FLUJO E INVENTARIO DE DIÓXIDO DE CARBONO, ACIDIFICACIÓN Y SALUD OCEÁNICA EN CAMPAÑAS OCEANOGRÁFICAS REPETIDAS EN EL OCÉANO ATLÁNTICO (FICARAM+)

DOCUMENTOS

1. CVA: X.A. Padin
2. CVA: F.F. Pérez
3. Resumen extendido del proyecto

Fecha del CVA	27/01/2024

Parte A. DATOS PERSONALES

Nombre	JOSE ANTONIO		
Apellidos	PADIN ALVAREZ		
Sexo	Hombre	Fecha de Nacimiento	28/02/1977
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URL Web			
Dirección Email	padin@iim.csic.es		
Open Researcher and Contributor ID (ORCID)	0000-0002-4277-3410		

A.1. Situación profesional actual

Puesto	Científico Titular		
Fecha inicio	2021		
Organismo / Institución	Consejo Superior de Investigaciones Científicas		
Departamento / Centro	OCEANOLOXÍA / Instituto de Investigaciones Marinas		
País		Teléfono	
Palabras clave	250000 - Ciencias de la Tierra y del Espacio		

A.3. Formación académica

Grado/Master/Tesis	Universidad / País	Año
Programa Oficial de Doctorado en Ciencias del Mar	Universidade de Vigo	2009
Analytical studies of DSP in norwegian mussels with chromatography technique (HPLC).	UNIVERSIDADE DE VIGO	2002
Licenciado en Ciencias del Mar Orientación Medio Ambiente y Contaminación Marina	Universidade de Vigo	2000

Parte C. LISTADO DE APORTACIONES MÁS RELEVANTES

C.1. Publicaciones más importantes en libros y revistas con "peer review" y conferencias

AC: Autor de correspondencia; (nº x / nº y): posición firma solicitante / total autores. Si aplica, indique el número de citaciones

1 **Artículo científico**. Séverine Methion; Oriol Giralt Paradell; Xosé Antonio Padín; Thierry Corrège; Bruno Díaz López. 2023. Group size varies with climate and oceanographic conditions in bottlenose dolphins. Marine Biology. 170-7, pp.https://doi.org/10.1007/s00227-022-04154-4.

2 **Artículo científico**. A. Velo; X.A. Padin. 2022. Advancing real-time pH sensing capabilities to monitor coastal acidification as measured in a productive and dynamic estuary (R´ıa de Arousa, NW Spain).Frontiers Marine Science. https://doi.org/10.3389/fmars.2022.941359. http://hdl.handle.net/10261/285248. 9.

3 **Artículo científico**. Pablo Sánchez-Jerez; Jose M. F. Babarro; X.A. Padin; Angeles Longa Portabales; Silvia Martínez-Llorens; Jose David Ballester Bermane; Gianluca Sara; Maria Cristina Mangano. 2022. Cumulative climatic stressors strangles marine aquaculture: Ancillary effects of COVID 19 on Spanish mariculture. Aquaculture. Science Direct. 549-737749.

4 **Artículo científico**. Elisabet R. Cruz; Rita Nolasco; Xosé A. Padin; Miguel Gilcoto; Jose M. F. Babarro; Jesús Dubert; Fiz F. Pérez. 2021. A High-Resolution Modeling Study of the Circulation Patterns at a Coastal Embayment: Ría de Pontevedra (NW Spain) Under Upwelling and Downwelling Conditions. Frontiers in Marine Science. Frontiers.

5 **Artículo científico**. Xosé A. Padin; Jose M.F. Babarro; Elsa Silva; M. Ángeles Longa Portabales; Silvia Calvo; Rita Nolasco. 2021. Variability in strength of byssus attachment and index condition of subtidal mussels during the maximum growth stage.Aquaculture Research. Willey Online Librery. 52-8, pp.3485-3497.

6 **Artículo científico**. Jihene Lassoued; XA Padín; Luc A. Comea; Nejla Bejaoui; Fiz F. Pérez; Jose MF Babarro. 2021. The Mediterranean mussel Mytilus galloprovincialis: responses to climate change scenarios as a function of the original habitat. Conservation Physiology. Oxford Academic. 9-1.

7 **Artículo científico**. Xosé Antonio Padin; Antón Velo; Fiz F. Pérez. 2020. ARIOS: a database for ocean acidification assessment in the Iberian upwelling system. Earth System Science Data. Copernicus. 12, pp.2647-2663.

8 **Artículo científico**. Marcos Fontela; Fiz F. Pérez; Lidia I. Carracedo; Xosé A. Padín; Antón Velo; Maribel I. García-Ibañez; Pascale Lherminier. 2020. The Northeast Atlantic is running out of excess carbonate in the horizon of cold-water corals communities. Scientific Reports. Nature. 10-14714.

9 **Artículo científico**. Jose M. F. Babarro; Ramón Filgueira; Xosé A. Padín; M. Angeles Longa Portabales. 2020. A Novel Index of the Performance of Mytilus galloprovincialis to Improve Commercial Exploitation in Aquaculture. Frontiers in Marine Sciece. Frontiers. 7-719.

10 **Artículo científico**. Lassoued J.; Babarro JMF; Padín XA; Comeau LA; Bejaoui N; Perez FF. 2019. Behavioural and eco-physiological responses of the mussel Mytilus galloprovincialis to acidification and distinct feeding regimes. Marine Ecology Progress Serie. Inter-Research Science Publisher. 626, pp.97-108.

11 **Artículo científico**. J.M.F. Babarro; X.A. Padin; R. Filgueira; H. El Morabet; M. A. Longa Portabales. 2019. The impact of the sea anemone Actinothoe shpyrodeta on mussel cultivation (Galicia, NW Spain).Biofouling. 34, pp.1138-1149.

12 **Artículo científico**. X.A. Padin; A. Alonso-Fernández; A. Lijó; V. Otero; J. Otero. 2018. Environmental drivers of lesser weever stings on the northeast Atlantic coast (A Lanzada beach, Spain). Ecological Indicators. 95, pp.242-249.

13 **Artículo científico**. Corinne Le Quéré; Robbie M. Andrew; Pierre Friedlingstein; Stephen Sitch; ...; X. Antonio Padin; ...; Dan Zhu. 2018. Global Carbon Budget 2017. Earth System Science Data. 10, pp.405-448.

14 **Artículo científico**. Fiz F. Perez; Marcos Fontela; Maribel I. García-Ibáñez; et al; Elisa F. Guallart. 2018. Meridional overturning circulation conveys fast acidification to the deep Atlantic Ocean. Nature. 554, pp.515-518.

15 **Artículo científico**. L.I. Carracedo; F.F.Pérez; M.Gilcoto; A.Velo; X.A.Padin; G.Rosón. 2018. Role of the circulation in the anthropogenic CO2 inventory in the North-East Atlantic: a climatological analysis. Progress in Oceanography. 161, pp.78-86.

16 **Artículo científico**. Luc Comeau; Jose Babarro; M. Angeles Longa Portabales; Xosé Antonio Padín Álvarez. 2017. Valve-gaping behavior of raft-cultivated mussels in Ría de Arousa, Spain.Aquaculture Reports. 9, pp.68-73.

17 **Artículo científico**. AIDA F RÍOS; LAURE RESPLANDY; MARIBEL I. GARCÍA-IBÁÑEZ; et al; Fiz F. Pérez. 2015. Decadal acidification in the water masses of the Atlantic Ocean. Proceedings of National Academic of Science (PNAS). 112-32, pp.9950-9955.

18 **Artículo científico**. Patricia Zunino; Pascale Lherminier; Herlé Mercier; Xose A. Padin; Aida F. Rios; Fiz F. Pérez. 2015. Dissolved Inorganic Carbon budgets in the eastern Subpolar North Atlantic in the 2000s from in situ data. Geophysical Research Letters. 42, pp.9853-9861.

19 **Artículo científico**. Elisa F. Guallart; Noelia M. Fajar; Xosé Antonio Padin; et al; Fiz F. Pérez. 2015. Ocean acidification along the 24.5ºN section in the subtropical North Atlantic. Geophysical Research Letters. 42, pp.450-458.

20 **Artículo científico**. B. Pfeil; A. Olsen; D.C.E. Bakker; ...; X.A. Padin; ...; H. Yoshikawa-Inoue. 2013. A uniform, quality controlled Surface Ocean CO2 Atlas (SOCAT). Earth Syst. Sci. Data. 5, pp.125-143.

21 **Artículo científico**. Z.-P. Jiang; D.J. Hydes; T. Tyrrell; S.E. Hartman; M.C. Hartman; C. Dumousseaud; X.A. Padin. 2013. Key controls on the seasonal and interannual variations of the carbonate system in the Northeast Atlantic. Journal of Geophysical Research. 118, pp.785-800.

22 **Artículo científico**. P OTERO; XA PADIN; M RUIZ-VILLAREAL; L GARCIA-GARCIA; AF RIOS; FF PÉREZ. 2013. Net sea-air CO2 flux uncertainties in the Bay of Biscay based on the choice of wind speed products and gas transfer parameterizations.Biogeosciences. 10, pp.2993-3005.

23 **Artículo científico**. Cobo-Viveros, A.M.; Padin, X.A.; Otero, P.; de la Paz, M.; Ruiz-Villareal, M.; Ríos, A.F.; Pérez, F.F.2013. Short-term variability of surface carbon dioxide and air-sea CO2 fluxes in the shelf waters of the Galician coastal upwelling. Scientia Marina. 77, pp.37-48.

24 **Artículo científico**. C. L. Sabine; S. Hankin; H. Koyuk; ...; X.A. Padin; ...; H. Yoshikawa-Inoue. 2013. Surface Ocean CO2 Atlas (SOCAT) gridded data products. Earth Syst. Sci. Data. 5, pp.145-153.

25 **Artículo científico**. Vazquez-Rodríguez, M.; Padin, X.A.; A.F. Ríos; F.F. Pérez. 2012. The subsurface layer reference to calculate preformed alkalinity and air-sea CO2 disequilibrium in the Atlantic Ocean. Tellus. 94, pp.52-63.

26 **Artículo científico**. XA PADIN; CG CASTRO; AF RÍOS; FF PEREZ. 2011. Chemical characterization and biogeochemical variability of the Eastern North Atlantic Cental Water at two contrasted NAO scenarios. Journal of Marine Systems. 84, pp.67-77.

27 **Artículo científico**. Pardo, P.C.; Padin, X.A.; Gilcoto, M.; Farina-Busto, L.2011. Evolution of upwelling systems coupled to the long term variability of sea surface temperature and Ekman transport. Climate Research. 48, pp.231-246.

28 **Artículo científico**. de la Paz, M.; Huertas, E.M.; Padin, X.A.; et al; Ríos, A.F.2011. Reconstruction of the seasonal cycle of air-sea CO2 fluxes in the Strait of Gibraltar. Marine Chemistry. 126, pp.155-162.

29 **Artículo científico**. XA PADIN; M VAZQUEZ RODRÍGUEZ; M CASTAÑO; et al; XA PADIN. 2010. Air-sea CO2 fluxes in the Atlantic as measured during boreal spring and autumn. Biogeosciences. 7, pp.1587-1606.

30 **Artículo científico**. Ríos, A.F.; Vázquez-Rodríguez, M.; Padin, X.A.; Pérez, F.F. 2010. Anthropogenic carbon dioxide in the South Atlantic western basin. Journal of Marine Systems. 83, pp.38-44.

31 **Artículo científico**. Velo, A.; Vazquez-Rodríguez, M.; Padin, X.A.; Gilcoto, M.; Ríos, A.F.2010. Interpolation of anthropogenic CO2 over the World Ocean Atlas (WOA05) with a multiparametric method. Sciencia Marina. 74, pp.21-32.

32 **Artículo científico**. Fiz F. Pérez; XA Padin; Yolanda Pazos; Miguel Gilcoto; Mª Dolores Doval; Manuel Cabanas; Luis Fariña-Busto. 2010. Plankton response to weakening of coastal upwelling. Global Change Biology. 16, pp.1258-1267.

33 **Artículo científico**. de la Paz, M.; Padín, X.A.; Ríos, A.F.; Pérez, F.F.2010. Surface fCO2 variability in the Loire plume and adjacent shelf waters: High spatio-temporal resolution study using ships of opportunity. Marine Chemistry. 118, pp.108-118.

34 **Artículo científico**. Andrew J. Watson; Ute Schuster; Dorothee C. E. Bakker; et al; Rik Wanninkhof. 2009. A network to accurately estimate the North Atlantic sink for atmospheric CO2.Science. 326, pp.1391-1393.

35 **Artículo científico**. M. Vázquez-Rodríguez; X.A. Padín; Aida F. Ríos; R.G.J. Bellerby; F. F. Pérez. 2009. An upgraded carbon-based method to estimate the anthropogenic fraction of dissolved CO2 in the Atlantic Ocean. Biogeosciences. 5, pp.1669-1679.

36 **Artículo científico**. Vázquez-Rodríguez, M.; Touratier, F.; Lo Monaco, C.; et al; Pérez, F.F.2009. Anthropogenic carbon distributions in the Atlantic Ocean: data-based estimate from the Arctic to the Antarctic. Biogeosciences. 6, pp.439-451.

37 **Artículo científico**. M. Telszewski; A. Chazottes; U. Schuster; et al; R. Wanninkof. 2009. Estimating the monthly pCO2 distribution in the North Atlantic usinga self-organizing neural network. Biogeosciences. 6, pp.1405-1421.

38 **Artículo científico**. XA PADIN; G NAVARRO; M GILCOTO; AF RÍOS. 2009. Estimation of air-sea CO2 fluxes in the Bay of Biscay using an empirical relationships and remotely sensed observations. Journal of Marine Systems. 75, pp.280-289.

39 **Artículo científico**. F.F. Pérez; M. Vázquez-Rodríguez; E. Louarn; X.A. Padin; H. Mercier. 2008. Temporal variability of the anthropogenic CO2 storage in the Irminger Sea. Biogeosciences. 5.

40 **Artículo científico**. XA PADIN; CG CASTRO; AF RÍOS; FF PÉREZ. 2008. fCO2sw variability in the Bay of Biscay during ECO cruises. Continental Shelf Research. 28, pp.904-914.

41 **Artículo científico**. P. Quay; R. Sonnerup; J. Stutsman; J. Maurer; A. Kortzinger; X.A. Padin; C. Robinson. 2007. Anthropogenic CO2 accumulation rates in the North Atlantic Ocean from changes in the 13C/12C of disolved inorganic carbon. Global Biogeochemical Cyles. 21.

42 **Artículo científico**. X.A. Padin; M. Vázquez-Rodríguez; A.F. Ríos; F.F. Pérez. 2007. Atmospheric CO2 measurements and error analysis on seasonal air-sea CO2 fluxes in the Bay of Biscay. Journal of Marine Systems. 66, pp.285-296.

43 **Artículo científico**. XA PADIN; M VAZQUEZ-RODRIGUEZ; AF RÍOS; FF PEREZ. 2007. Surface CO2 measurements in the English Channel and Southern Bight of North Sea using voluntary observing ships.Journal of Marine Systems. .-66, pp.297-308.

44 **Dataset**. Velo, A.; Padín, X.A.; Álvarez, P; Rey-Muras, J; Almécija, C; Torres, S; Pérez, F.F.2022. SURCOM pH and temperature data collection registered at Cortegada Platform (Ria de Arousa - Spain) from 2020 to 2021. Zenodo.

C.3. Proyectos o líneas de investigación

1 **Proyecto**. Research, development and innovation of a Coastal Observation network: Ría de Arousa. José Antonio Padín Álvarez. (Plan Estatal de Investigación Científica y Técnica y de Innovación 2021-2023). 2022-2025. 244.950 €.

2 **Proyecto**. MENUDO FOROACUI: INNOVACIÓN Y DIVULGACIÓN DE LOS RECURSOS DEL MAR Y DE LA ACUICULTURA. (Fundación Española para la Ciencia y la Tecnología). 01/07/2023-30/06/2024. 32.000 €.

3 **Proyecto**. Effects of Ocean Waves in the Rías Baixas Upwelling System: surface dynamics on selected biological case studies. Miguel Gil Coto. (Agencia Estatal Consejo Superior de Investigaciones Científicas). 2021-2023. 267.410 €.

4 **Proyecto**. Riesgos biológicos y ambientales en el cultivo de Mytilus galloprovincialis en el marco de cambio climático. JOSE FERNÁNDEZ BABARRO. (Consejo Superior de Investigaciones Científicas). 2014-2017.

5 **Proyecto**. Tránsitos a bordo del BIO Sarmiento de Gamboa para la medida de CO2 y otras variables (TRANCOS). (Consejo Superior de Investigaciones Científicas). 2010-2011.

6 **Proyecto**. Marine Carbon Sources and Sinks Assessment (CARBOOCEAN). CENTRO DE ACUSTICA APLICADA Y EVALUACION NO DESTRUCTIVA. (Consejo Superior de Investigaciones Científicas). 2005-2009. Contratado.

7 **Proyecto**. Observación y evaluación de la variabilidad climática en aguas oceánicas del Atlántico Norte. (Consejo Superior de Investigaciones Científicas). 2003-2005.

8 **Proyecto**. Evolución del incremento de CO2 usando buques de oportunidad: Costa de Galicia y Golfo de Vizcaya. (Consejo Superior de Investigaciones Científicas). 2002-2005. BECARIO.

Fecha del CVA	20/01/2024

Parte A. DATOS PERSONALES

Nombre	Fiz		
Apellidos	Fernandez Perez		
Sexo	Hombre	Fecha de Nacimiento	23/09/1957
DNI/NIE/Pasaporte	36020991R		
URL Web			
Dirección Email	fiz.perez@iim.csic.es		
Open Researcher and Contributor ID (ORCID)	0000-0003-4836-8974		

A.1. Situación profesional actual

Puesto	Profesor de Investigacion		
Fecha inicio	2003		
Organismo / Institución	Consejo Superior de Investigaciones Científicas		
Departamento / Centro	Oceanografia / Instituto de Investigaciones Marinas		
País		Teléfono	
Palabras clave	251002 - Oceanografía química		

A.2. Situación profesional anterior (incluye interrupciones en la carrera investigadora - indicar meses totales, según texto convocatoria-)

Periodo	Puesto / Institución / País
1993 - 2003	Investigador Científico CSIC / Instituto de Investigaciones Marinas
1987 - 1993	Cientifico Titular / Instituto de Investigaciones Marinas

Parte B. RESUMEN DEL CV

CSIC Research Professor since 2003. 20 doctoral theses supervised. 5 postdoctoral fellowships (JAE, PostMEC, Xunta).

Member of the Real Academia Galega de Ciencias (07/09/2021).

Adjunt Faculty of Ocean Department of Stanford University (14/10/2022 to 30/06/2023).

6 sexenios quality research (last 2012/18). 8 CSIC favorable five-year periods.

212 scientific articles: 203/207 included in SCI / SCOPUS. 155 articles in Q1. Citations: SCOPUS 8572 (H = 51) 8169 WOK (H = 50). 12278 Google Scholar (H = 63). D-index 59: 1273 in the World Ranking and 13 in the National Ranking in Earth Science of Research.com

54 research projects, principal investigator in 28 of them. Principal investigator in 6 oceanographic campaigns. Participation in 28 cruises covering a total of 620 days in peninsular, Atlantic and Antarctic waters. 22 invited lectures in simposiums "corresponding author" of a total of 177 oral works or posters. Organizer of the "XV SEMINARIO IBÉRICO DE QUÍMICA MARINA". CLIVAR Coordinator of the Spanish Network. Miembro de la Comision de Area de Recursos Naturales del CSIC (1996-2000 y 2008-2012).

B.1. Breve descripción del Trabajo de Fin de Grado (TFG) y puntuación obtenida

He did his doctoral thesis in 1985 "On the thermodynamics of the CO2 system in seawater" under the supervision of Dr. Fraga. In his postdoctoral stage, he focused on the analysis of water masses by multiparametric methods, evaluating the aging of water masses. In 1989 he directed his first national plan project "Exchange processes between the shelf and the Galician Rías Bajas: short-term temporal variability" for the evaluation of C, N, O2 and P sources and sinks in the Galician Rías and their relationship with upwelling cycles. In the framework of this project, he was the thesis supervisor of the first two Ph.D. students (Drs. Rosón and Álvarez-Salgado), and they start the research line on dissolved organic carbon dynamics with their measurements using the HTC technique.

During the 1990s, he promoted the incorporation of Spanish Oceanography to the international WOCE program (1992-2002) and then to CLIVAR. He participated in the observations of the carbon cycle in the international WOCE sections (A05, A13, A17 and A25) and also promoted the incorporation of three PhD students in Physical Oceanography. All this later led to the coordination of CLIVAR-Spain together with Roberta Boscolo (WRCP), resulting in the publication CLIMATE IN SPAIN: PAST, PRESENT AND FUTURE. Since 2000, he led studies for the assessment of anthropogenic CO2 uptake by the ocean in the Atlantic and Southern Ocean together with Dr. Aida F. Rios, and also assessed the impact on ocean acidification. During this period, he continuously participated in European projects, initiating and maintaining a close cooperation with the LOPS group of IFREMER in Brest to observe every two years from 2002 to the present the section A-25 (OVIDE). It has assessed the rates of CO2 increase and acidification in the different Atlantic water masses. At the same time, it has determined the factors affecting the North Atlantic in CO2 storage, and for this purpose, it has generated optimized parameterizations of some CO2 system variables and a new method to determine the anthropogenic component. In addition, the design of new systems for the automatic observation of acidification in marine systems.

In addition to the supervision of 19 doctoral theses, Drs. Emilio Fernández, Antón Álvarez-Salgado, Mercedes de la Paz and Rosa Reboreda have supervised the postdoctoral stage. It should be noted that most of the trained doctors continue researching in Marine Sciences in the CSIC or in other organizations (Drs. G. Rosón (Uvigo), A. Álvarez-Salgado, C. González-Castro, M. Gil-Coto, D. Doval (Intecmar), E. Nogueira (IEO), J. Gago (IEO), Antonio Padin, Maribel Garcia-Ibañez, E. Fernandez-Guallart (IEO) and A. Velo). Finally, an important dedication and scientific contribution of advice for the management of the PRESTIGE spill-oil should be highlighted FUTURE (2006).

Parte C. LISTADO DE APORTACIONES MÁS RELEVANTES

C.1. Publicaciones más importantes en libros y revistas con “peer review” y conferencias

AC: Autor de correspondencia; (nº x / nº y): posición firma solicitante / total autores. Si aplica, indique el número de citaciones

1 **Artículo científico**. Müller, Jens Daniel; Gruber, N; Carter, B; et al; Zhu, D. 2023. Decadal Trends in the Oceanic Storage of Anthropogenic Carbon From 1994 to 2014. AGU advances.Wiley Periodicals, Inc.,. 4-4.

2 **Artículo científico**. 2023. Magnitude, Trends, and Variability of the Global Ocean Carbon Sink From 1985 to 2018. Global Biogeochemical Cycles. American Geophysical Union John Wiley & Sons. 37-10, pp.1. ISSN 0886-6236.

3 **Artículo científico**. Cainzos, Veronica; Velo, Anton; Perez, Fiz F.; Hernandez-Guerra, Alonso. 2022. Anthropogenic Carbon Transport Variability in the Atlantic Ocean Over Three Decades. GLOBAL BIOGEOCHEMICAL CYCLES. 36-11. ISSN 0886-6236.

4 **Artículo científico**. Perez, FF; Olafsson, J; Olafsdottir, SR; Fontela, M; Takahashi, T. 2022. Contrasting drivers and trends of ocean acidification in the subarctic Atlantic (vol 11, 13991, 2021). SCIENTIFIC REPORTS. 12-1. ISSN 2045-2322.

5 **Artículo científico**. Marcos Fontela; Anton Velo; Miguel GilCoto; Fiz F Perez. 2021. Anthropogenic CO2 and ocean acidification in Argentine Basin Water Masses over almost five decades of observations. SCIENCE OF THE TOTAL ENVIRONMENT. ELSEVIER. 779. ISSN 1879-1026. WOS (0)

6 **Artículo científico**. Fontela, Marcos; (2/7) Perez, Fiz F.; Carracedo, Lidia I; Padin, Xose A; Velo, Anton; Garcia-Ibanez, Maribel I.; Lherminier, Pascale. 2020. The Northeast Atlantic is running out of excess carbonate in the horizon of cold-water corals communities. SCIENTIFIC REPORTS. Nature Publishing Group. 10-1, pp.14714.

7 **Artículo científico**. Broullon, Daniel; (2/10) Perez, Fiz F.; Velo, Anton; et al; Kozyr, Alex. 2020. A global monthly climatology of oceanic total dissolved inorganic carbon: a neural network approach. EARTH SYSTEM SCIENCE DATA. Copernicus Publications. 12-3, pp.1725-1743.

8 **Artículo científico**. S.K. Lauvset; B.R. Carter; (3/7) Fiz F Perez; L-Q Jiang; Richard A. Feely; Anton Velo; Are Olsen. 2020. Processes Driving Global Interior Ocean pH Distribution. GLOBAL BIOGEOCHEMICAL CYCLES. AGU. 34-1, pp.1-17.

9 **Artículo científico**. 2019. GLODAPv2.2019 – an update of GLODAPv2. EARTH SYSTEM SCIENCE DATA. Copernicus Publications. 11, pp.1437-1461.

10 **Artículo científico**. J Lassoued; JMF Babarro; XA Padín; XA Comeau; LA Bejaoui; (6/6) Fiz F Pérez. 2019. Behavioural and eco-physiological responses of the mussel Mytilus galloprovincialis to acidification and distinct feeding regimes. MARINE ECOLOGY PROGRESS SERIES. Inter-Research Science Publisher. 626, pp.97-108.

11 **Artículo científico**. M. Fontela; H. Mercier; (3/3) Fiz F. Pérez. 2019. Long-term integrated biogeochemical budget driven by circulation in the eastern subpolar North Atlantic. PROGRESS IN OCEANOGRAPHY. Elsevier. 173, pp.51-65.

12 **Artículo científico**. 2019. The oceanic sink for anthropogenic CO2 from 1994 to 2007. SCIENCE. AMER ASSOC ADVANCEMENT. 363-6432, pp.1193. ISSN 1095-9203.

13 **Artículo científico**. (1/11) Fiz F. Pérez; Marcos Fontela; Maribel I. García-Ibáñez; et al; Xose A. Padin. 2018. Meridional overturning circulation conveys fast acidification to the deep Atlantic Ocean. NATURE. NPG. 554, pp.515-518.

14 **Artículo científico**. M de la Paz; M. Garcia-Ibañez; R Steinfeldt; A. Rios; (5/5) Fiz F. Perez. 2017. Ventilation versus biology: What is the controlling mechanism of nitrous oxide distribution in the North Atlantic?. GLOBAL BIOGEOCHEMICAL CYCLES. AGU. 31, pp.1-16.

15 **Artículo científico**. 2016. A new global interior ocean mapped climatology: The 1° × 1° GLODAP version 2. EARTH SYSTEM SCIENCE DATA. Copernicus Publications. 8-2, pp.325-340.

16 **Artículo científico**. 2016. The global ocean data analysis project version 2 (GLODAPv2) - An internally consistent data product for the world ocean. EARTH SYSTEM SCIENCE DATA. Copernicus Publications. 8-2, pp.297-323.

17 **Artículo científico**. 2016. Ocean acidification in the subpolar North Atlantic: rates and mechanisms controlling pH changes. BIOGEOSCIENCES. Copernicus Publications. 13-12, pp.3701-3715.

18 **Artículo científico**. P Zunino; P Lherminier; H Mercier; X A. Padín; AF. Ríos; (6/6) Fiz F. Pérez. 2015. Dissolved Inorganic Carbon budgets in the eastern Subpolar North Atlantic in the 2000s from in situ data. GEOPHYSICAL RESEARCH LETTERS. AGU Wiley. 42-21.

19 **Artículo científico**. 2015. Global Carbon Budget 2015. EARTH SYSTEM SCIENCE DATA. Copernicus. 7, pp.349-396.

20 **Artículo científico**. AF Rios; R Resplandy; MI Garcia-Ibanez; et al; FF Perez. 2015. Decadal acidification in the water masses of the Atlantic Ocean. PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES OF THE UNITED STATES OF AMERICA. 112-32, pp.9950-9955.

21 **Artículo científico**. Elisa F Guallart; Noelia M Fajar; Xose Antonio Padín; et al; (9/9) Fiz F Pérez. 2015. Ocean acidification along the 24.5°N section in the subtropical North Atlantic. GEOPHYSICAL RESEARCH LETTERS. AGU. 42, pp.450-458.

22 **Artículo científico**. L.I. Carracedo; M. Gilcoto; H. Mercier; F.F. Pérez. 2015. Quasi-synoptic transport, budgets and water mass transformation in the Azores–Gibraltar Strait region during summer 2009. PROGRESS IN OCEANOGRAPHY. Pergamon Press Ltd. 130, pp.47-64. ISSN 0079-6611.

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C.2. Congresos

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C.3. Proyectos o líneas de investigación

1 **Proyecto**. PID2019-104279GB-C21, OBSERVACION BIENAL DEL CARBONO, ACIDIFICACION, TRANSPORTE Y SEDIMENTACION EN EL ATLANTICO NORTE. BOCATS2. MICIN. Antonio Luciano Velo Lanchas. (Instituto Investigaciones Marinas). 01/01/2020-31/12/2023. 180.000 €. Investigador principal.

2 **Proyecto**. 820989, COMFORT - Our common future ocean in the Earth system ¿quantifying coupled cycles of carbon, oxygen, and nutrients .... Union Europea. Emma Huertas Cabido. (Consejo Superior de Investigaciones Científicas). 01/09/2019-31/08/2023. 110.927,48 €. Miembro de equipo.

3 **Proyecto**. CTM2016-76146-C3, ACIDIFICACION EN LAS RIAS Y PLATAFORMA OCEANICA IBERICA - ARIOS. MINECO. Fiz Fernandez Perez. (Instituto Investigaciones Marinas). 30/12/2016-31/12/2019. 281.000 €. Coordinador.

4 **Proyecto**. CTM2013-41048-P, OBSERVACION BIENAL DEL CARBONO, ACIDIFICACION, TRANSPORTE Y SEDIMENTACION EN EL ATLANTICO NORTE BOCATS. MINECO. Fiz Fernandez Perez. (Instituto Investigaciones Marinas). 01/01/2014-31/12/2016. 158.510 €. Coordinador.

1. ***PROPOSAL DATA***

IP 1: [Antonio Padín Alvarez]

IP 2: [Fiz Fernández Pérez] (RAGC)

TÍTULO DE PROYECTO (ACRÓNIMO): Flujo e Inventario de dióxido de Carbono, Acidificación y salud oceánica en campañas oceanográficas repetidas en el Océano Atlántico (**FICARAM+**)

TITLE OF THE PROJECT (ACRONYM): Flux and Inventory of carbon dioxide, acidification and ocean health in repeated oceanographic cruises in the Atlantic Ocean (**FICARAM+**)

2. **JUSTIFICATION AND NOVELTY OF THE PROPOSAL**

2.1. ***Adequacy of characteristics and the purpose of selected modality.***

Since the beginning of global industrialisation, the ocean has absorbed 20-30% of all anthropogenic carbon dioxide (CO_2) emitted from fossil fuel combustion, cement production and land-use change (Friedlingstein et al., 2023; Gruber et al., 2023). Without ocean uptake, atmospheric CO_2 (dry air mixing ratio) would be ~80 parts per million (ppm) higher than its current value of 419 ppm (2022 annual mean, Tans & Keeling, 2023). The ocean thus slows down the increase in anthropogenic CO_2, the main agent of global climate change (IPCC, 2021). Anthropogenic CO_2 (Cant) absorbed by the ocean alters the ocean's carbonate chemistry (DeVries, 2022) by reducing pH and carbonate ion content (CO_3^{2-}), the building block for calcifying marine organisms, in a process commonly referred to as ocean acidification (**OA**) (Caldeira and Wickett, 2003). **OA** is hindering the building of calcareous structures of organisms (Kroeker et al., 2013) such as coral reefs (Albright et al., 2016), including deep-sea reefs (Perez et al., 2018) and other marine ecosystems (Gattuso et al., 2015; Kawahata et al., 2019).

From 1750 to 2000, global mean surface ocean pH decreased by ~0.11 units, that is, an increase in hydrogen ions by ~30% (Jiang et al., 2019). From 2000 to 2100, this amount is projected to decrease by 0.3-0.4 units under high emissions and low mitigation (Kwiatkowski et al., 2020). Such a deep and rapid change in ocean chemistry is likely to threaten important ocean ecosystem goods and services - including food security, fisheries and aquaculture, recreational enterprises and other activities related to the Blue Economy - for millions of people.

Global Oceanic Biogeochemical Models (**GOBM**) allow simulating and projecting changes for some ocean carbon variables such as **OA** as a tool for ocean research and management under global stressors (global warming and **OA**). However, these models show significant uncertainty and notable discrepancies with in situ ocean measurements (Kwiatkowski et al., 2020; Steiner et al., 2014; Terhaar et al., 2022). In addition to pH and temperature measurements, other variables such as salinity show interannual variability associated with climate change (Durack et al., 2012; Zika et al., 2018) that changes total alkalinity (**A_T**), especially in polar areas (Terhaar et al., 2021), and consequently pH forecasts. Observational data are therefore essential to improve global model projections and our predictive ability by providing more realistic reference conditions and minimizing model bias and drift (Orr et al., 2005; Séférian et al., 2016).

The effectiveness of the North Atlantic (**NAtl**) thermohaline circulation, better known as the Atlantic Meridional Overturning Current (**AMOC**), in accumulating Cant is a key forcing to explain patterns of variability in the global ocean carbon cycle (Pérez et al., 2013, Müller et al., 2023). Changes in CO_2 uptake are currently occurring particularly strongly in the high latitudes of the South Atlantic (**SAtl**). Therefore, these pronounced changes in CO_2 uptake can only be analyzed and interpreted with sustained observations of ocean carbonate system in the interior along the Atlantic Ocean. This transport of heat and carbon fluxes in the **NAtl** across the **AMOC** is also responsible for the climatological conditions around the Iberian Peninsula.

FICARAM+ plans to carry out a pole-to-pole quasi-synoptic section following three oceanographic cruises that were carried out in the past. Specifically, the cruises, which will be described below, are: OVIDE (Daniault et al., 2016), FICARAM (Ríos et al., 2015) and FRUELA (Álvarez et al., 2002) (Figure 1).

The number of samples with biogeochemically relevant and high-quality measurements between the surface and the seabed, which reach depths in the sparsely sampled abyssal zone (below 5,000 meters), would be: 800 in FRUELA, 1,800 in OVIDE and 2,500 in FICARAM. Taking into account that each depth will have information from about 10 different tracers, the volume of new data that will be acquired during the FICARAM+ project exceeds 40,000 discrete samples. As an example, in the most cited global reference database (+100 citations/year) for ocean carbon studies, the inclusion of the FICARAM cruise in 2019 accounted for 37% of the 10,000 actual measurements of new data from the **AtlO** south of the Canary Islands (Olsen et al., 2020). Since data accessibility provides near real-time answers to highly relevant questions, data from the latest FICARAM cruise was openly distributed in 2020. In particular, the FICARAM+ research team, which has an infrastructure and human team tested in high-quality seawater pH analyzes (Fontela et al., 2023), is the main contributor of the pH measurements in the interior ocean of the **SAtl** with 100% of new observations during GLODAP updates in the period 2019-2020 and 40% of the total (Lauvset et al., 2024).

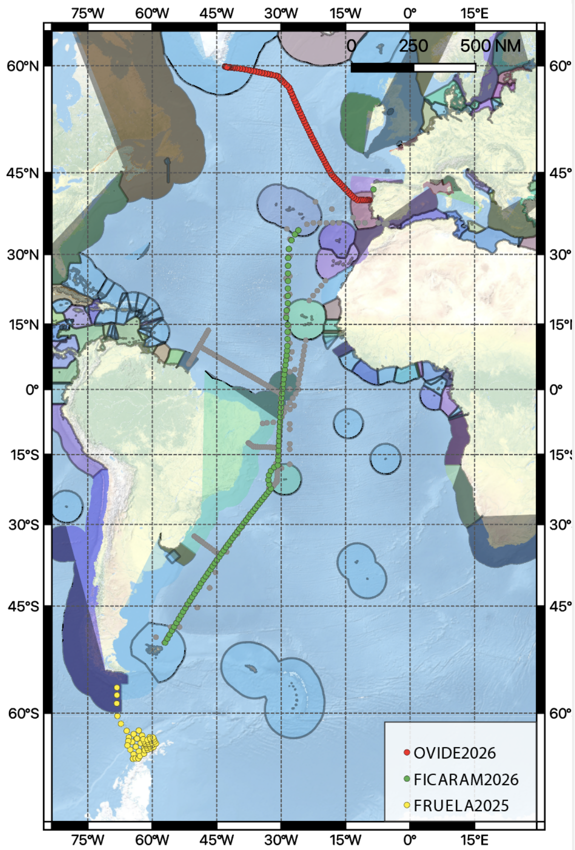

Figure 1: FICARAM+ plans to conduct a quasi-synoptic pole-to-pole section across the **AtlO** on three oceanographic cruises that are reference sections of the GO-SHIP Programm These cruises were initially conducted by oceanographic research vessels as part of the World Ocean Circulation Experiment (WOCE) during the 1990s. Specifically, the campaigns to be carried out are called (planned dates): **FRUELA2025** (Dec,2025), **FICARAM2026** (Mar-Apr,2026) y **BOCATS2026** (Jun-Jul,2026).

This intensive biogeochemical analysis of the water column (pH, total alkalinity, inorganic nutrients, dissolved oxygen and salinity) and ocean-atmosphere CO_2 fluxes will update the carbon system measurements of these three reference sections.

This proposal responds directly to research called for by the following supranational programmes through their objectives and actions:

- "**Prevent** and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution" (14.1) and "Minimize and address the impacts of **OA**, including through enhanced scientific cooperation at all levels" (14.3) are targets of goal 14 "Conserve and sustainably use the oceans, seas and marine resources" of the **Sustainable Development Goals (SDG) of UN**.
- **Contributing** to strengthening the ocean - climate nexus and our understanding of the ocean and polar regions, as an integral part of the Earth's climate system is the focus of the call "Land, ocean and water for climate action" (HORIZON-CL6-2021-CLIMATE-01) of the **Horizon Europe Framework Programme (HORIZON)**.

- Promoting initiatives to improve biodiversity knowledge, education and capacity to increase the resilience of our societies to future threats such as the effects of climate change is one of the objectives of the Biodiversity strategy for 2030 of the **EU's Biodiversity Strategy for 2030**.
- Strategic actions on CLIMATE, ENERGY AND MOBILITY (SA5) and FOOD, BIOECONOMICS, NATURAL RESOURCES AND ENVIRONMENT (SA6) are taken up in the **National Strategy for Green Infrastructure and Connectivity and Ecological Restoration**.

The principal investigators (IPs) of the FICARAM+ project have led the following projects since 2013 related to the **carbonate system (ocean acidification),** climate change and ocean health:

MYTIGA (Biological and environmental risks in the culture of Mytilus galloprovincialis under climate change; Ref: AGL2013-45945-R). Period: 2014-2017. **IP1**

RIA (Optimizing and Enhancing the Integrated Atlantic Ocean Observing System. Ref: H2020-FOOD/0015). Period: 2015-2019. **IP2**

ARIOS (Acidification in the Iberian Rías and Oceanic Platform; Ref: CTM2016-76146-C3). Period: 2016-2019. **IP1-IP2**

COMFORT (Our common future ocean in the Earth system – quantifying coupled cycles of carbon, oxygen, and nutrients for determining and achieving safe operating spaces with respect to tipping points, Ref: H2020-CLIMA/0514). Period: 2019-2023. **IP2**

BOCATS2 (Observación bienal del carbono, acidificación, transporte y sedimentación en el Atlántico Norte,, Ref: PID2019-104279GB-C21). Period: 2020-2023. **IP2**

REDEIRA (Research, development and innovation of a Coastal Observation network: Ría de Arousa; Ref: TED2021-132188B-I00). Period: 2022-2025. **IP1**

This research proposal aimed at improving our ability to face a global challenge is also supported by the 96 publications (**71 D1 and 21 Q1**) of the research and work group since 2013.

3. *OBJECTIVES, METHODOLOGY AND WORK PLAN*

3.1. *General and specific objectives*.

The overall objective is to assess the main drivers of climate change (anthropogenic carbon, ocean acidification, warming, O_2 concentration, greenhouse gasses,...) in transoceanic sections from Arctic to Antarctic waters.

In order to accomplish its general aim, FICARAM+ pursues the following specific objectives:

1. Construct a multidisciplinary ocean dataset which is integrated within a wider ‘‘pole-to-pole” observatory concept.
2. Quantify the accumulation of anthropogenic CO_2 in the Antarctic and Atlantic Ocean
3. To unravel physical and biogeochemical mechanisms controlling the spatial (vertical and geographical) distribution of the anthropogenic CO_2 inventory.
4. Estimate the rates of the **OA** and $CaCO_3$ saturation identifying the natural and anthropogenic forcings.
5. Provide essential data in the Antarctic and Atlantic Ocean for global biogeochemical model development and validation.
6. Quantify the air-sea exchange of climate active gasses
7. To disseminate and communicate the generated database attending to the FAIR data principles and the gained knowledge to different audiences (from academic levels to the general public) as a contribution to the United Nations Decade of the Ocean (2021-2030).

3.2. *Description of the methodology*.

The methodology to be developed during the FICARAM+ has been structured in different work packages for the correct exploitation of the information collected during the three oceanographic cruises.

WP1. On-board sampling and analysis of high quality biogeochemical measurements

Task 1.1 Biogeochemical measurements: Biogeochemical analysis during the FICARAM2026 and FRUELA2025 cruises at 24 (full depth)/14 (mid-depth) depth levels in all the stations. Discrete seawater samples will be collected at different depths of the water column for determination of marine carbon system (pH, alkalinity and pCO_2 which will also be measured in OVIDE2026 cruise), salinity, dissolved O_2 concentration and nutrients (NO_2^-, NO_3^-, PO_4^{3-}, SiO_3H_2).

WP2. FICARAM+ dataset construction and dissemination

Task 2.1. Database generation: Biogeochemical parameters and compounds determined in WP2 during each oceanographic cruise be compiled into a database to be published on Digital CSIC. Prior to this, quality control will be conducted for each of the variables analyzed in the laboratory, including the physical parameters measured by the CTD-O_2 multiparameter probe and the continuous system sensors (thermosalinometer, fluorometer, weather station, and GPS) on board. For the Quality Control of biogeochemical measurements, we will use the Atlantos software by A. Velo (IIM-CSIC).

Task 2.2. Fluxes of the GHGs: *The CO_2 fluxes* between the atmosphere and the surface seawater during the track of the oceanographic cruises will be estimated here. Fv for each GHG will be calculated using the expression F=kw (Cw-Ca) where kw (cm/h) is the gas transfer rate, Cw is the gas measured concentration in seawater, and Ca is the gas equilibrium concentration in seawater based on the molar atmospheric fraction recorded at the NOAA Palmer station. kw will be calculated using a recommended parametrization based on wind speed (Nightingale et al., 2000) data which will be downloaded from the Cross-Calibrated Multi-Platform (CCMP).

Task 2.3 Water mass characterization from Optimum Multiparameter (OMP) analysis: To solve the water mass structure of the AtlO used OMP analysis (Tomczak and Large, 1989). This technique has previously been used to describe in detail the origin, pathways and transformation of the main water masses in the North Atlantic (Tanhua et al., 2005; Álvarez et al., 2004, 2005; García-Ibáñez et al., 2015). From the physical and chemical properties (*temperature, salinity, O_2 and nutrients*), the OMP analysis solves the mixing between source water types by a least-square method giving the fractions of each water type in each water sample. This analysis is necessary to identify the distribution of the different types of water bodies in the sampled section and to be able to perform an inventory of biogeochemical properties or the calculation of trends in relation to the water masses.

Task 2.4 Calculation of other variables of the Marine Carbonate System (MCS) and Cant: From the the pH, total alkalinity and ancillary parameters (in situ temperature, salinity and nutrients), DIC, A_T, carbonate concentration and aragonite saturation were determined using the CO2SYS thermodynamic equations in seawater (Humphreys et al., 2022), the CO_2 dissociation constants of Lueker et al. (2000). The effect of pressure on the equilibrium constants of CO2SYS is included in the software developed by Lewis & Wallace (1998). Cant is computed using the phi-Ctº method (Pérez et al. 2008).

WP3.- Anthropogenic and natural CO_2 accumulation rates in the AtlO and Southern Ocean

Task 3.1. Determine acidification rates: The rates of acidification in terms of pH, hydrogen ion concentration, and $CaCO_3$ saturation will be assessed across various water masses in the AtlO and the Southern Ocean. Additionally, the influence of OA drivers (such as warming, changes in freshwater, CO_2, and A_T) on alterations in hydrogen ion concentration and carbonate saturation will be evaluated within regionalized water masses. This assessment will cover the period from 1995 to 2025 for polar waters based on data from FRUELA cruises, from 1993 to 2026 utilizing data from FICARAM cruises, and from 2002 to 2026 for the OVIDE cruises.

Task 3.2. Trend, mean and variability of the Cant and natural carbon: Natural carbon and Cant will be estimated using the back-calculation method (Perez et al. 2008), utilizing DIC determinations from measurements of pH and A_T. This analysis will focus on: 1) estimating the variability of Cant transport in the AtlOc, examining deep convection processes in response to the phase change of the NAO and the Southern Ocean Mode index. Additionally, 2) estimates of Cant accumulation rates and their sources of uncertainty trends will be made in the Western Antarctic Peninsula.

***Task 3.3 Quantification of the natural and anthropogenic signal in the ocean acidification and aragonite saturation*:** The description of the forcings will be initiated following the methodologies and experience of articles already published in the group, both to evaluate the natural and anthropogenic component and the effect of additional factors such as the thermohaline ones (García-Ibáñez et al., 2016). The rates and relationships obtained between pH (aragonite saturation) variation and its drivers will be applied to determine the relative influence of each of the processes and evaluate future evolution in relation to the future projection of the different drivers.

Task 3.4. Comparing the in-situ MCS observations and Cant estimates of the AtlO and Southern Ocean with results extracted from global biogeochemical models: The MCS and Cant variability obtained during FICARAM+ project will be compared with the outcomes for the global biogeochemical ocean models.

4. *OCEANOGRAPHIC CRUISES*

The methodology and work packages to be carried out in the FICARAM+ Project will be directly linked to the repetition of historical oceanographic cruises that were key in the generation of relevant scientific knowledge, serving as a reference in the preparation of IPCC reports. The MCS measurements of these historical cruise and other biogeochemical variables were conducted by the IIM research group. The FICARAM+ project requests the following oceanographic cruises (Fig. 1):

FRUELA2025.- The FRUELA cruise was part of the Spanish contribution to the study of carbon fluxes in the polar waters of the **SAtl** (Bransfield Strait and Gerlache Strait) during the austral summer of 1995-96. The FICARAM+ project will repeat the original FRUELA cruise after 30 years with the addition of the SR01 section in the Drake Passage which is also a GO-SHIP Reference Section. This highly productive region (Huntley et al., 1991) is a paradigm of the complexity of processes that can dominate coastal zones where shelf and slope waters, frontal zones (the southern boundary of the Antarctic Circumpolar Current) and the open ocean meet. Antarctic oceanic waters play a fundamental role in CO_2 uptake and storage and are therefore of great importance as a sink for Cant (Sarmiento et al., 1998). The initial objective of FRUELA, which is also shared by FICARAM+, was the quantification of biogeochemical CO_2 fluxes on the west coast of the Antarctic Peninsula that led to several publications that revealed the characterization of CO_2 fluxes between the atmosphere and the ocean (Álvarez et al., 2002) and the variability of CO_2 fluxes between its different water masses (Anadón and Estrada, 2002; Doval et al., 2002). From the measurements of the initial cruise, FRUELA2025 will allow the analysis of the main biogeochemical changes in the area in the context of climate change after three decades and will serve to test global oceanographic models, whose results in the Southern Ocean show notable discrepancies with in situ observations (Pérez et al., under review).

FICARAM 2026.- The FICARAM cruises between the Iberian Peninsula and Patagonia were based on the section A17 carried out in the **SAtl** in 1994. The FICARAM section, which also adds the **NAtl** part of section A16, was carried out in 2001, 2002, 2013 and 2019. This basin-scale southern section constitutes a unique time series with uniquely extensive quality observations describing the structure and biogeochemical properties of water masses in the AtlO. The main objective of the FICARAM cruises is to understand the Cant inventory, its accumulation rates and the acidification of waters. Previous studies (Ríos et al., 2010, 2012, 2015; Fontela et al. 2021) allowed for the first time the quantification of acidification rates in North and South Atlantic water masses from observations that were compared with results from climate models. These cruises together with the transits of Spanish polar ships between Spain and Patagonia in successive years also allowed the characterization of the zonal and interannual variability of sea-air fluxes (Padin et al., 2010). In the FICARAM cruise conducted in 2013, N_2O measurements were made for the first time as part of a new international effort to establish a harmonized N_2O measured network (Bange et al., 2019).

OVIDE2026 cruise will be carried out during the summer of 2026 on board the French ship Thalassas and will be led by the French Institute for Ocean Science (IFREMER) where the IIM-CSIC will be in charge of the analysis of the MCS. The inclusion of this cruise in FICARAM+ aims to obtain the necessary funding to cover the expenses derived from the analytical tasks and the participation of 3 people included in the FICARAM+ team. The OVIDE project (Observatoire de la Variabilité Interannuelle à Décennale en Atlantique Nord), also known in the spanish editions as BOCATS (Biennial Observation of Carbon, Acidification, Transport and Sedimentation in the North Atlantic) follows the WOCE A25 section between the Iberian Peninsula and the east coast of Greenland made during the 1990s. The collaboration between IFREMER and IIM-CSIC has repeated this basin-scale section 11 times from 2002 to 2023. These cruises have allowed the assessment of the decadal and interannual variability of Cant evolution in the Subpolar **NAtl** in numerous studies (Alvarez and Gourcuff, 2010; Fontela et al., 2020, 2019, 2016; Perez et al., 2013, 2010, 2008; Racape et al., 2018, 2013; Zunino et al., 2015, 2014). These publications have contributed significantly to the advancement of knowledge on the variability of the natural and anthropogenic components of CO_2 in the **NAtl** and **OA** (Fontela et al., 2020; Garcia-Ibanez et al., 2021, 2016; Perez et al., 2018; Vazquez-Rodriguez et al., 2012).