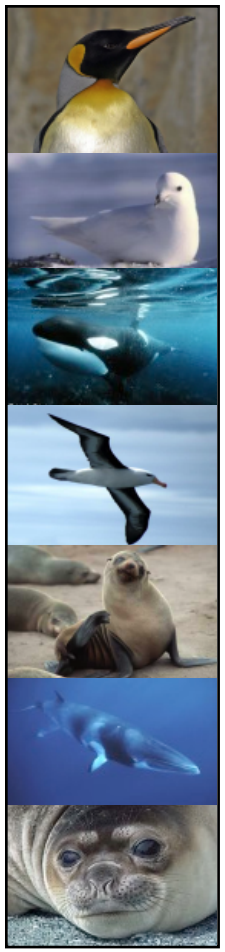
Centre d'Études Biologiques de Chizé

cnrs dépasser les frontières

Marine Predators Team

La Rochelle Université

Zones Ateliers LTSER FRANCE ANTARCTIQUE



Southern Ocean shift from physical forcing to marine Biology

Christophe Guinet, Baptiste Picard et al.

Centre d'Études Biologiques de Chizé

SMRU

Muséum National d'Histoire Naturelle

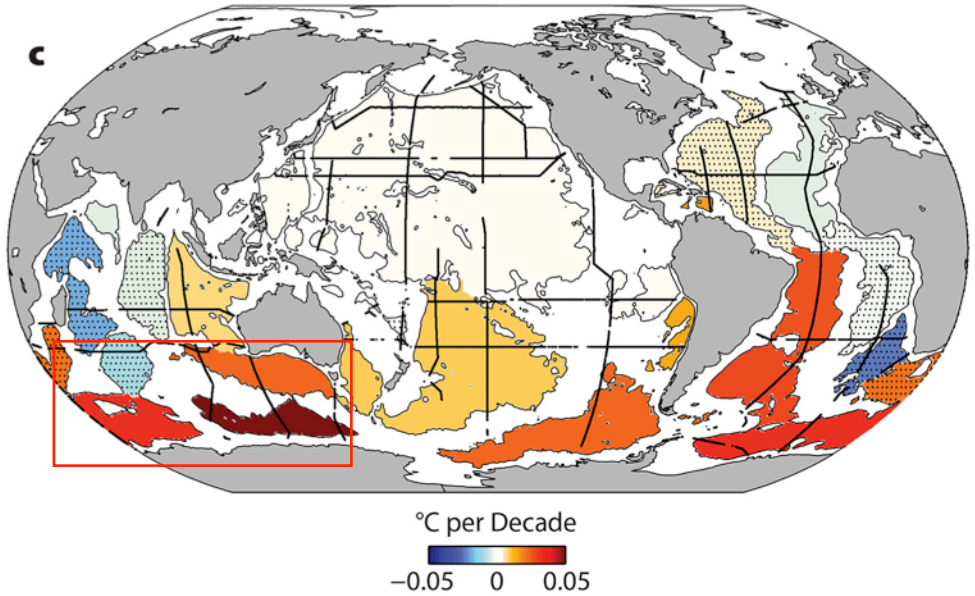
ANR Agence Nationale de la Recherche

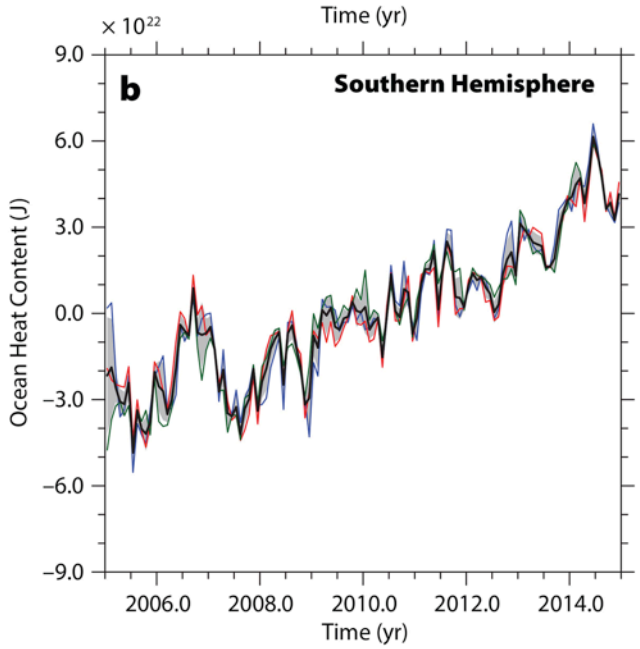
cnes Centre National d'Études Spatiales

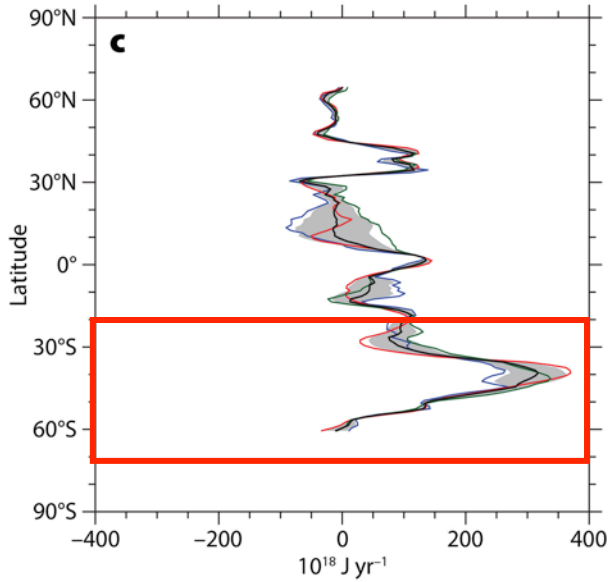
Institut Polaire Français Paul-Émile Victor

They are increasing evidences that the Southern Ocean is changing:

1. The heat content of the Southern Ocean is rapidly increasing

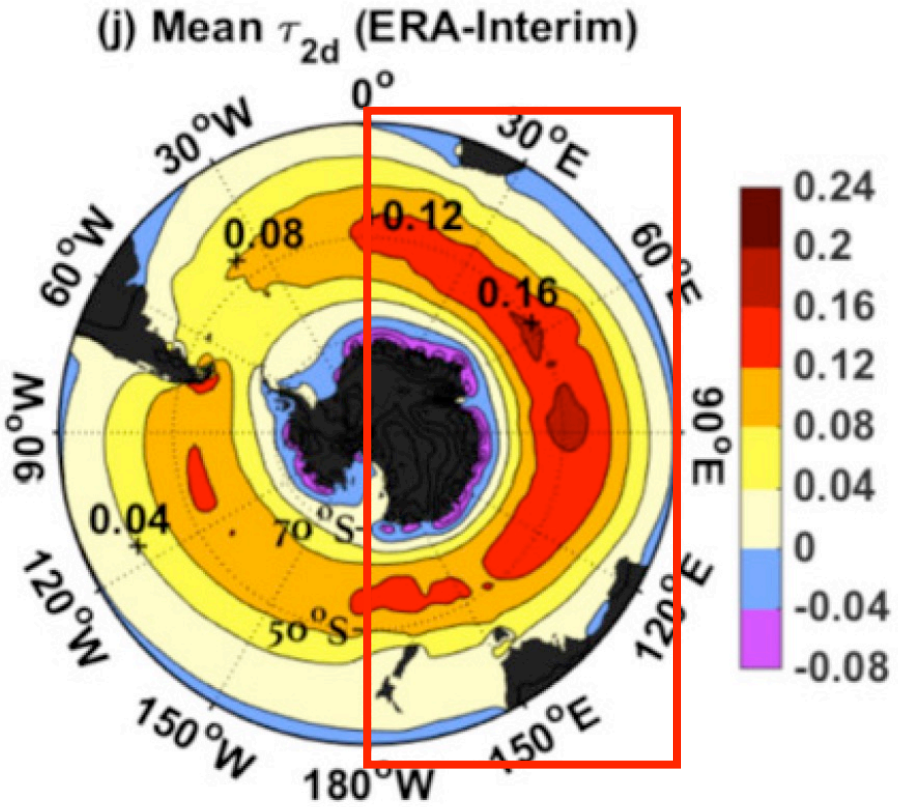


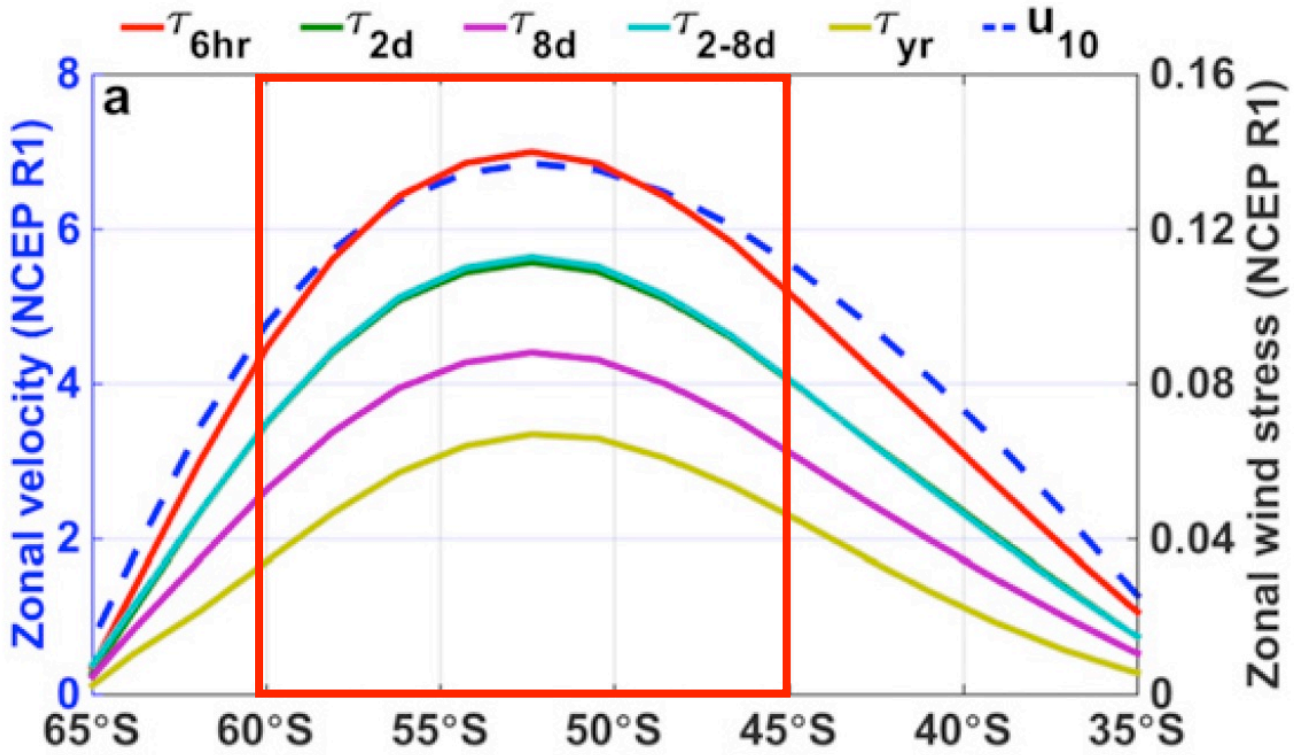




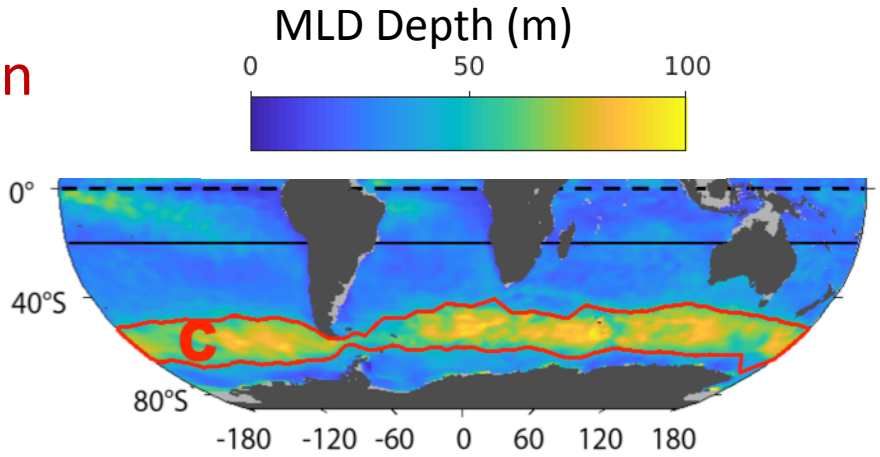
Sallée, J.-B. 2018. Southern Ocean warming. Oceanography 31(2):52–62, https://doi.org/10.5670/oceanog.2018.215.

2. Wind stress (N.m^2) is increasing : + 40 % (1979 -2016) (Lin et al. 2018, J. Climate)

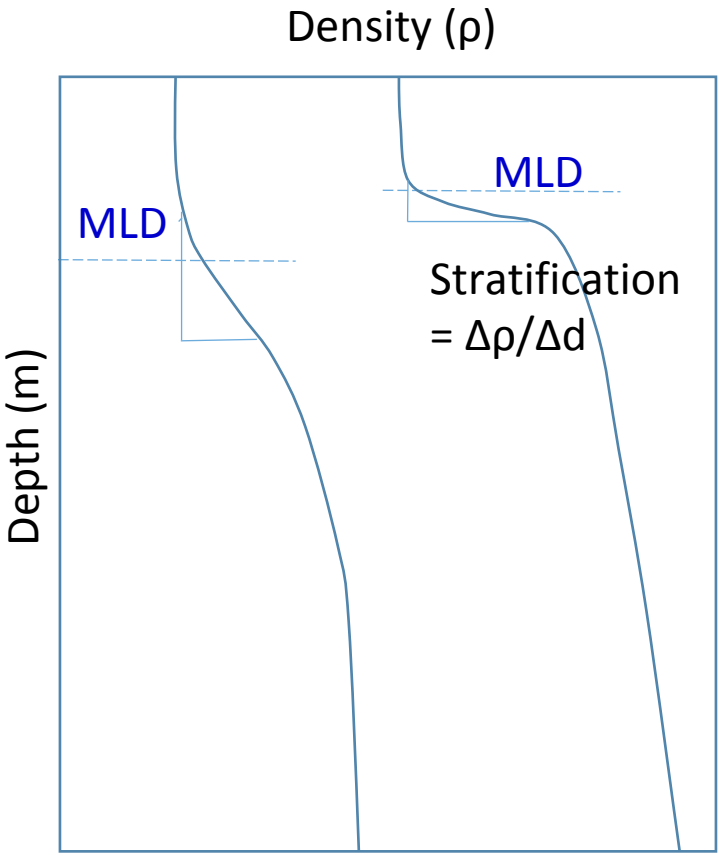




3. Increasing MLD and Stratification



Summer climatological mixed layer depth



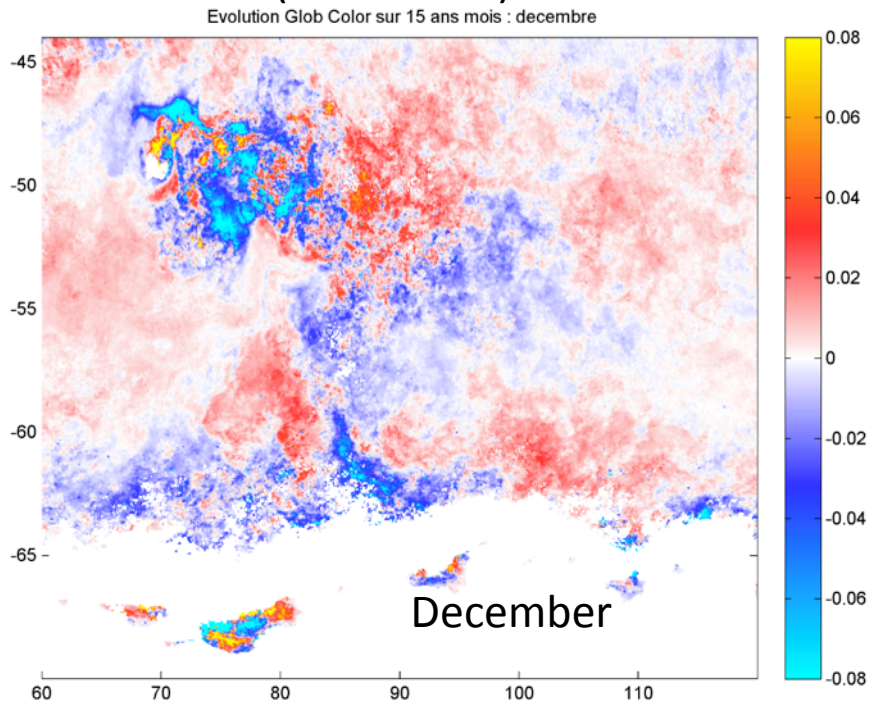
Observed trend in the Southern Ocean

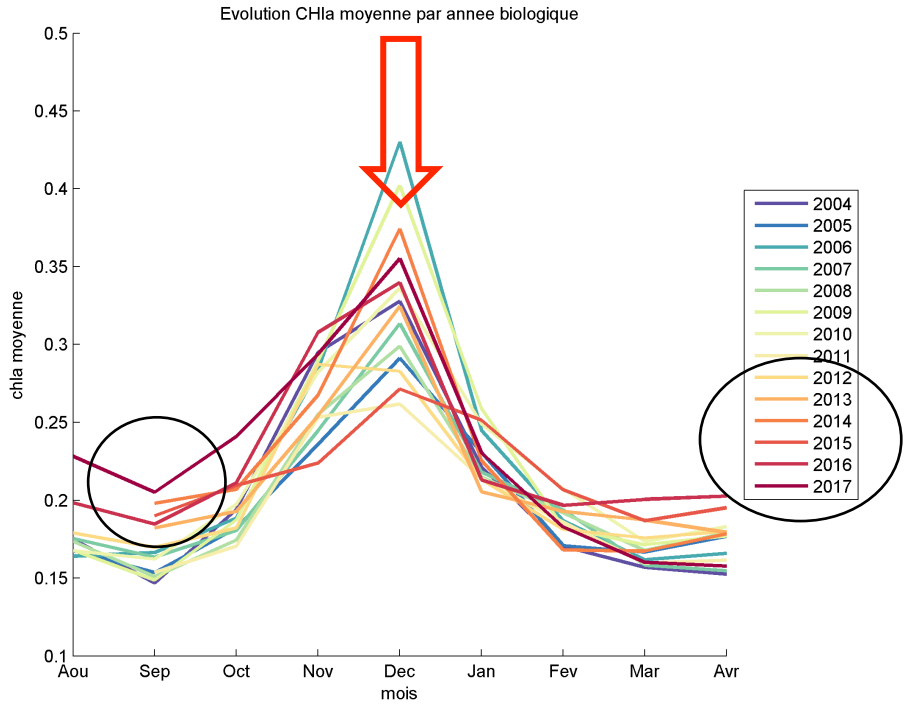
Increasing Stratification and deepening of the Mixed Layer Depth

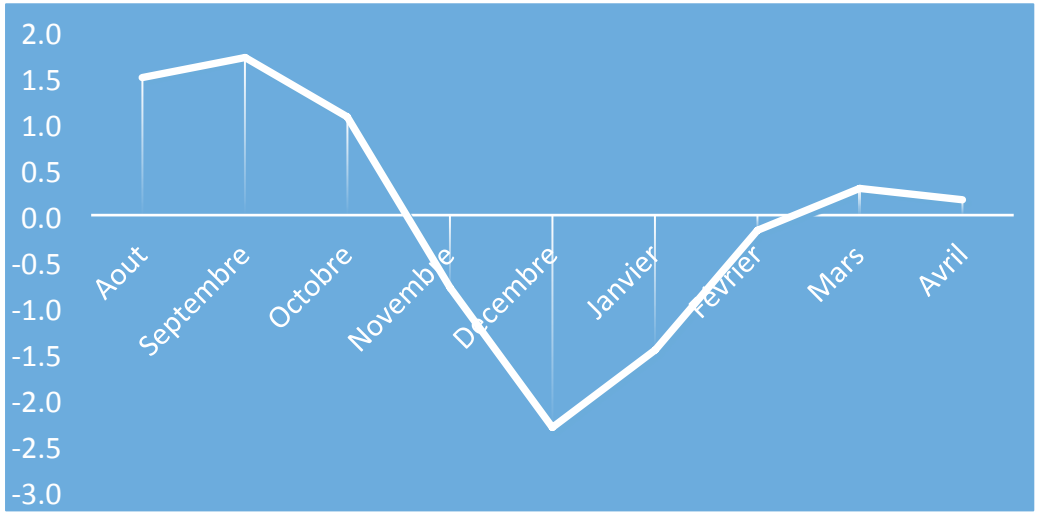
Sallé et al. (in revision)

4. Phytoplankton phenology is shifting (2004 -2017)

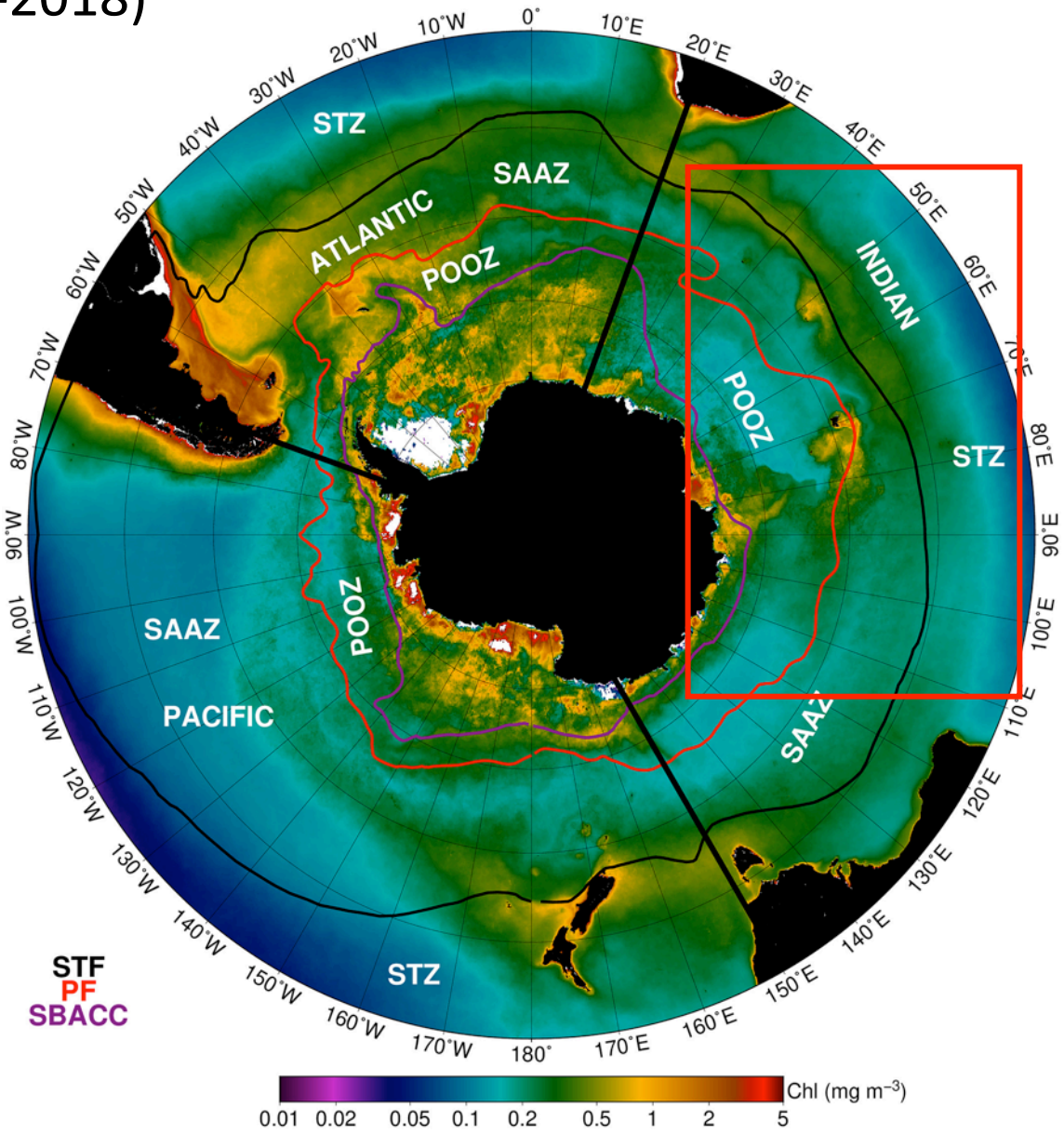
(2004-2017)

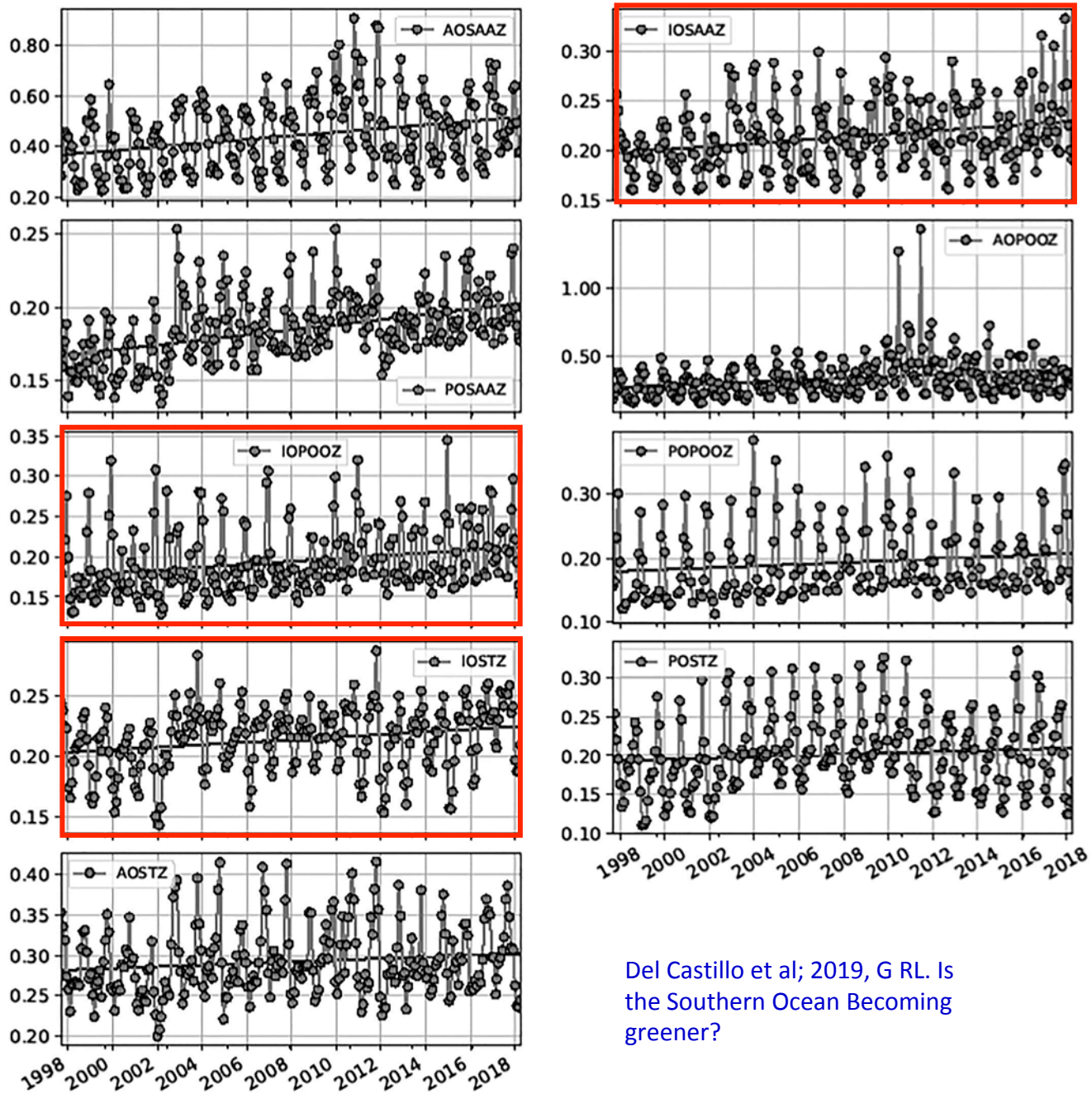






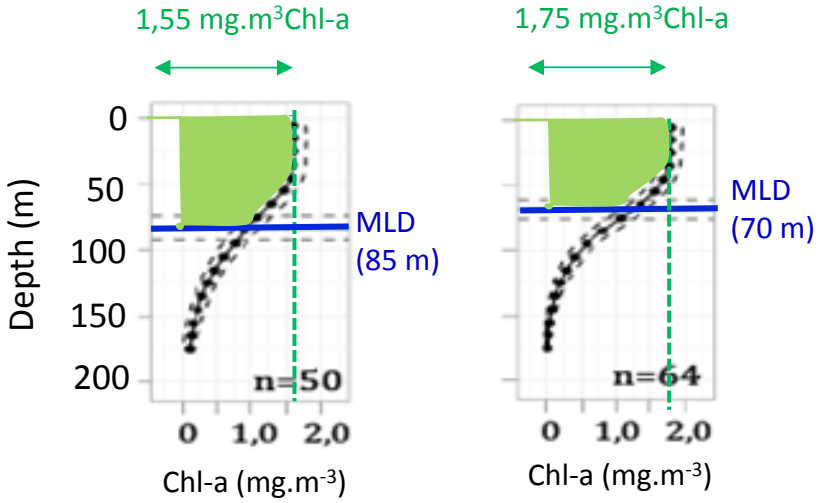
5. Surface chlorophyll-a biomass (mg.m^3) is increasing : (+10, 22 & 28 %) (1997 -2018)





Del Castillo et al; 2019, G RL. Is the Southern Ocean Becoming greener?

6. What about the overall phytoplankton biomass : likely to be increasing (1997 -2018)



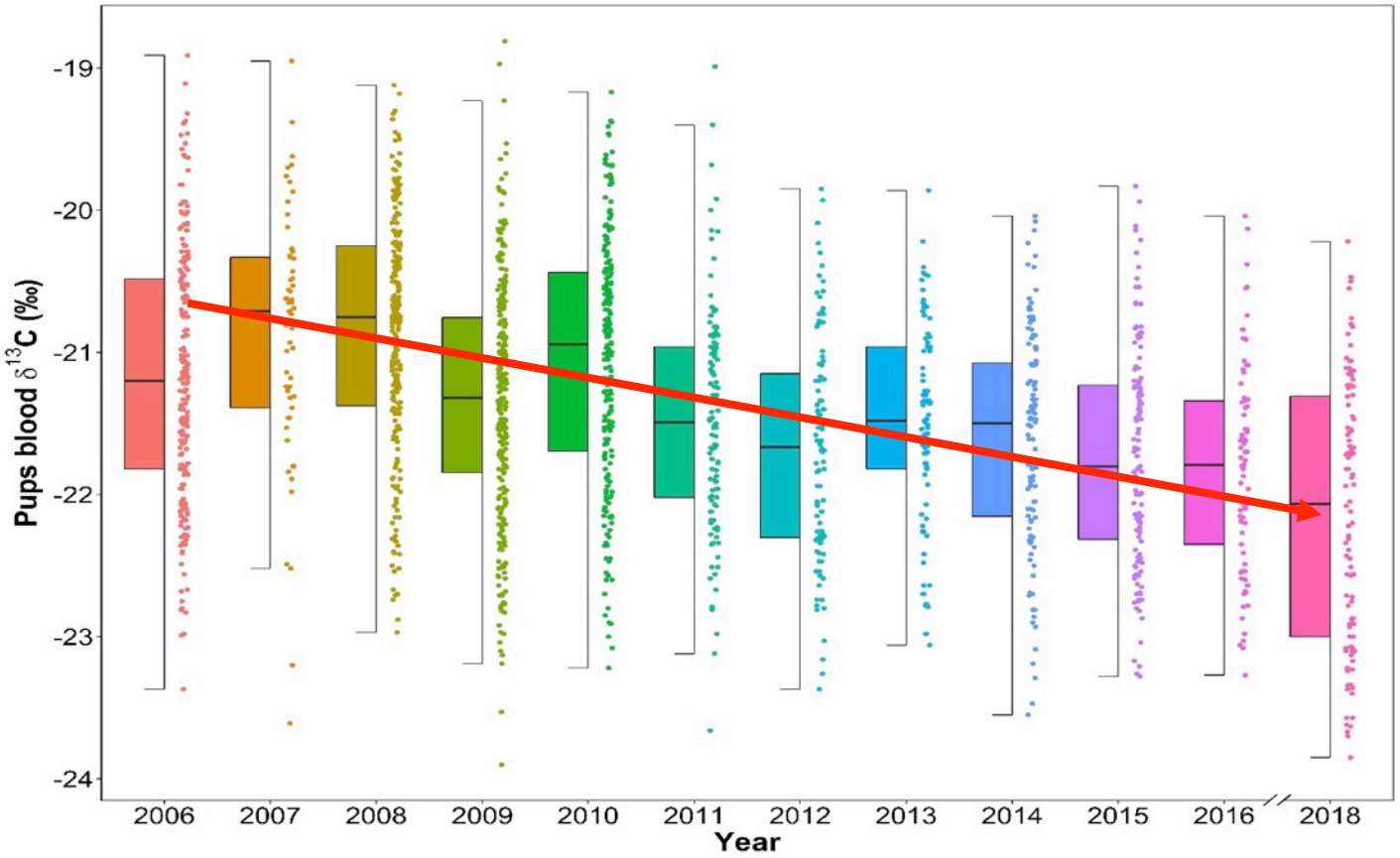
Integrated Biomass = 85 x 1,55 = **131,75** mg Chl-a

Integrated Biomass = 70 x 1,75 = **122,5** mg Chl-a

To estimate the total biomass in Chl-a it is therefore essential to have satellite measurements of water color but also to take into account the depth of the mixing layer.

This depth cannot be measured by satellite: models (CMEMS) and in-situ measurements.

7. Ecological changes : a continuous decline in $\delta^{13}C$ stable isotope signature (2006-2018)



$\delta^{13}C$ = **-0.09 * year** + 160; n = 1684, p-value < 0.001, R^2 = 0.11;

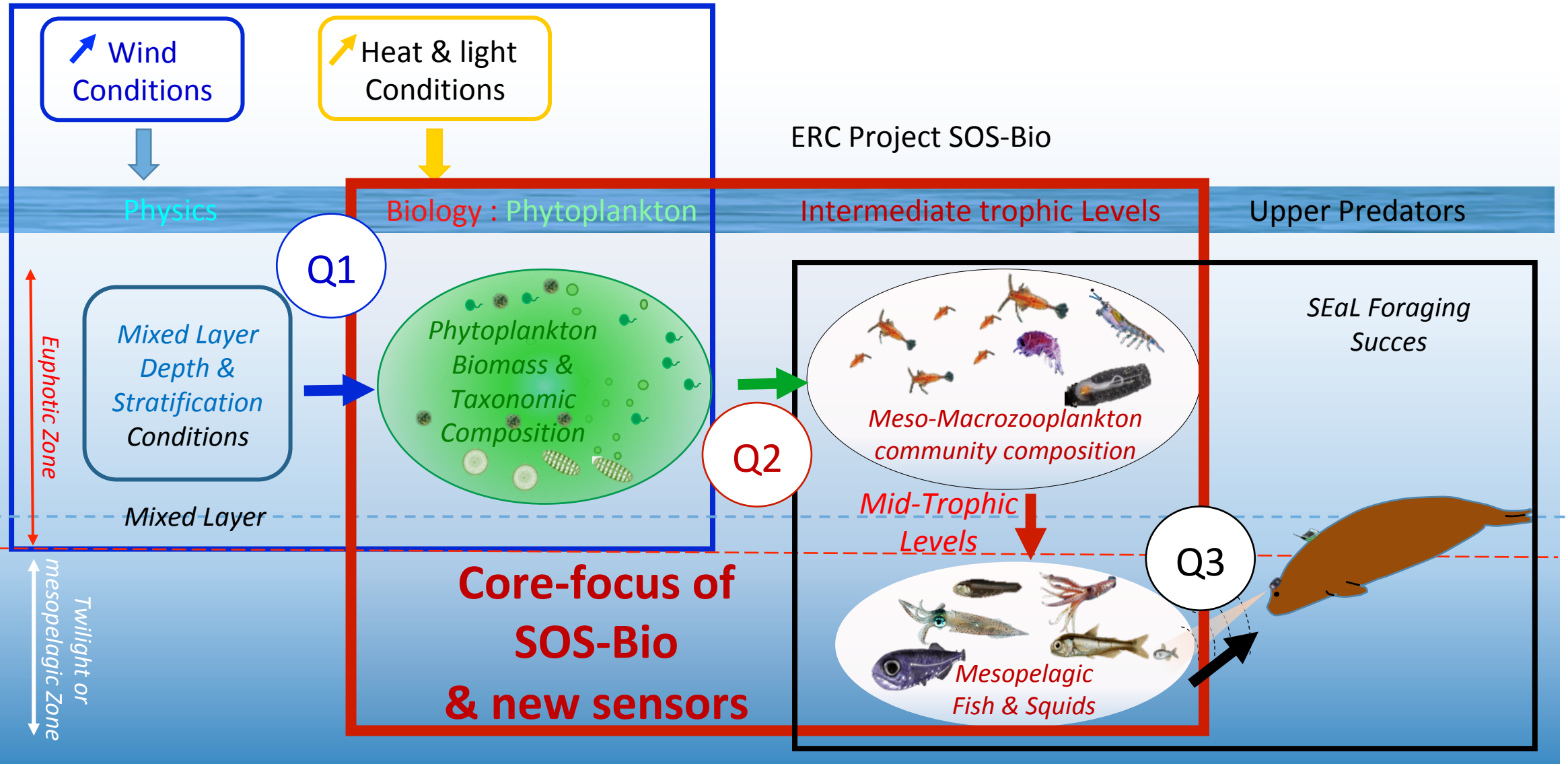
an overall decrease of 1.08 ‰ (2006-2018)

Most likely hypothesis : a change in the composition of phytoplankton community with a decrease in diatoms and an increase in pico-phytoplankton related to change in MLD and stratification conditions

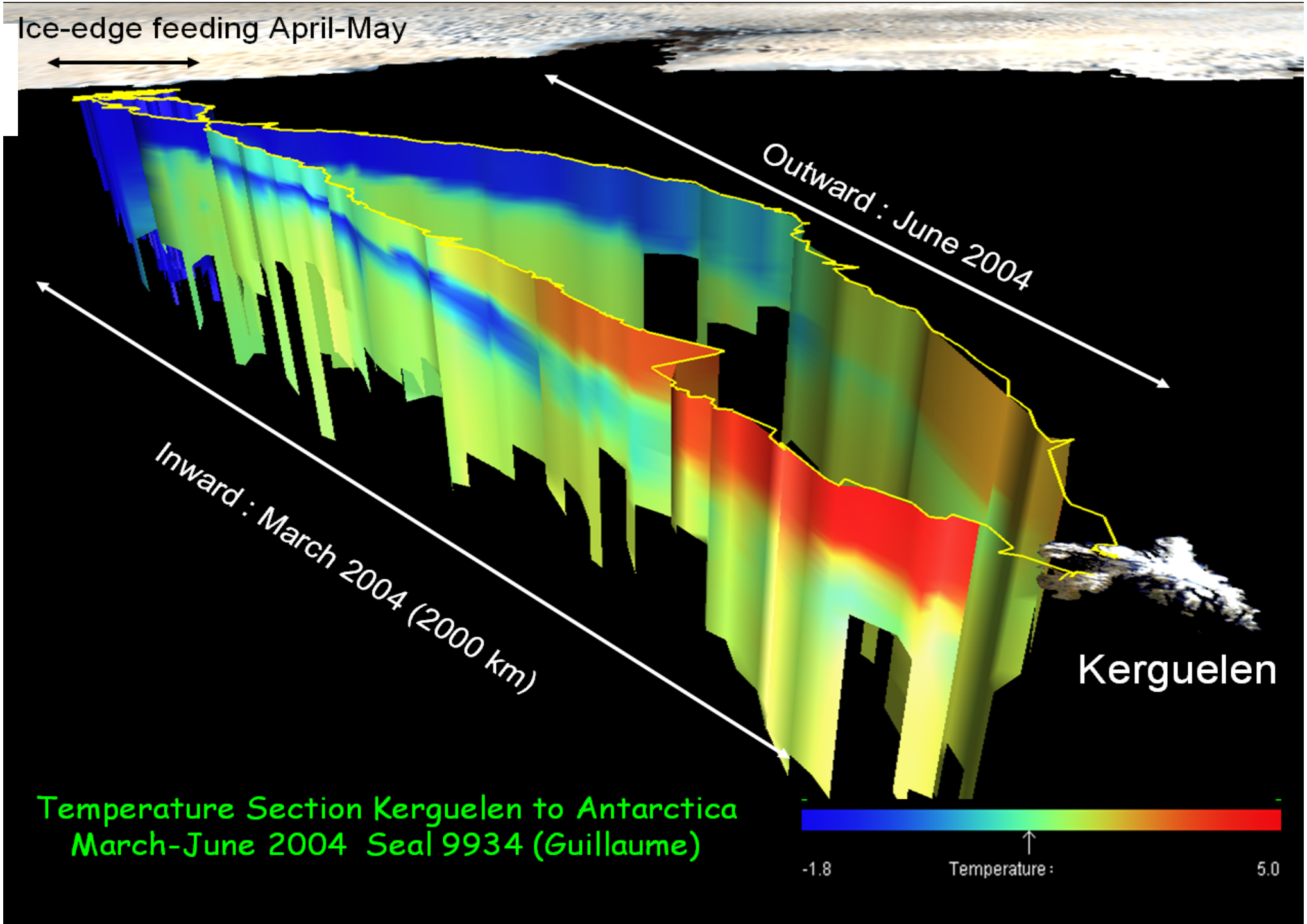
MESTRE J, AUTHIER M, CHEREL Y, HARCOURT R, MCMAHON CR, HINDELL MA, CHARRASSIN JB, GUINET C (2020) Decadal changes in blood δ13C values, at-sea distribution, and weaning mass of southern elephant seals from Kerguelen Islands. Proc. R. Soc. B, 20201544.http://dx.doi.org/10.1098/rspb.2020.1544

Thèse Julie Mestre (C. Guinet et J.B. Charrassin)

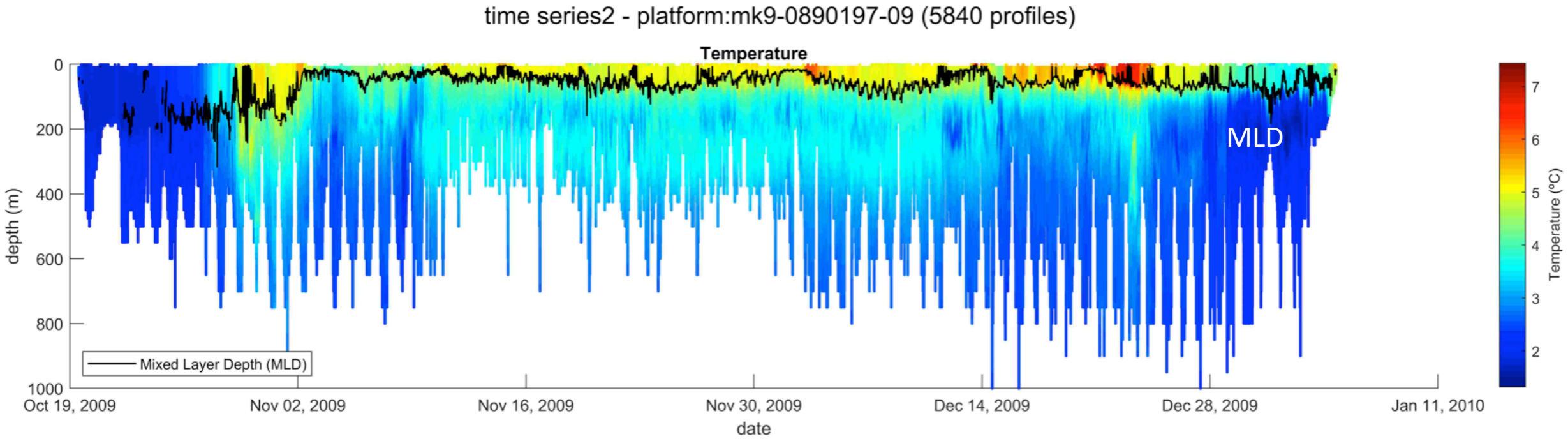
But what are the consequences of all the changes on Southern Ocean ecosystems? The elephant seal approach



Temperature & Salinity



High frequency MLD from SES data



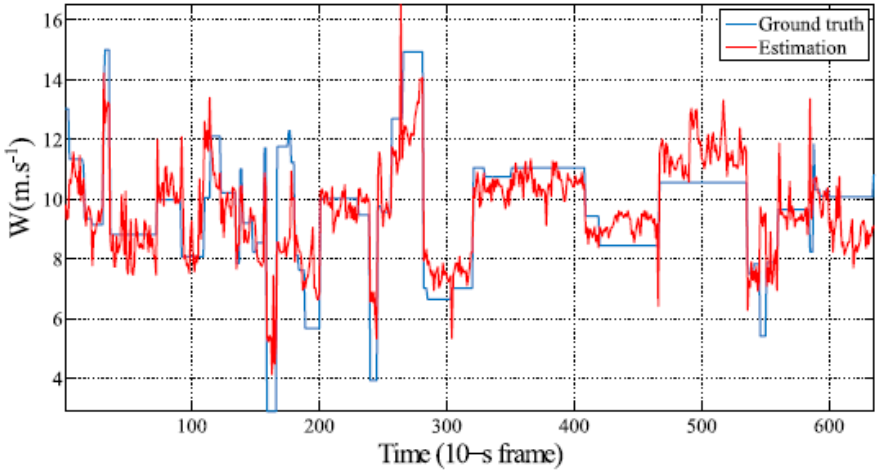
Thèse L. Le Ster (CEBC-LOV)

Hydrophone + accelerometer

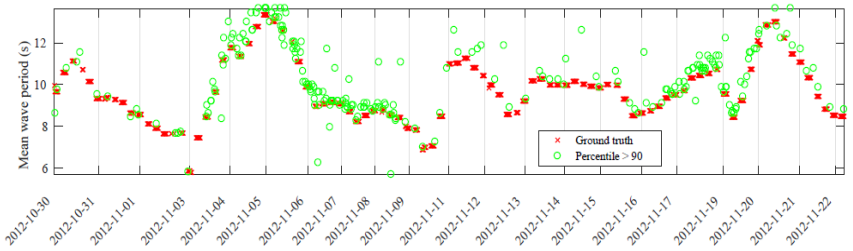
CAZAU D., BONNEL J., JOUMA'A J., LE BRAS Y., GUINET C. (2017) Measuring the marine soundscape of the Indian Ocean with Southern Elephant Seals used as acoustic gliders of opportunity. Journal of Atmospheric and Oceanic Technology. DOI: 10.1175/JTECH-D-16-0124.1

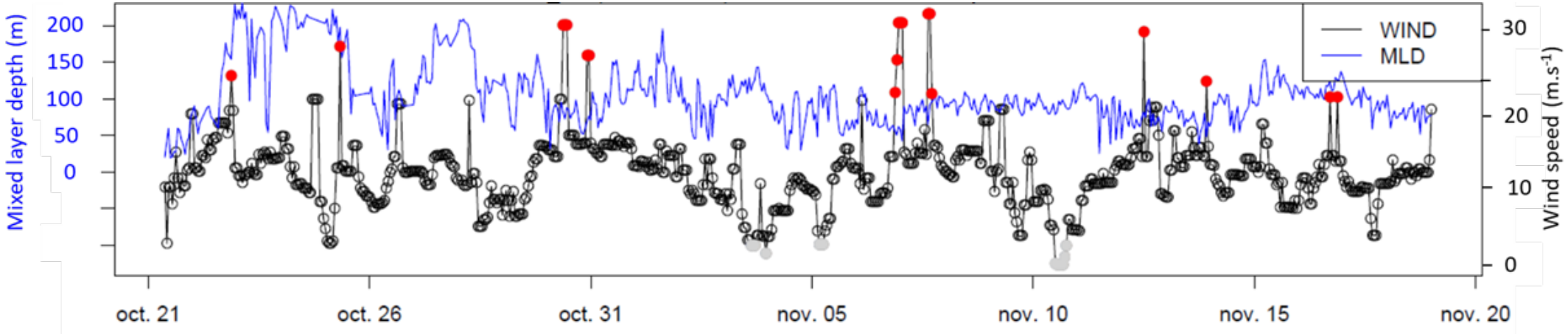
CAZAU, D., PRADALIER, C., BONNEL, J., GUINET, C., (2017) "Do Southern Elephant Seals Behave Like Weather Buoys?", Oceanography,

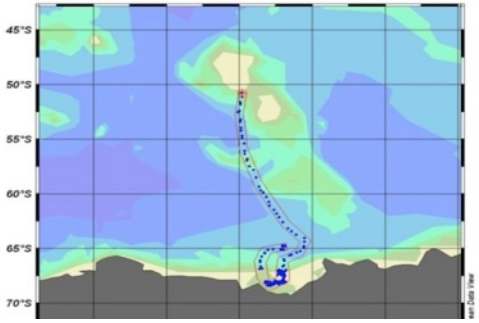
In-situ estimations from the noise level recorded by SES when diving

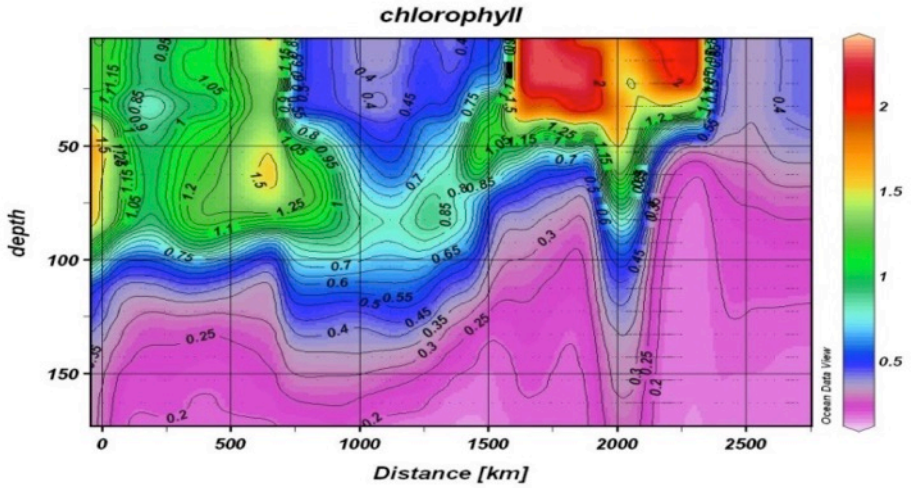


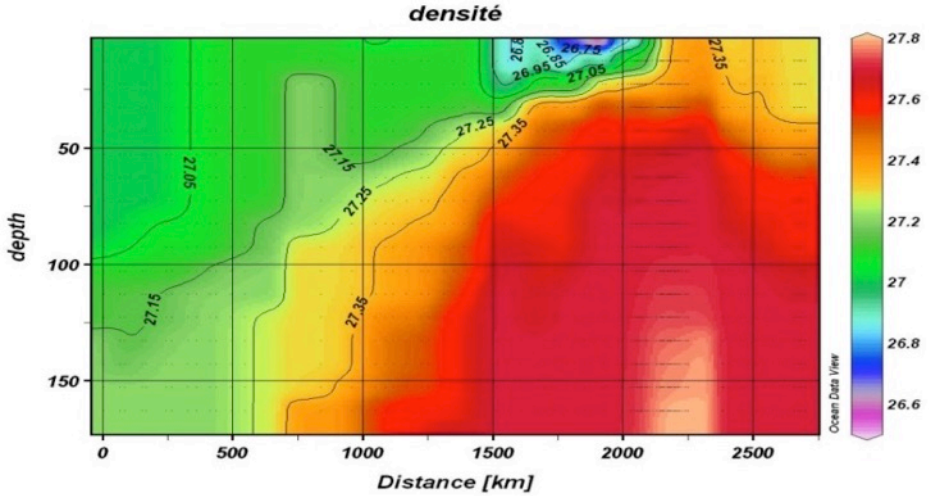
Waves frequency and amplitudes (acceleration)

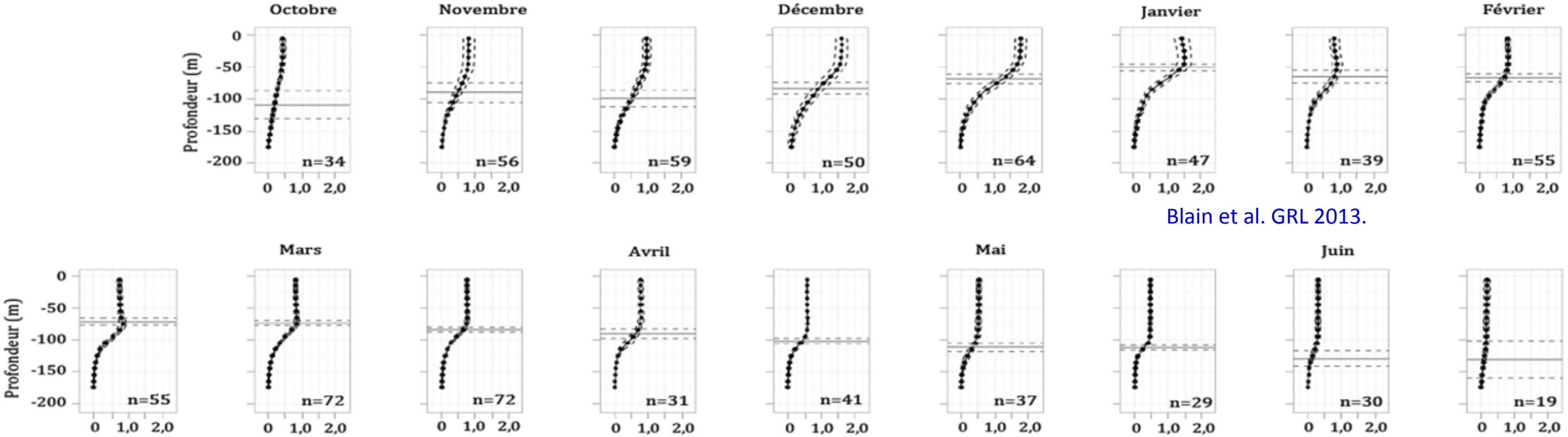








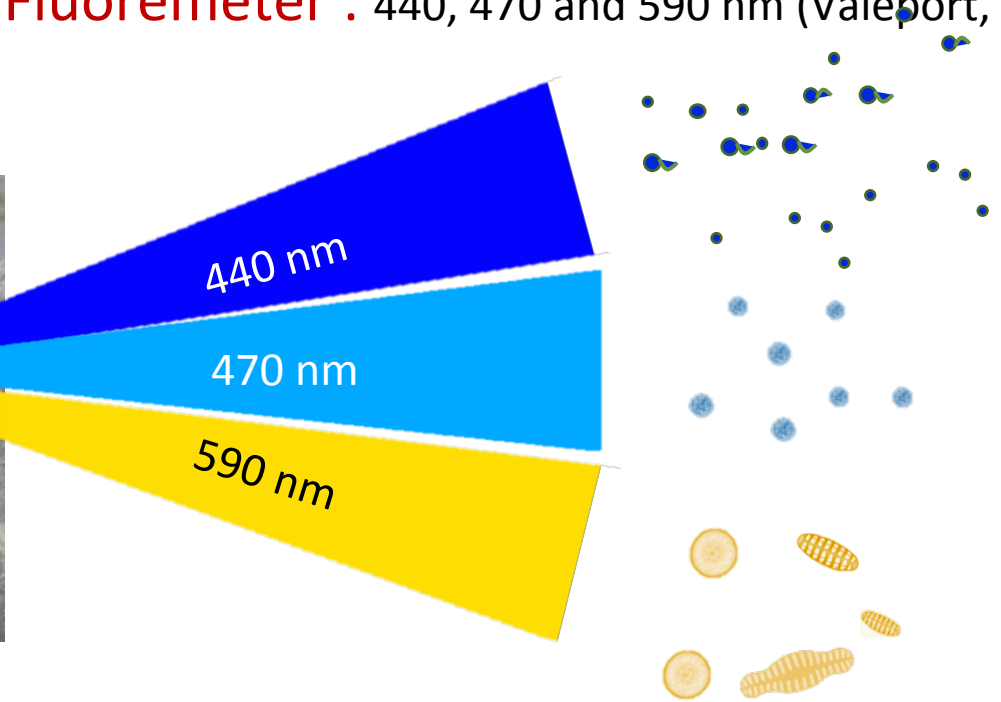


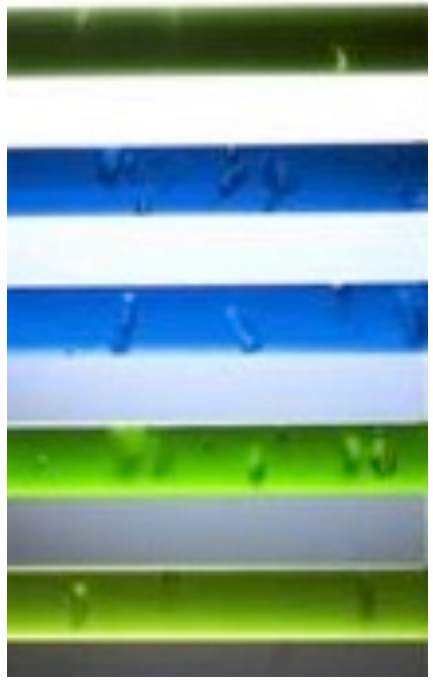


Blain et al. GRL 2013.

In-situ evaluation of the composition of phytoplankton community

Under development : Multispectral Fluoremeter : 440, 470 and 590 nm (Valeport, UK)

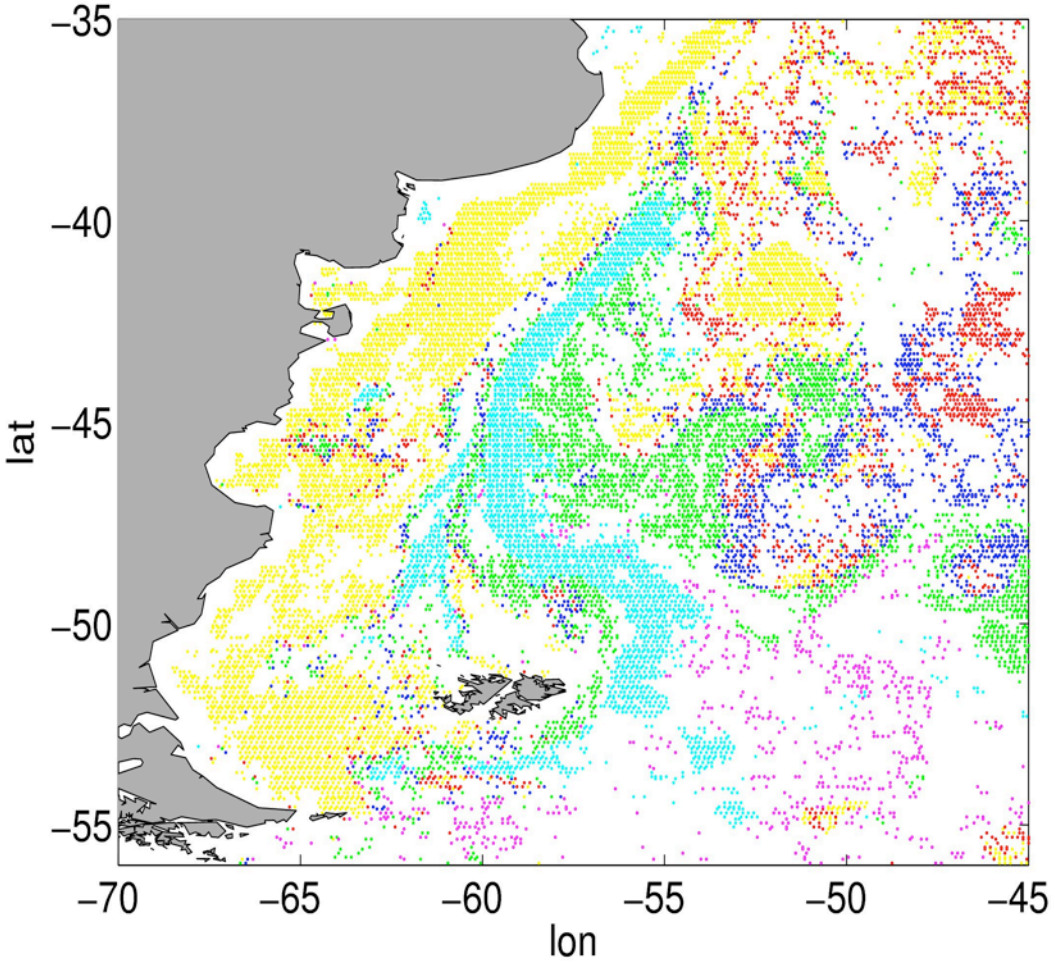


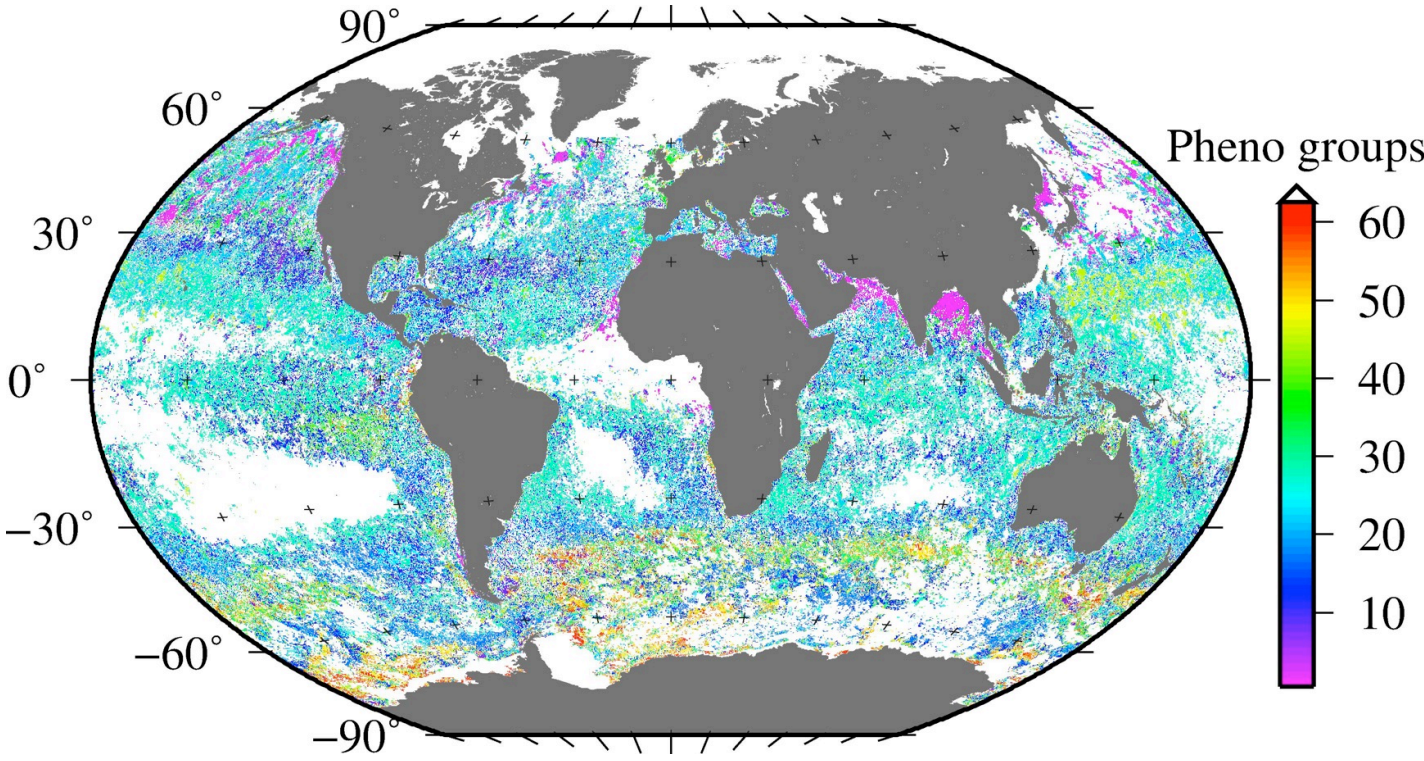


The multi-spectral fluorescence approach is based on selective excitation of the different chlorophylls [Chl-a, Chl-b, Chl-c] and pigments [phycocyanin, fucoxanthin, peridin, phycoerythrin…] highly specific to phytoplankton taxonomic groups and provides a fluorescence “fingerprint” of the main ones.

PHYSAT: Assessing Phytoplankton Functional Groups

Change in phytoplankton community composition changes over the last 20 years. (L. Le Ster Thèse CEBC-LOV)

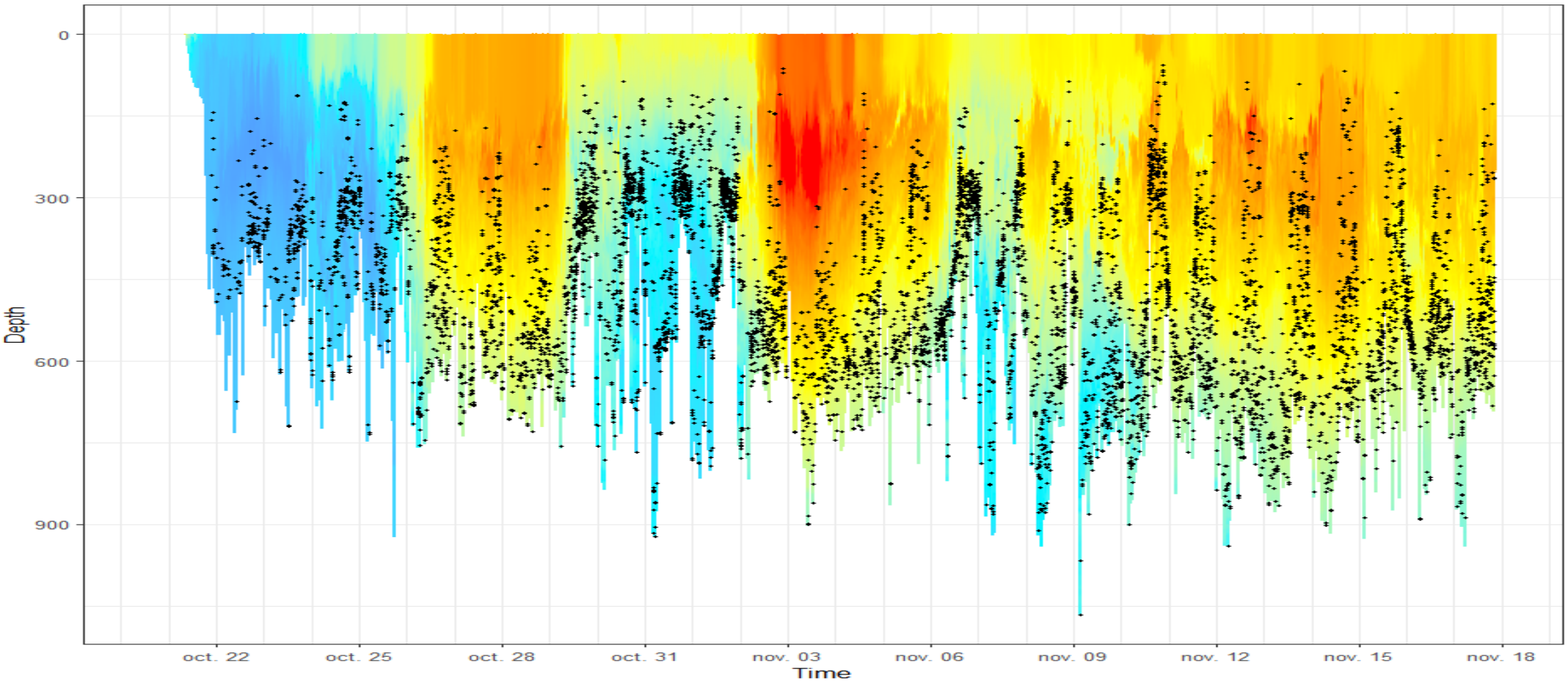


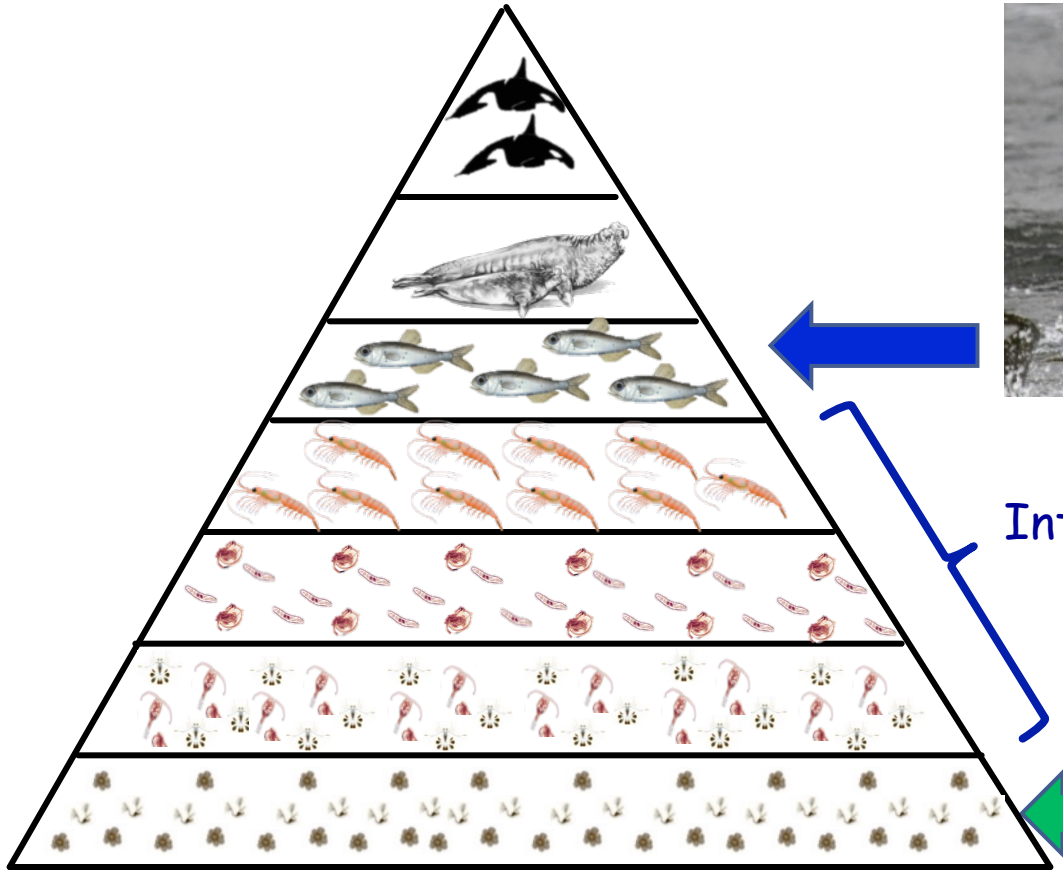


Alvain S. HDR

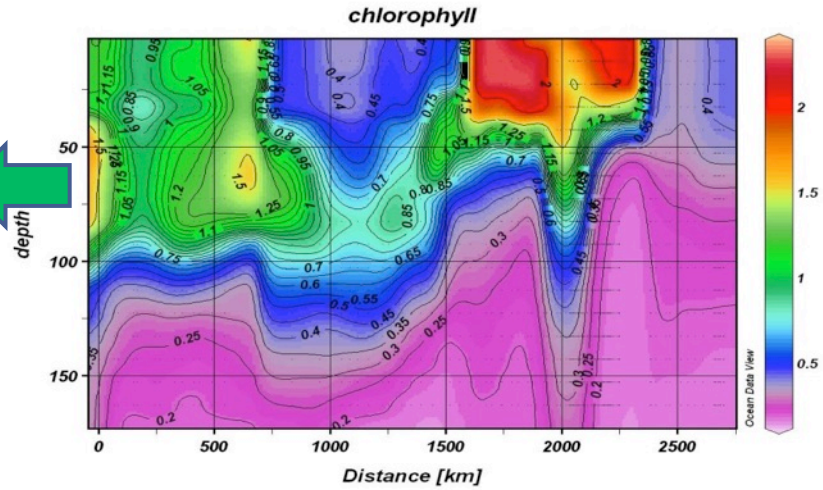
D'Ovidio et al. 2010. PNAS

diatoms (green),
Prochlorococcus (red),
Synechococcus (dark blue),
nanoeukaryotes (yellow),
Phaeocystis (magenta),
coccolithophorids (cyan).


0
300
600
900
Depth
oct. 22
oct. 25
oct. 28
oct. 31
nov. 03
nov. 06
nov. 09
nov. 12
nov. 15
nov. 18
Time
Temperature (0C)
8.0
6.0
4.0
2.0
0.0
-1.8



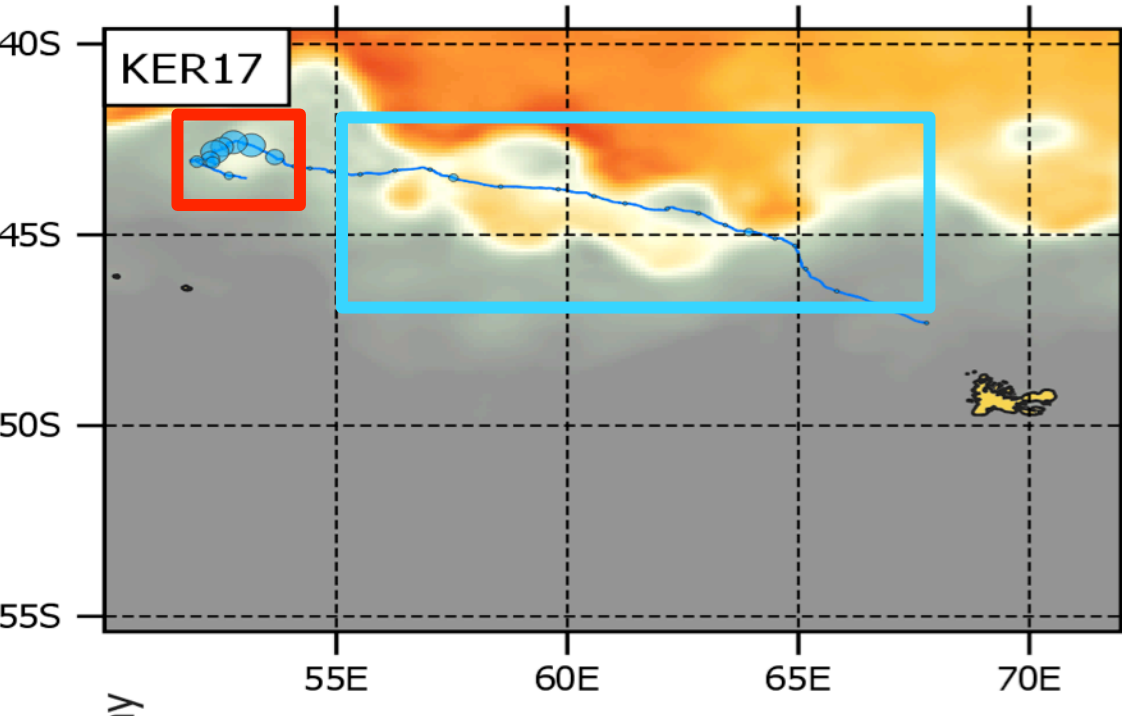
Intermediate levels ?

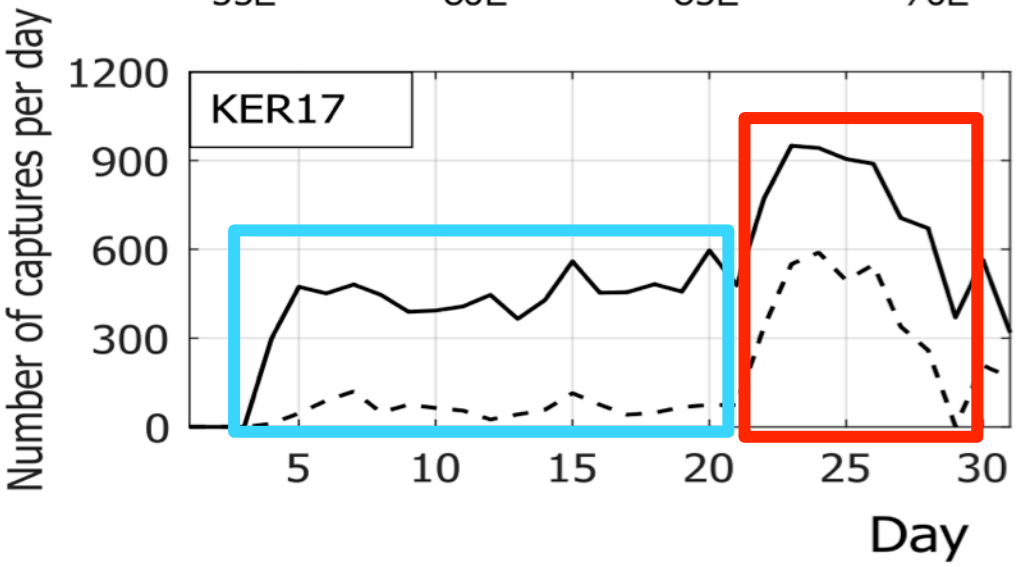


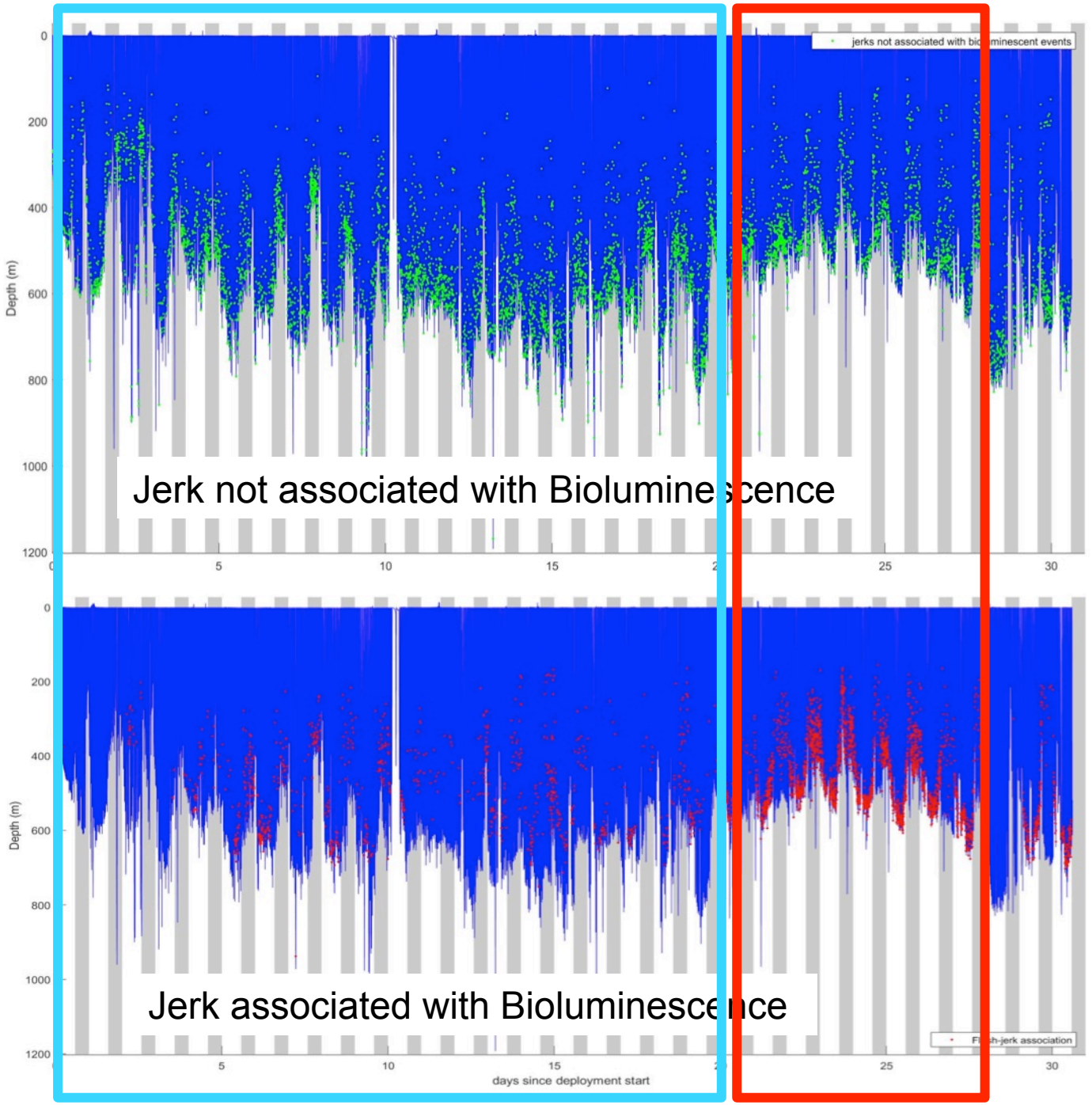
Developping new biollogging techniques to observe and investigate intermediate trophic levels

(Collaboration M. Johnson & P. Goulet Sea Mammal Research Unit)

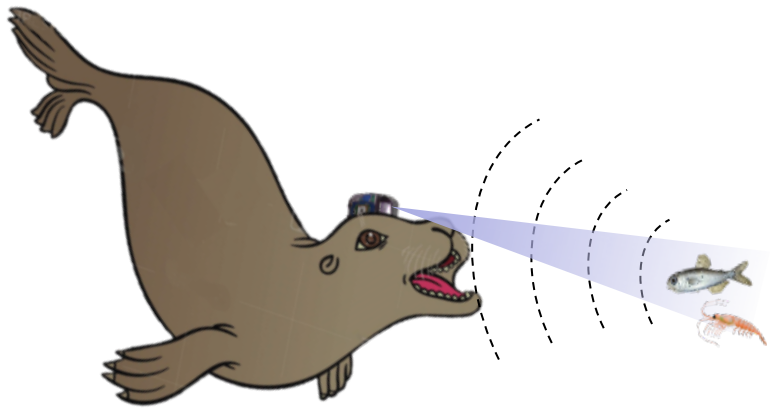
High sensitivity-High frequency 50 hZ sampling Light sensor

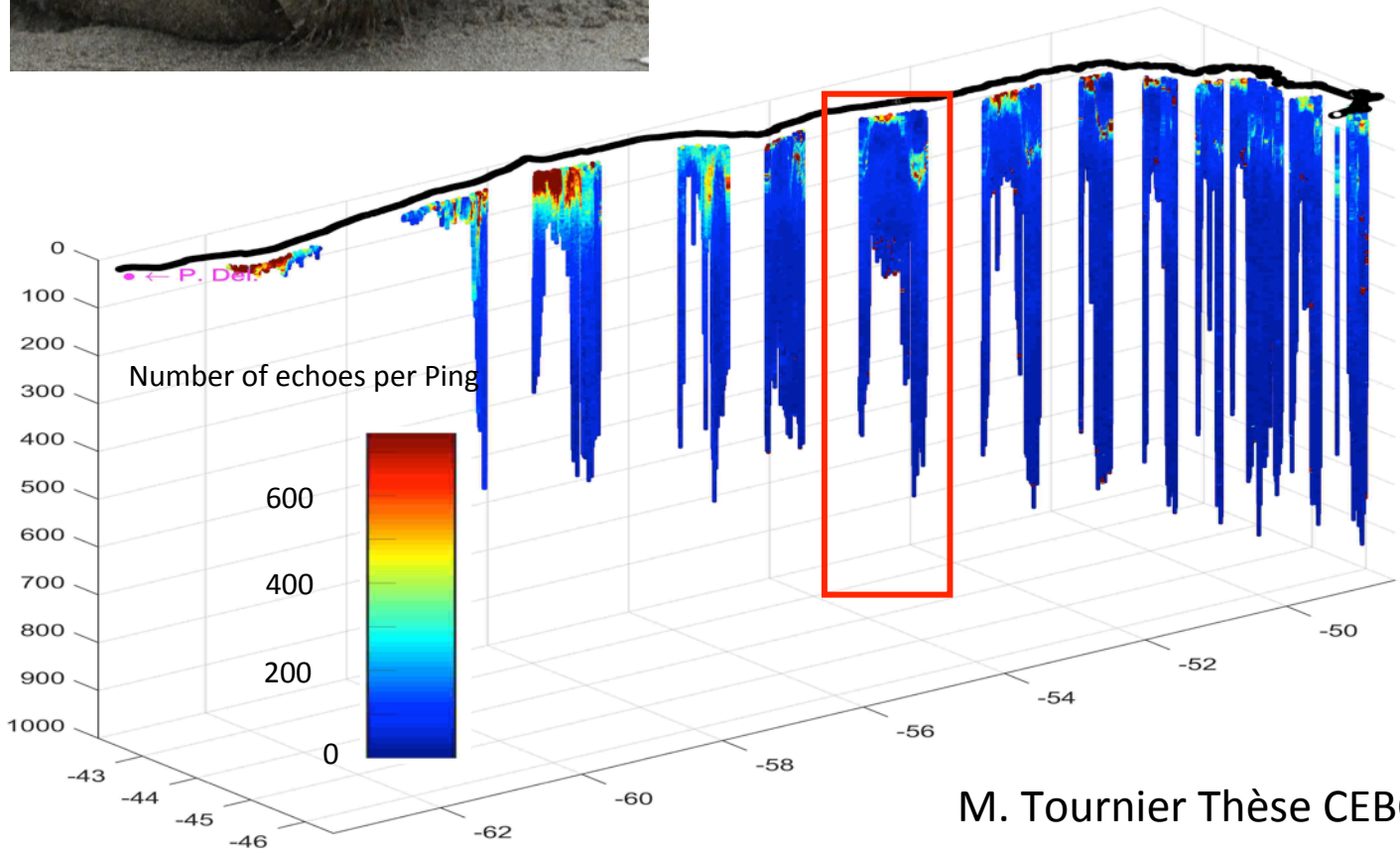




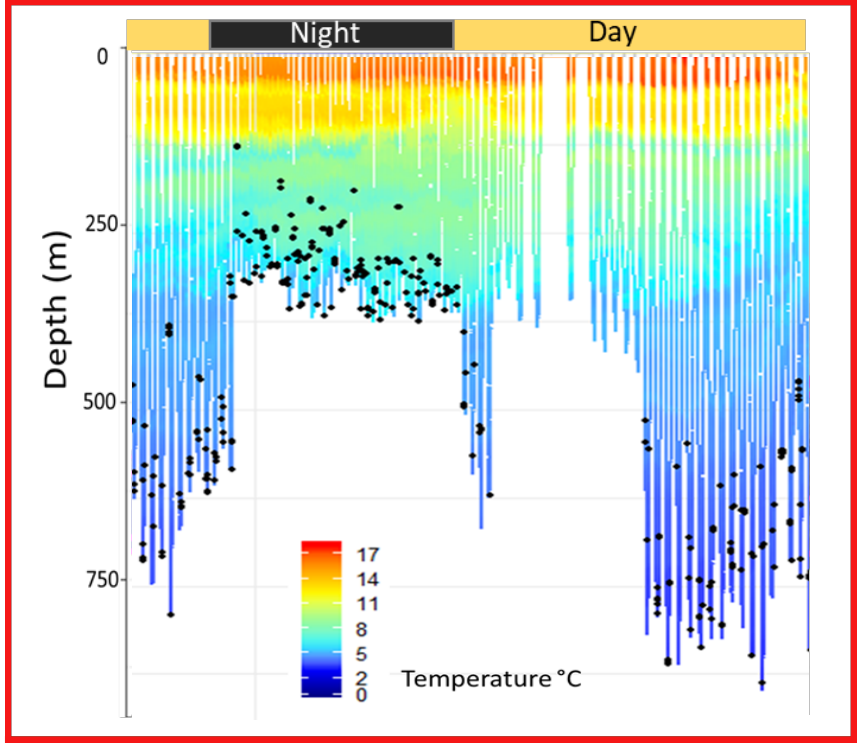


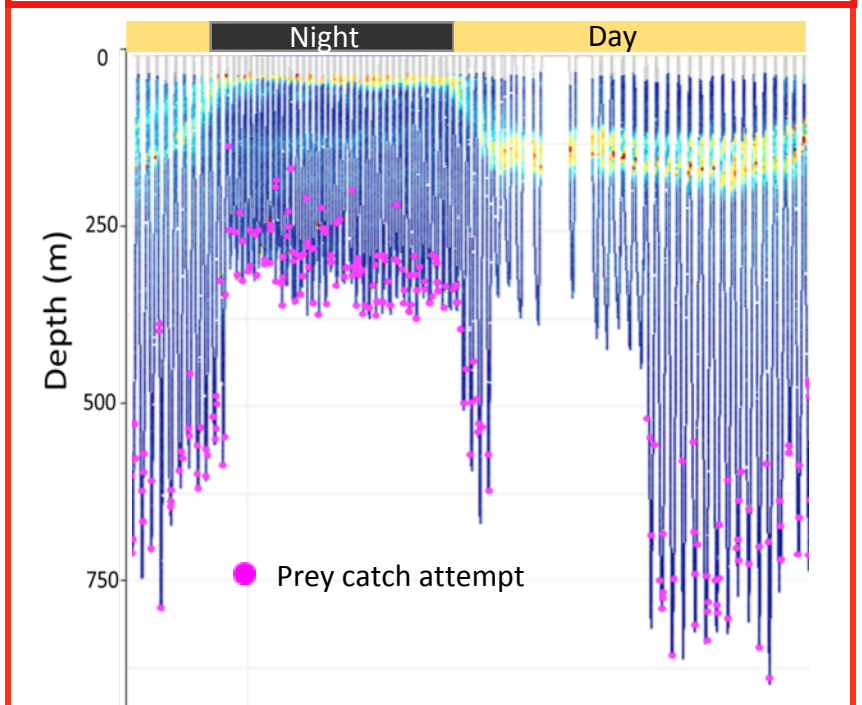
Goulet et al. 2020 J. Exp. Biol.





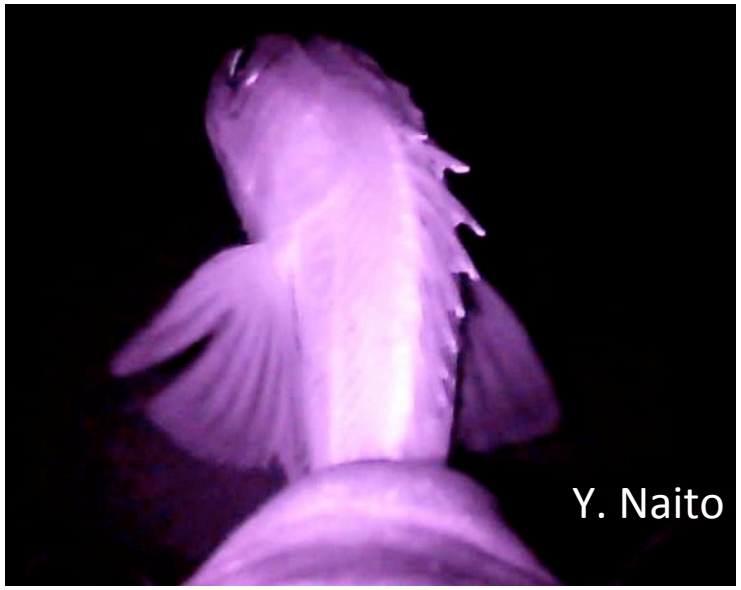
M. Tournier Thèse CEBC

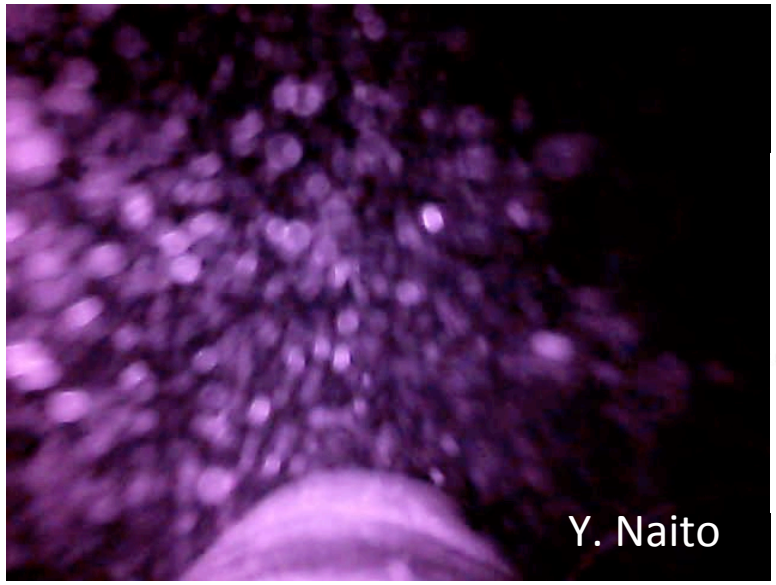


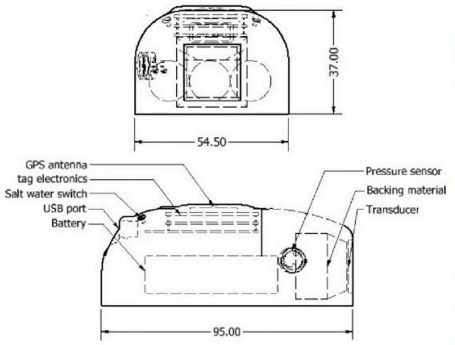


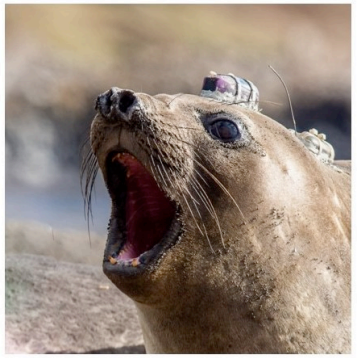
Dominique Filippi

Under development: a micro-camera





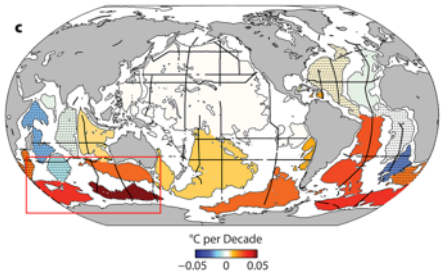


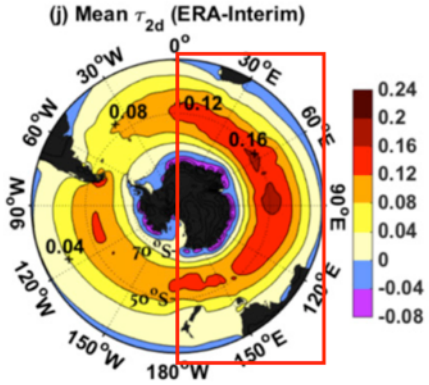


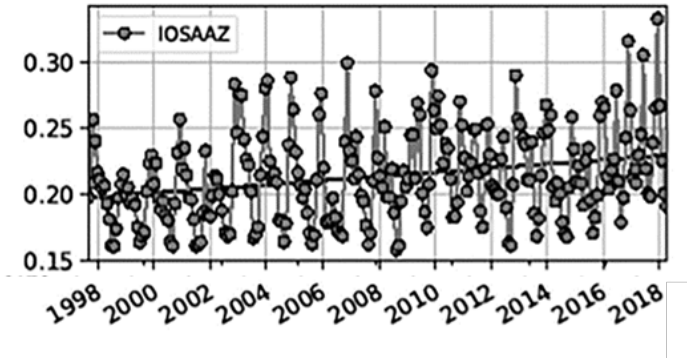
Naito : video camera (not sharp enough to identify small organisms (zooplankton taxonomic groups)

The Indian sector of the Southern Ocean constitute a unique multidisciplinary Study Site located in a rapidly changing Environnement with existing long term time series: KerTrend project (F. D'Ovidio PI)

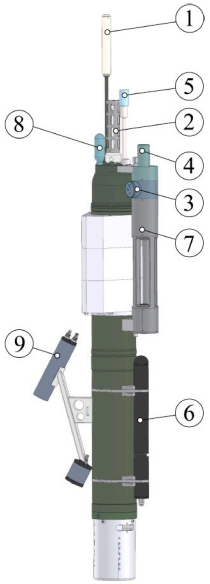
Zones Ateliers
LTSER FRANCE ANTARCTIQUE



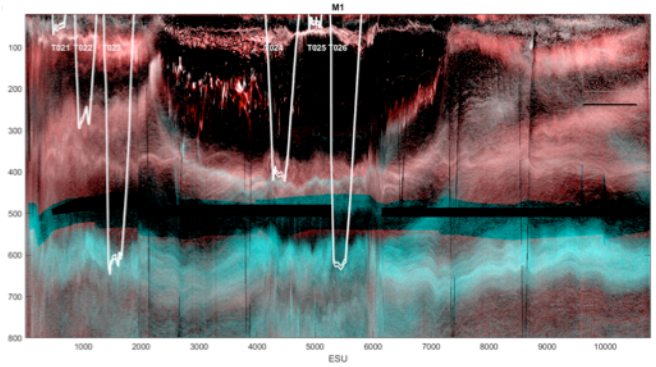




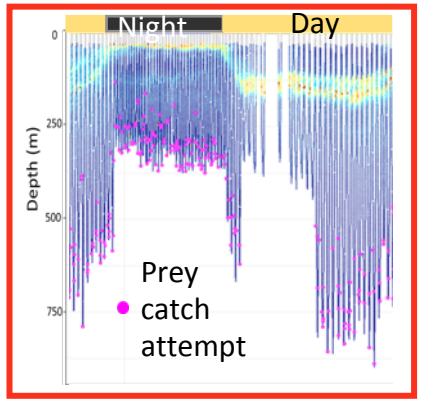
Biogeochemistry profiler



Oceanographic Campaigns



Animal samplers



Long term demographic and population trend monitoring