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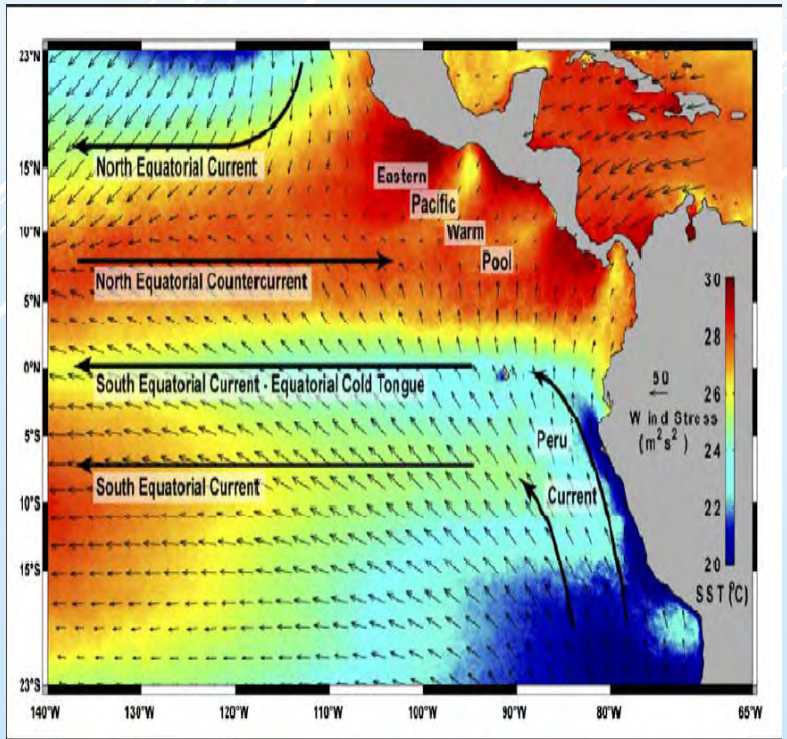
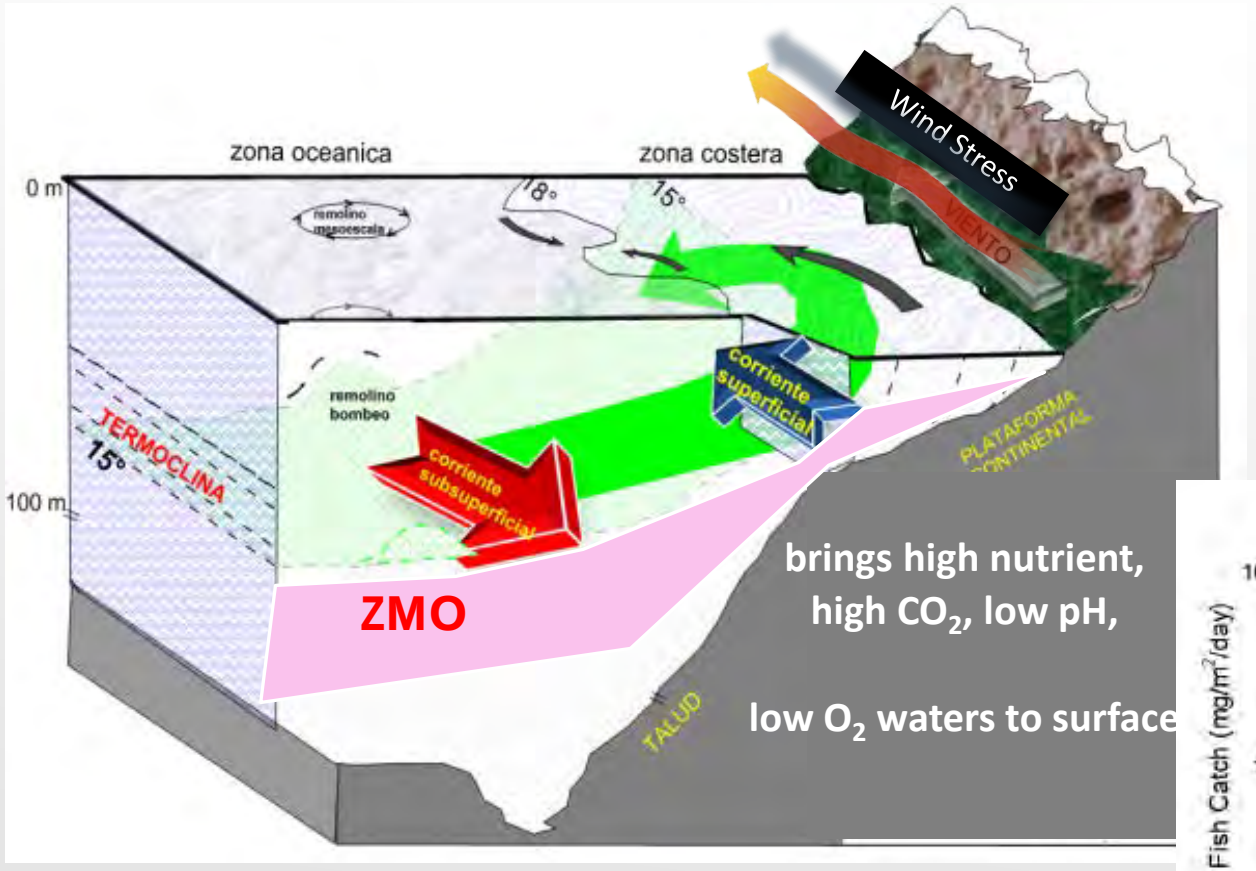
CONNECTIONS BETWEEN THE PERUVIAN COASTAL UPWELLING AND OPEN OCEAN BIOGEOCHEMISTRY WITH THE PLANKTON VARIABILITY

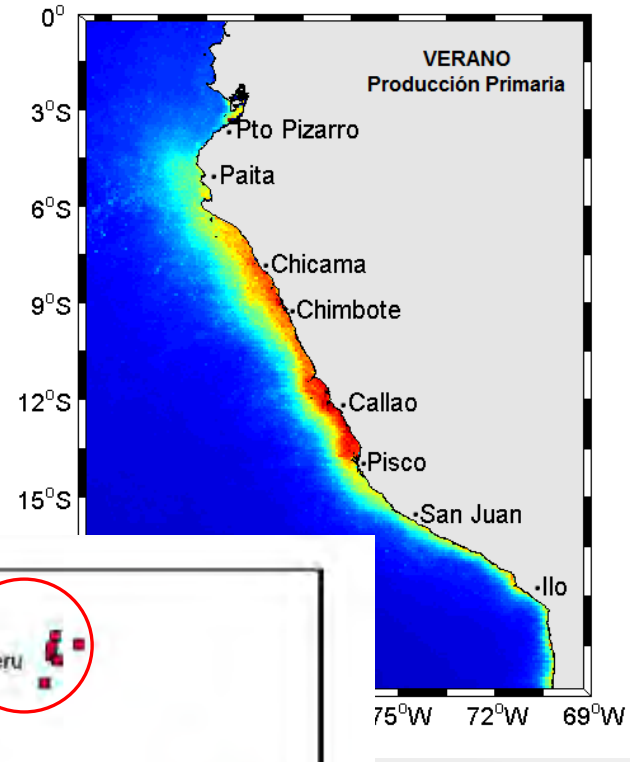
Michelle Graco, *Avy Bernales, Wilson Carhuapoma, Diana Alvites, David Correa, Roberto Quesquén, Jesús Ledesma, Tony Anculle, Georgina Flores, Octavio Morón and Dimitri Gutiérrez*

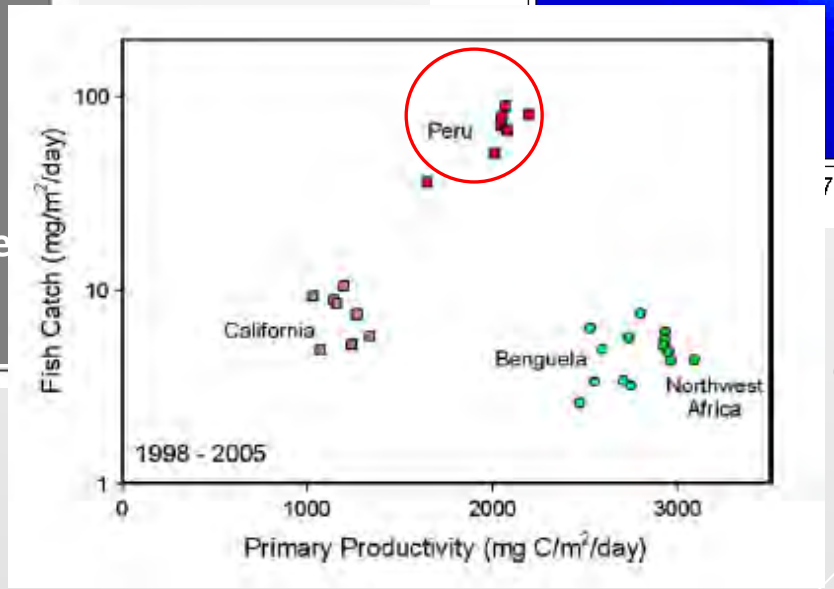


Project: Integrated Study of the Coastal Upwelling of Central Perú

Libro de Oro IMARPE, 2014





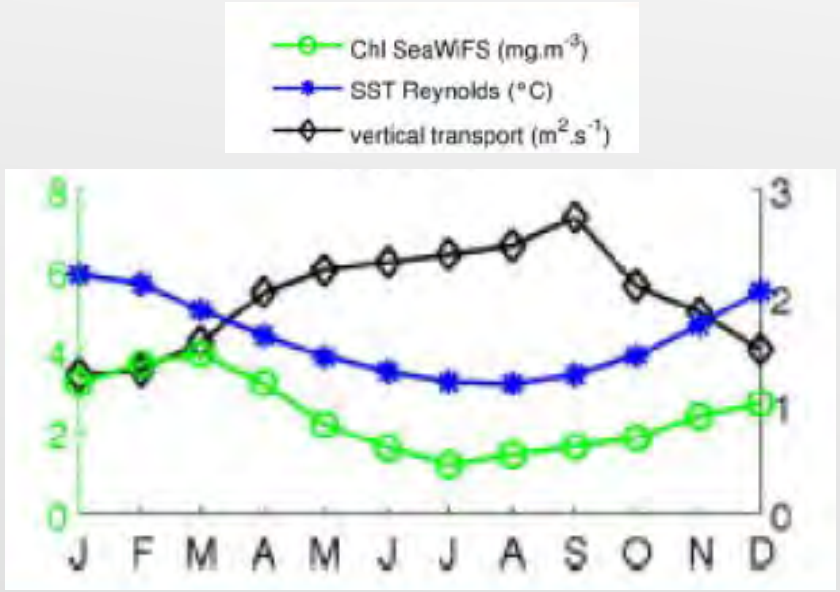


Chávez et al., 2008

PERUVIAN COASTAL UPWELLING SYSTEM, PRODUCTIVE, NATURALLY SOUR AND BREATHLESS

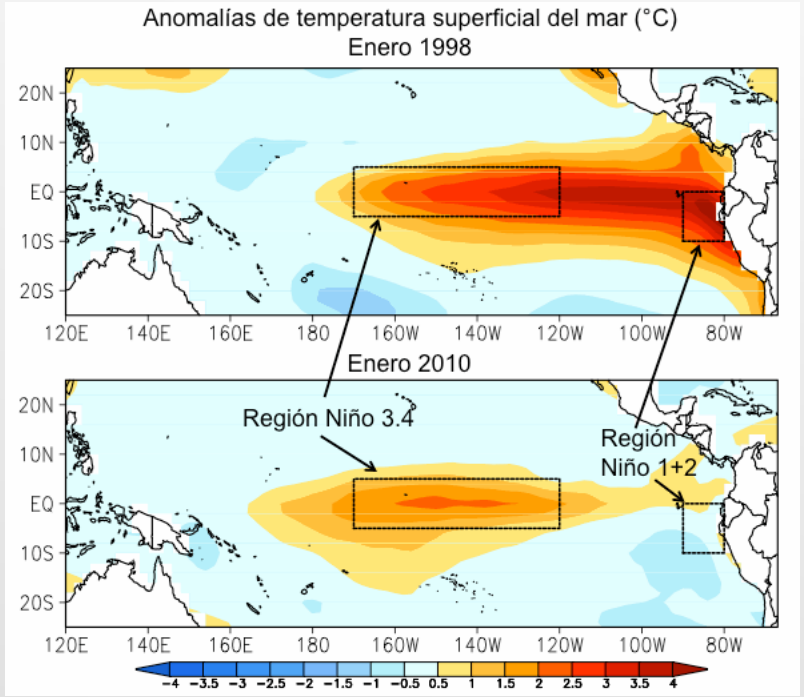
IN A HIGH VARIABILITY

Seasonal Variability -winds



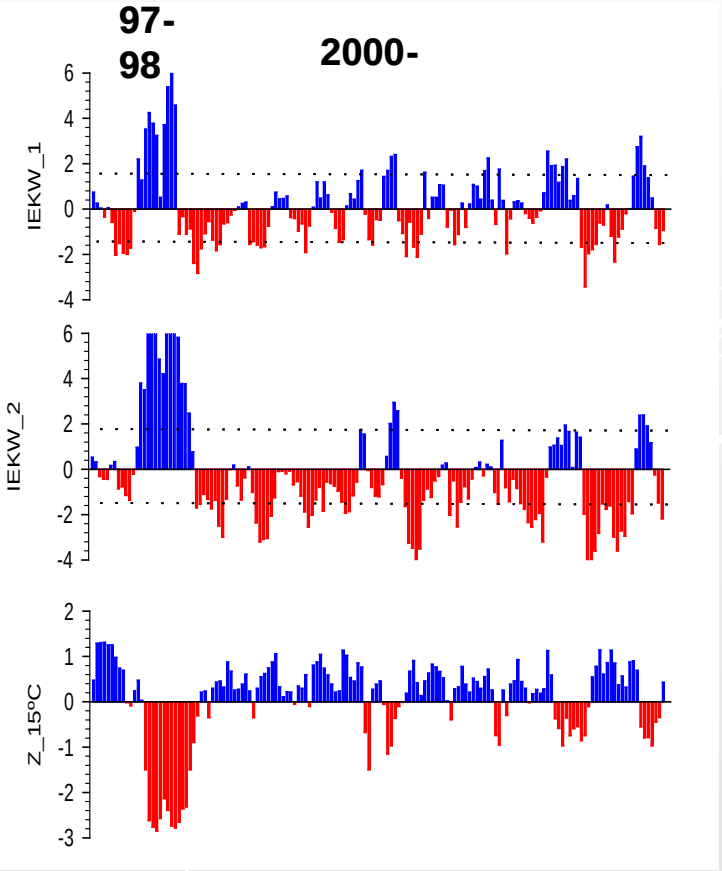
Chavez et al.,PIO 2008

Interannually- El Niño



http://www.met.igp.gob.pe/variabclim/indices.html

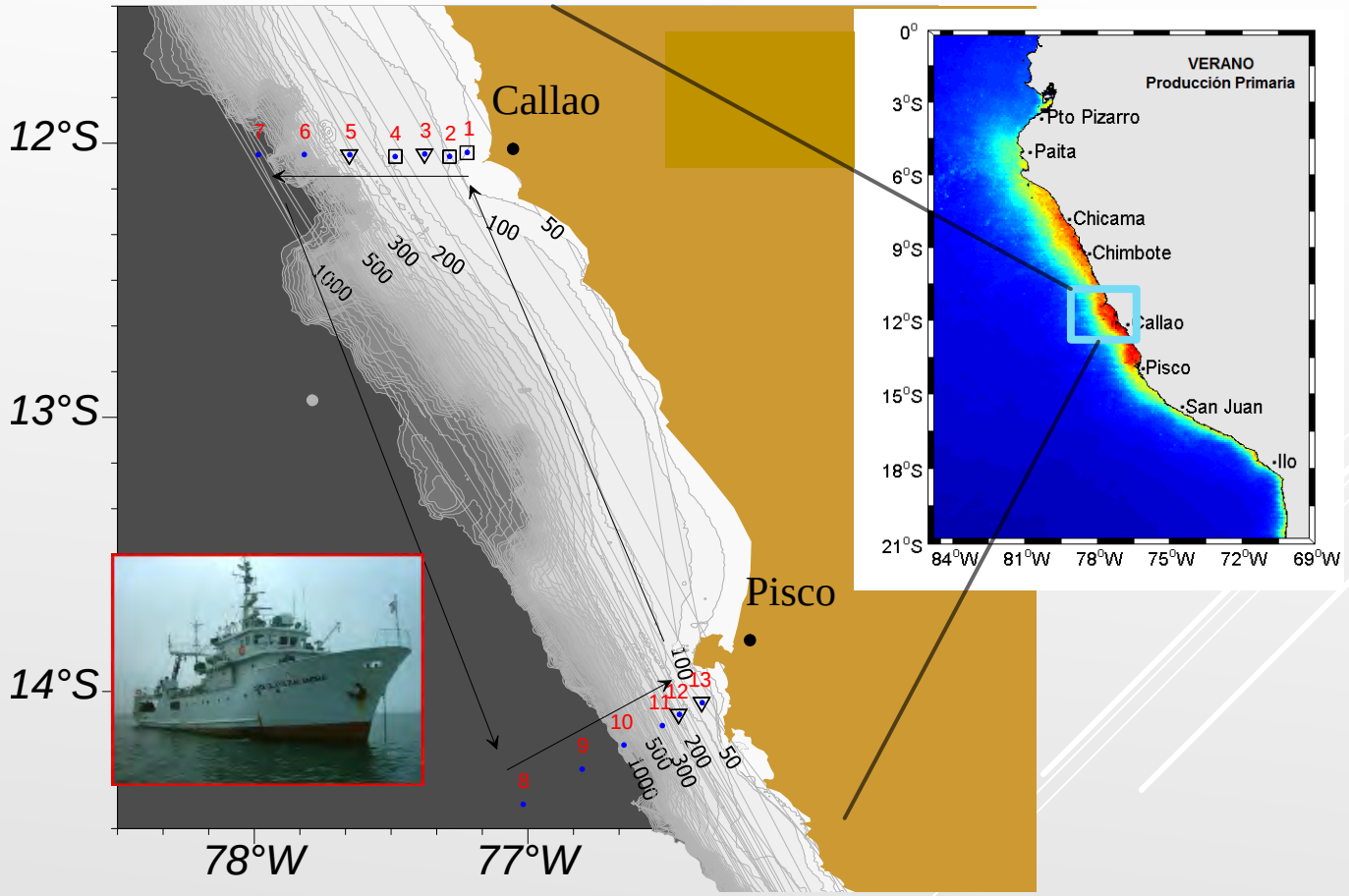
Remote forcing/ local processes



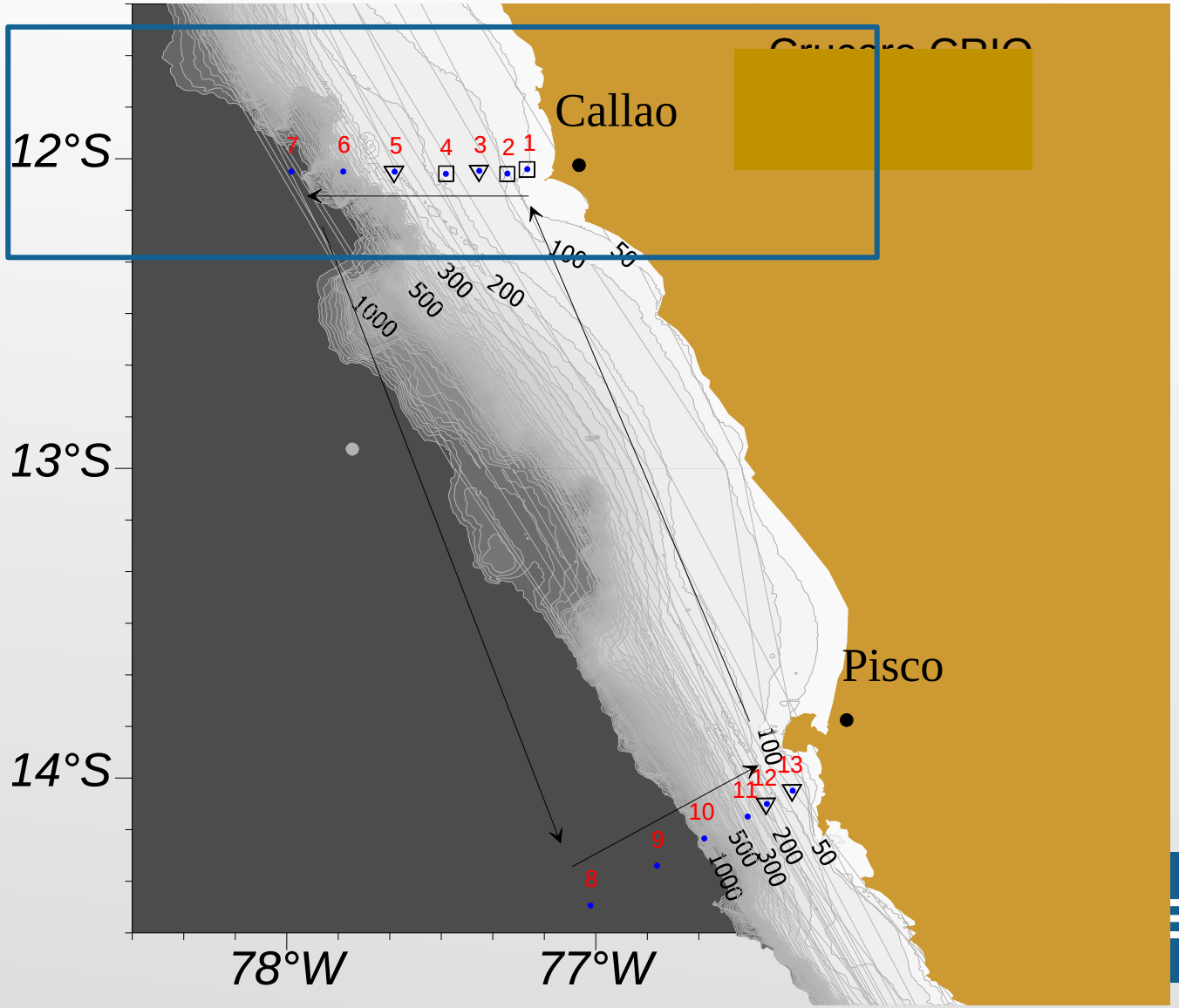
Graco et al. Biogeoscience 2017.

PROJECT: "INTEGRATED STUDY OF COASTAL UPWELLING"

ACTIVITIES	2013- 2017---and more
Callao Field trip- 0-50 mn	February, April, June, August, October, December
CRIO callao-Pisco 0-50 mn	April, August
Data and Analysis	Satellite – winds. Upwelling index. Oceanographic data T (ºC), Salinity (ups) Nutrients, Oxygen, pH. Carbonate system. Phytoplankton, zooplankton Benthos, Sediments (OM, porewater).



To investigate the physical, chemical processes, the atmosphere-oceanic exchange and the planktonic and benthic communities associated to the **Peruvian coastal upwelling**, with emphasis on the **onshore-offshore gradient** off Central Peru and its variability **at different time scales**.

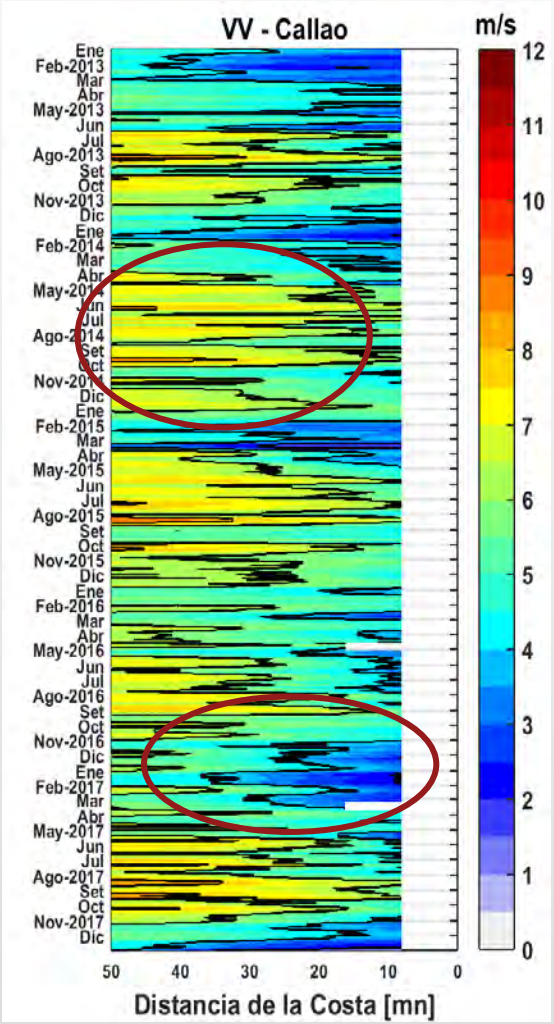

Callao
Pisco
12°S
13°S
14°S
78°W
77°W
1
2
3
4
5
6
7
8
9
10
11
12
13
50
100
200
300
500
1000

ESULTS

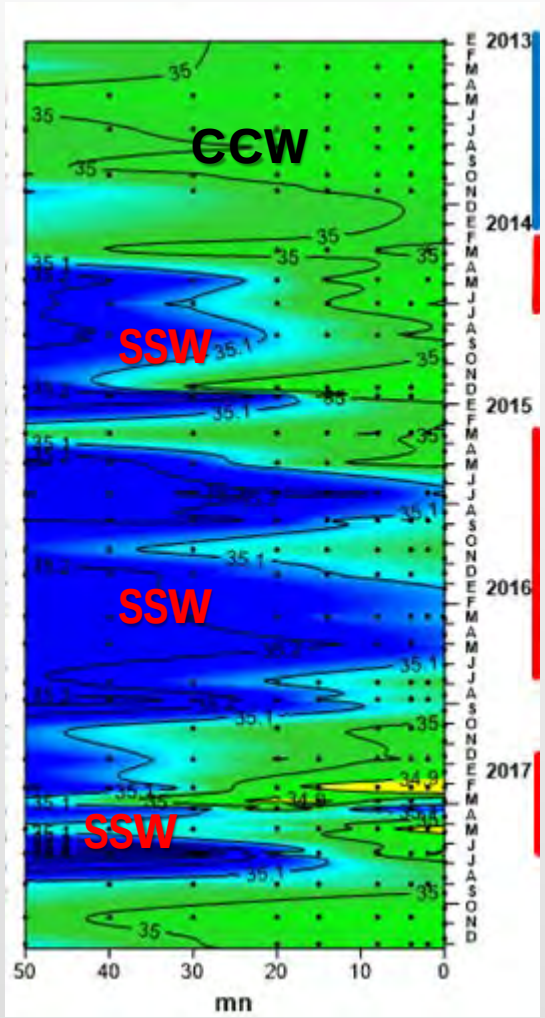
❑ Physical changes (2013 LN- 2014 , 2015-2016 EN, 2017 EN Costero)

Graco et al., 2016 Boletín IMARPE

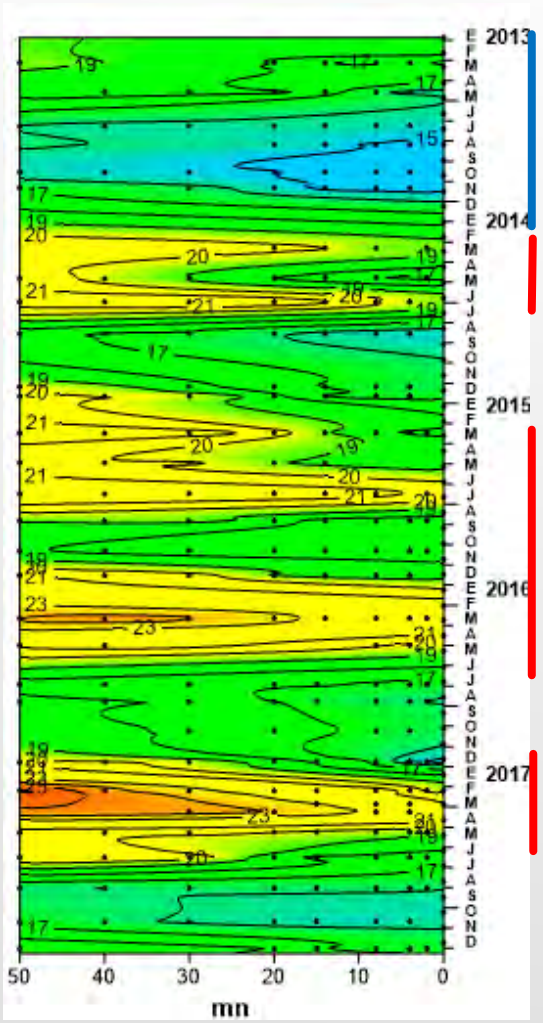
WINDS (m/s)



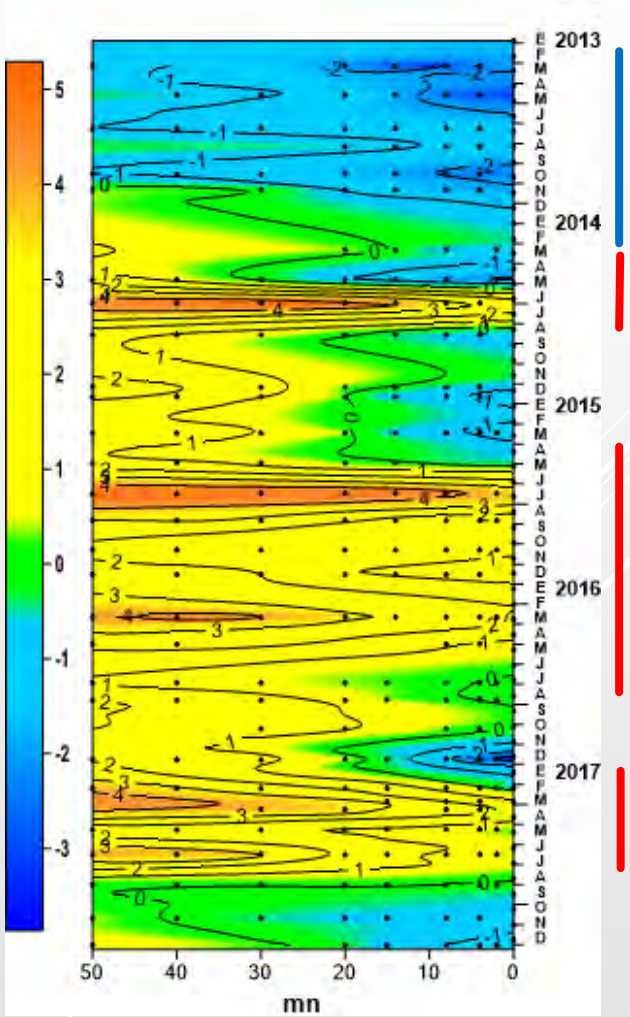
SALINITY



TEMPERATURE (°C)



SST ANOMALIES (°C)



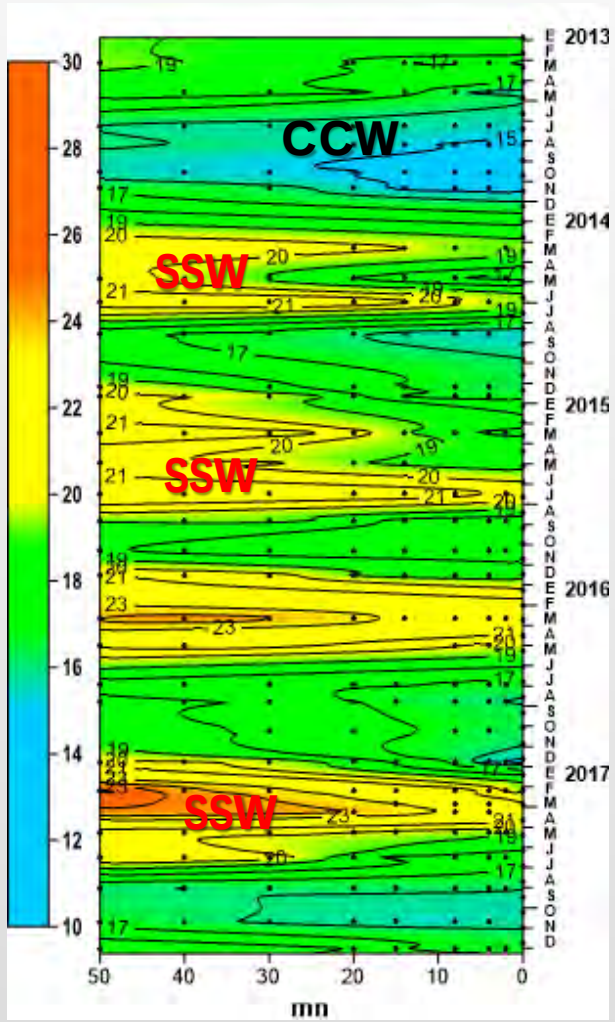
OFFSHORE **COAST**

Strong impact of the remote forcing/ modulated by the local impact of the wind

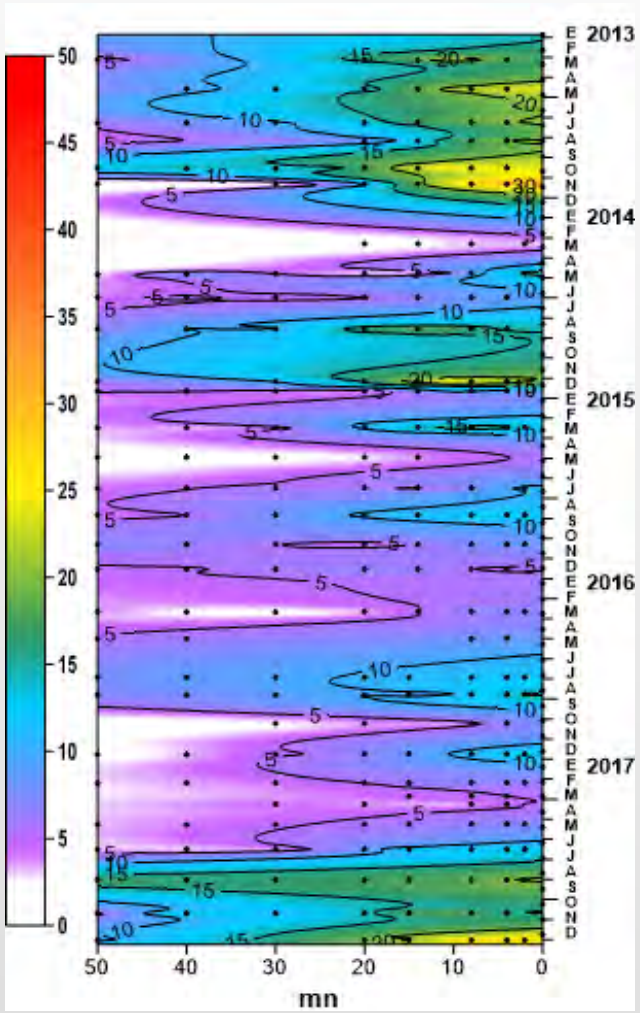
❑ Chemical changes

Graco et al., 2016 Boletín, IMARPE

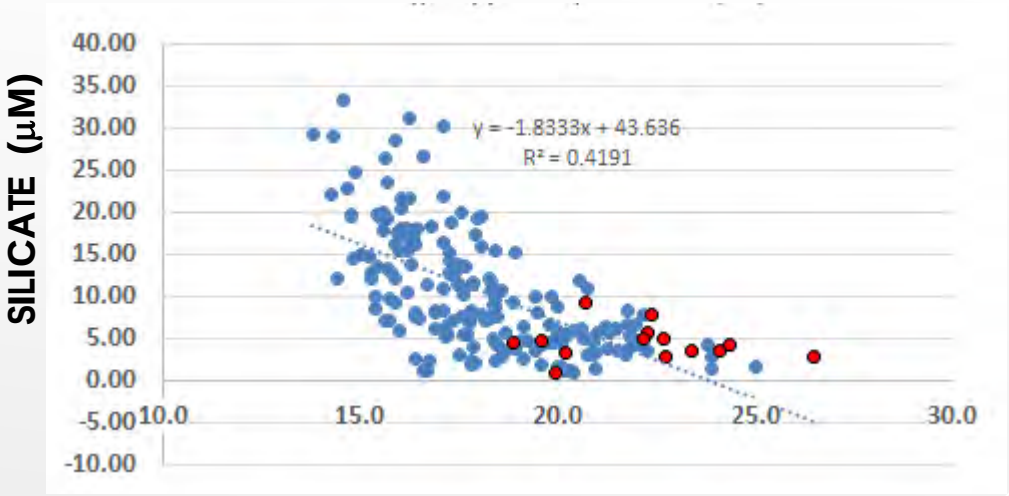
TEMPERATURE (°C)

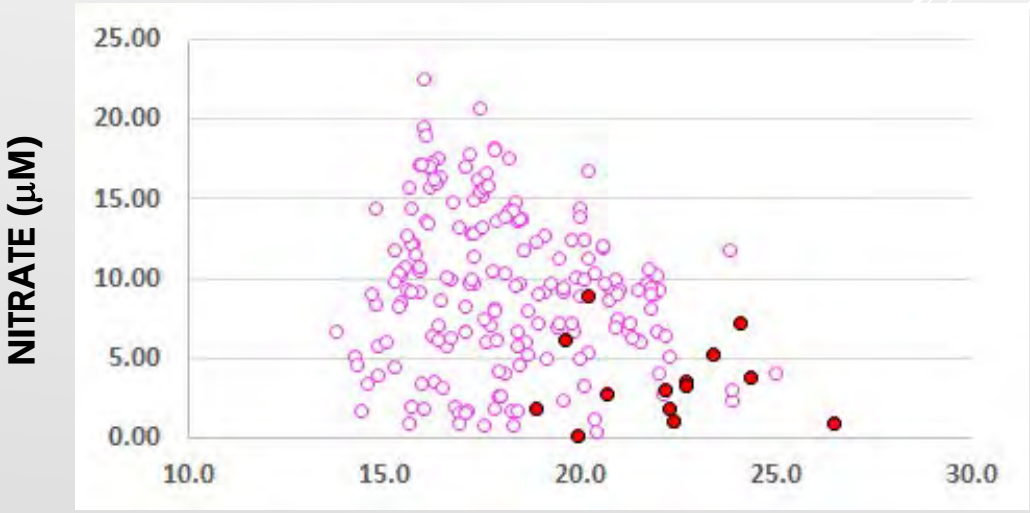


SILICATE (μM)



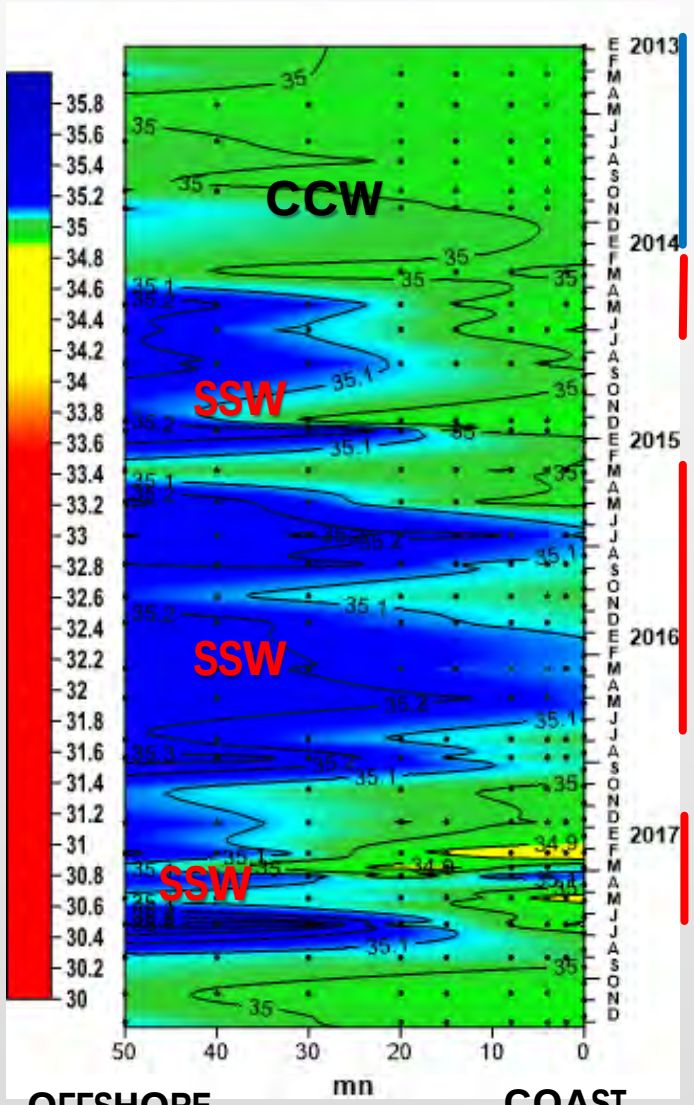
OFFSHORE **COAST**



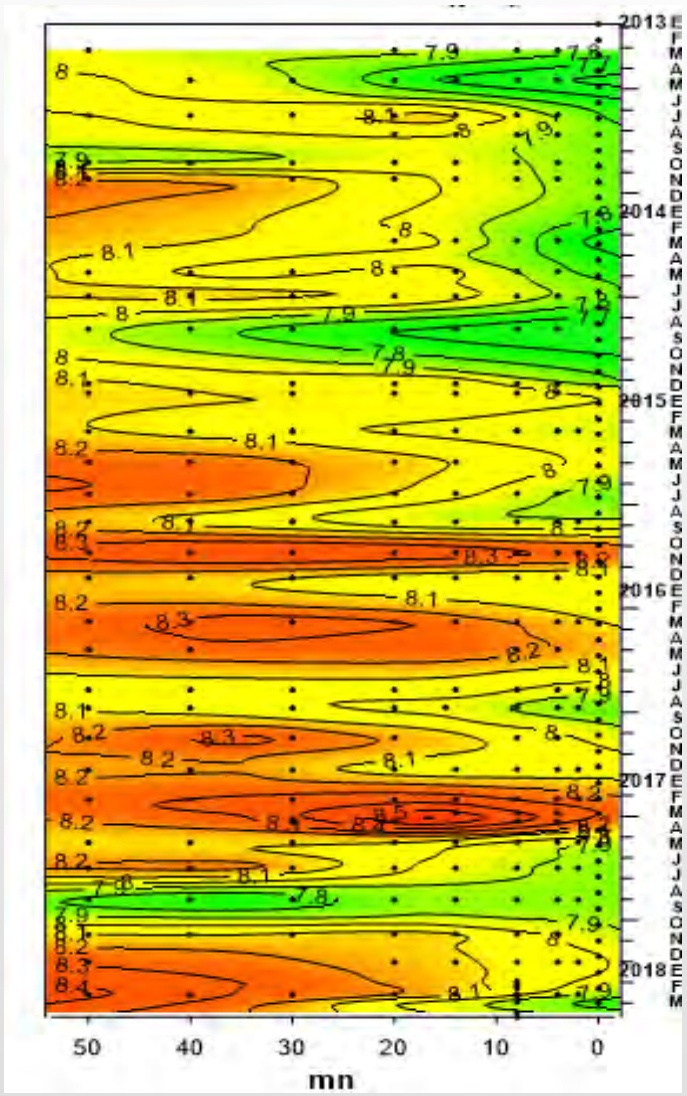


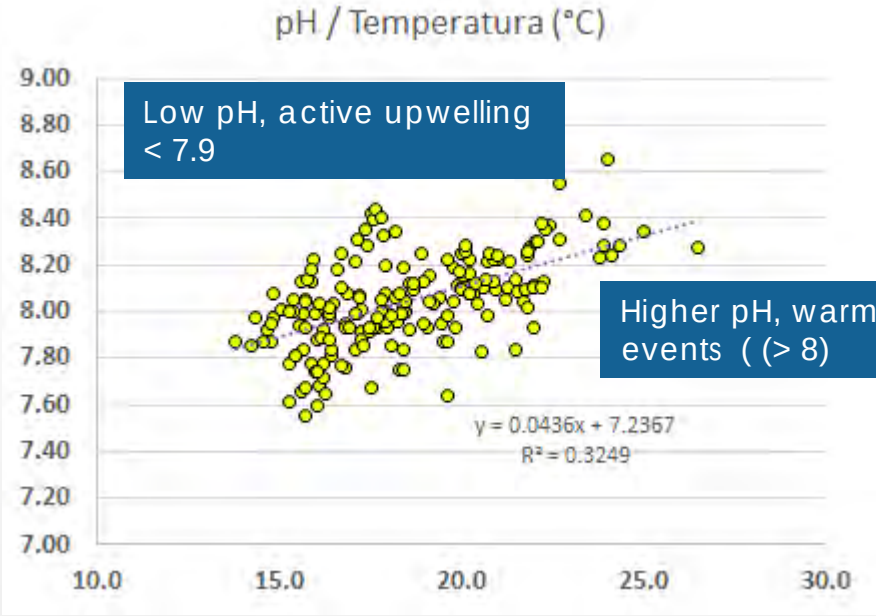
❑ Chemical changes

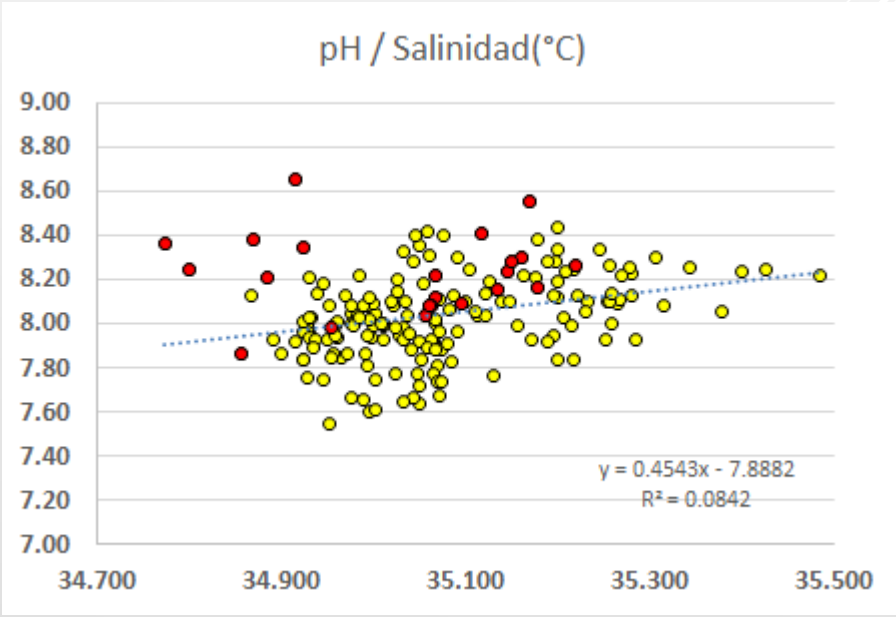
SALINITY



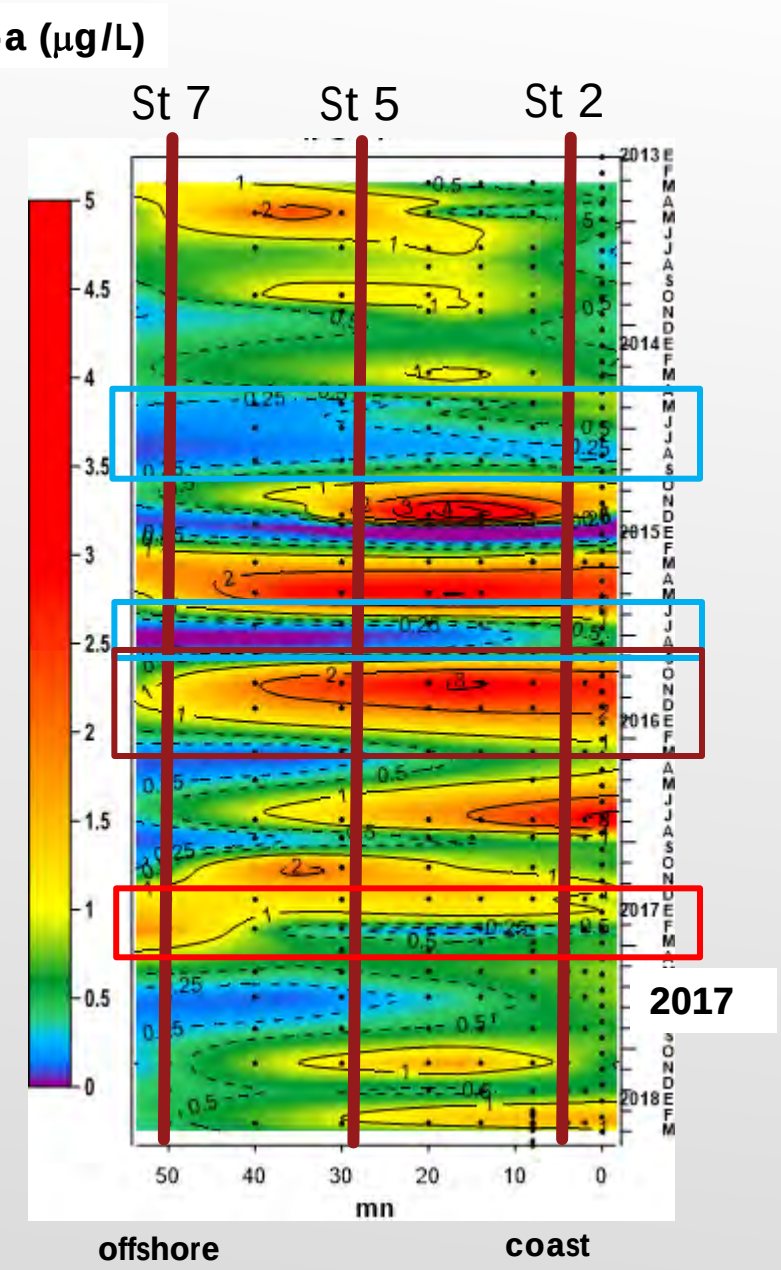
pH

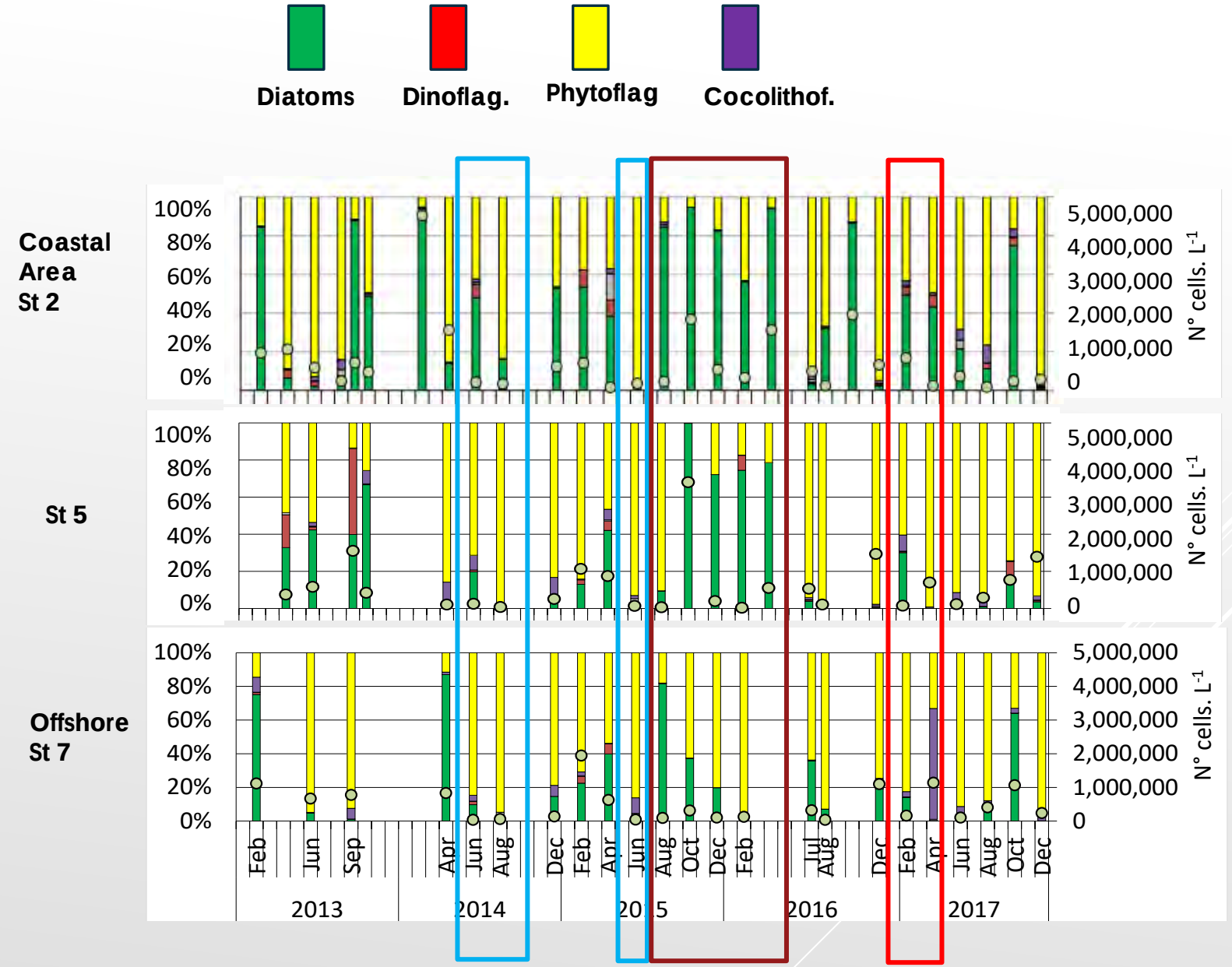






❑ Phytoplankton





Bernales A. en prep.2017
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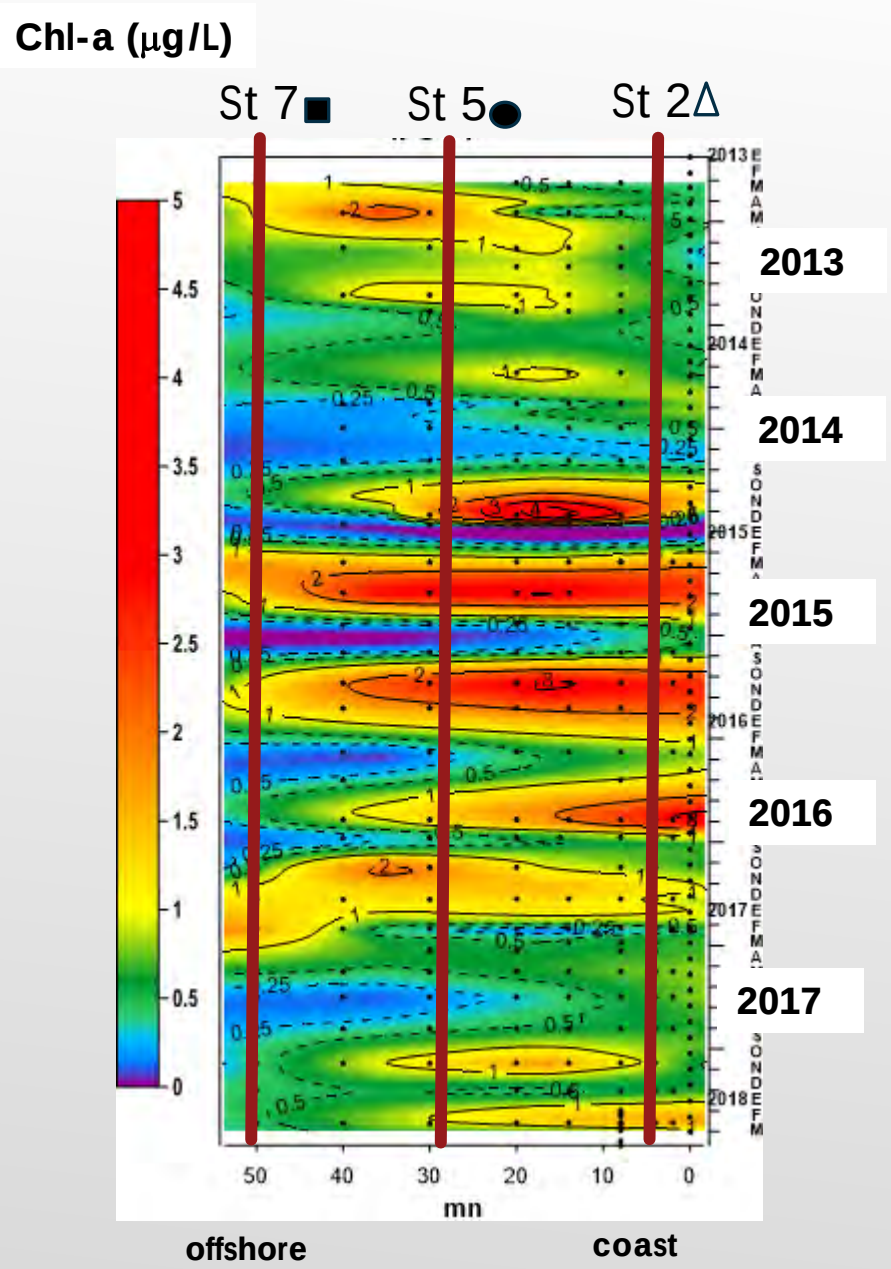
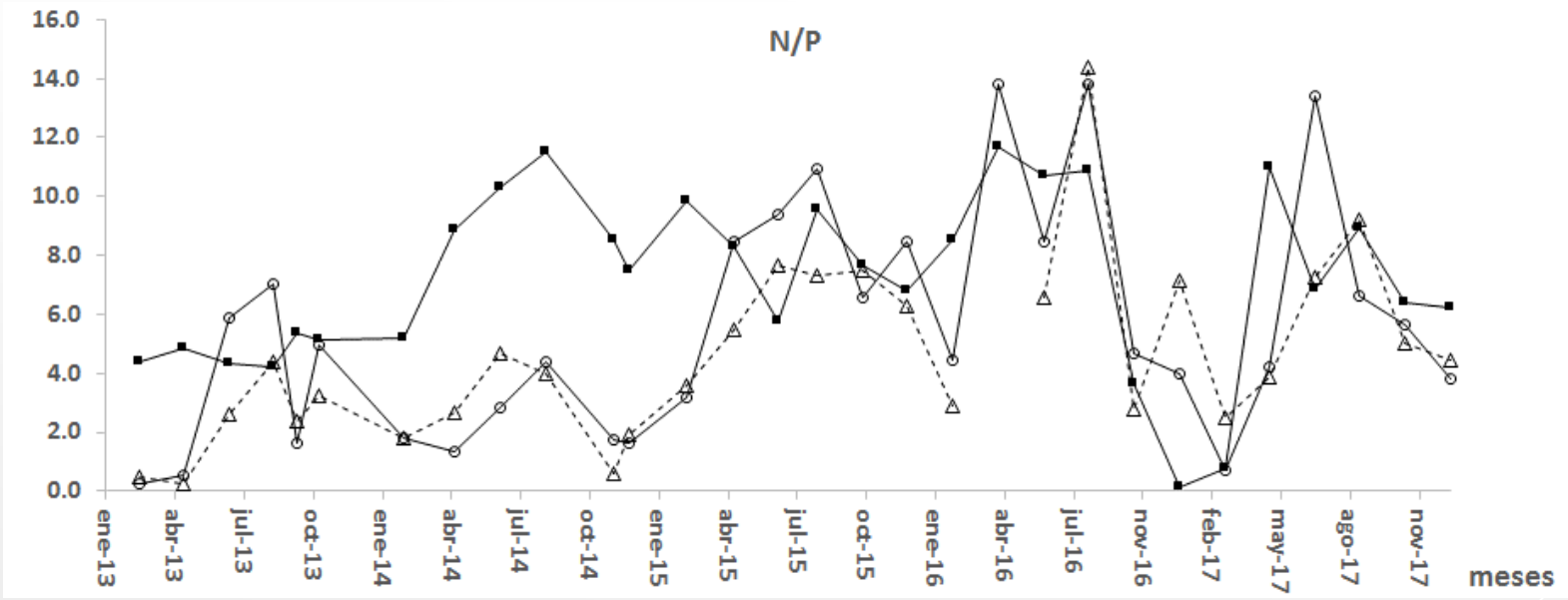
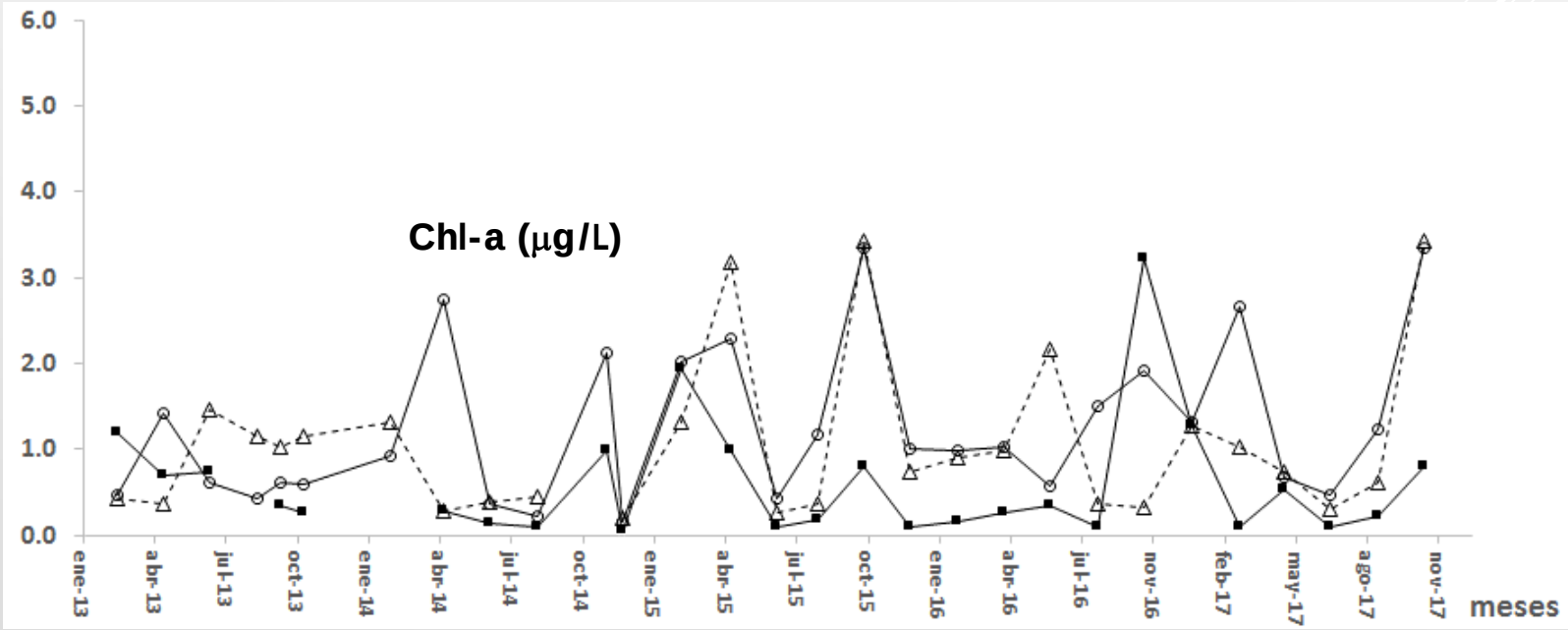
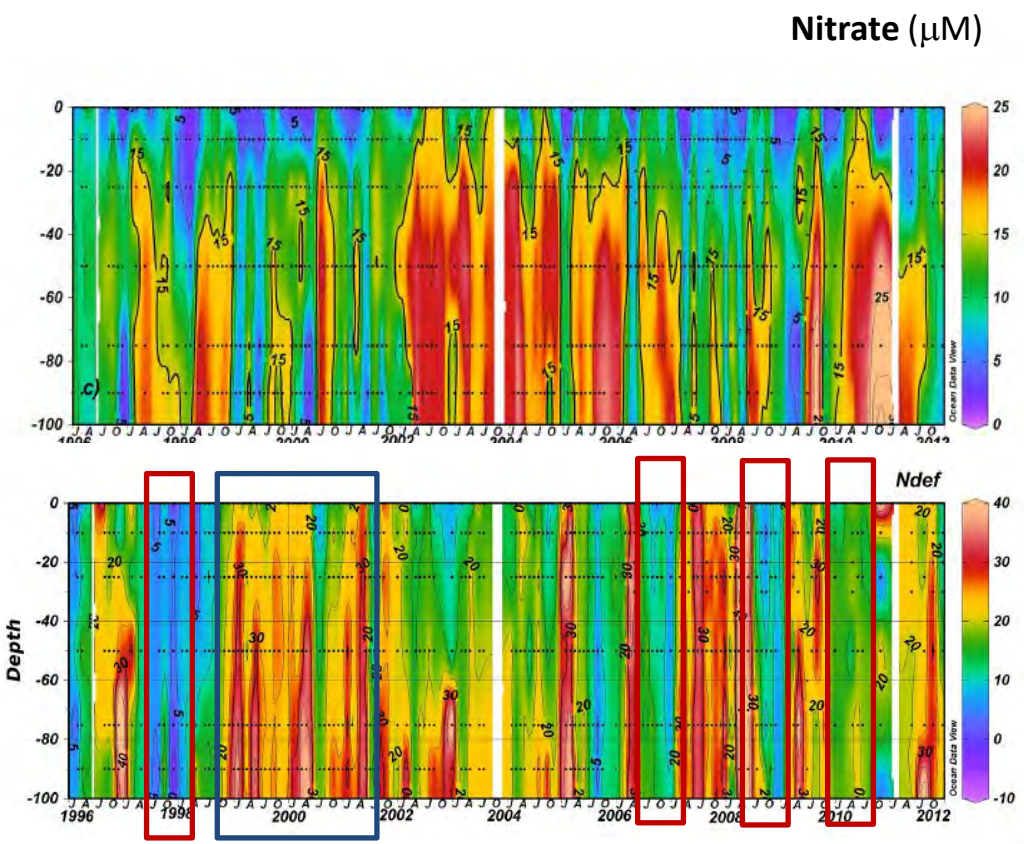
❑ Productivity changes

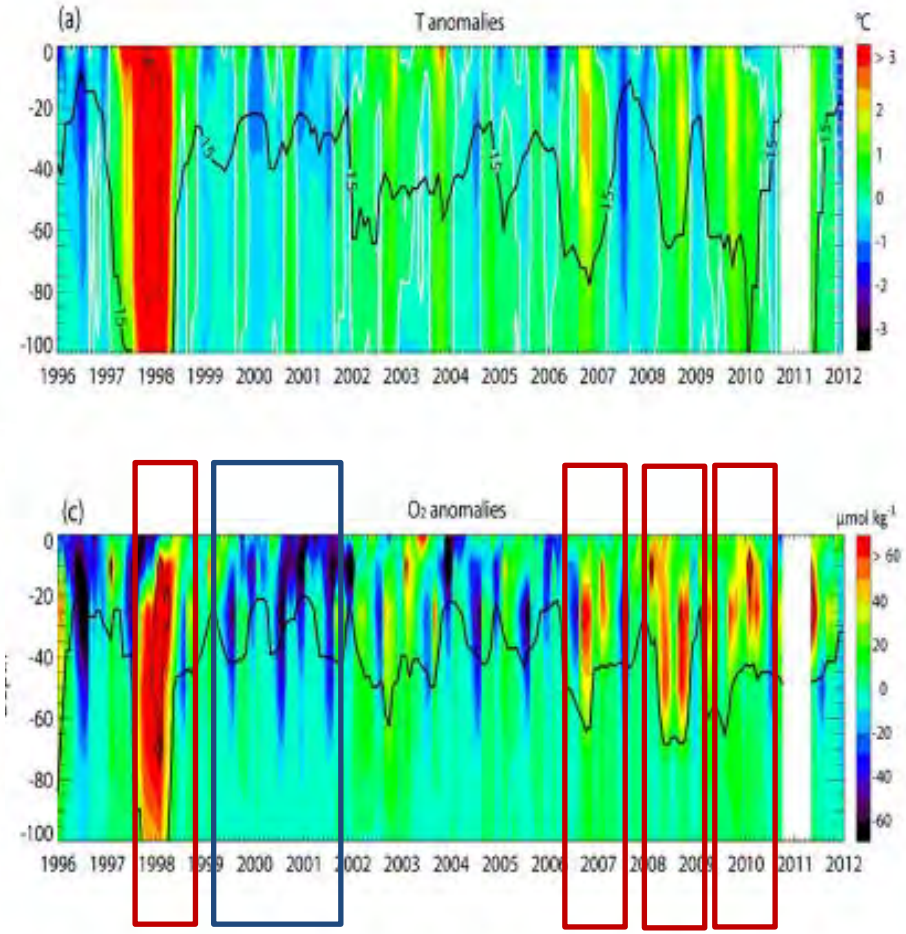


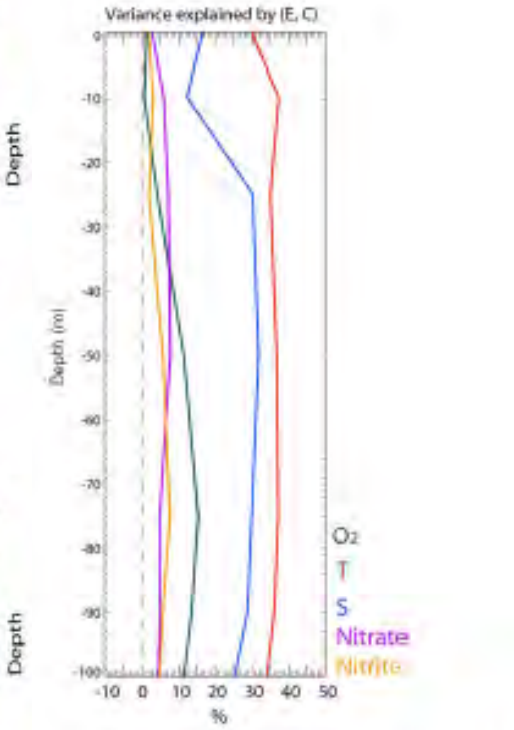




❑ THE IMPACT OF OMZ ON NUTRIENT





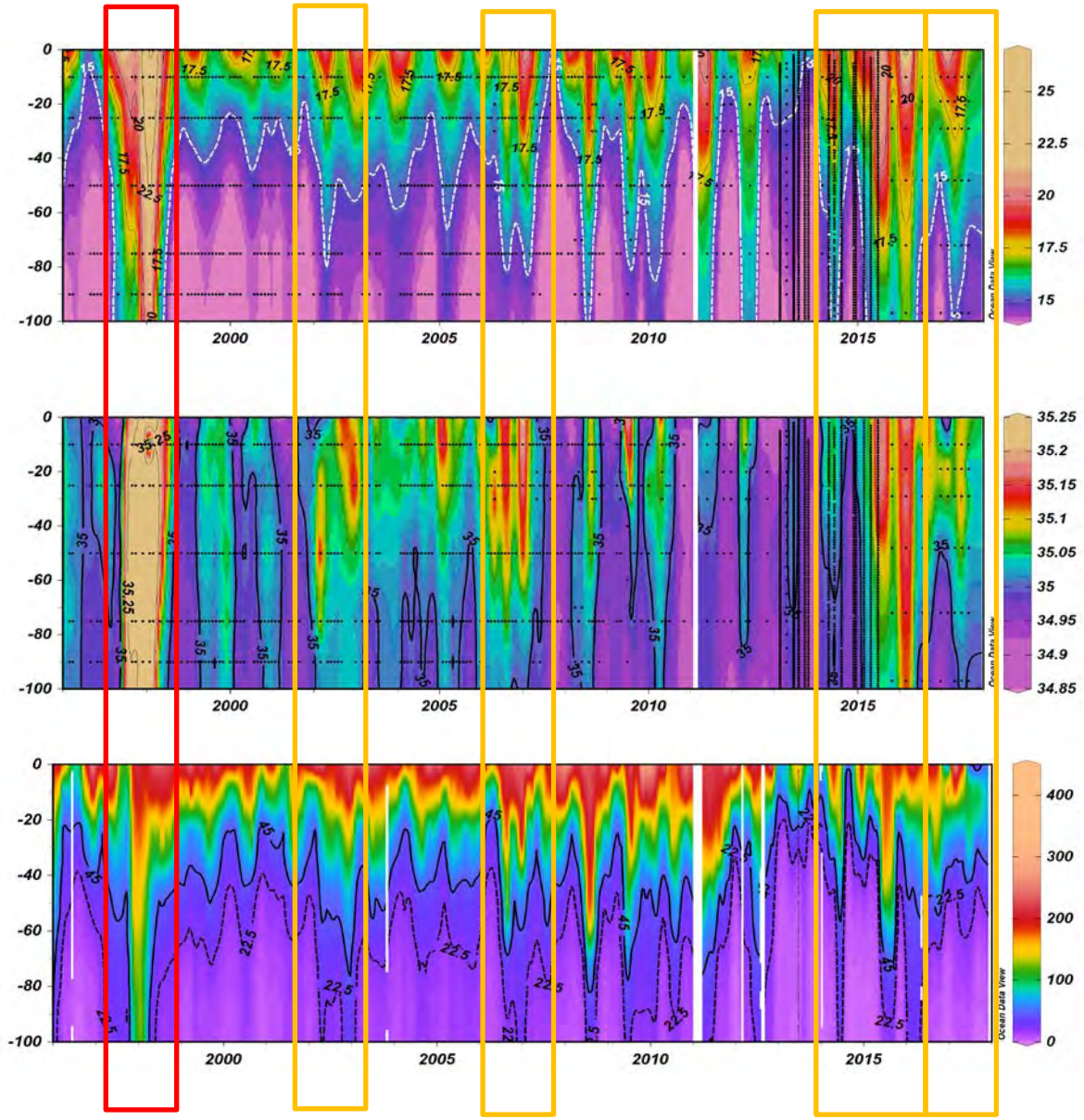


Percentage of variance explained by the projection of the
e *E* and *C* modes as a function of depth for temperature
nity (blue), oxygen (dark green), nitrate (purple) and ni-
ge).

Graco et al., BGC 2017

Next steps…
Remote forcing vs local Impact ZMO/ associated with nutrients (N)

❑ The impact of OMZ on nutrient



EP (extraordinario) CP (2002-03) CP/EP (2006-07) CP (2015-2016) El Niño costero 2017

Table 2. Slope of the linear fit for oxygen, temperature, salinity, nitrate and nitrite as a function of depth over the period 1999–2011. The slope for thermocline and oxycline depths are also provided as a function of season. The confidence level estimated based on a Student's *t* test is indicated in parenthesis when larger than 80 %.

Depth (meter)	O_2 (μmol kg^{-1} decade^{-1})	T (°C decade^{-1})	S (PSU decade^{-1})	Nitrate (μmol L^{-1} decade^{-1})	Nitrite (μmol L^{-1} decade^{-1})
0	24.03 (90 %)	−0.04	0.026	0.93	0.11
10	47.55 (95 %)	0.53 (80 %)	0.013	−0.17	−0.22 (80 %)
25	40.35 (95 %)	0.65 (90 %)	0.025 (80 %)	−1.67	−0.01
50	14.40 (85 %)	0.50 (90 %)	0.003	0.01	−0.15
75	6.04 (90 %)	0.34 (90 %)	−0.002	1.85	−0.57
90	6.76 (95 %)	0.42 (95 %)	−0.001	2.51 (80 %)	−0.75
100	7.53 (95 %)	0.46 (95 %)	0.003	2.95 (80 %)	−0.88

Annual	OMZ (m decade^{-1}) −0.64 (95 %)		Thermocline (m decade^{-1}) −0.30 (95 %)	
Seasonal	Summer −0.74 (95 %)	Winter −0.77 (95 %)	Summer −0.63 (95 %)	Winter 0.03
	Fall −0.76 (95 %)	Spring −0.69 (95 %)	Fall −0.49 (95 %)	Spring −0.48 (95 %)

1999-2011

Graco et al., BGC 2017- updated until 2018

Summary

- The Coastal Peruvian Upwelling ecosystems, and particularly the coast-open ocean interaction is a very dynamic **transition zone**, highly variable on the oceanographic conditions that determine changes in the upwelling front associated with the equatorial forcing but also local conditions, as winds but also other processes (mesoscale activity).
- Significant changes in the chemistry was observed during 2013-2017 that changed the gradient between the coast and offshore conditions. Silicates and pH appear as a good tracer of the physical dynamic. Nitrates, in turn, are more variable and related to the changes in the oxygen and the OMZ.
- N/P and chlorophyll-a are significantly modified under cold or warm periods but in a different way. Low N/P appear under intense OMZ during more favorable upwelling periods. Chlorophyll-a appear to increase during the warm period, particularly 2015-2016. However, the concentration is low compared with previous studies.
- Diatoms are not the only dominant phytoplankton group in coastal areas and phytoflagelates appear more significant than previous was consider that could represent an important carb on source to support productivity.
- **Multidiciplinary approach is important to understand transition zones as the complex and variable Coastal Upwelling System of Peru. In this context monitoring is a key and we need to articulate and integrated better our observing system to resolve the different scales of variability and determine trends and future scenarios of productivity.**


Gracias por su atención...