Formation of thin layers of phytoplankton in the upwelling region off NW Iberia: biological growth versus physical accumulation

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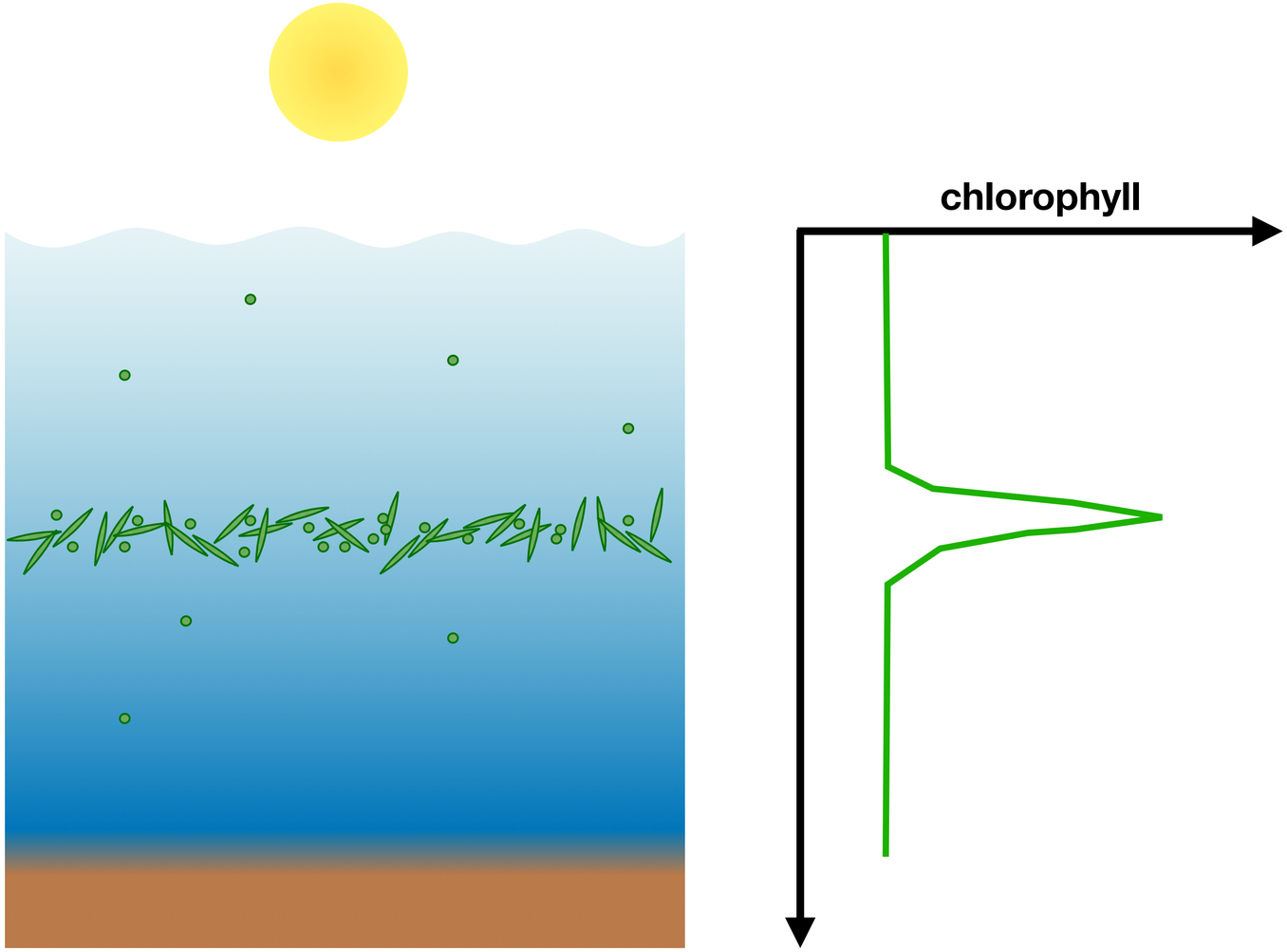
INSTITUTO ESPAÑOL DE OCEANOGRAFÍA

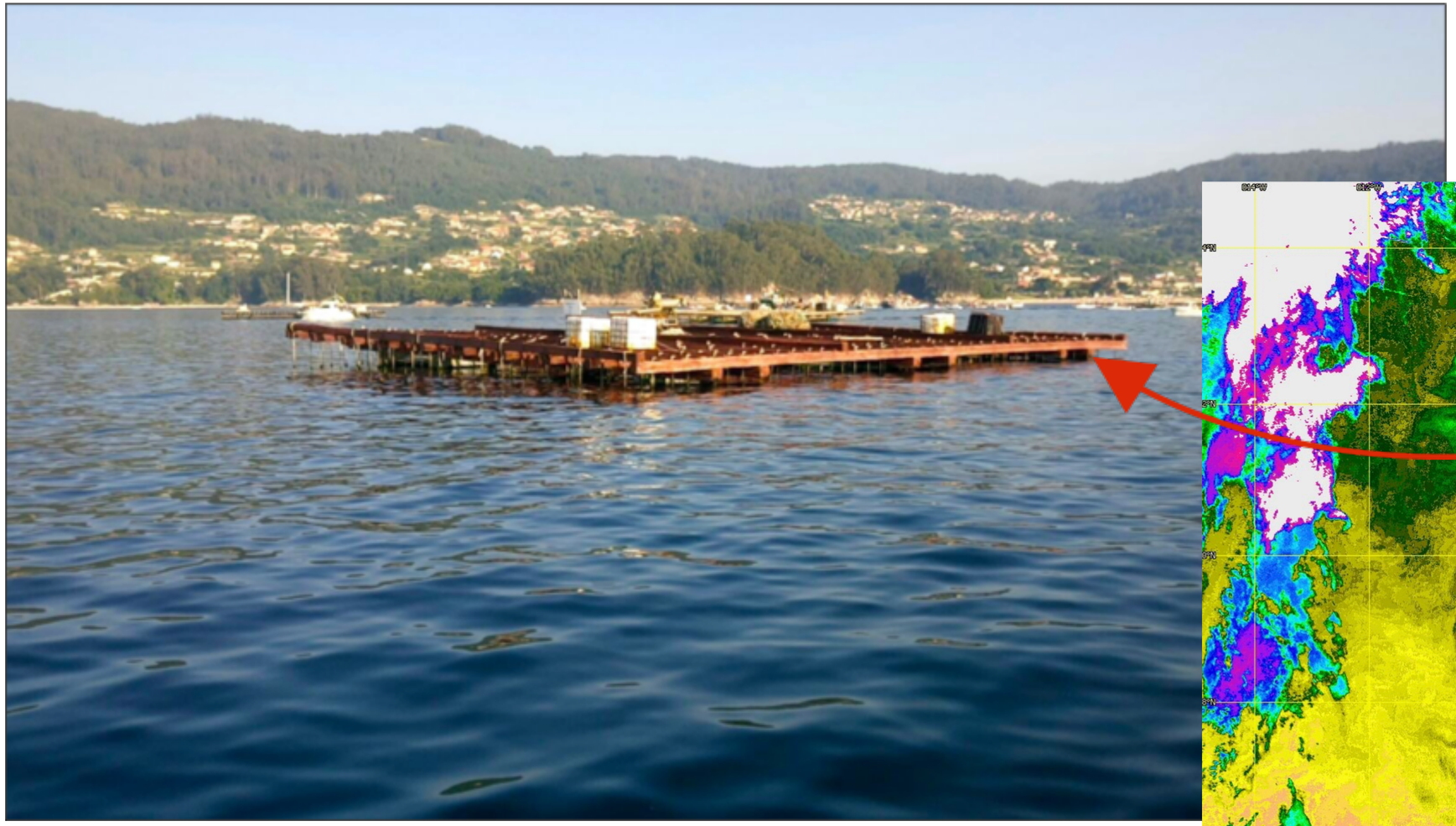
Ocean Sciences Meeting 2020

What are thin layers of phytoplankton?



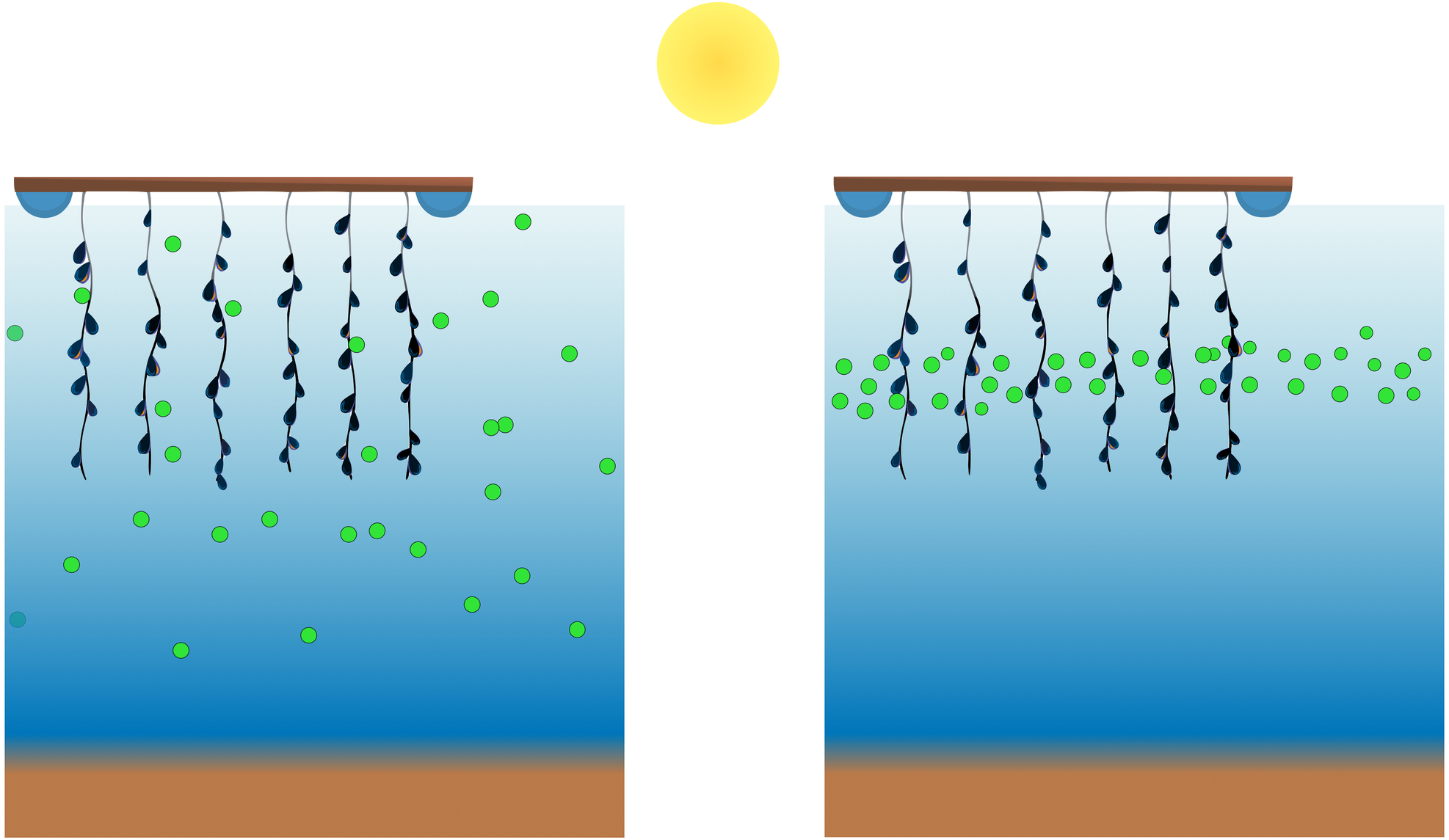
- Thickness < 3 m
- Intensity > 2 x Background
- TL can extent horizontally over several km and persist for several days

Motivation

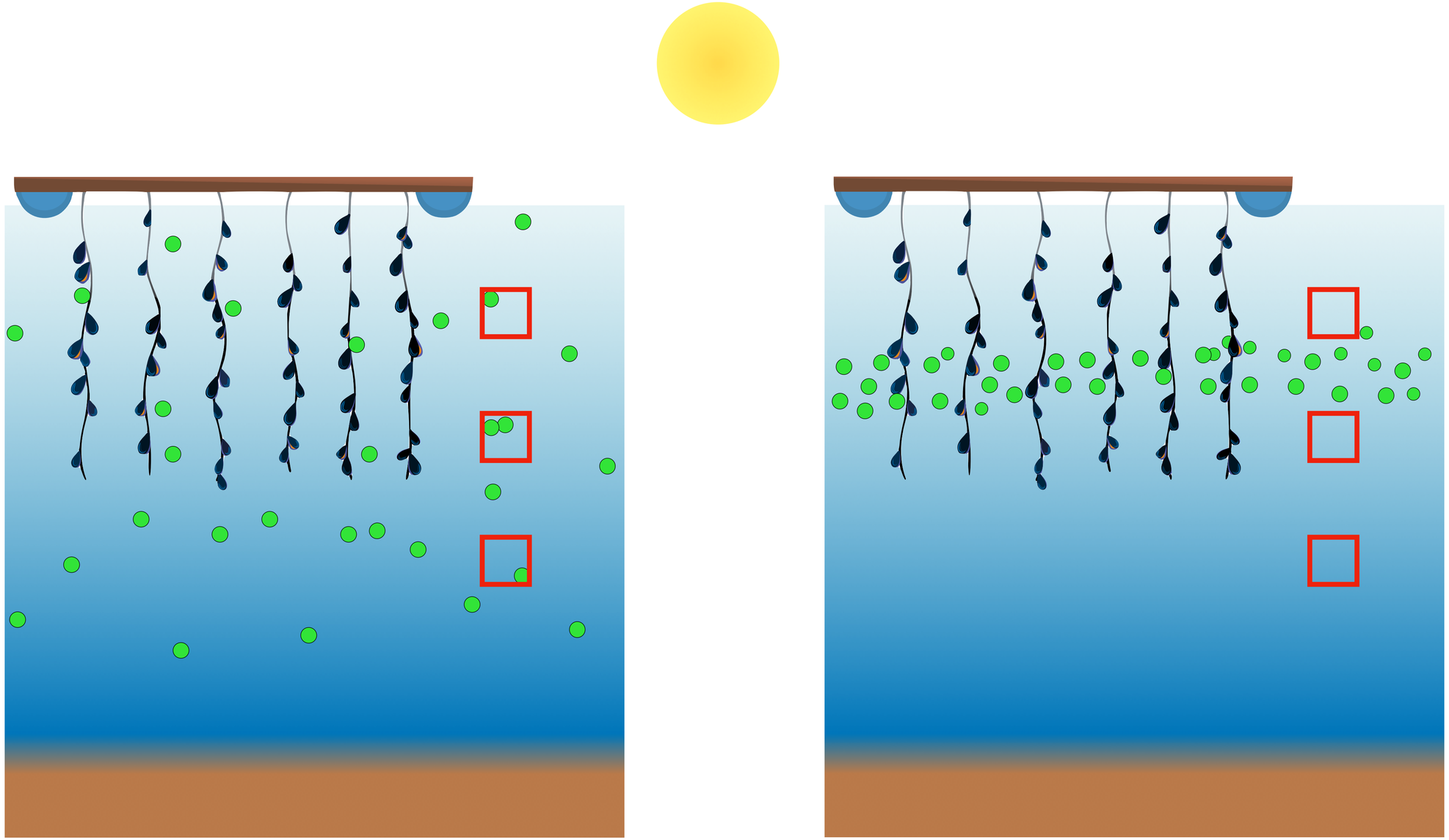


Mussel raft, Ría de Pontevedra

Motivation



Motivation



Questions

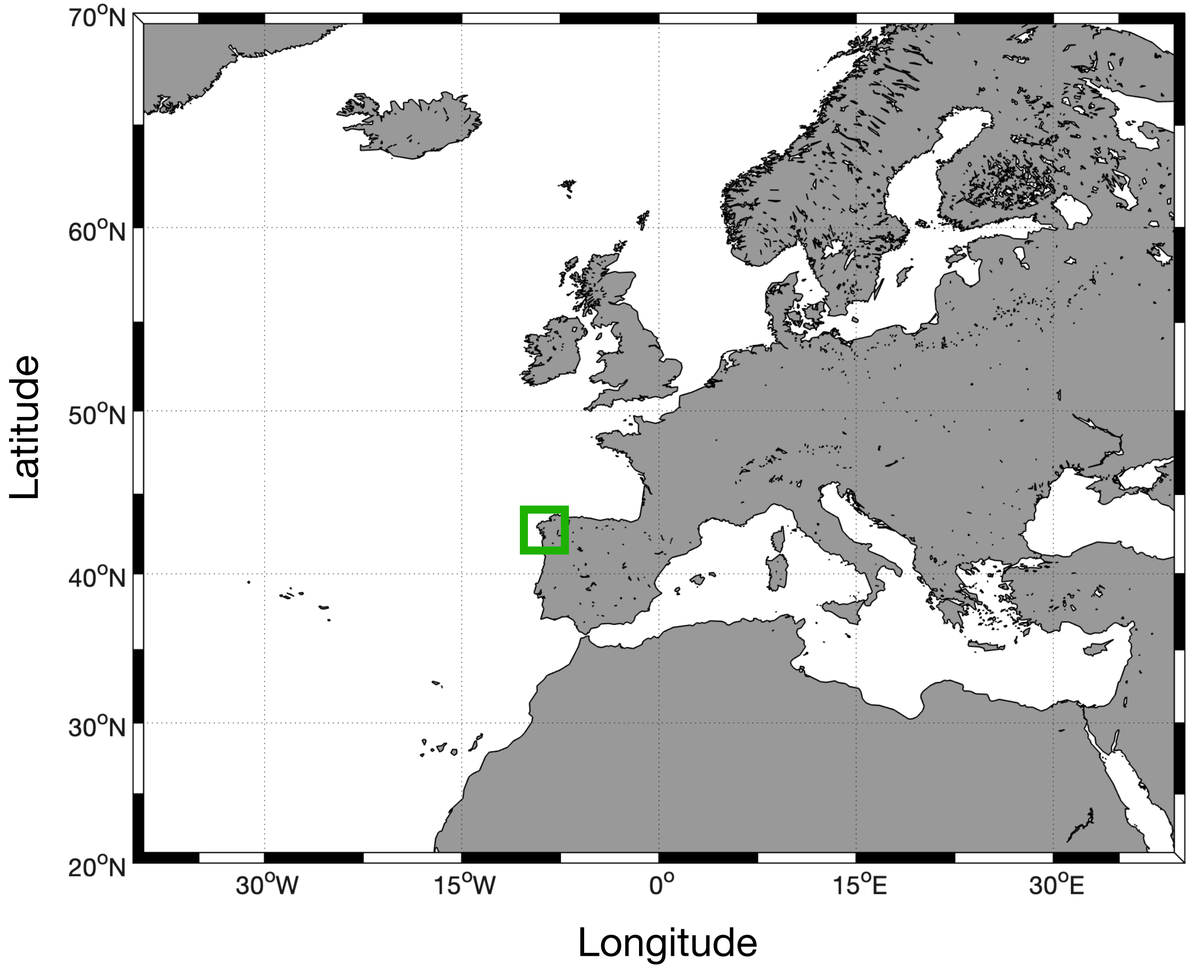
✳What are the **dynamics** of a thin layer of phytoplankton?

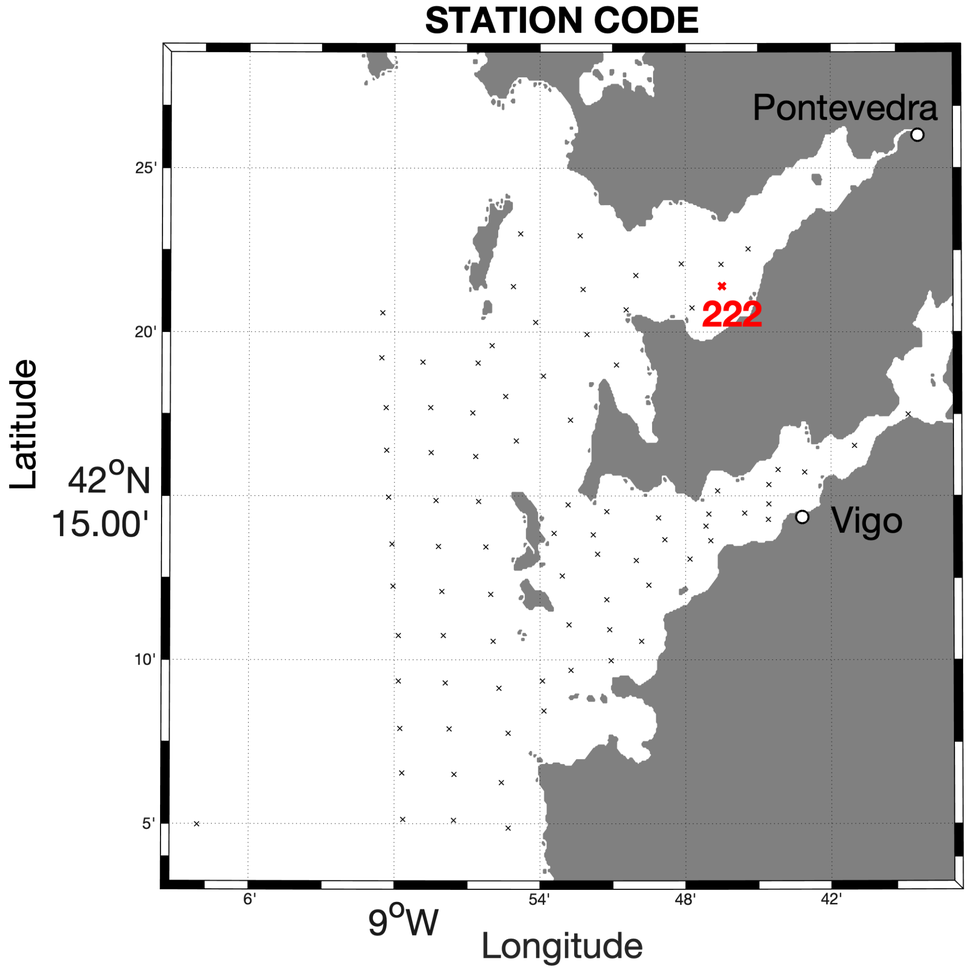
✳What is the **spatial extent**?

✳What is the contribution of **physical and biological processes** to their formation?

Research design

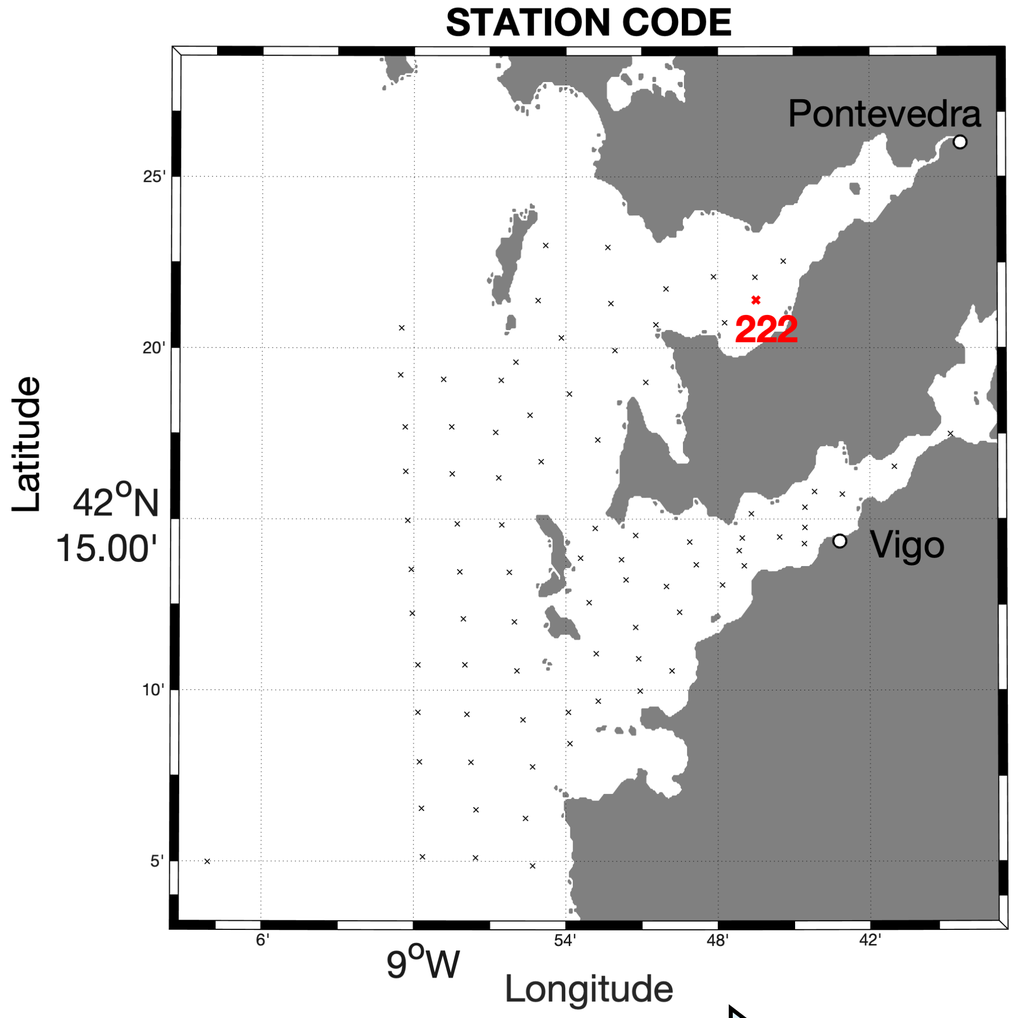
REMEDIOS-TLP cruise, July 2018





Research design

- 4 SURVEY samplings through the 84 stations
  - 1 CTD cast per station (total = 225 profiles)
- 3 INTENSIVE samplings at station 222
  - 5 high resolution CTD profiles every 30 minutes (total = 1674 profiles)
  - 1 sampling with Niskin bottles at different depths every 6 hours



SURVEY1	INTENSIVE 1	SURVEY2	INTENS. 2	SURVEY3	INTENSIVE 3	SURVEY4

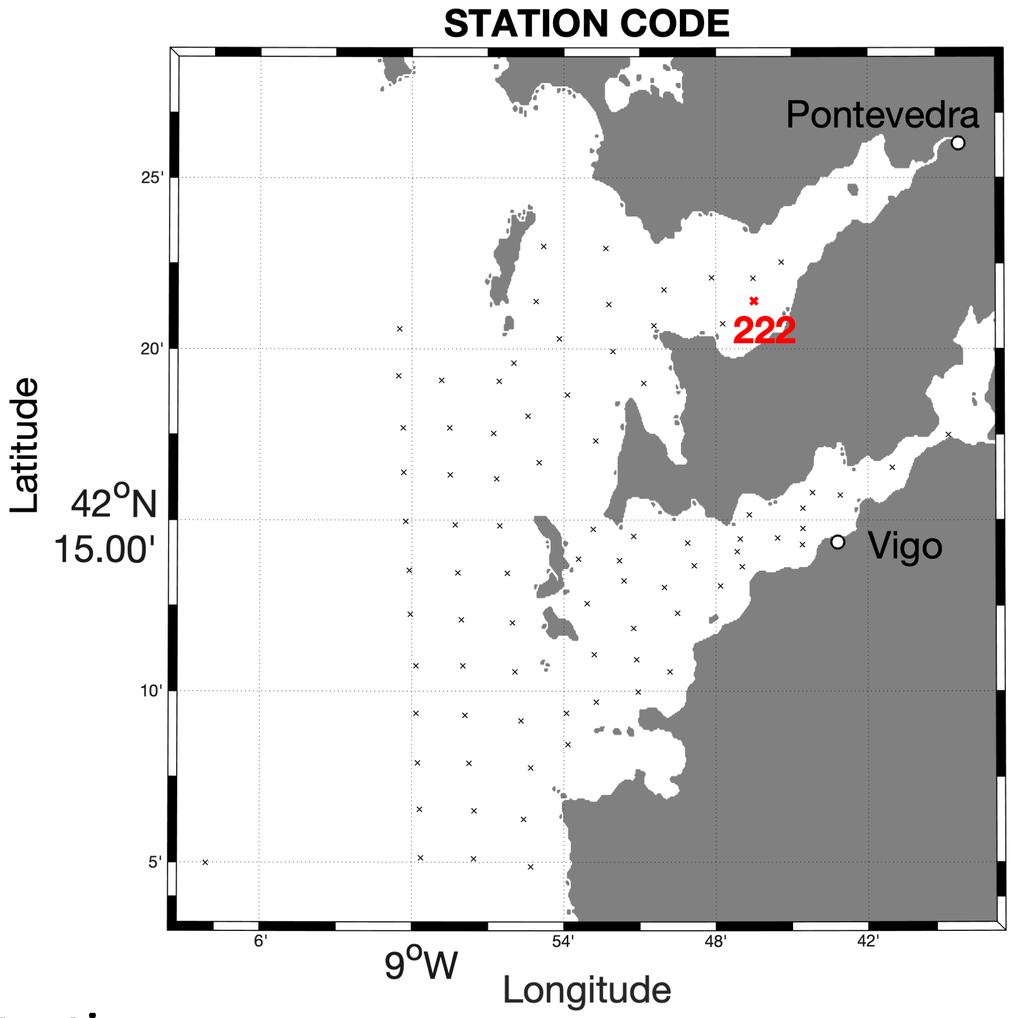
Variables

INTENSIVE SAMPLINGS (222)

- High resolution CTD
  - ✳ **Temperature**
  - ✳ **Chlorophyll *a* (from fluorescence)**
- Niskin bottles
  - ✳ **Nitrate**
  - ✳ **Chlorophyll *a***
  - ✳ **Primary production ^{14}C**

SURVEY SAMPLINGS

- 1 CTD cast per station
  - ✳ **Fluorescence** profiles -> thin layers detection



Main goals

✳What are the **dynamics** of the thin layer detected during the REMEDIOS-TLP cruise?

✳What is the **spatial extent** of the thin layer of phytoplankton?

✳What is the contribution of **physical and biological processes**?

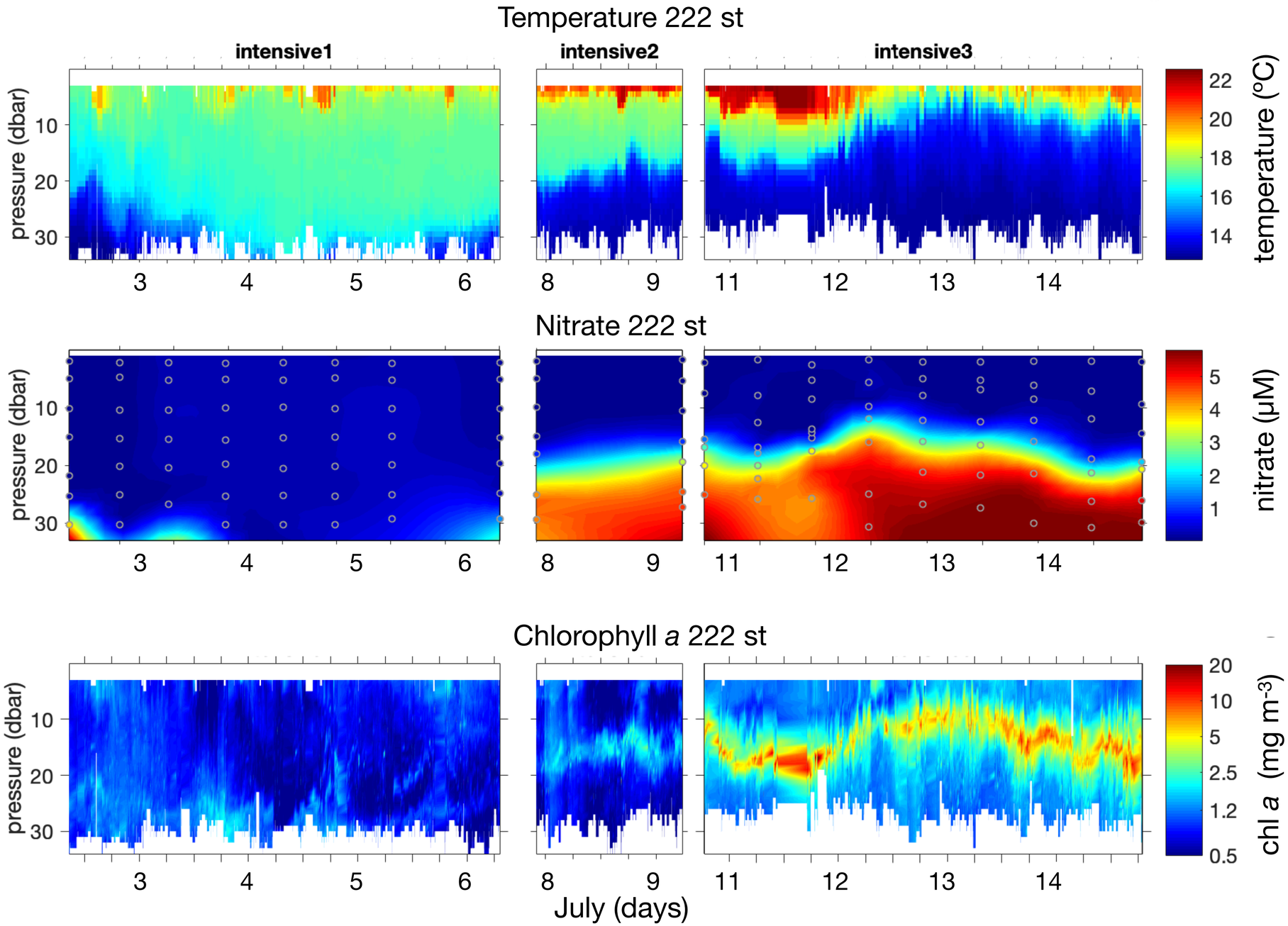
Main goals

- What are the **dynamics** of the thin layer detected during the REMEDIOS-TLP cruise?

- What is the **spatial extent** of the thin layer of phytoplankton?

- What is the contribution of **physical and biological processes**?

What is the temporal variability?



Main goals

- What are the **dynamics** of the thin layer detected during the REMEDIOS-TLP cruise?

- What is the **spatial extent** of the thin layer of phytoplankton?

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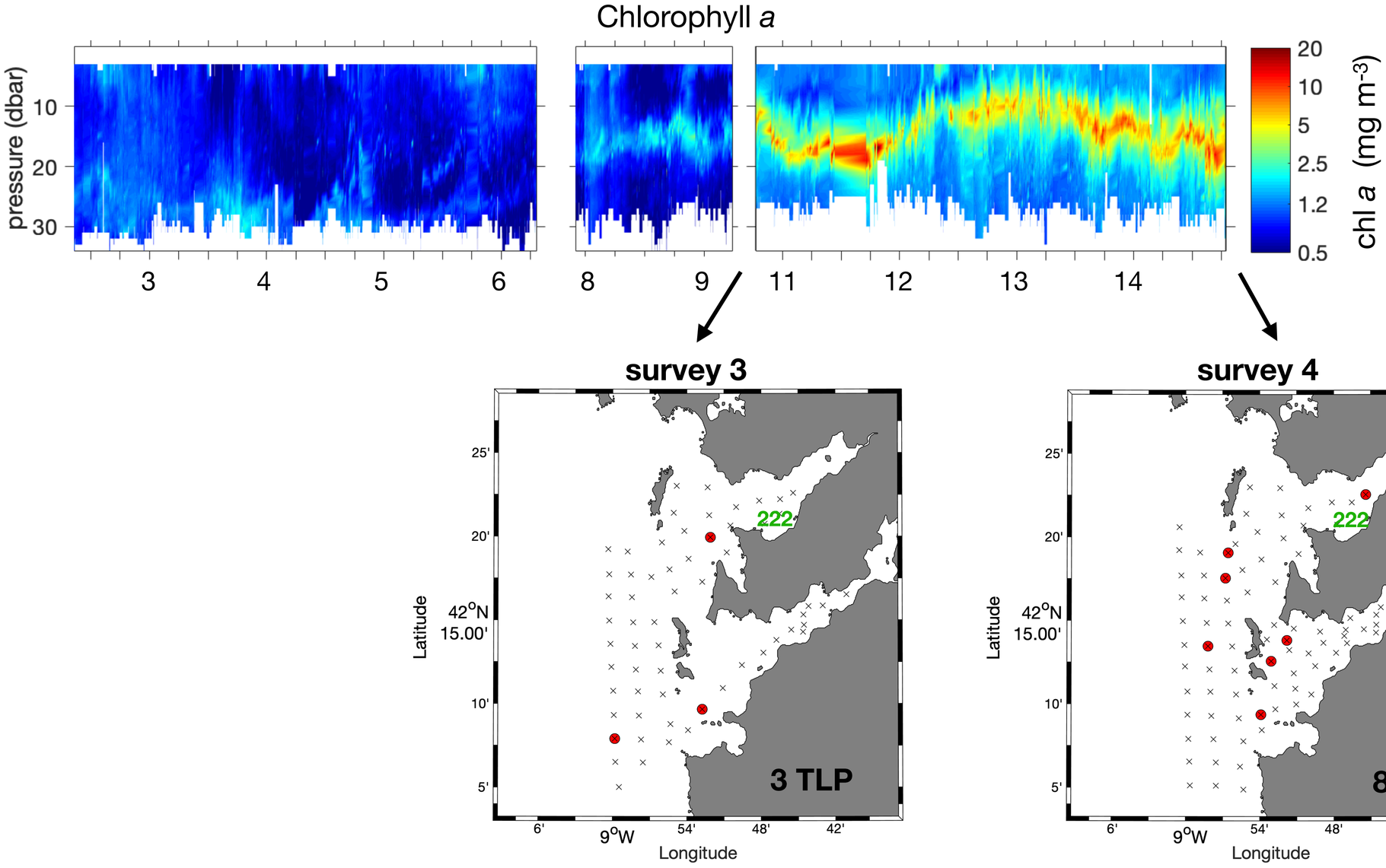
Spatial extent



222 Station

Main goals

- What are the **dynamics** of the thin layer detected during the REMEDIOS-TLP cruise?

- What is the **spatial extent** of the thin layer of phytoplankton?

- What is the contribution of **physical and biological processes**?

How did it form?

$$\frac{\partial chl\ a}{\partial t} = \left(\frac{\partial chl\ a}{\partial t}\right)_{gains} - \left(\frac{\partial chl\ a}{\partial t}\right)_{losses}$$

$$\frac{\partial chl\ a}{\partial t} = \left(\frac{\partial chl\ a}{\partial t}\right)_{biological} + \left(\frac{\partial chl\ a}{\partial t}\right)_{physical} - \left(\frac{\partial chl\ a}{\partial t}\right)_{biological} - \left(\frac{\partial chl\ a}{\partial t}\right)_{physical}$$

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$$\frac{\partial chl\ a}{\partial t} = \left(\frac{\partial chl\ a}{\partial t}\right)_{biological} + \left(\frac{\partial chl\ a}{\partial t}\right)_{physical} - \left(\frac{\partial chl\ a}{\partial t}\right)_{biological} - \left(\frac{\partial chl\ a}{\partial t}\right)_{physical}$$

Net rate

How did it form?

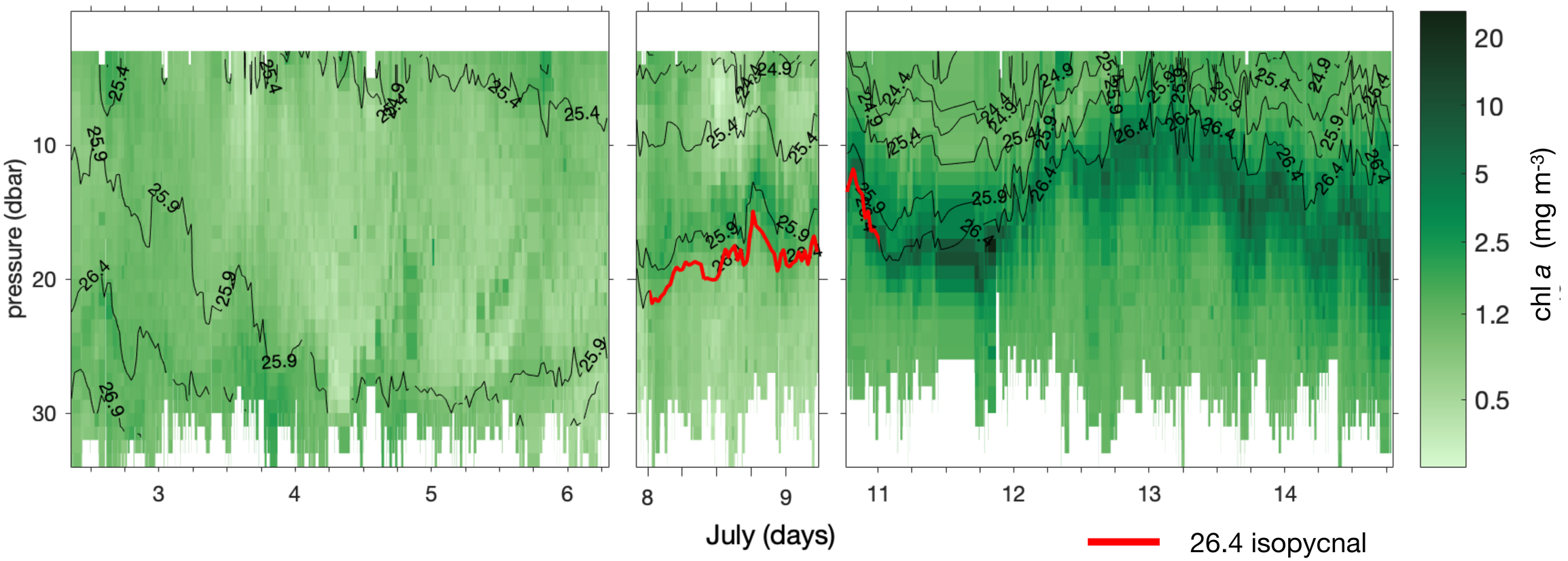
$$\frac{\partial chl\ a}{\partial t} = \left(\frac{\partial chl\ a}{\partial t}\right)_{gains} - \left(\frac{\partial chl\ a}{\partial t}\right)_{losses}$$

$$\frac{\partial chl\ a}{\partial t} = \left(\frac{\partial chl\ a}{\partial t}\right)_{biological} + \left(\frac{\partial chl\ a}{\partial t}\right)_{physical} - \left(\frac{\partial chl\ a}{\partial t}\right)_{biological} - \left(\frac{\partial chl\ a}{\partial t}\right)_{physical}$$

Growth rate

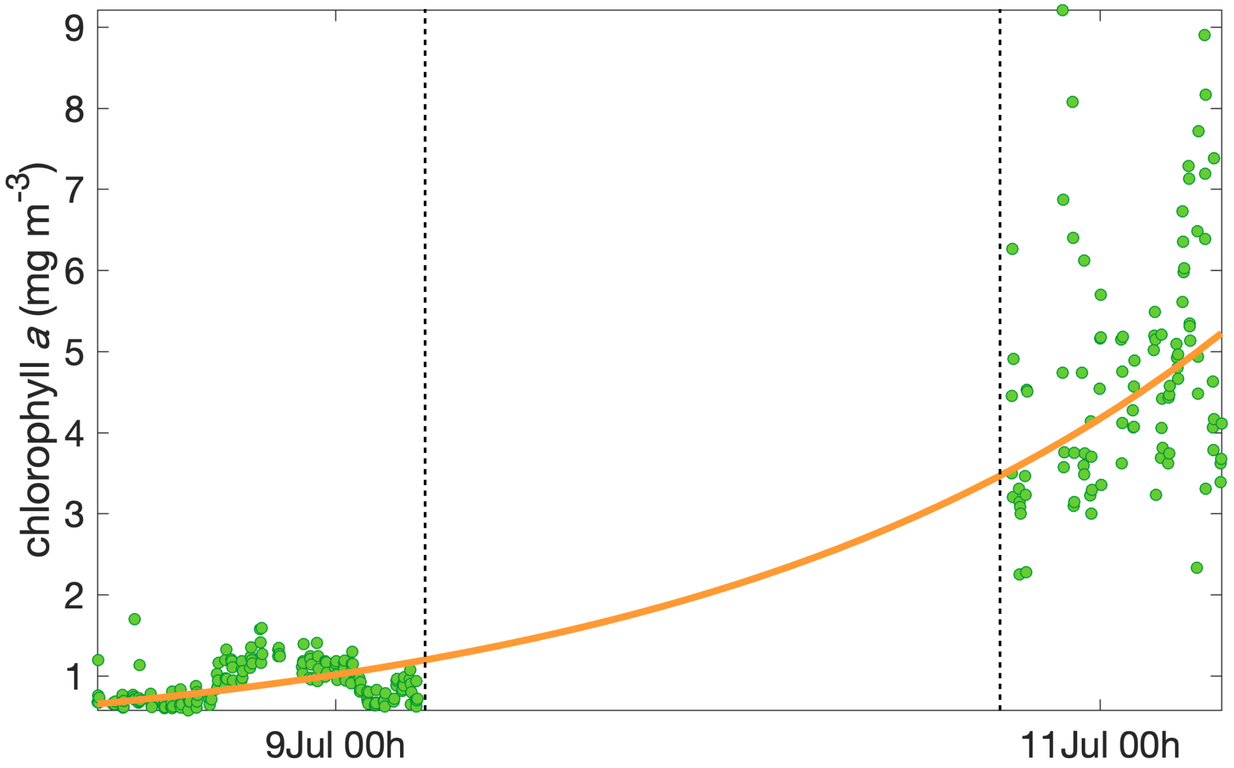
Net rate

Chlorophyll values at 26.4 isopycnal
between PP experiments



Net rate

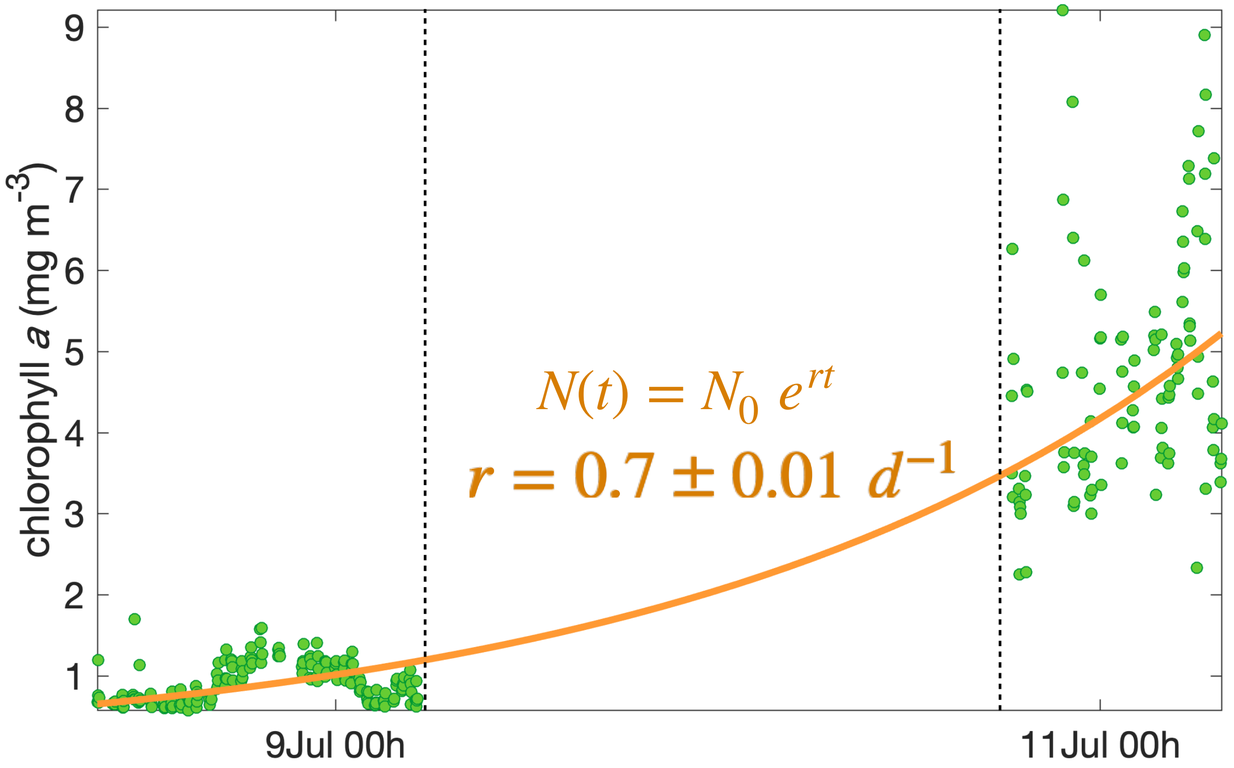
Chlorophyll *a* values at **26.4 isopycnal**
between PP experiments



Net rate

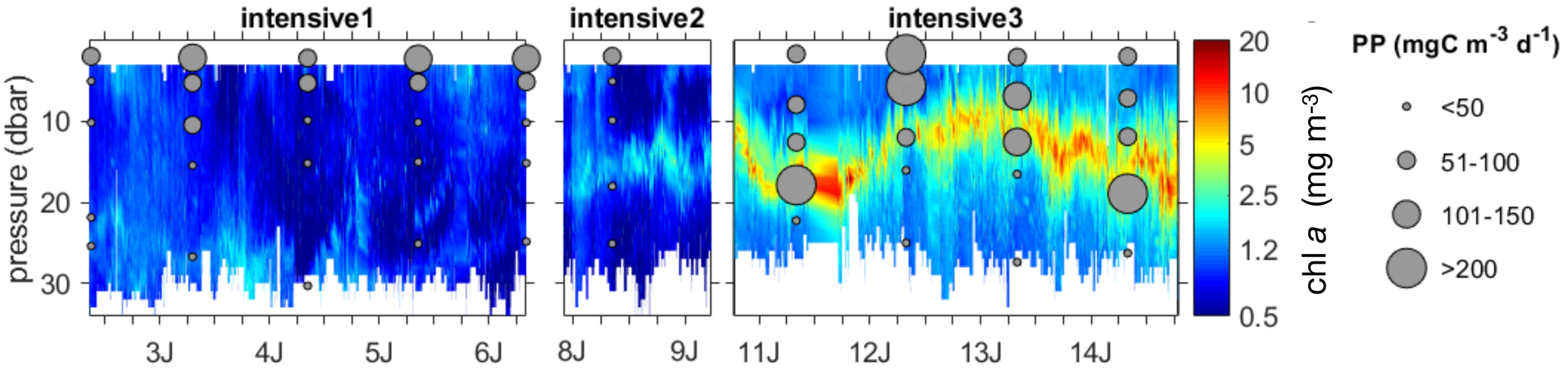
physical + biological

Chlorophyll *a* values at **26.4 isopycnal**
between PP experiments

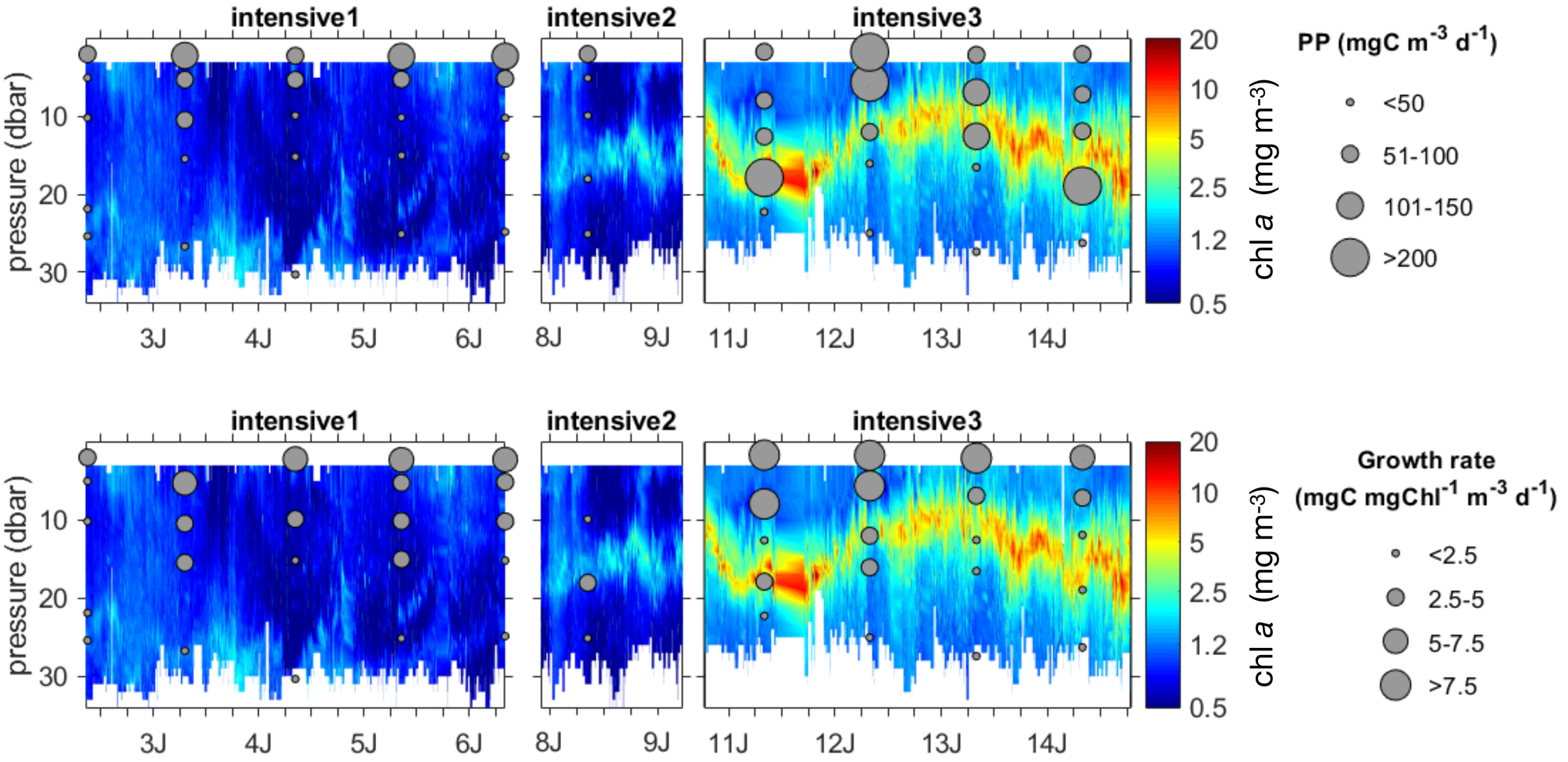


SURVEY 2	INTENSIVE 2	SURVEY 3	INTENSIVE 3

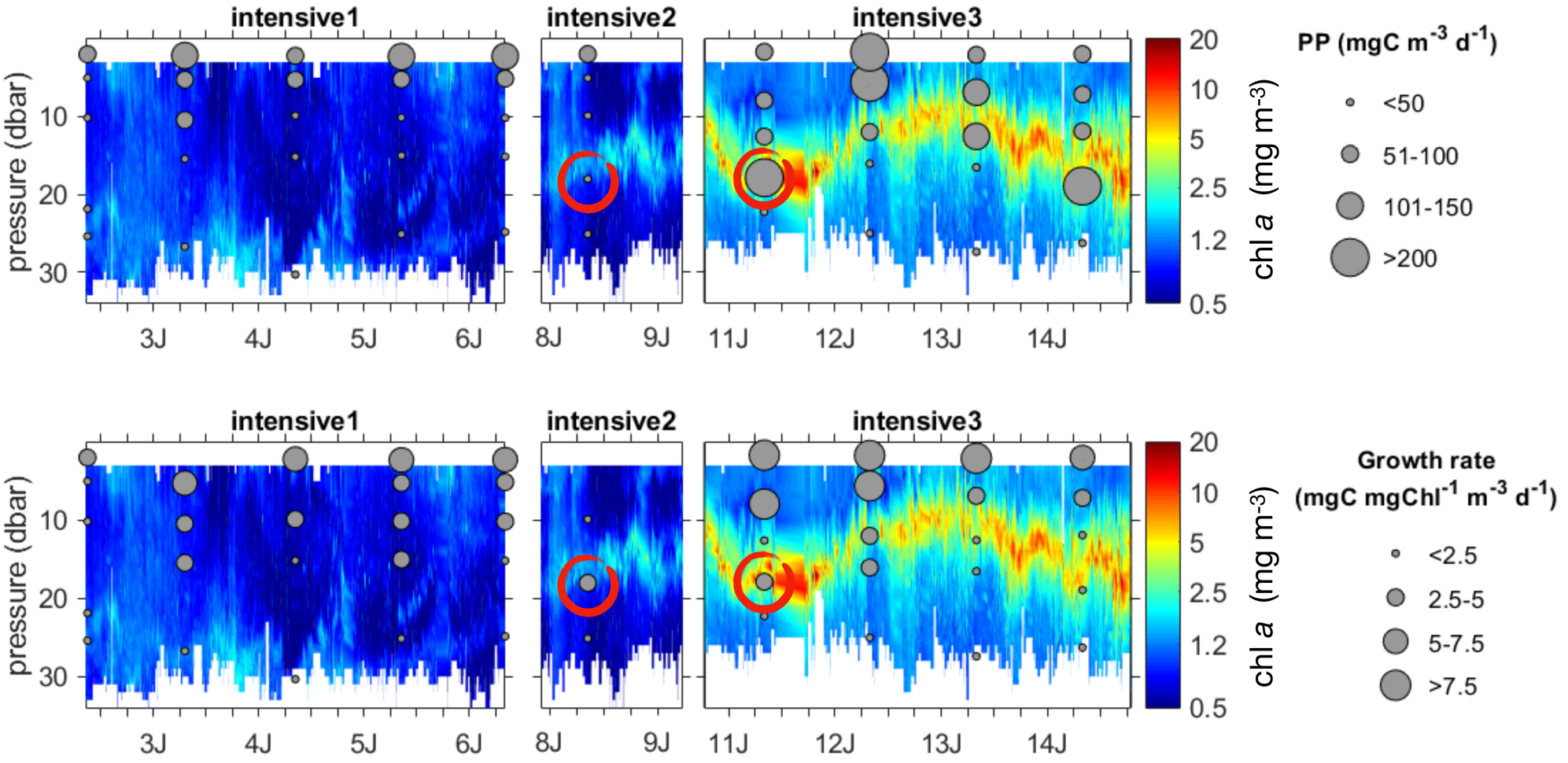
Biological processes



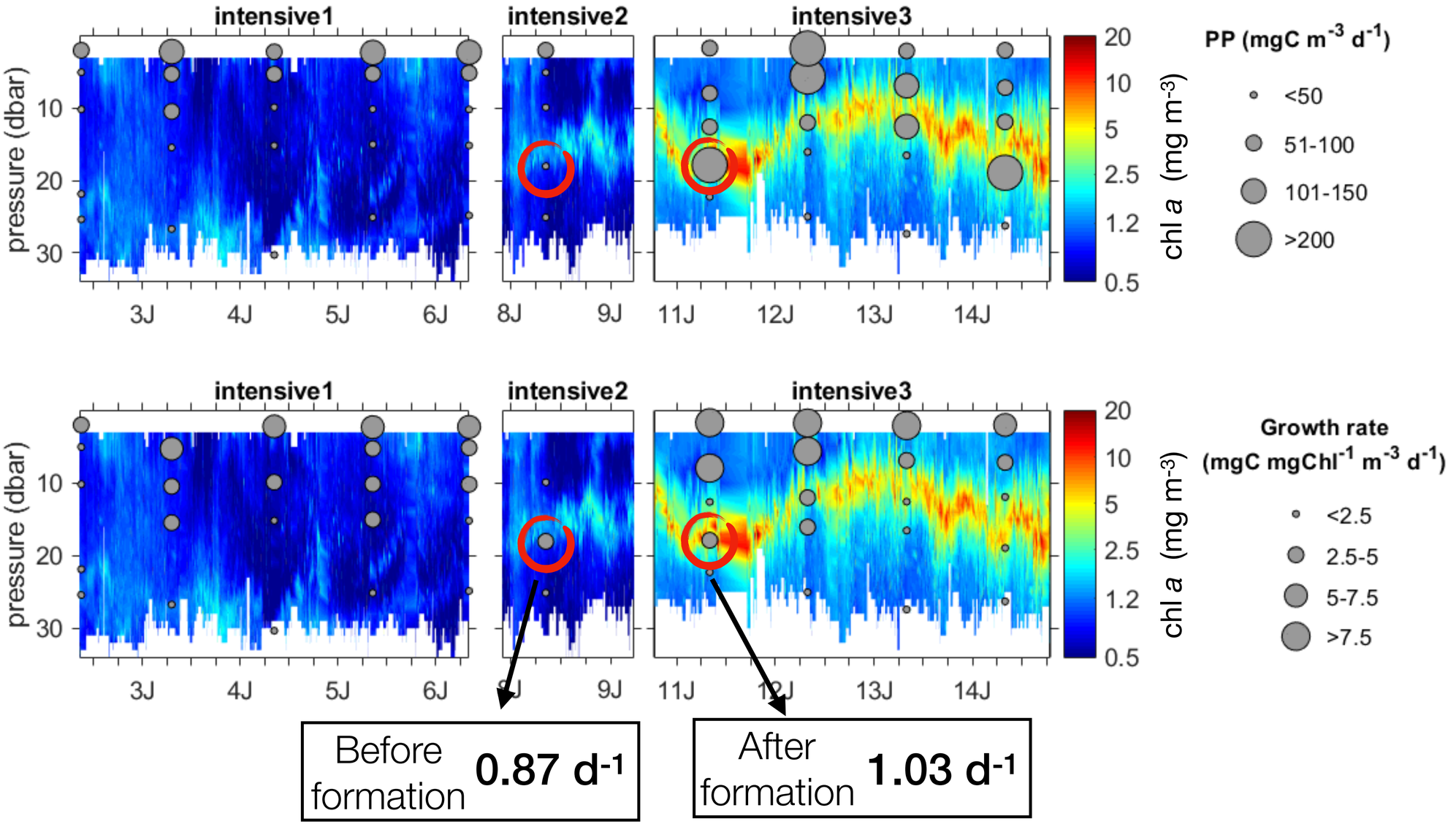
Biological processes



Biological processes



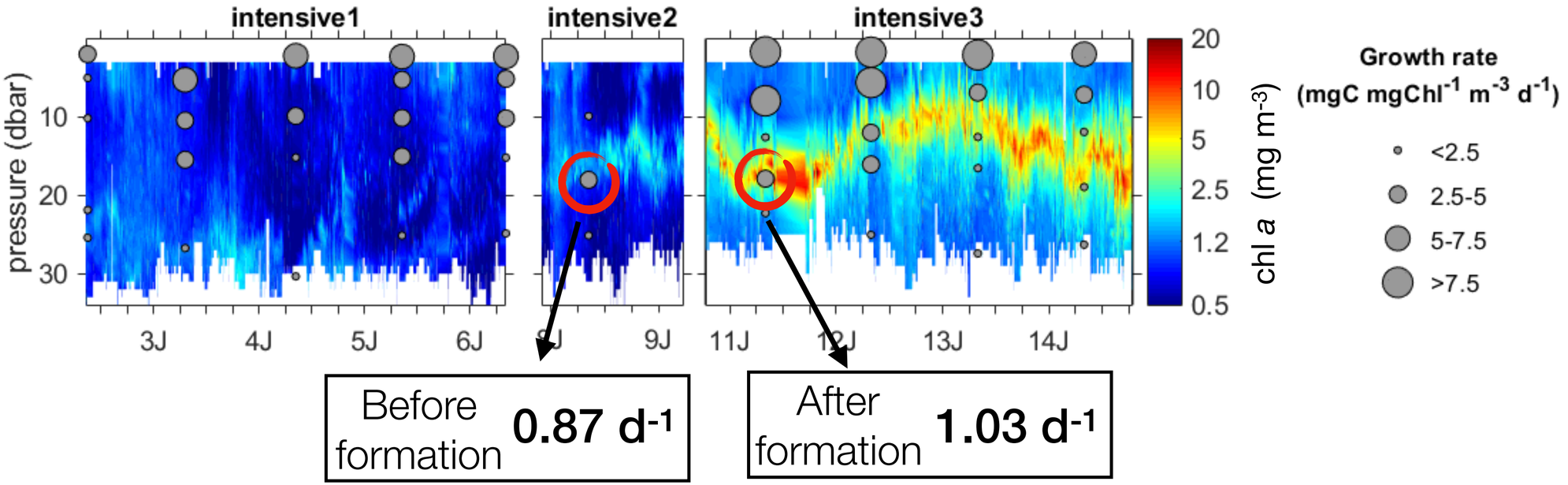
Growth rate


intensive1
intensive2
intensive3
pressure (dbar)
10
20
30
3J
4J
5J
6J
8J
9J
11J
12J
13J
14J
20
10
5
2.5
1.2
0.5
chl a (mg m-3)
PP (mgC m-3 d-1)
<50
51-100
101-150
>200
Growth rate
(mgC mgChl-1 m-3 d-1)
<2.5
2.5-5
5-7.5
>7.5
Before formation 0.87 d-1
After formation 1.03 d-1

Growth rate

$$Growth\ rate\ = \frac{0.87\ d^{-1} + 1.03\ d^{-1}}{2}$$

$$Growth\ rate\ = 0.95 \pm 0.11\ d^{-1}$$



What was the contribution of physical and biological processes?

$$\frac{\partial chl\ a}{\partial t} = \left(\frac{\partial chl\ a}{\partial t}\right)_{biological} + \left(\frac{\partial chl\ a}{\partial t}\right)_{physical} - \left(\frac{\partial chl\ a}{\partial t}\right)_{biological} - \left(\frac{\partial chl\ a}{\partial t}\right)_{physical}$$

Net rate vs Growth rate

If… Growth rate = Net rate → Biological processes could explain net accumulation

If… Growth rate < Net rate → Both combination

If… Growth rate > Net rate → Physical processes are decreasing concentration

$$Growth\ rate\ = 0.95 \pm 0.11\ d^{-1} \quad > \quad Net\ rate = 0.7\ \pm 0.01 d^{-1}$$

Conclusions

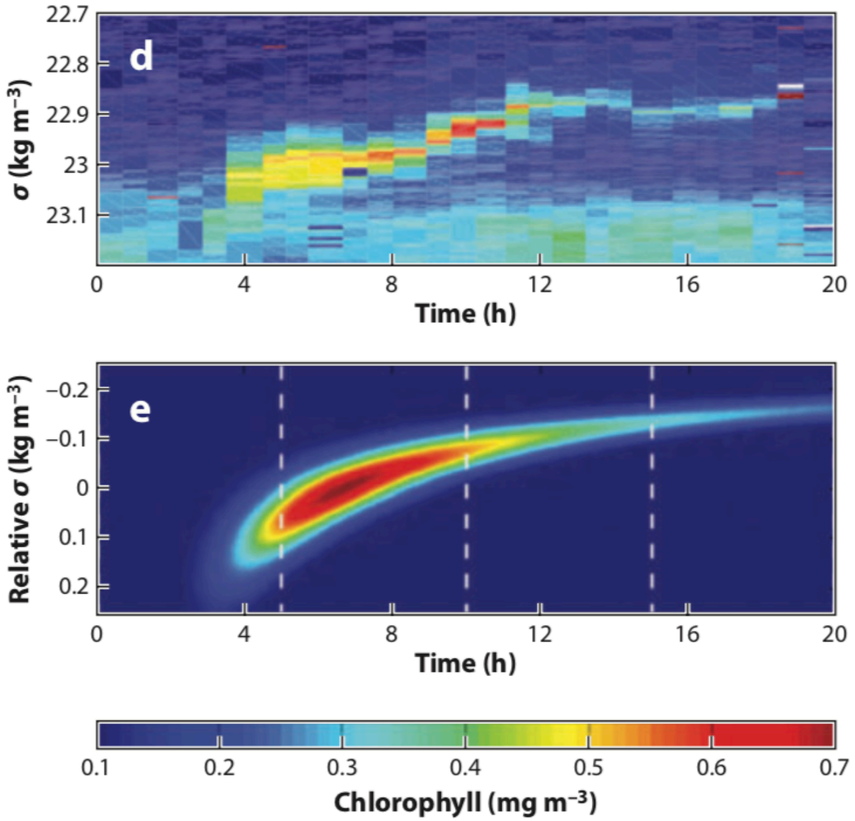
1. Thin layer was formed during the **transition from downwelling to upwelling** over a period less than two days

2. It was a **local feature** present in only one station

3. Our analyses are not enough to explain which processes were the main responsible of the thin layer formation

Next step

To apply a model that can reproduce the thin layer to know what mechanisms are forming this features in this region



Hodges & Fratantoni, 2009

Acknowledgments

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http://proyectoremedios.com

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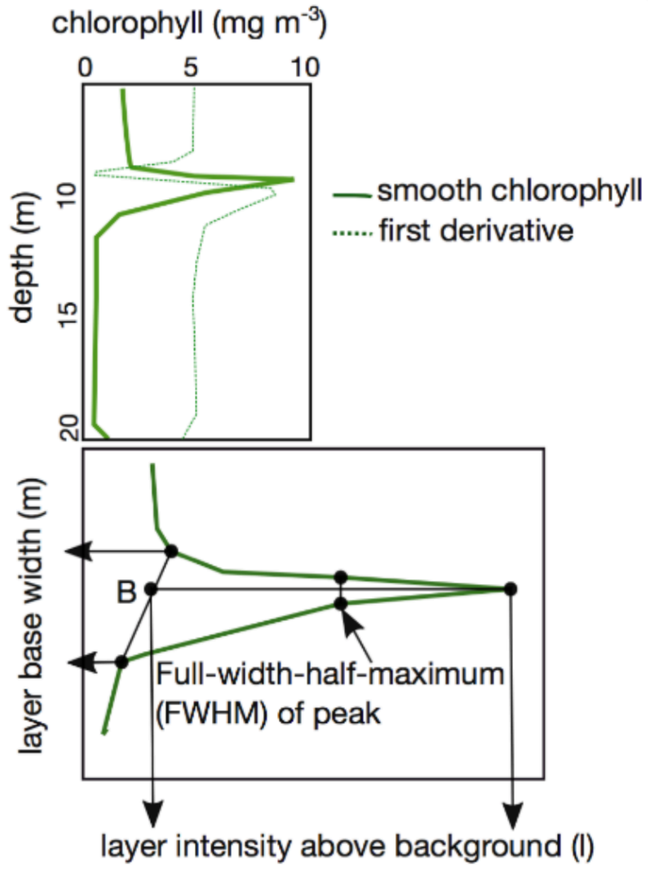
Thin layers detection:



✳ Thickness < 3 m

✳ Intensity > 2 x Background

Growth rate calculations:

$$Growth\ rate = \frac{PPnet \times 0.8}{extracted\ chl\ a \times (C : chl\ a\ ratio)}$$