Impact of ocean stratification on small-scale physical oases for pelagic life

Daniel **Grados**; Ronan Fablet; Francois Colas; Alexis Chaigneau;
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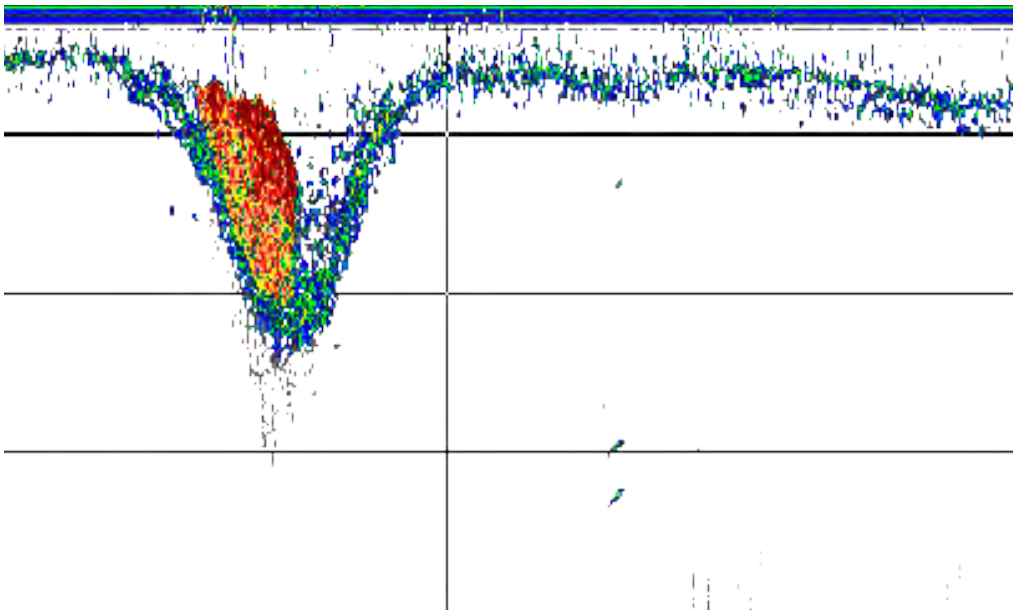
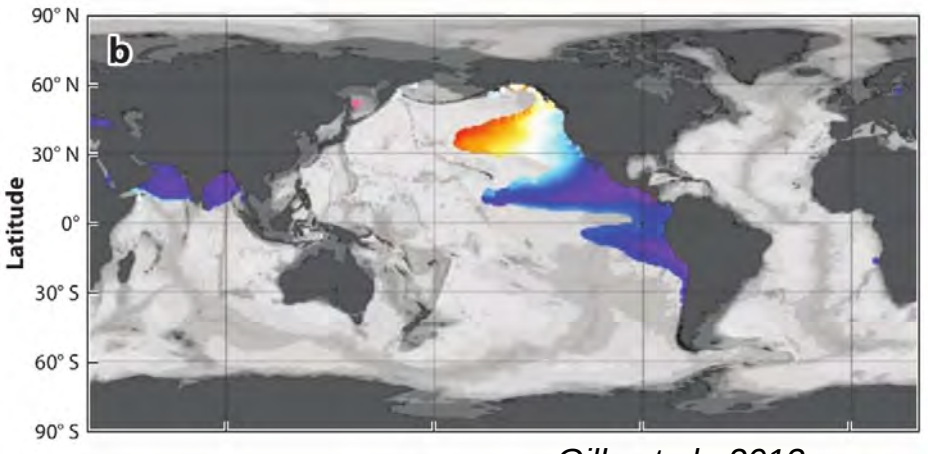


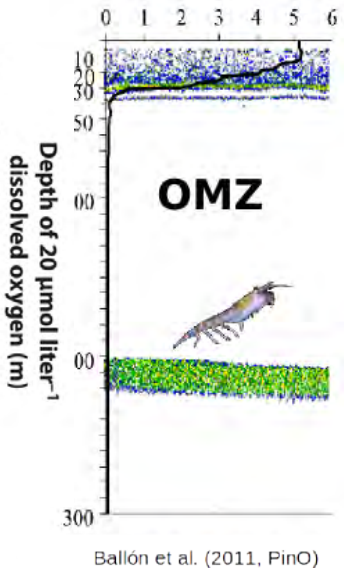
Dynamics of the Humboldt Current system

DISCOH

The Humboldt Current System: General characteristics



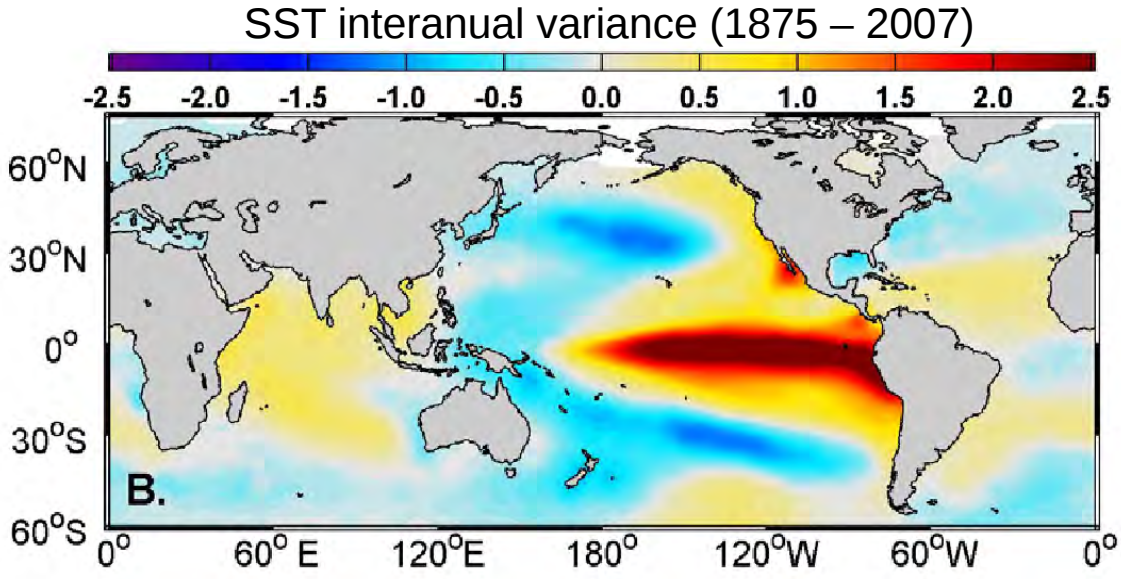
Gilly et al., 2013



Very intense and shallow oxygen minimum zone (OMZ)

Structure the marine ecosystem, vertically

HCS: region where El Niño, and climate variability in general, is most notable

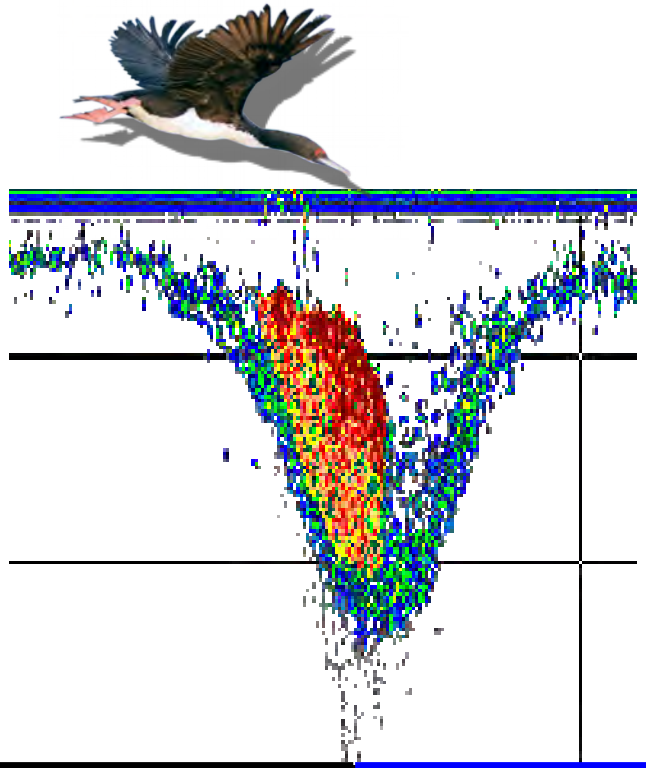


Chavez et al., 2008

The Humboldt Current System: Bottom-up structuring evidence

Physical forcing of the surface ocean includes a variety of processes, ranging from internal waves (100s of m - km) to submesoscale (kms) and mesoscale (10s of kms).

Recent work showed that ocean dynamics at scales <10 km play the foremost role in shaping the seascape from zooplankton to seabirds *(Bertrand et al., 2014 - Nature com.).*



Ocean surface turbulence creates ephemeral oases, which concentrate organisms ranging from zooplankton to seabirds

- **Quantify the aggregation power of surface physical structures**

- **Quantify the potential impact of climate change on these fine-scale oases for life:**

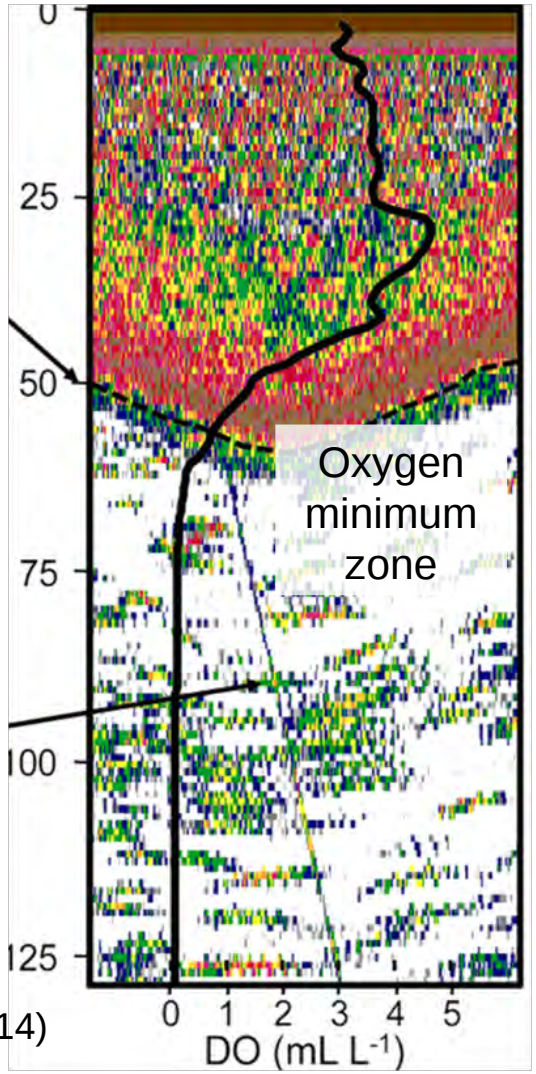
→ **Climate change is expected to increase ocean stratification *(Behrenfeld et al., 2006)*.**

→ **What can be the impact of a more stratified ocean on the intensity of physical structures and marine life interactions?**

Observing and quantifying the surface ocean dynamics

Vertical extension of the epipelagic communities: 98% quantile

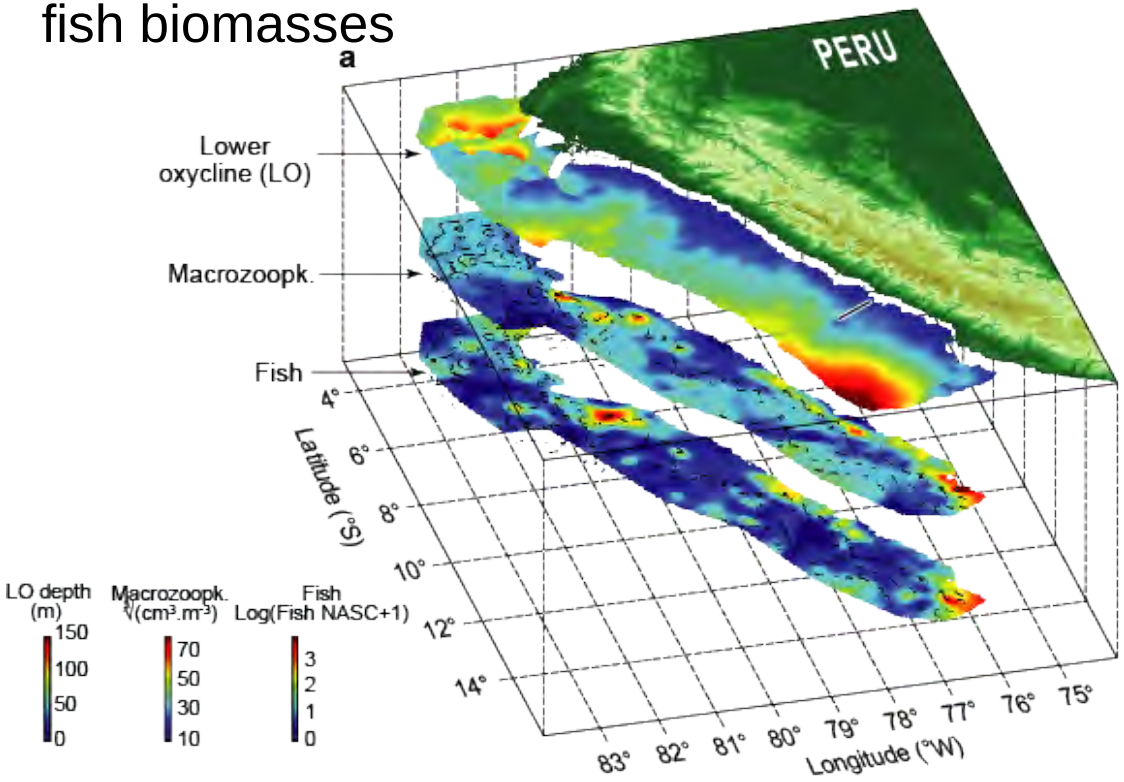
CTDO track



Bertrand et al. (2010, 2014)

→robust proxy of the oxycline depth
→ robust proxy of the pycnocline
→ reveal upper ocean dynamics

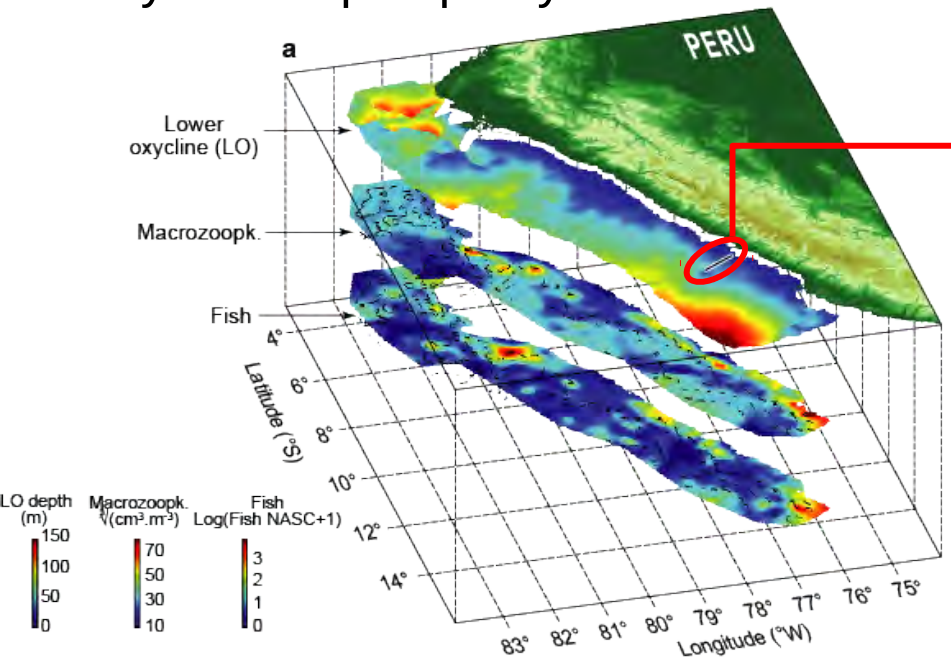
Acoustics: high resolution data on upper ocean turbulence, and zooplankton and fish biomasses



11 surveys (6 spring, 5 summer)

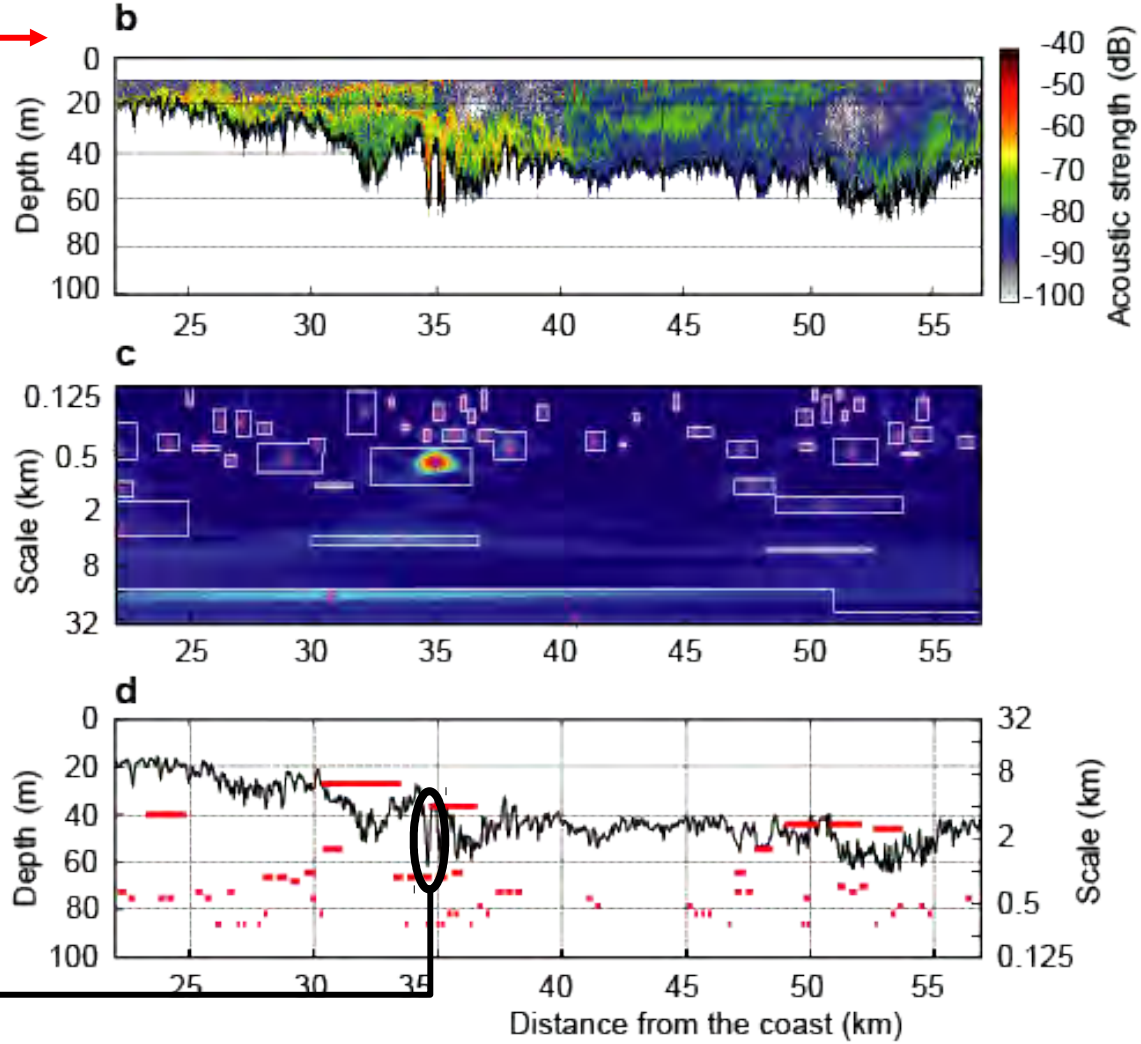
Observing and quantifying the surface ocean dynamics

Oxycline depth: proxy of ocean turbulence

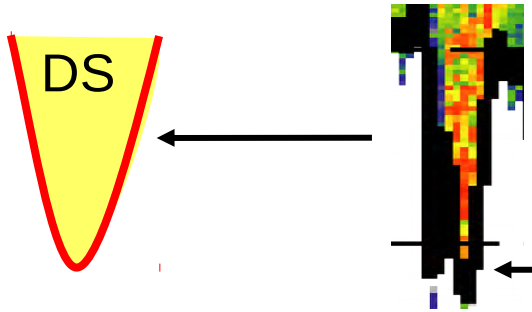


Bertrand et al. (2014)
Grados et al. (2016)

Extract physical structures along scales: wavelet-based method



Scale
Size
DS

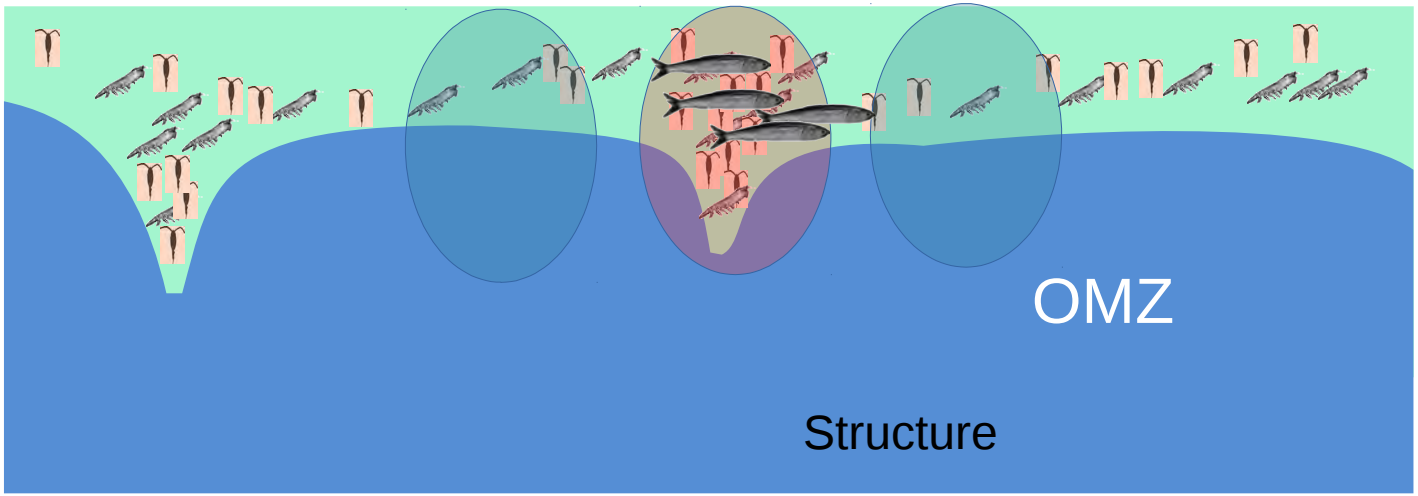


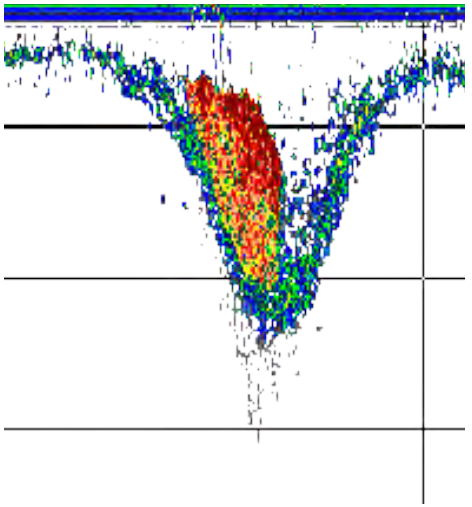
DS: Downward Deformation Surface in m^2

Observing and quantifying the surface ocean dynamics

Compute the aggregation power (RI) of each kind of physical structure on the density and biomass of zooplankton and fish

No Structure





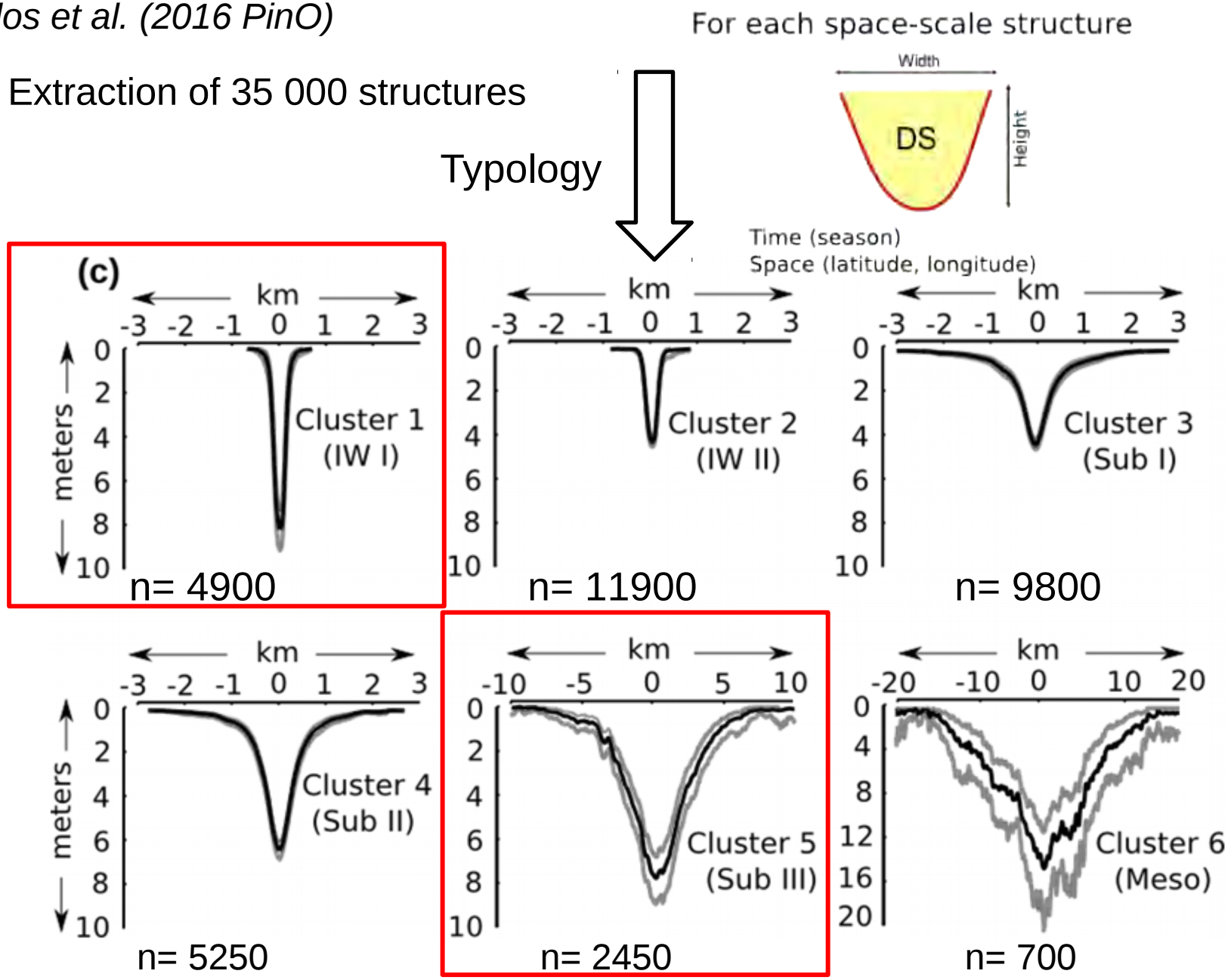
$$RI = \frac{Density_{struc} - Density_{Nostruc}}{Density_{Nostruc}}$$

Observing and quantifying the surface ocean dynamics

Grados et al. (2016 PinO)

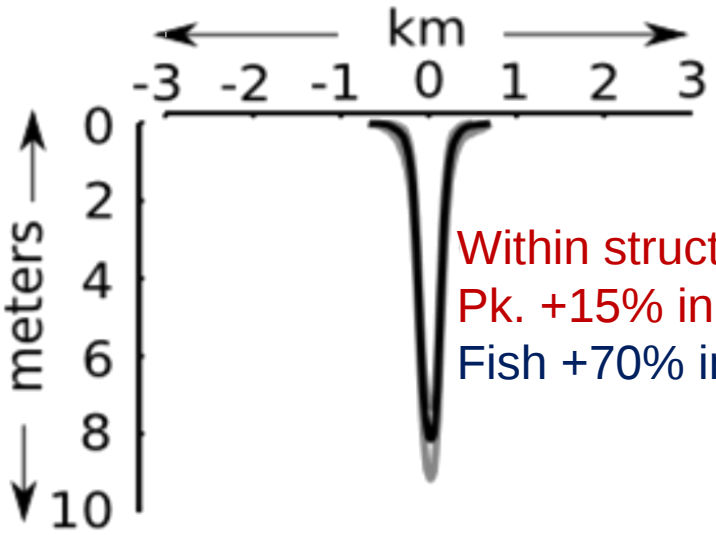
Extraction of 35 000 structures

Typology

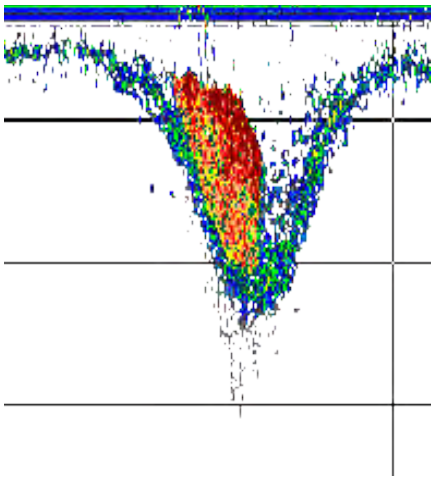


Quantifying the power of aggregation of physical structures

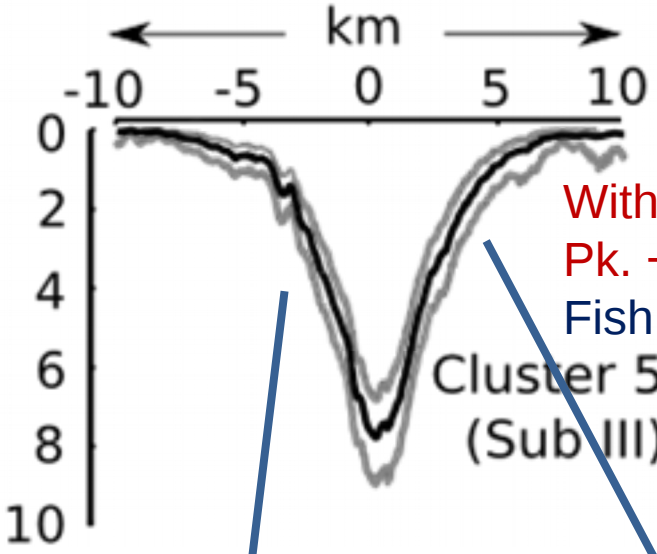
Cluster at the Internal Wave scale



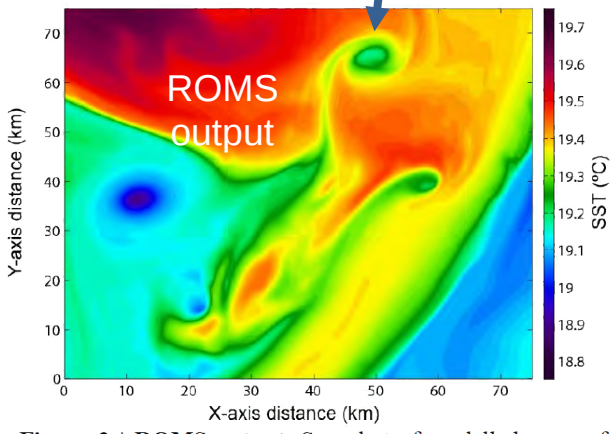
Within structures:
Pk. +15% in density
Fish +70% in density

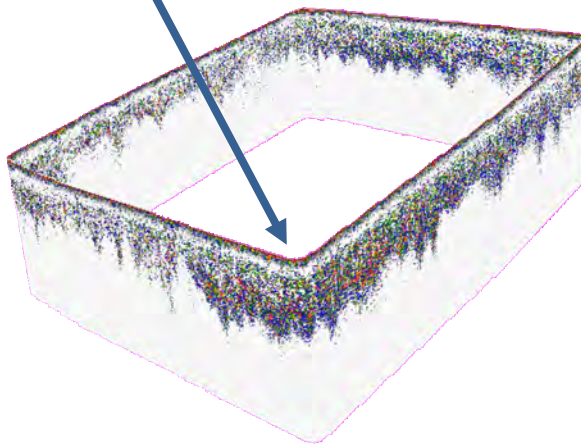


Cluster at the submeso-scale



Within structures:
Pk. +15% in density
Fish +100% in density





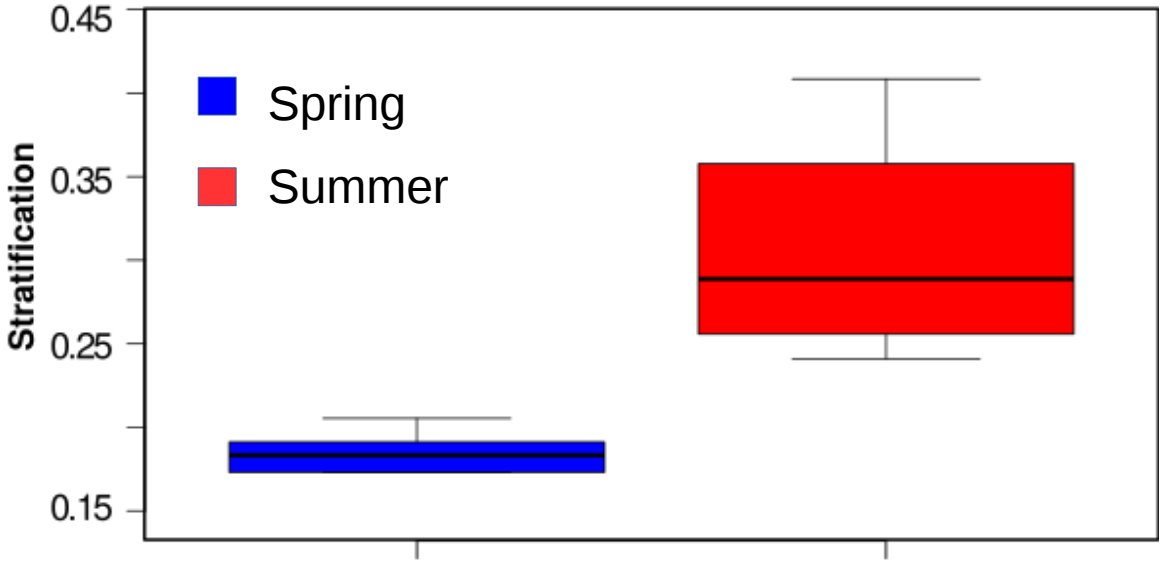
How ocean stratification impact physical structures

- **Quantify the potential impact of climate change on these fine-scale oases for life:**

→ **Climate change is expected to increase ocean stratification *(Behrenfeld et al., 2006)*.**

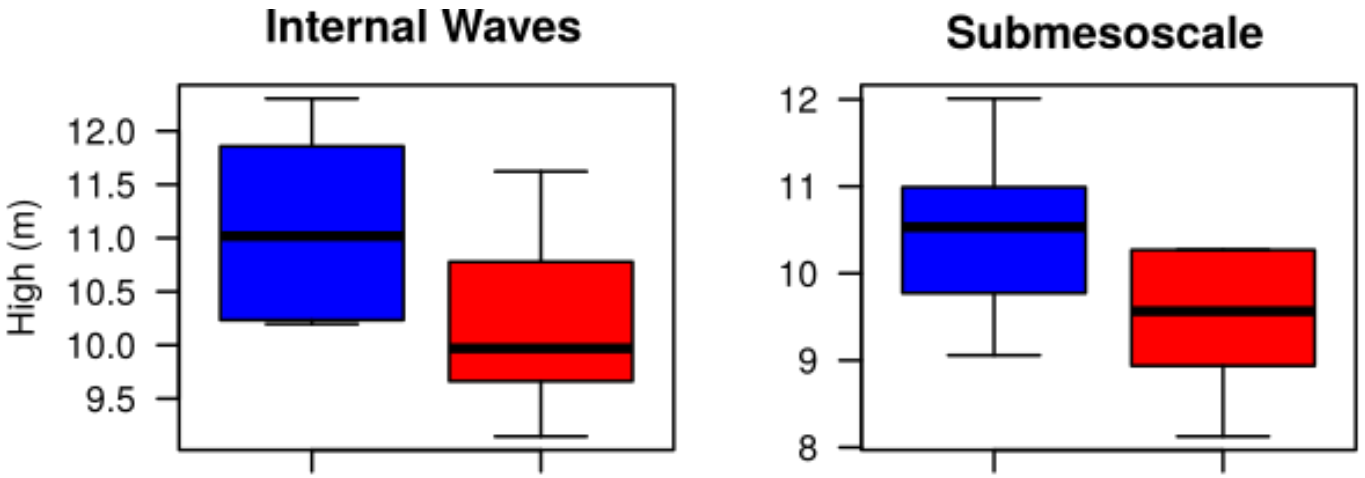
→ **What can be the impact of a more stratified ocean on the intensity of physical structures and marine life interactions?**

How ocean stratification impact physical structures



Stratification significantly higher in summer than spring

Does a higher stratification decreases the strength of the physical structures?



Physical structures are significantly lower in summer than spring

How ocean stratification impact physical structures

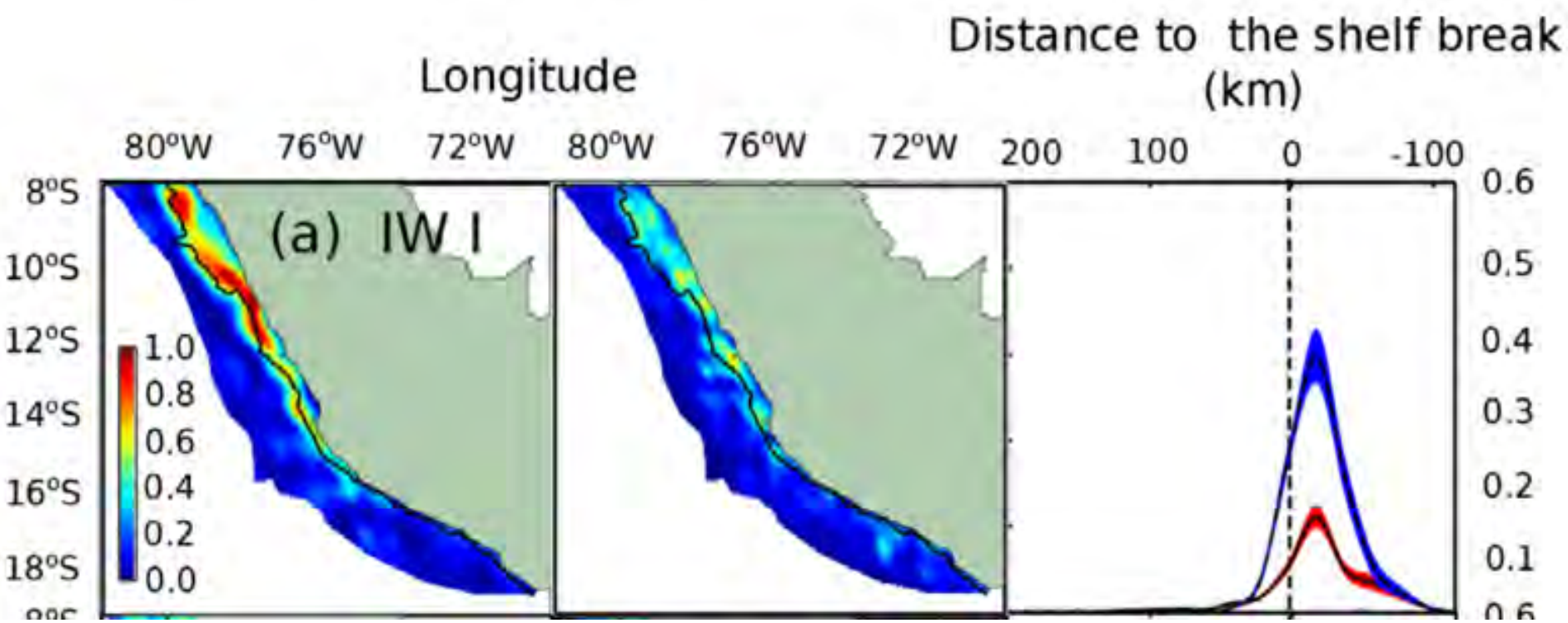
Mapping the physical structures at scale < 10 km

Spring

Stratification

Summer

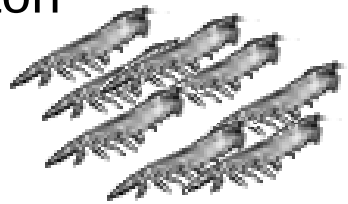
Stratification



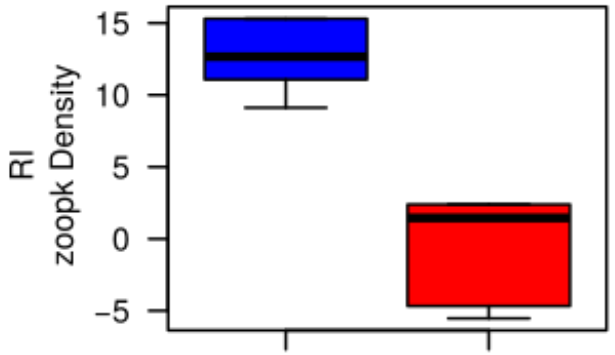
More physical activity in spring than summer

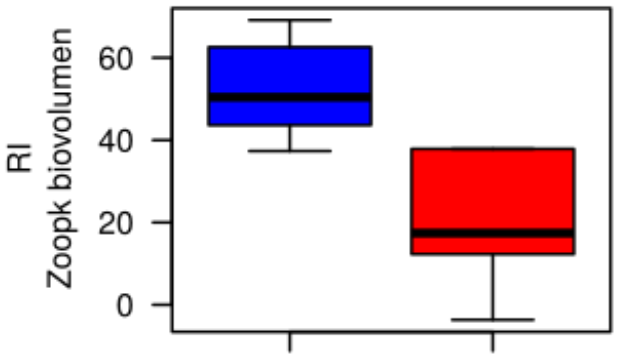
How ocean stratification impact the power of aggregation of physical structures

How much physical structures aggregate zooplankton

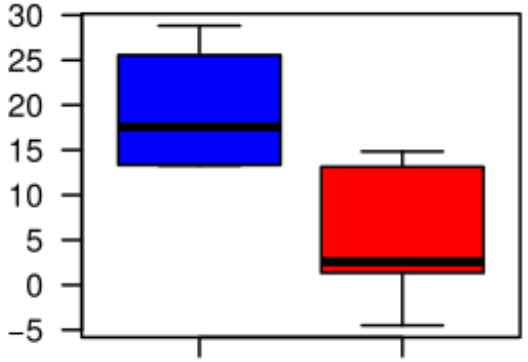


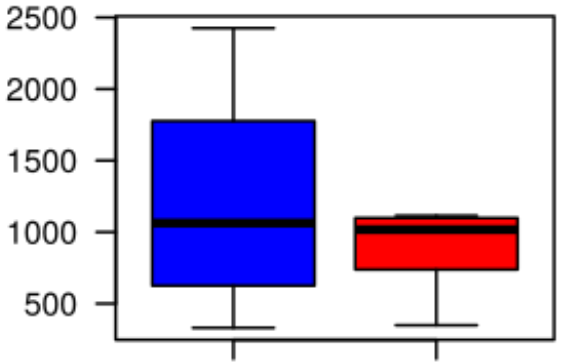
Internal wave scale





Submesoscale

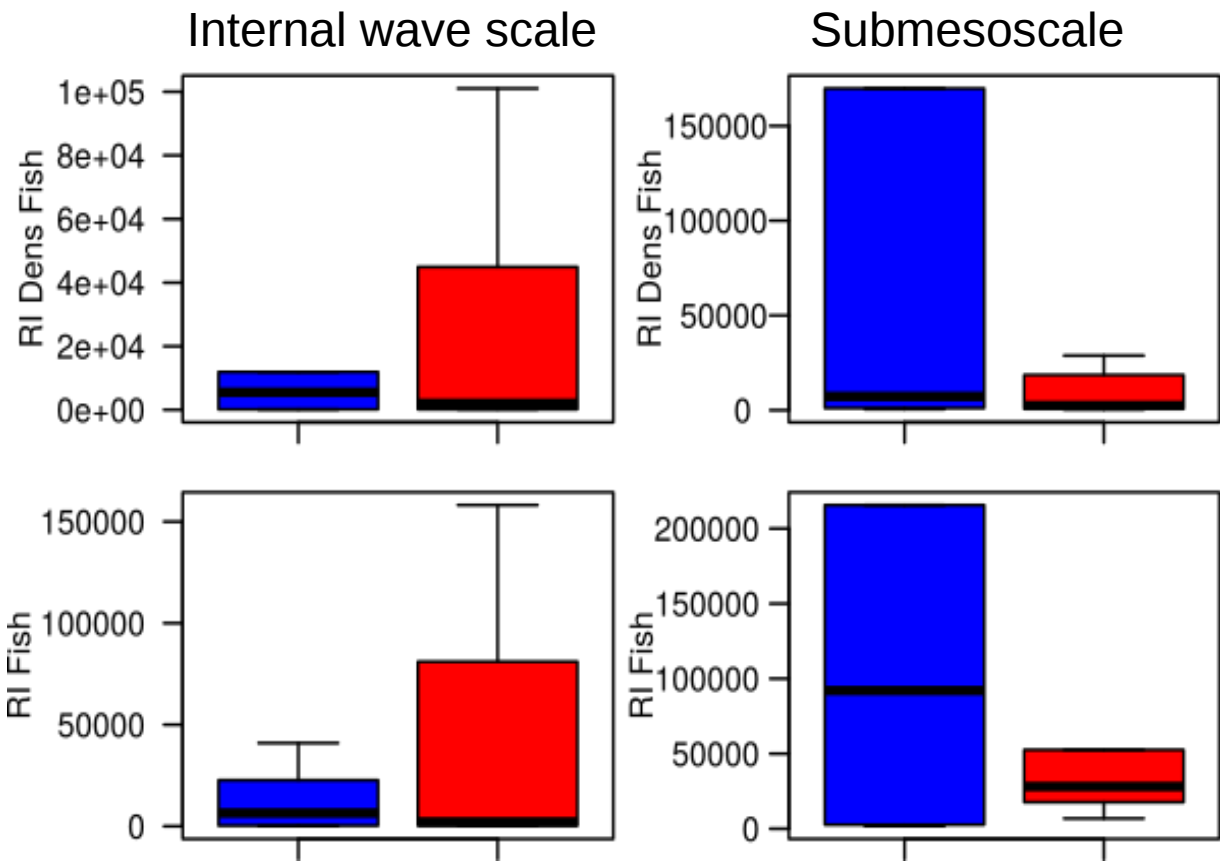




Significantly higher power of aggregation of physical structures in lower (spring) than higher (summer) stratification conditions

How ocean stratification impact the power of aggregation of physical structures

How much physical structures aggregate fish



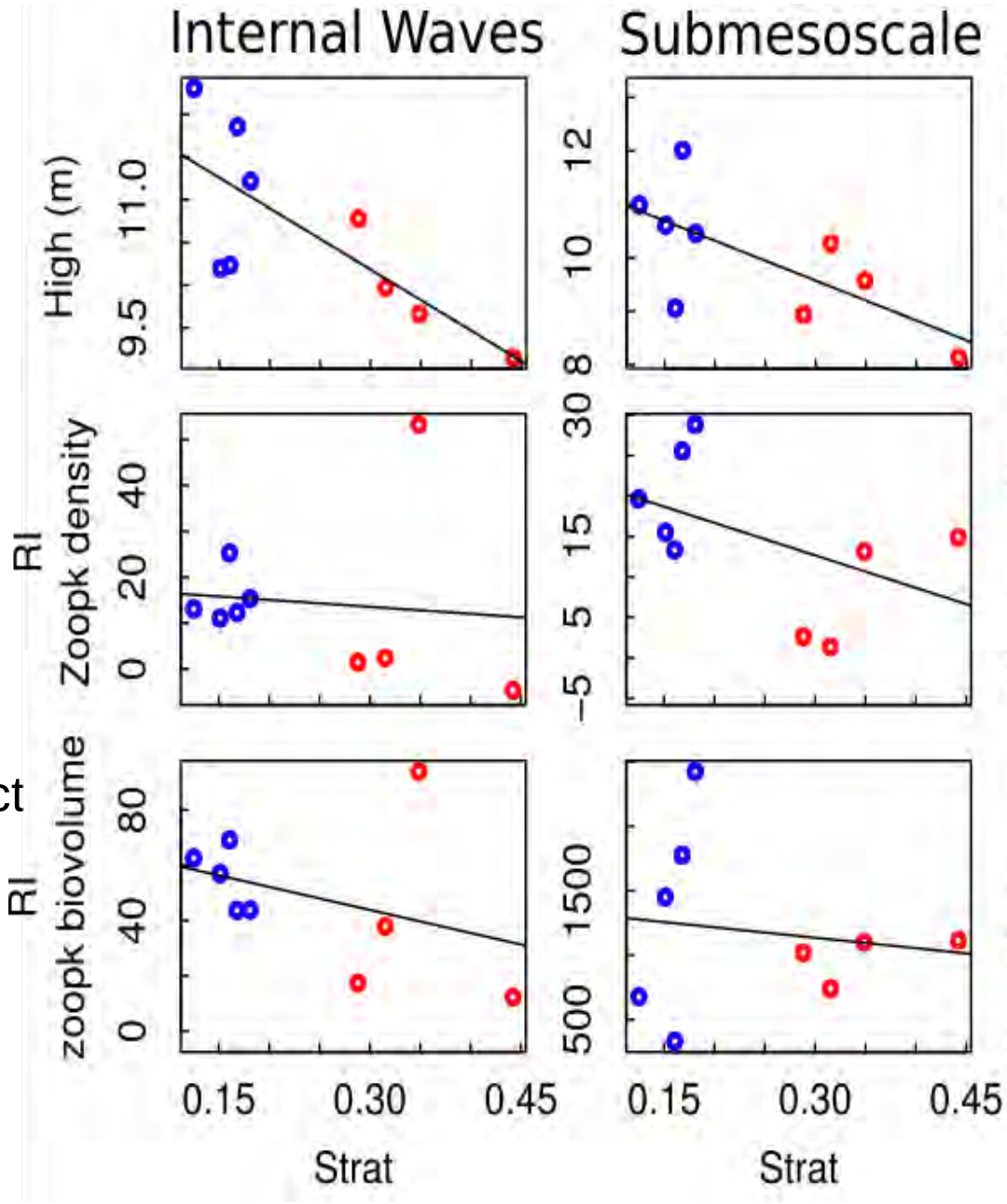
Higher (but not significant) power of aggregation of physical structures in lower (spring) than higher (summer) stratification conditions

How ocean stratification impact the power of aggregation of physical structures

Working at the survey scale along the stratification gradient

Ocean stratification significantly reduces the vertical deformation of physical processes

But we could not observe significant effect of ocean stratification on the power of aggregation of physical structures



General conclusions

- Surface oceanic structures ranging from the internal wave to the submeso-scale significantly aggregate marine life (zooplankton and fish)
- Higher stratification is expected in a warmer ocean

→ The strength physical structures decreases with stratification

→ We could evidence a negative impact of ocean stratification on the power of aggregation at a broad scale (spring vs. season) but not at the survey scale. More data are need to provide a robust conclusion