Occurrence of thin layers of phytoplankton in the Galician Rías

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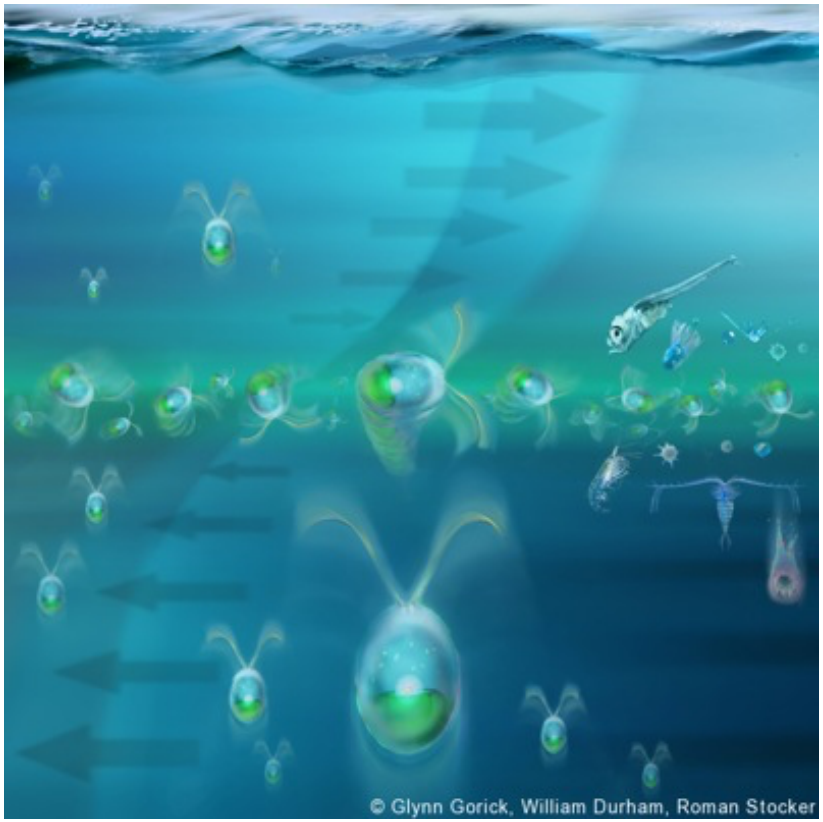
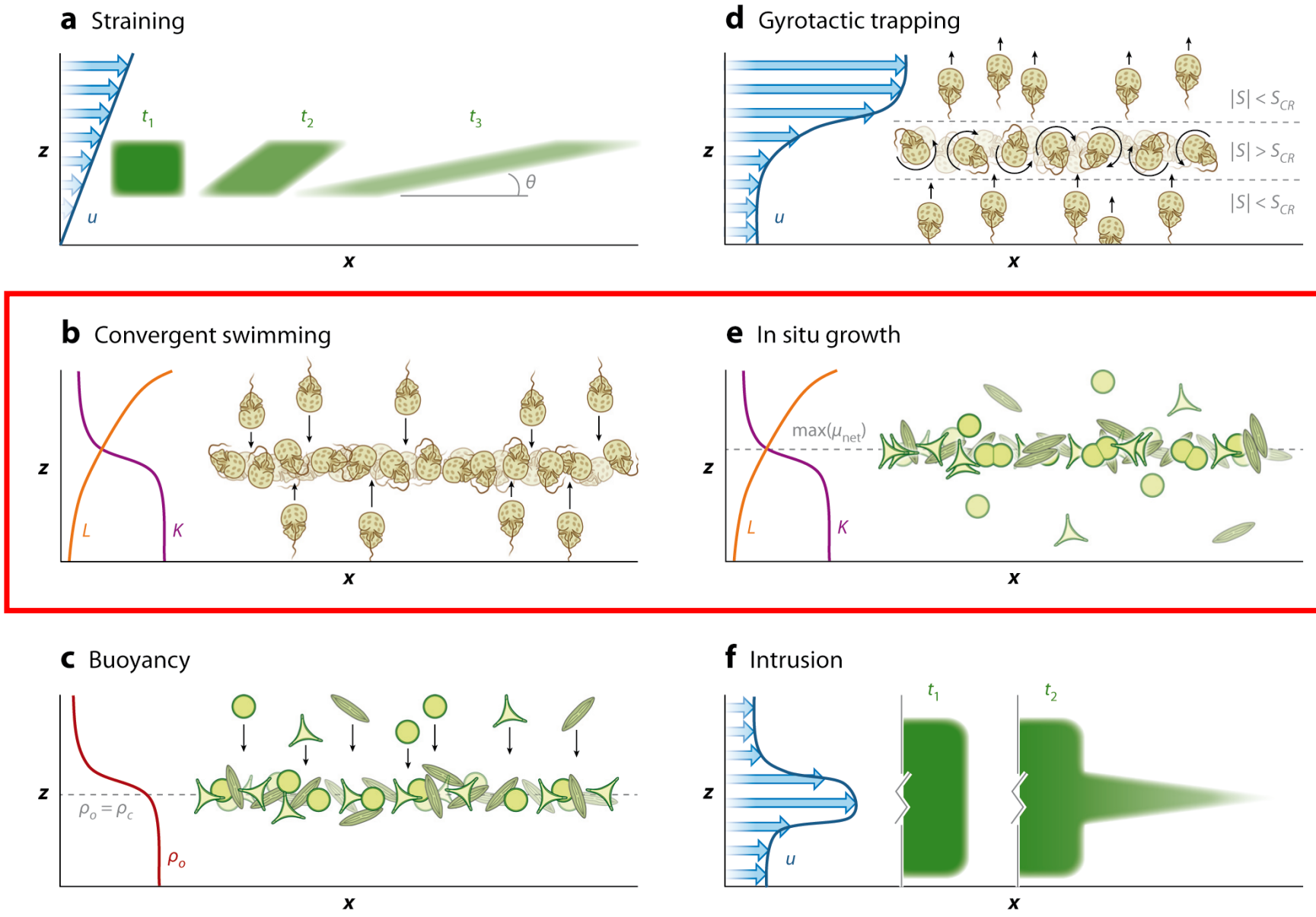
The kaleidoscope ocean

Martin (2005, PTRS)

Thin layers of phytoplankton (TLP)

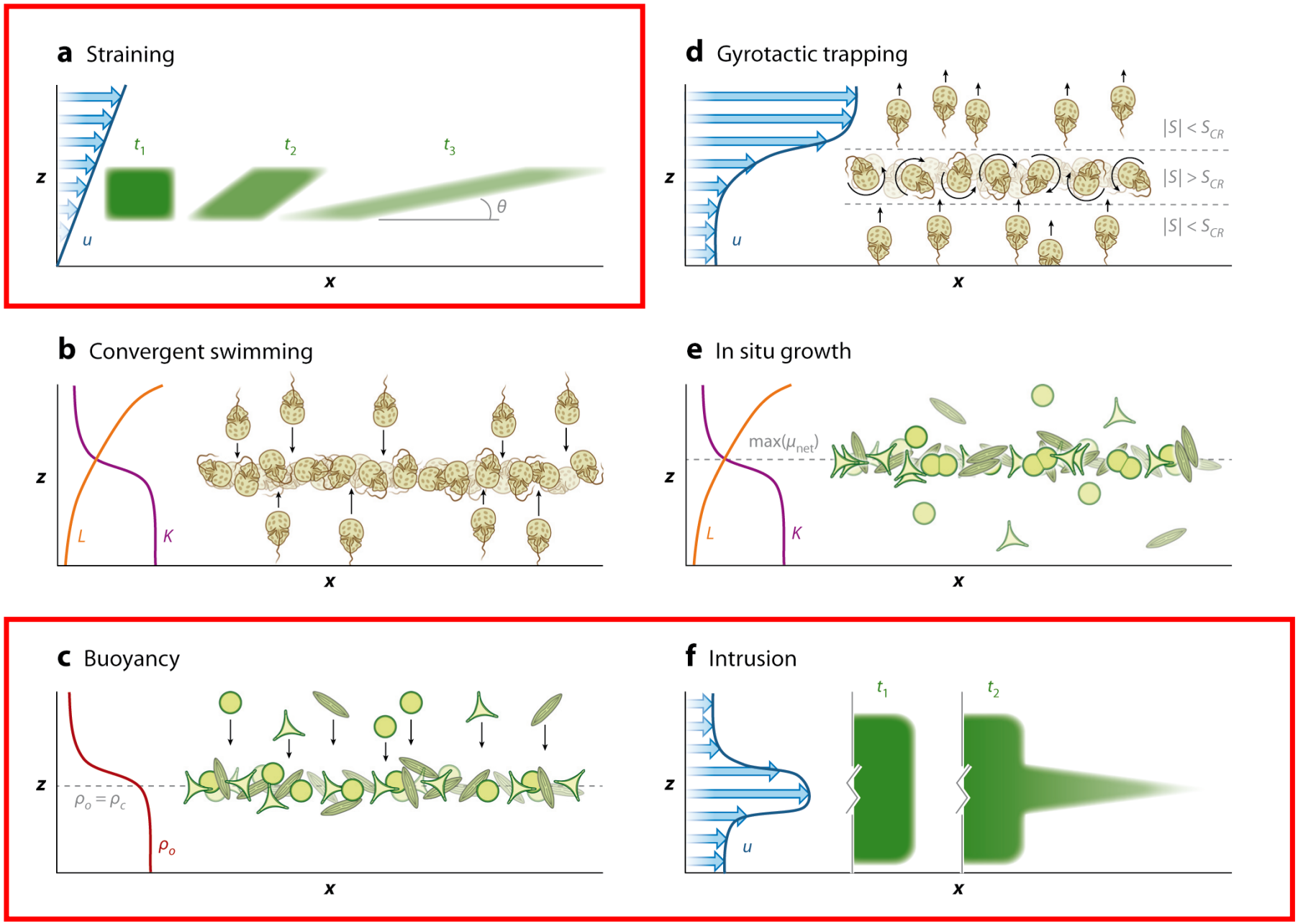


Thin layers of phytoplankton (TLP): Formation



Durham WM, Stocker R. 2012.
Annu. Rev. Mar. Sci. 4:177–207

Thin layers of phytoplankton (TLP): Formation



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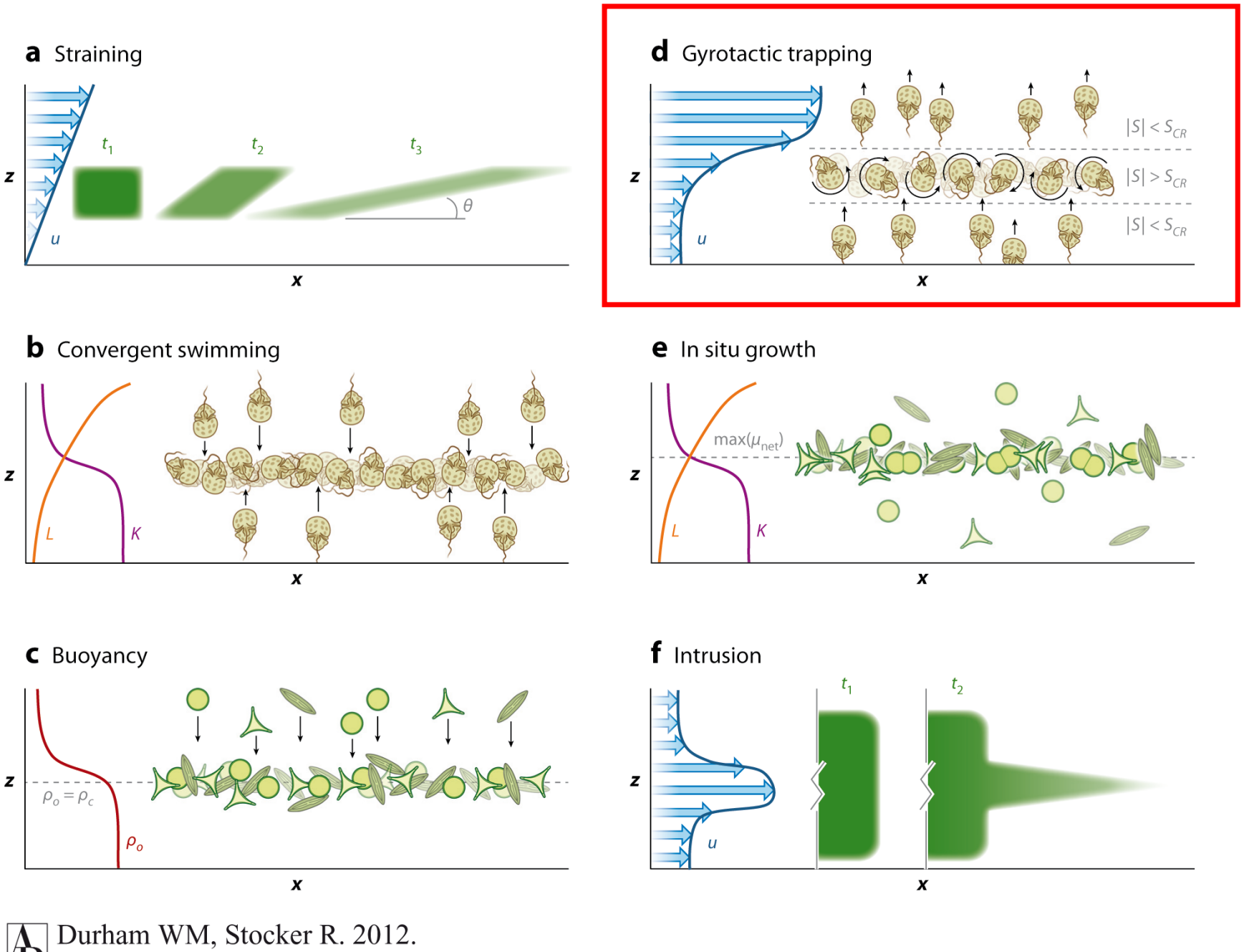
Thin layers of phytoplankton (TLP): Formation



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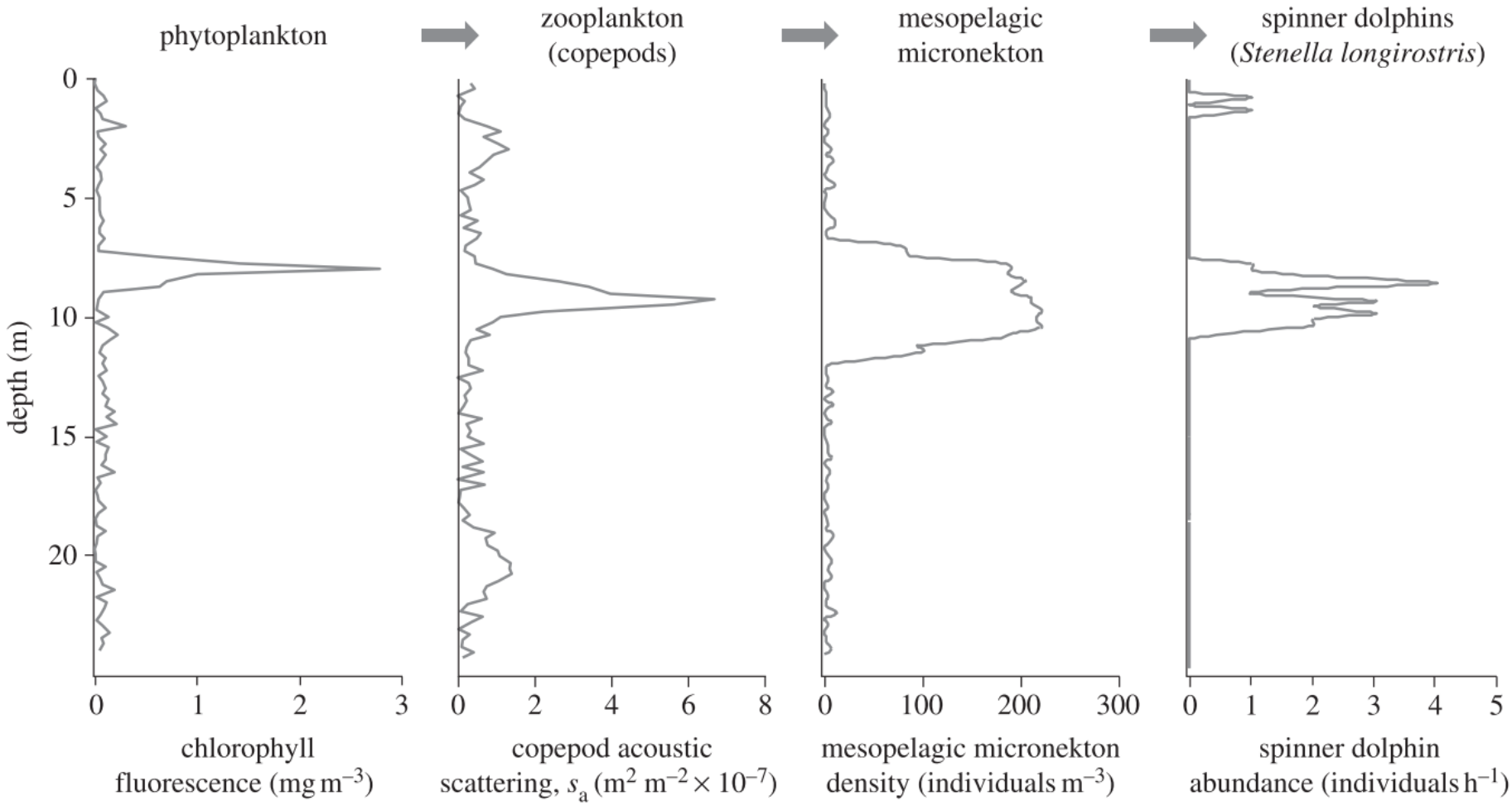
Thin layers of phytoplankton (TLP): Ecological relevance



Benoit-Bird & McManus (2012, BL)

HABs go undetected because blooms are initially concentrated in TLP, which are easily missed by conventional sampling (McManus et al., 2008)

A limited number of studies have described the occurrence of TLP in the Galician Rías (P2) (Velo-Suárez et al., 2008; Velo-Suárez et al., 2010; Díaz et al., 2014)

Our goals

1. Which are the properties of TLP in the Galician Rías?

2. Which are the mechanisms responsible for the formation of TLP?

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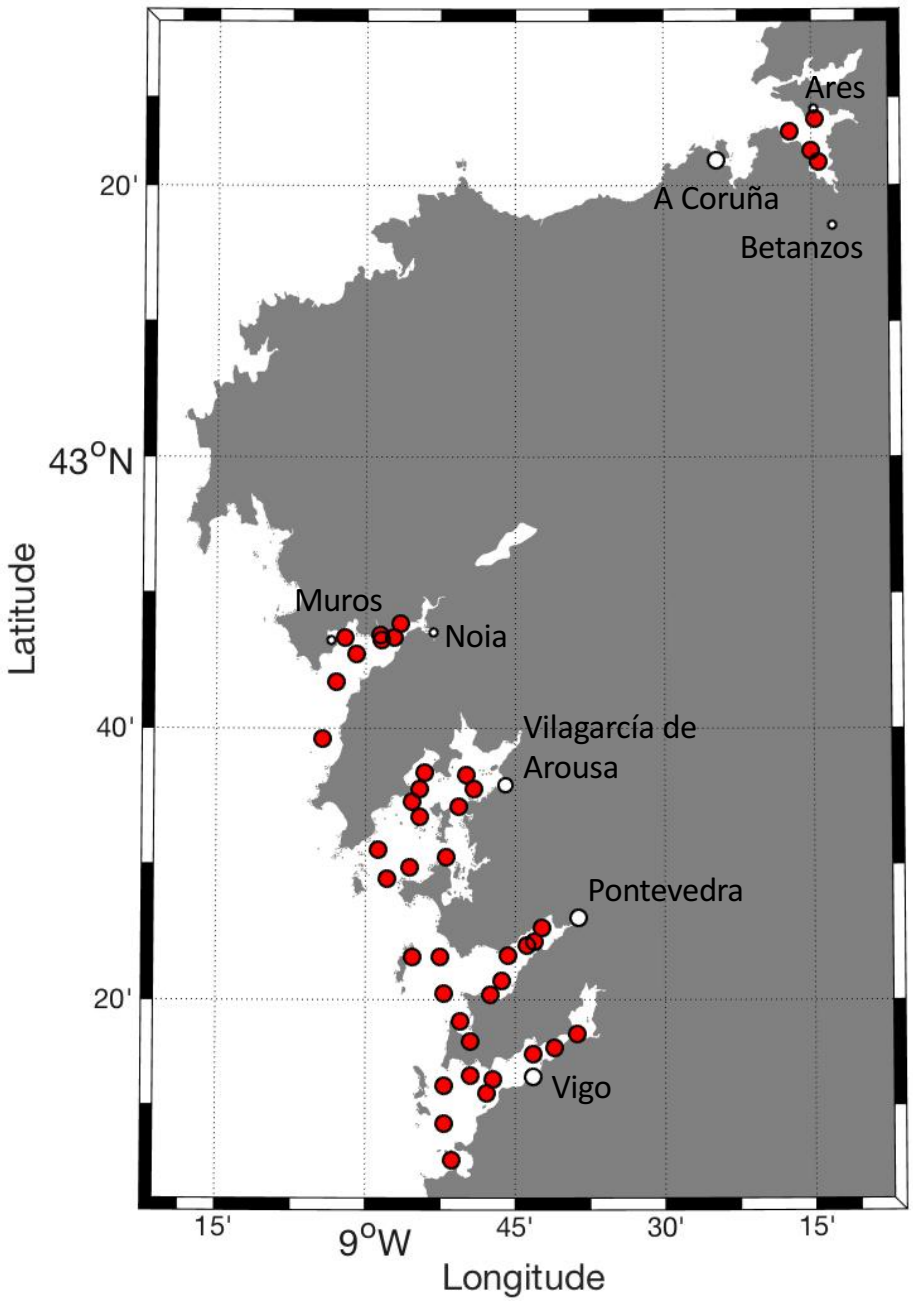
Monitoring program by the INTECMAR



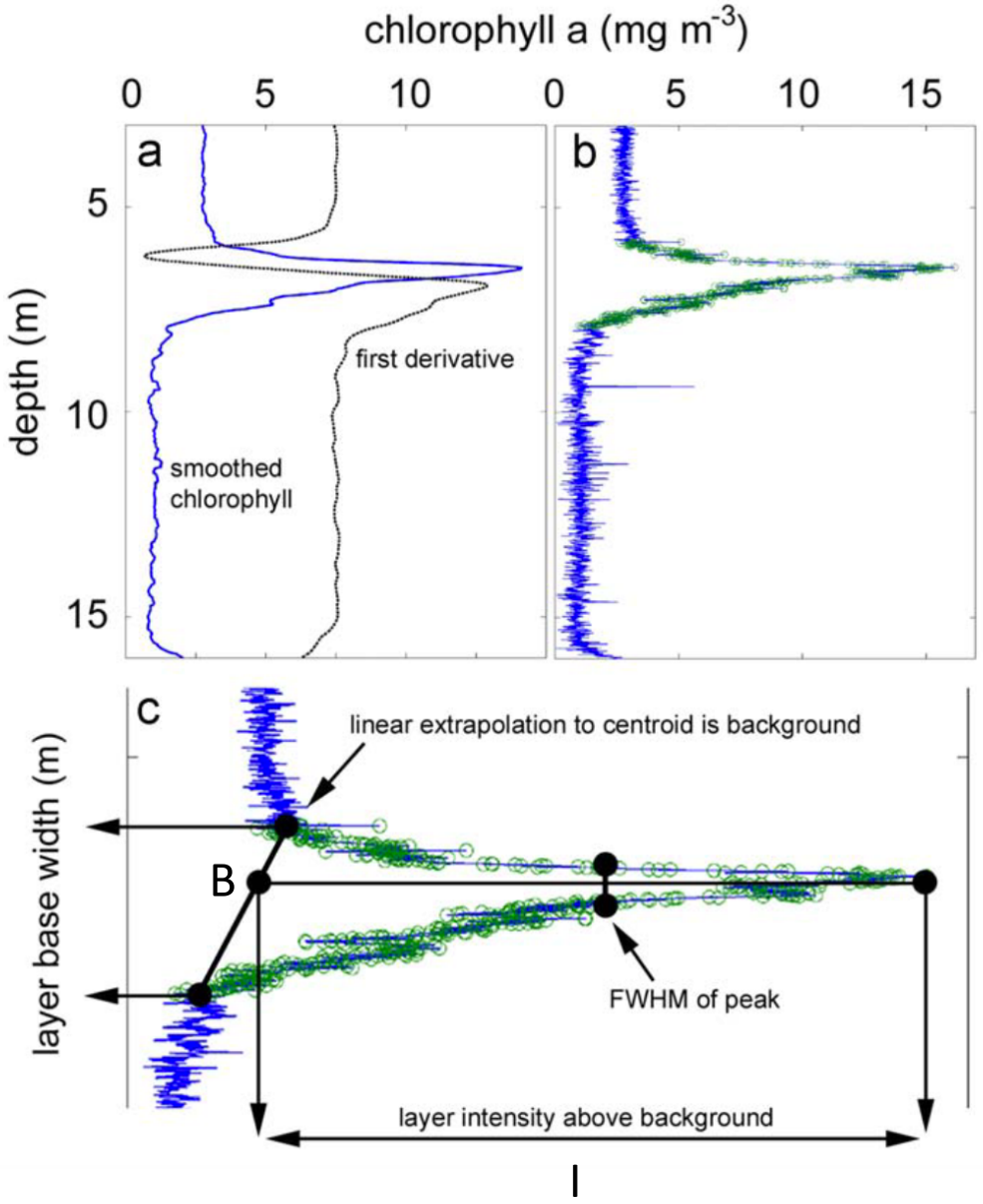
http://www.intecmar.org (public access)

Weekly sampling

43 stations (4-58 m depth)

2012-2015: 6572 CTD profiles

Detection of TLP

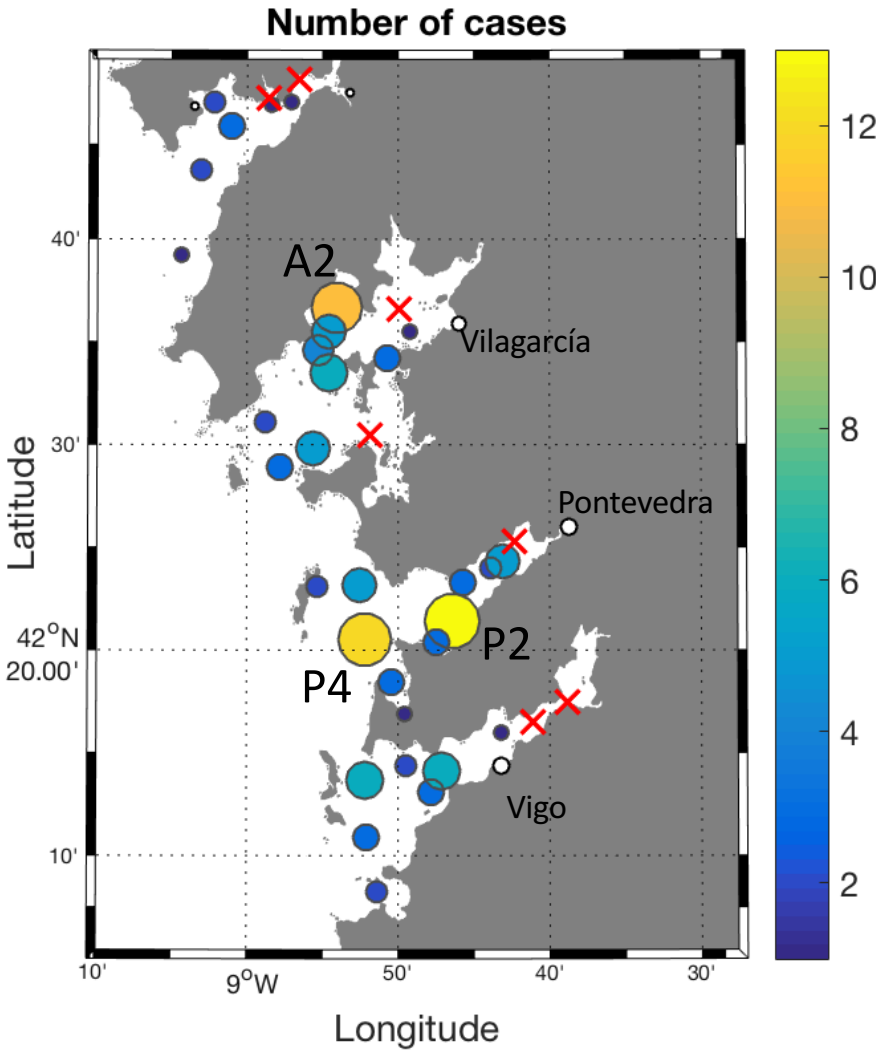


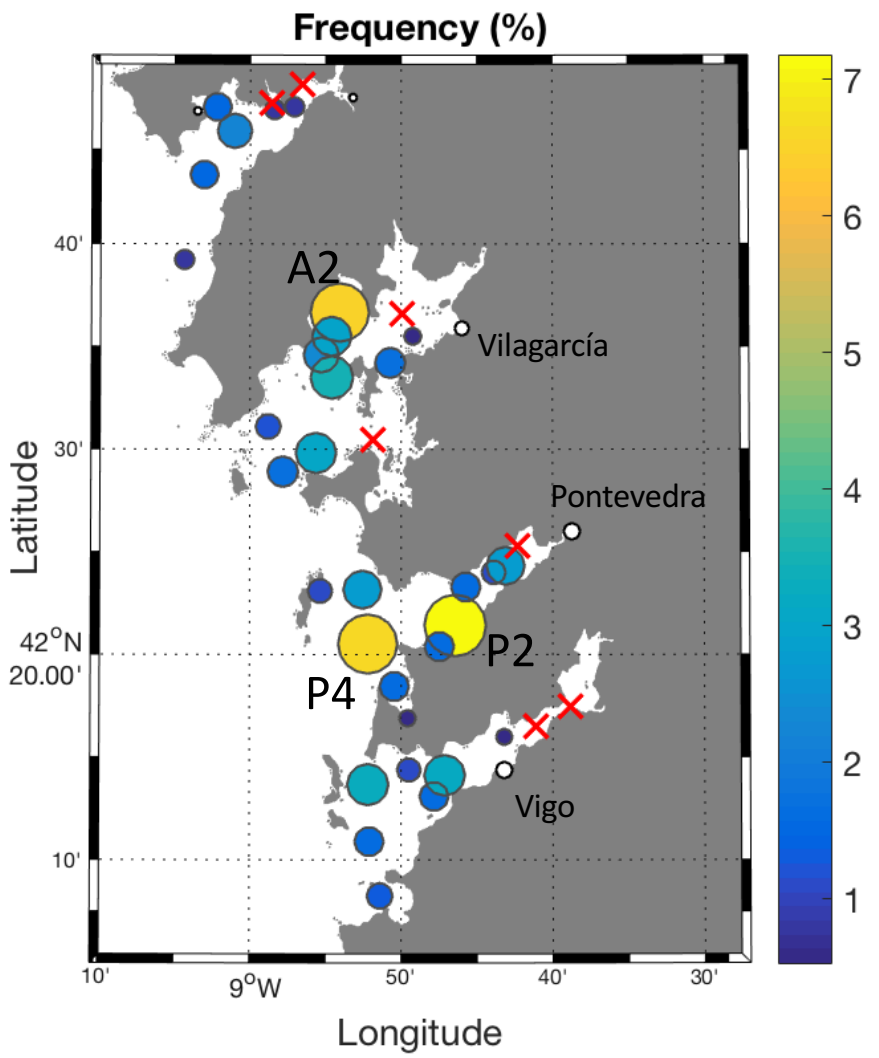
B=Background
I=Intensity
FWHM=Full-width-half-maximum

I > 2xB
FWHM < 3 m

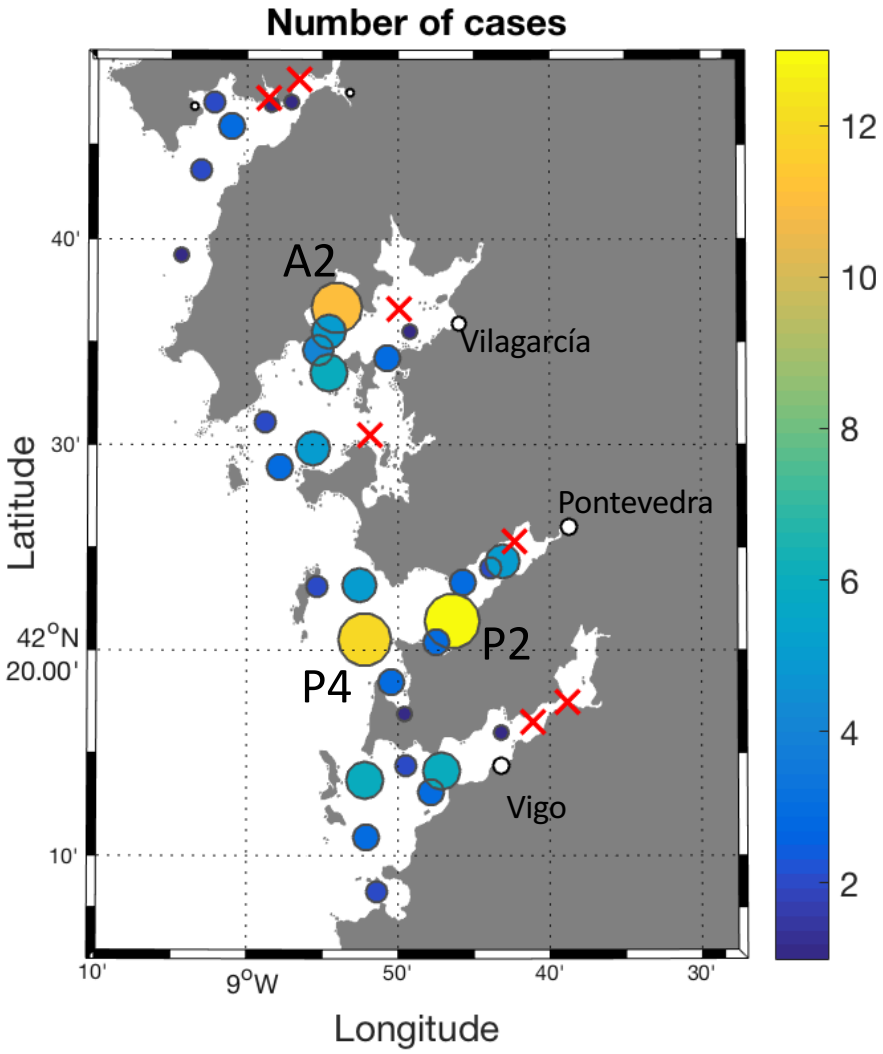
(Sullivan et al. 2010, CSR)

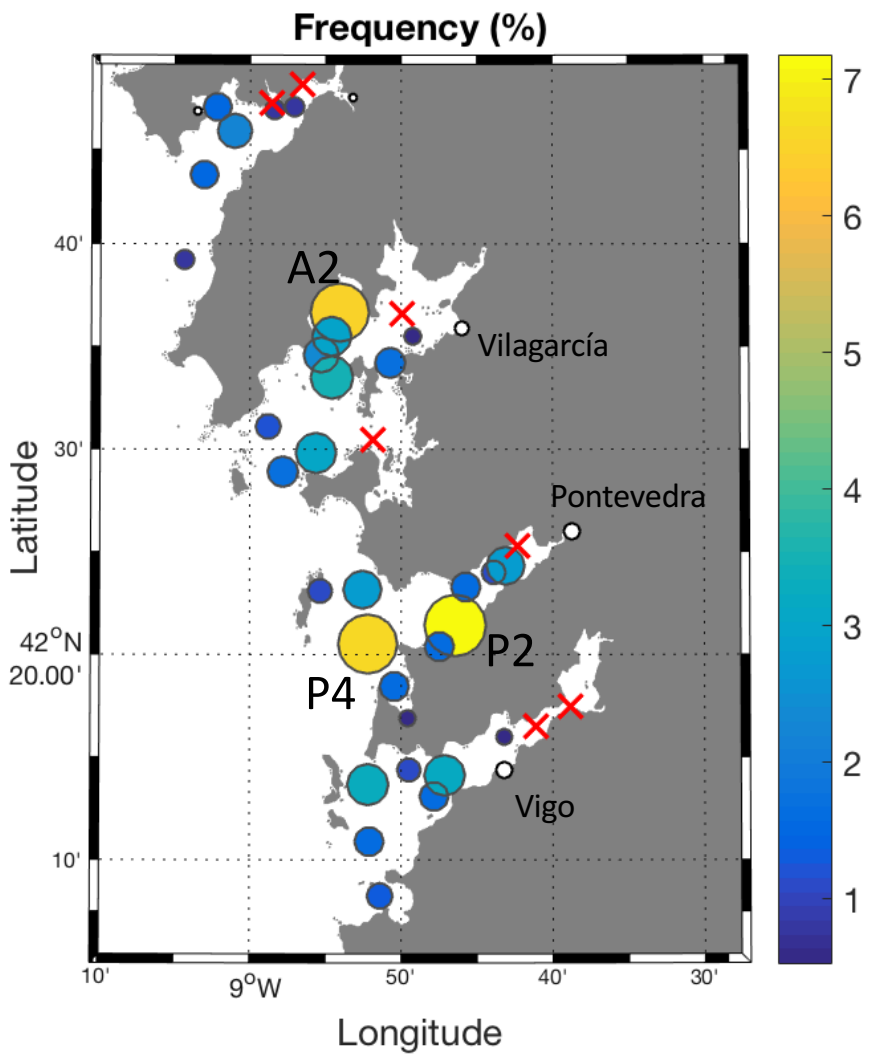
Occurrence of TPL in the Galician Rías (2012-2015)





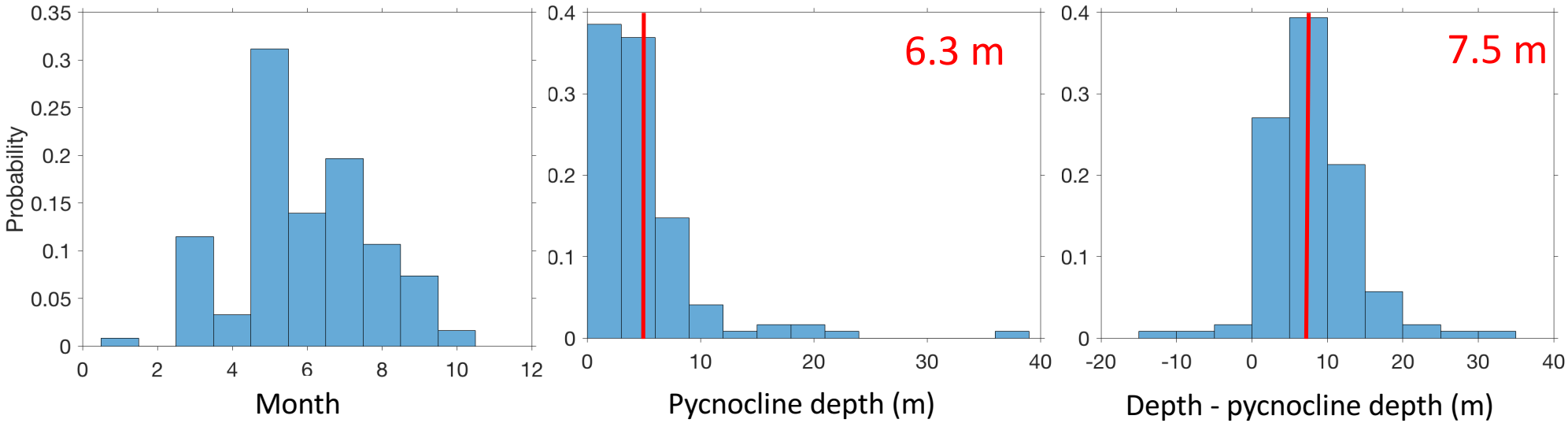
Occurrence of TPL in the Galician Rías (2012-2015)



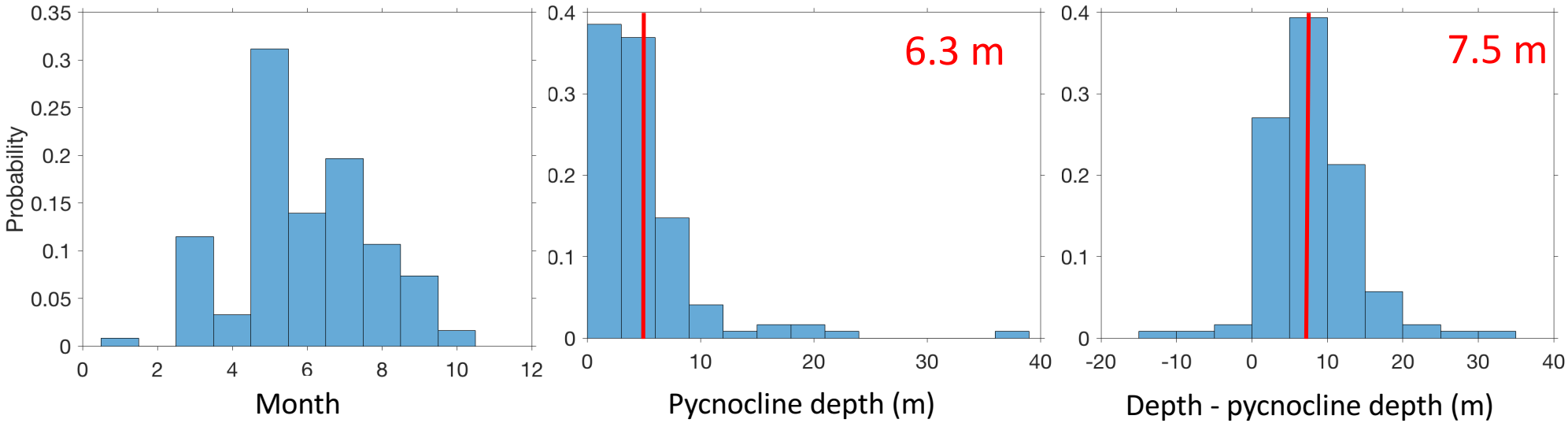


122 TLP (2%) detected, maximal occurrence (12TLP, 7%) observed at P2, P4 (Pontevedra) and A2 (Arousa)

Properties of TLP in the Galician Rías (2012-2015)



Properties of TLP in the Galician Rías (2012-2015)



TLP occur more frequently between May-Jul, associated with shallow pycnoclines and located slightly deeper

Our goals

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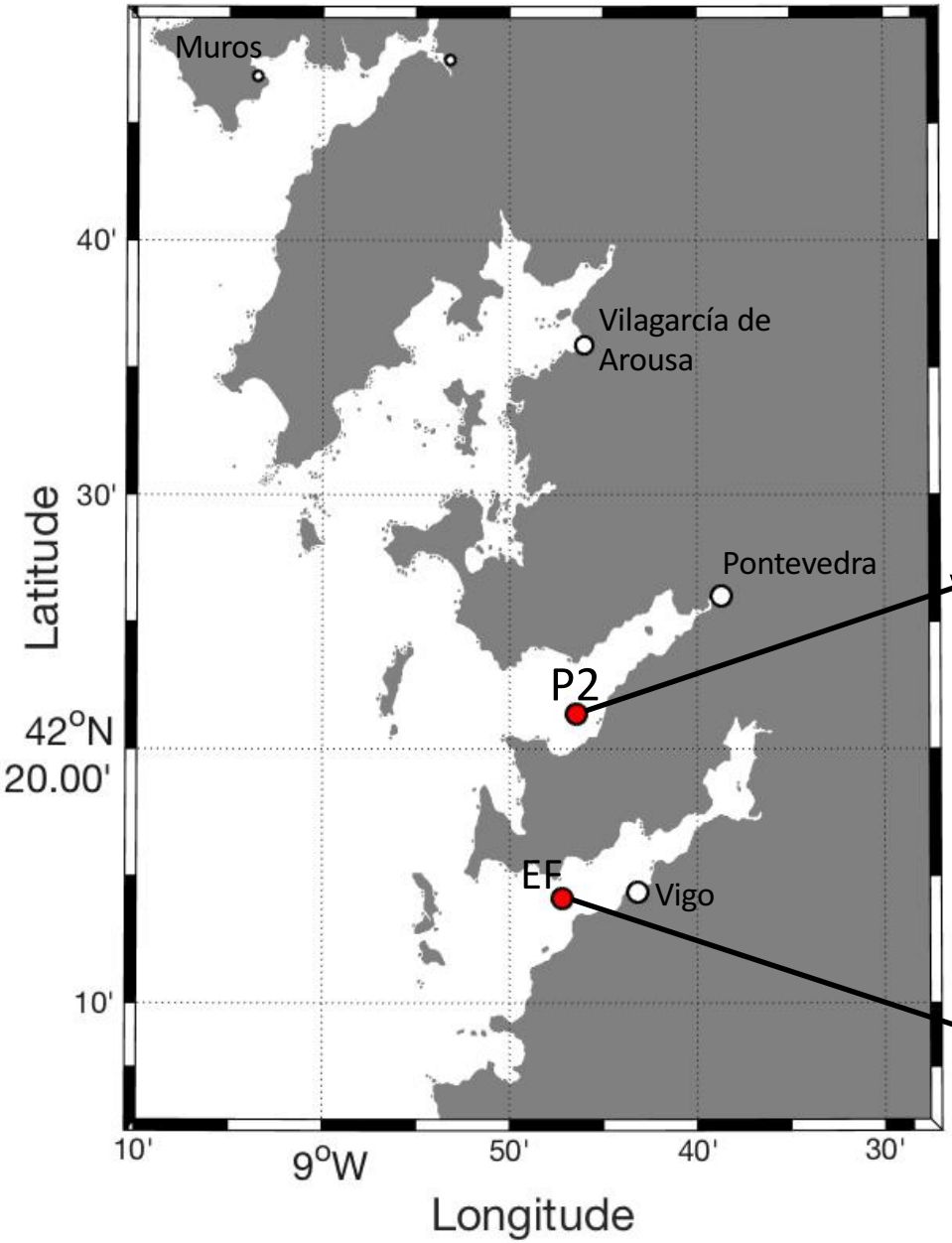
Microstructure observations in the Galician Rías



ASIMUTH
18-20 Jun2013: 36 hours sampling

DISTRAL-REIMAGE
Feb2012-Jan2013: 10 samplings

Microstructure turbulence profiler

1. Dissipation rate of turbulent kinetic energy (ε):

$$\varepsilon = 7.5\nu\left(\frac{\partial u}{\partial z}\right)^2$$

2. Turbulent mixing (K_ε):

$$K_\varepsilon = \Gamma\frac{\varepsilon}{N^2}$$

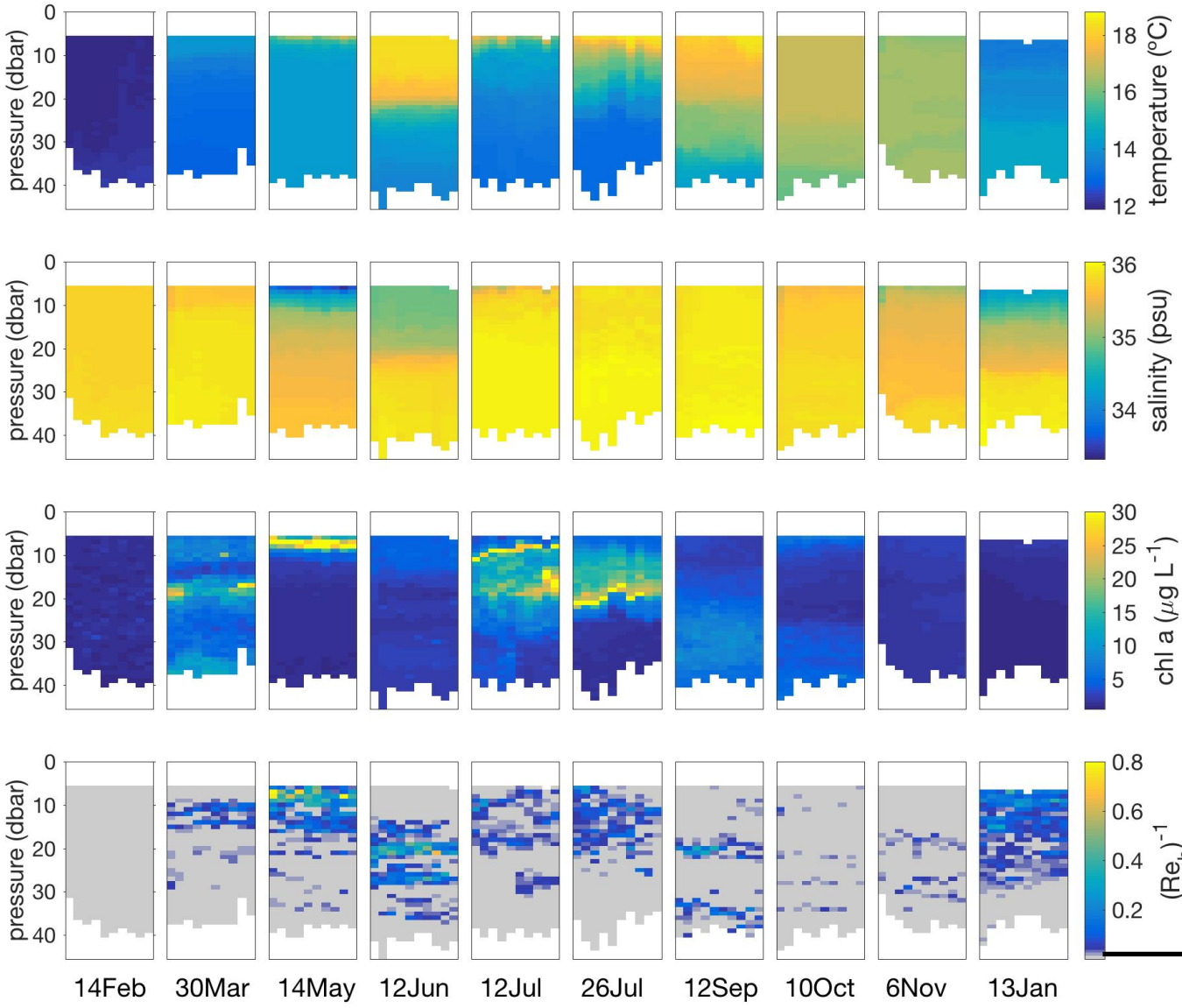
3. Buoyancy Reynolds number (Re_b):

$$Re_b = \frac{\varepsilon}{\gamma N^2}$$

$Re_b \geq 100$; $(Re_b)^{-1} \leq 0.01$ STRONG TURBULENCE
$Re_b < 100$; $(Re_b)^{-1} > 0.01$ WEAK TURBULENCE

Microstructure observations in the Ría de Vigo (EF)

Feb 2012- Jan 2013

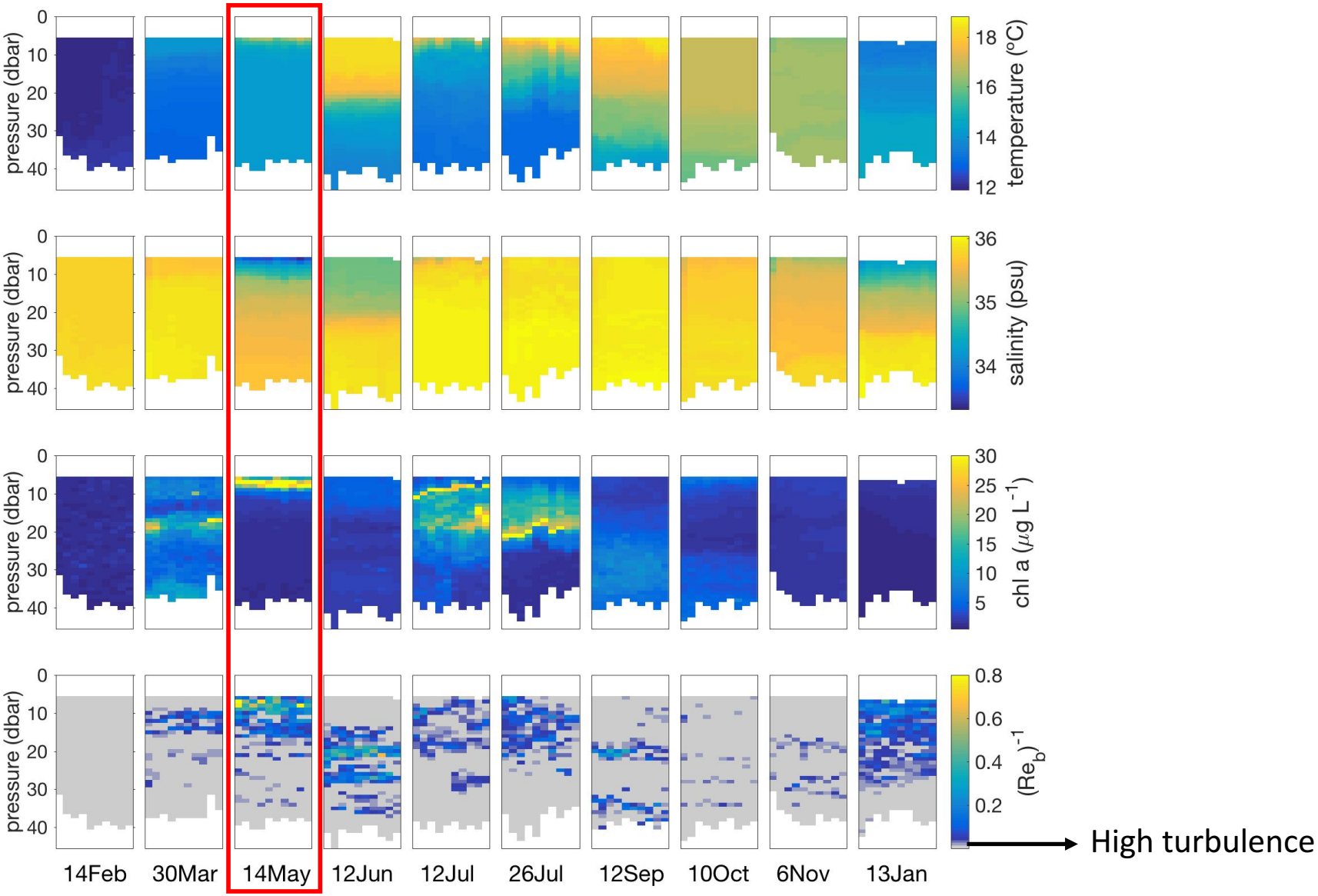


High turbulence

$(Re_b)^{-1} \leq 0.01$

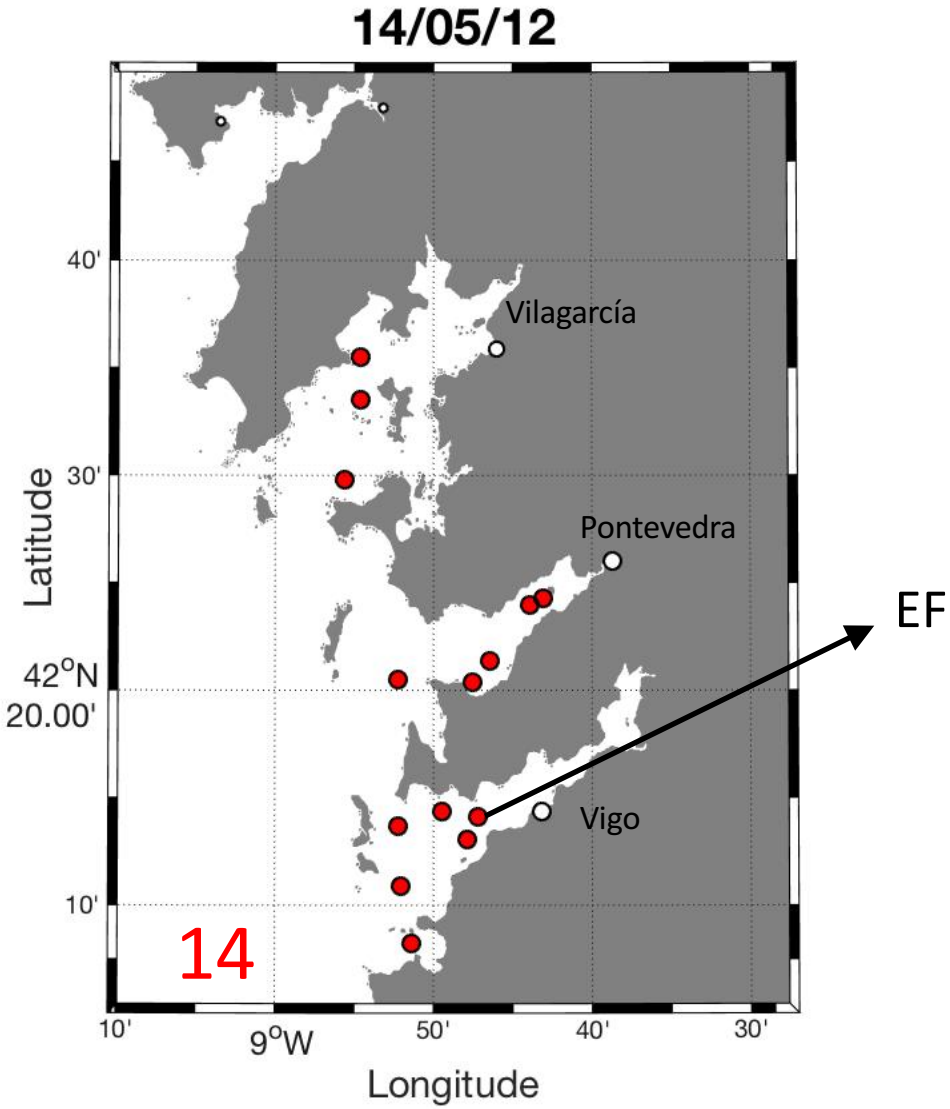
Microstructure observations in the Ría de Vigo (EF)

Feb 2012- Jan 2013



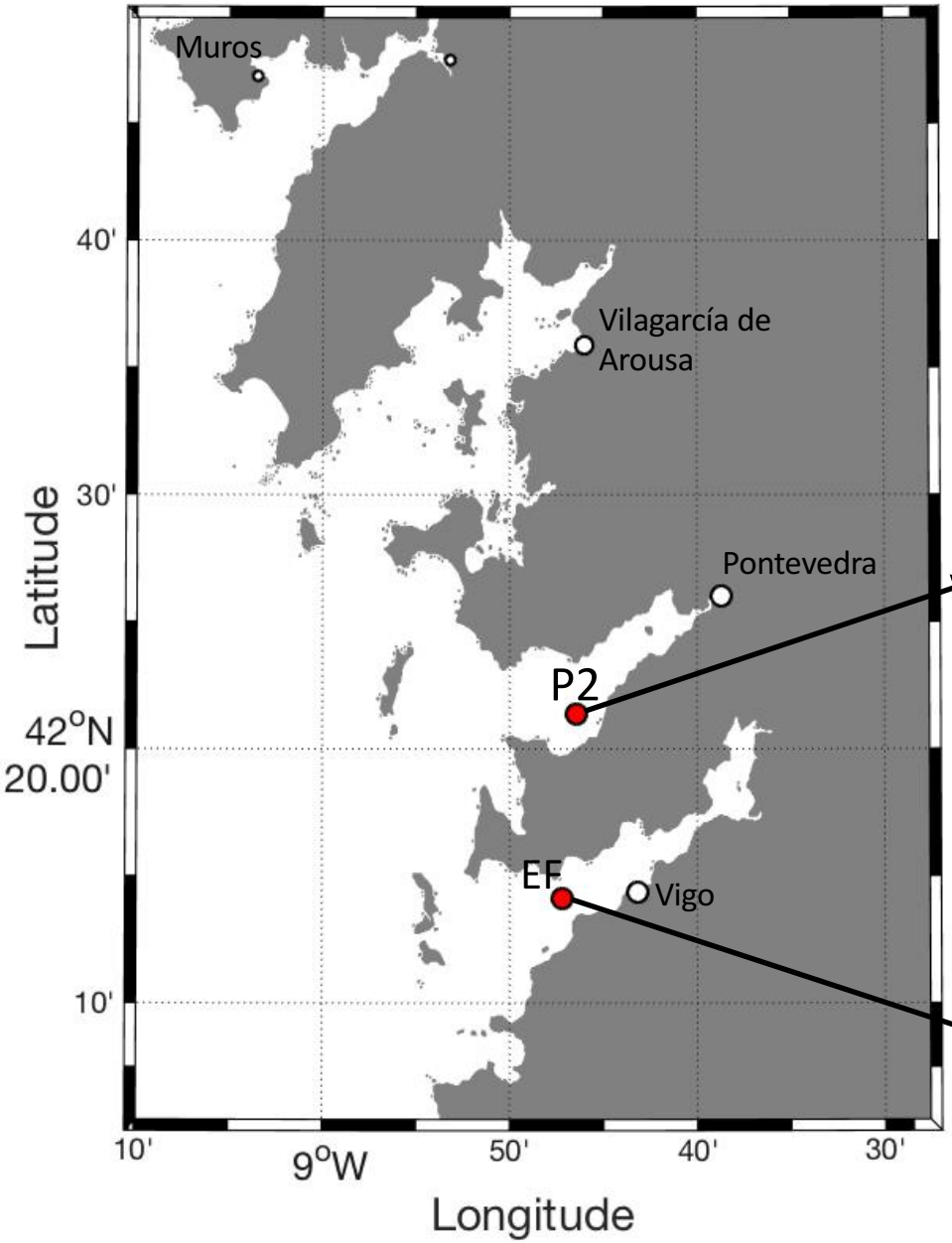
TLP on 14/05/2012 associated to low mixing due to surface haline stratification

Spatial persistence of TLP in the Galician Rías (INTECMAR)



TLP detected at 14 stations on 14/05/12: TLP events exhibit large spatial distribution

Microstructure observations in the Galician Rías

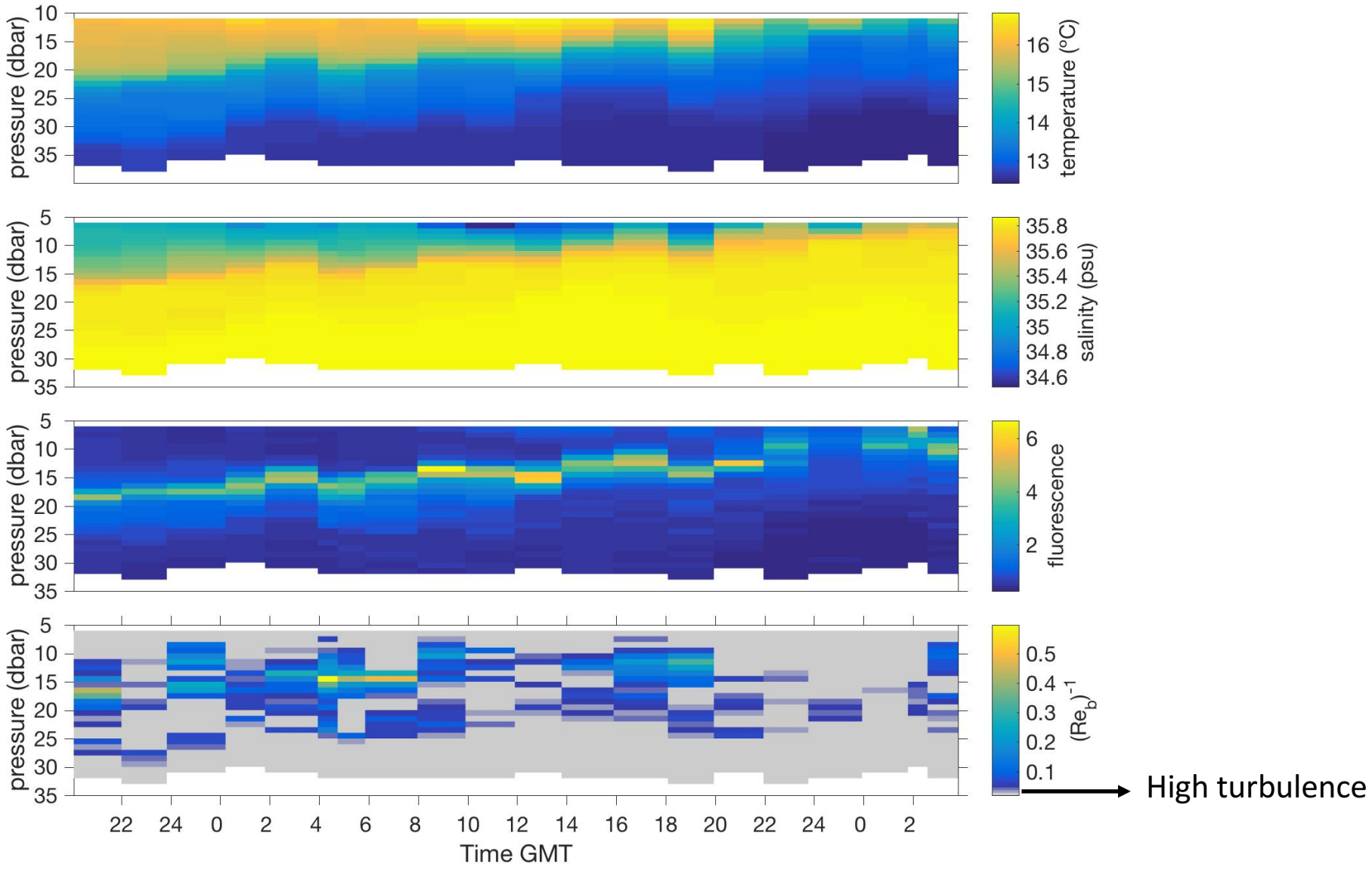


ASIMUTH
18-20 Jun2013: 36 hours sampling

DISTRAL-REIMAGE
Feb2012-Jan2013: 10 samplings

Microstructure observations in the Ría de Pontevedra (P2)

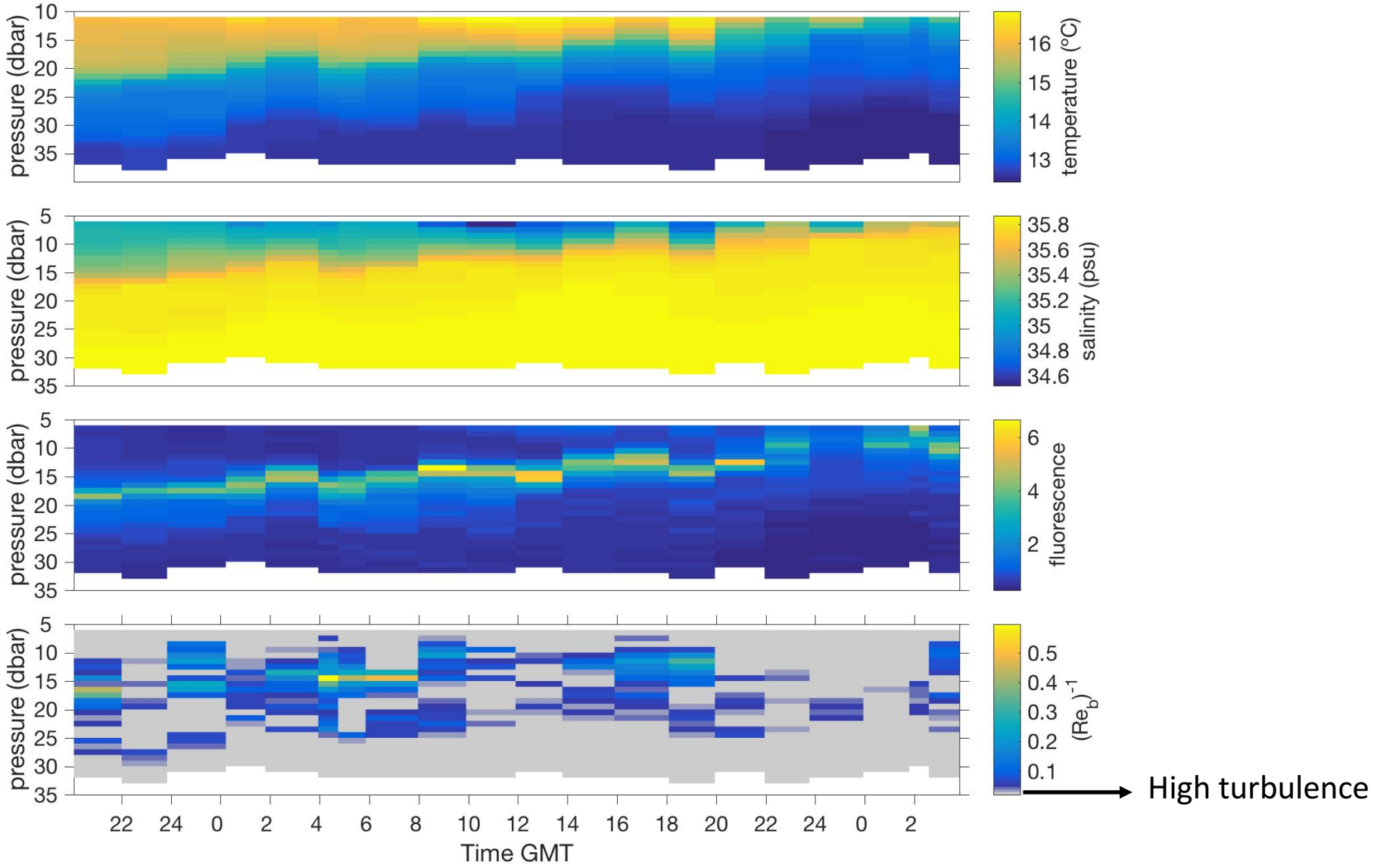
18-20 Jun 2013



TPL (*Chaetoceros spp.* and *Detonula pumila*) linked to the pycnocline during intensifying upwelling

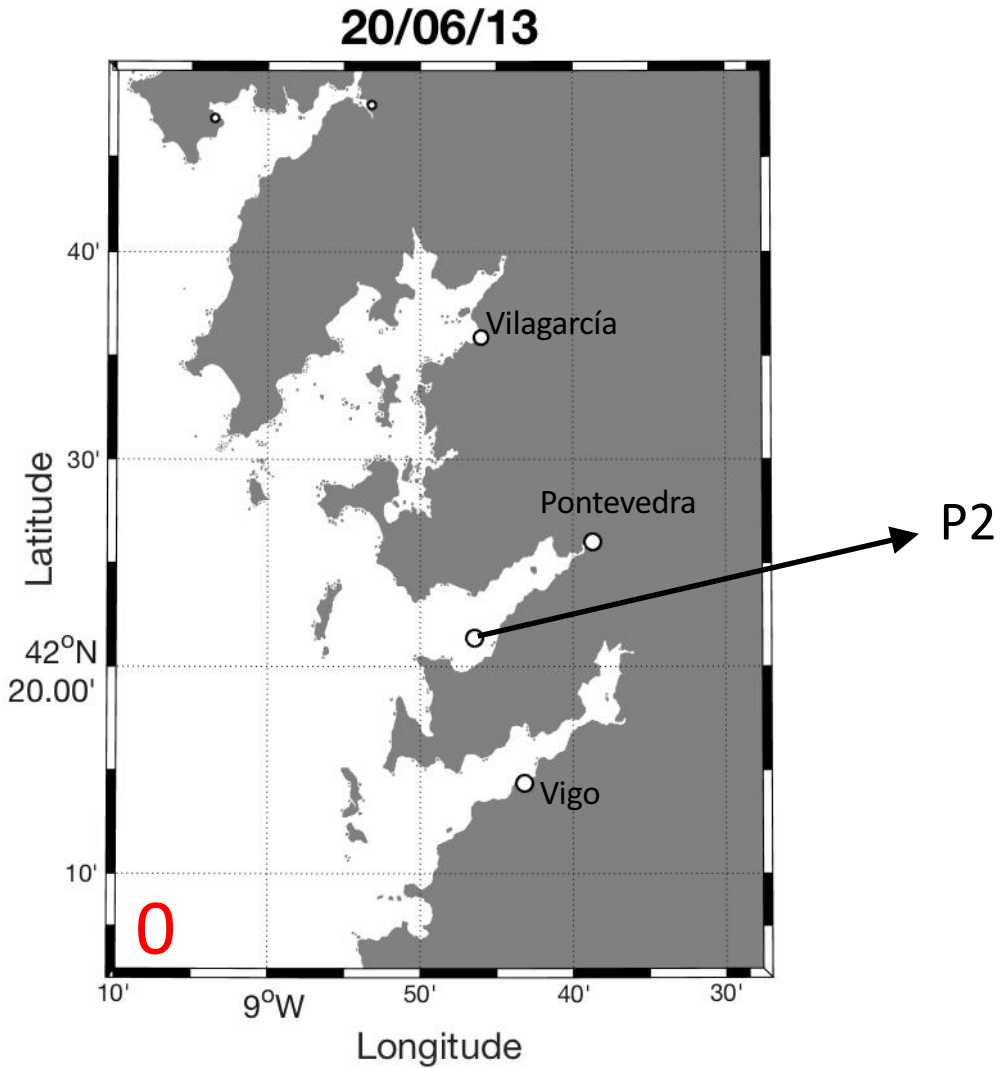
Microstructure observations in the Ría de Pontevedra (P2)

18-20 Jun 2013



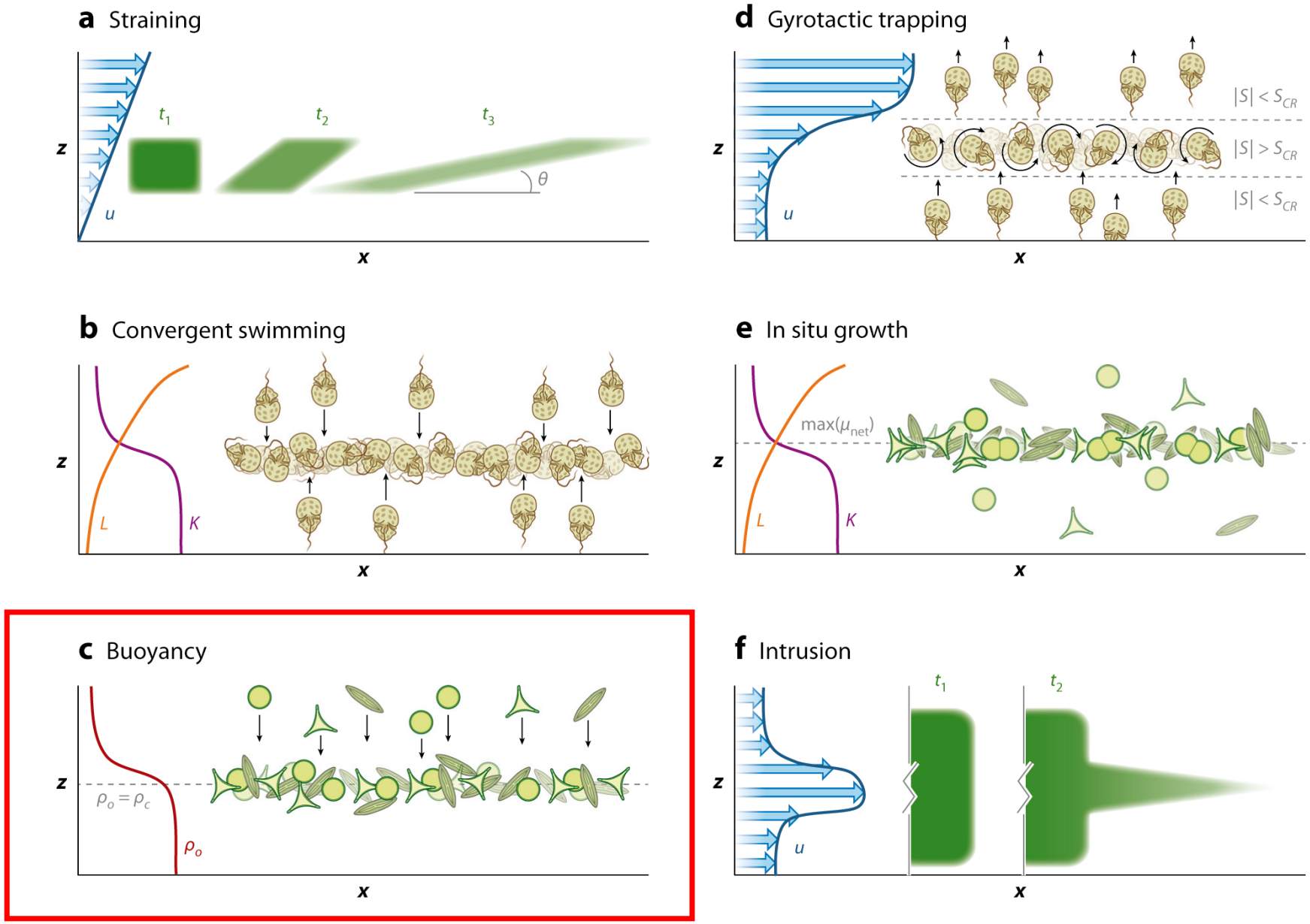
Short-term variability in TLP maintenance linked to mixing conditions

Temporal variability of TLP in the Galician Rías (INTECMAR)



No TLP detected on 20/06/13: TLP events exhibit short-term variability

Thin layers of phytoplankton (TLP): Formation



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Model approach to investigate TLP formation

Convergence-diffusion balance:

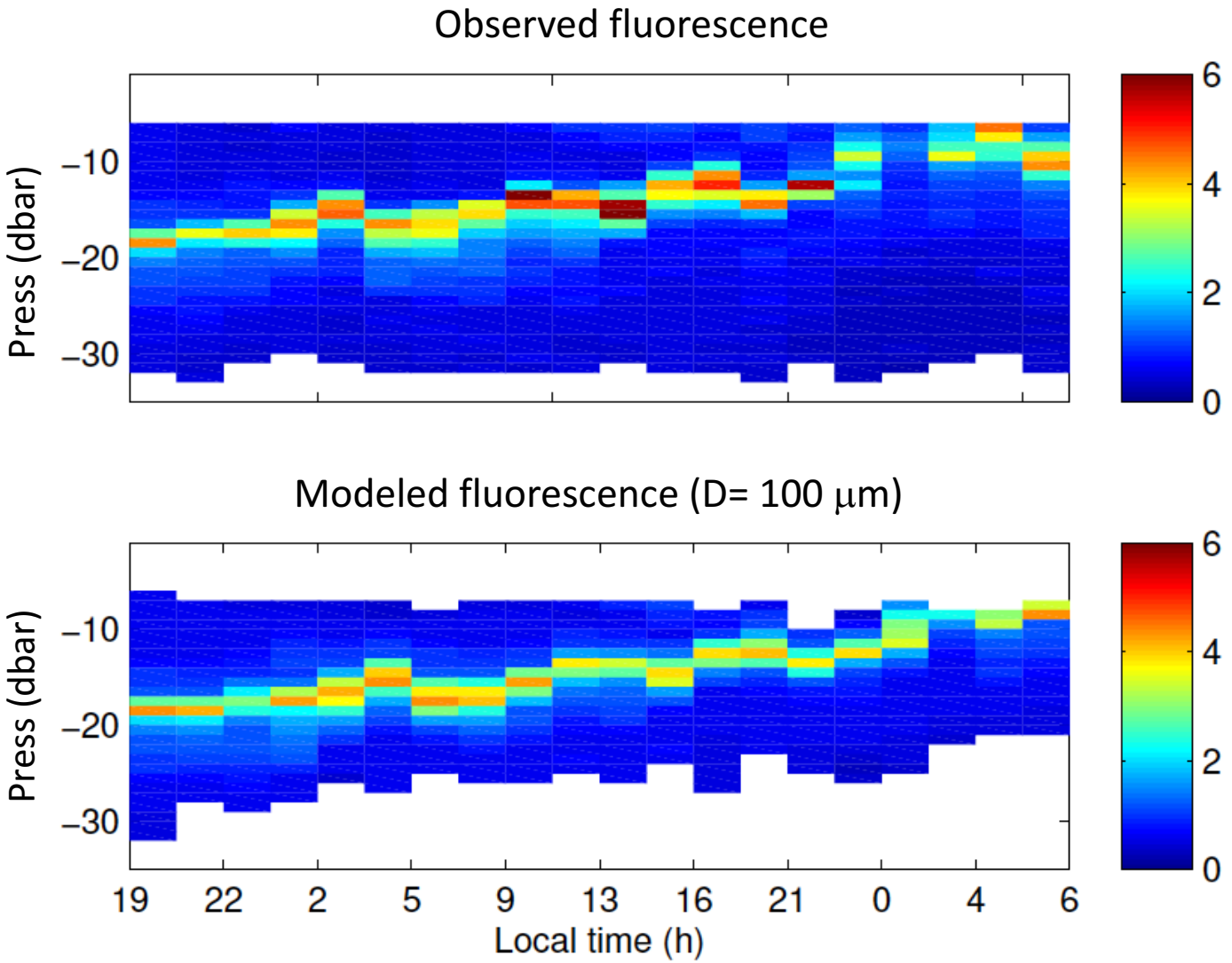
$$\left(\frac{\partial F}{\partial t}\right)_{net} = -\left(\frac{\partial F}{\partial t}\right)_{convengence} + \left(\frac{\partial F}{\partial t}\right)_{diff}$$

Buoyancy-diffusion balance:

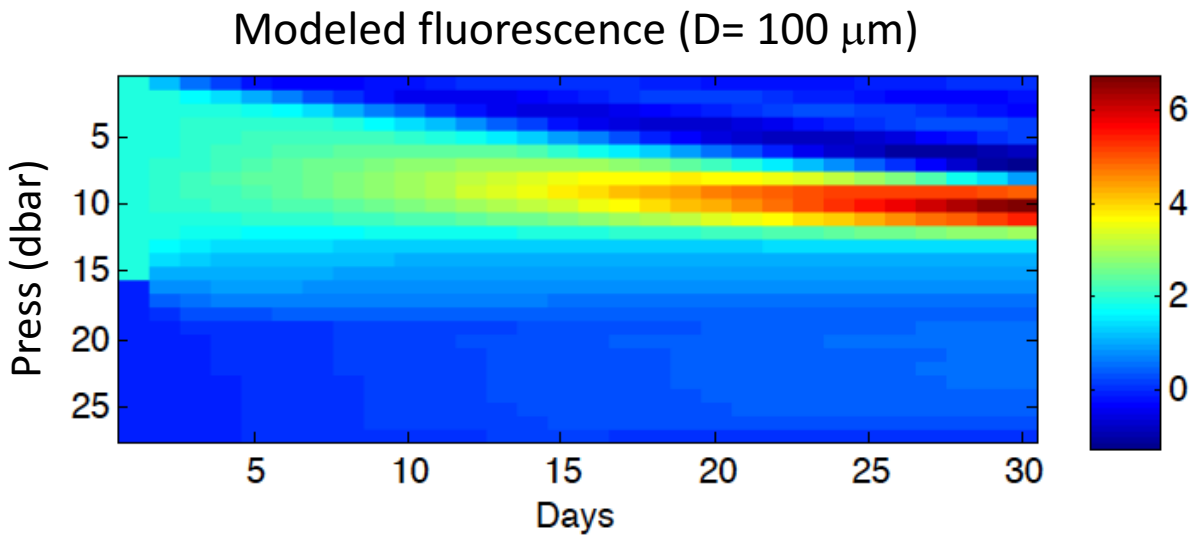
$$\frac{\partial F}{\partial t} = \frac{-\partial(cW)}{\partial z} + \frac{\partial}{\partial z}\left(Kz \cdot \frac{\partial c}{\partial z}\right)$$

$$V_{settle} = W = \frac{N^2 D^2}{18\gamma}(z - z_0)$$

Model approach to investigate TLP formation



Model approach: Time required for the TLP formation



Buoyancy partially contributes to formation and maintenance of TLP

Conclusions

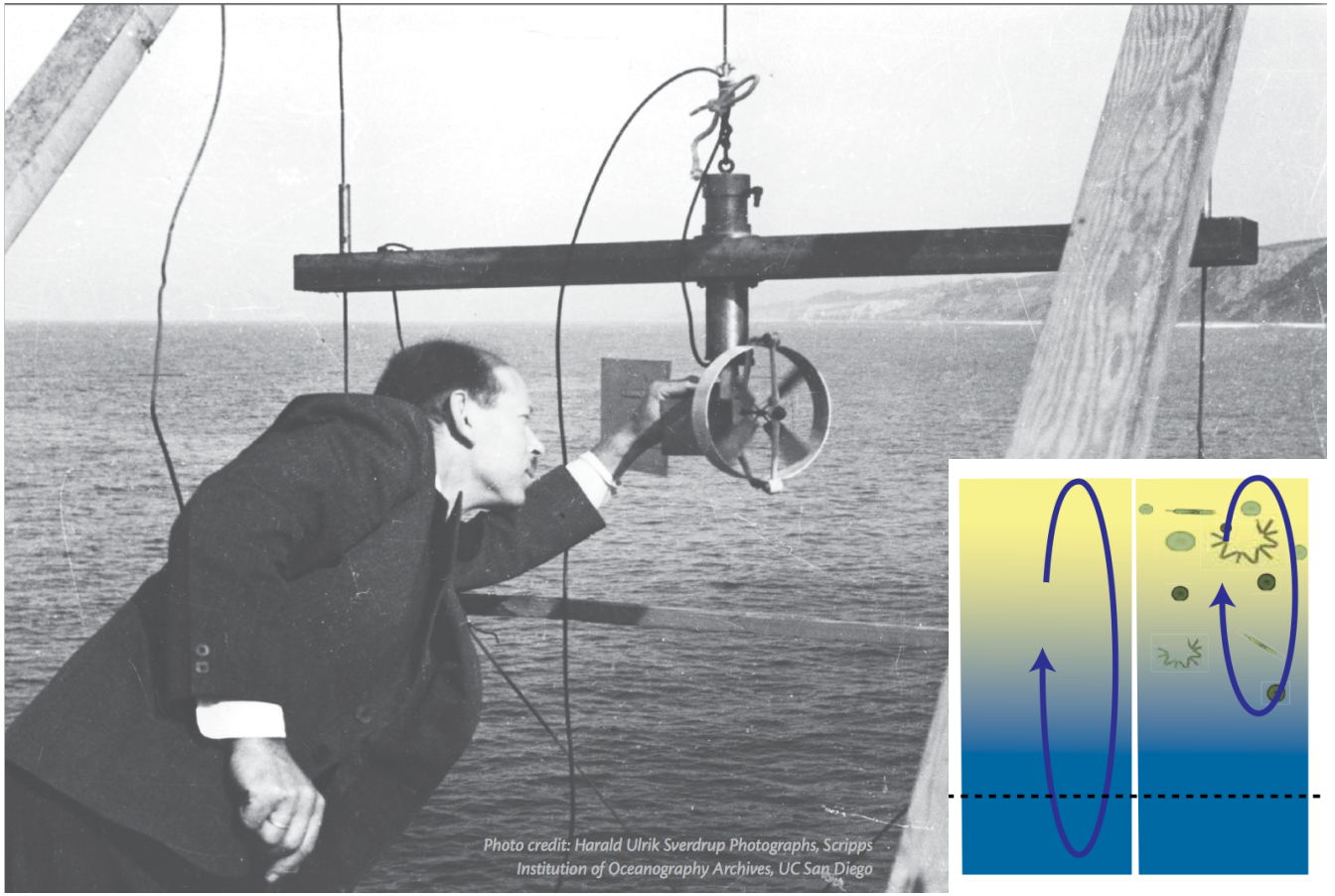
1. Maximal occurrence at P2, P4 & A2
2. More frequent May-Jul
3. Large spatial distribution & short-term variability
4. Buoyancy (& low mixing) contributes to formation and maintenance

Thanks to

- Grant CTM2012-30680 to B. Mouriño-Carballido (Spanish goverment)
- Grant CTM2016-75451-C2-1-R to B. Mouriño-Carballido (Spanish goverment)
- Grant CTM2016-75451-C2-2-R to E. Nogueira (Spanish goverment)

What is next?

Revisit the Critical Depth Hypothesis (Sverdrup, 1953)



RolE of Mixing on phytoplankton bloom initiation, maintEnance and DIssipatiOn in the galician ríaS (REMEDIOS)

Graciñas

What is next?

Is there any relationship between TLP occurrence and HABS?