A acidificación das augas costeiras de Galicia: impactos biolóxicos

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REDEMAR

XUNTA DE GALICIA

UNIÓN EUROPEA
Fondo Europeo Marítimo e de Pesca (FEMP)

Grupo de traballo | Situación dos recursos marisqueiros na costa:
Ría de Muros-Noia-Costa da Morte

A acidificación das augas costeiras de Galicia: impactos biolóxicos

X.A Padin

2 de maio de 2023

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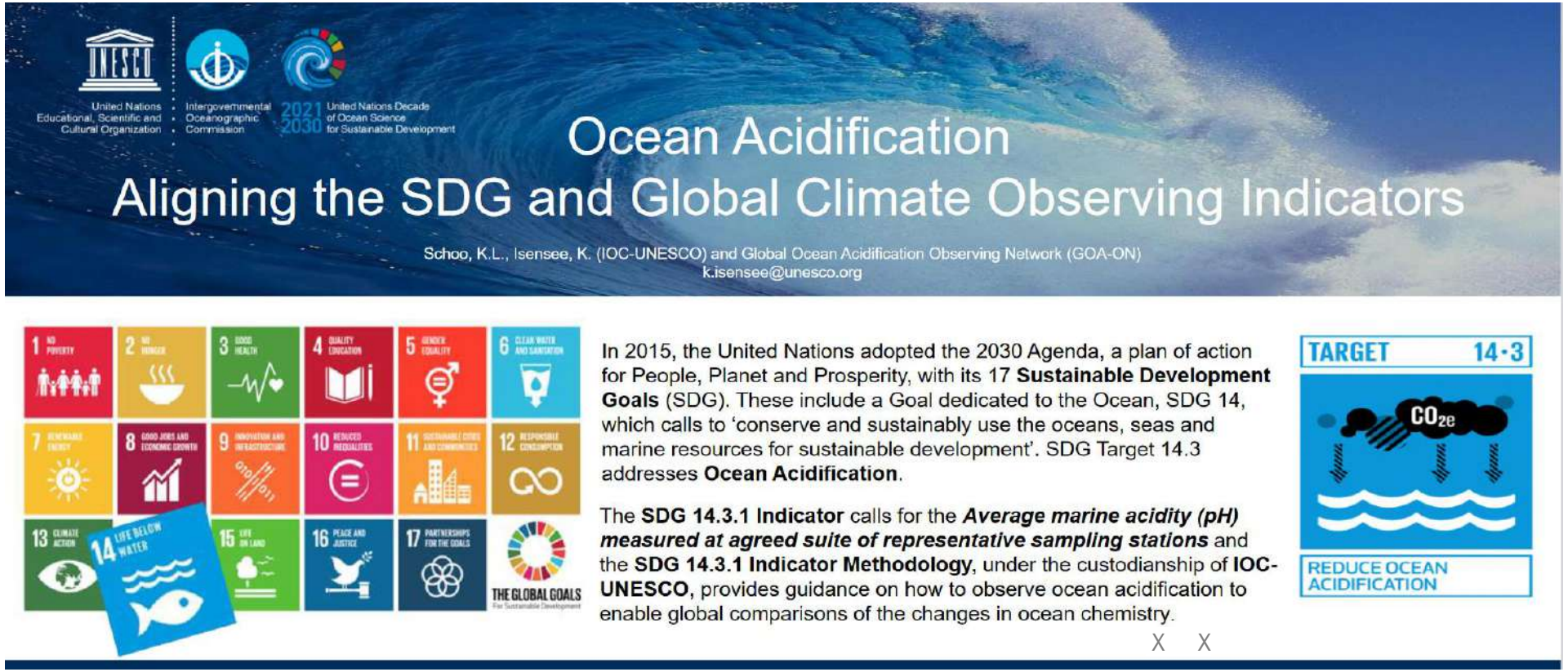


14 LIFE BELOW WATER

Target

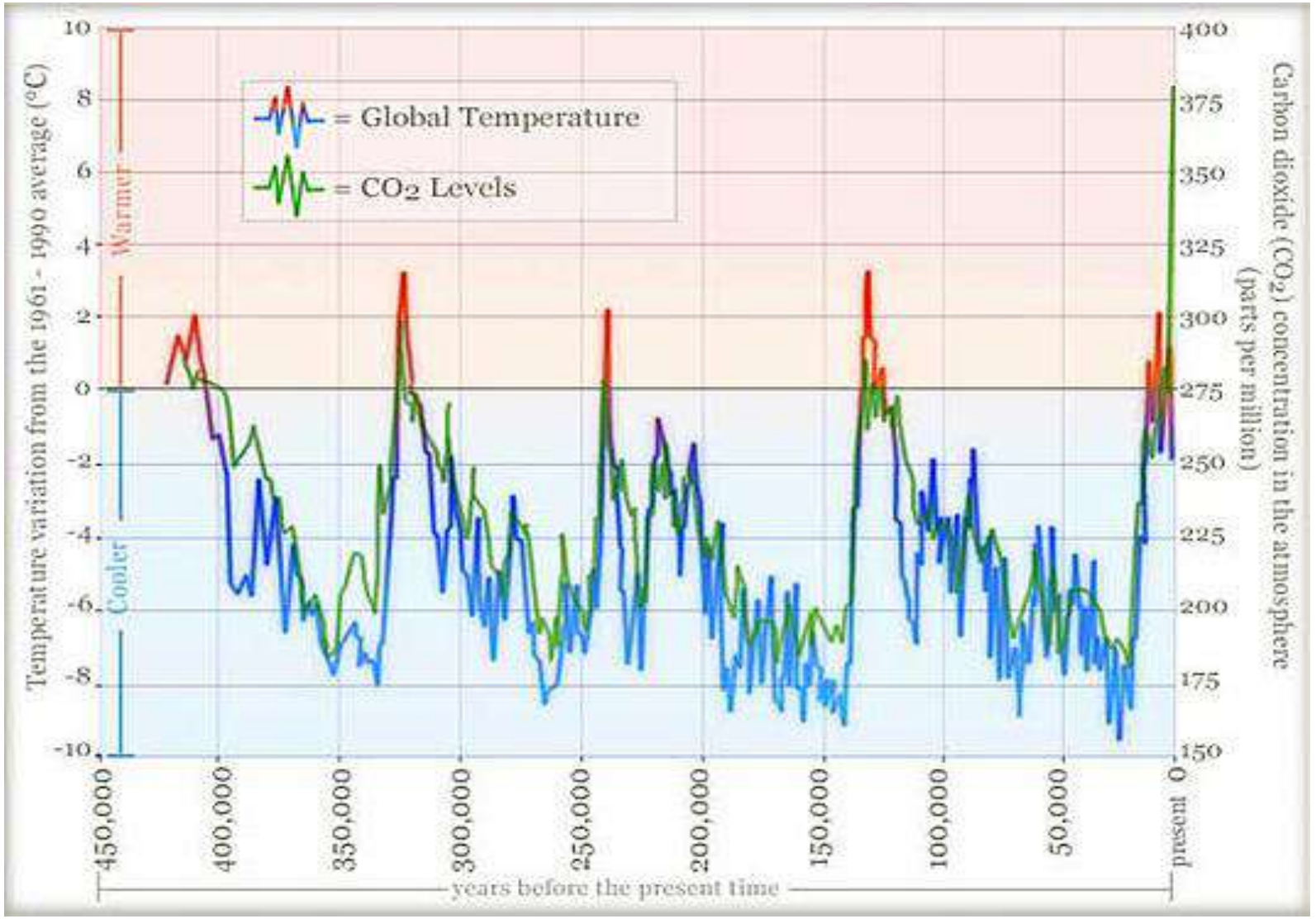
14.3

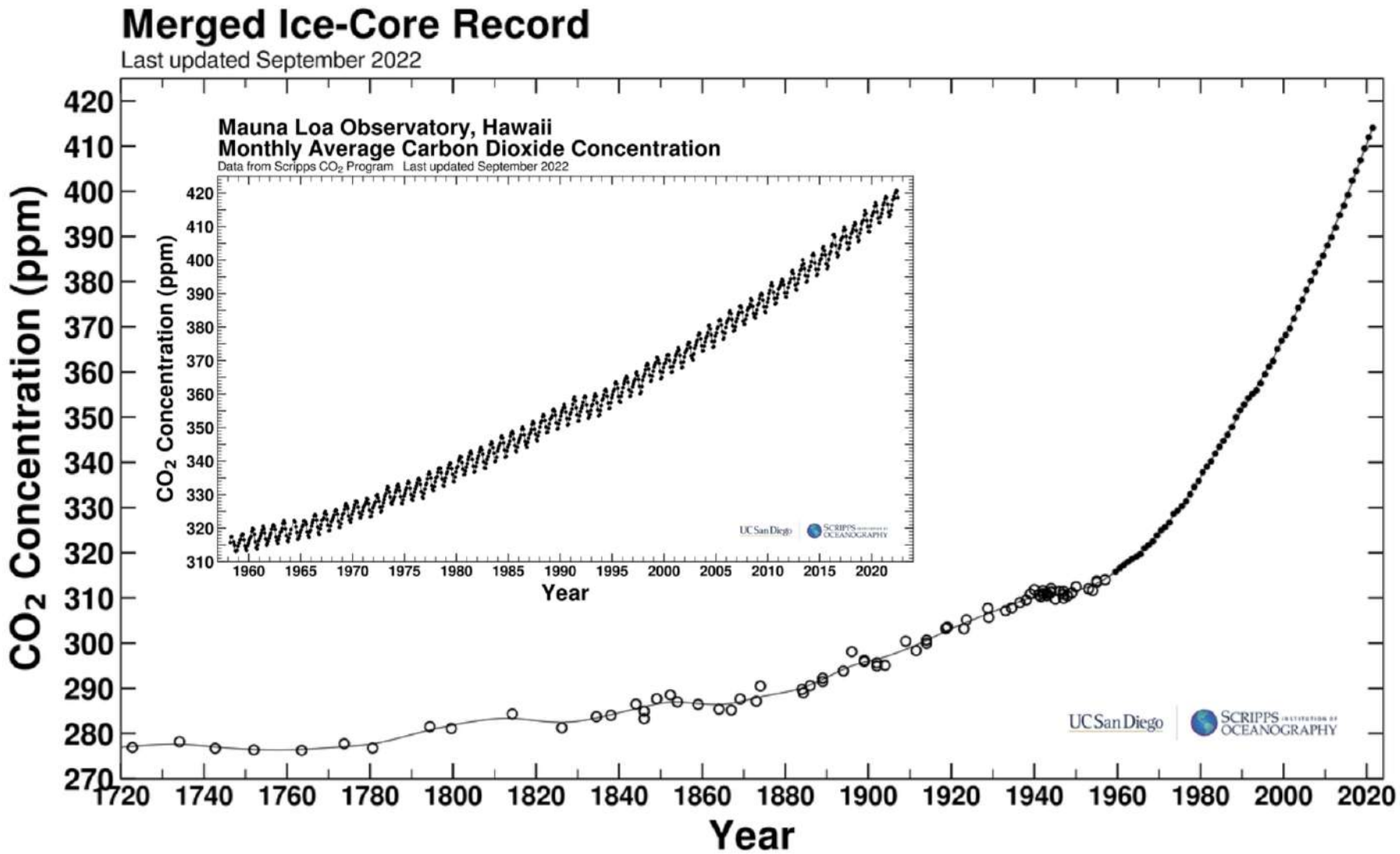
Minimize and address the impacts of ocean acidification, including through enhanced scientific cooperation at all levels

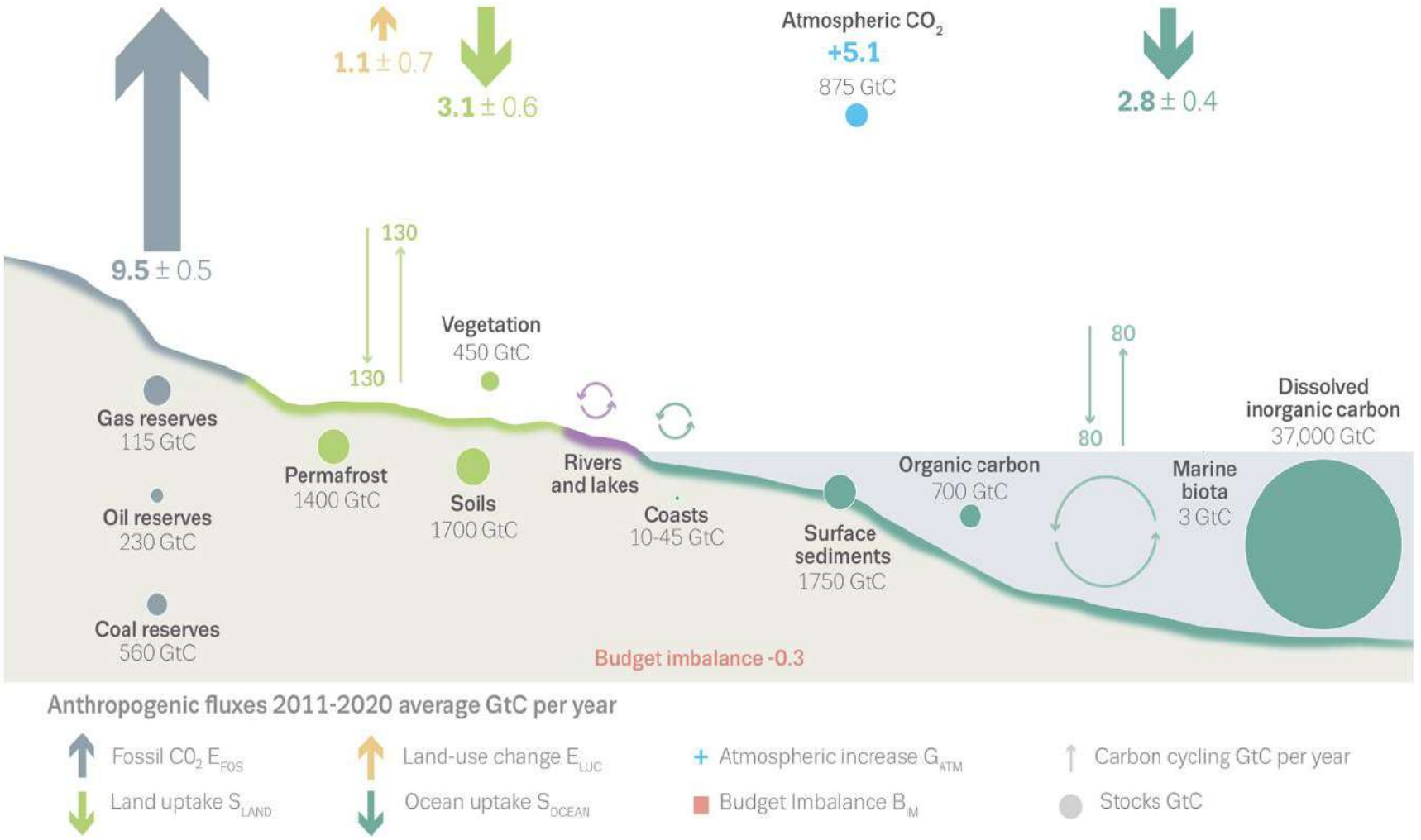
Indicators ▲

14.3.1

Average marine acidity (pH) measured at agreed suite of representative sampling stations

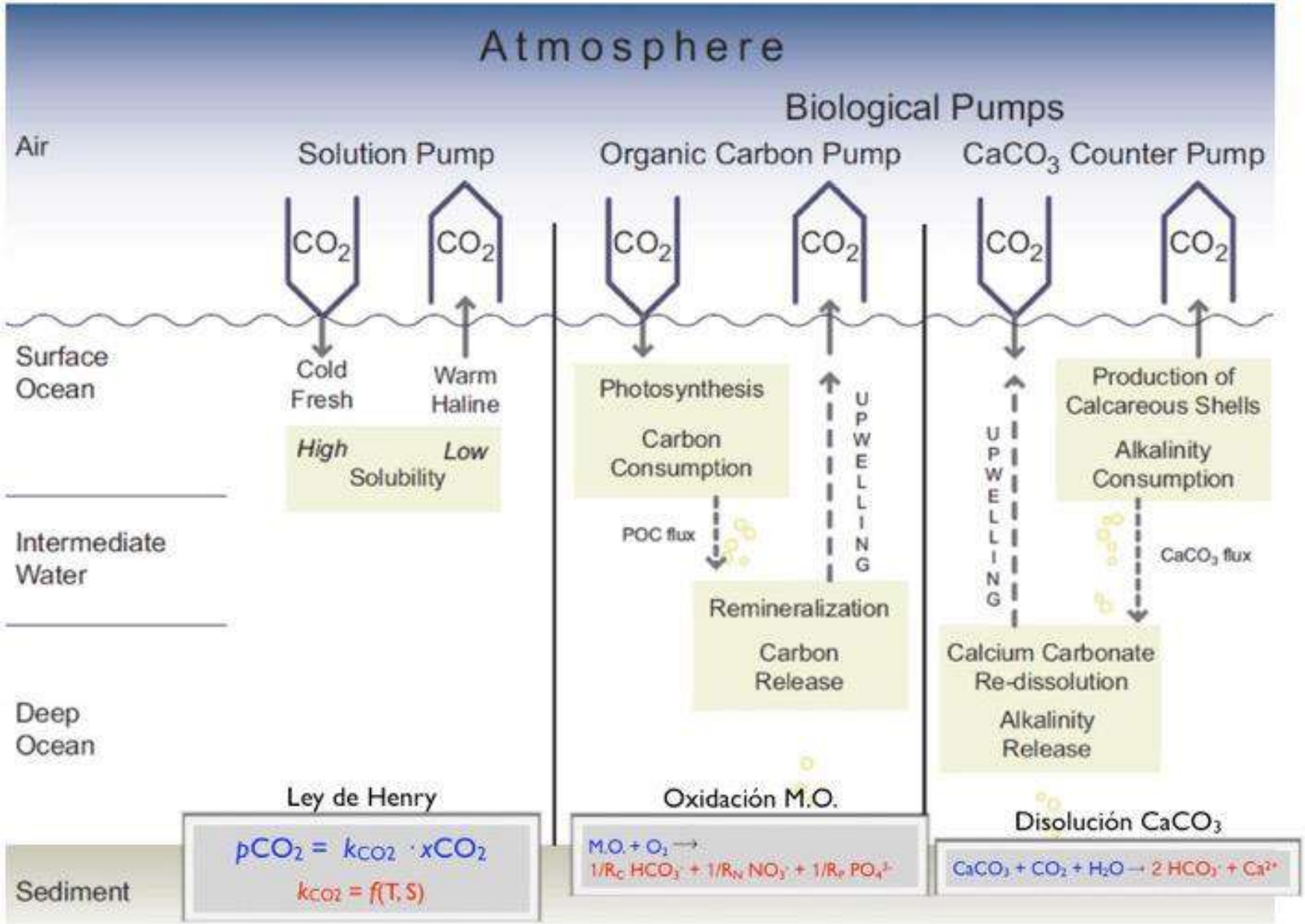

= Global Temperature
= CO2 Levels
Warmer
Cooler
Temperature variation from the 1961 - 1990 average (°C)
Carbon dioxide (CO2) concentration in the atmosphere (parts per million)
10
8
6
4
2
0
-2
-4
-6
-8
-10
400
375
350
325
300
275
250
225
200
175
150
450,000
400,000
350,000
300,000
250,000
200,000
150,000
100,000
50,000
present 0
years before the present time


Merged Ice-Core Record
Last updated September 2022
CO2 Concentration (ppm)
Year
Mauna Loa Observatory, Hawaii
Monthly Average Carbon Dioxide Concentration
Data from Scripps CO2 Program Last updated September 2022
CO2 Concentration (ppm)
Year
UC San Diego
SCRIPPS INSTITUTION OF OCEANOGRAPHY

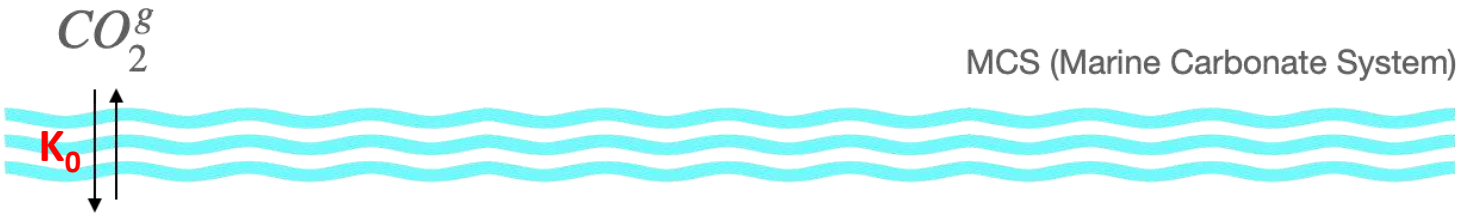


PgC = GtC

P. Friedlingstein et al.: Global Carbon Budget 2021


Atmosphere
Biological Pumps
Air
Solution Pump
Organic Carbon Pump
CaCO3 Counter Pump
CO2
CO2
CO2
CO2
CO2
CO2
Surface Ocean
Cold Fresh
Warm Haline
High
Low
Solubility
Photosynthesis
Carbon Consumption
UPWELLING
Production of Calcareous Shells
Alkalinity Consumption
POC flux
CaCO3 flux
Intermediate Water
Remineralization
Carbon Release
UPWELLING
Calcium Carbonate Re-dissolution
Alkalinity Release
Deep Ocean
Ley de Henry
pCO2 = kCO2 · xCO2
kCO2 = f(T, S)
Oxidación M.O.
M.O. + O2 →
1/RC HCO3- + 1/RN NO3- + 1/RP PO4 3-
Disolución CaCO3
CaCO3 + CO2 + H2O → 2 HCO3- + Ca2+
Sediment

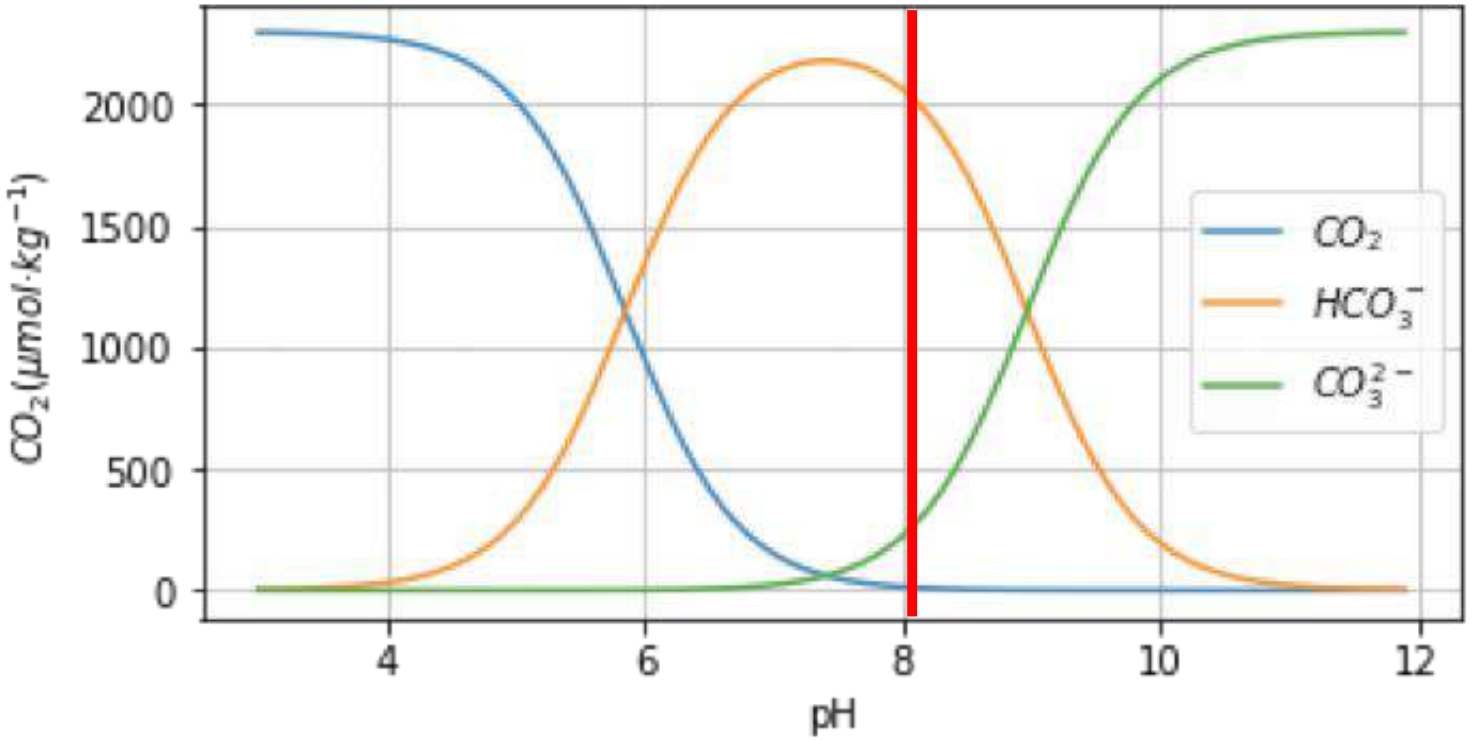
Equations for CO_2 Speciation



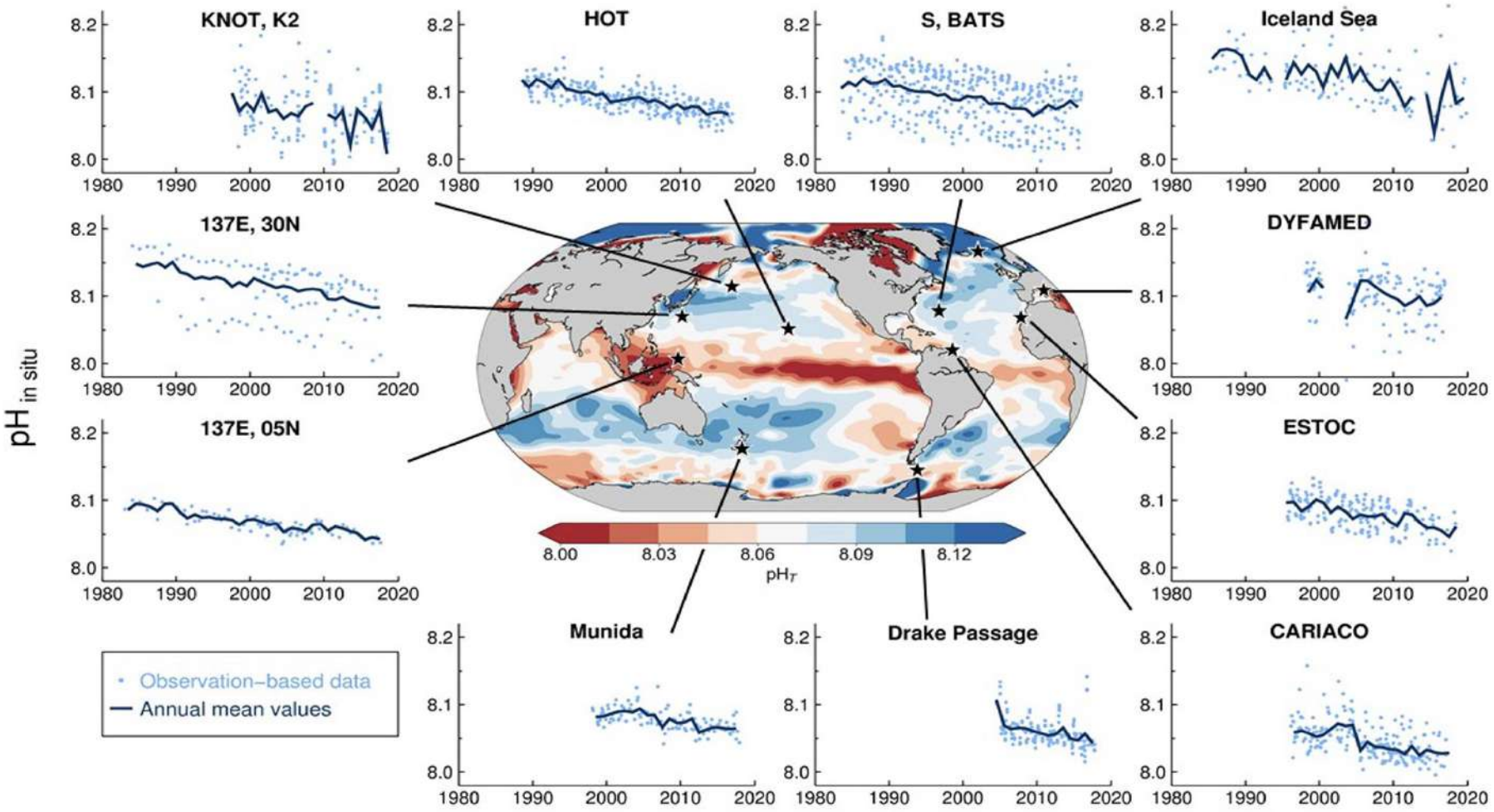
$$CO_2^{aq} + H_2O \rightleftharpoons H_2CO_3 \overset{K_1}{\rightleftharpoons} H^+ + HCO_3^- \overset{K_2}{\rightleftharpoons} 2H^+ + [CO_3^{2-}]$$

Carbonic Acid — Bicarbonate — Carbonate

$pH = -\log [H_3O^+]$

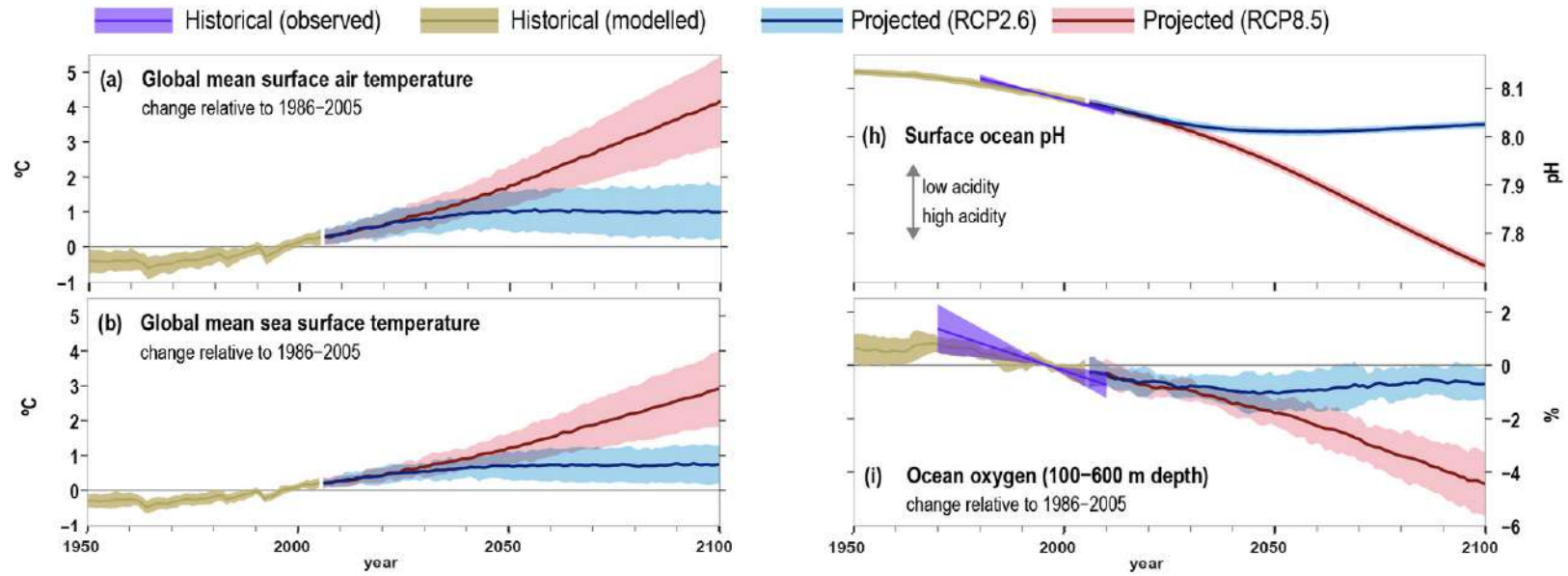


Change in pH from ocean acidification already measurable

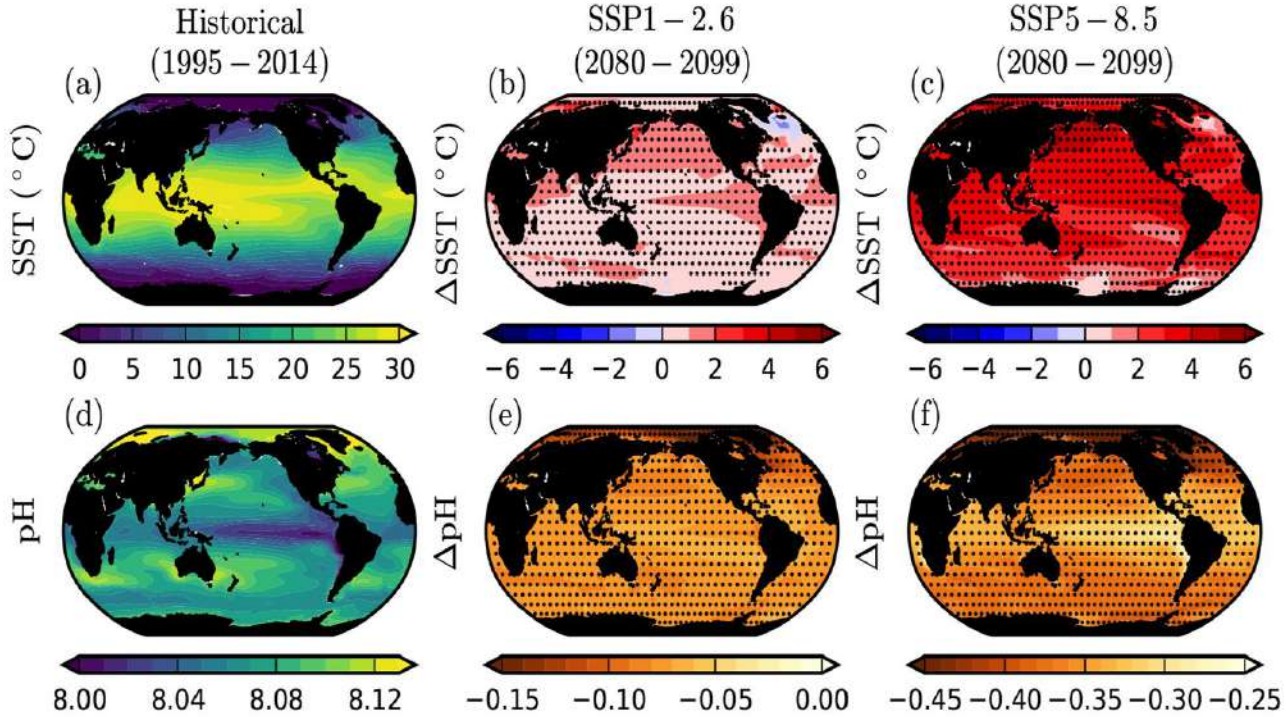


IPCC AR6 WG1 Report, Chap. 5 (2021)

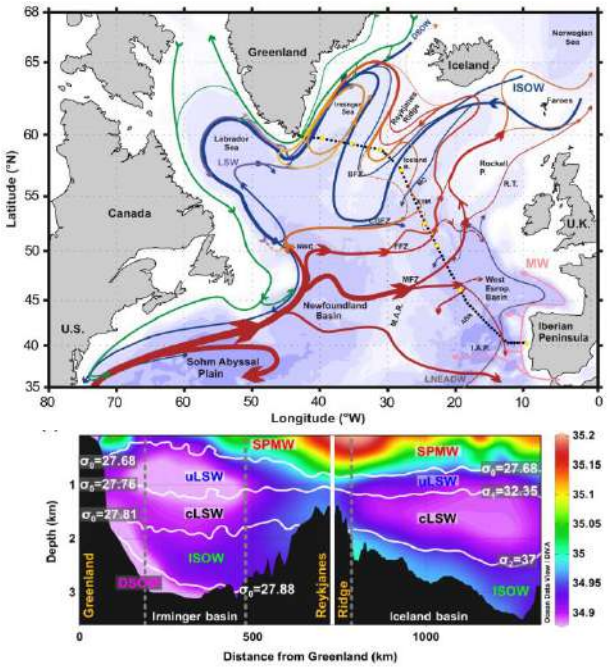
In-situ pH change = -0.002 yr^{-1}

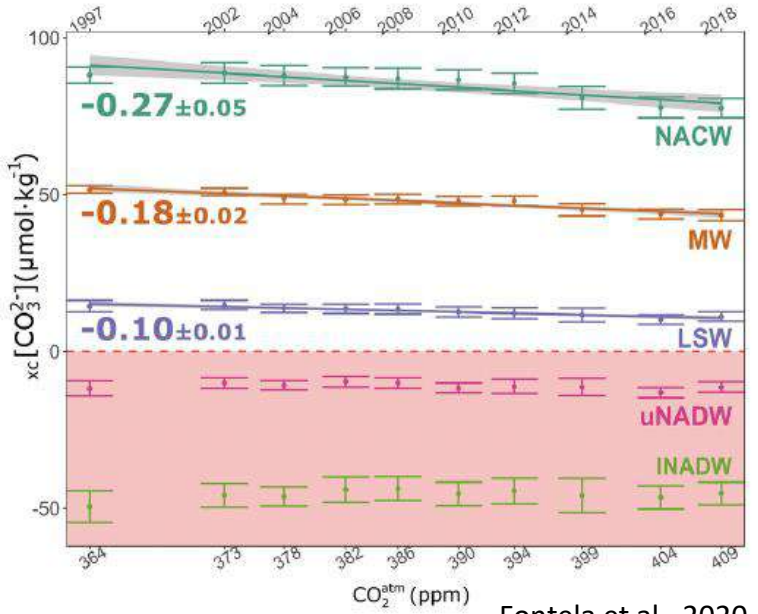


IPCC

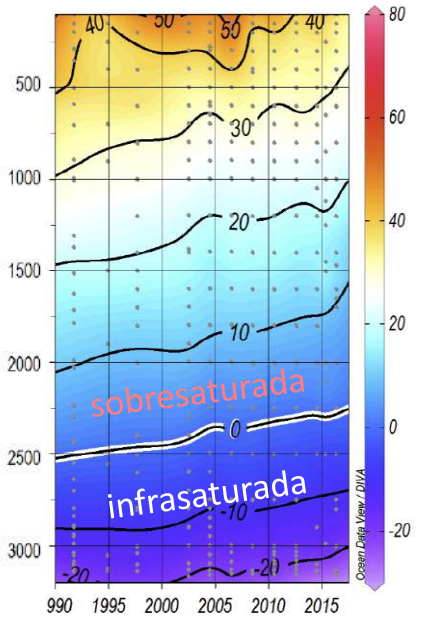


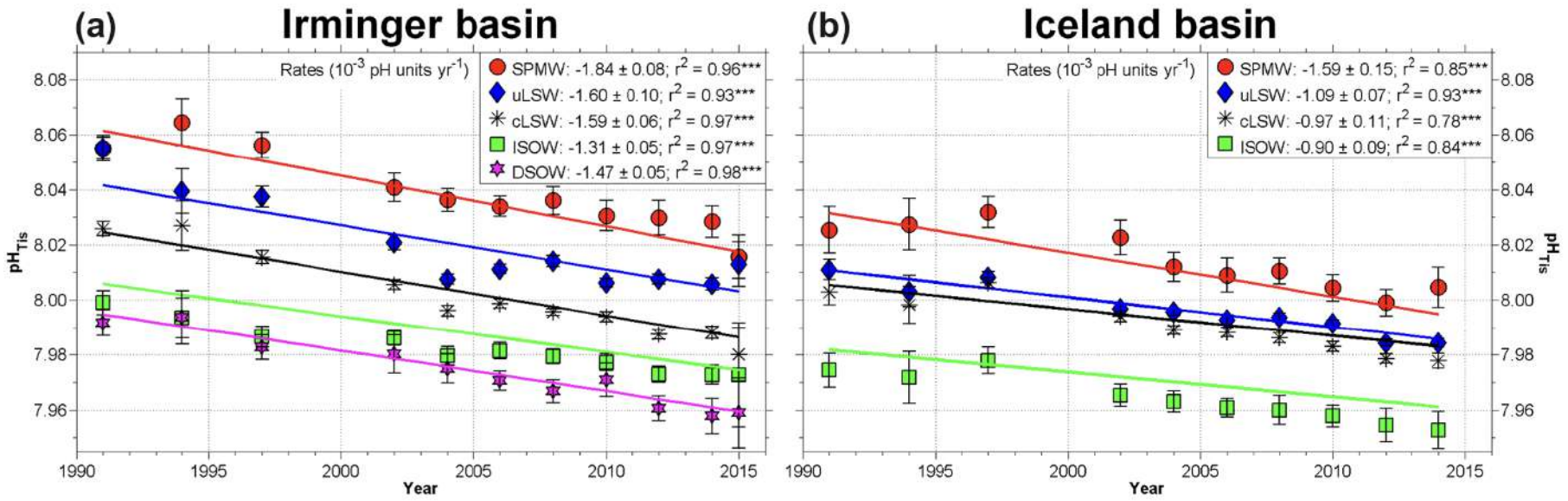
Kwaitkowski et al 2020





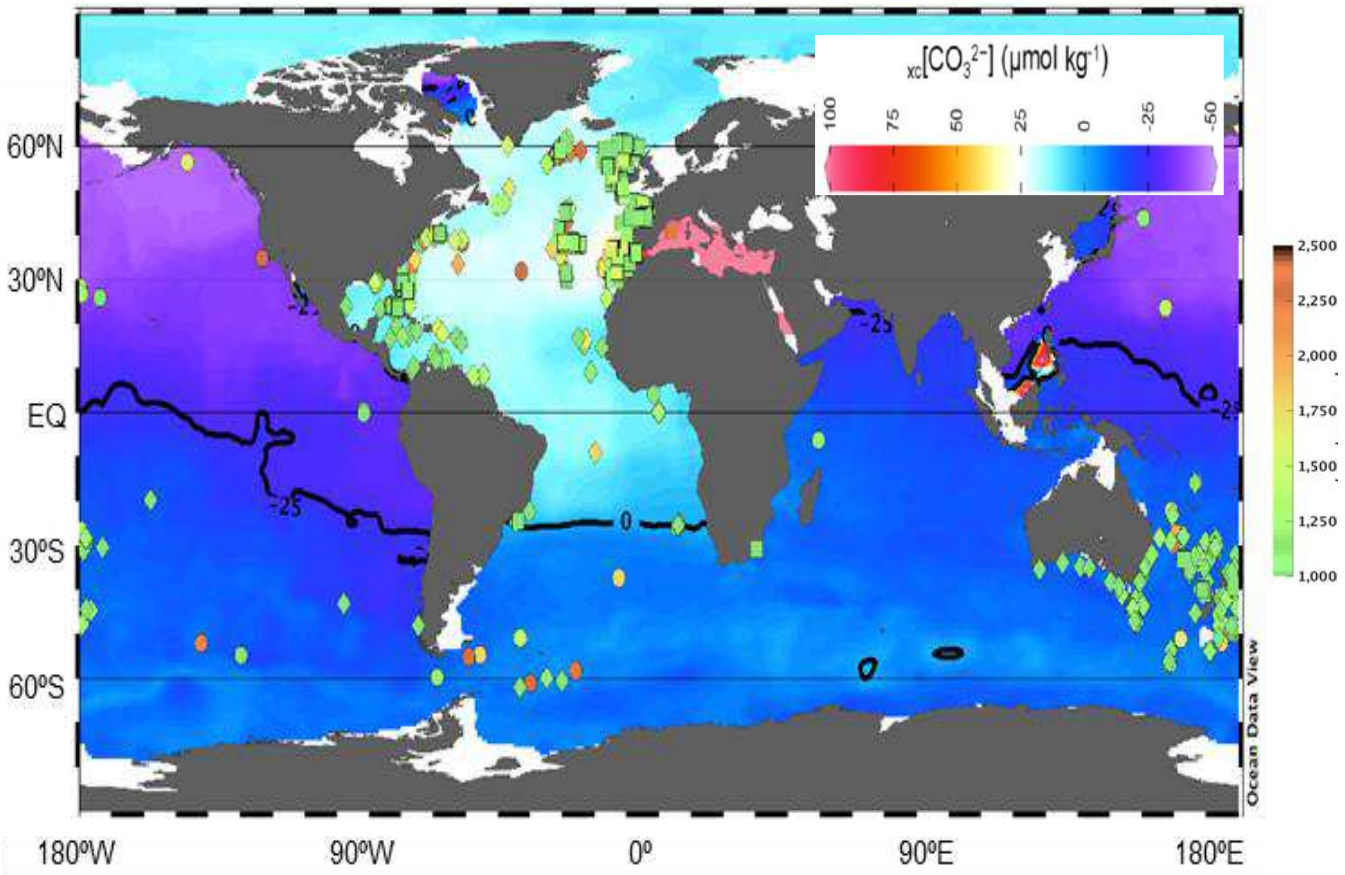
Fontela et al., 2020



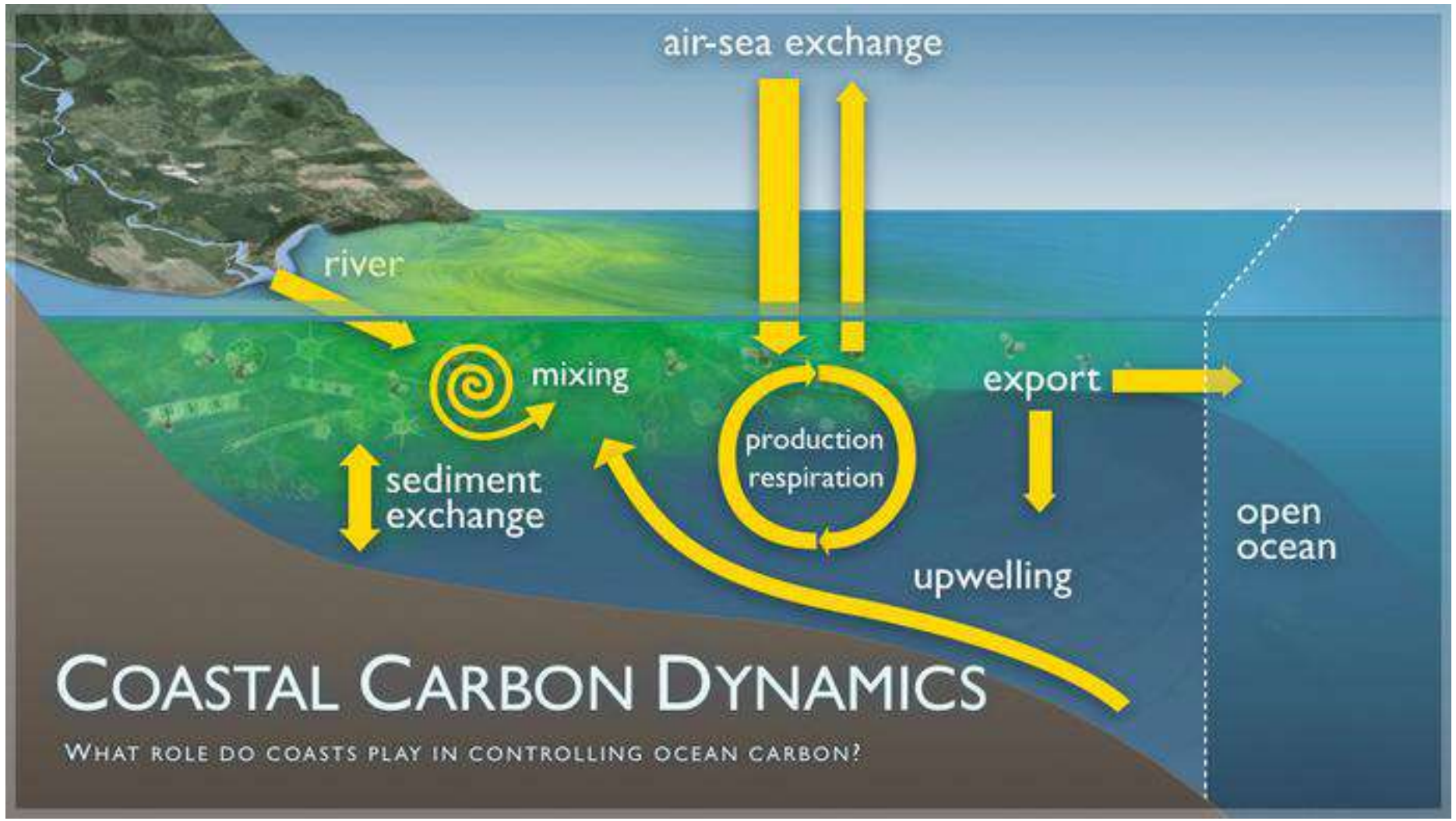


Pérez et al., 2018

Lophelia pertusa (Guinotte 2006)



Pérez et al 2018


air-sea exchange
river
mixing
sediment
exchange
production
respiration
export
open
ocean
upwelling
COASTAL CARBON DYNAMICS
WHAT ROLE DO COASTS PLAY IN CONTROLLING OCEAN CARBON?

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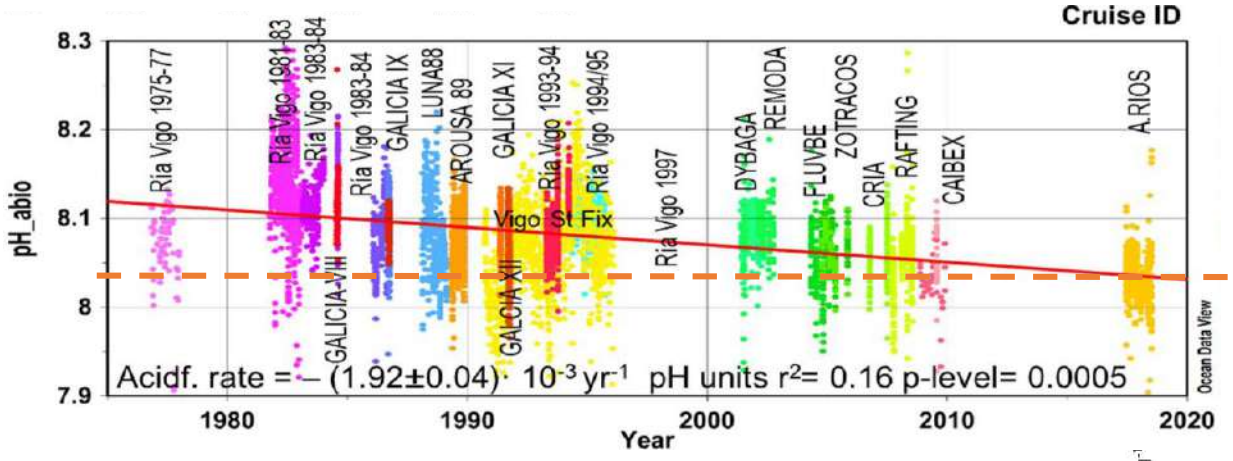
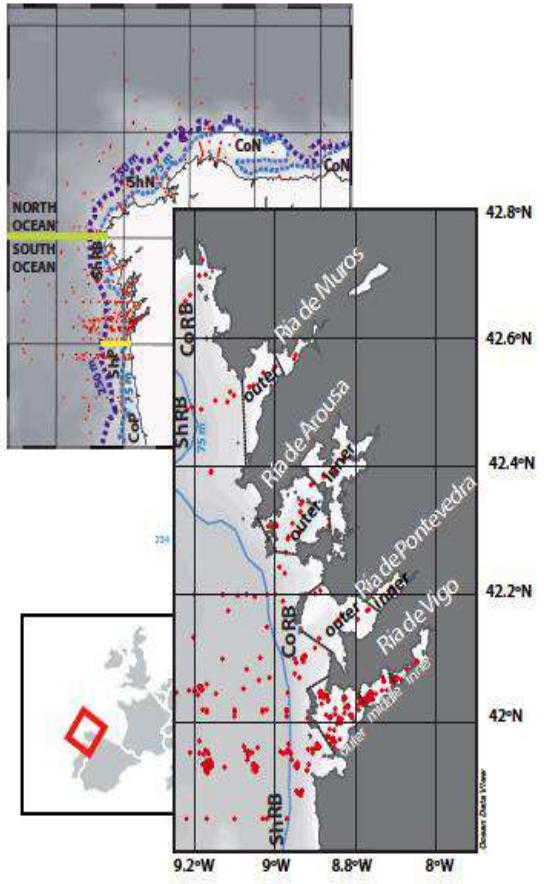
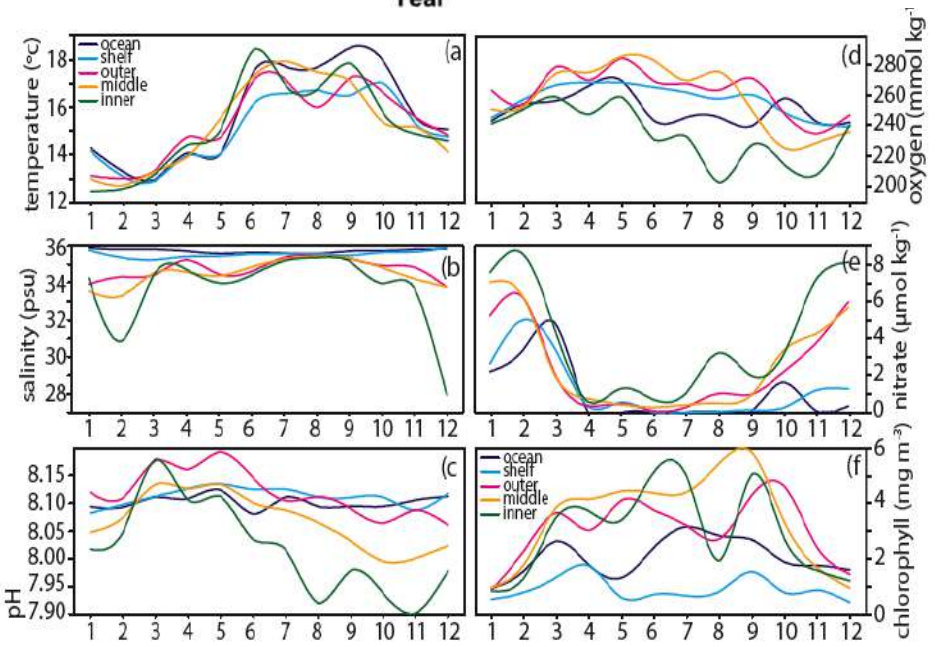
Proxecto ARIOS
Acidificación nas Rías e plataforma oceánica ibérica
Ministerio de Ciencia e Innovación
(Ref. CTM2016-76146-C3-2-R)







	SSrange	r^2ss	$t_{interannual}$	r^2	p value
OCEAN	0.050	0.17	-0.0012 ± 0.0002	0.21	0.0000
SHELF	0.050	0.06	-0.0017 ± 0.0003	0.15	0.0009
OUTER	0.120	0.24	-0.0027 ± 0.0003	0.21	0.0000
MIDDLE	0.130	0.28	-0.0022 ± 0.0005	0.03	0.0000
INNER	0.260	0.47	-0.0039 ± 0.0005	0.34	0.0000

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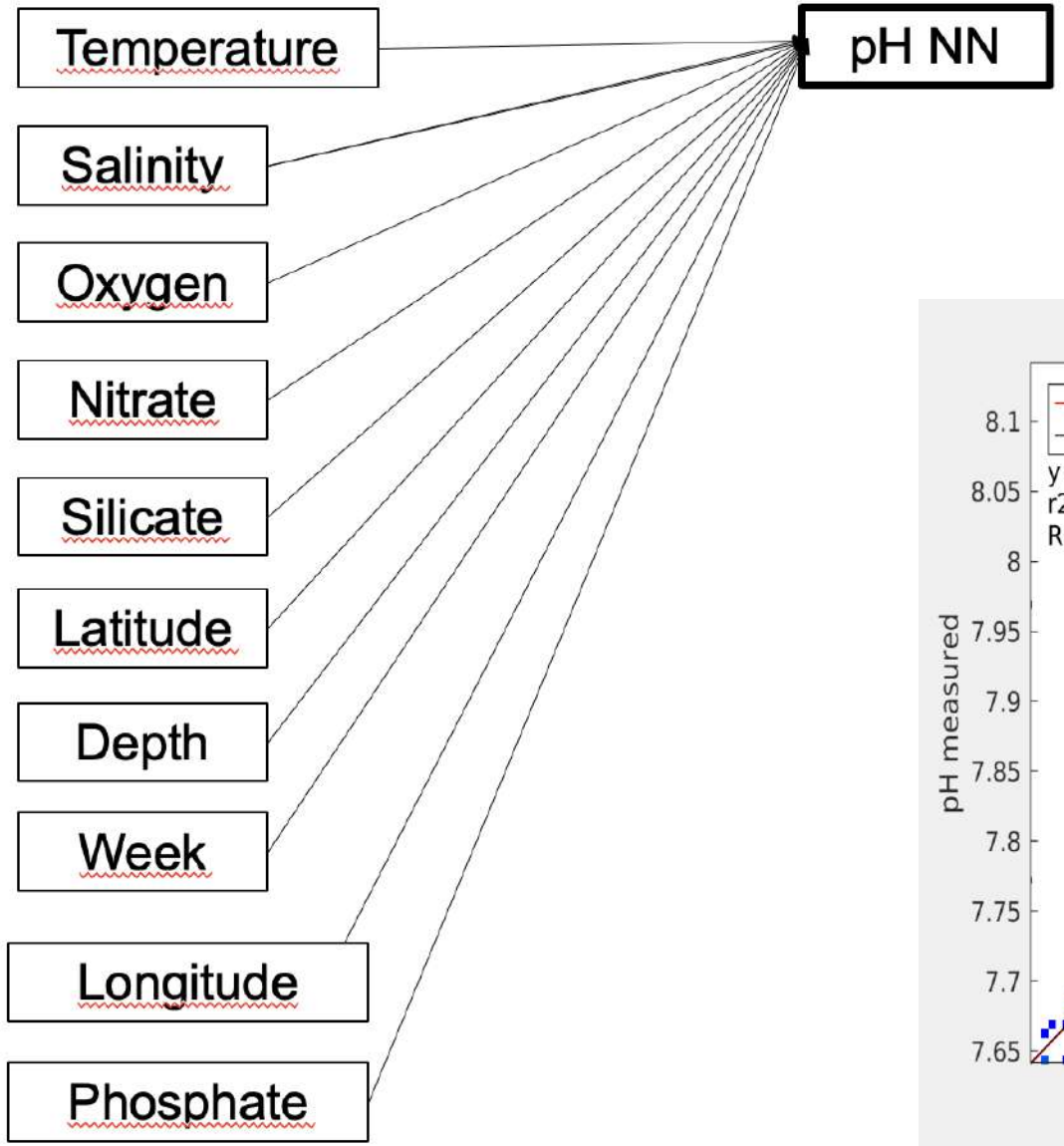

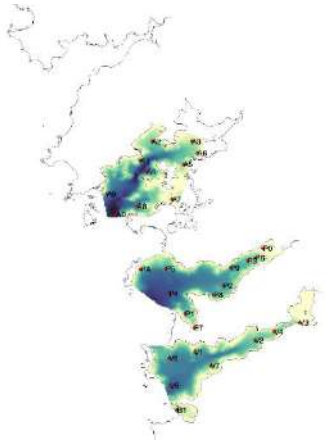

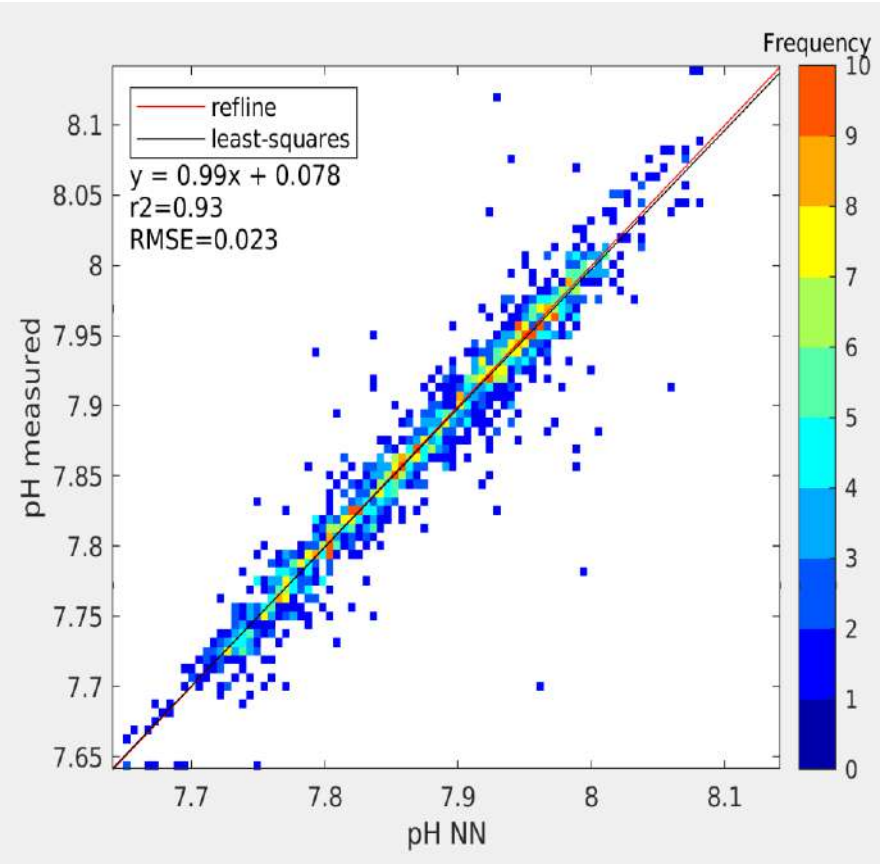

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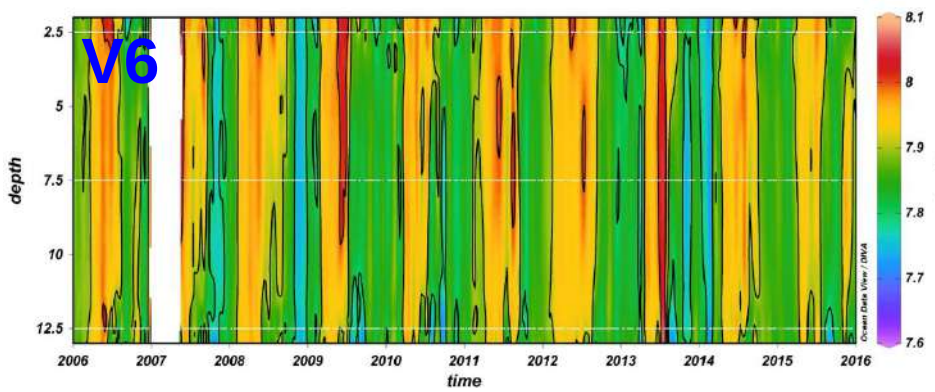

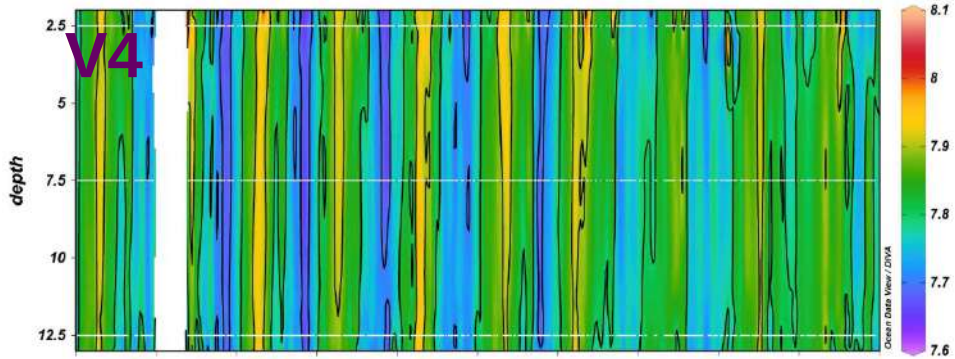

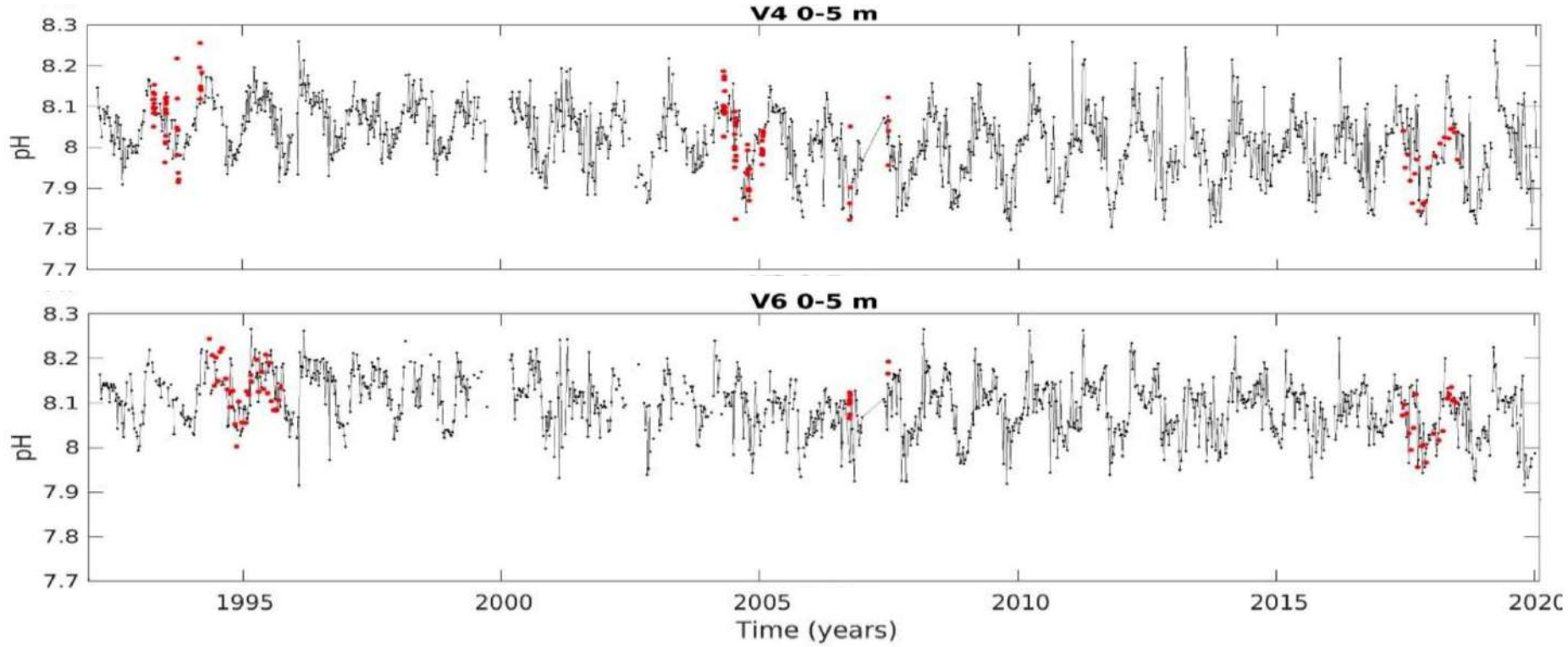

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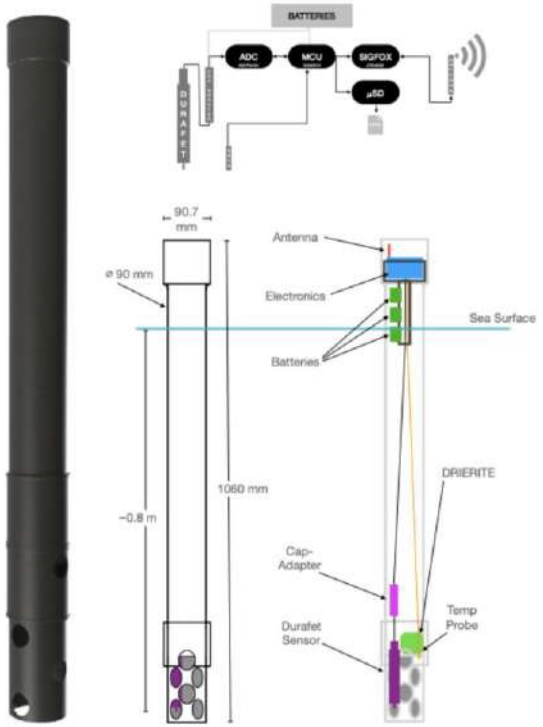
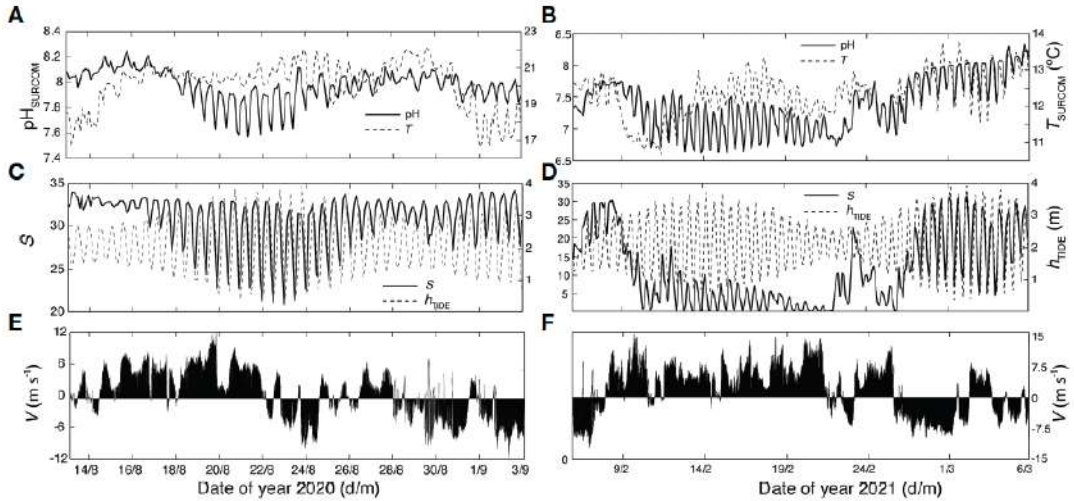
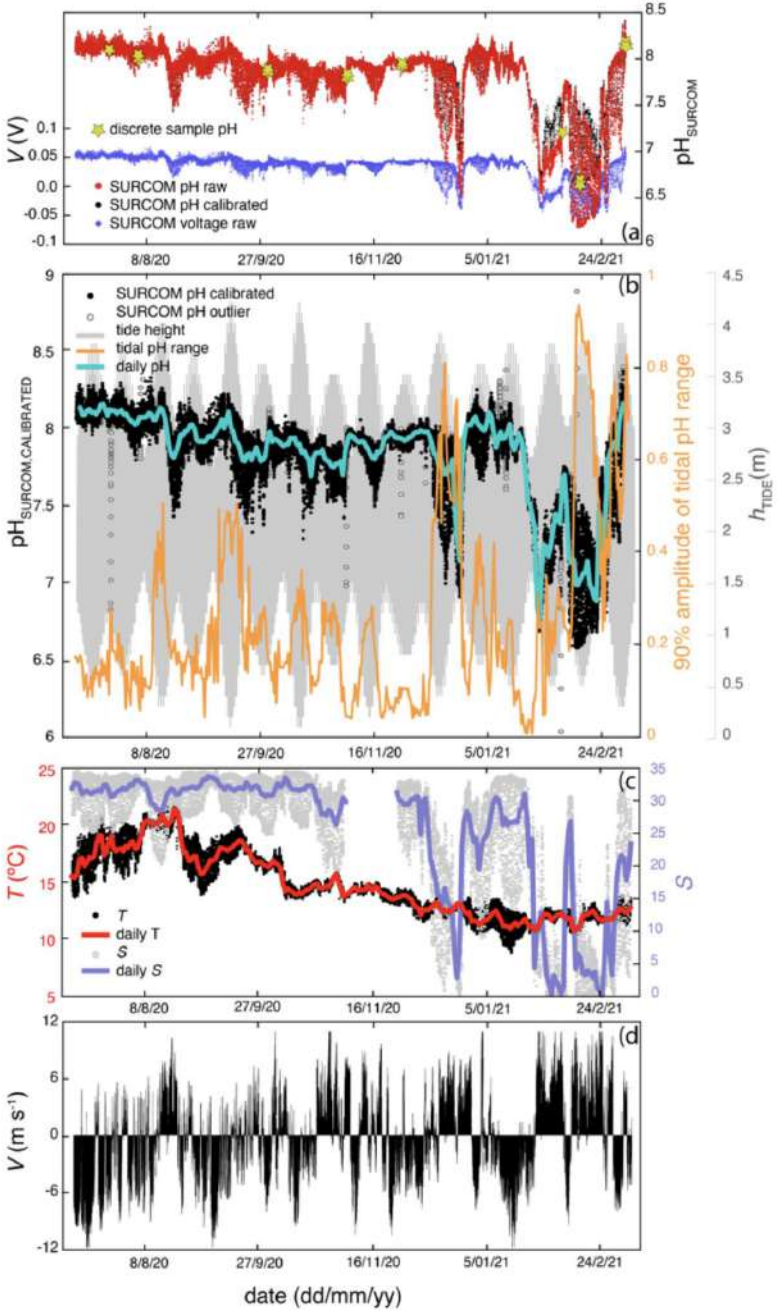
Equipo SURCOM-pH

Low cost
Low consumption electronics
Low cost case
High precision



https://co2.iim.csic.es/monitoring/d/surcom_cortegada/surcom-cortegada





Velo e Padin, 2022

Investigación, desenvolvemento e innovación dunha rede de observación costeira: Ría de Arousa (REDEIRA; ref: TED2021-132188B-I00)

Proxeto Estratéxico Orientado á Transición Ecolóxica e a Transición Dixital . 2022-2024

OBXECTIVOS

1. Desenvolver un sistema de observación do cambio global extrapolable. Ría de Arousa, como caso de estudo.
2. Construir unha rede de observación casi en tiempo real.
3. Desenvolvemento dun sistema oceanográfico preditivo.
4. Análisis de tendencias e detección de eventos extremos.
5. Crear ferramentas e recursos dixitais para a visualización de indicadores ambientais.
6. Sensibilizar e mellorar a comunicación dos resultados

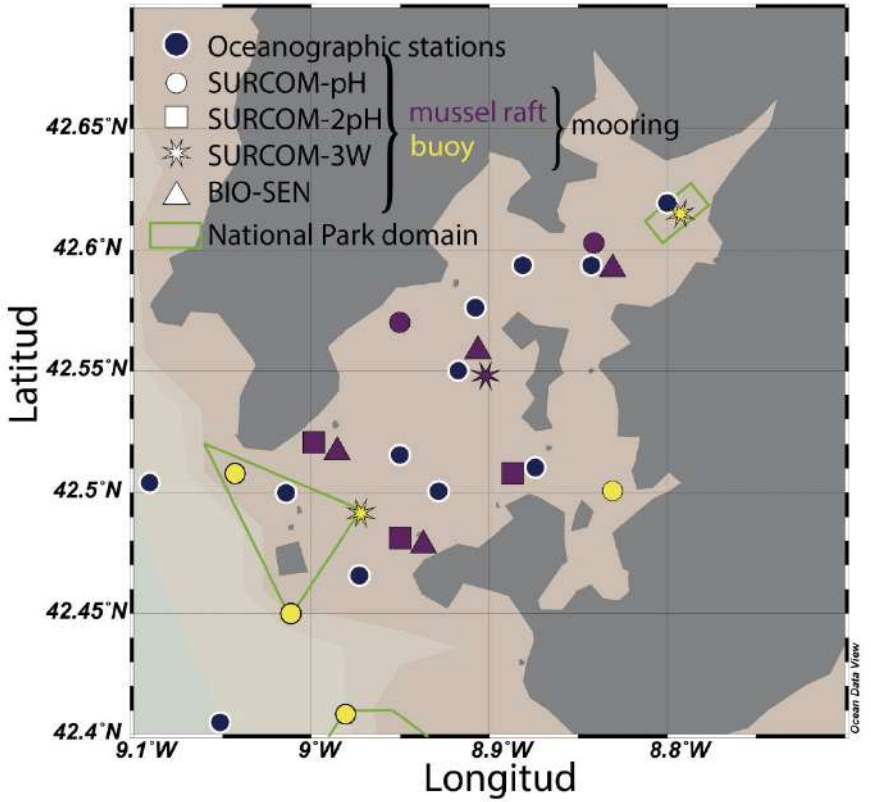
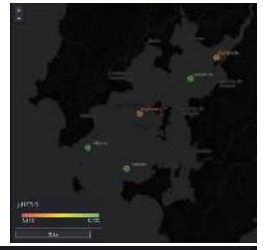
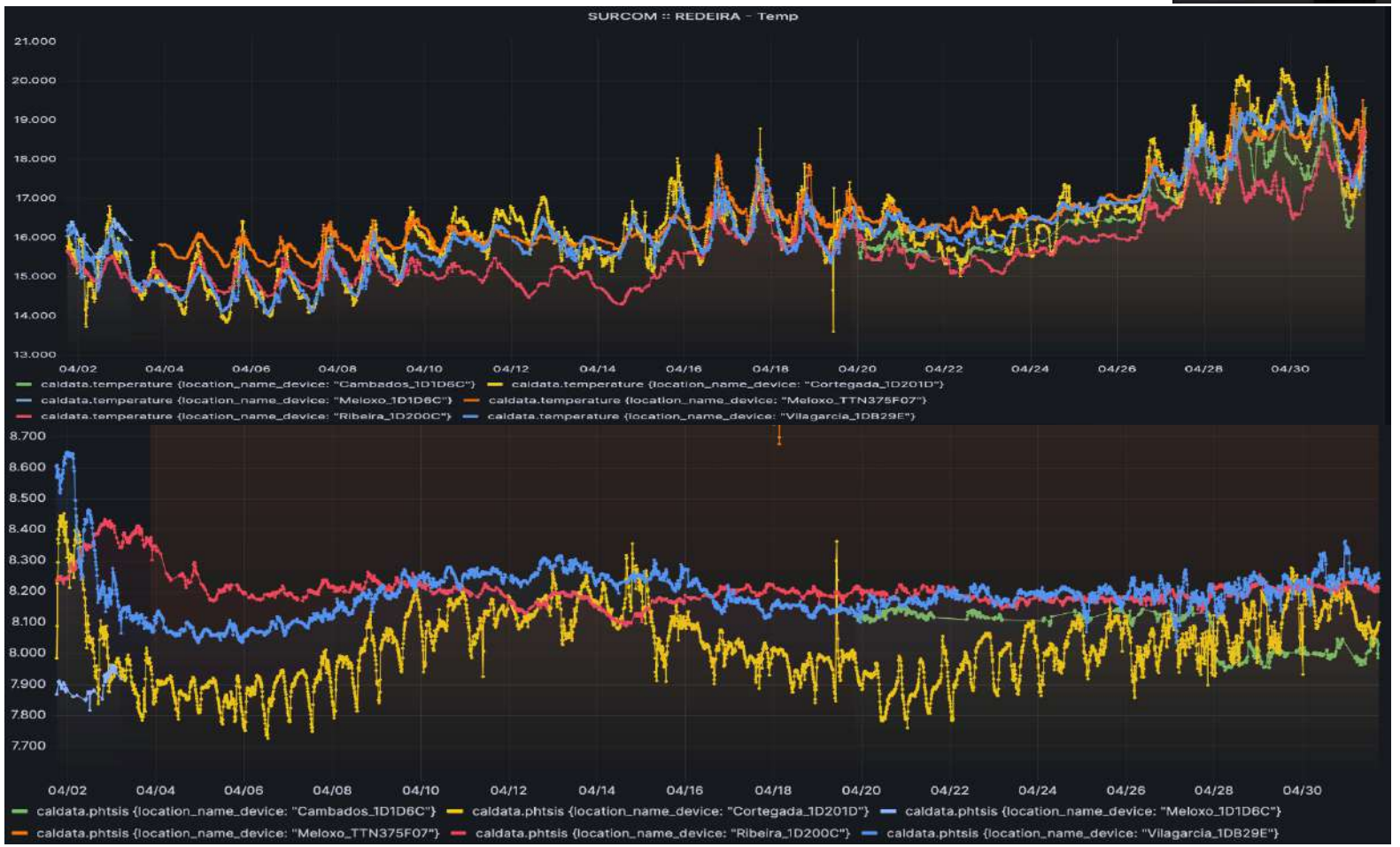


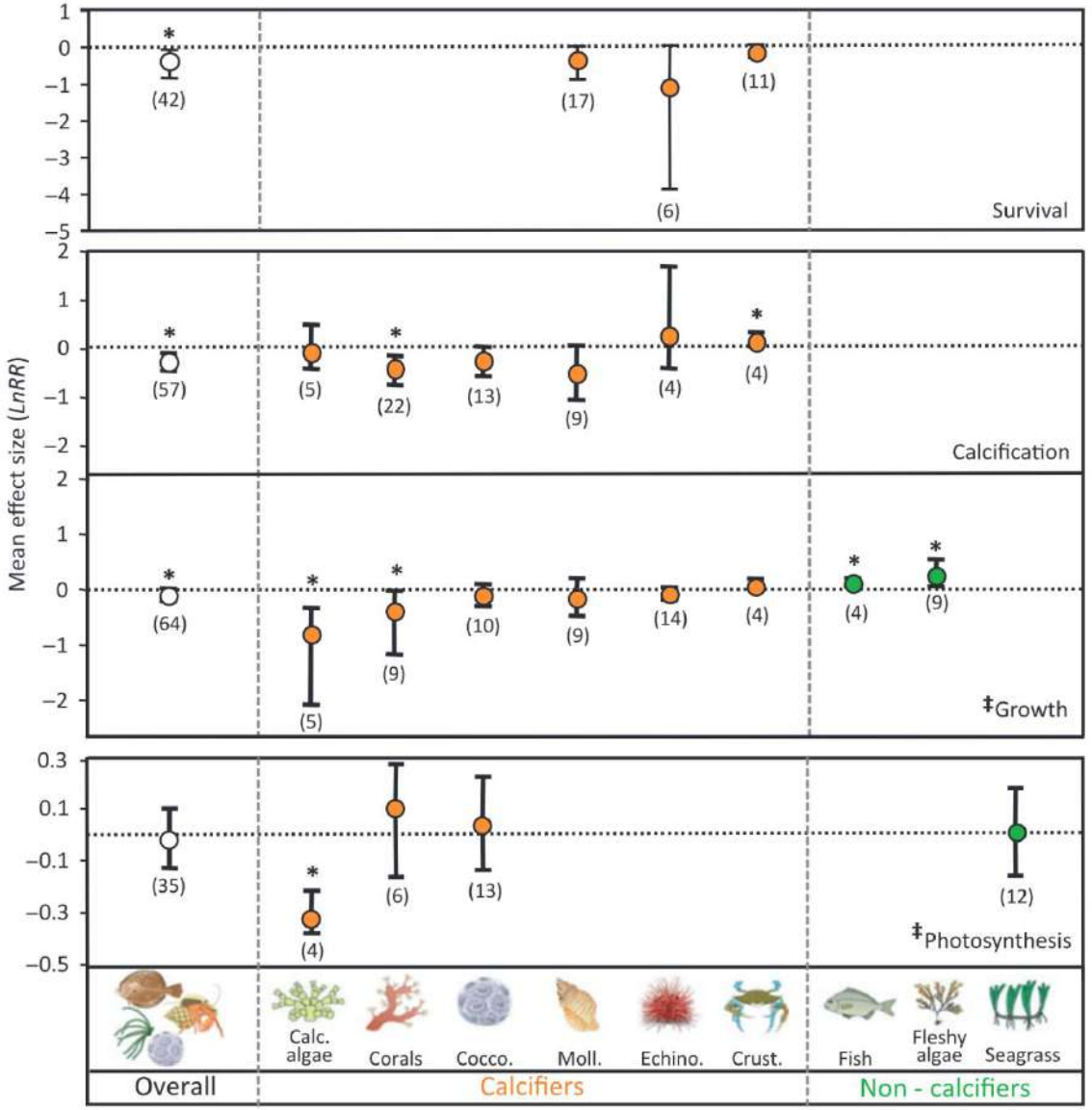
Figure 4: Map of Ría de Arousa and the positions of oceanographic stations and the sensor deployments.

https://co2.iim.csic.es/monitoring/d/SURCOM_calibrated/surcom-ph-calibrated





Taxa	Response	Mean Effect
Calcifying algae	Survival	
	Calcification	
	Growth	
	Photosynthesis	−28%
	Abundance	−80%
Corals	Survival	
	Calcification	−32%
	Growth	
	Photosynthesis	
	Abundance	−47%
Coccolithophores	Survival	
	Calcification	−23%
	Growth	
	Photosynthesis	
	Abundance	
Mollusks	Survival	−34%
	Calcification	−40%
	Growth	−17%
	Development	−25%
	Abundance	
Echinoderms	Survival	
	Calcification	
	Growth	−10%
	Development	−11%
	Abundance	
Crustaceans	Survival	
	Calcification	
	Growth	
	Development	
	Abundance	
Fish	Survival	
	Calcification	
	Growth	
	Development	
	Abundance	
Fleshy algae	Survival	
	Calcification	
	Growth	+22%
	Photosynthesis	
	Abundance	
Seagrasses	Survival	
	Calcification	
	Growth	
	Photosynthesis	
	Abundance	
Diatoms	Survival	
	Calcification	
	Growth	+17%
	Photosynthesis	+12%
	Abundance	



Kroeker et al. 2010, 2013

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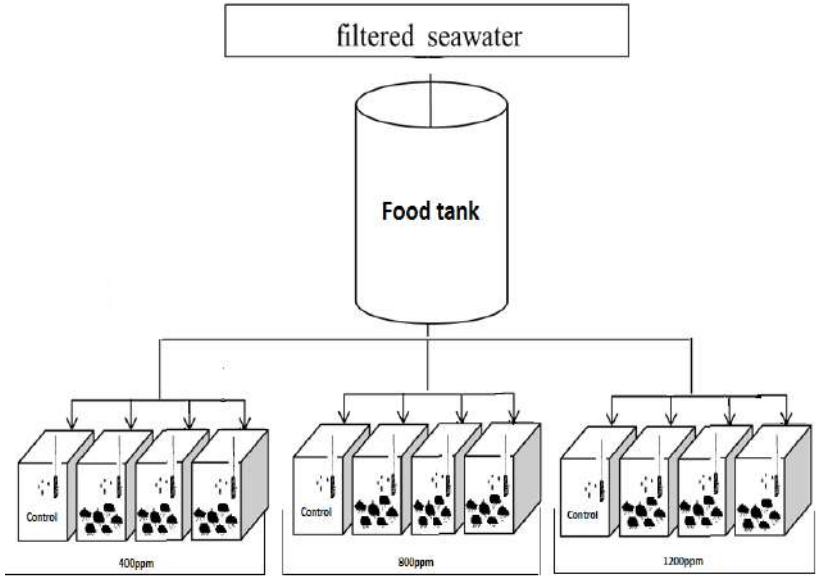
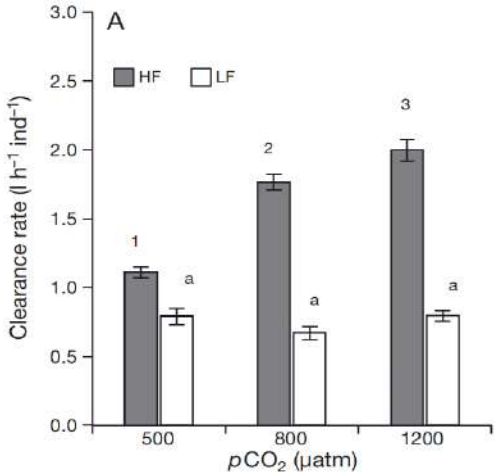
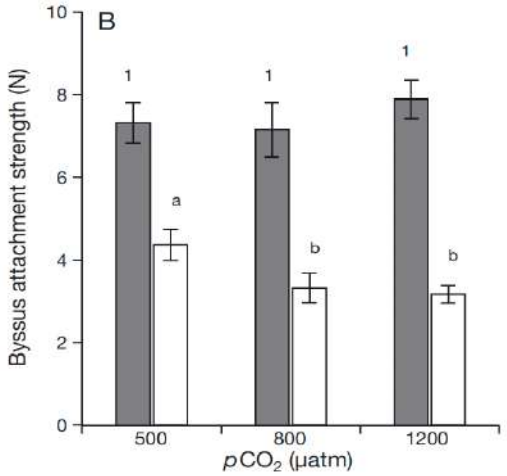
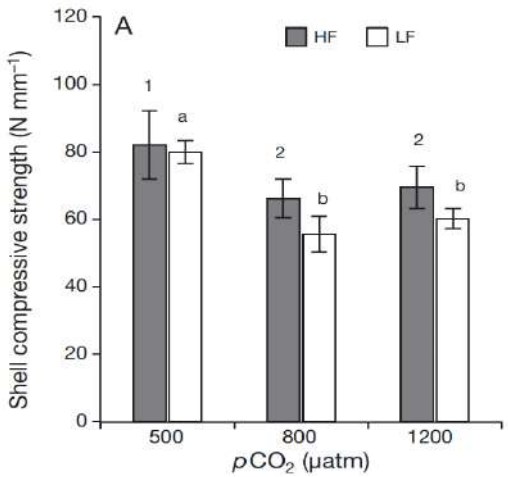
Acidificación nas Rías e Plataforma oceánica ibérica
Ministerio de Ciencia e Innovación (Ref. CTM2016-76146-C3-2-R)









Lassoued et al. 2019. MEPS 626: 97–108

Investigación sobre a eliminación del dióxido de carbono

	Duration of Storage (years)	Scale Potential (Gt CO_2 / yr)	Estimated Cost ($ / tCO_2 removal)	Current Readiness
Direct Air Capture [1,2,3,4,5]	High, *using geologic storage* (> 1000 Years)	Low - High (0 - 11)	Low - High ($40 - $1000)	High
Soil Carbon [2,6,7,8,9,10]	Low, *potentially reversible* (< 30 - 40 years)	Moderate (2 - 6)	Low ($0-$100)	High
Afforestation and Reforestation [2,11,12,13]	Low - Moderate, *potentially reversible* (10 - 100 years)	Low - High (0 - 12)	Low - Moderate ($2 - $150)	High
Macroalgal Cultivation [2,3,14,15,16]	Low - Moderate (10 - 100)	Low (0. 1 -0.6)	Low - Moderate ($25 - $125)	Moderate
Alkalinity Enhancement [2,14,17]	High (>20,000)	Moderate - High (1 - 15+)	Low - Moderate ($25 - $160)	Low - Moderate
Direct Ocean Capture [14,17,18]	High, *using geologic storage* (> 1000 Years)	Moderate (1 - 10)	High ($400 - $600)	Low - Moderate
Ocean Fertilization [2,14,19]	Low - Moderate (10 - 100)	Low - Moderate (0.1 - 1+)	Low - Moderate ($50 - $125)	Moderate
Artificial Upwelling / Downwelling [4]	Low - Moderate (10 - 100)	Low (0.1 - 1)	Moderate ($100 - $150)	Low
Coastal Blue Carbon [14,16,19,20]	High (> 1000)	Low (0.1 - 0.4)	Low ($10 - $50)	High
Ecosystem Recovery [14]	Low - Moderate (10 - 100)	Low (0.1 - 1)	Low ($10 - $50)	Moderate

[1] Minx et al., 2018, [2] Fuss et al., 2018, [3] Nemet et al., 2018, [4] Fasihi, Efimova, and Breyer, 2019, [5] Keith et al., 2018, [6] Smith, 2012, [7] Smith, 2016, [8] NASEM 2019, [9] Paustian et al., 2019, [10] UNEP, 2017, [11] Liu et al., 2016, [12] Smith et al., 2016b, [13] NASEM 2015, [14] NSEM 2021, [15] Krause-Jensen and Duarte, 2016, [16] NOAA CBC White Paper, [17] Eisamann, 2010, [18] de Lannoy et al., 2018, [19] NOAA 2010 OF White Paper, [20] Braswell et al., 2020, [21] Macreadie et al., 2019, [22] NRC 2019

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GRAZAS

Ocean Acidification in the North Pacific Ocean

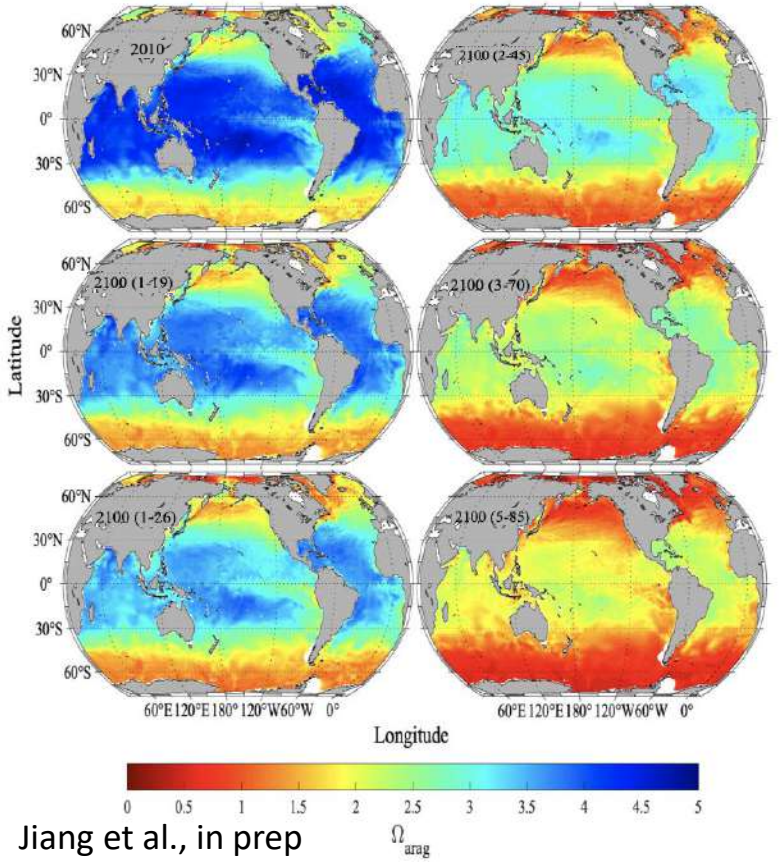
Conclusions

1. Surface anthropogenic CO_2 concentrations generally increase from high latitudes to low latitudes, with the lowest values occurring in the strong upwelling regions where older water upwells to the surface.

2. Anthropogenic CO_2 is the major source of decrease pH and aragonite saturation state in surface waters; however decadal changes in circulation and upwelling processes can cause decadal changes in acidification rates.

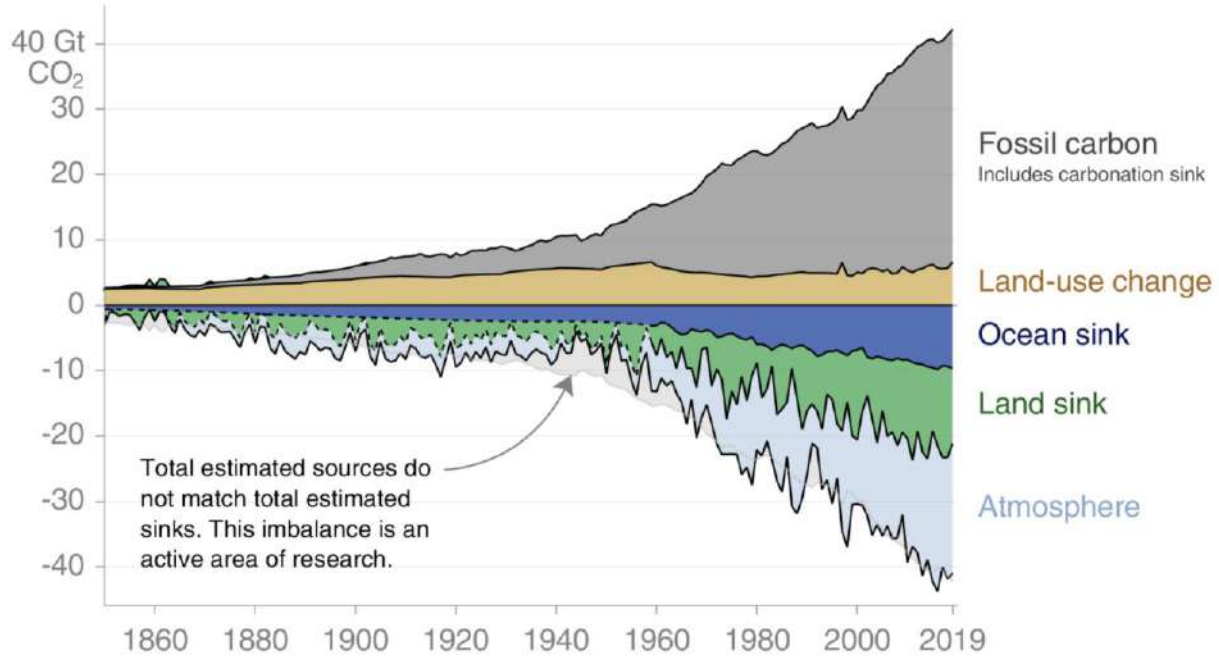
3. Long-term decreases in aragonite saturation state and pH are primarily controlled by the amount and rate of exchange of CO_2 emissions from the atmosphere.

Projected Aragonite Saturation State Changes



Jiang et al., in prep

The Global Carbon Budget

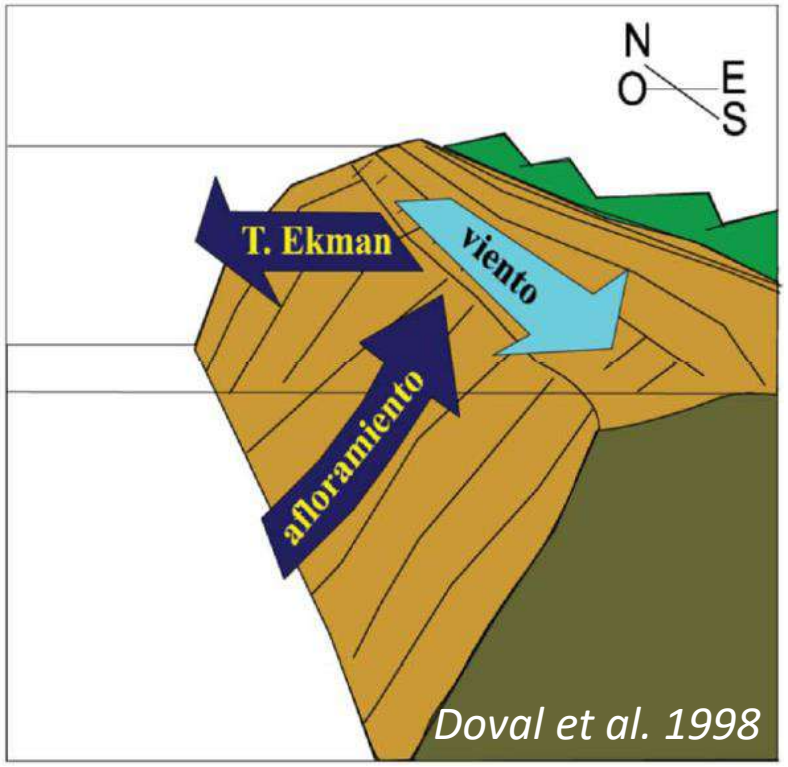


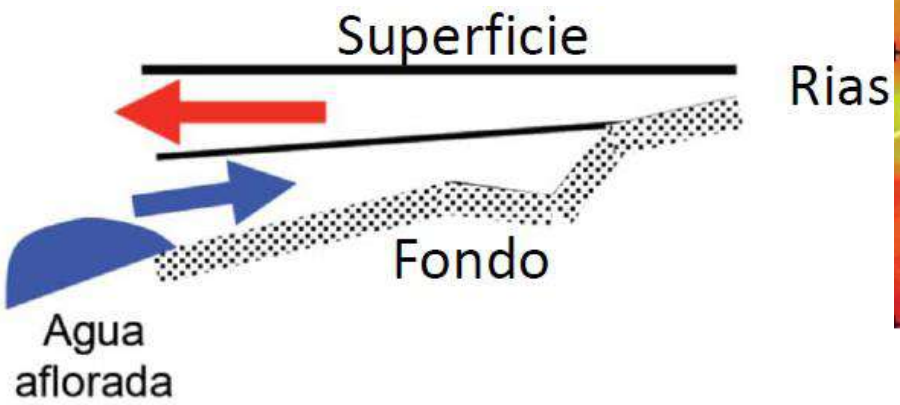
Friedlingstein et al 2020

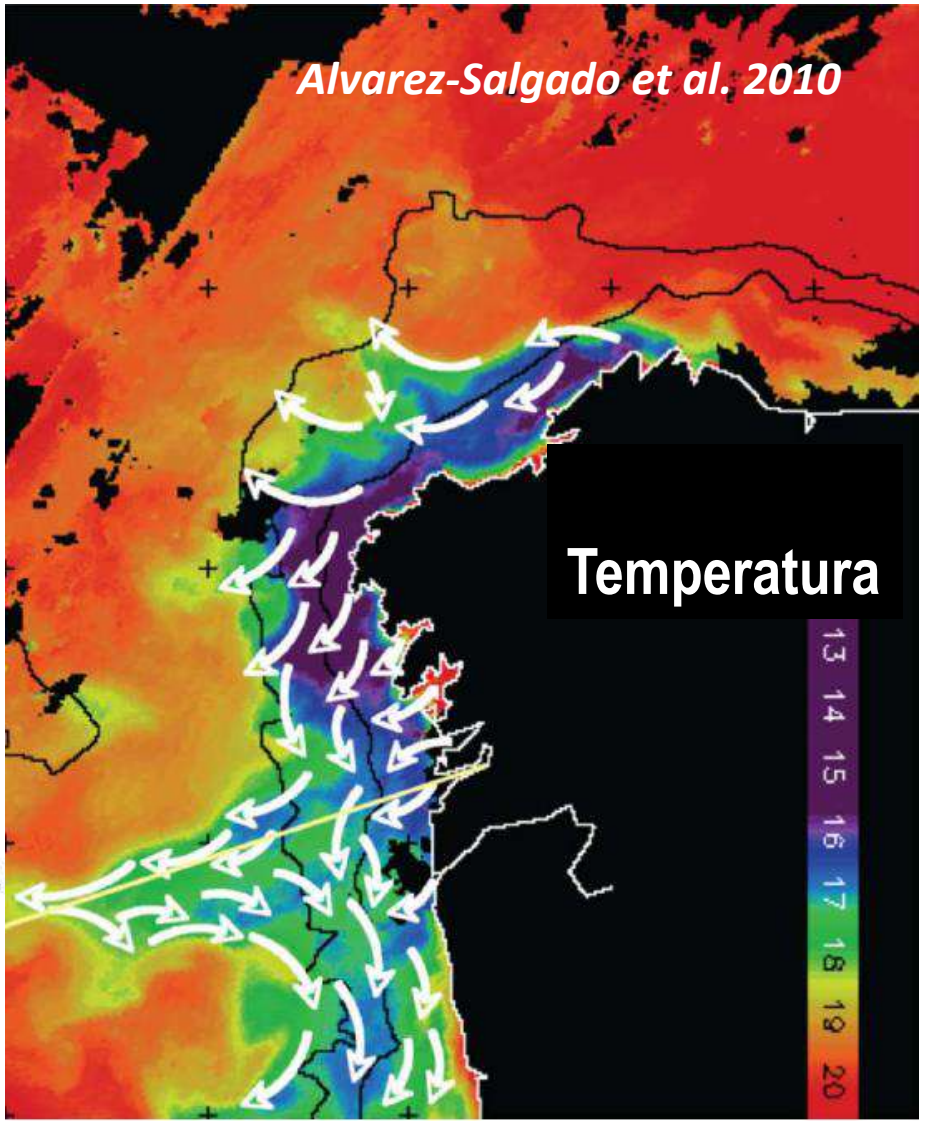
Major Scientific Questions

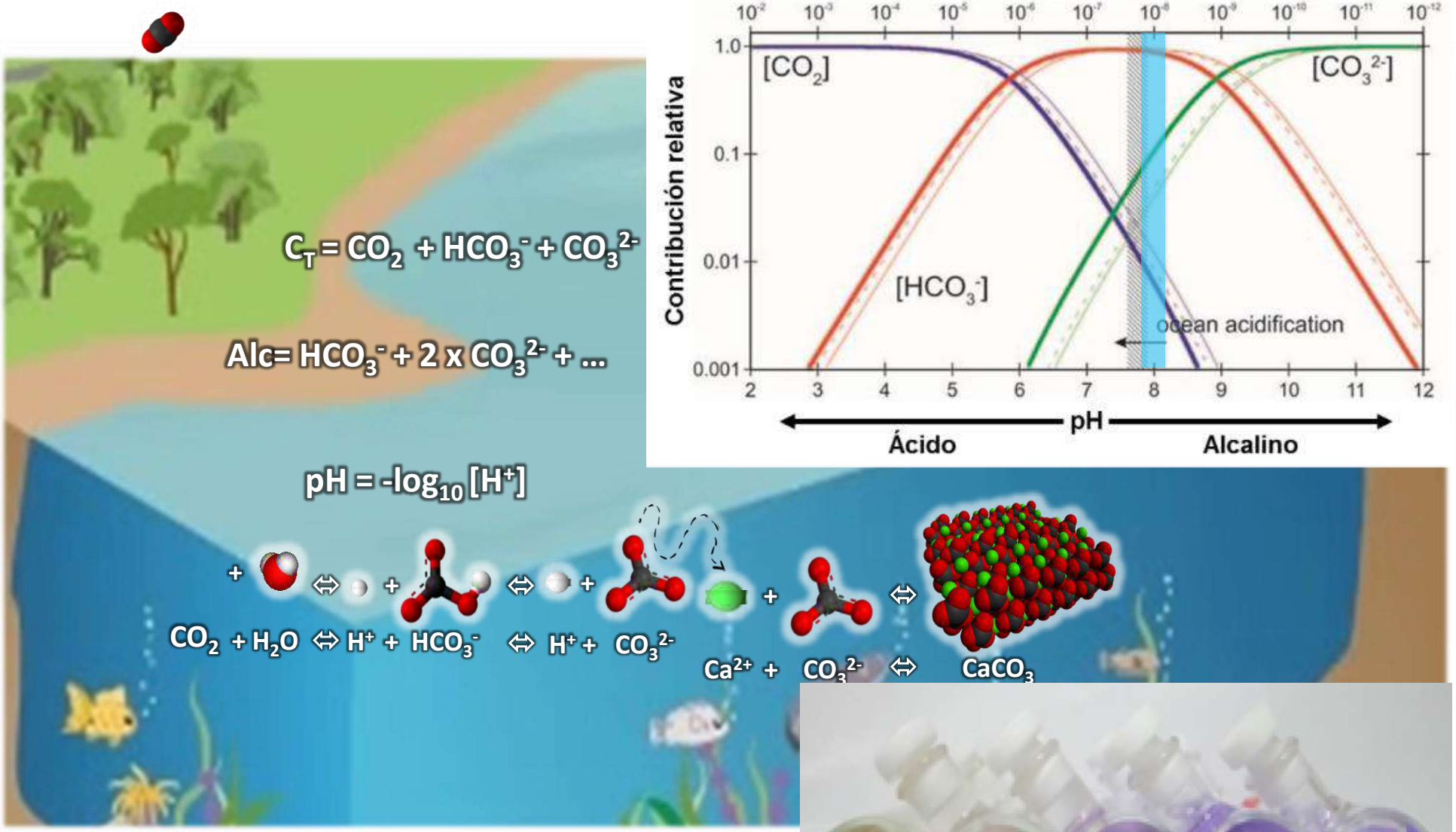
- What controls the seasonal and decadal variations in CO_2 uptake and pH decline?
- How do these short-term variations affect the acidification of the ocean?
- How will this acidification affect organisms and ecosystems?

AFLORAMENTO COSTEIRO

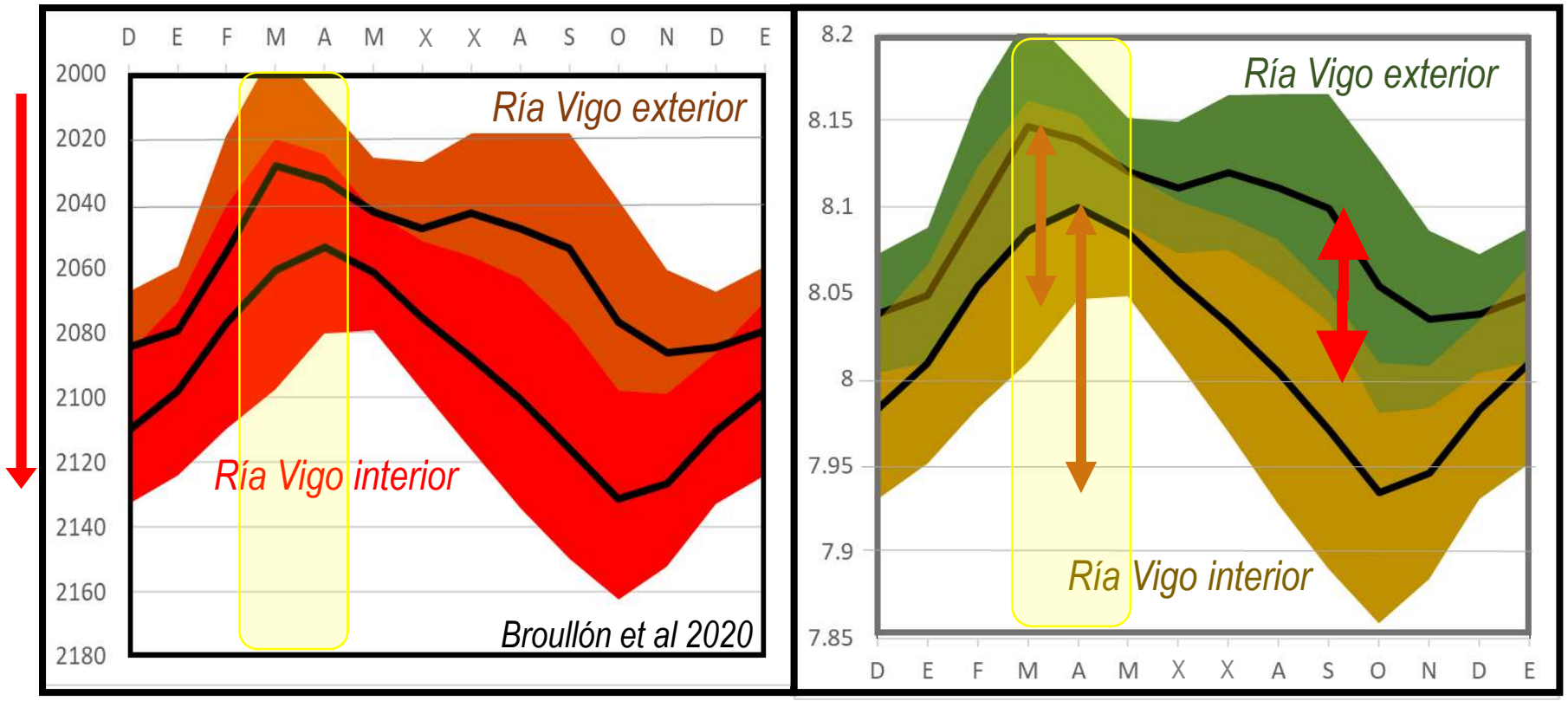








García-Ibañez, 2015
Fajar 2012



-0.0019

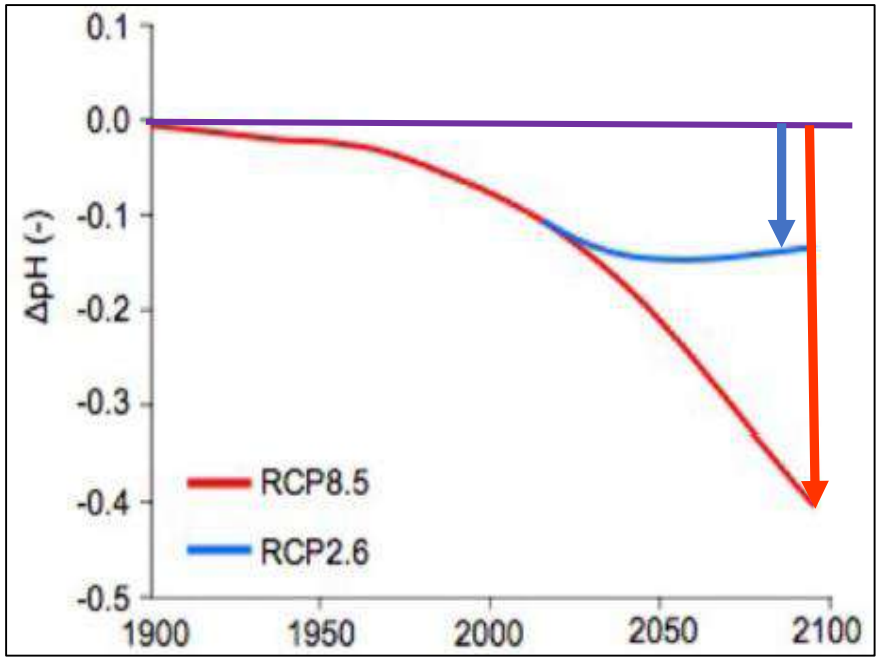
Padín et al 2020

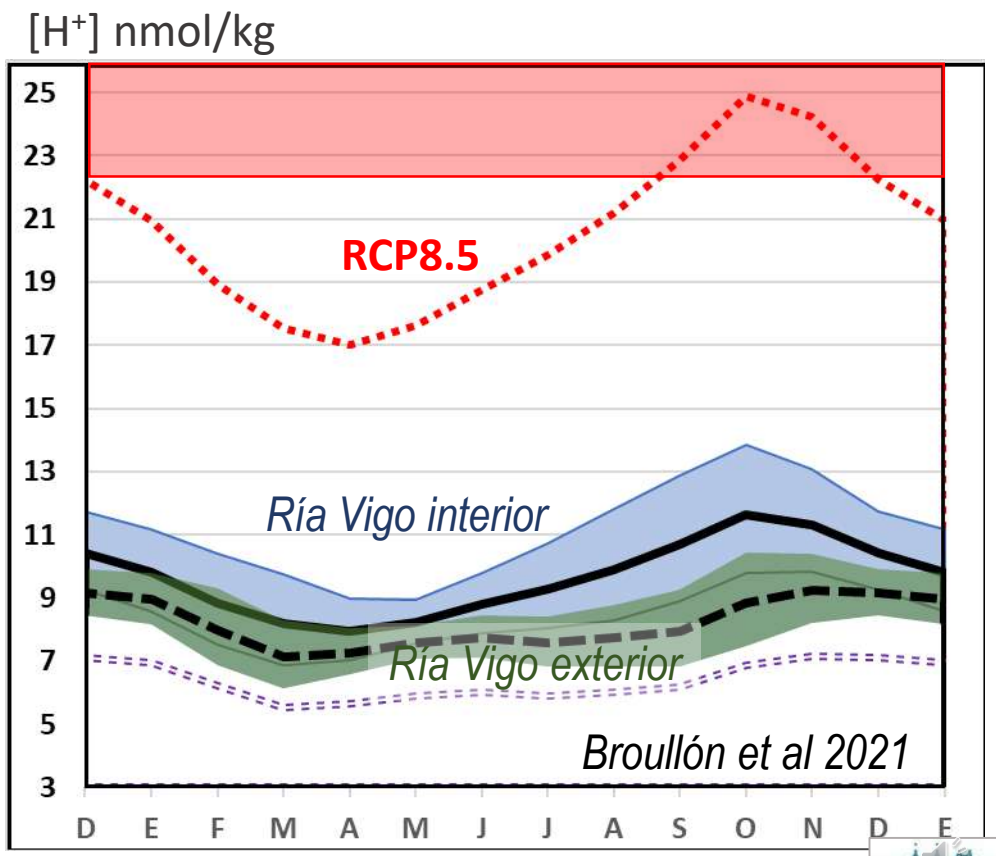
Spectrophotometric pH

8.1

7.4

A acidificación nas Rías





5.- Experimentación en acuarios y mesocosmos: impactos en organismos y ecosistemas en escenarios futuros.

Proyecto ARIOS

REMO

Radiotrazadores para el estudio de Ecosistemas Marinos y Oceánicos

Levante
EL MERCANTIL VALENCIANO

CSIC y Oceanogràfic estudian los efectos del cambio climático en corales y moluscos con una técnica pionera en España

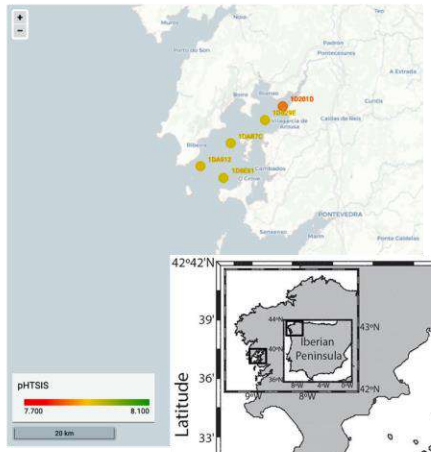
Un equipo conjunto analizará el elevado nivel de acidez de mares y océanos

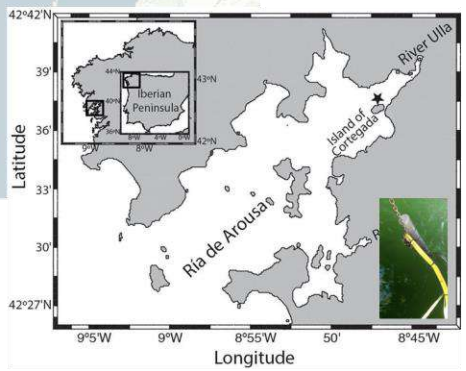
EP/ED

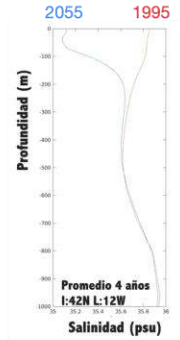
València | 09·03·22 | 11:20 | Actualizado a las 11:23

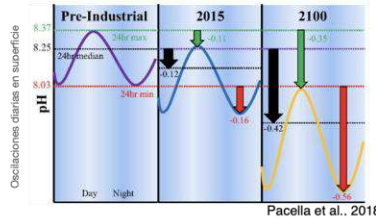
Equipo del IFIC y del Oceanogràfic que participa en el proyecto. / IFIC.

3.- Red costera de monitorización autónoma de pH en tiempo real

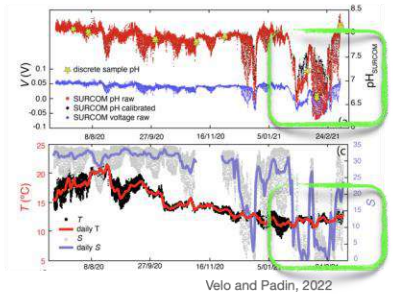




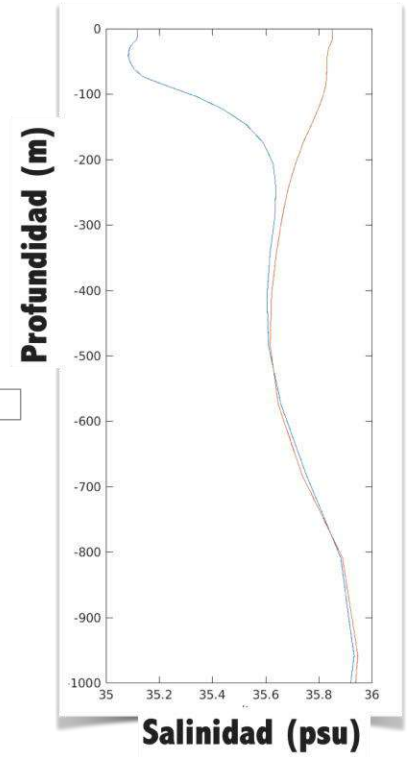




Pacella et al., 2018



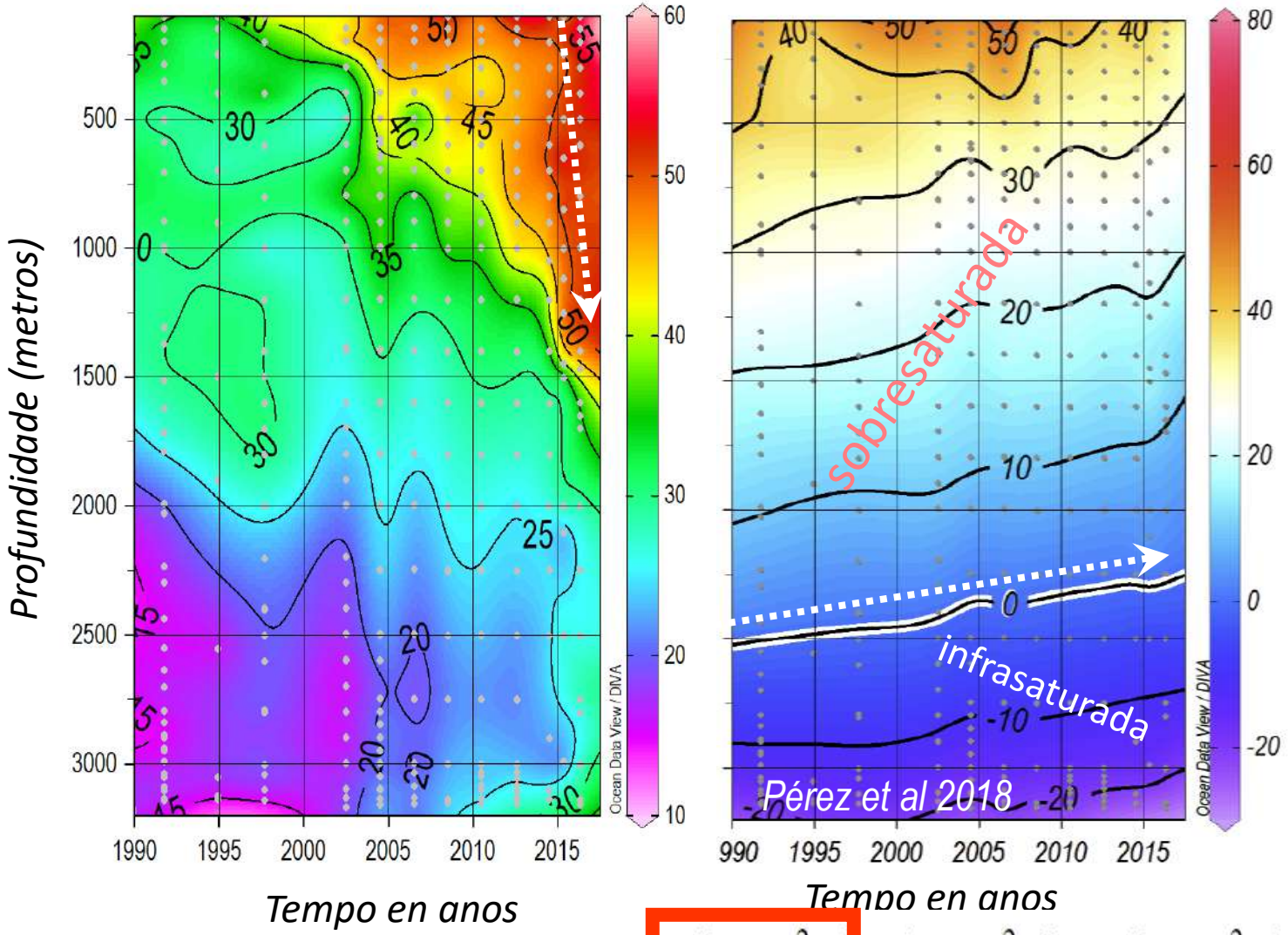
Velo and Padin, 2022



1	2	3	4	5	6	7	8	9	10

Incremento do ***CO_2 antropogénico*** *e diminución da* ***saturación de aragonita***

Estación Central do Mar do Irminger 1991-2016



$$_{xc}[CO_3^{2-}] = [CO_3^{2-}]_{is} - [CO_3^{2-}]_{sat(\Omega_A=1)}$$

INSTITUTO DE INVESTIGACIÓNS MARIÑAS

CSIC

Consejo Superior de Investigaciones Científicas

Conclusións:

- O rexistro das mínimas variacións [case ceros] de medidas básicas como pH e temperatura, [obtidas con metodoloxías que permiten unha alta precisión], en series persistentes no tempo, mostra a súa importancia na detección de problemas no vasto océano, así como facer proxeccións sobre o impacto futuro das nosas actuacións.
- A Acidificación Oceánica é moi evidente no Atlántico afectando a biodiversidade das augas profundas. É un problema común, pero o ritmo ao que acontecen os cambios e as súas consecuencias son diferentes nas zonas costeiras.
- A forte estacionalidade do pH nas zonas costeiras como as Rías, que é de orixe biolóxico, dificulta a detección do impacto da Acidificación Oceánica sendo necesarias series temporais longas e de alta frecuencia. De xeito similar acontece coa detección do quecemento.
- É necesario un bo modelado numérico dos procesos físicos, químicos e biolóxicos para asesorar sobre o futuro dos nosos ecosistemas mariños e avaliar o impacto do cambio climático na saúde das Rías e na acuicultura.
- Posiblemente cheguemos tarde na supervivencia dos corais de auga fría, pero para moitos ecosistemas como a nosas Rías, aínda estamos a tempo.

GRAZAS !!!!