Esperanza Broullón Mandado
Supervised by Beatriz Mouriño Carballido and Bieito Fernández Castro

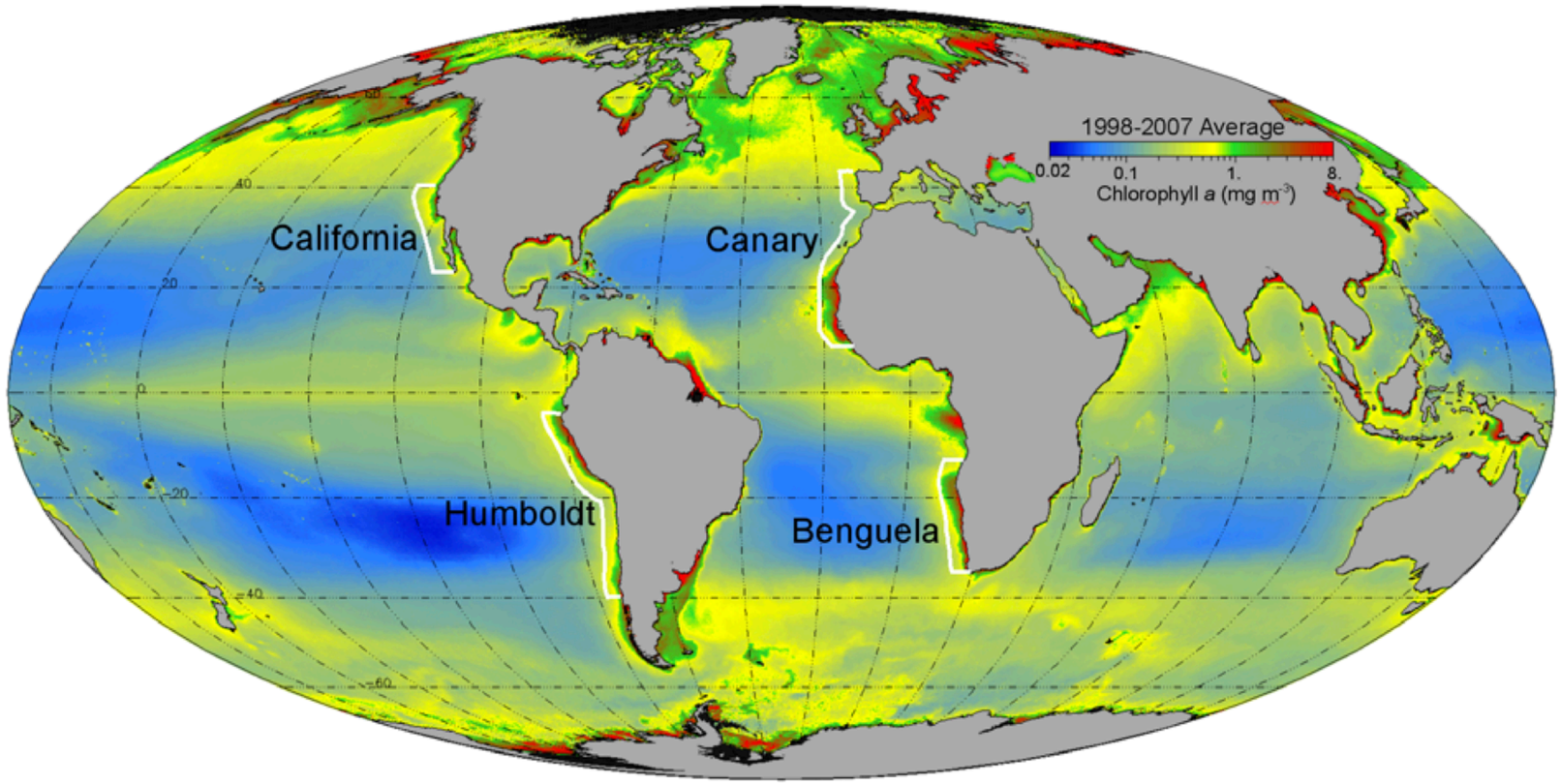
28th June, 2024

Thin layers of phytoplankton in the Rías Baixas (NW off Iberia): occurrence, formation and relevance

PhD defense

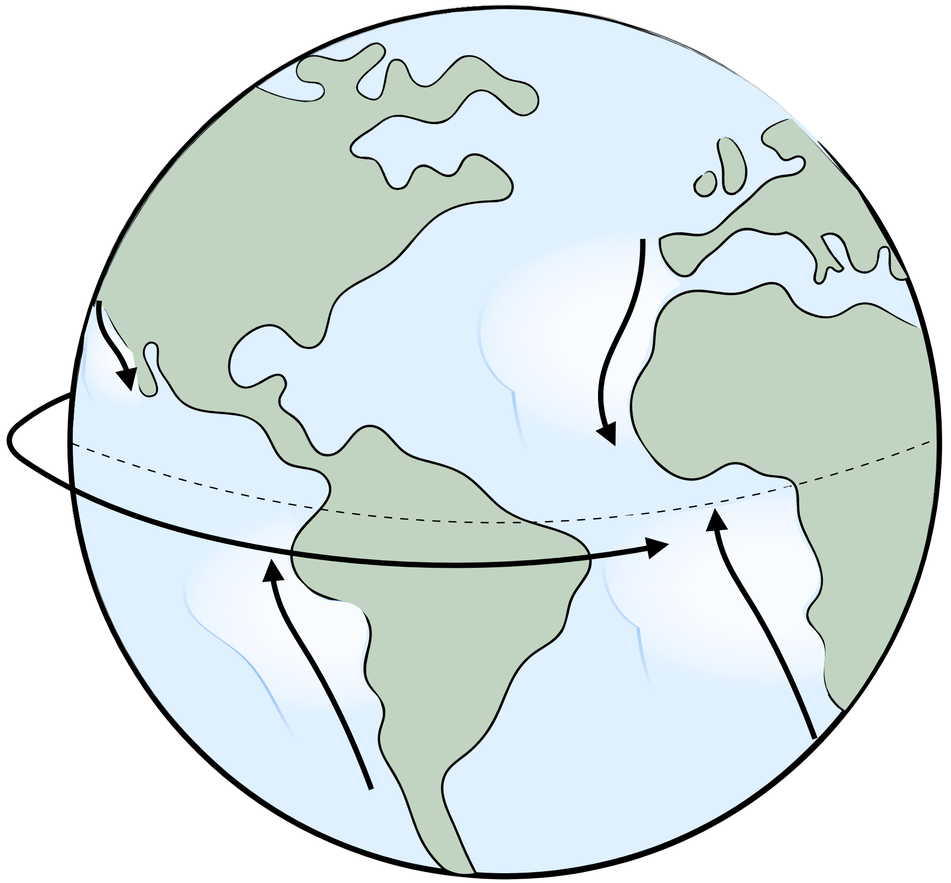
Phytoplankton

Eastern Boundary Upwelling Systems

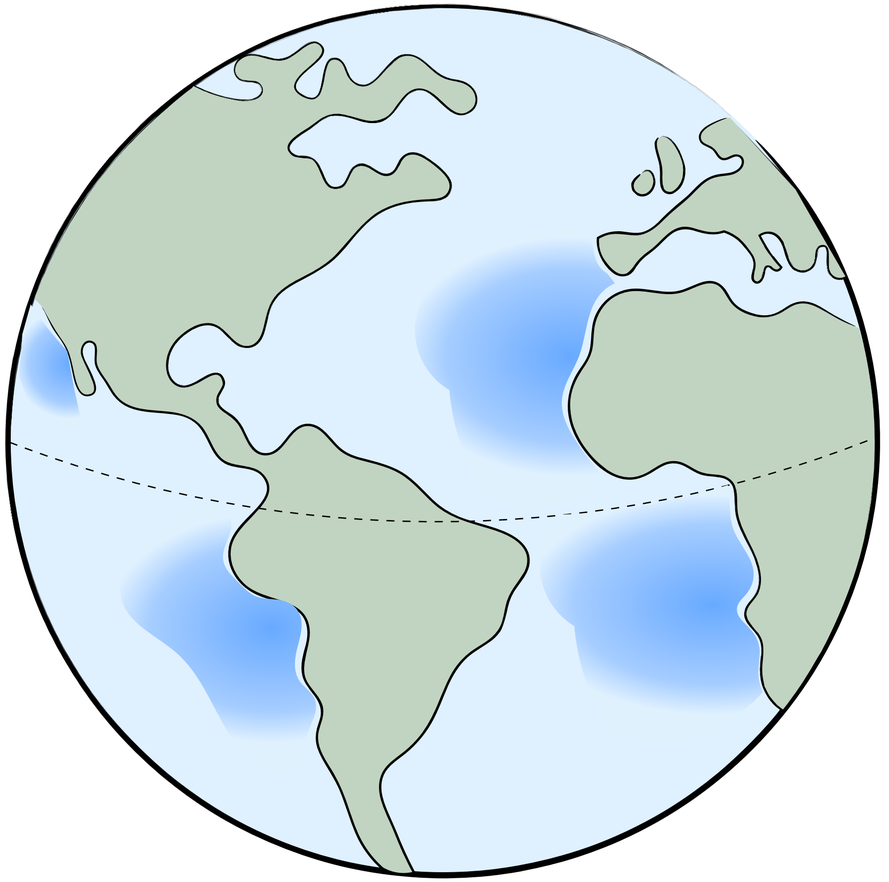


Freón et al., 2009 (*Progress in Oceanography*)

Eastern Boundary Upwelling Systems

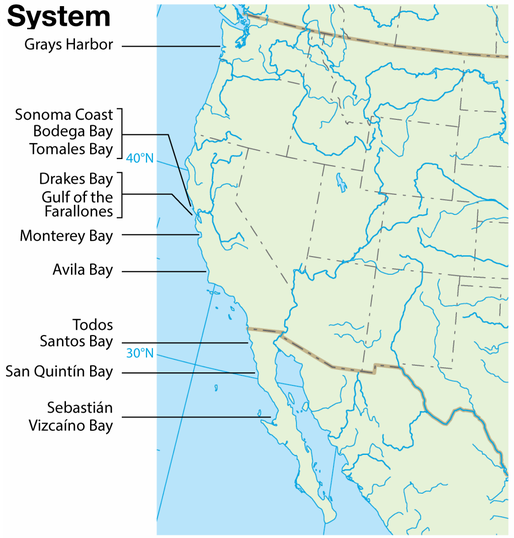


Eastern Boundary Upwelling Systems

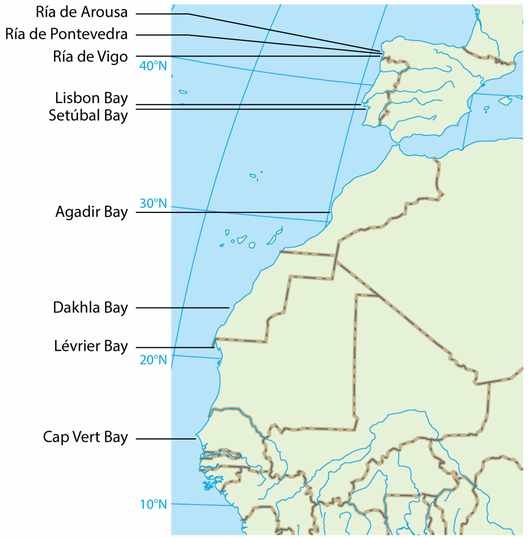


EBUS: upwelling bays

a. California Current System

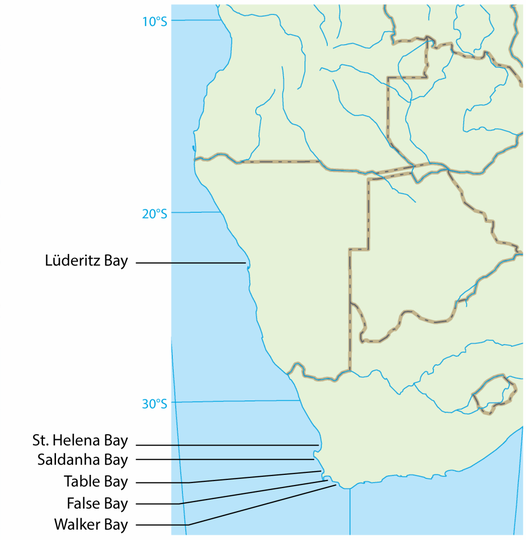


c. Canary Current System



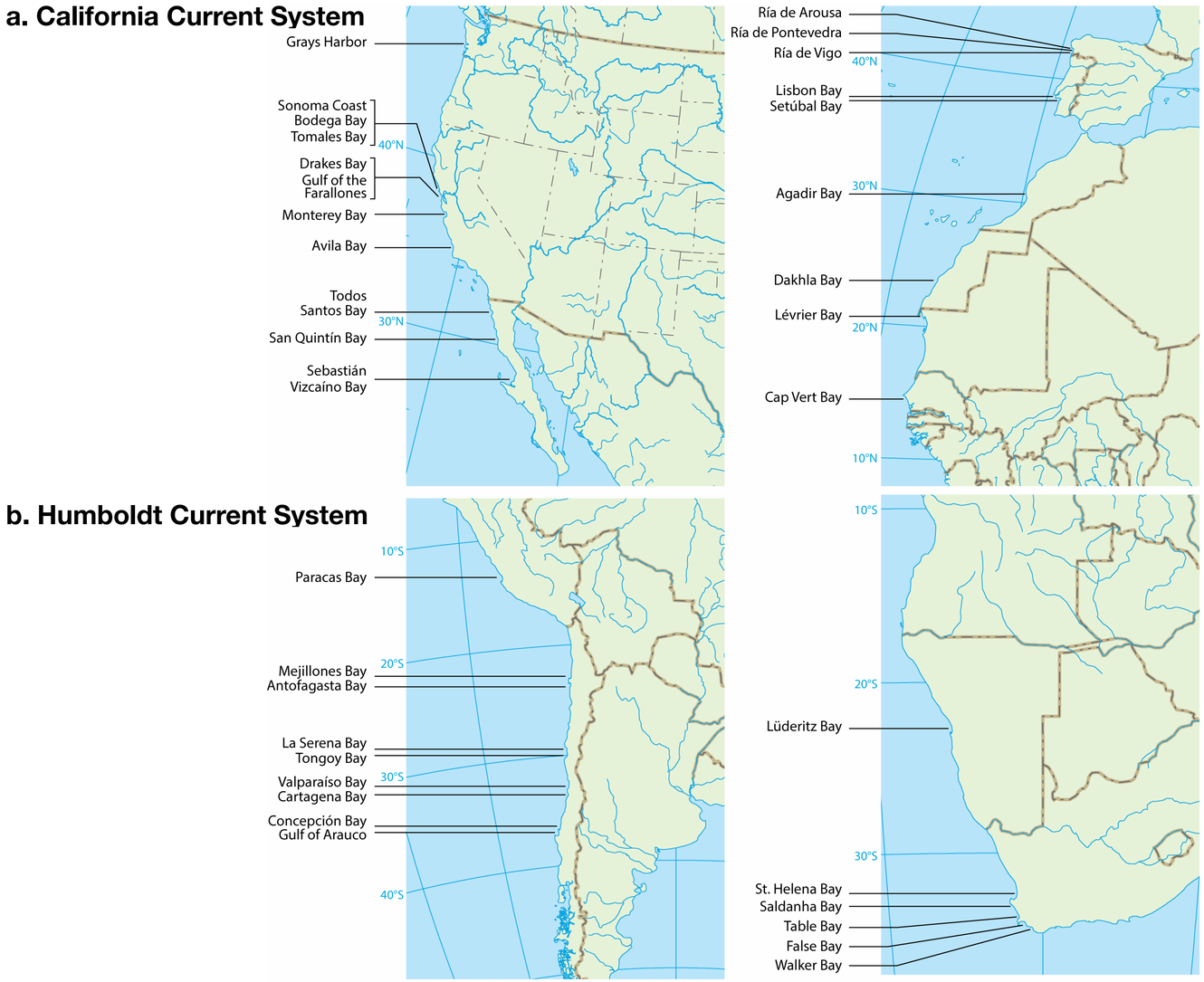
b. Humboldt Current System

d. Benguela Current System



Largier, 2020 (Annual Review of Marine Science)

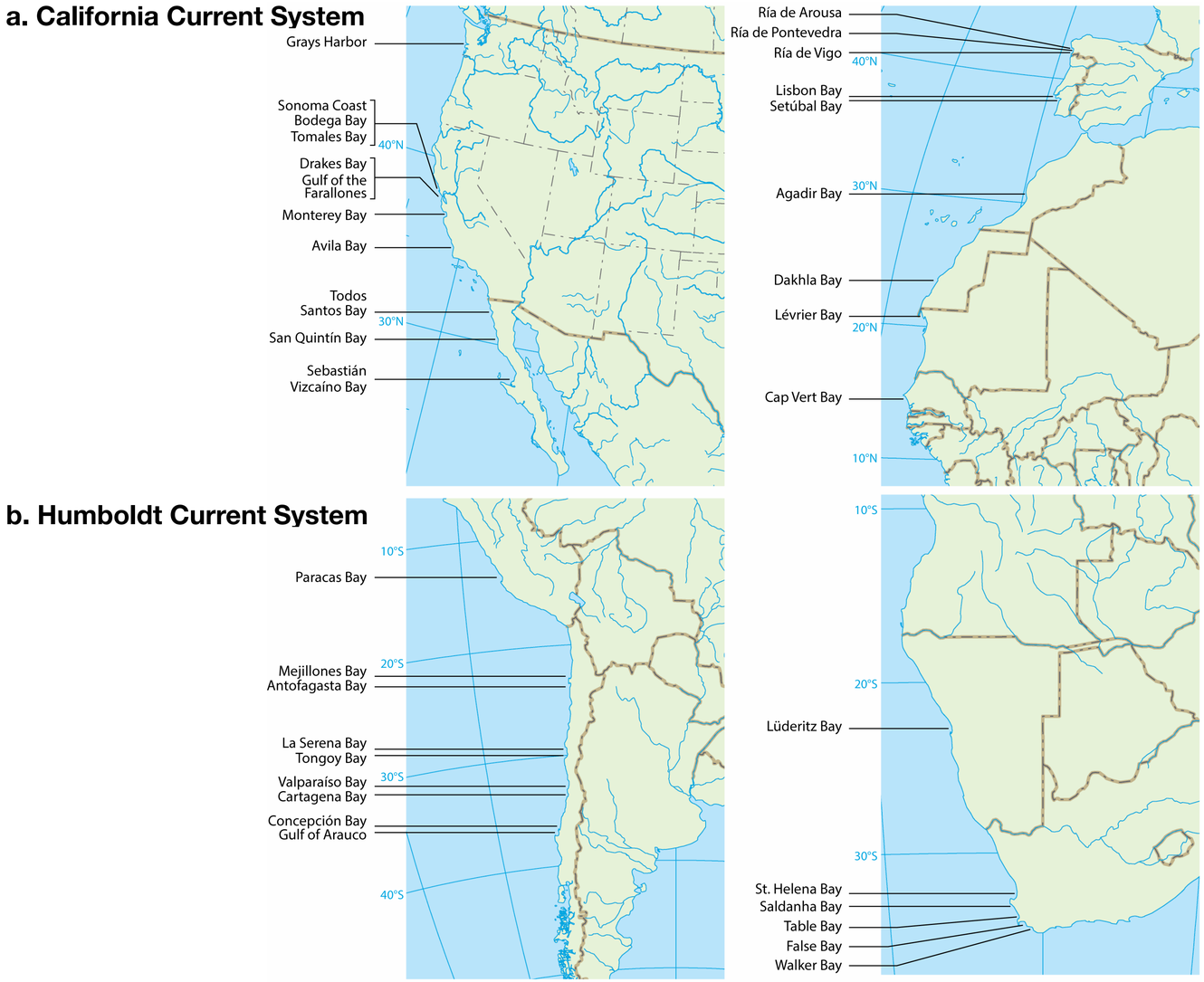
EBUS: upwelling bays



Retention time

Largier, 2020 (Annual Review of Marine Science)

EBUS: upwelling bays

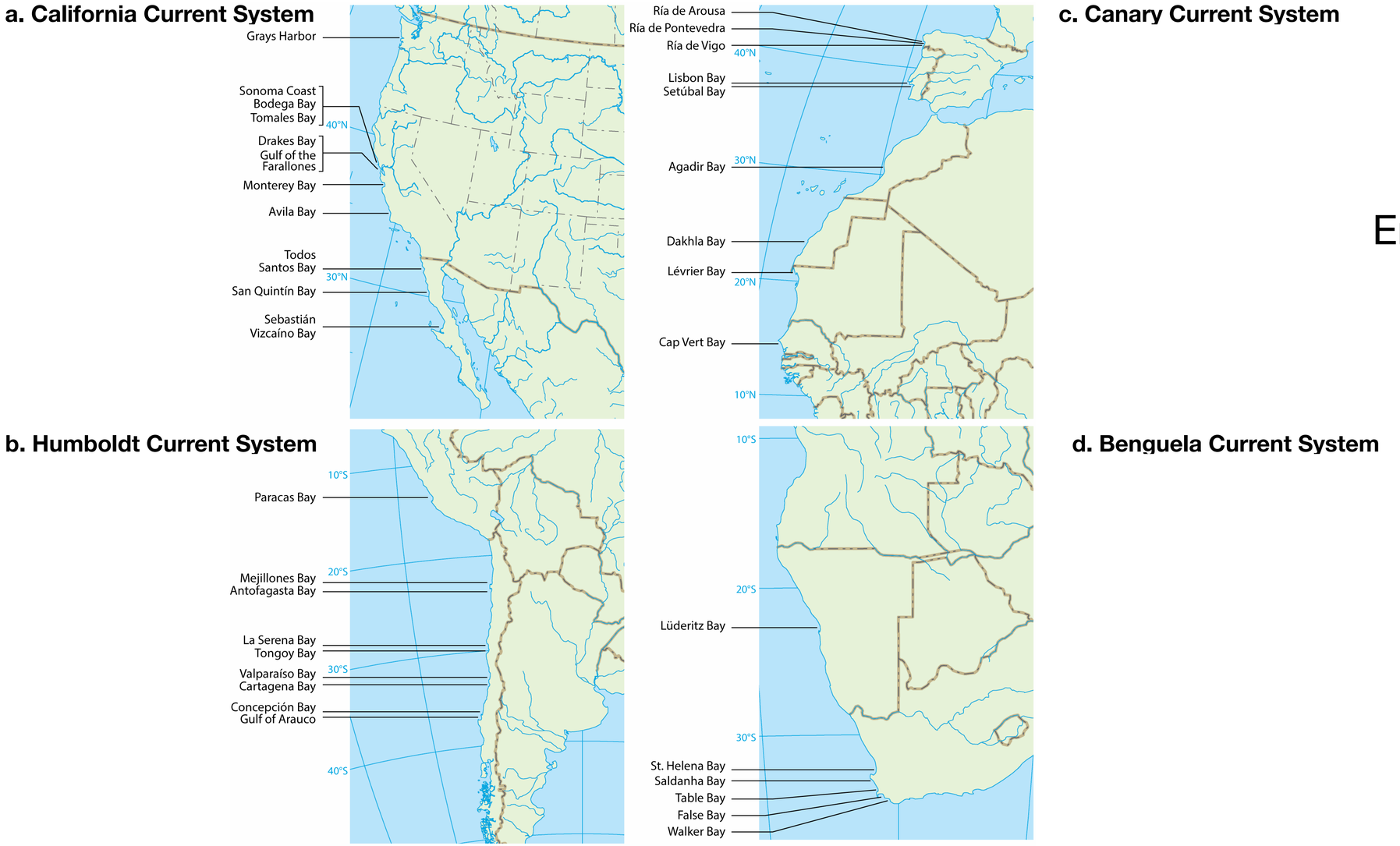


Retention time

Enhanced upwelling and stratification

Largier, 2020 (Annual Review of Marine Science)

EBUS: upwelling bays



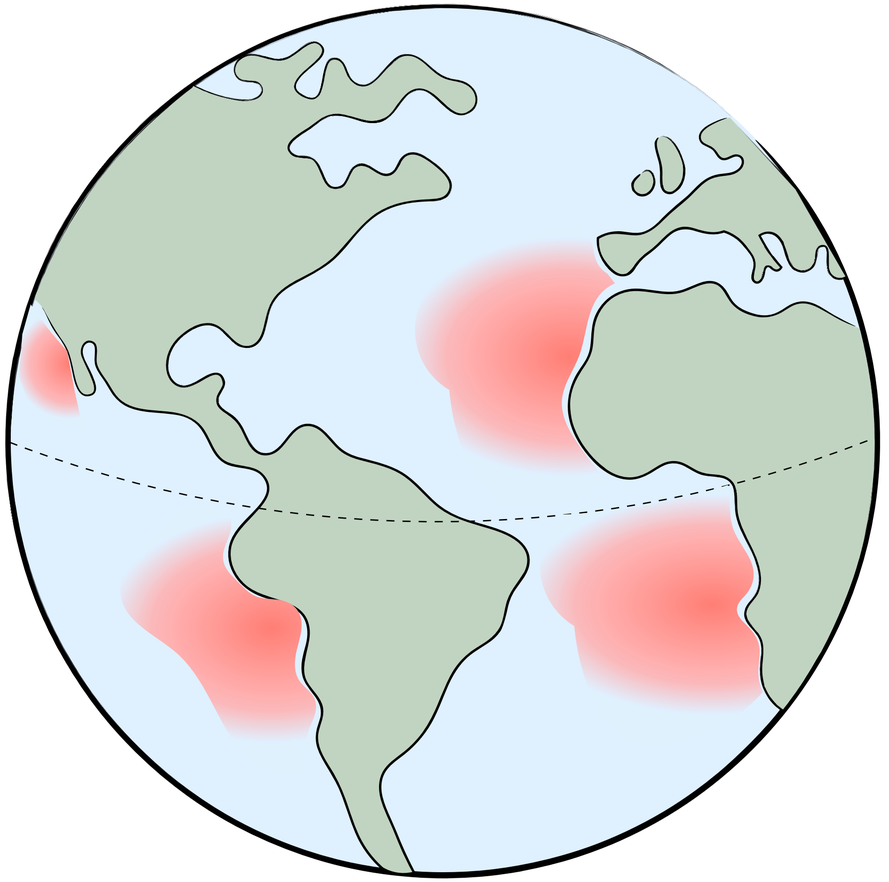
Retention time

Enhanced upwelling and stratification

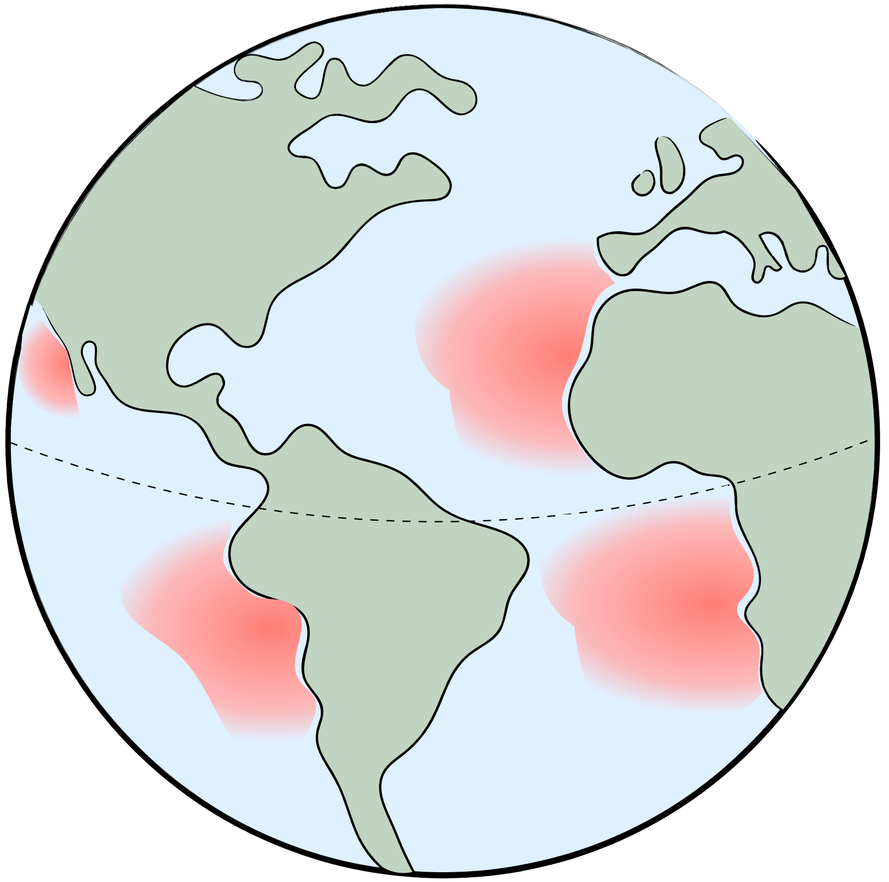
Extra nutrient input

Largier, 2020 (Annual Review of Marine Science)

EBUS: harmful algal blooms



EBUS: harmful algal blooms



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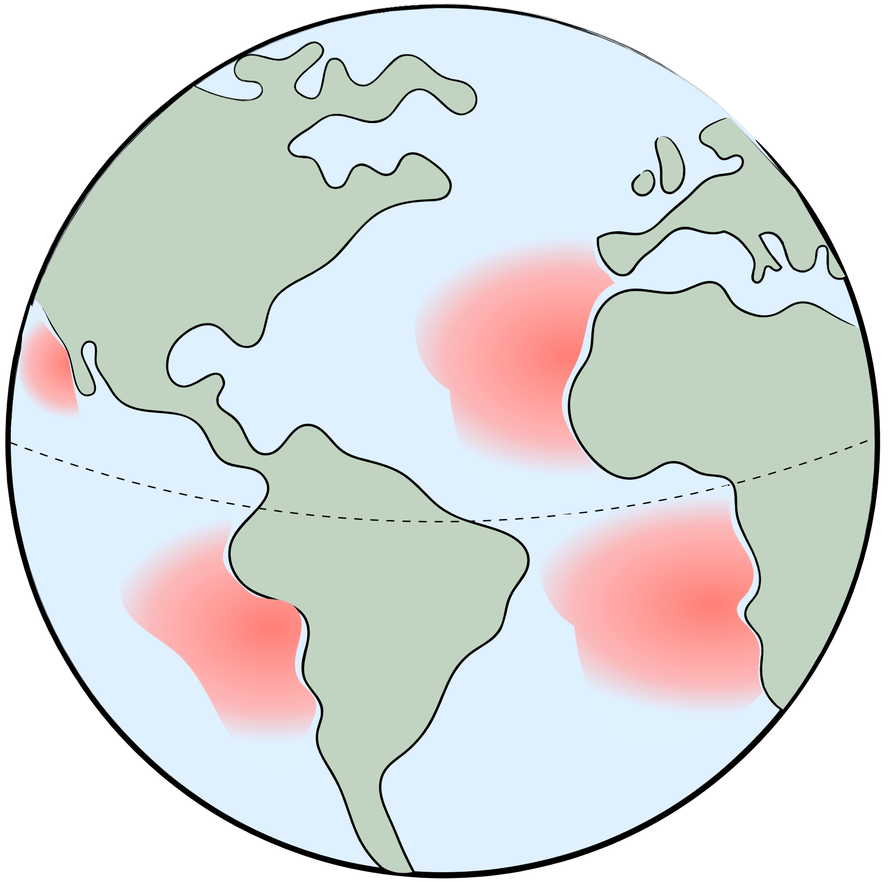
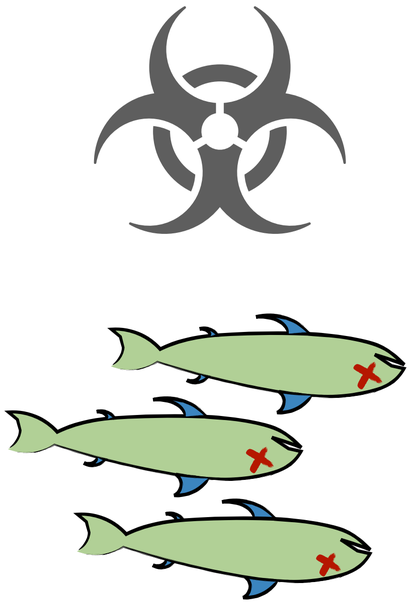
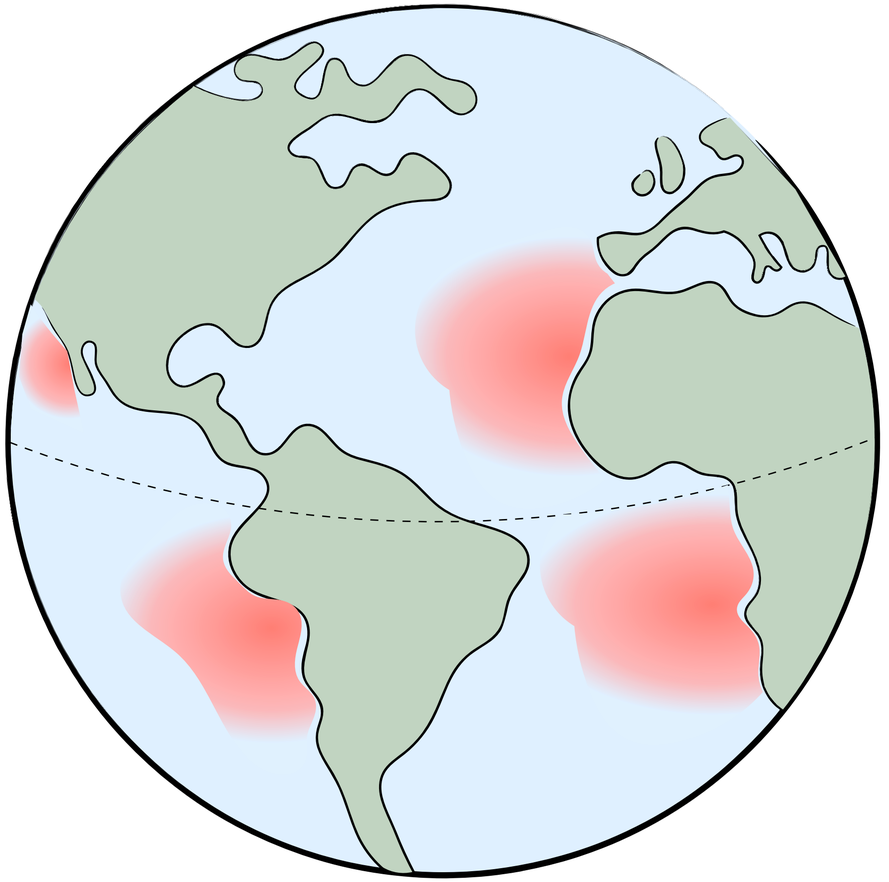
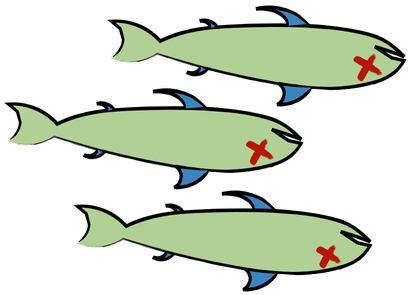
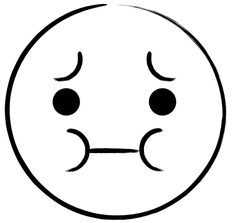




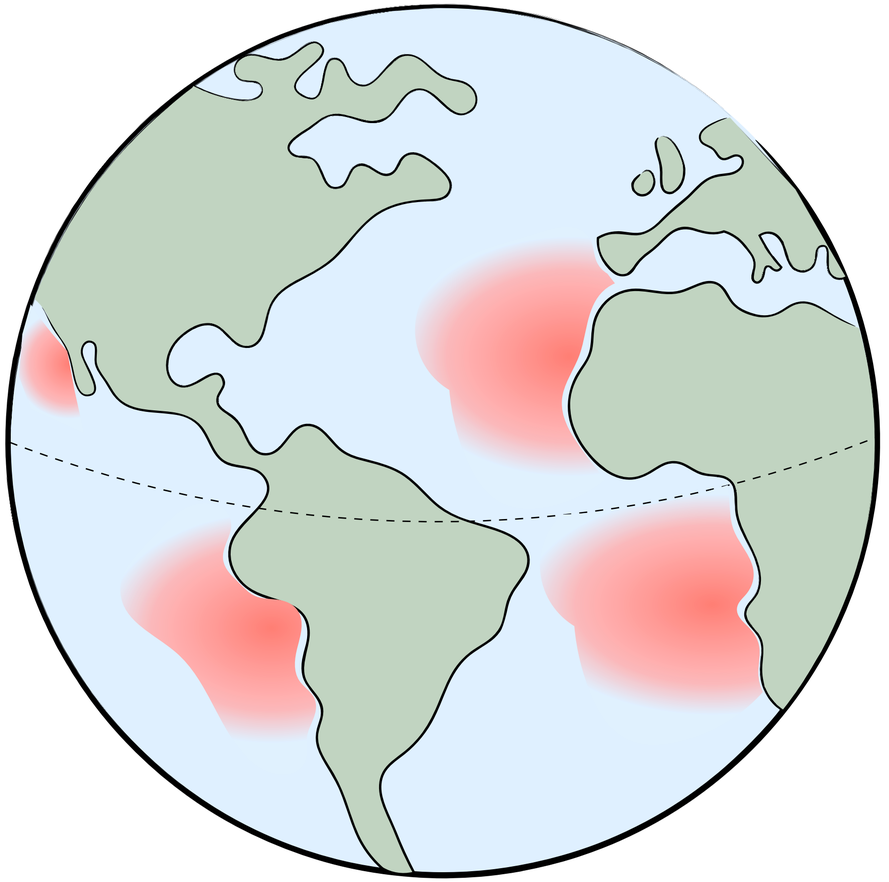
EBUS: harmful algal blooms

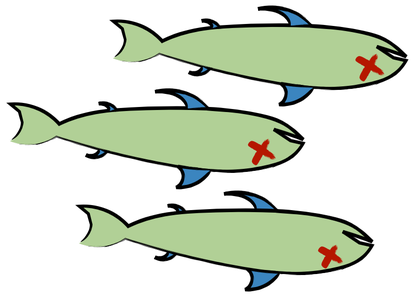


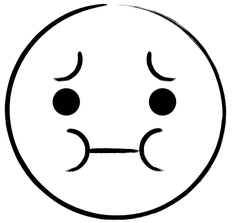


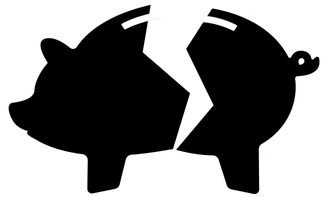


EBUS: harmful algal blooms

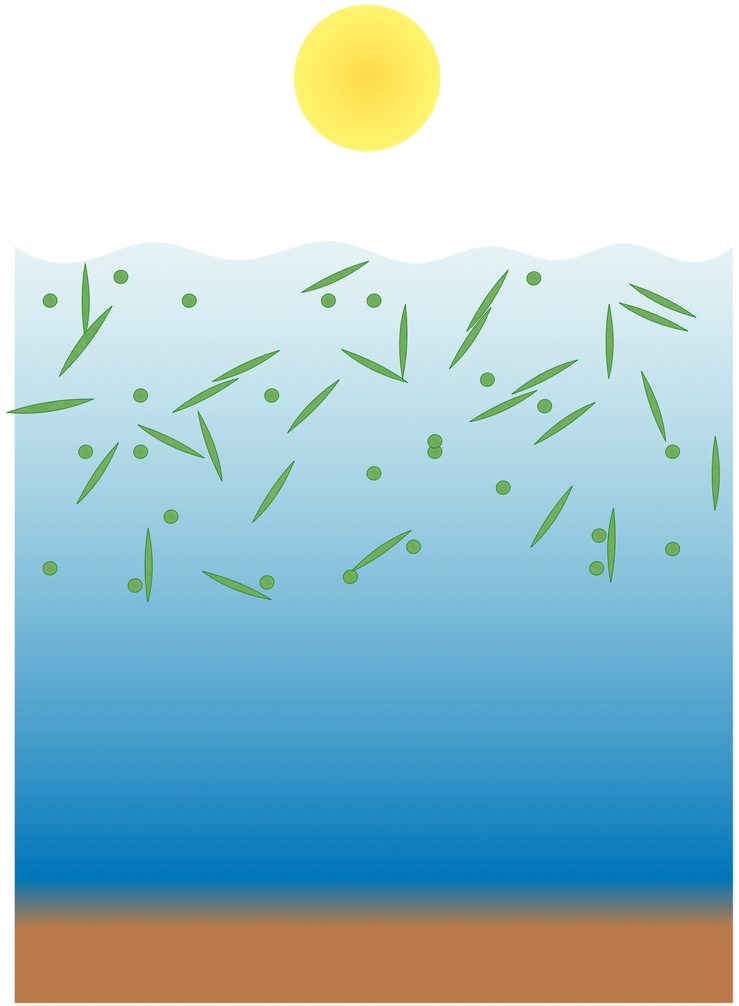


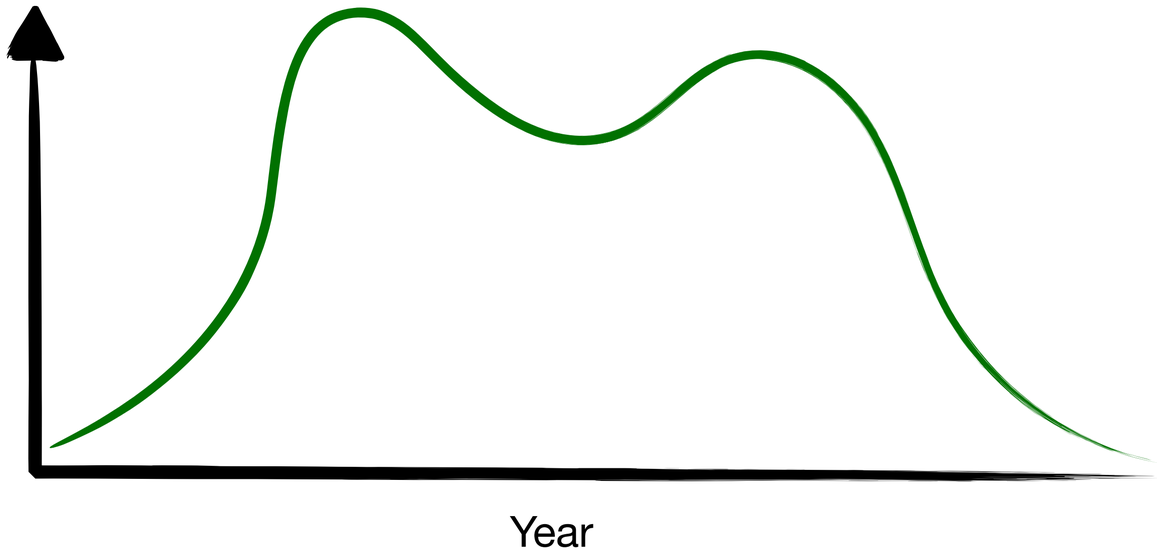




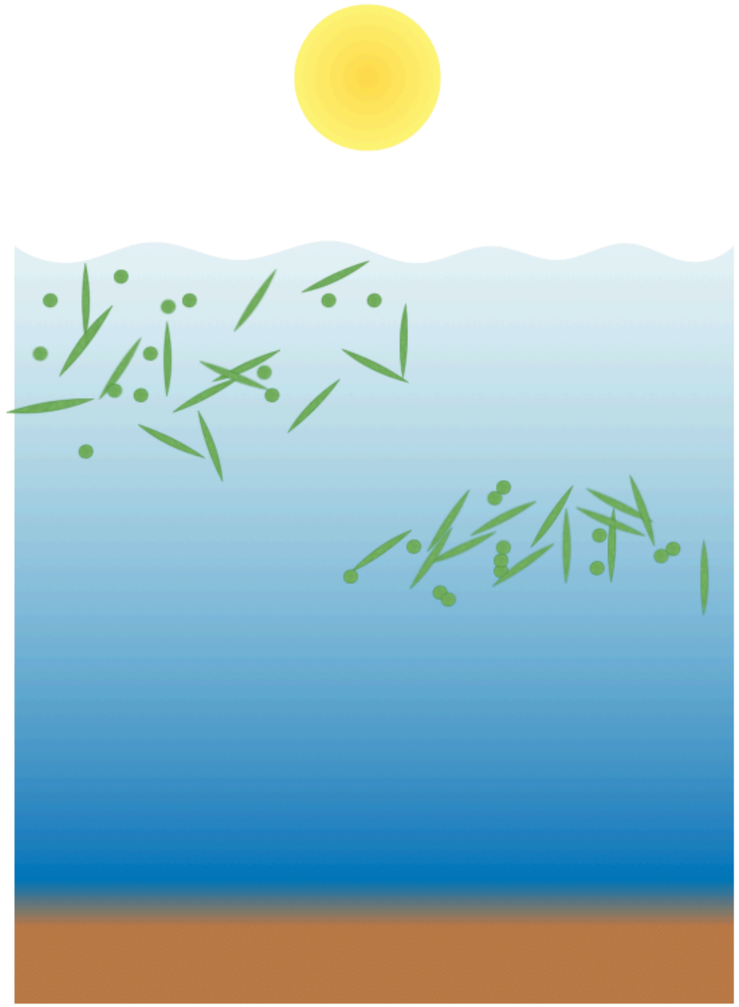


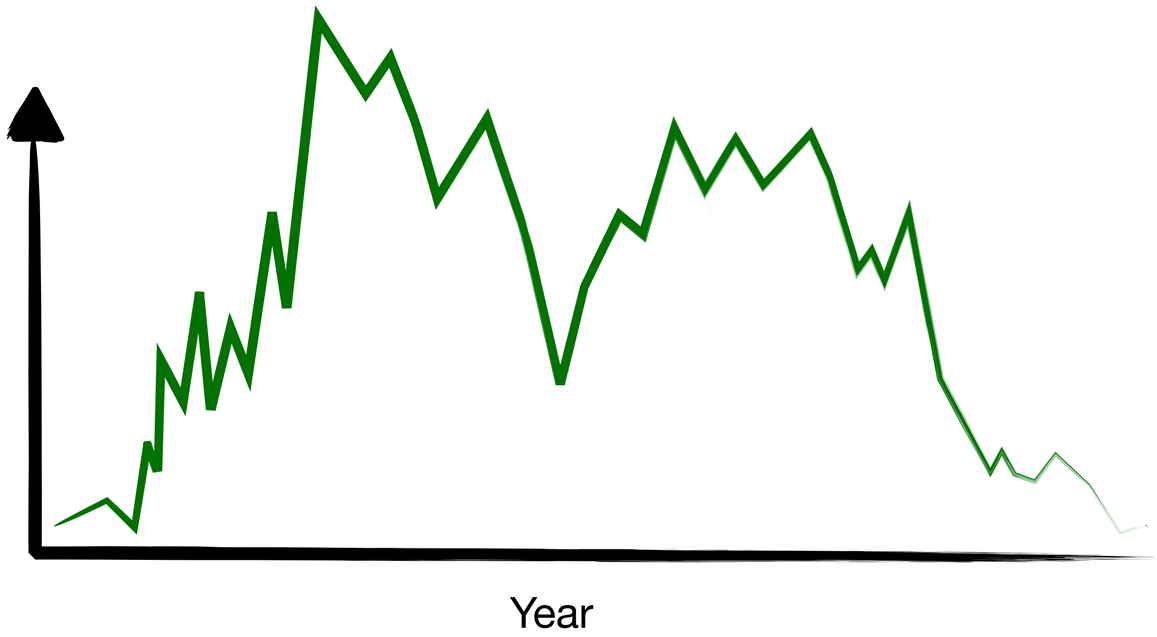
Phytoplankton bloom dynamics



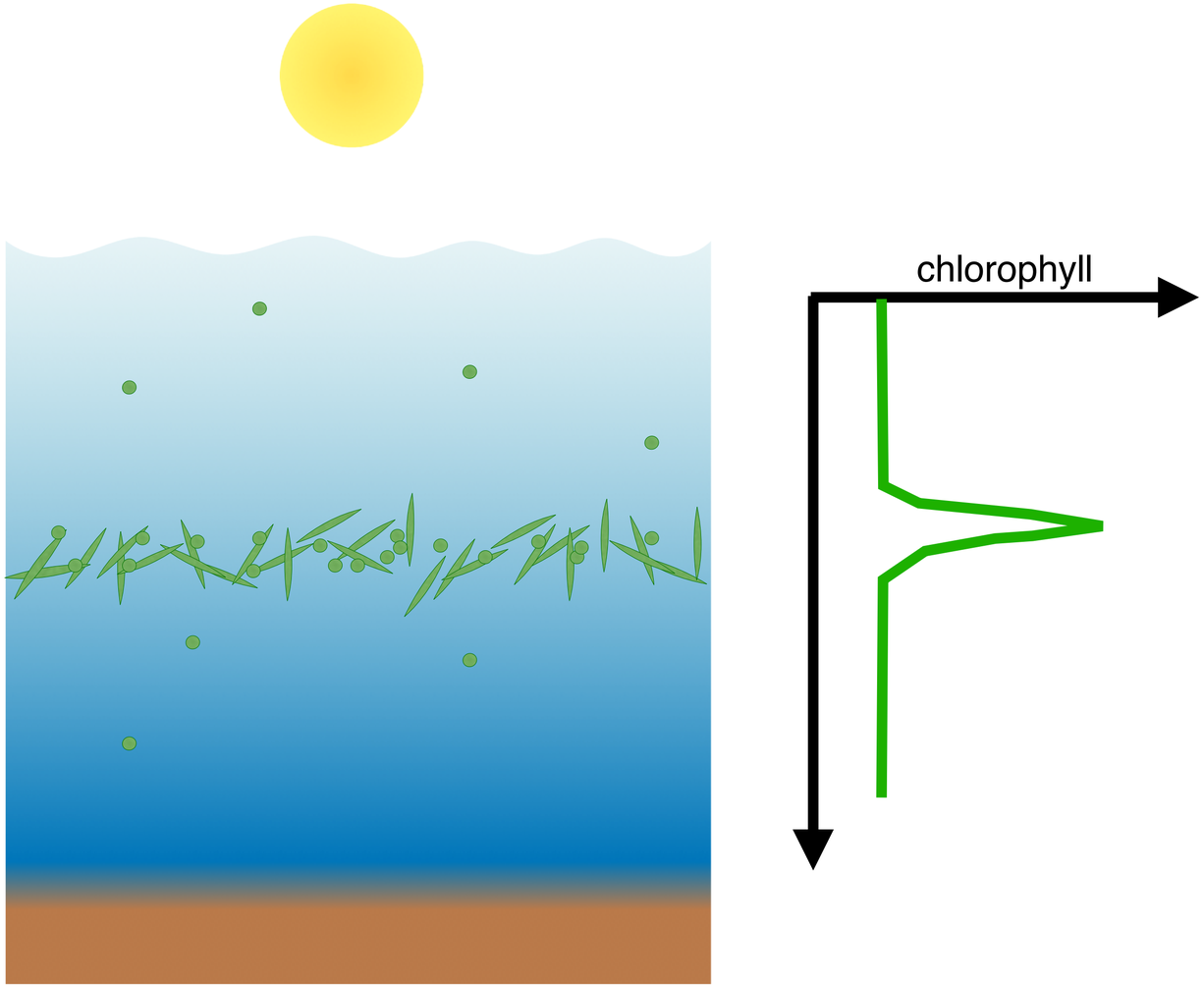


Phytoplankton bloom dynamics



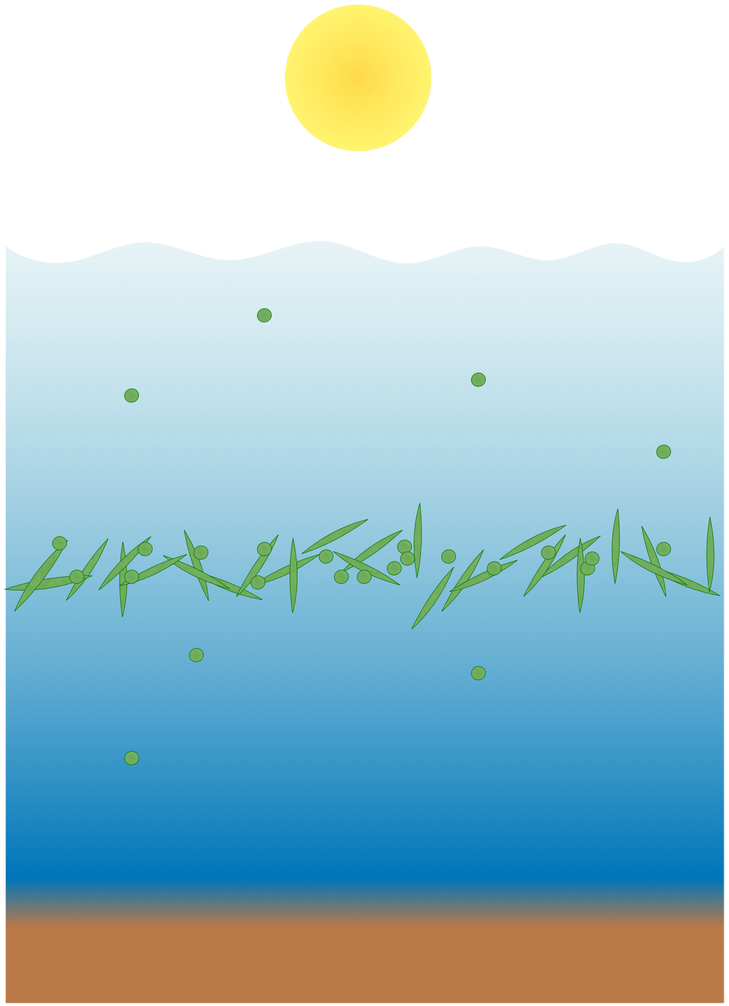


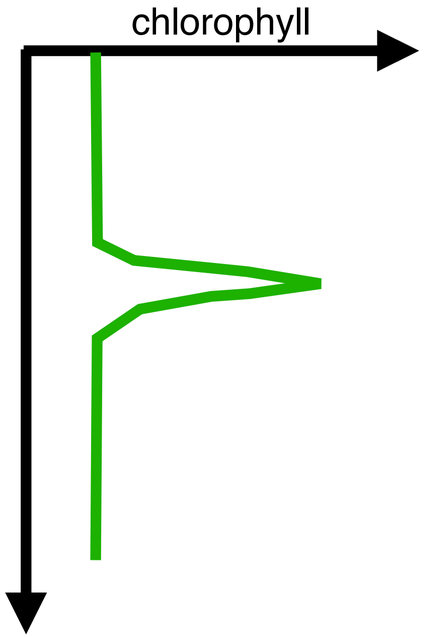
What are *thin layers of phytoplankton*?



Strickland (1968), Durham & Stocker (2012)

What are *thin layers of phytoplankton*?

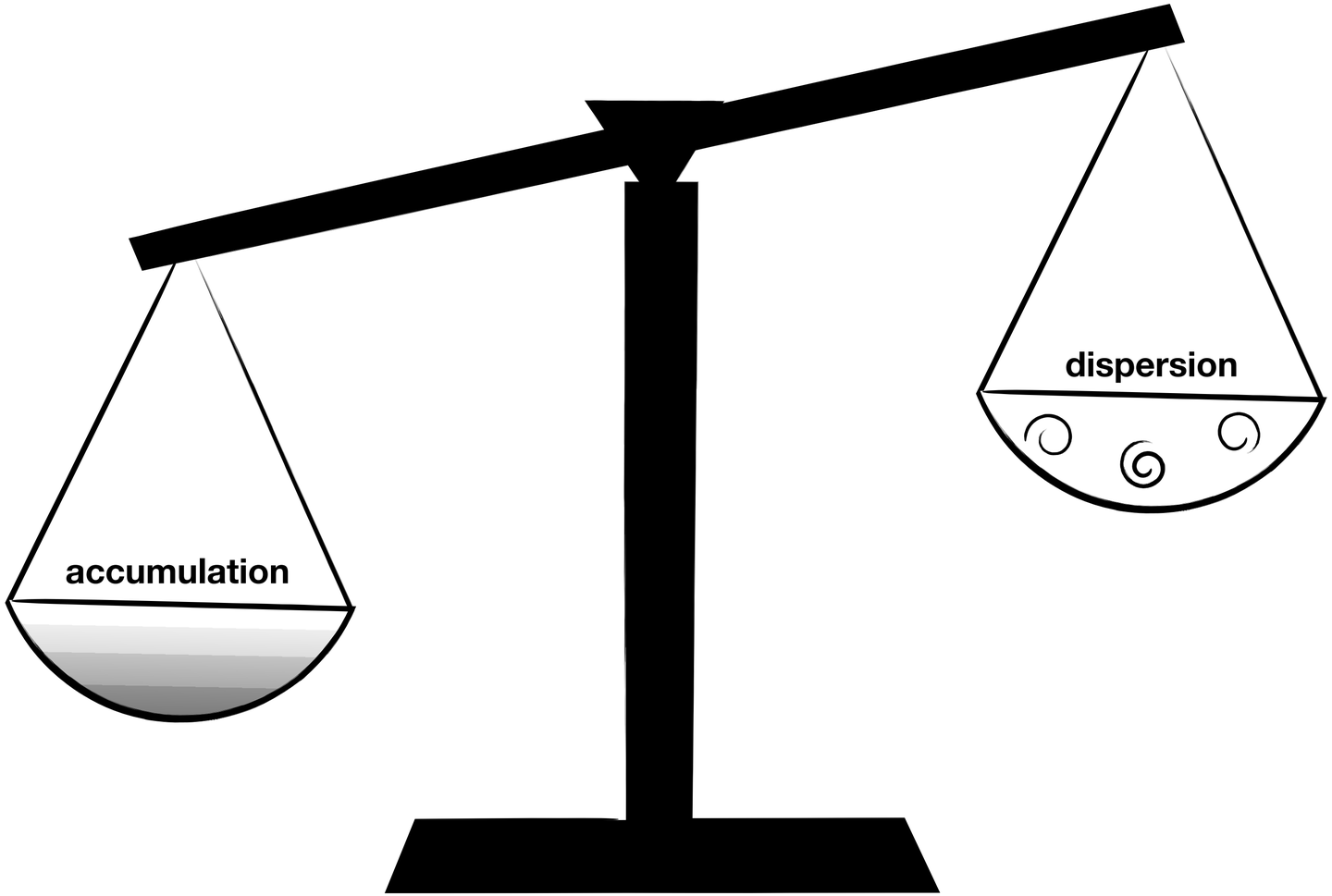




- Thickness < 5 m
- Intensity > 2 x Background
- TLP can extent horizontally over several km and persist for several days

Strickland (1968), Durham & Stocker (2012)

How do TLP form?



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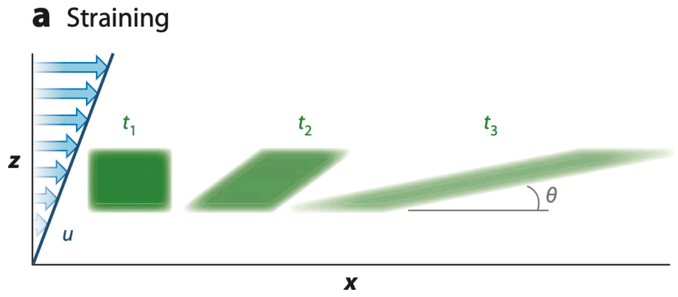
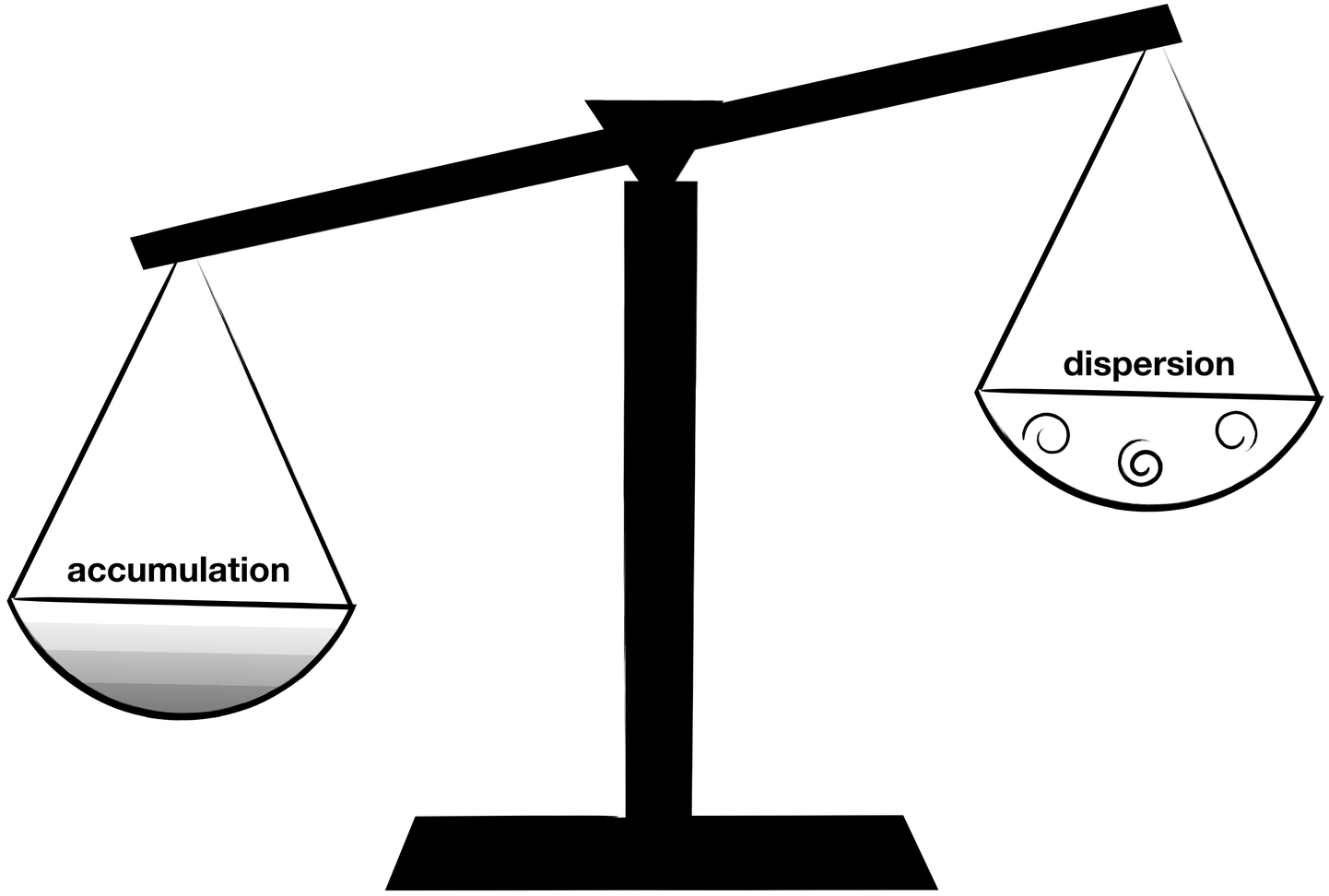
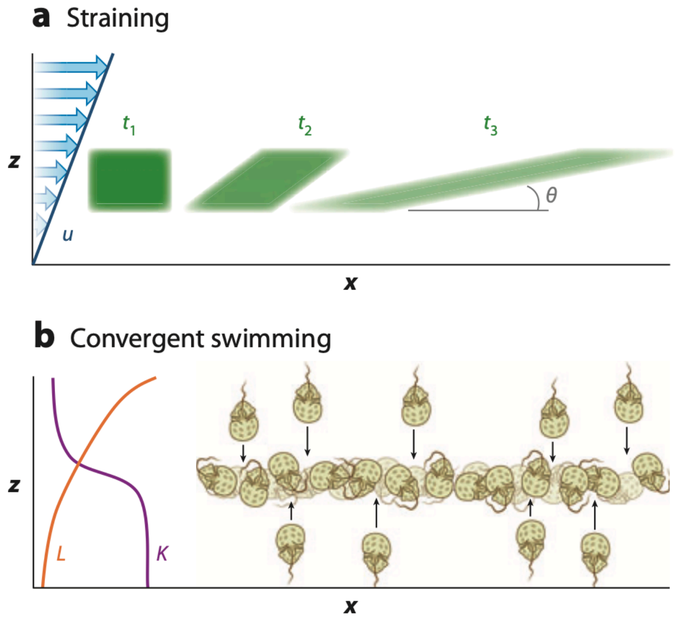
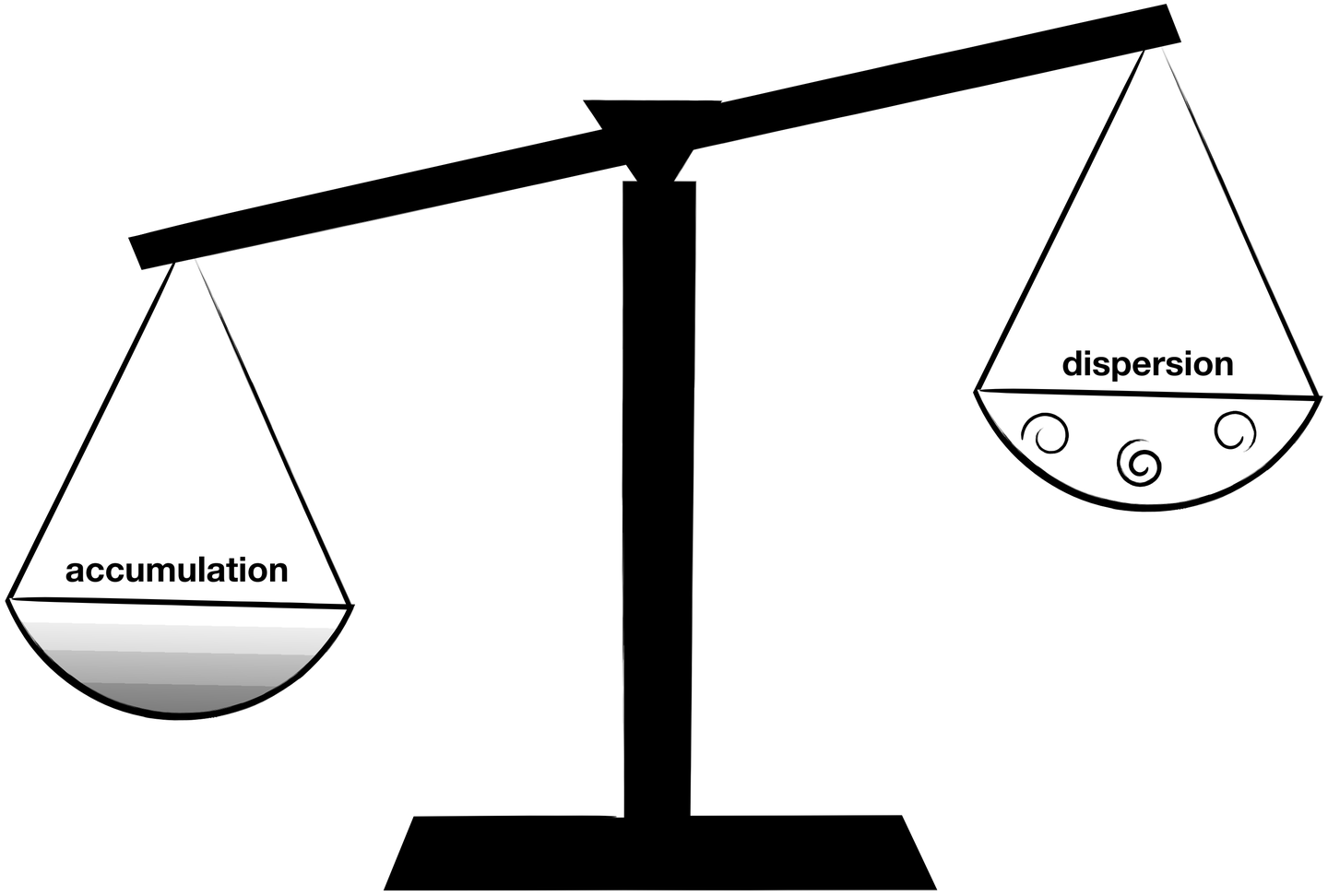




Durham & Stocker (2012)

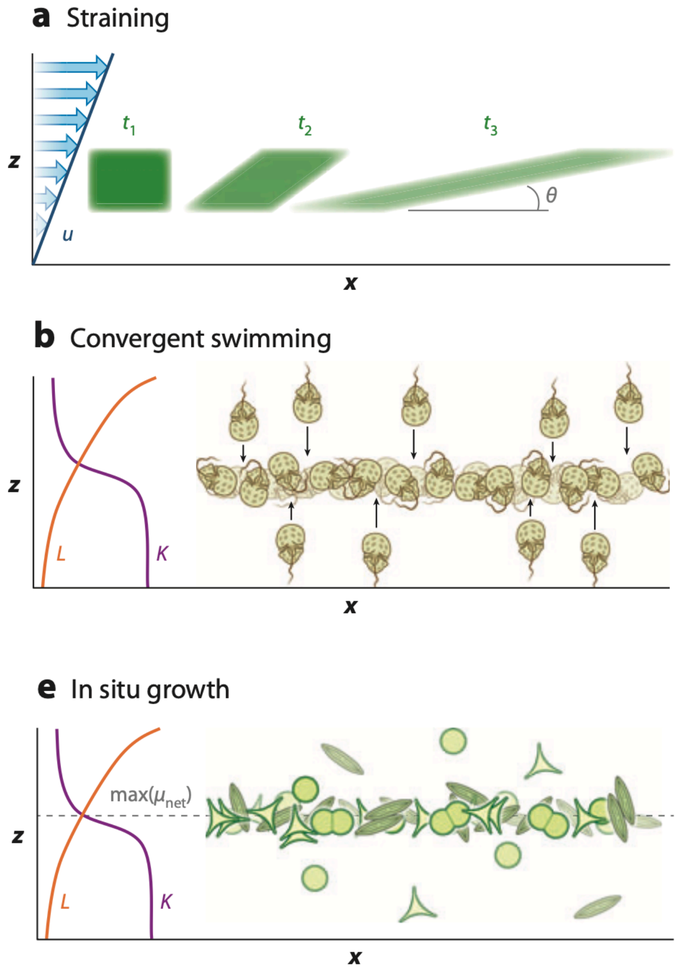
How do TLP form?



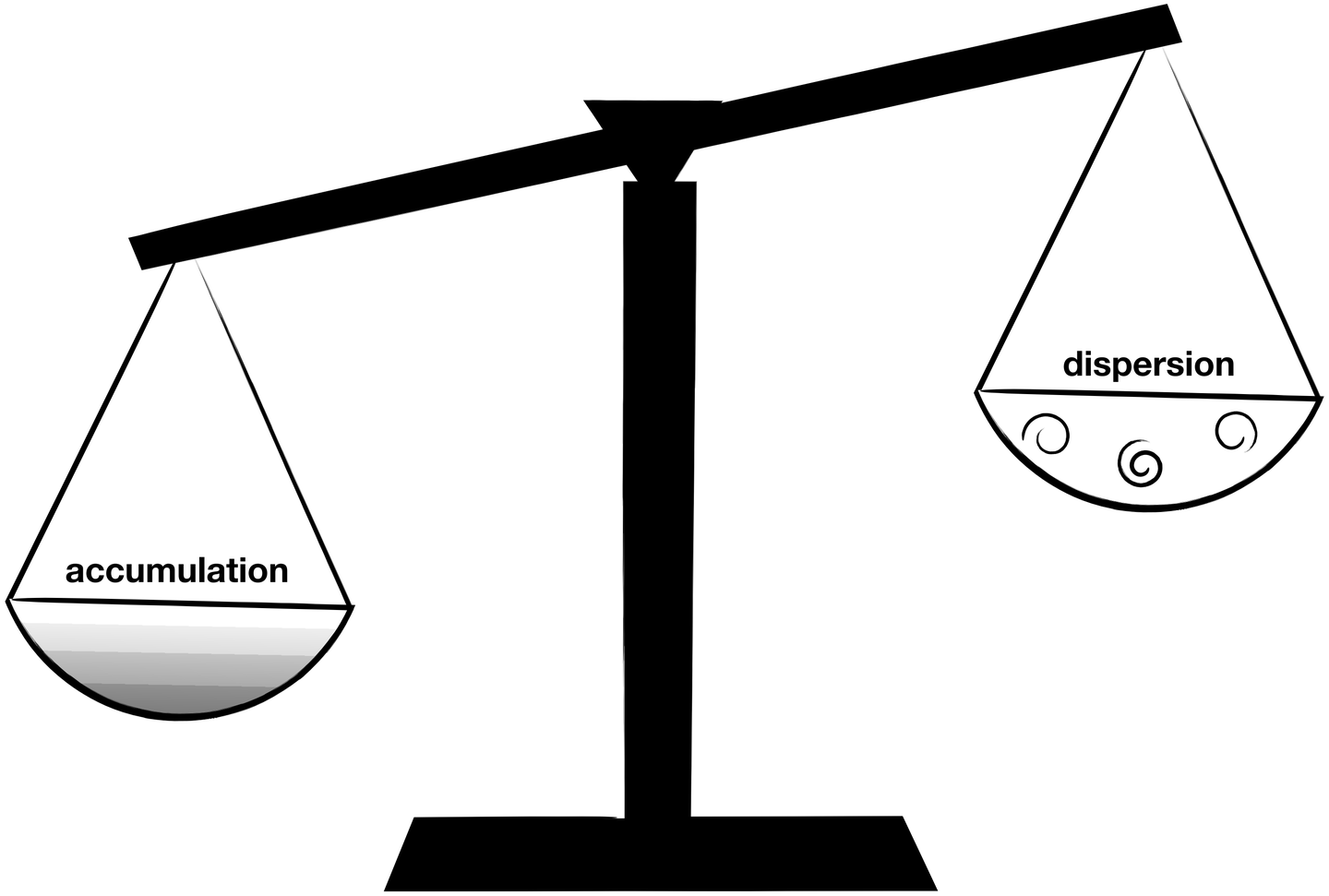


Durham & Stocker (2012)

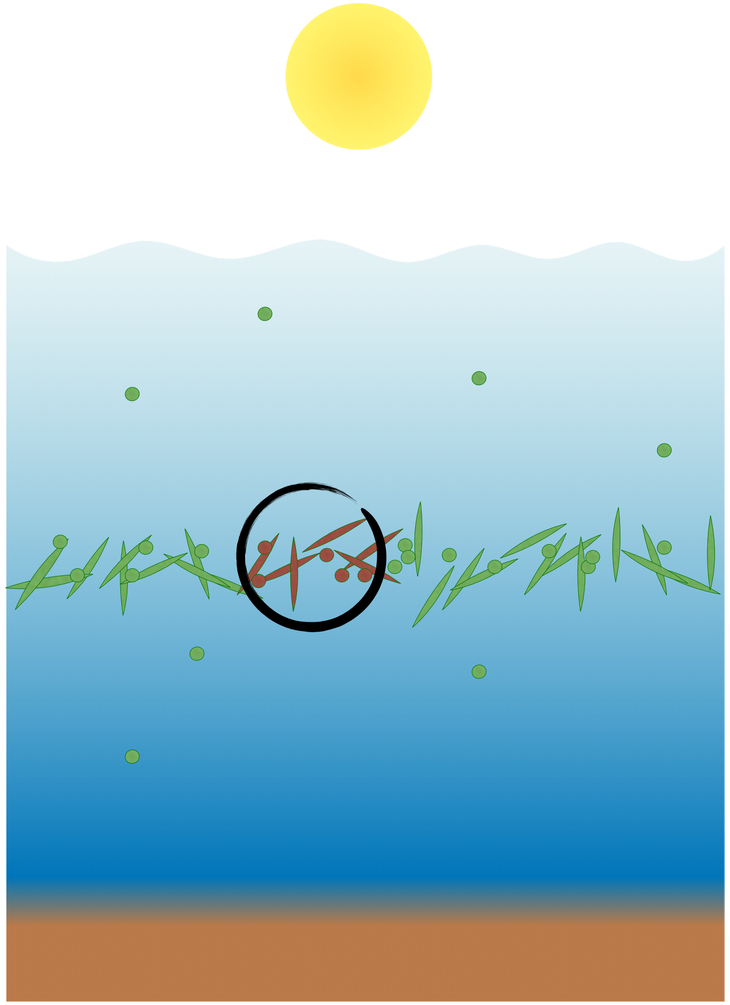
How do TLP form?



Durham & Stocker (2012)



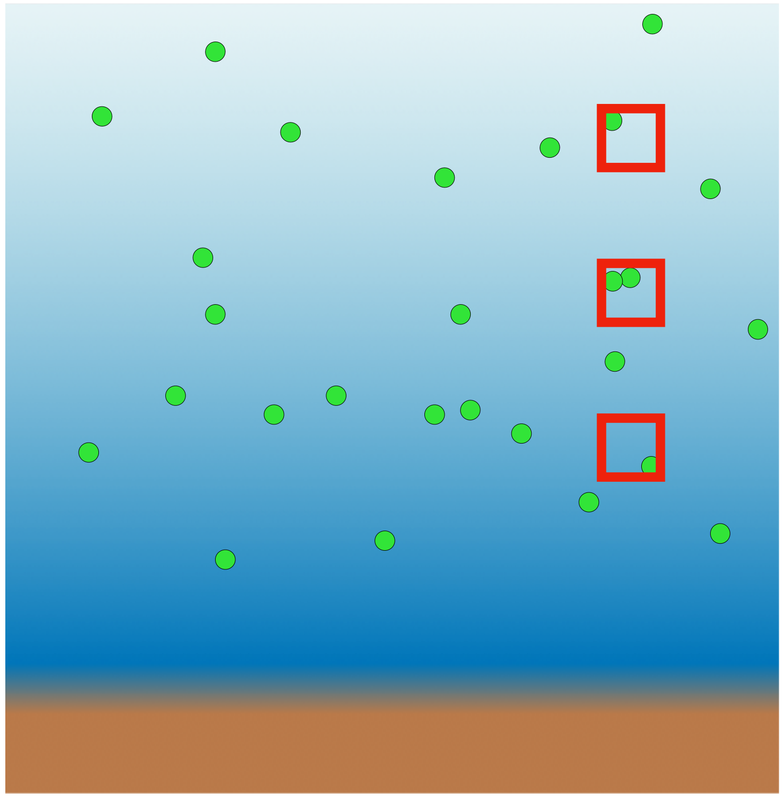
Thin layers and harmful algal blooms

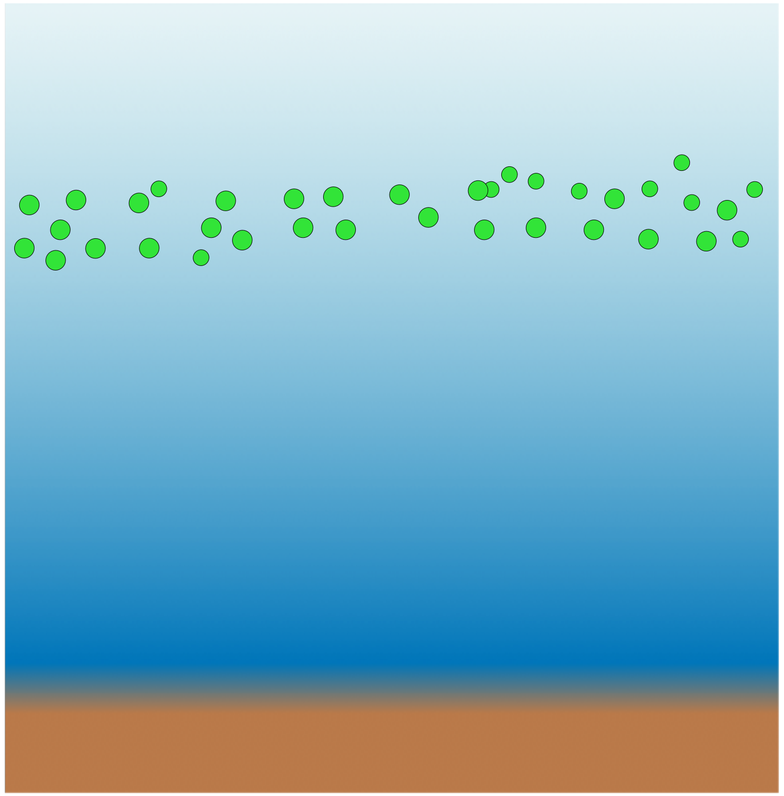


Several studies showed the presence of toxin-producing species within TLP

Velo-Suárez et al. (2008), Díaz et al. (2014, 2019), McManus et al., (2003)

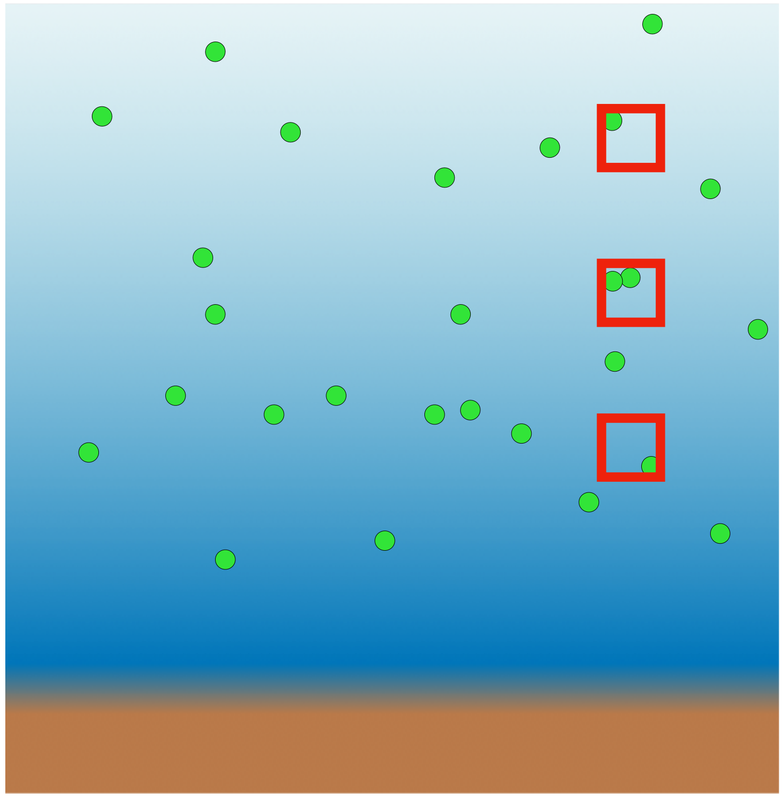
Thin layers detection

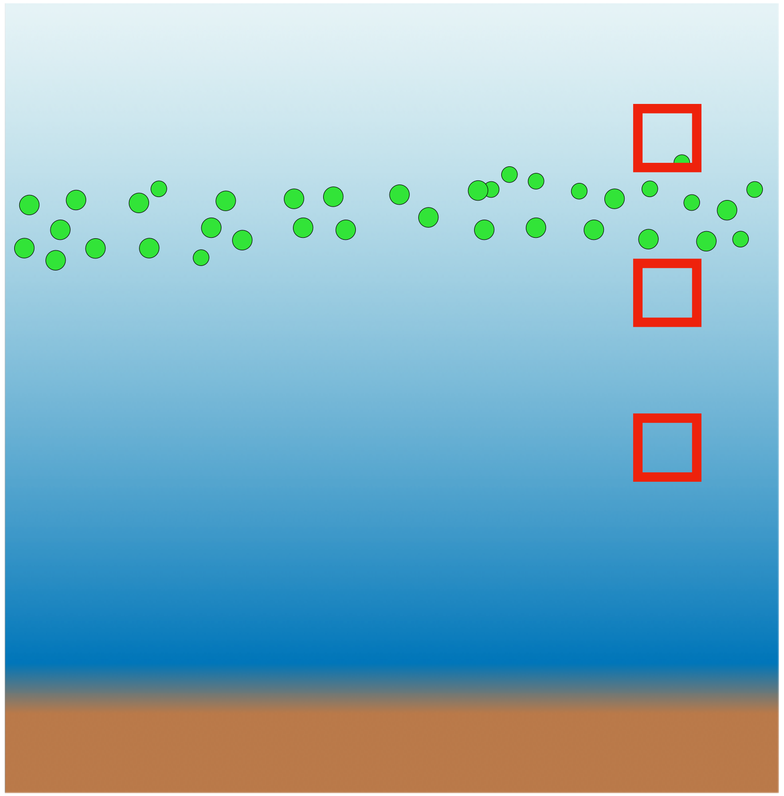




Escalera et al., 2012 (*Marine Pollution Bulletin*)

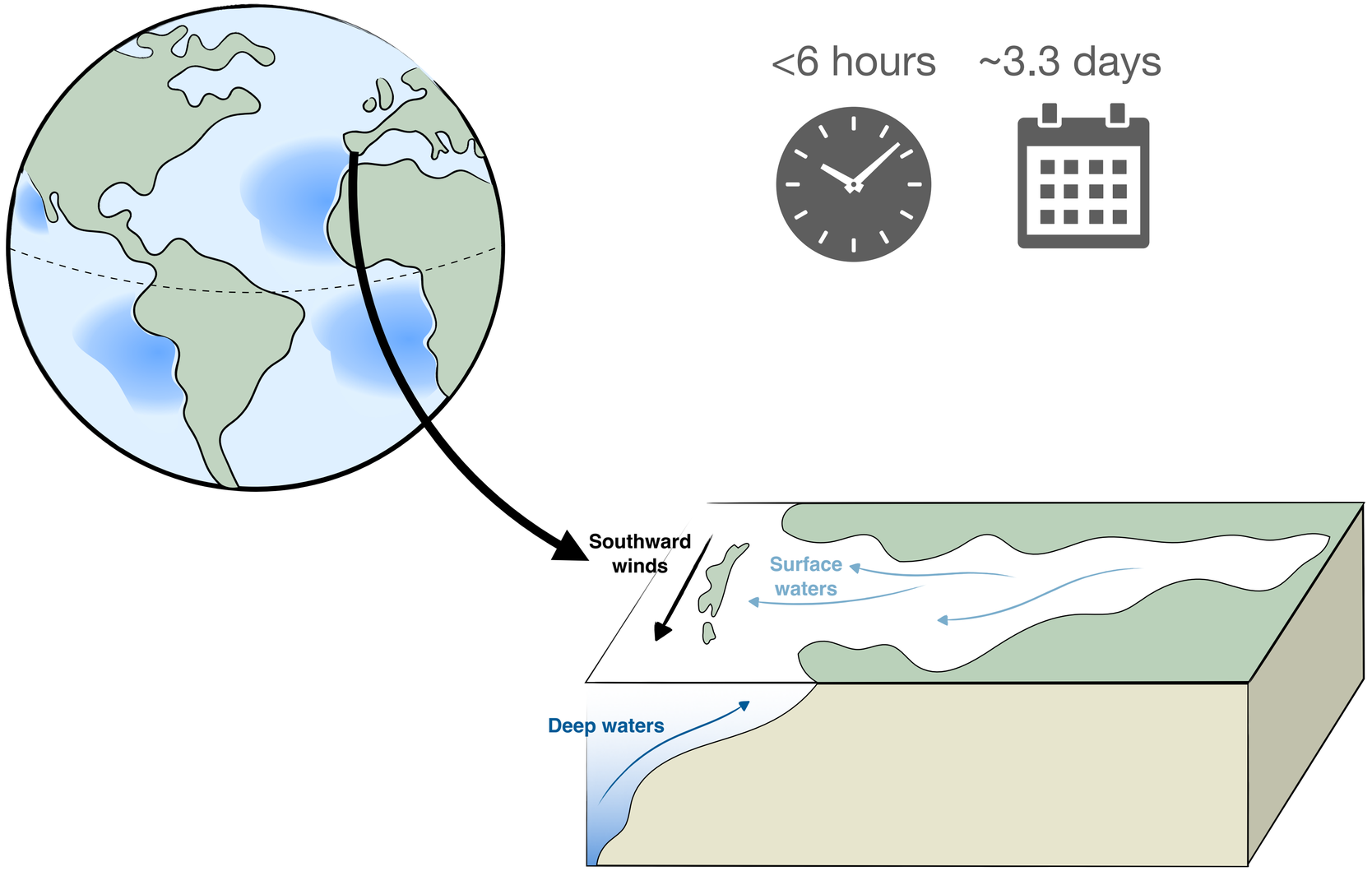
Thin layers detection





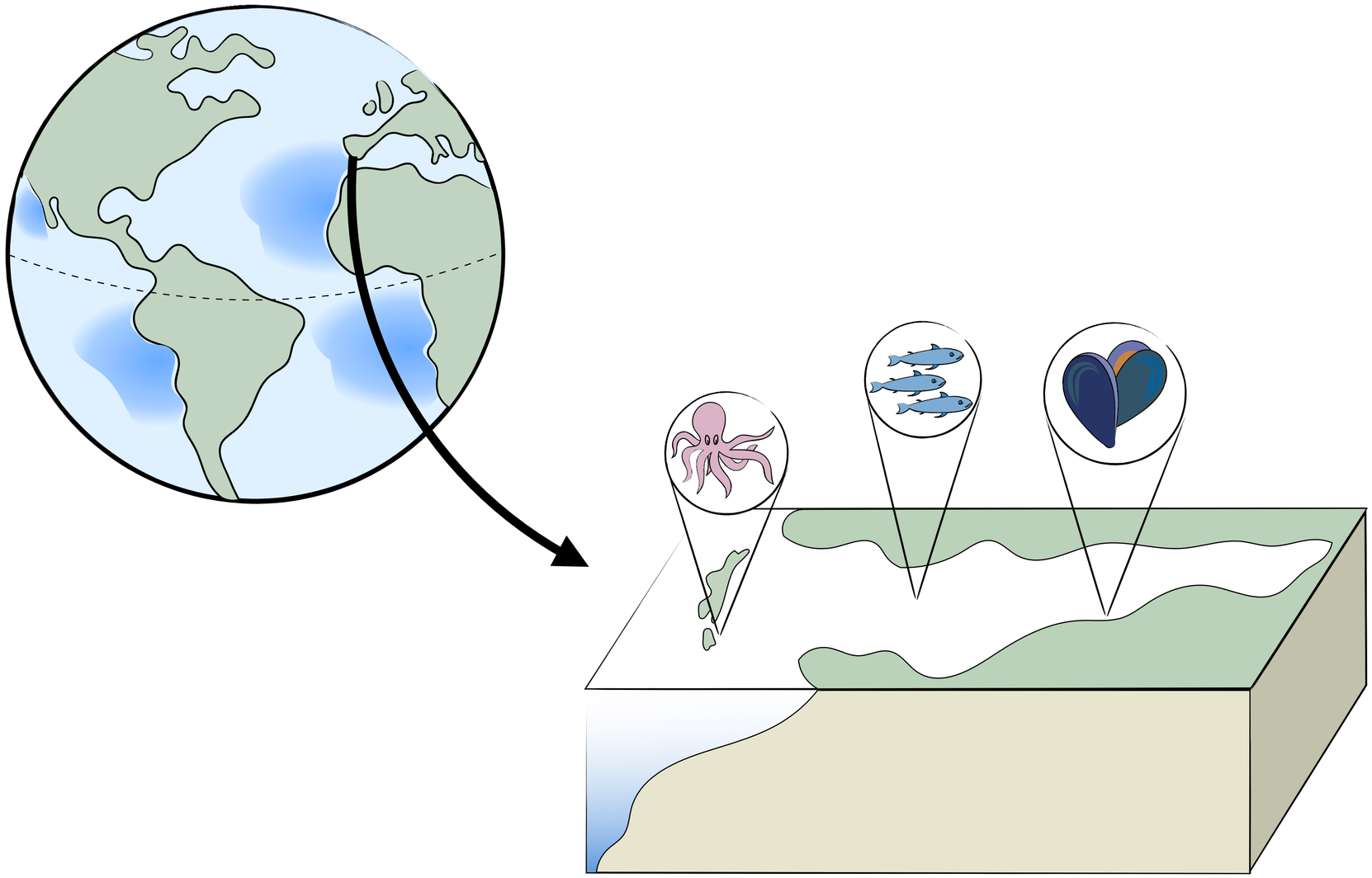
Escalera et al., 2012 (*Marine Pollution Bulletin*)

Upwelling bays: the Galician Rías Baixas

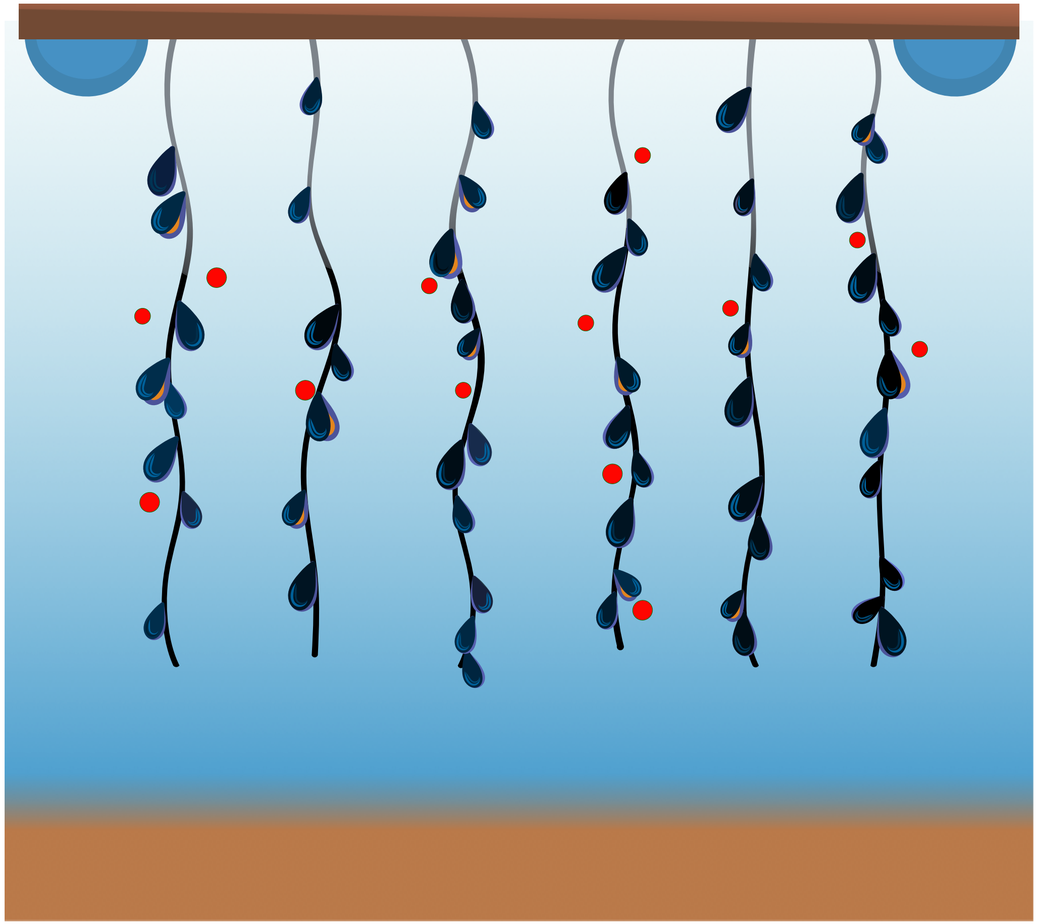


Gilcoto et al., 2017 (*Geophysical Research Letters*)

Upwelling bays: the Galician Rías Baixas



Harmful algal blooms in the Galician Rías



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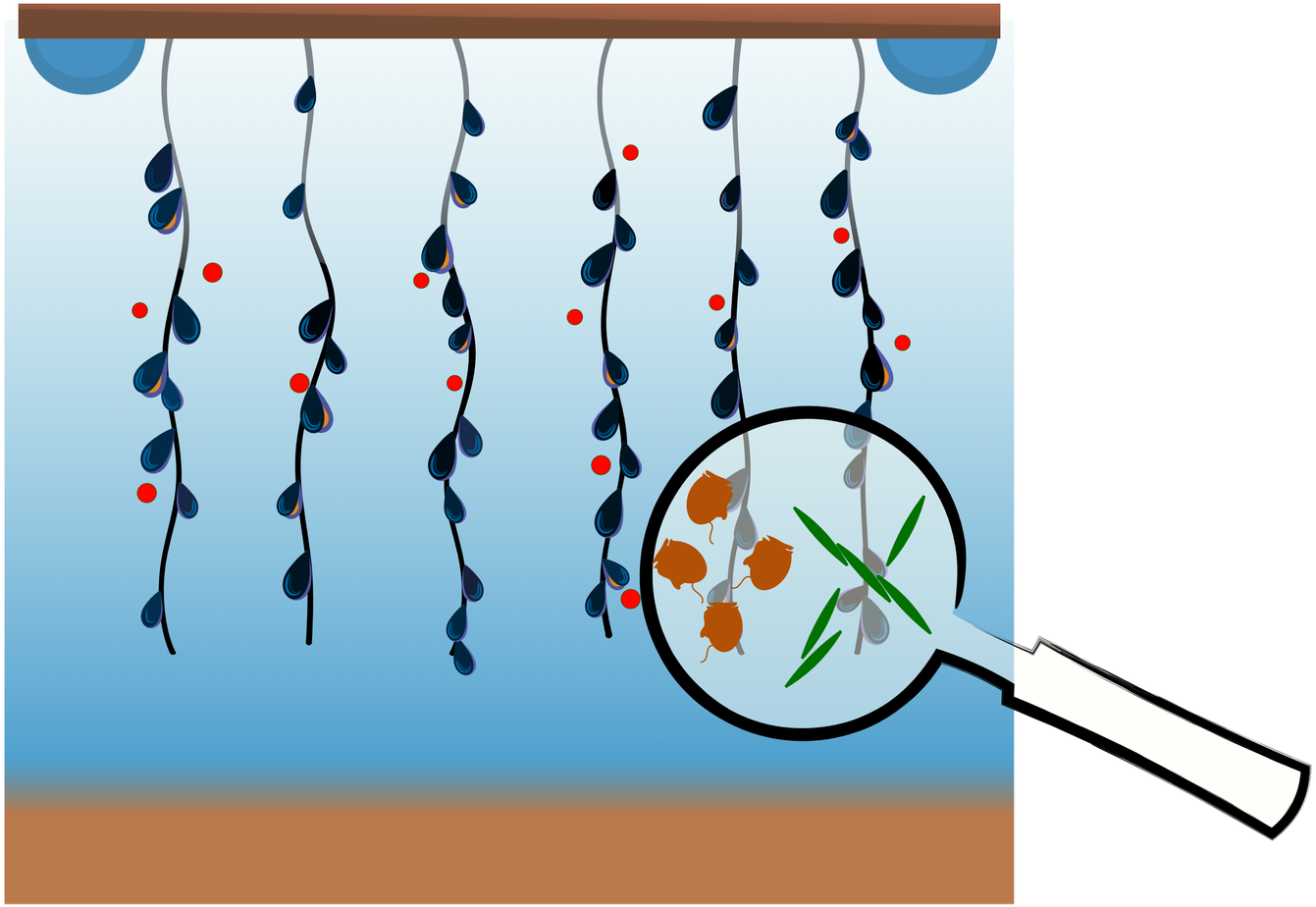

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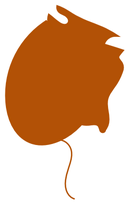
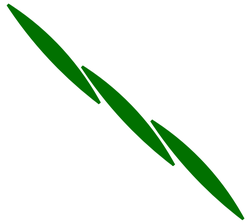
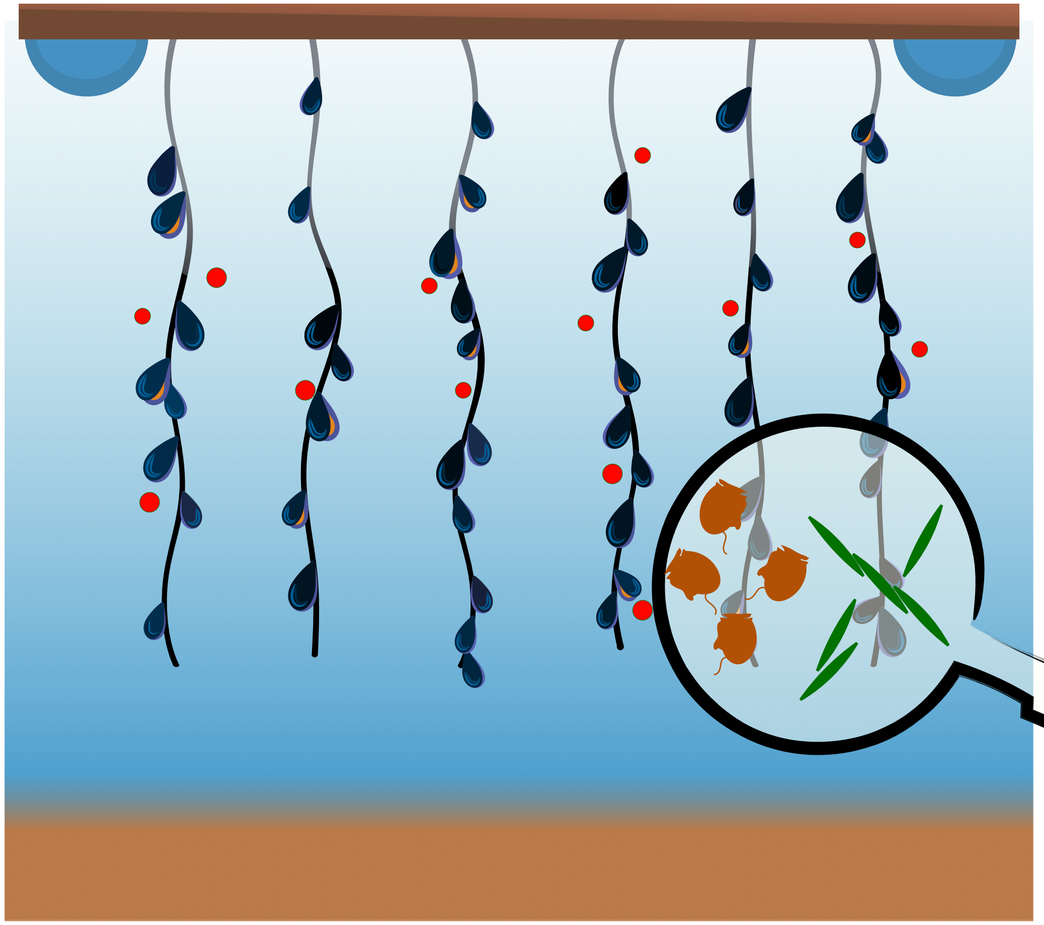
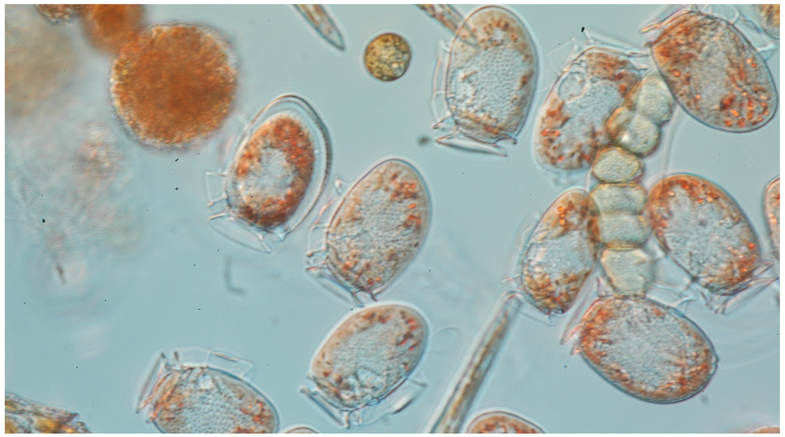


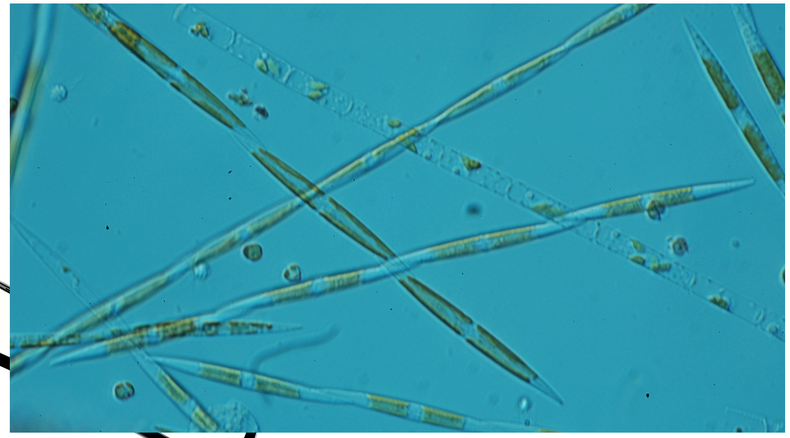
Dinophysis



Pseudo-nitzschia

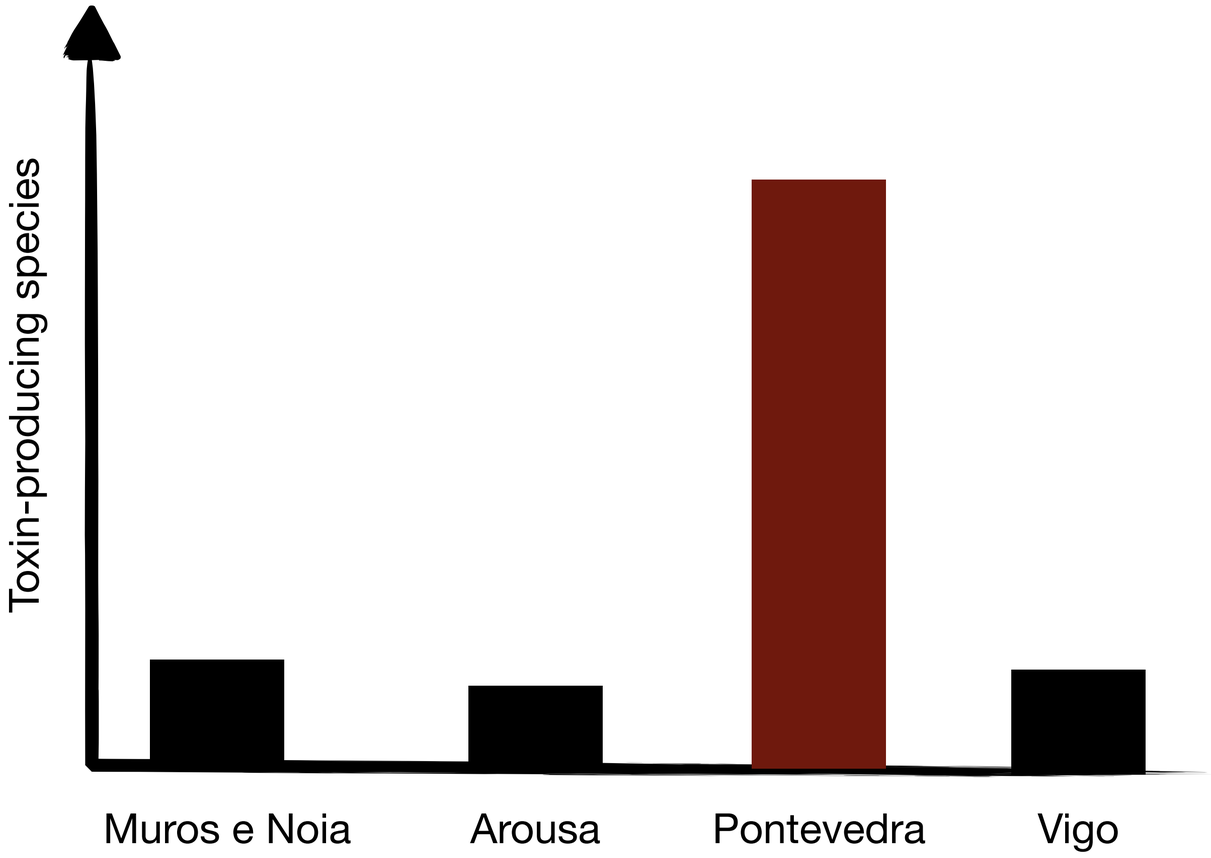






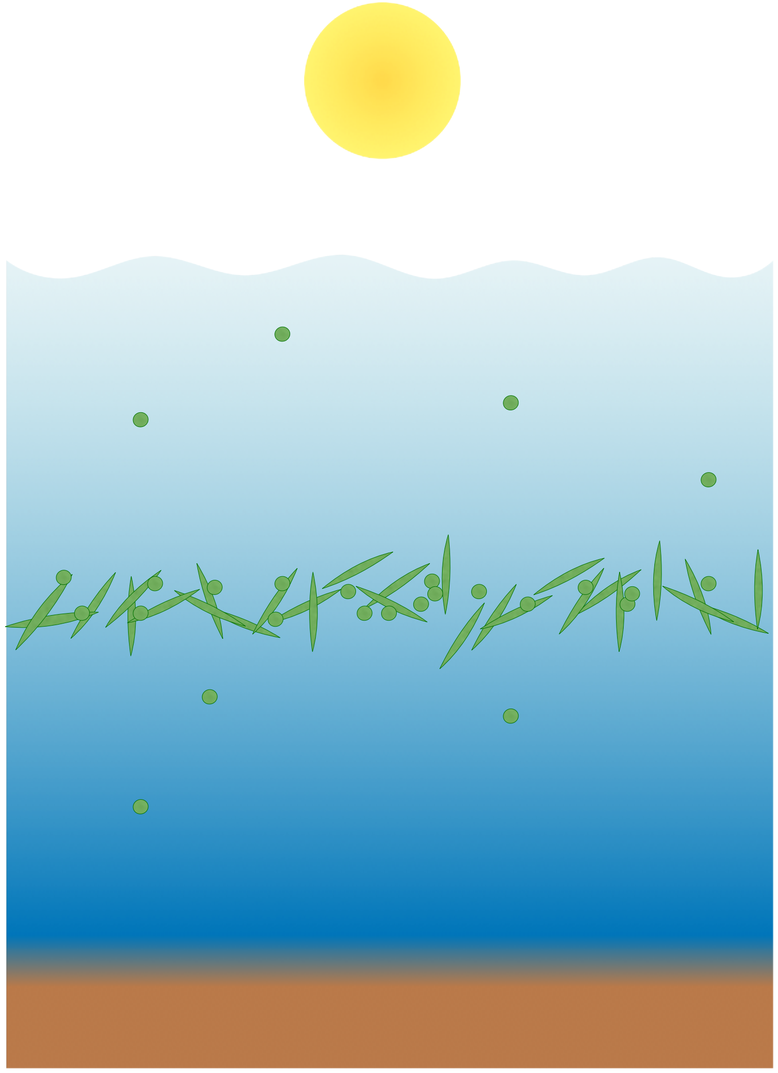
Photographs: Beatriz Reguera

Harmful algal blooms in the Galician Rías



Sacilotto Detoni et al., (2024), Blanco et al., (2019)

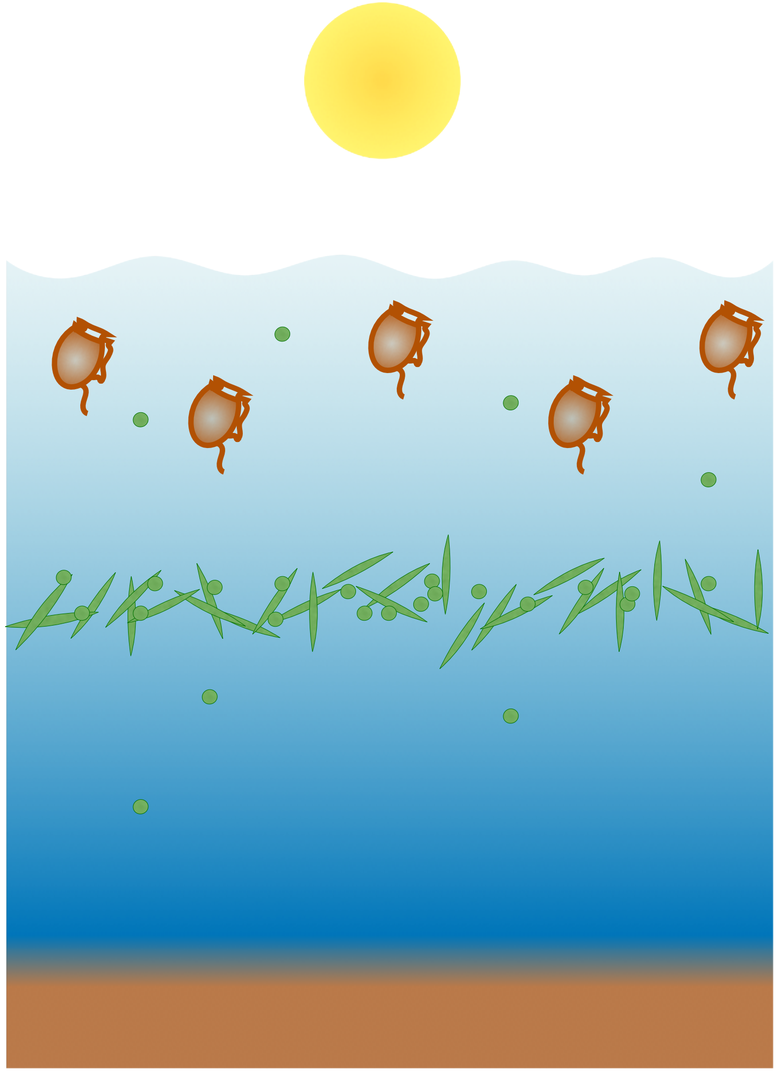
TLP and HAB in the Galician Rías



- May-June 2005
- Toxin-producing *Pseudo-nitzschia* TLP
- Ría de Pontevedra (Bueu-222)
- Associated with stratification

Velo-Suárez et al., (2008, 2010)

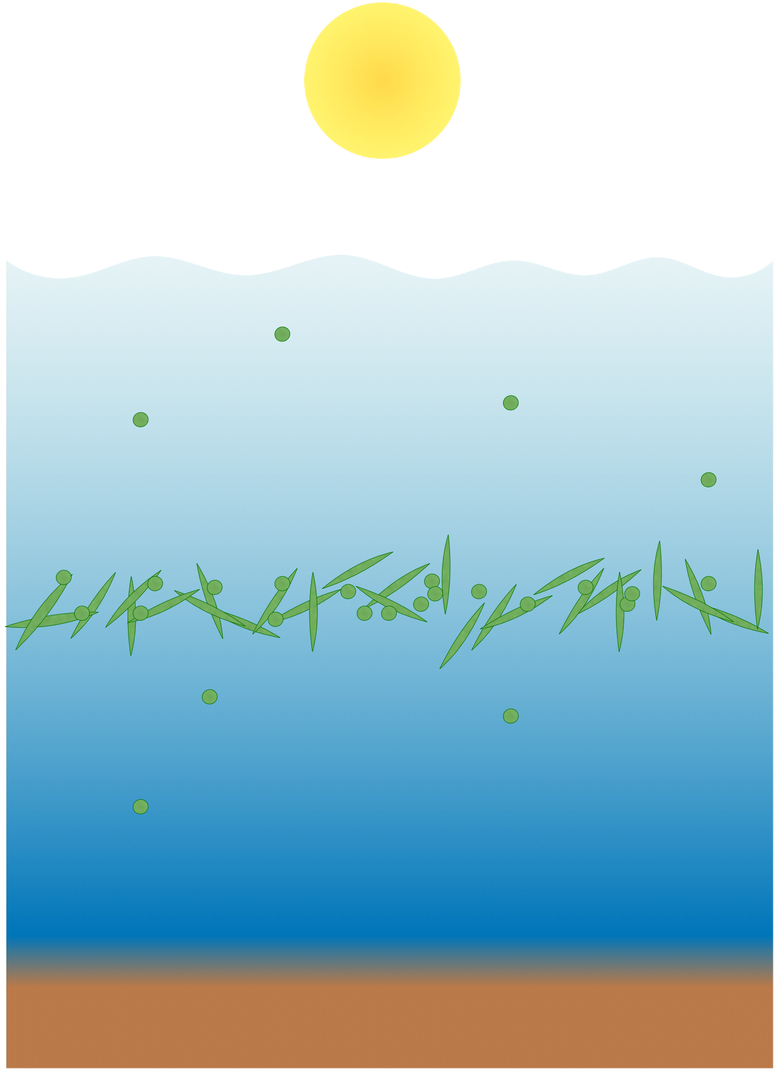
TLP and HAB in the Galician Rías



- May-June 2005
- Toxin-producing *Pseudo-nitzschia* TLP
- Ría de Pontevedra (Bueu-222)
- Associated with stratification
- Co-occurrence with surface *Dinophysis acuminata* populations

Velo-Suárez et al., (2008, 2010)

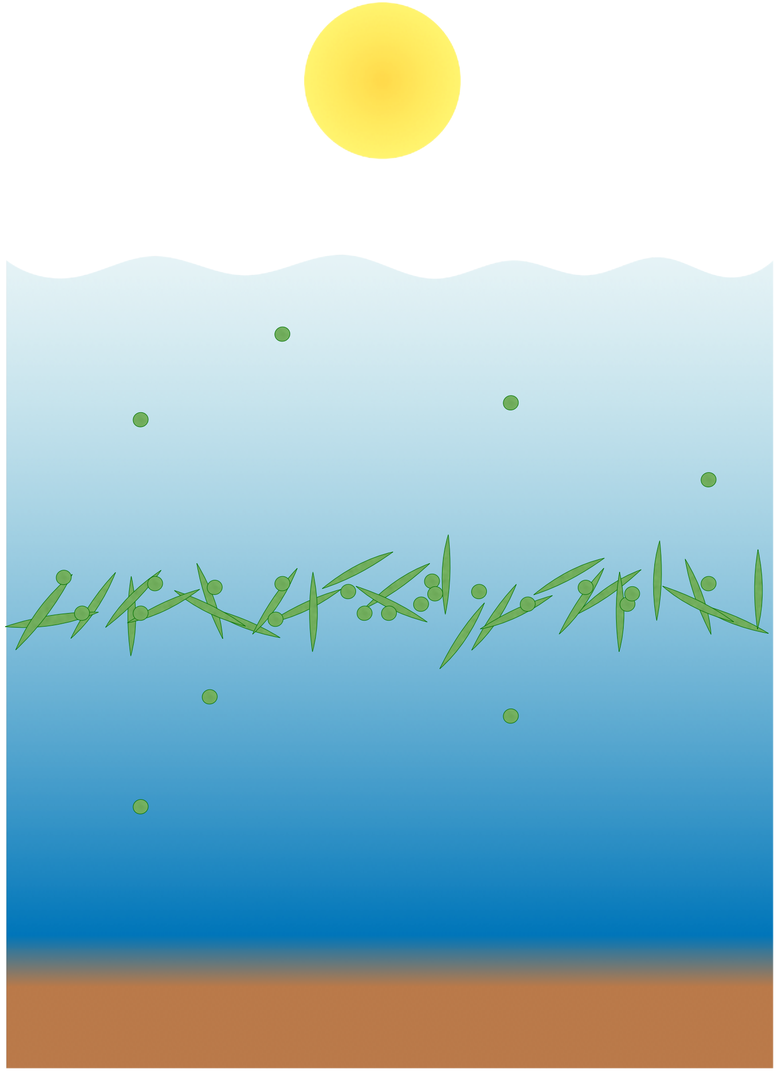
TLP and HAB in the Galician Rías



- May-June 2007
- Toxin-producing *Pseudo-nitzschia* TLP
- Same station in the Ría de Pontevedra (Bueu-222)
- Modulated by the tidal cycle: high temporal variability

Díaz et al., (2014)

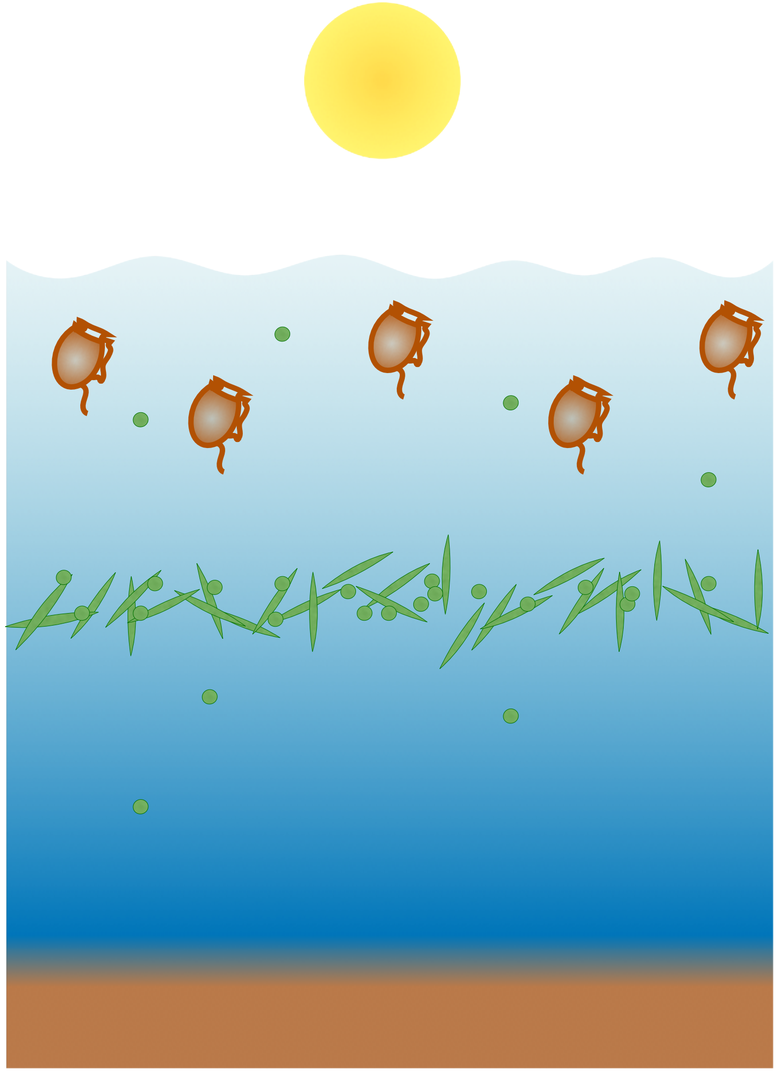
TLP and HAB in the Galician Rías



- June 2013
- Diatom-dominated TLP
- Same station in the Ría de Pontevedra (Bueu-222)
- Modulated by the upwelling cycle, associated with the isotherms

Díaz et al., (2019)

TLP and HAB in the Galician Rías



- June 2013
- Diatom-dominated TLP
- Same station in the Ría de Pontevedra (Bueu-222)
- Modulated by the upwelling cycle, associated with the isotherms

Díaz et al., (2019)

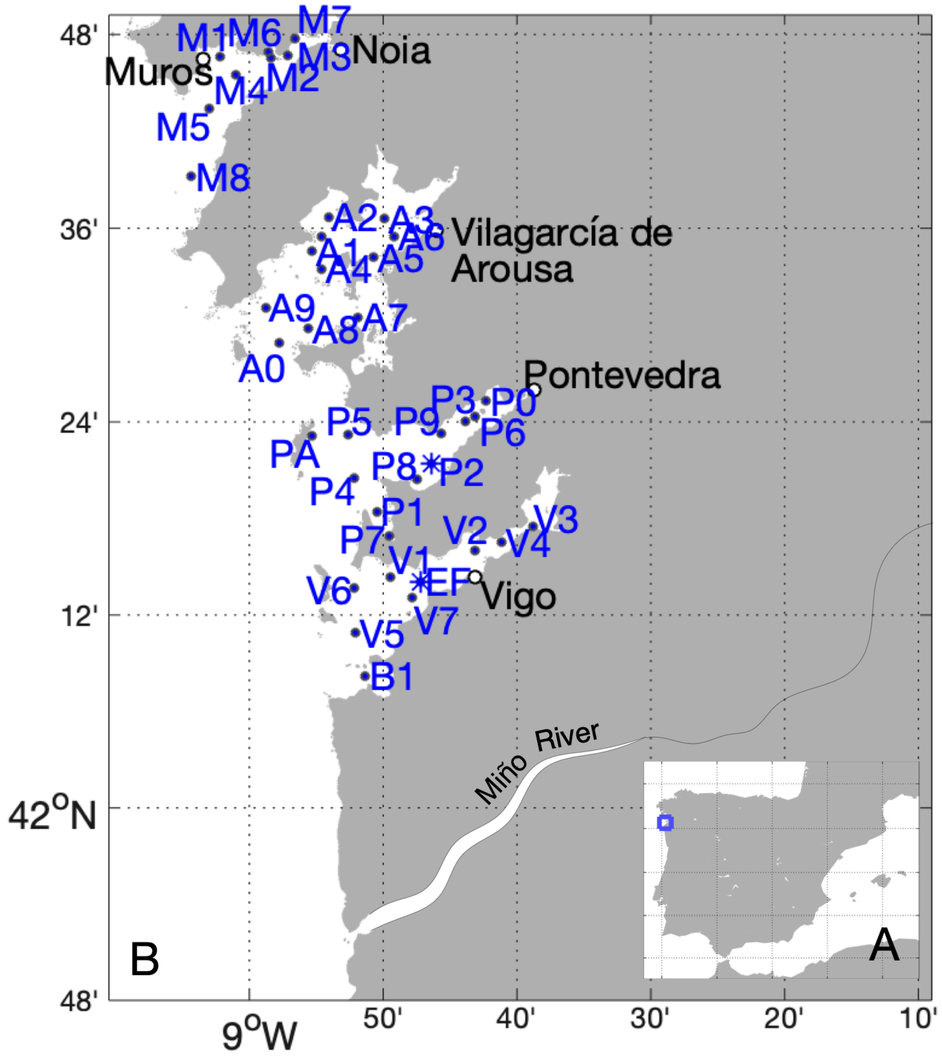
Question 1: is there a relationship between TLP and HAB in the Galician Rías?

Question 2: what are the mechanisms responsible for TLP formation?

Question 3: why is the Ría de Pontevedra a hotspot for toxicity?

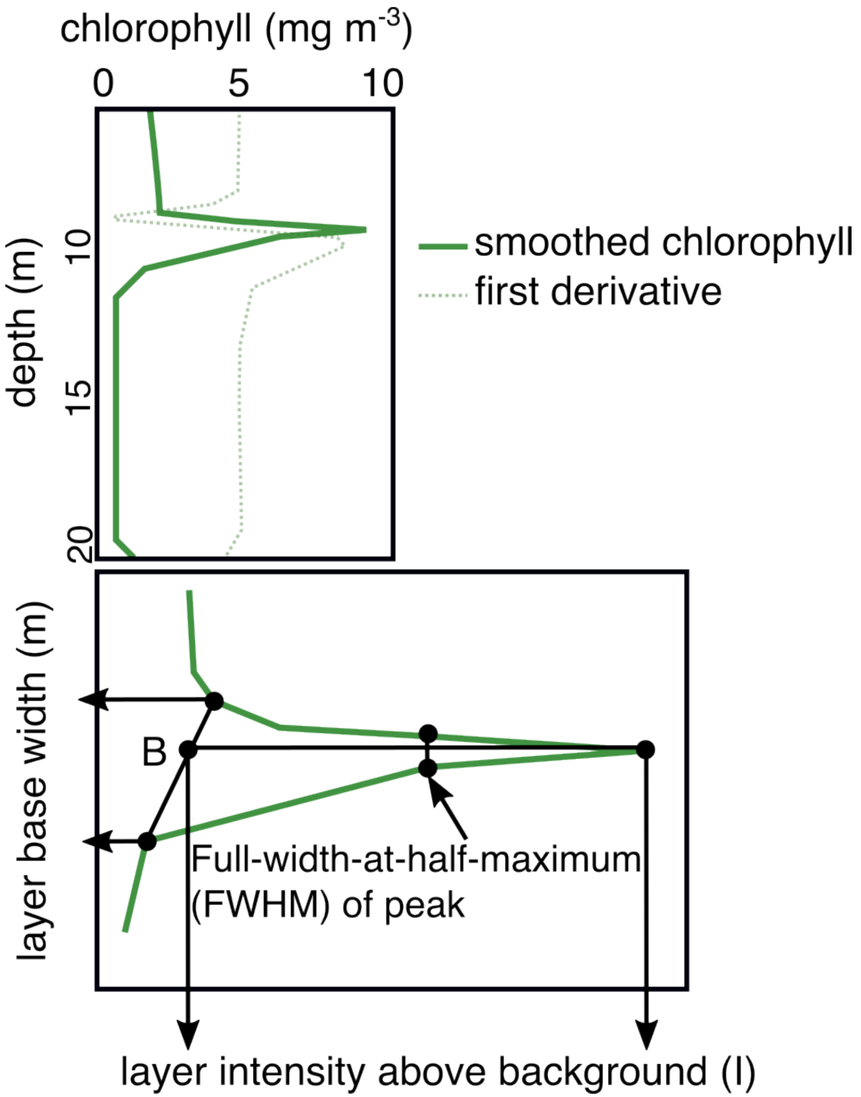
Part 1. Historical dataset

Monitoring program (INTECMAR)



- Weekly CTD (+ fluorescence)
- Period: 2012-2015
- 39 stations
- > 6000 profiles

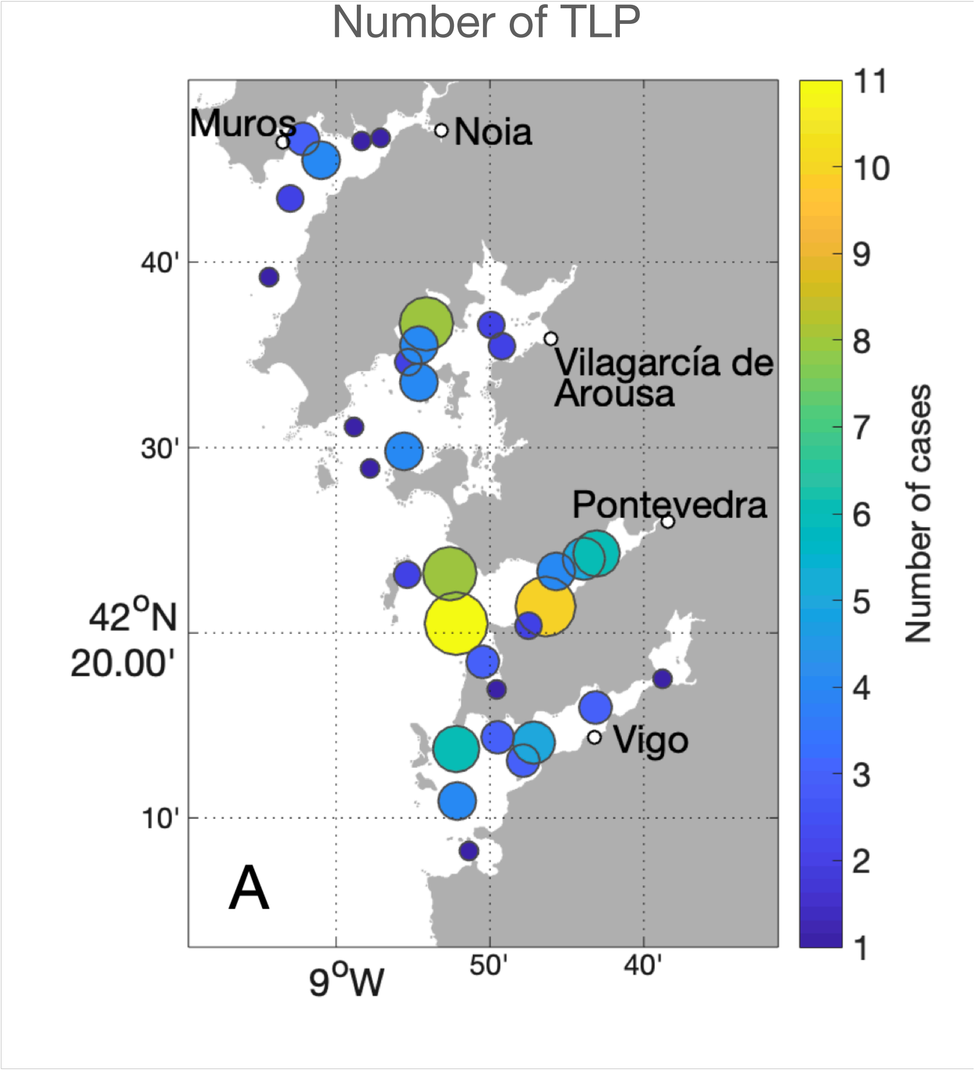
TLP detection



- Full width at half maximum < 3 m
- Peak value > 2x(background level)
- Peak intensity = Peak value - background level

Based on Sullivan et al. (2010) criteria

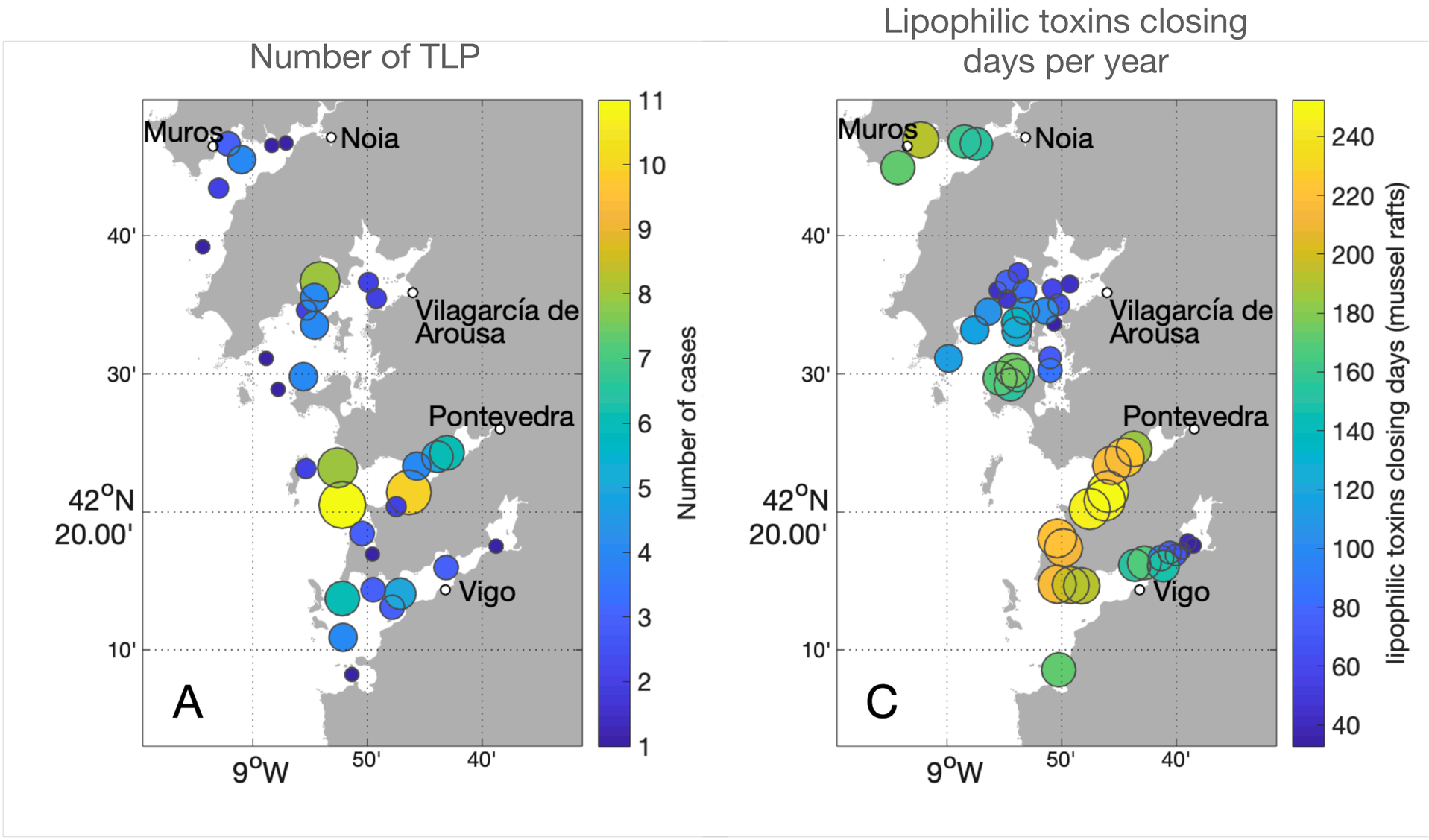
TLP characteristics



INTECMAR DATASET 2012-2015

- 118 TLP detected
- Mainly in Ría de Pontevedra

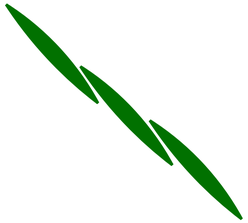
TLP characteristics



Relationship between TLP and HAB

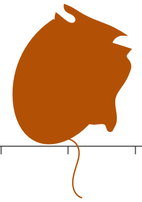
Relationship between TLP and HAB

D. acuminata

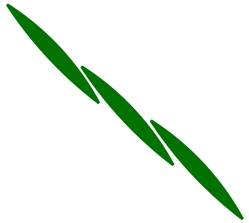


Pseudo-nitzschia

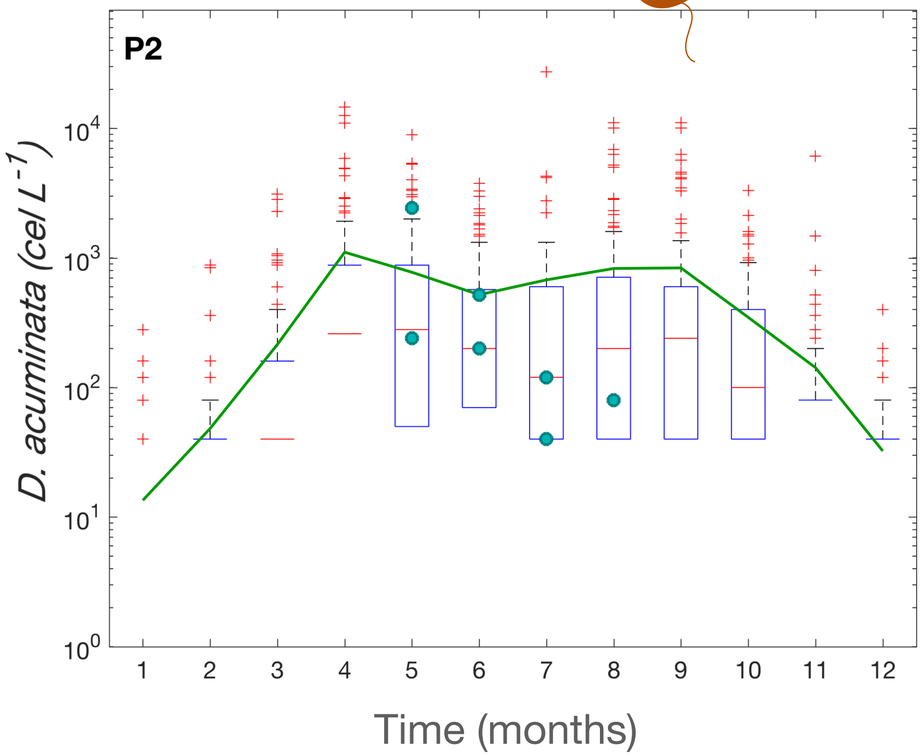
Relationship between TLP and HAB



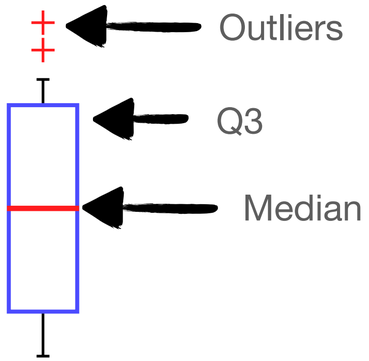
D. acuminata



Pseudo-nitzschia



Mean cell density at this station



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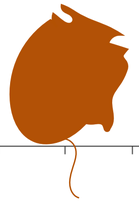
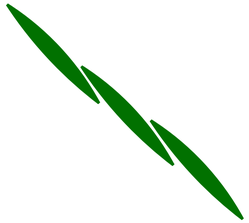
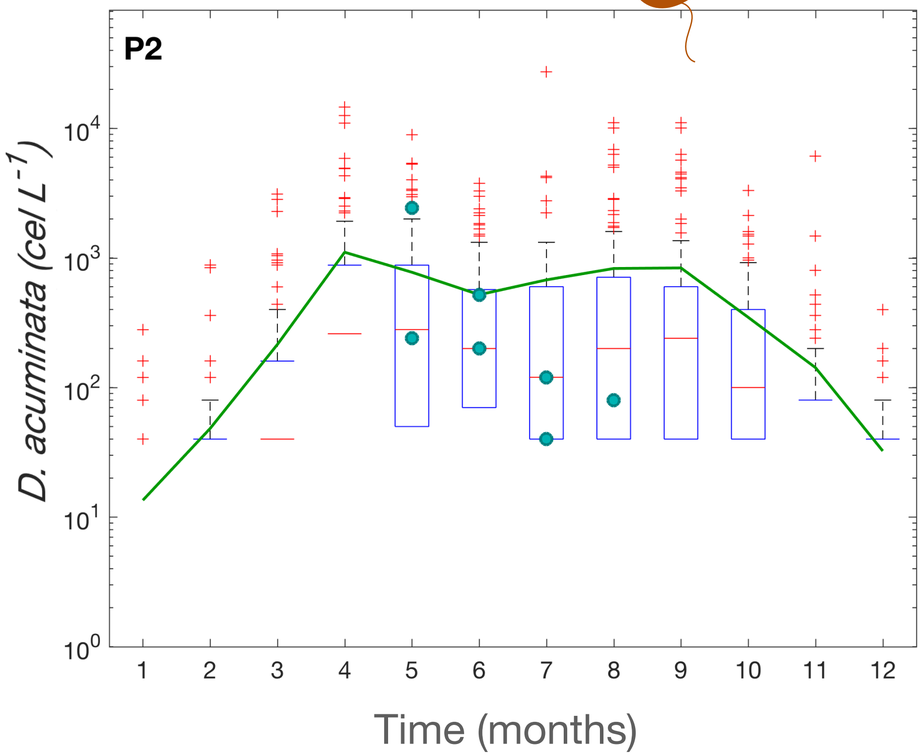


D. acuminata

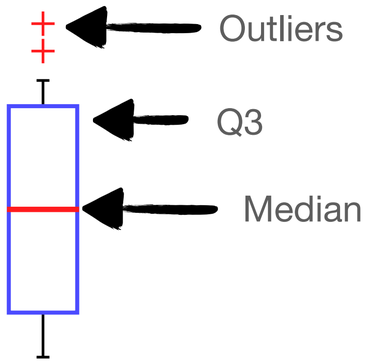


Pseudo-nitzschia



Cell densities on TLP sampling dates at this station

Mean cell density at this station



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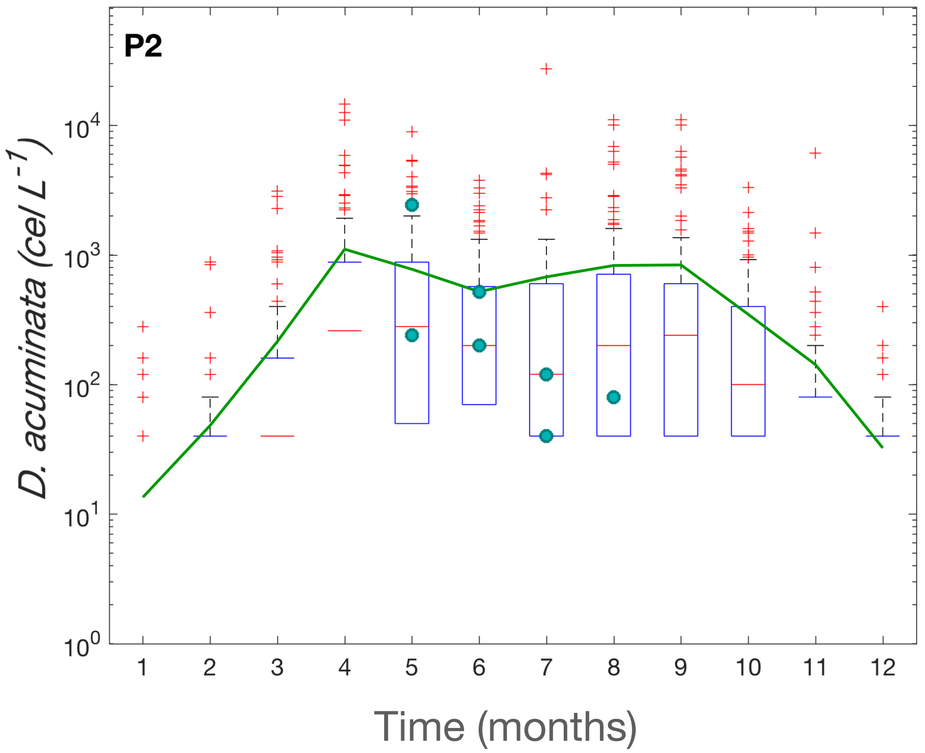
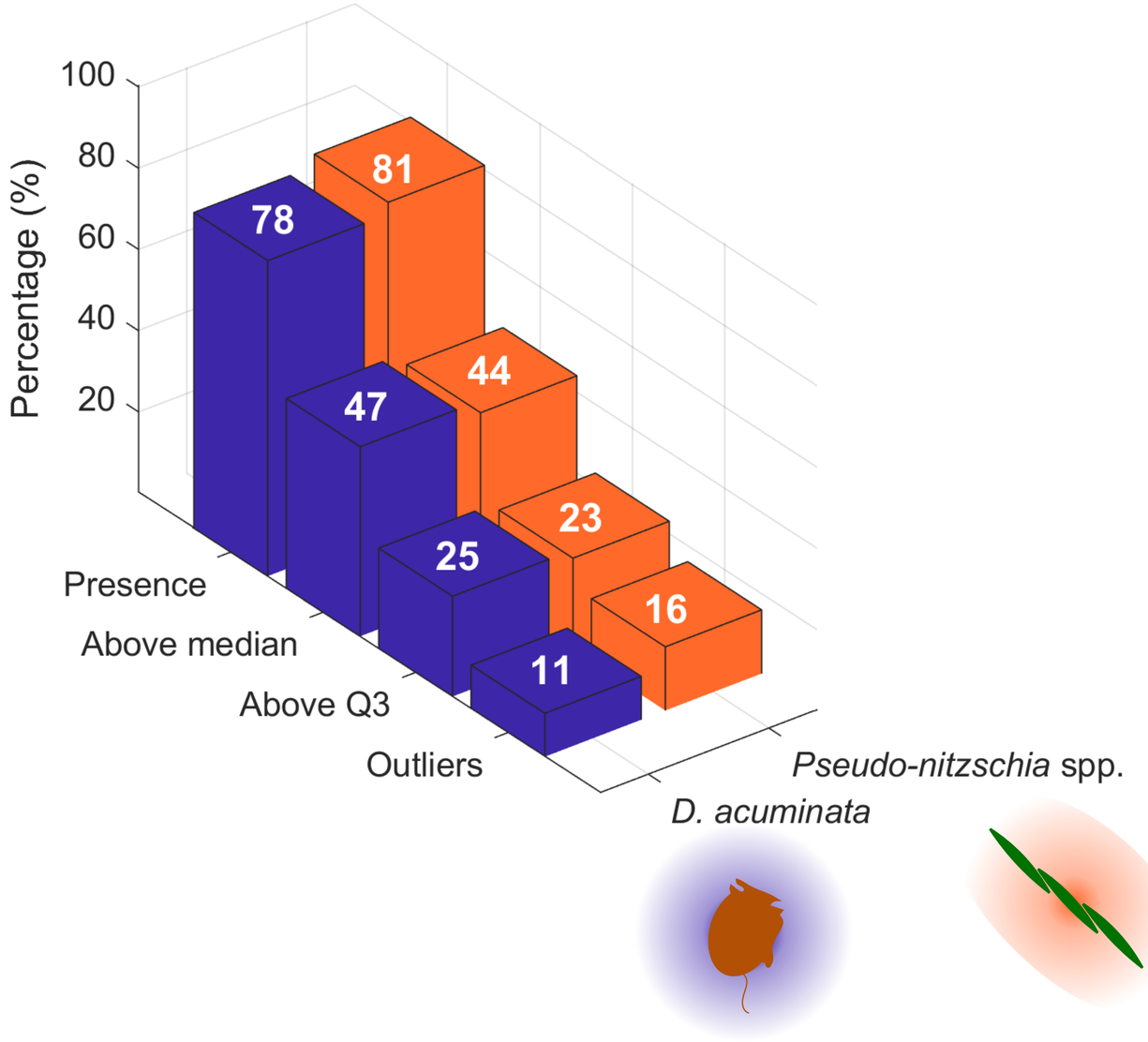
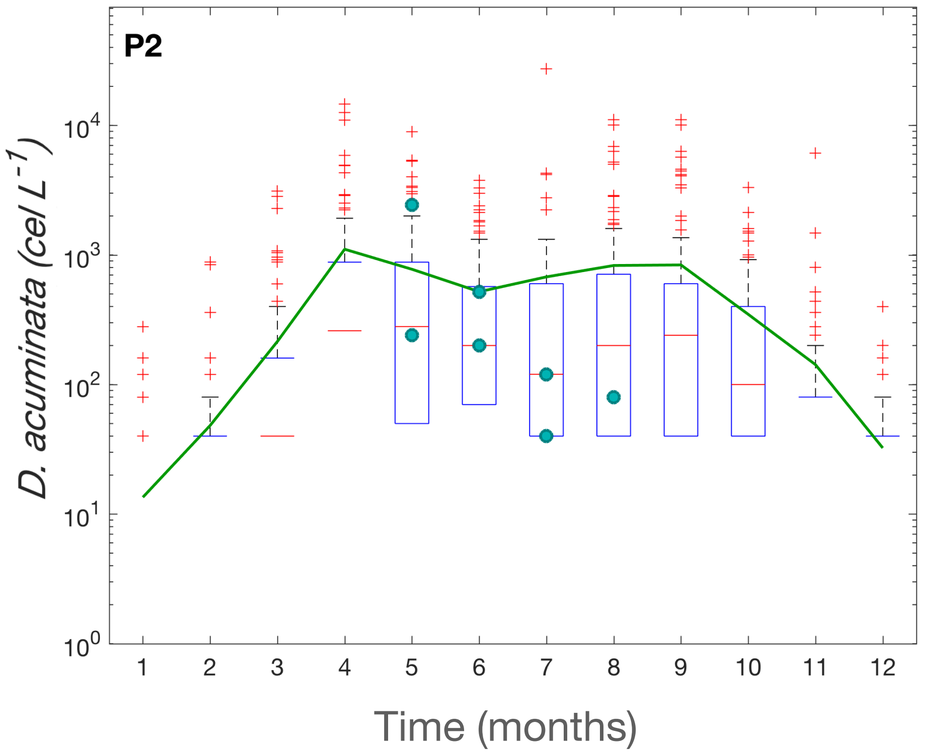
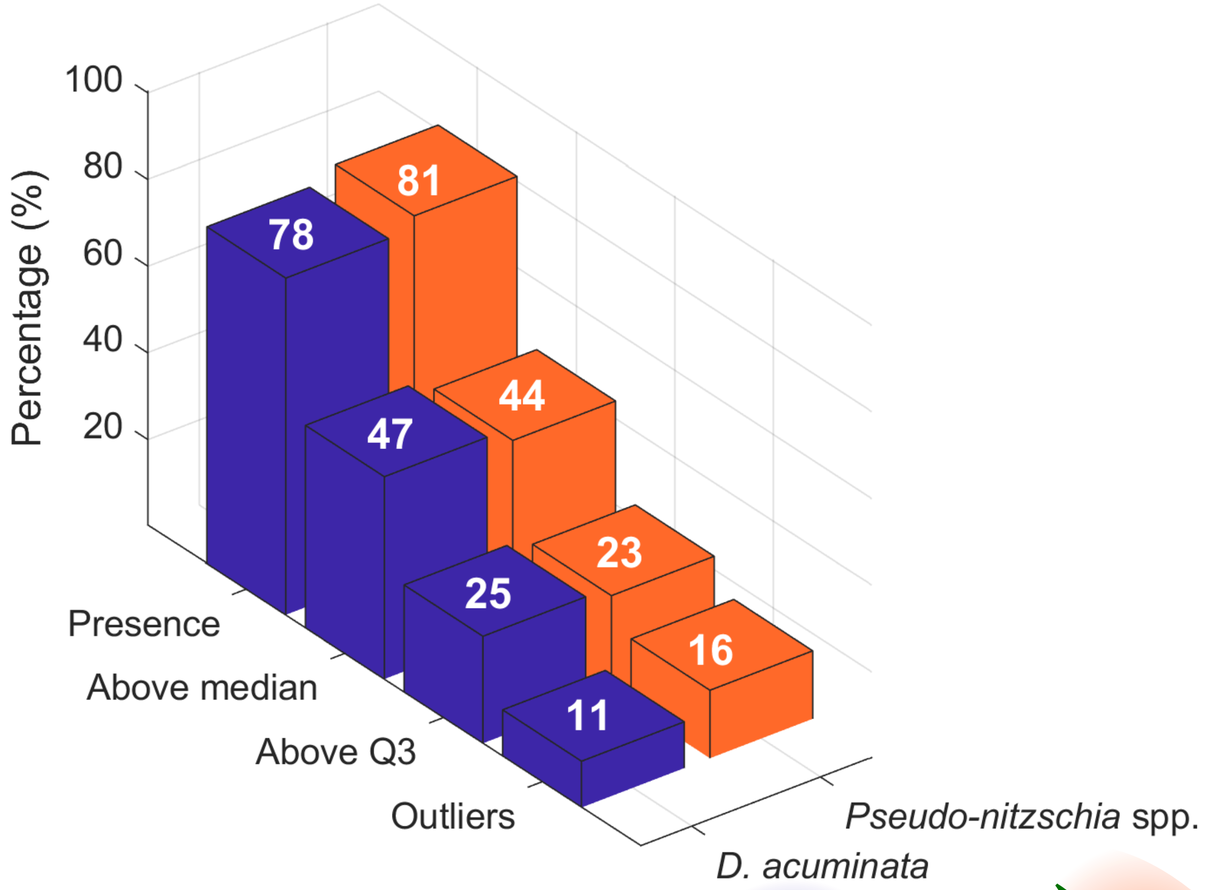




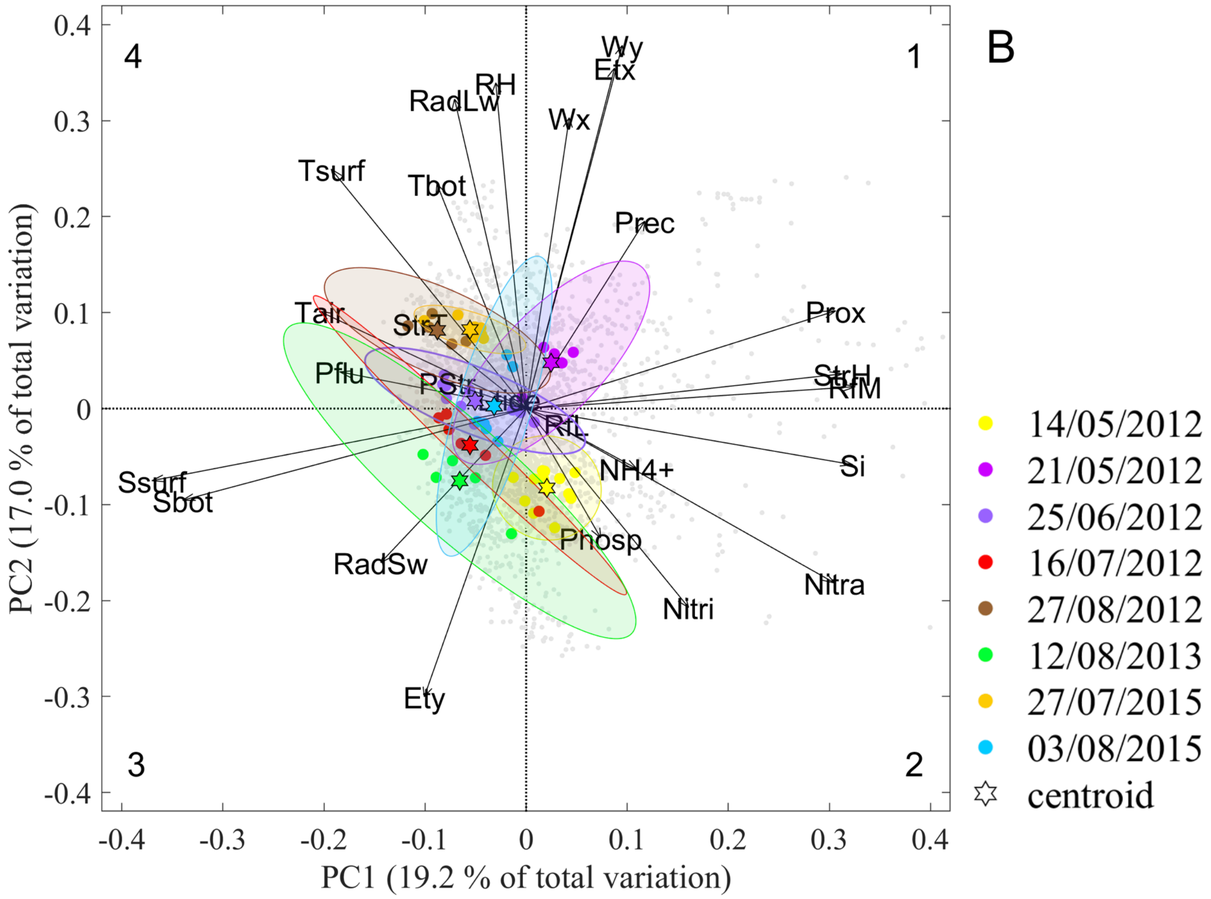
Relationship between TLP and HAB





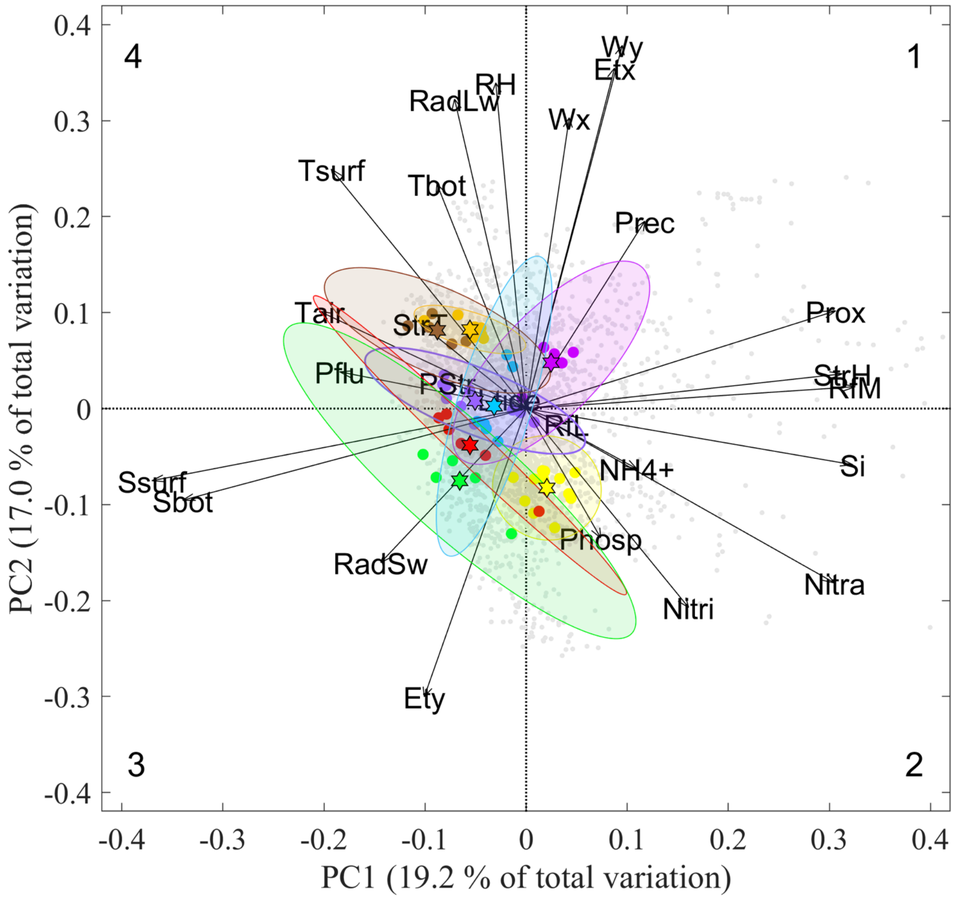
- ~25 % of the TLP were related to *Pseudo-nitzschia* and *D. acuminata*

Environmental conditions of the spatially-extended TLP



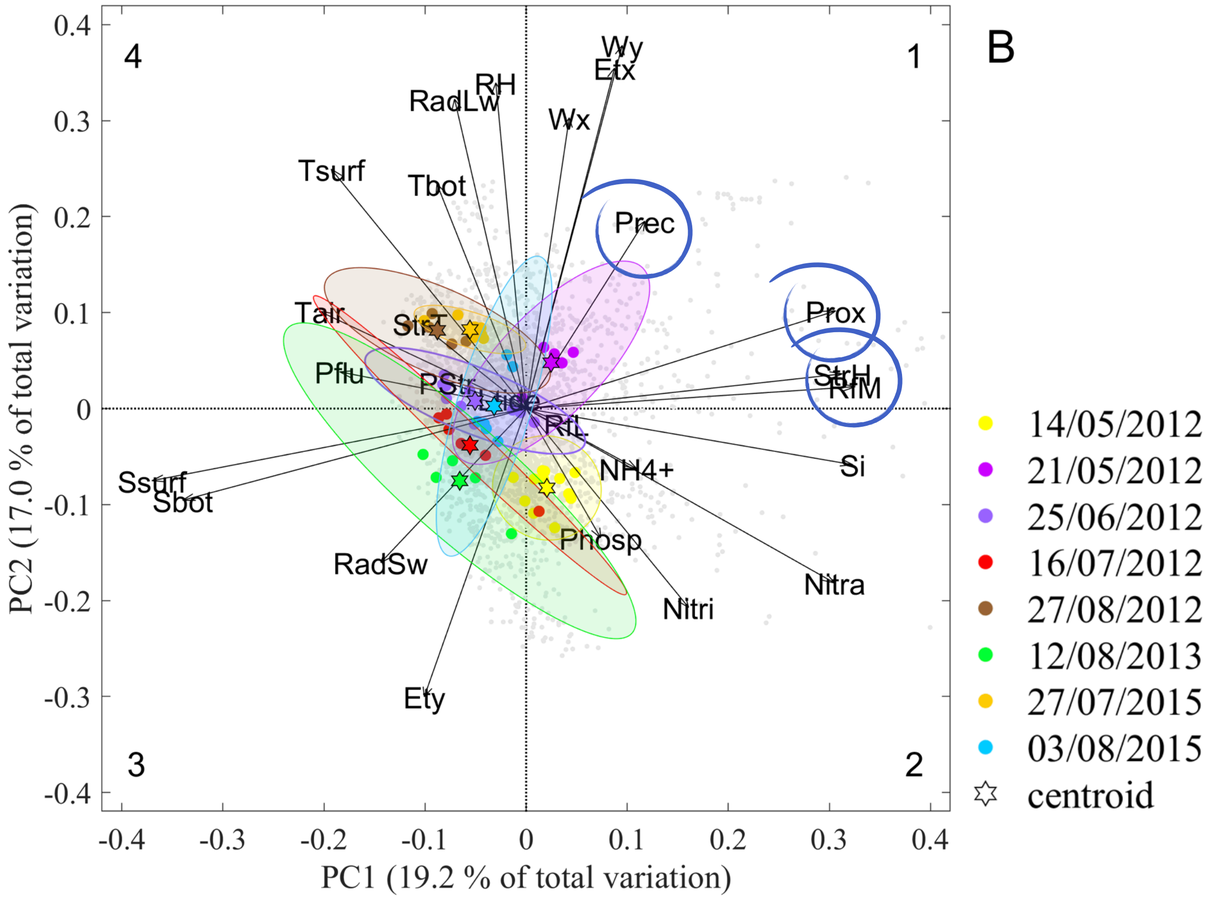
- 8 spatially-extended TLP events:

Environmental conditions of the spatially-extended TLP



- 8 spatially-extended TLP events:
  - 2 spring-downwelling → haline stratification

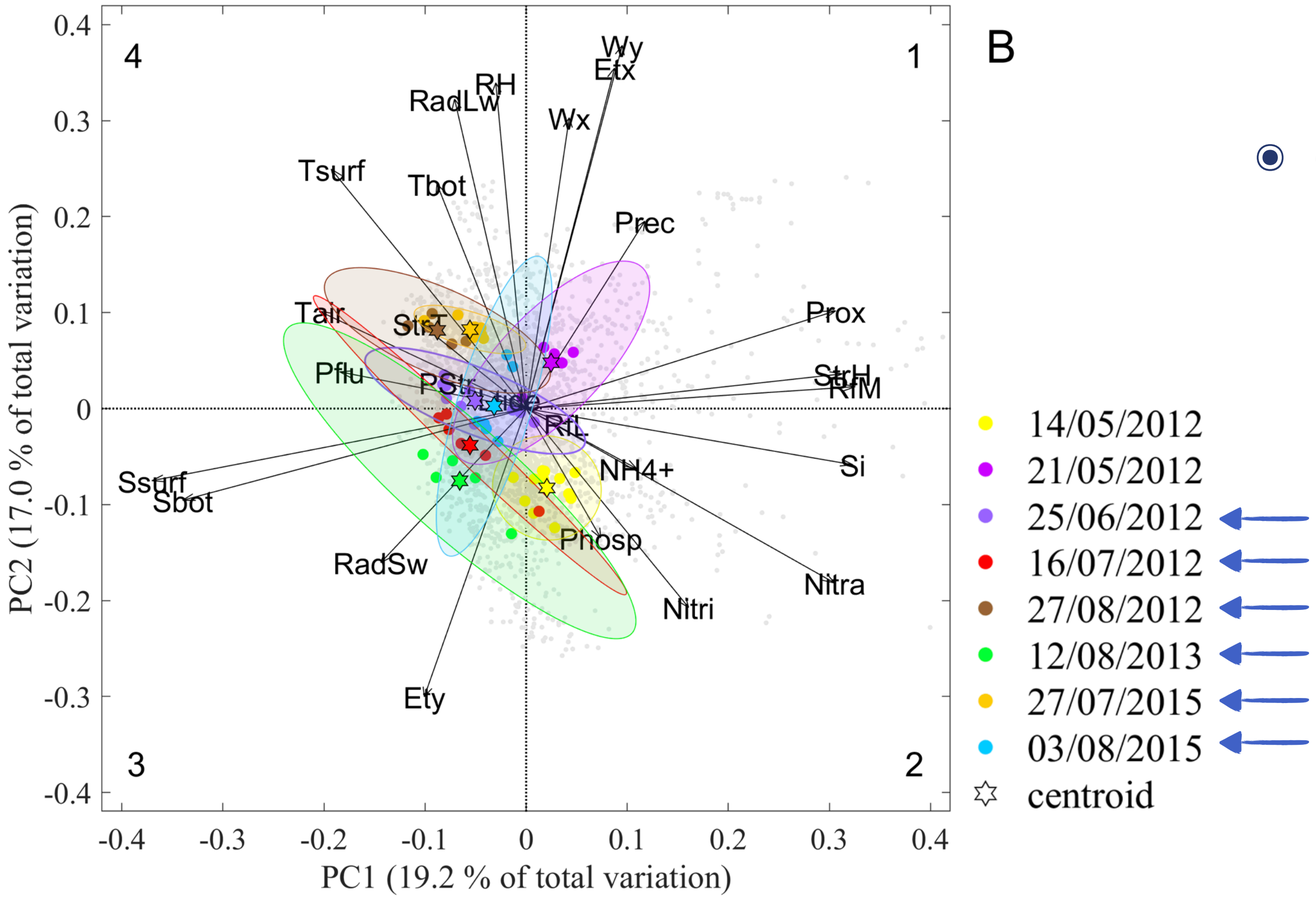
Environmental conditions of the spatially-extended TLP



- 8 spatially-extended TLP events:
  - 2 spring-downwelling → haline stratification
  - 6 summer-upwelling → thermal stratification

Precipitation, Miño River Plume, haline stratification…

Environmental conditions of the spatially-extended TLP



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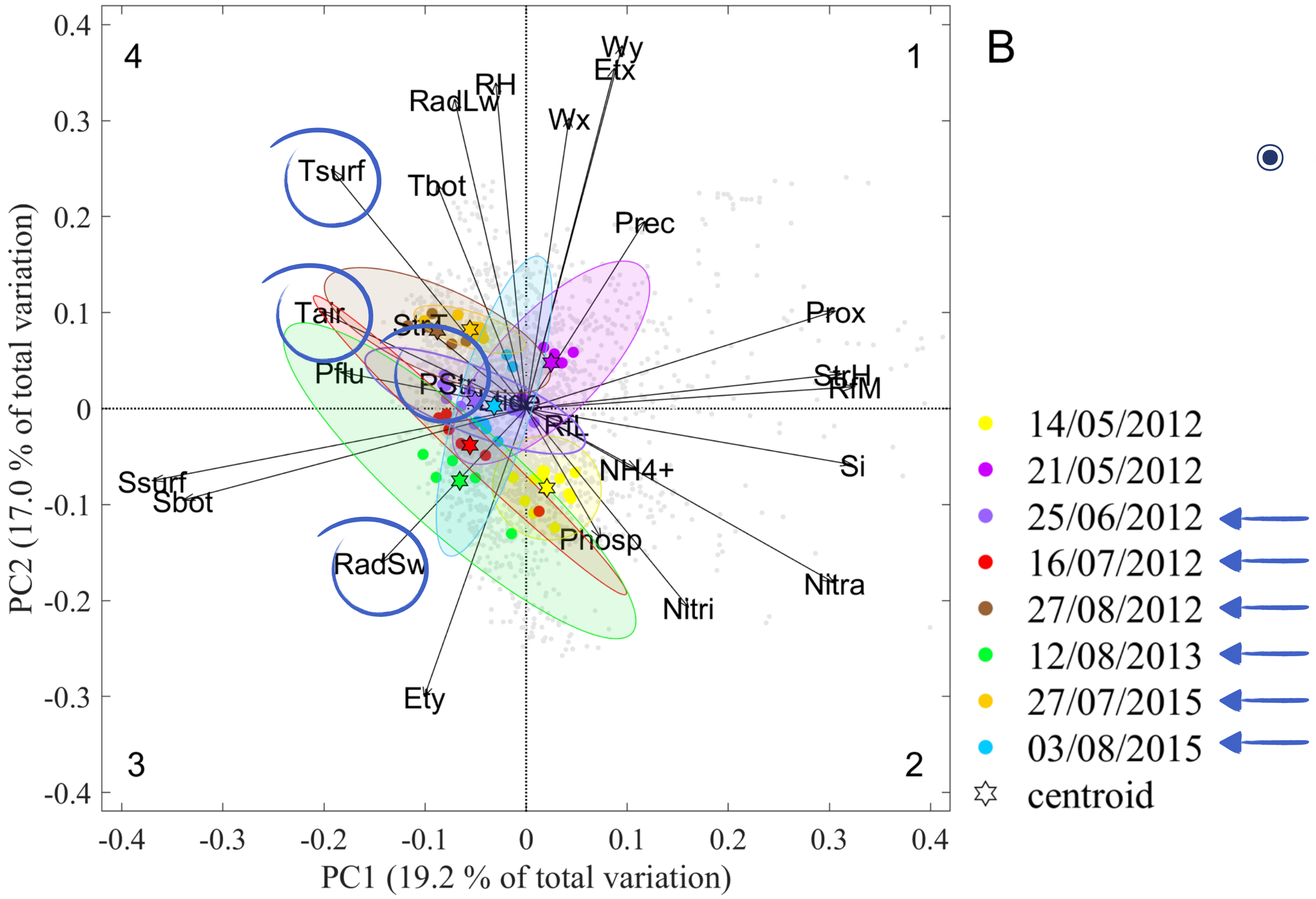

- 8 spatially-extended TLP events:
  - 2 spring-downwelling → haline stratification
  - 6 summer-upwelling → thermal stratification

Air and water temperature, radiation…

Part 1. Wrap-up

- TLP were **more common in the Ría de Pontevedra**, also characterized by longer **toxicity** episodes due to *Dinophysis* toxins
- Our results suggest a relationship between TLP and two HAB groups *D. acuminata* and *Pseudo-nitzschia*
- TLP formation appears to be related to **stratification** processes

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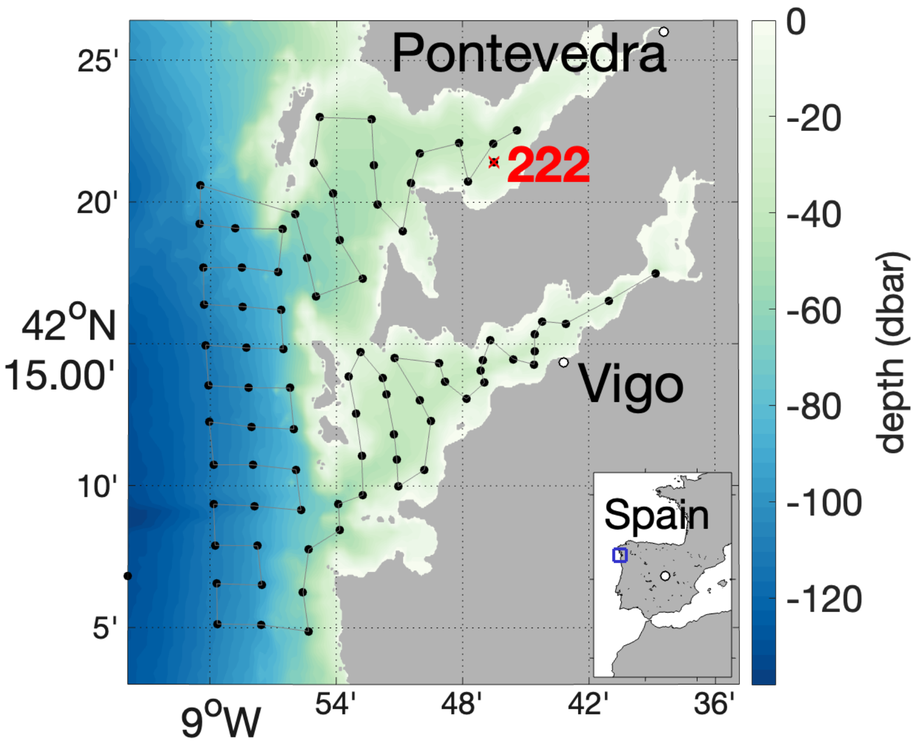
We need specific observations!

Part 2. Field observations

REMEDIOS-TLP cruise

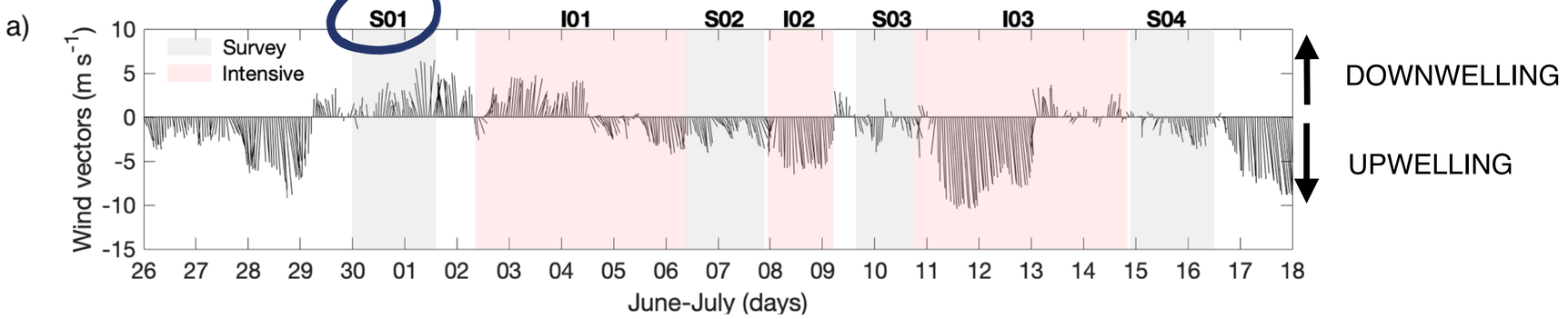


- Summer 2018
- 4 SURVEY (84 stations)
  - 1 CTD cast per station (225 profiles)
- 3 INTENSIVES at st. 222
  - 5 high resolution CTD cast every 30 min (1674 profiles)
  - 1 water sampling at different depths every 6 h

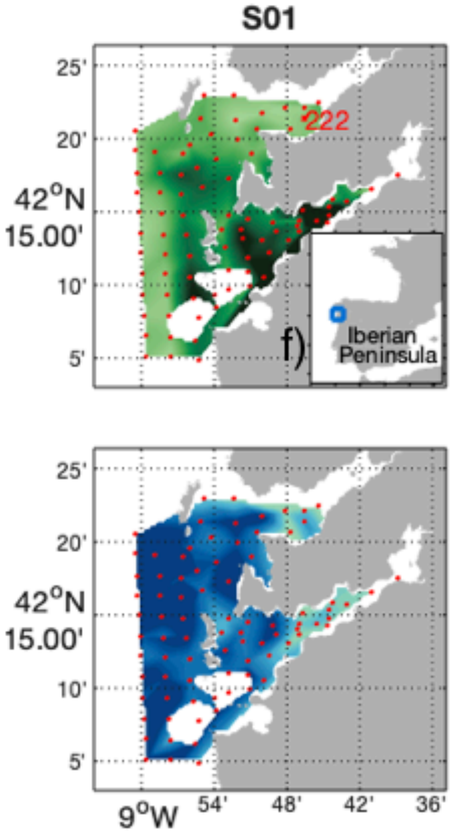
29 Jun — 16 Jul

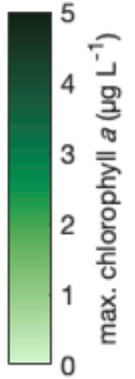
S01 | I01 | S02 | I02 | S03 | I03 | S04

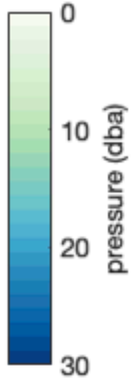
Spatial observations



Maximum chlorophyll and its depth at **σ_t=26.4-27**







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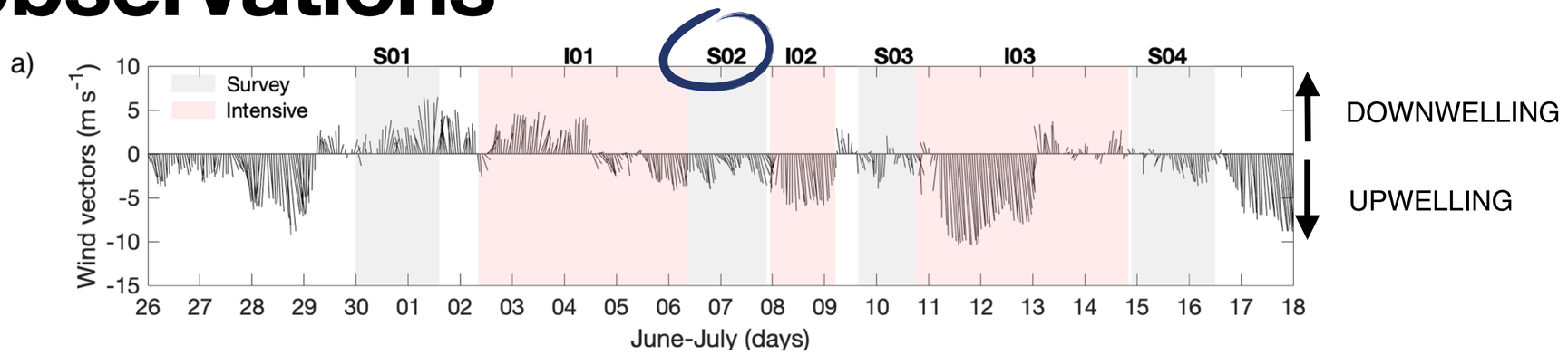

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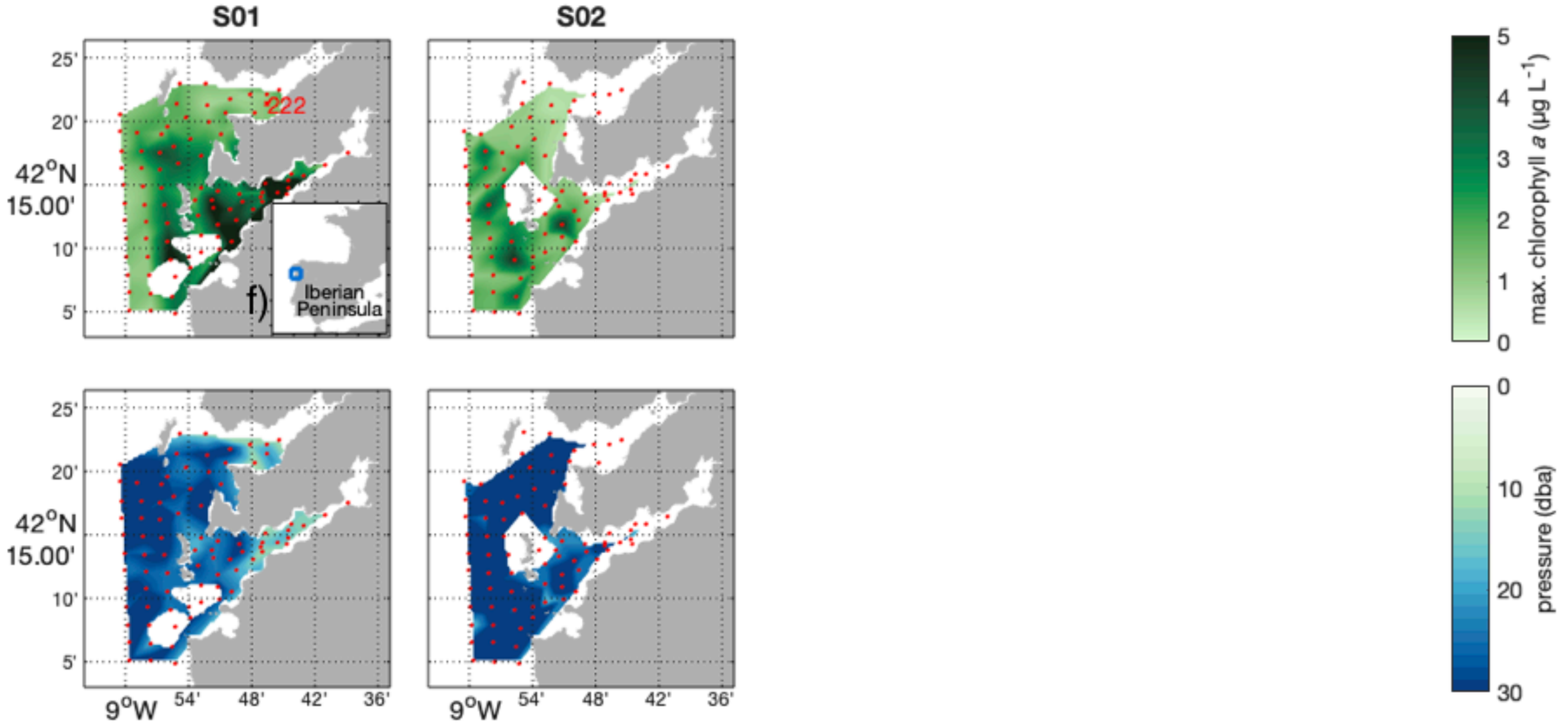

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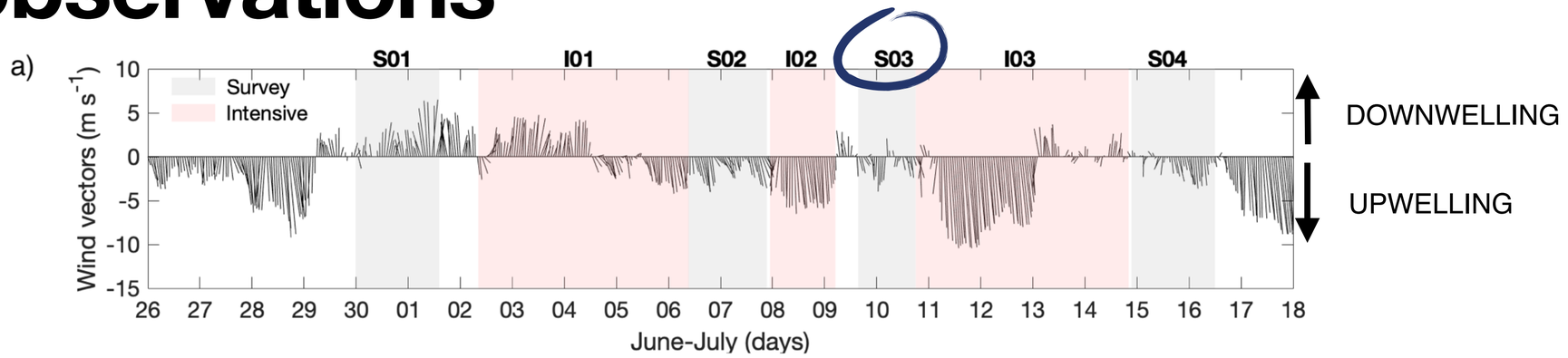

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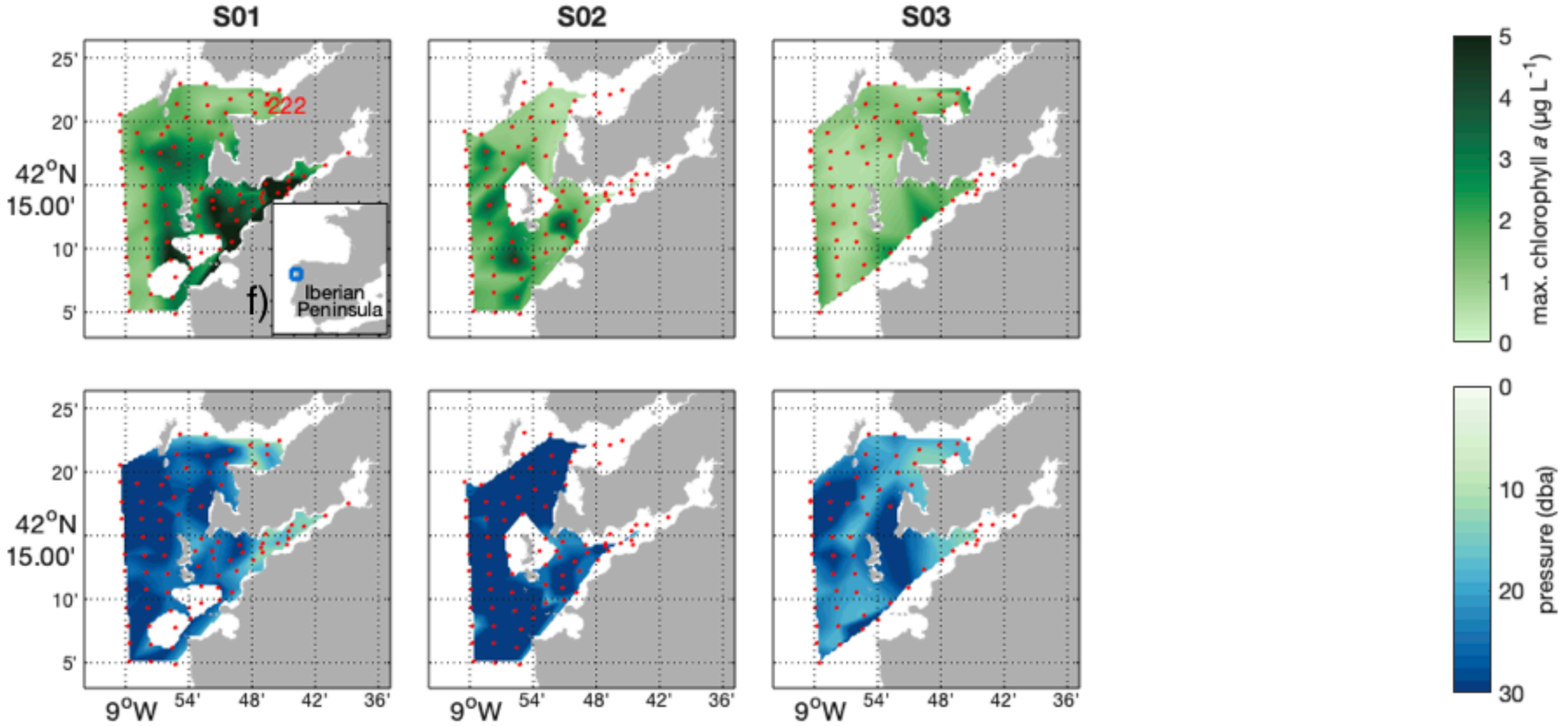

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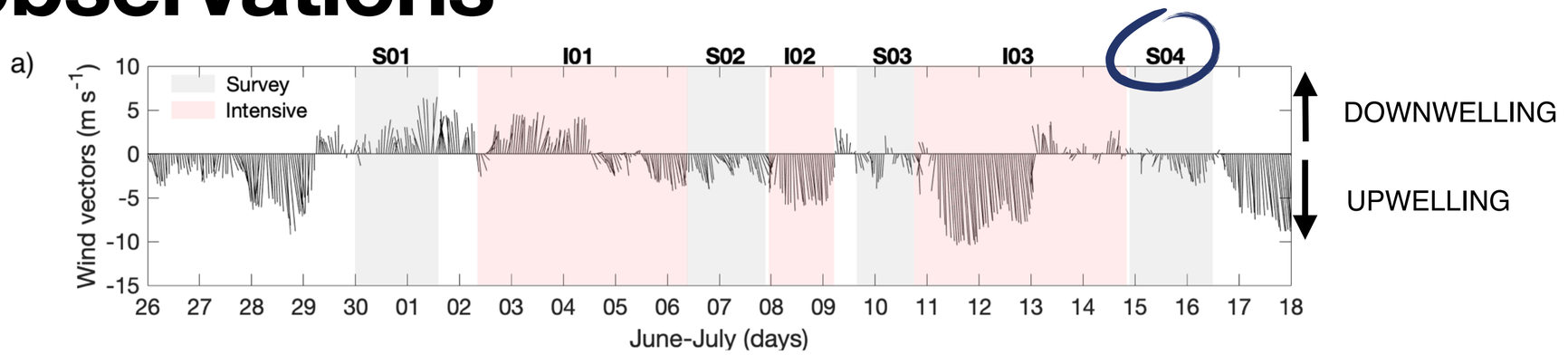

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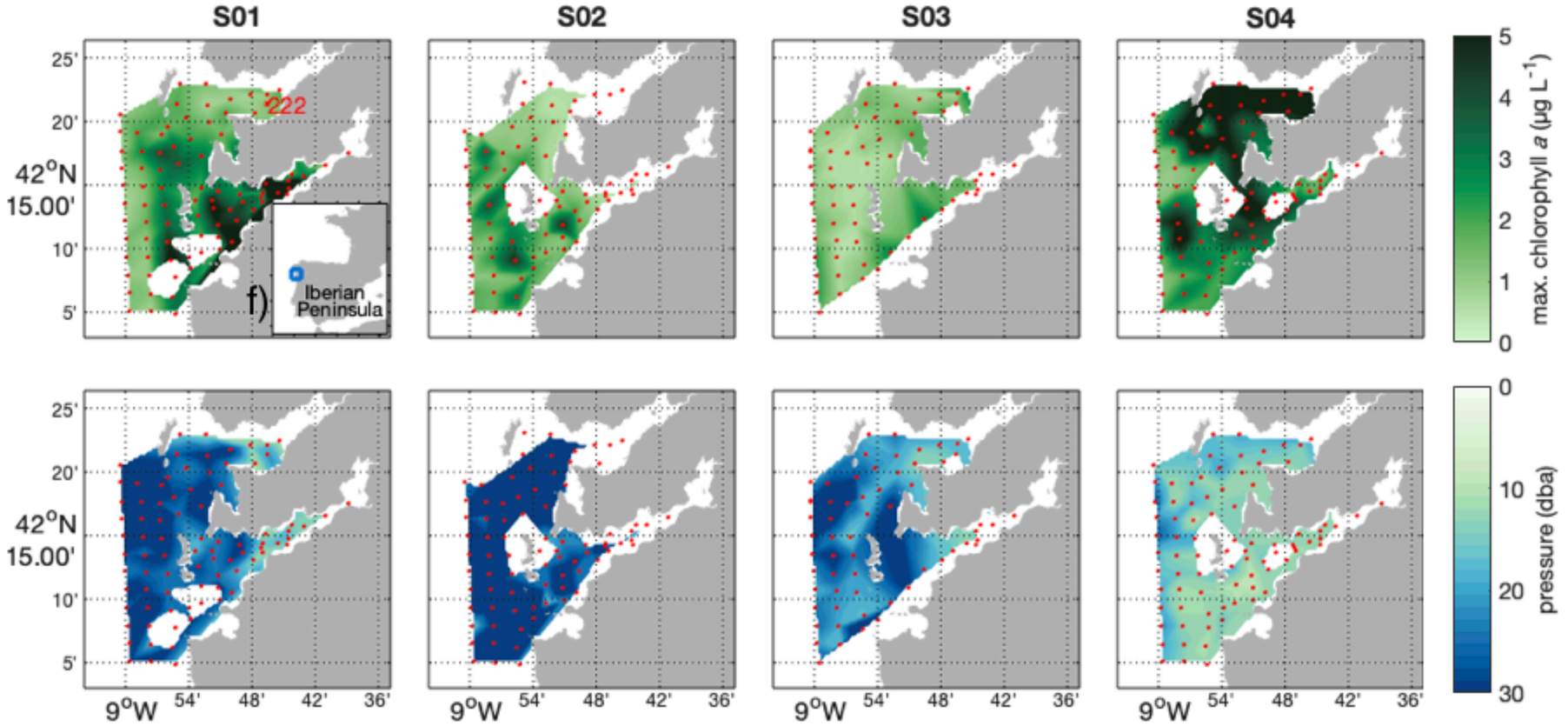
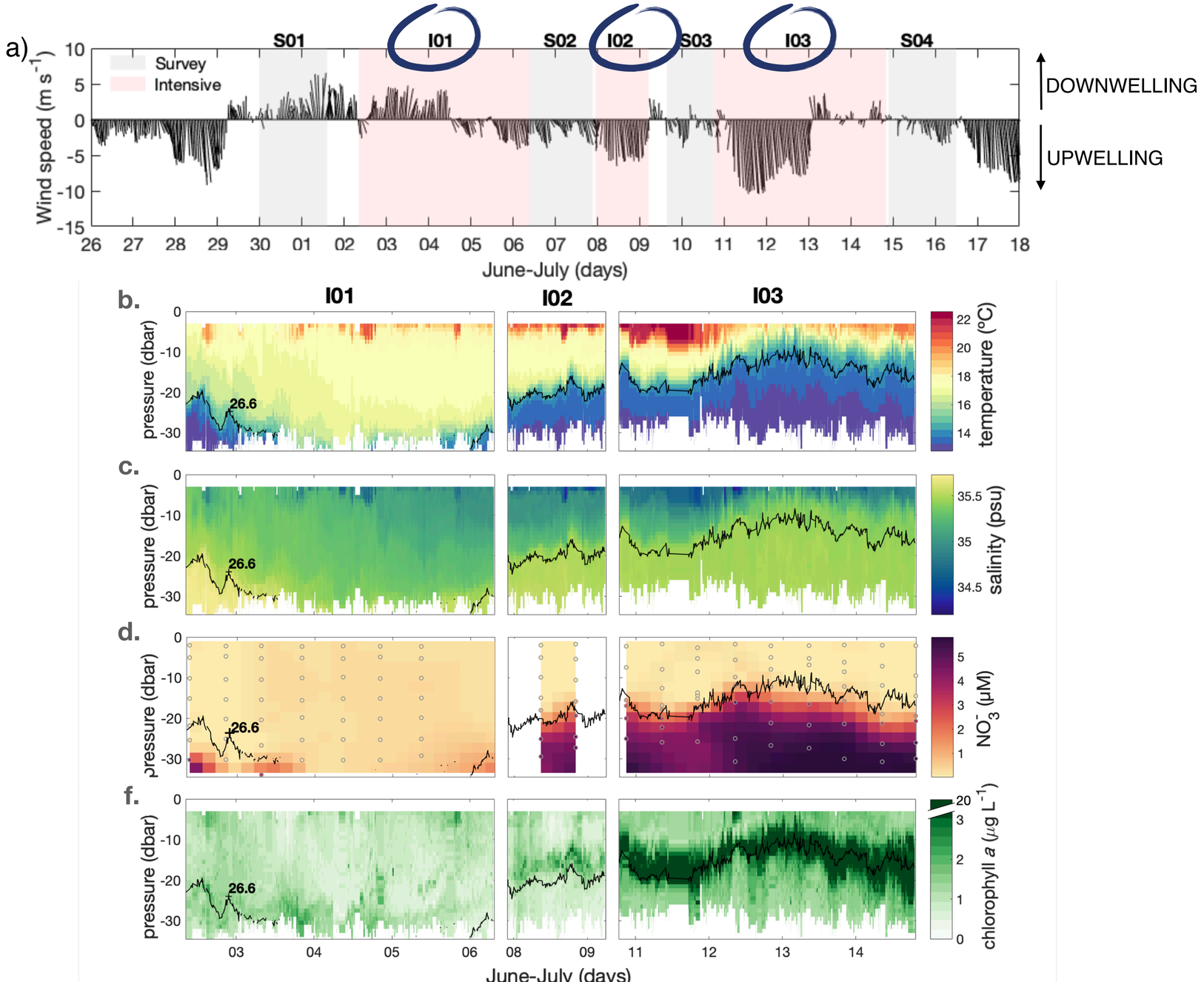
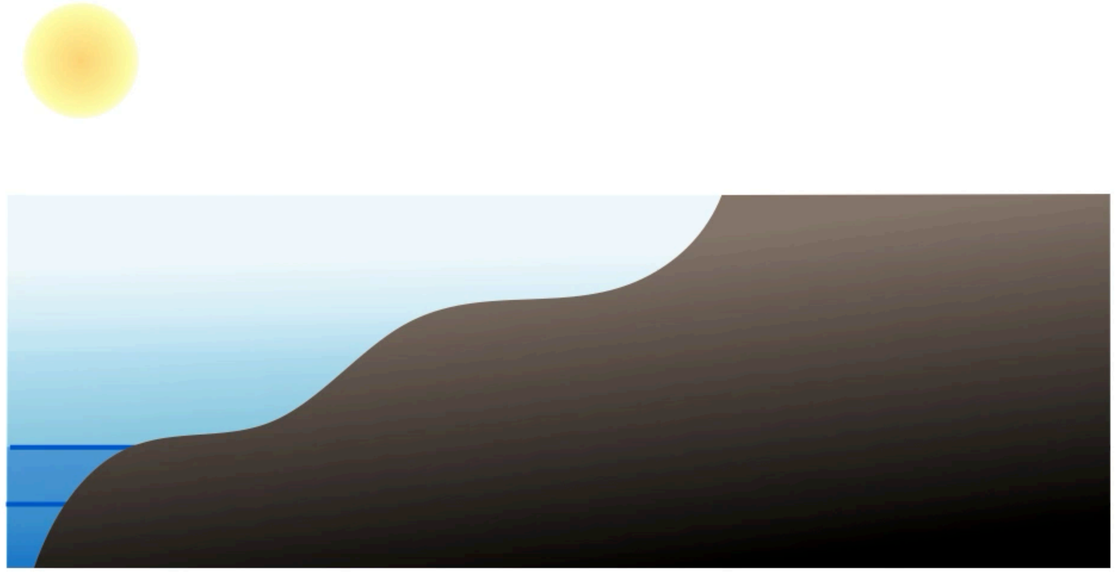


Intensive observations inside the Ría de Pontevedra



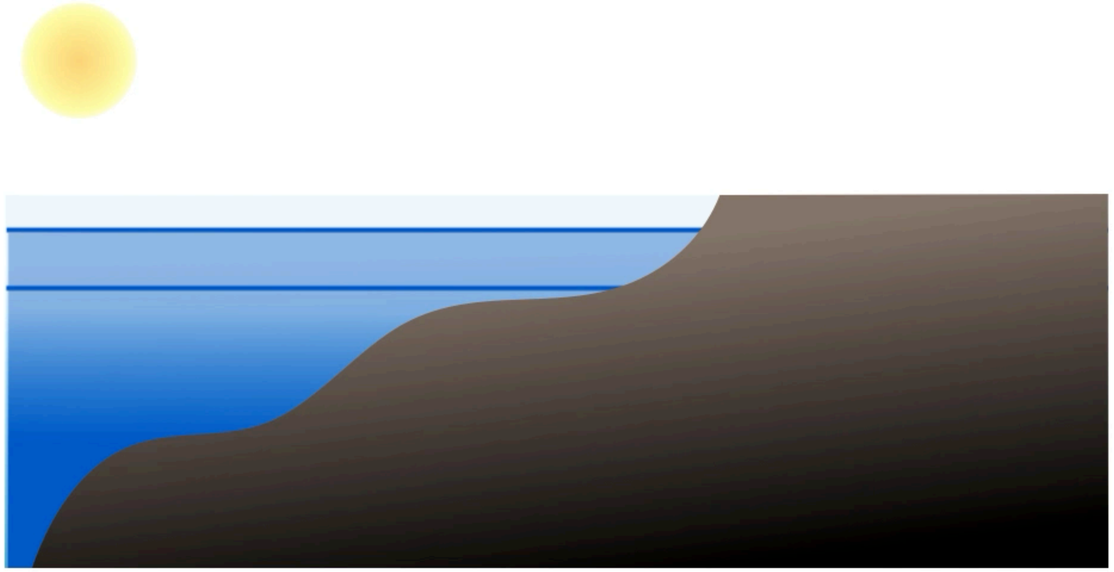
Bloom dynamics



- Phytoplankton bloom was associated with a narrow isopycnal interval
- Nutrient-rich isopycnals could seed and hide toxin-producing species offshore

Seegers et al., (2015)

Bloom dynamics



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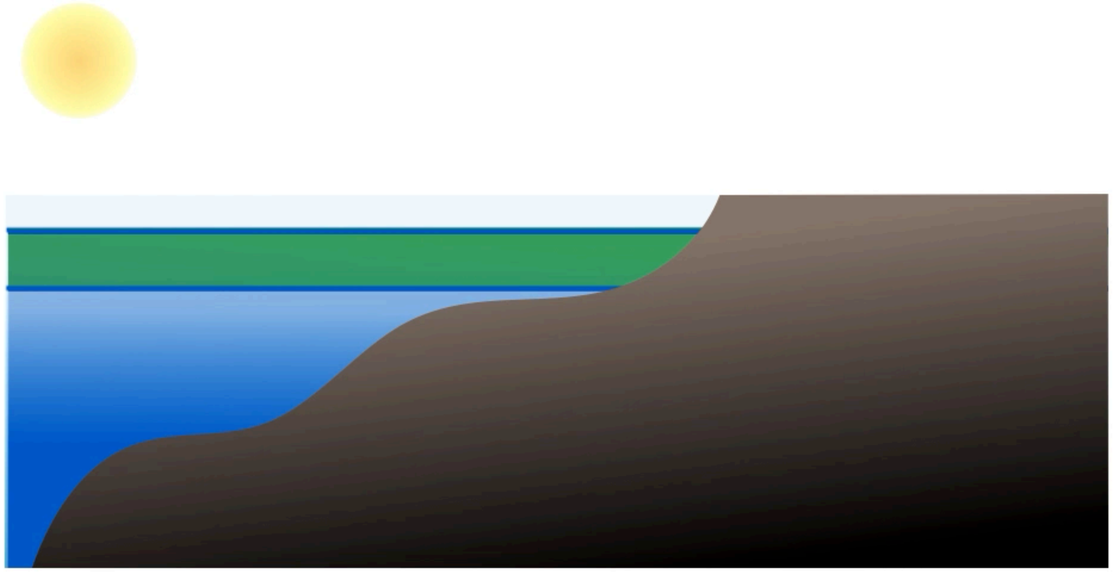

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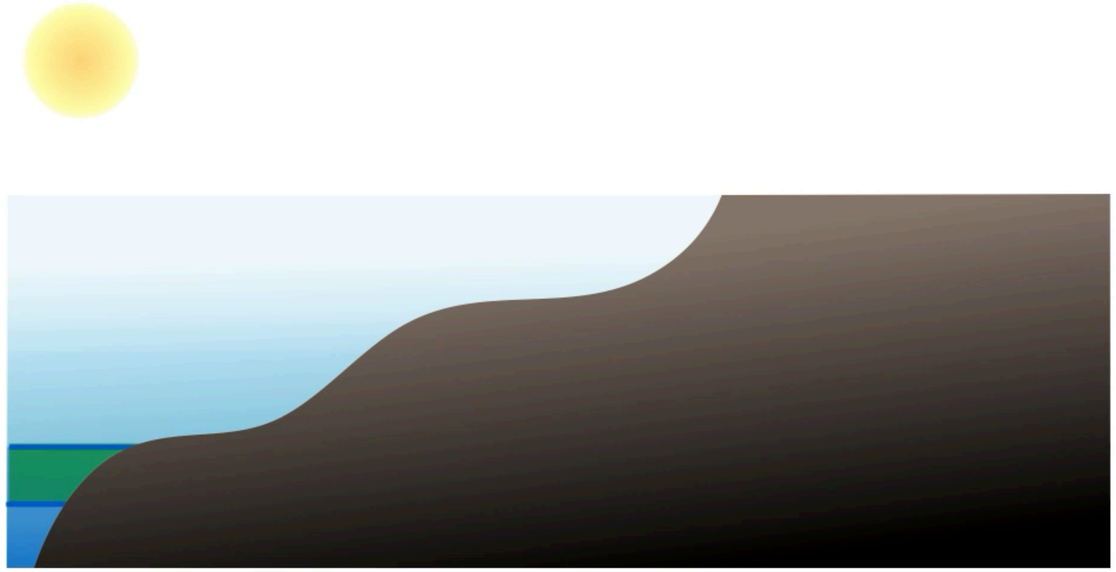

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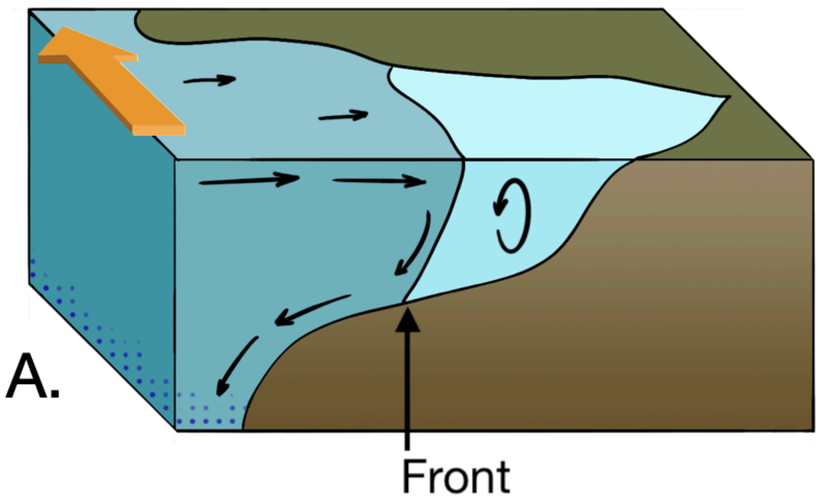
Mechanisms of TLP formation



Circulation

Mixed water

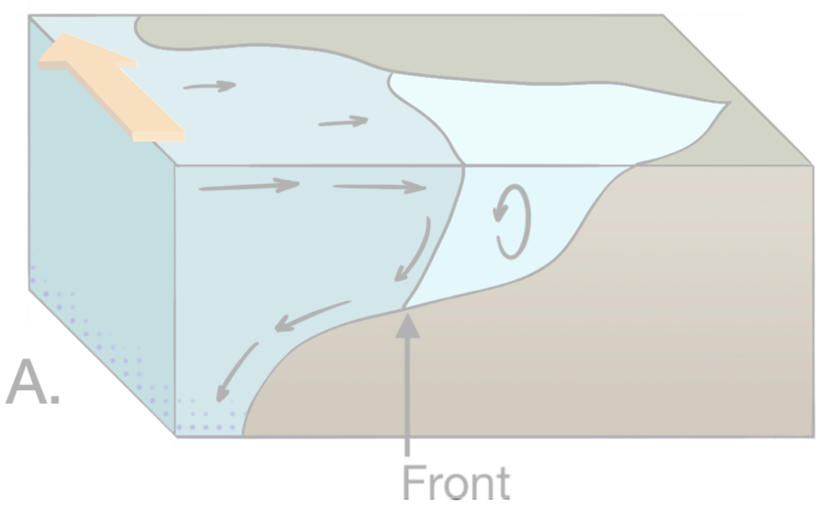
Lighter water

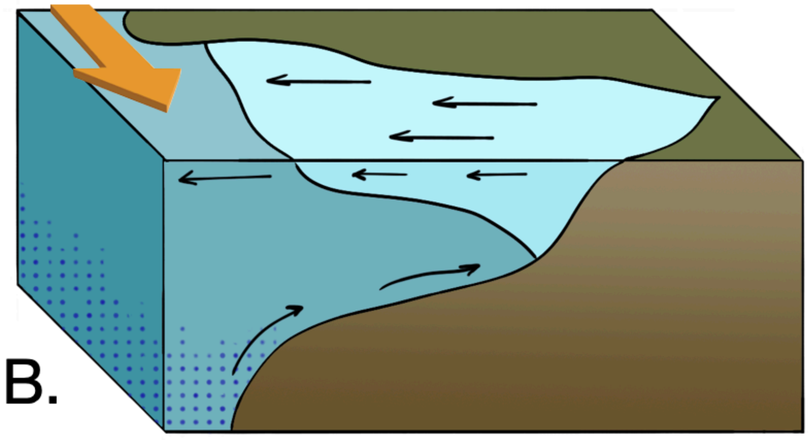
Oceanic water

Nutrients

Phytoplankton

Mechanisms of TLP formation





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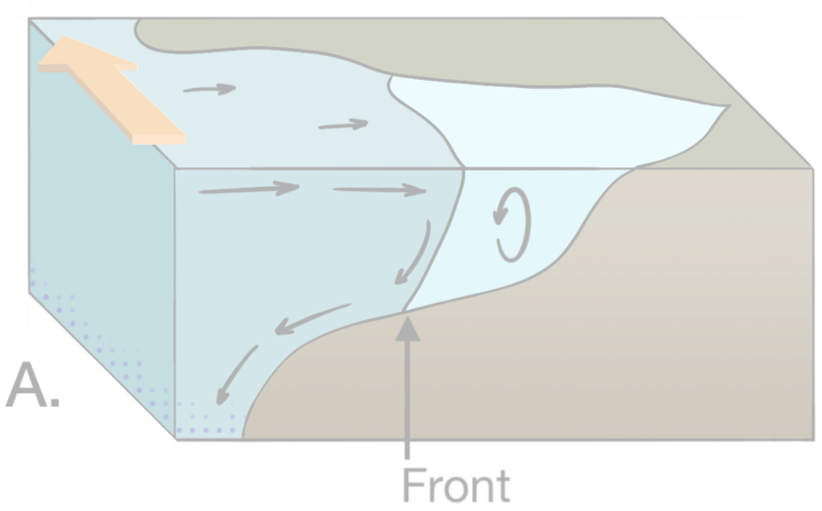

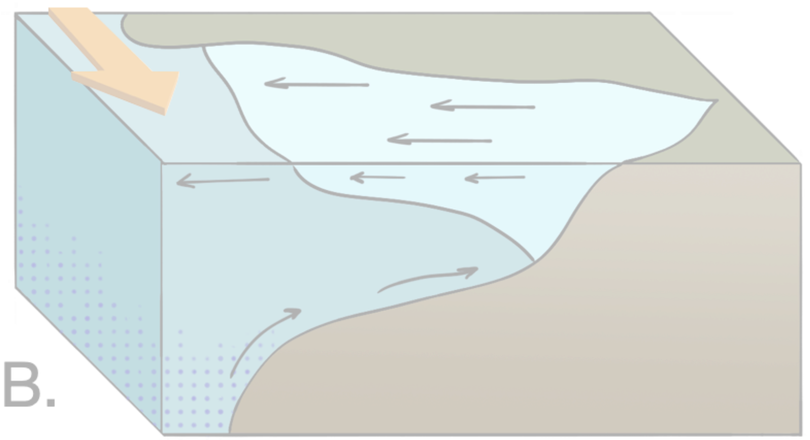

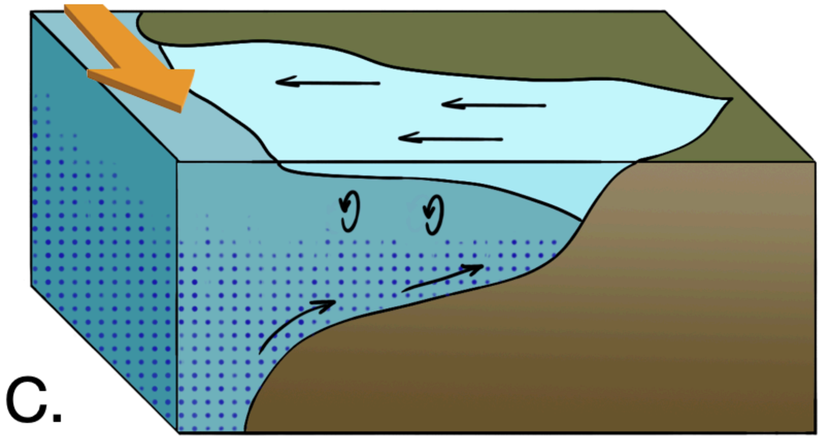

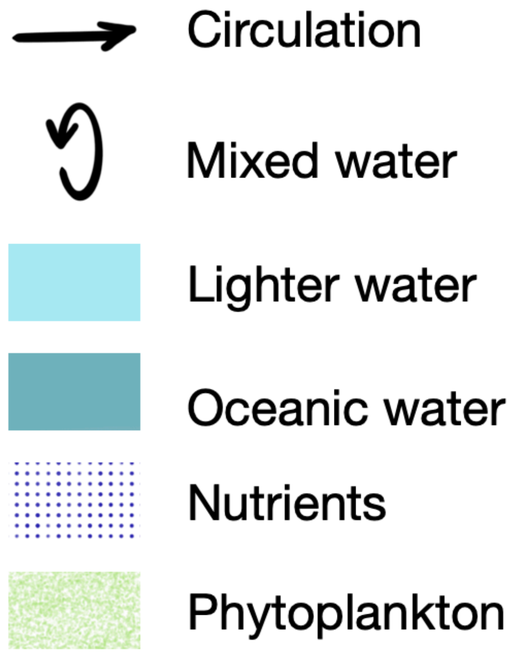

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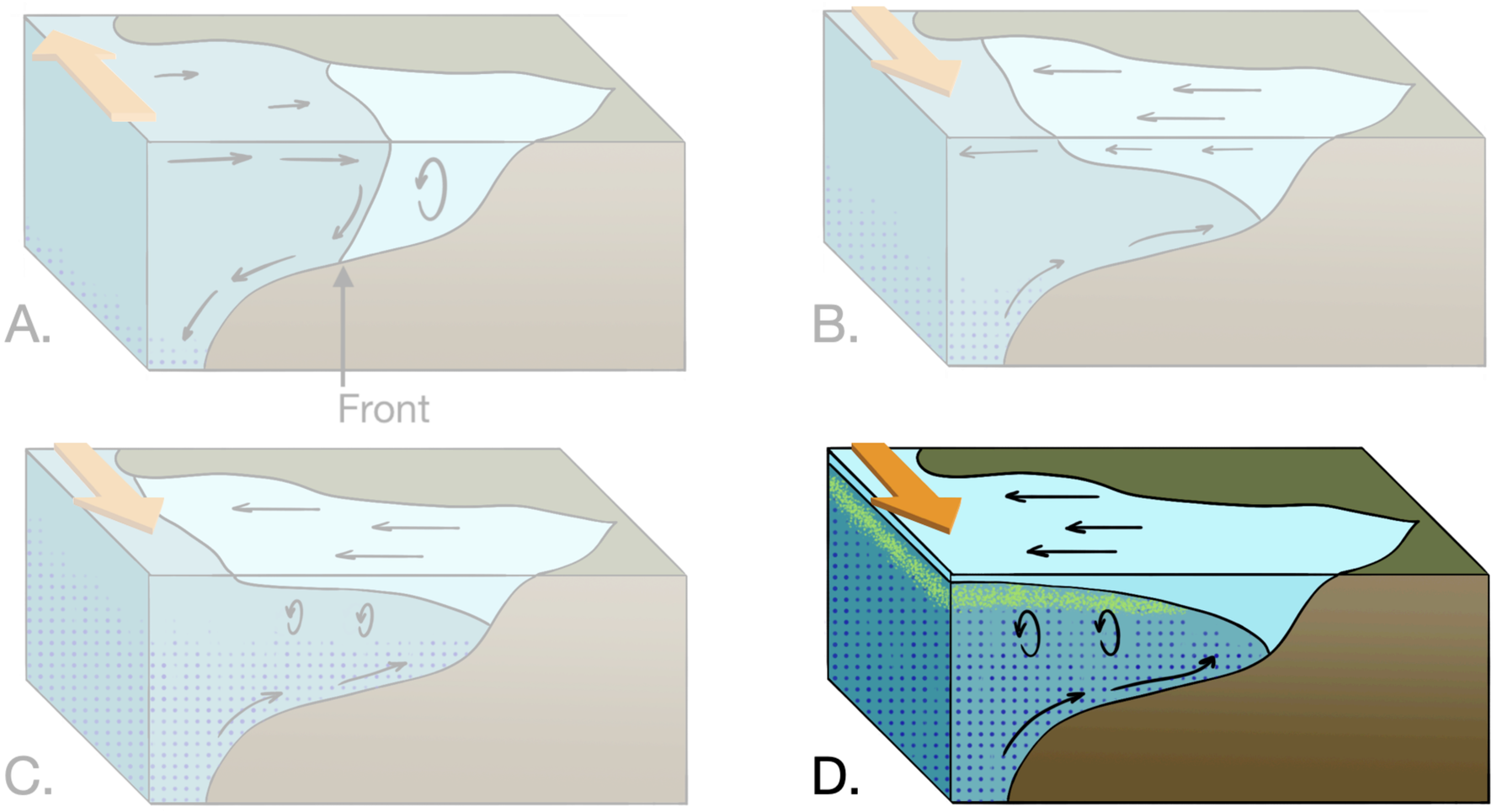
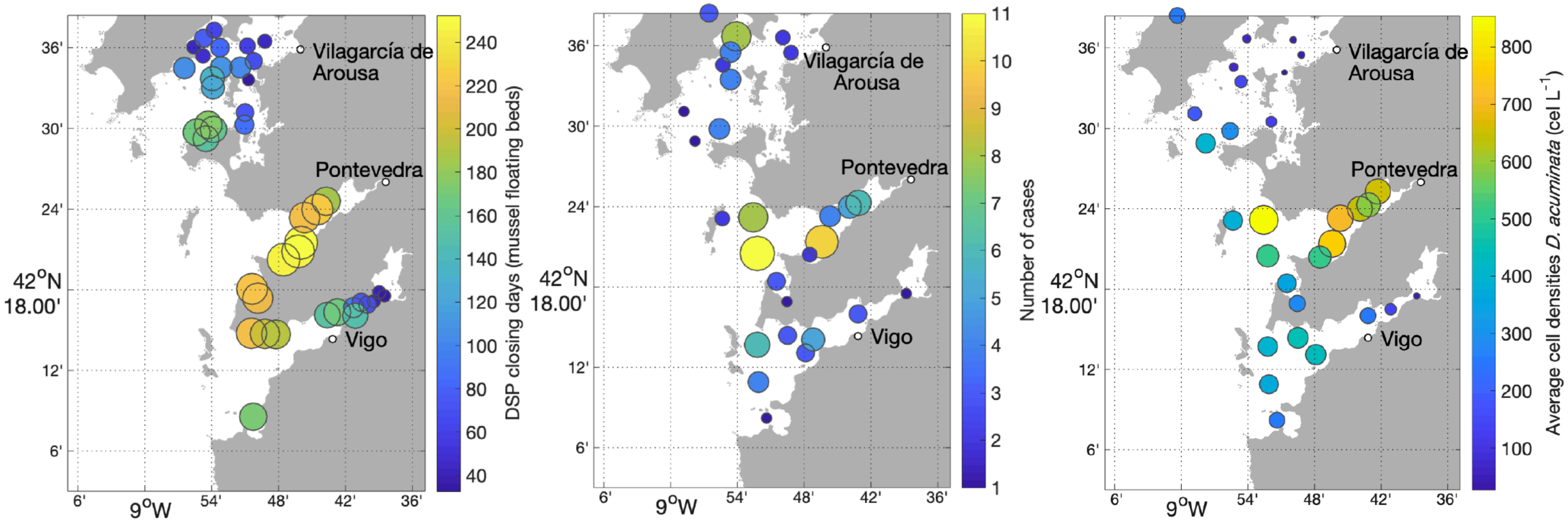
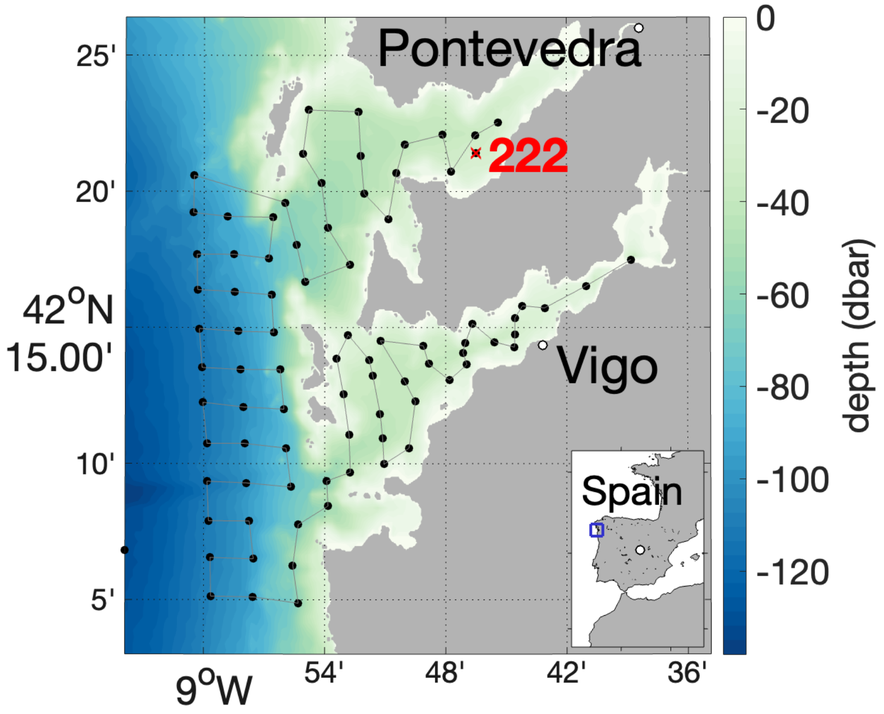
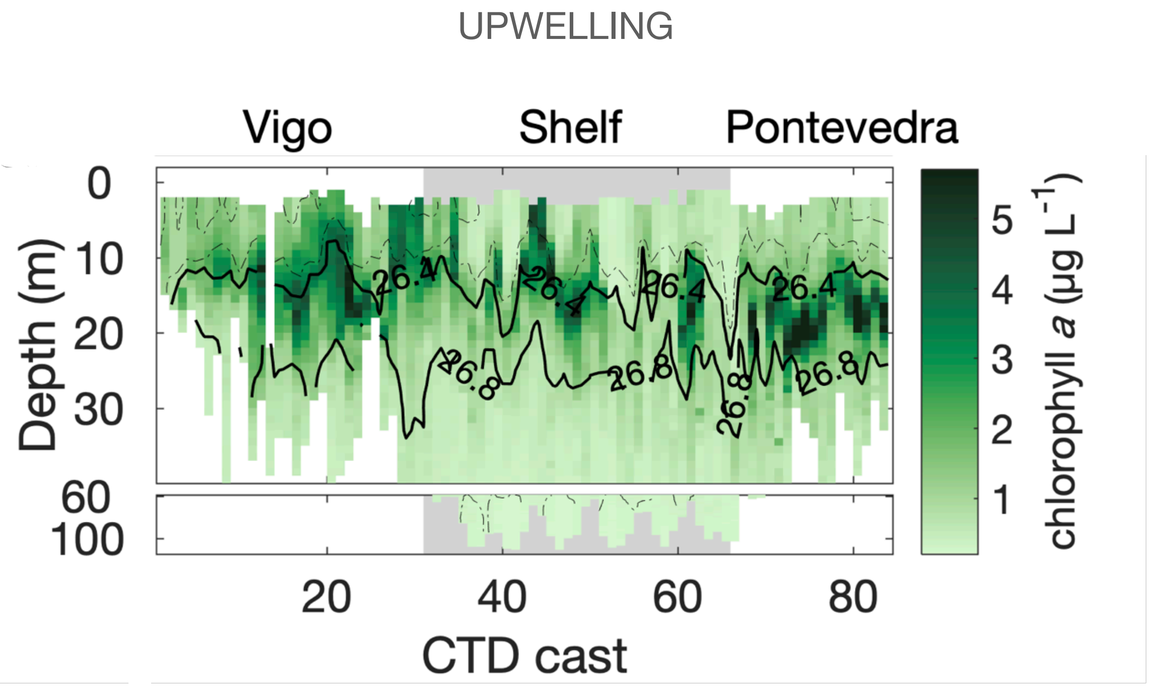


Ría de Pontevedra: a hotspot for toxicity and TLP



Subsurface chlorophyll maximum observations





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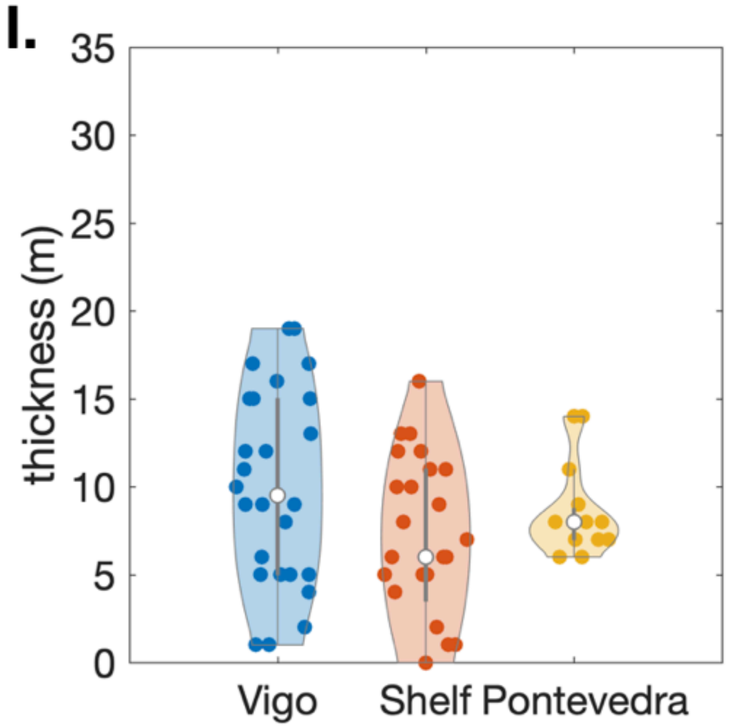
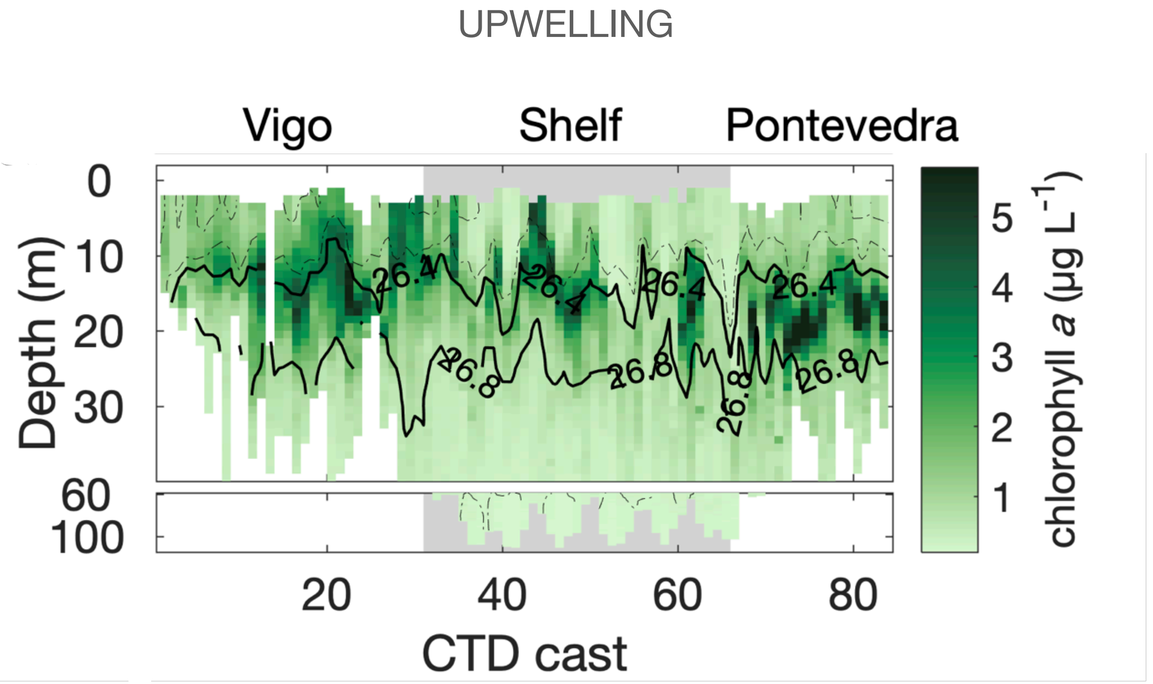
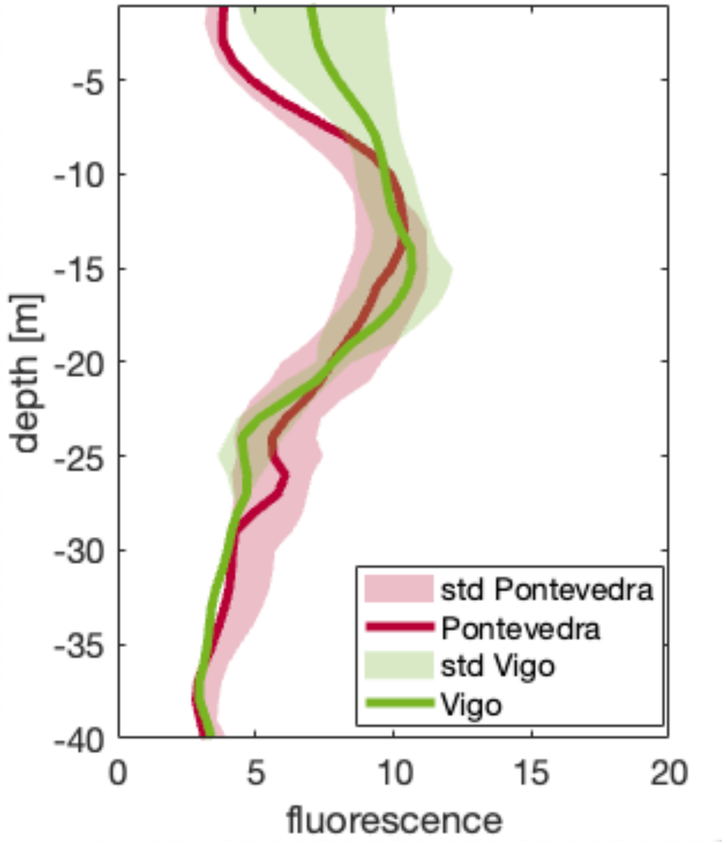


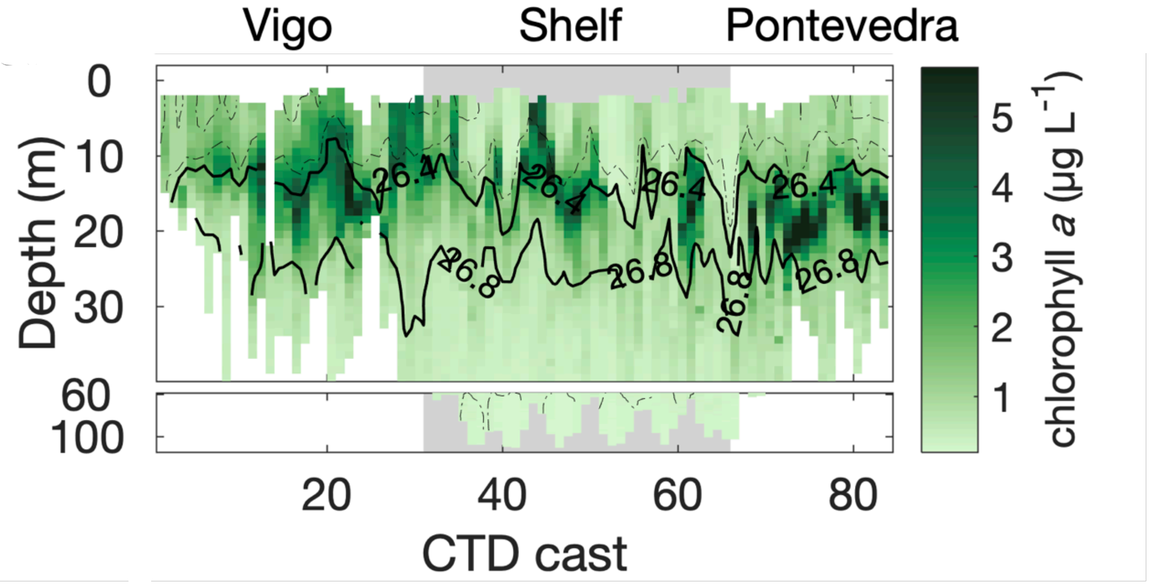


Subsurface chlorophyll maximum observations

2012-2015 INTECMAR profiles



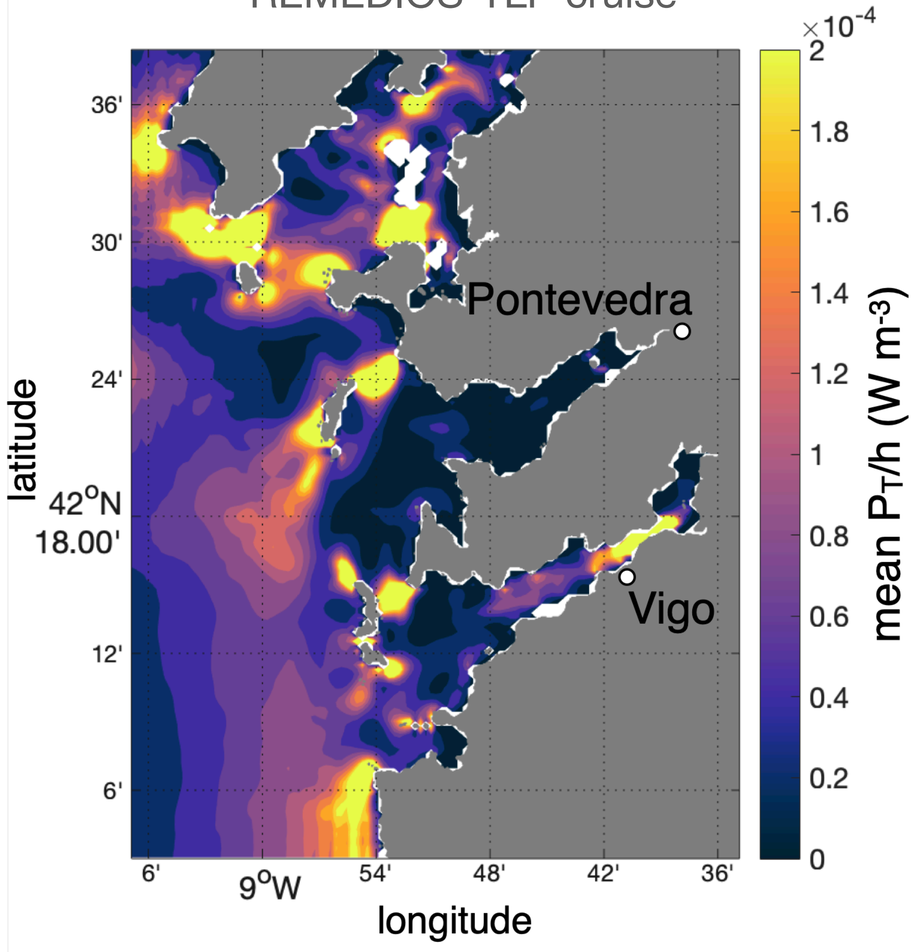
UPWELLING



From on-going master thesis by Blanca Marigomez

The Ría de Pontevedra: a hotspot for toxicity

Turbulent energy production due to bottom friction during 1.5 months spanning the REMEDIOS-TLP cruise



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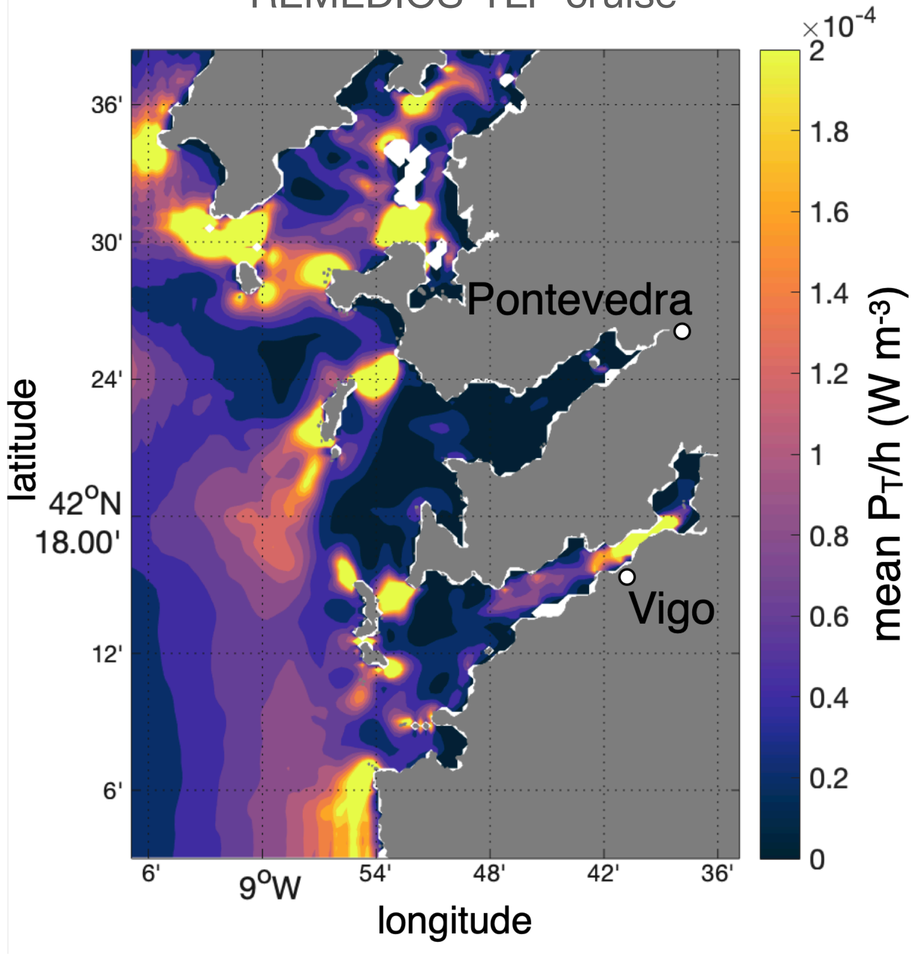
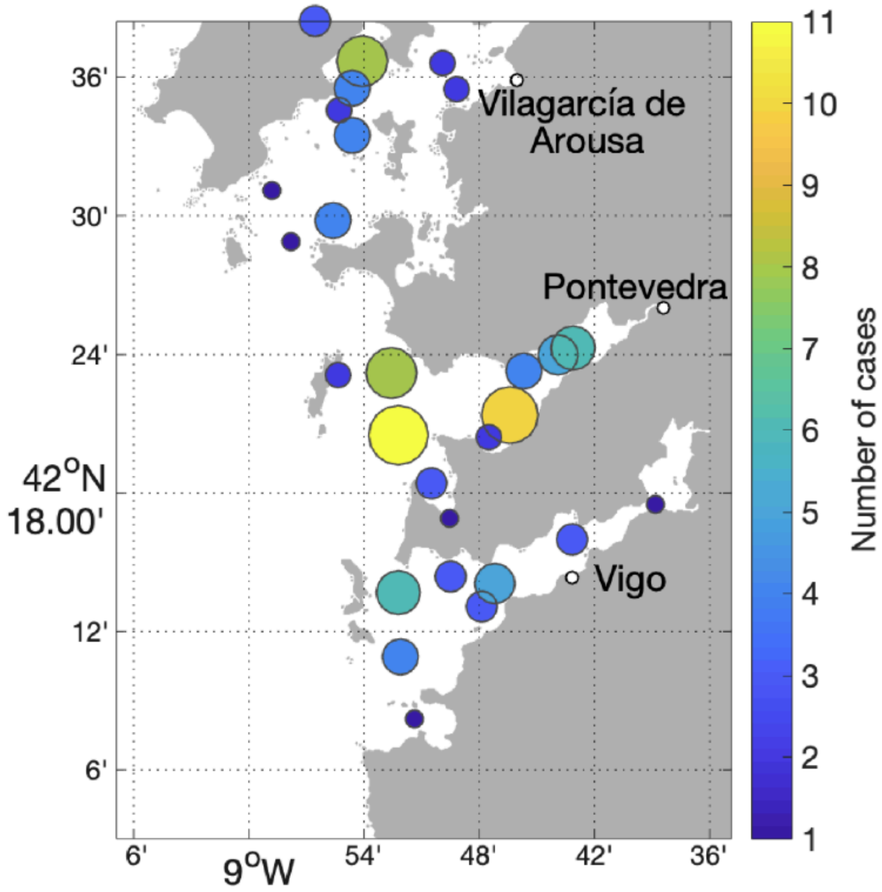


TLP number of cases



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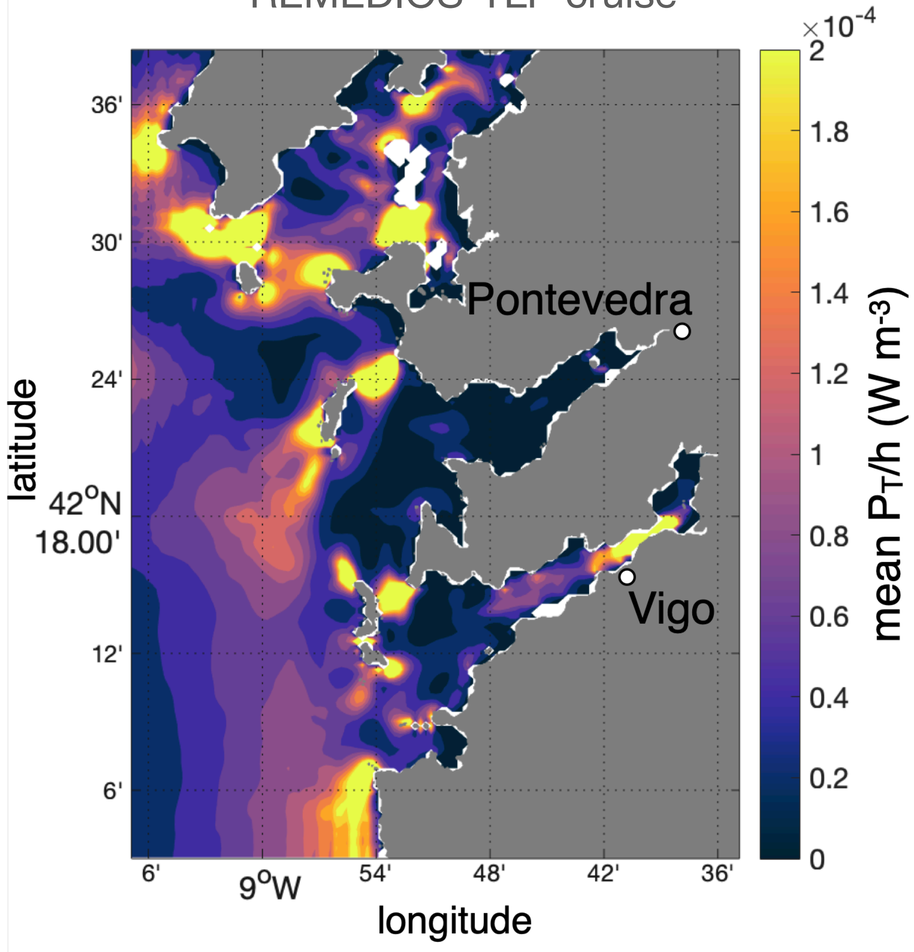
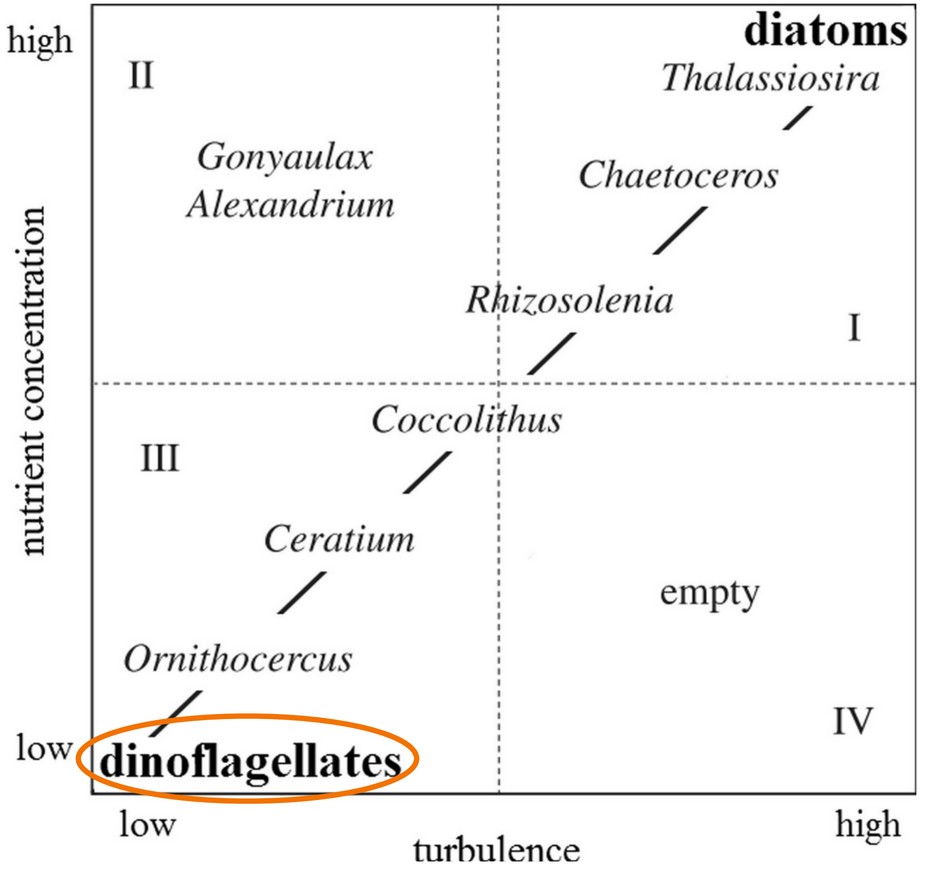


MARGALEF'S MANDALA



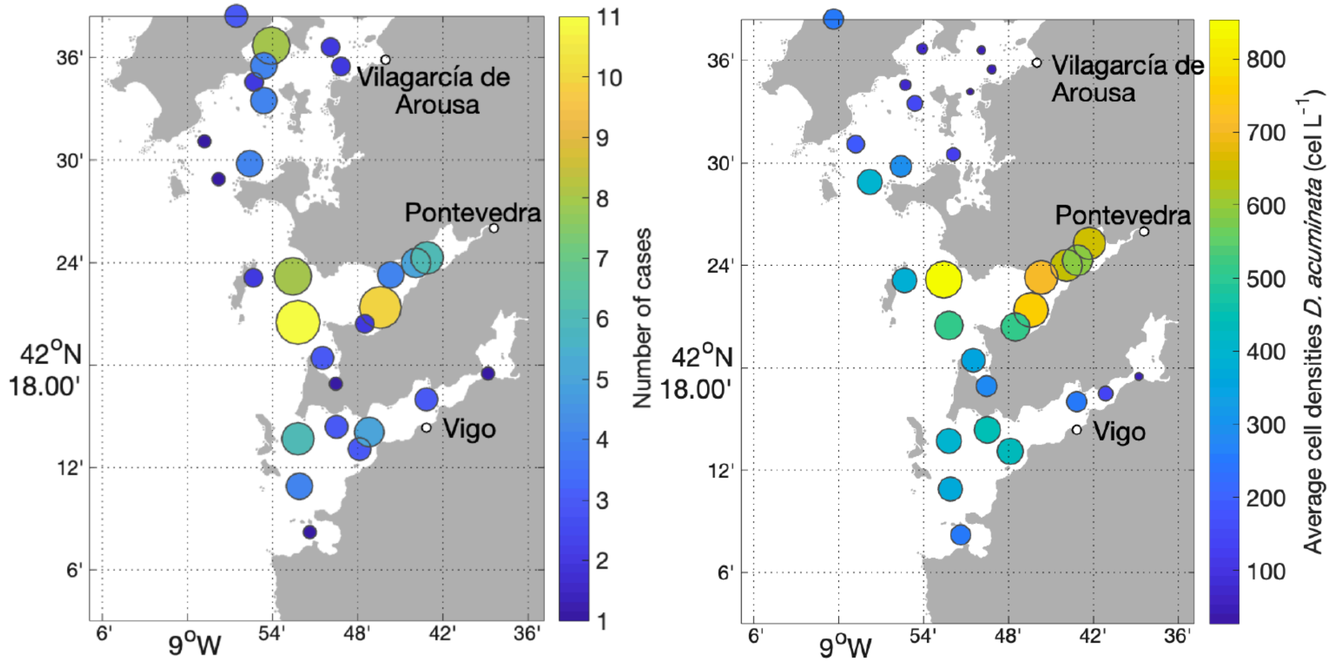
Margalef (1978)

Answers

Question 1: is there a relationship between TLP and HAB in the Galician Rías?

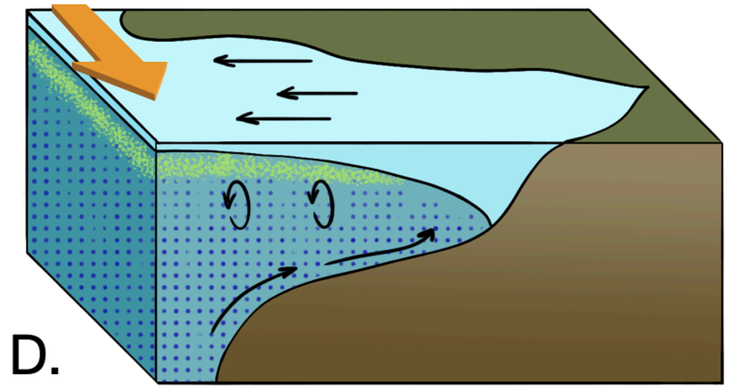
25% of the TLP were related to **elevated densities of HAB** phytoplankton groups:

D. acuminata and *Pseudo-nitzschia*



Question 2: what are the mechanisms responsible for TLP formation?

Straining and ***in situ* growth** under stratification conditions could explain the TLP formation in the Ría de Pontevedra

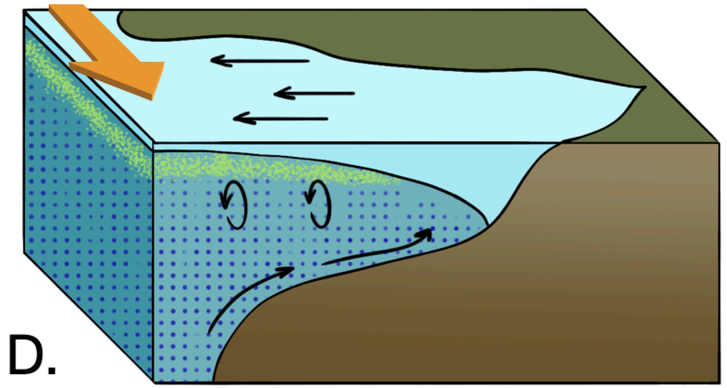


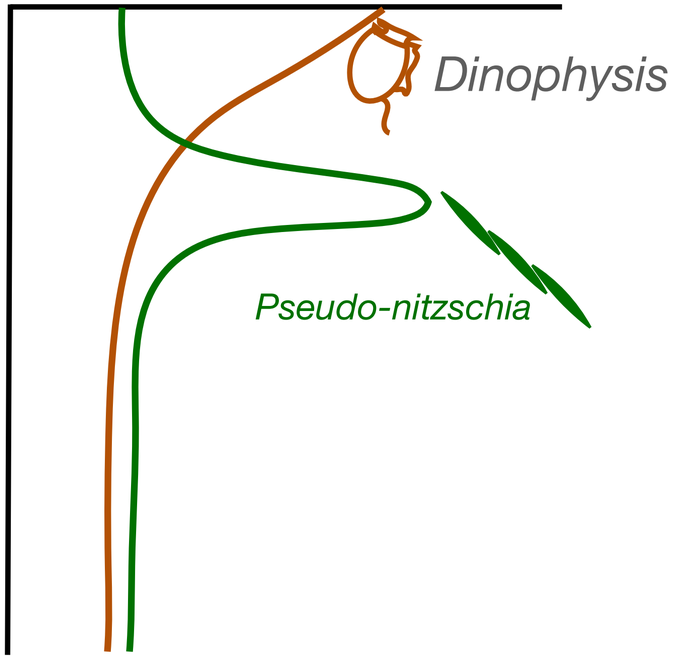
D.

Question 2: what are the mechanisms responsible for TLP formation?

Straining and ***in situ* growth** under stratification conditions could explain the TLP formation in the Ría de Pontevedra

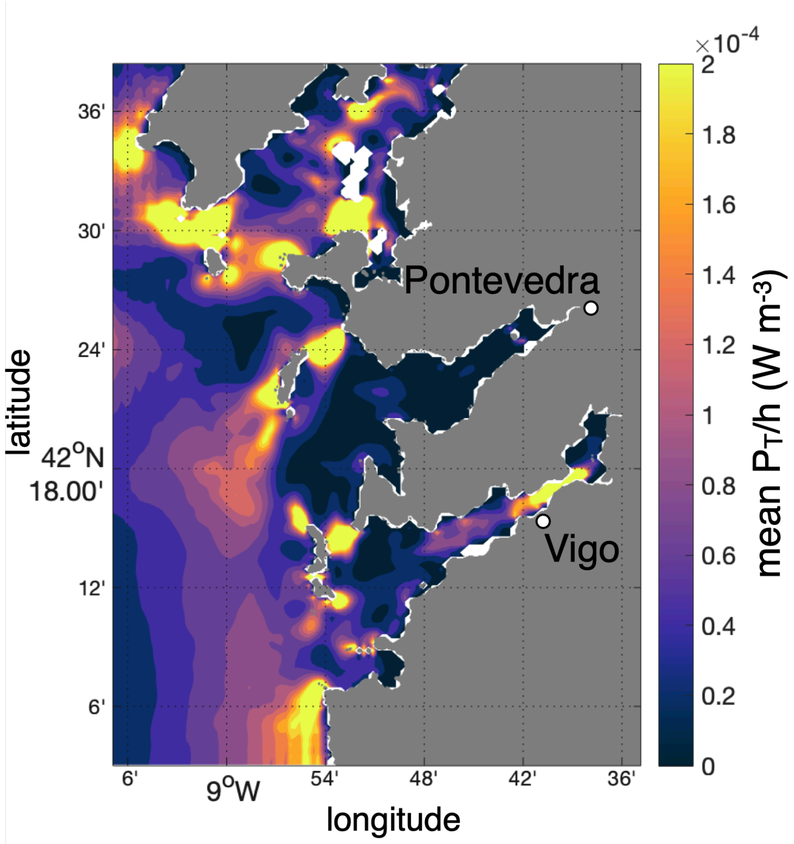
This mechanism could explain the **co-occurrence** of HABs dominated by ***Dinophysis*** in the surface, and thin layers of ***Pseudo-nitzschia*** within the chlorophyll maximum

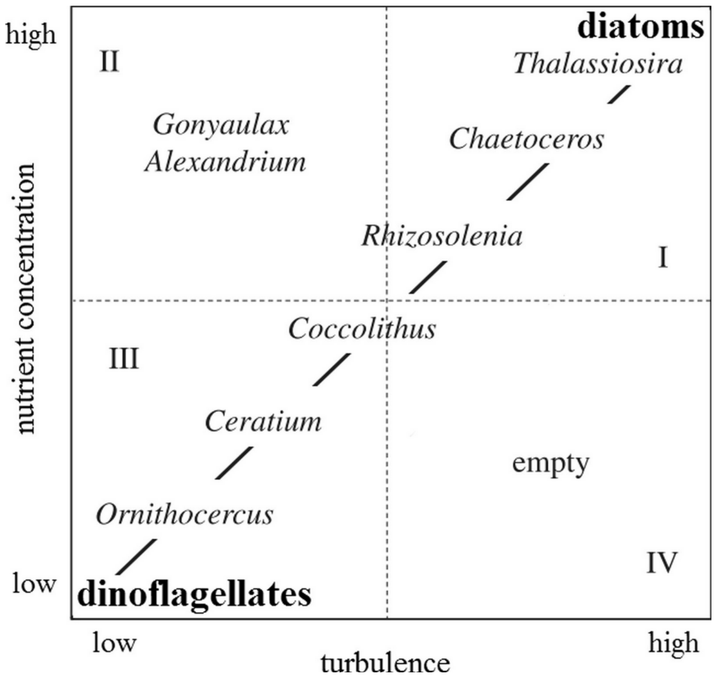




Question 3: why is the Ría de Pontevedra a hotspot for toxicity?

The persistance of **stratified** conditions in time could be explained by **the lower rate of turbulent energy production** that characterizes this Ría





Margalef (1978)