Biogeographic Belts

- Scenario 2: Neighboring belts of similar size overlap (collision)
- EQ vs Subtropical Gyre

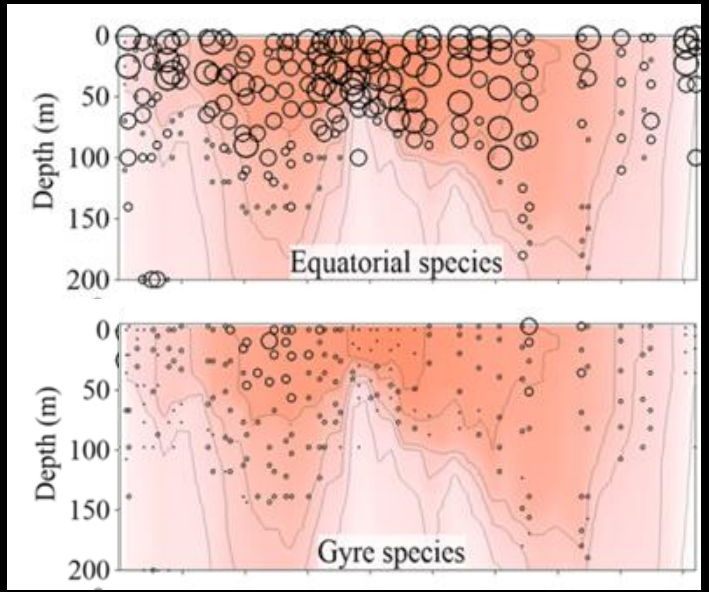




Colliding Galaxy 4567 and of NGC 4568
Credit: NASA

Organization of Tintinnid Biogeography

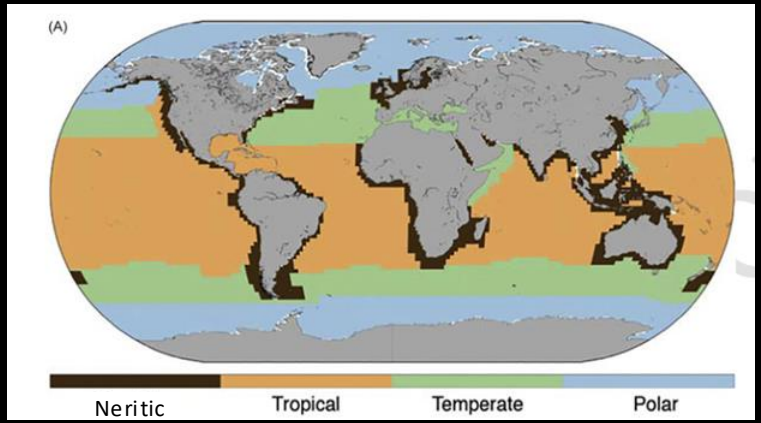
- Scenario 3: A large belt overshadows (engulfs) a small belt.
  - EQ vs Central
  - Antarctic Gyre vs Antarctic Slope Gyre

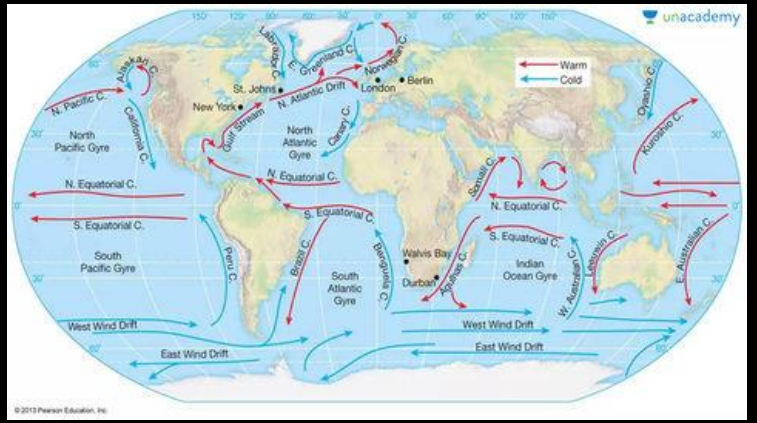


Merging galaxy pair II ZW 96
Credit: NASA

Current Knowledge Gap

- ❖Intra belt difference
  - Subpolar Gyres: North Atlantic vs North Pacific
  - EQ: Pacific vs Indian vs Atlantic
- ❖Neritic biome vs Oceanic biome





Thanks for Your Attention