iFADO project: contribution to the determination of the Good Environmental Status in the Atlantic Area through modeling and *in situ* monitoring approaches

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iFADO INNOVATION IN THE FRAMEWORK OF THE ATLANTIC DEEP OCEAN

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Abstract 3644

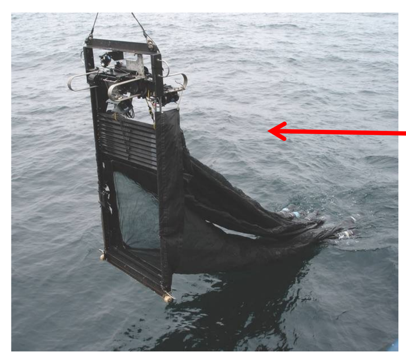
The project iFADO (*innovation in the Framework of the Atlantic Deep Ocean*) aims to combine conventional monitoring programs (with special focus on novel semi-automatic techniques that can be applied for *in situ* biological monitoring) with emerging technologies (such as gliders, satellite imagery, etc.) and modeling approaches to assist the implementation of the Marine Strategy Framework Directive (MSFD), providing tools for the optimization of observing strategies for better evaluation and forecasting of the Good Environmental Status (GES). Within this framework, the multidisciplinary iFADO cruise (within the RADPROF time series program, Instituto Español de Oceanografía) was carried out with transnational collaboration on summer 2020 along a standard coastal-oceanic transect off NW Iberian Peninsula, including physical, biogeochemical and biological measurements. Additionally, an effort is being made in the implementation and validation of existing and new biogeochemical models in the Atlantic margin, focusing on key variables for the implementation of MSFD Descriptors. The combination of iFADO models and *in situ* monitoring approaches not only might contribute data and potential indicators for MSFD Descriptors 1, 2, 3, 4, 5, 6, 7 and 10, from coastal to open-ocean environments, but they are essential tools to detect, model and predict temporal changes in marine ecosystems in the study area.

Methods

In situ monitoring

Zooplankton counting and identification: semi-automatic *versus* classic microscopy techniques.

Two samplings (day and night) were conducted with the MOCNESS net, at 7 depth layers from ~1600 to 0 m. Each sample was size-fractionated, preserved and subsequently split to compare classic and semi-automatic methods.



> 200 µm

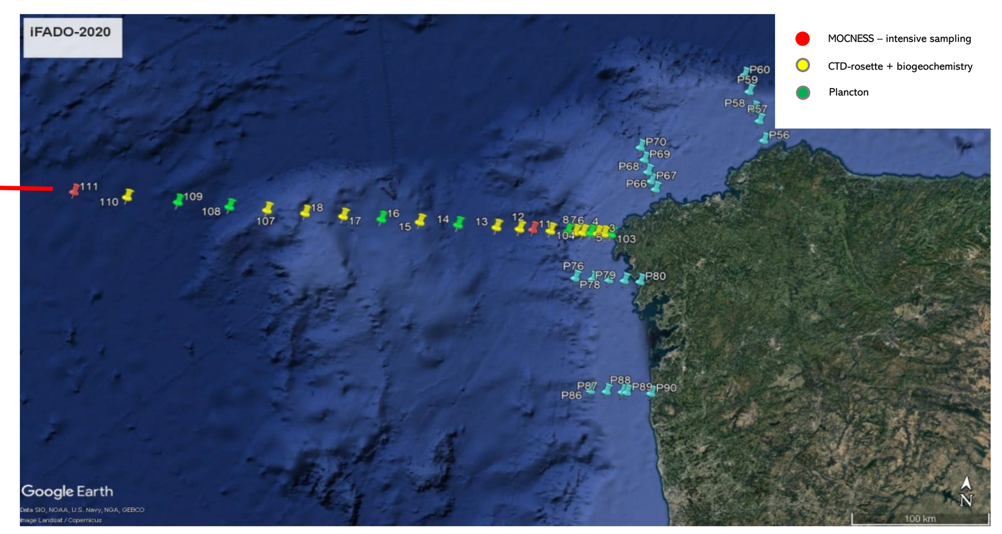
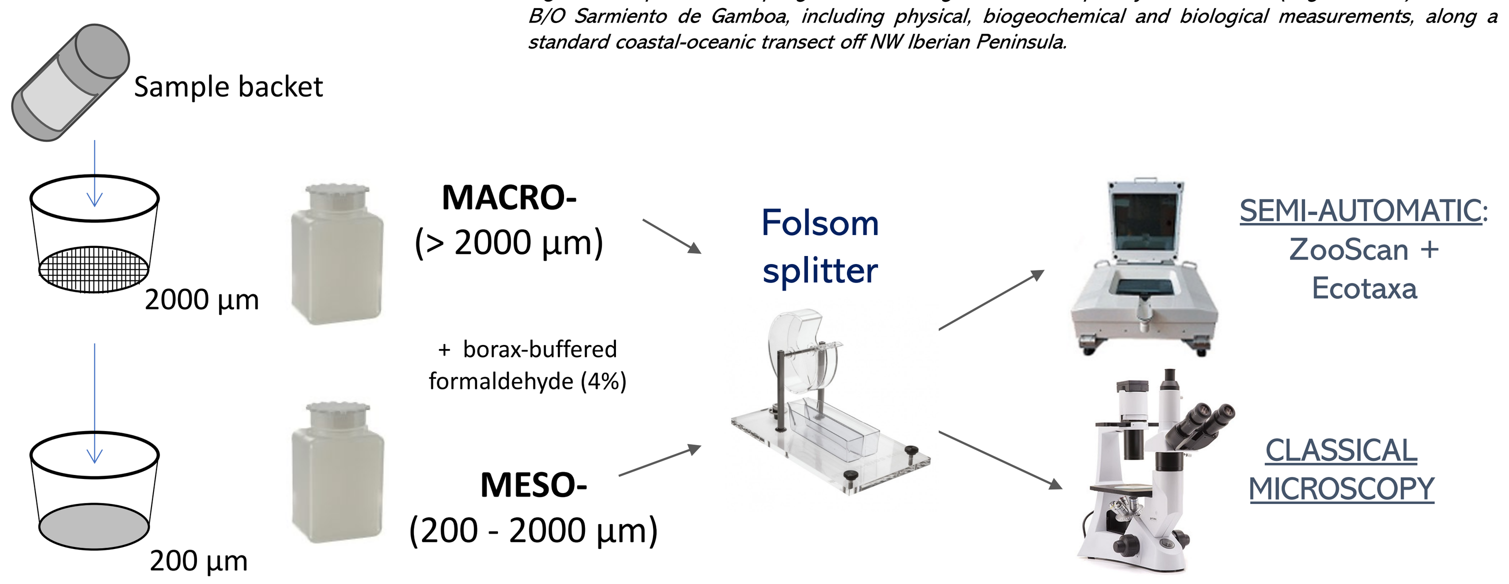
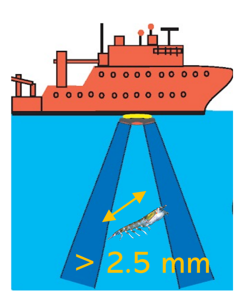


Figure 1. Map of the sampling stations during the multidisciplinary iFADO cruise (august 2020) onboard B/O Sarmiento de Gamboa, including physical, biogeochemical and biological measurements, along a standard coastal-oceanic transect off NW Iberian Peninsula.



Zooplankton biomass from acoustic measurements

ADCP Ocean Surveyor 150

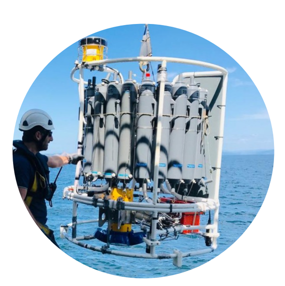


MACRO-ZOOPLANKTON

The Acoustic Doppler Current Profiler Ocean Surveyor 150 compiled data all along the cruise. Data were processed with CODAS (https://currents.soest.hawaii.edu/docs/adcp_doc/) and subsequently the echo intensity was calibrated following the methodology of Deines (1999) and Mullison (2017, 2019). Sound absorption coefficient was calculated according to Francois and Garrison (1982) from pressure, temperature and salinity from CTD casts.

Objects > 2.5 mm (large individuals or groups of small organisms) will reflect the acoustic signal.

LADCP vertical profiles



MESO-ZOOPLANKTON

Vertical profiles of backscatter intensity were derived from data obtained by a LADCP system fitted to the CTD frame, equipped with one downward-looking 150 kHz RDI QuarterMaster LADCP unit and one upward-looking 300 kHz RDI Workhorse Monitor.

As different sound frequencies are emitted, they will be reflected by particles of different sizes.

Satellite imagery

Real-time support of NEODASS (PML, UK): daily environmental conditions with maps of chlorophyll-a concentration and sea surface temperature (SST) derived from satellite data.

The combination of iFADO models and *in situ* monitoring approaches might contribute data and potential indicators for MSFD Descriptors 1, 2, 3, 4, 5, 6, 7 and 10, from coastal to open-ocean environments

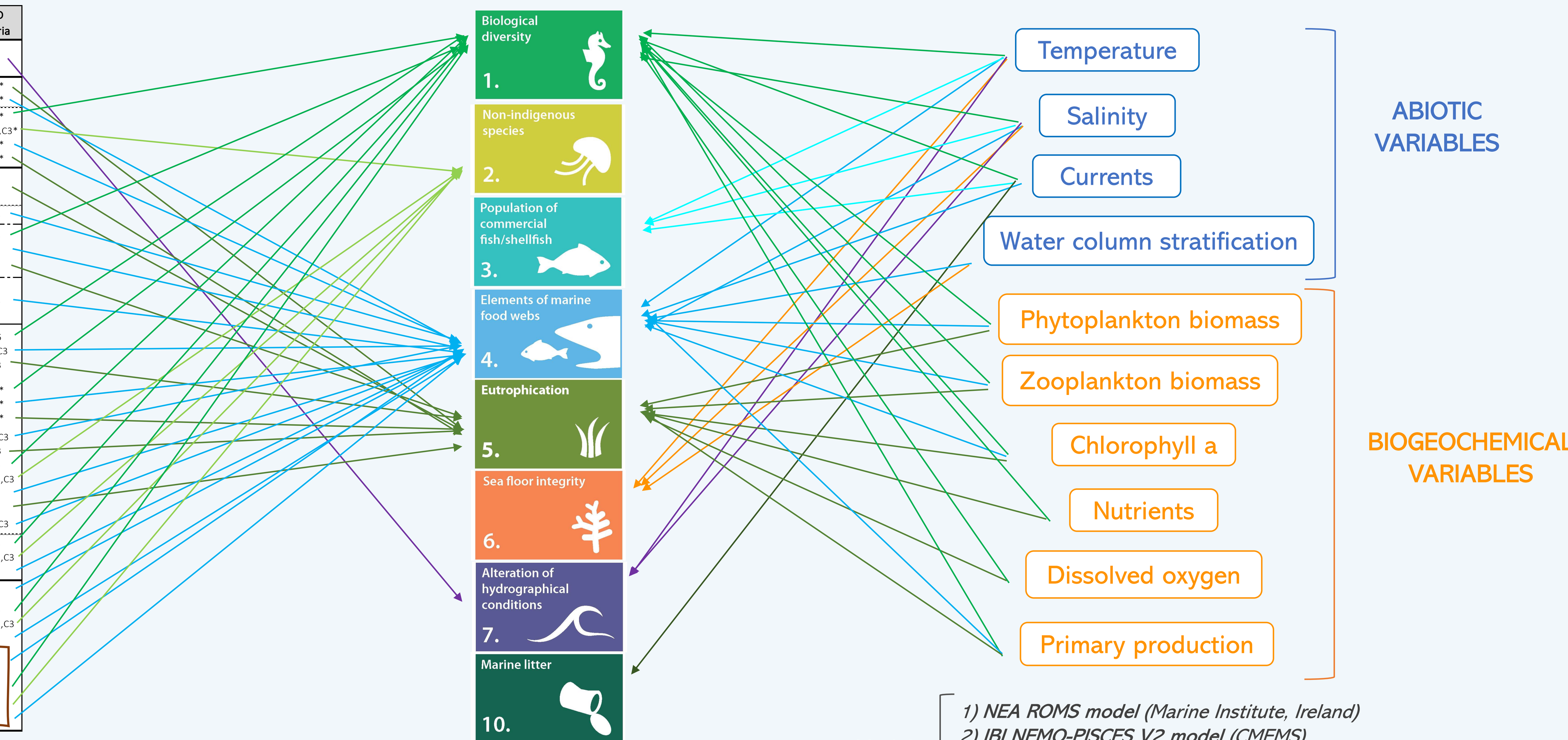
In situ monitoring

	SIZE CLASSES	SAMPLING	METHOD	VARIABLES	DERIVED VARIABLES	MSFD Criteria
HYDROGRAPHY		CTD		Conductivity + Temperature	Salinity	D7C1
				Pressure	Depth	
MICROORGANISMS (flagellates, bacterias)		CTD-rosette + preservation	Flow-Cytometry	Abundance + Biovolume	Biomass	D5C2* D4C2*
				Functional groups	Functional diversity	D1C6* D2C1,C2,C3* D4C1* D5C2*
PHYTOPLANKTON	Total / Size-fractionated	CTD-rosette + filtration	Spectrophotometry HPLC Fluorometry	[Chl a]	Biomass	D5C2
					Productivity	D4C4
			HPLC	[Chl a] [Accesory pigments]	Functional diversity	D1C6 D4C1 D5C2
		CTD-rosette	^{14}C uptake rate	Primary production	Productivity	D4C4
	Pico- (< 2 µm) Nano (2-20 µm)	CTD-rosette + preservation	Flow-Cytometry	Abundance + Biovolume	Biomass	D1C6 D4C2,C3 D5C3
				Functional groups	Functional diversity	D1C6* D4C1* D5C2*
	Nano- (2-20 µm) Micro (> 20 µm)	CTD-rosette + inverse filtration + preservation	FlowCam	Abundance + Biovolume	Biomass	D4C2,C3 D5C3
			FlowCam + ECOTAXA	Abundance + Community composit.	Diversity	D1C6 D2C1,C2,C3 D4C1 D5C3
	Micro- (40-200 µm)	Bongo net + filtration + preservation	Inverted microscope	Abundance	Biomass	D4C2,C3
				Abundance + Community composit.	Diversity	D1C6 D2C1,C2,C3 D4C1
ZOOPLANKTON	Micro- (40-200 µm)	Bongo-type net + mesh filtration + preservation	Inverted microscope	Abundance	Biomass	D4C2
				Abundance + Community composit.	Diversity	D1C6 D2C1,C2,C3 D4C1
	Meso- (200-2000 µm)	WP2 net + mesh filtration / MOCNESS (multi-depth sampling)	ZooScan	Abundance + Area	Biomass	D4C2
	Macro- (>2000 µm)		ZooScan + ECOTAXA	Abundance + Community composit.	Diversity	D1C6 D2C1 D4C1

We developed and compiled Standard Operating Protocols for the in situ semi-automatic monitoring techniques, implemented during the iFADO cruise

MSFD descriptors

Model-derived variables



Models
1) NEA ROMS model (Marine Institute, Ireland)
2) IBI NEMO-PISCES V2 model (CMEMS)
3) Mohid Water Quality (Instituto Superior Técnico, Portugal)
4) IEO ROMS biogeochemical model (IEO-CSIC, Spain)

Results

Assessing plankton communities in offshore areas

Semi-automatic

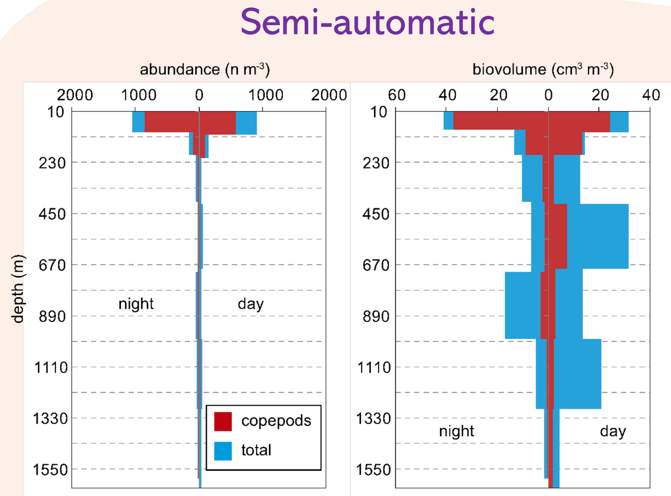


Figure 2. Abundance and biovolume profiles for plankton and seston (200-2000 µm) at night and day, in station 111.

Copepods dominated in abundance through the whole water column, however they only dominated in biovolume above 200 m.

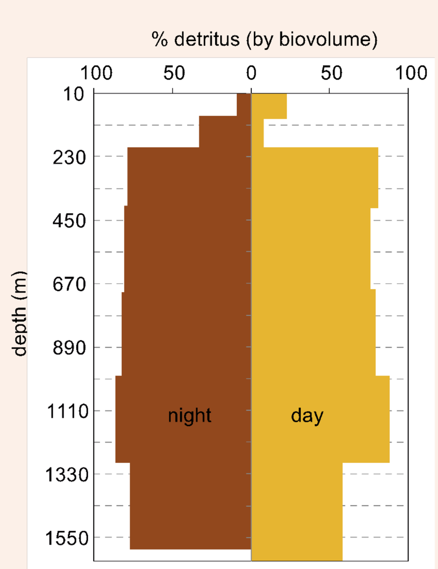


Figure 3. Biovolume (%) accounted by detritus at night and day in station 111.

Below 200m, > 75% of the biovolume of the size-fraction 200-2000 µm corresponded to detritus.

MESO- (200 - 2000 µm)

Semi-automatic *versus* microscopy

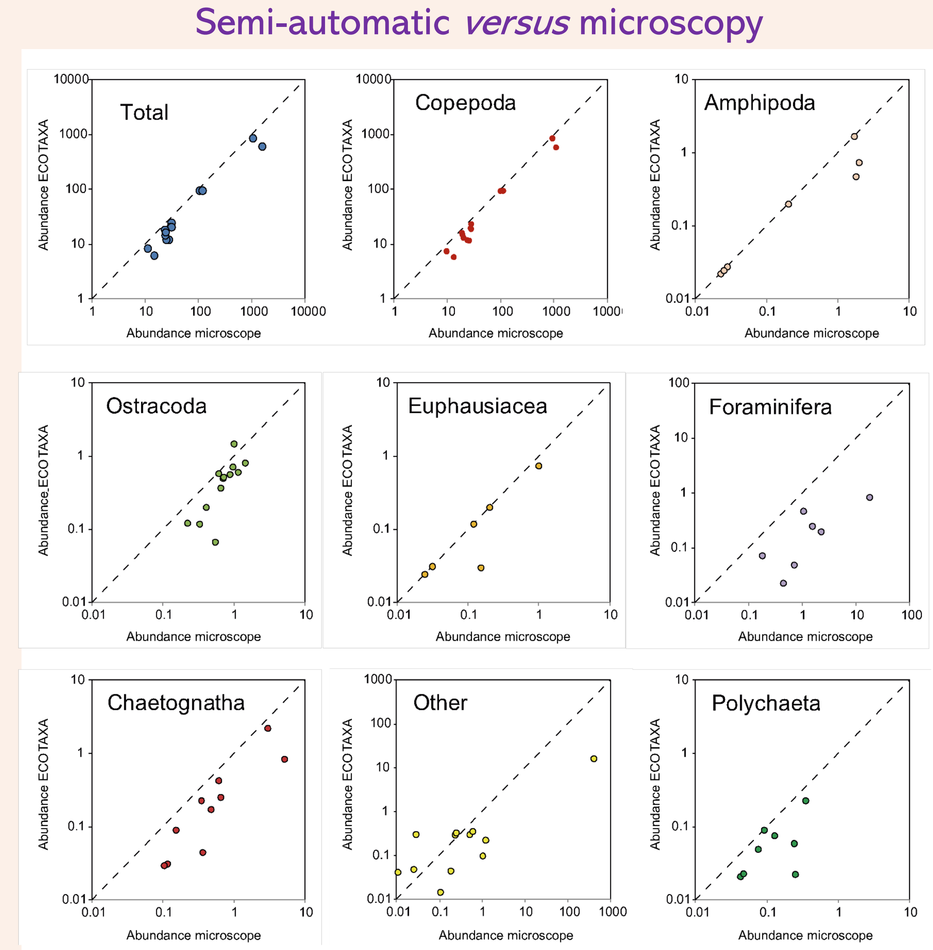


Figure 4. Abundance (number of individuals m^{-3}) of different zooplankton categories determined with ZooScan and Ecotaxa versus classic microscopy.

There is a good correlation between the abundances assessed by both techniques for abundant or relatively large organisms (e.g., copepods, amphipods and euphausiids). Contrarily, rare, in low abundance, organisms, or those producing low contrast images (e.g., foraminifera or chaetognaths) are underestimated by semi-automatic methods.

Backscattering from LADCP not processed yet

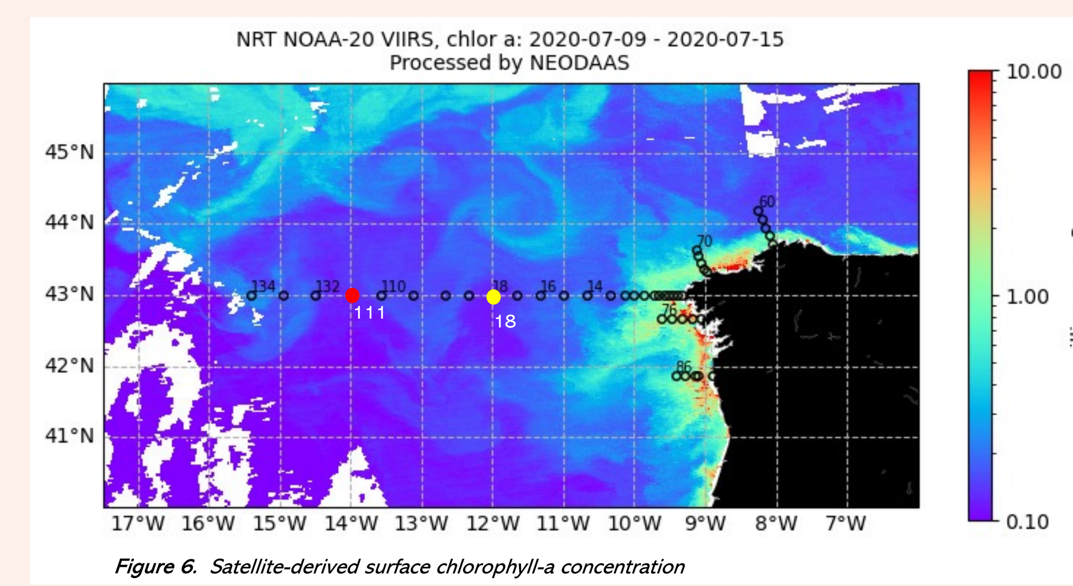


Figure 6. Satellite-derived surface chlorophyll-a concentration

The Finisterre upwelling filament was well developed in response to the intense upwelling conditions before and during the cruise, which resulted in high primary production

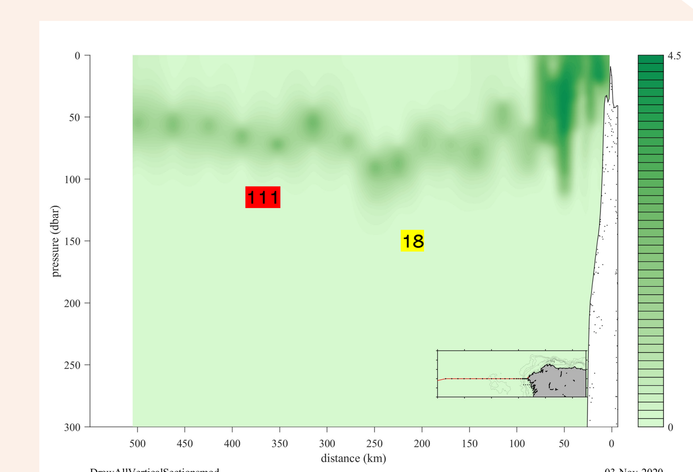


Figure 7. Vertical profile of fluorescence (chlorophyll-a) along the Fisterra transect during iFADO cruise.

High chlorophyll-a concentrations were found near the coast associated to the upwelling filament. DCM was deeper at station 18 as compared to station 111.

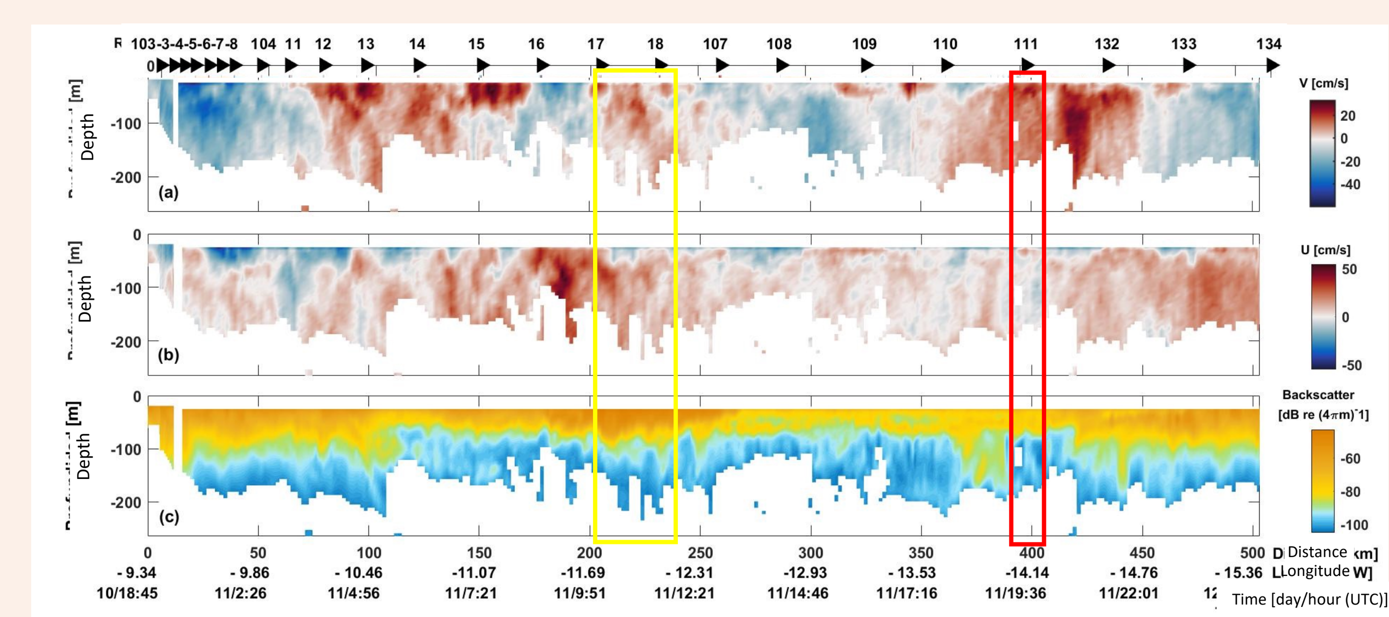


Figure 5. a) North (v) and, b) East (u) components of current speed, together with c) the absolute backscattering coefficient (dB re (4 πm)$^{-1}$) measured with the ADCP Ocean Surveyor 150, from station 103 (coast) towards station 134 (open-ocean).

Classical and semi-automatic abundance, biomass and taxonomy not available yet

MACRO- (> 2000 µm)

Maximum backscattering was associated to a northeastward current through the whole water column (0 to ≃ 100 m depth) between stations 17 and 18 (yellow rectangle), north of the Galician Bank.

In station 111 (red rectangle), the northward component (v) dominated the current. The lower backscatter suggests lower macrozooplankton biomass, likely due to the difference in time or in species composition in surface communities, as compared to station 18.

Deines, K. (1999). "Backscatter Estimation Using Broadband Acoustic Doppler Current Profilers," in *Proc. Sixth Working Conf. on Current Measurement*, San Diego, CA. IEEE, 249-253.

Francois, R. and Garrison, G. (1982). "Sound absorption based on ocean measurements: Part II: Boric acid contribution and equation for total absorption," *Journal of the Acoustical Society of America*, vol. 72, no. 6, pp. 1879-1890.

Mullison, J. (2017). "Backscatter Estimation Using Broadband Acoustic Doppler Current Profilers – Updated," presented at *ASCE Hydraulic Measurements & Experimental Methods Conference*, Durham, NH.

Mullison, J. (2019). "Backscatter Estimation Usings ADCPs – Twenty Years Later" In *2019 IEEE/OES Twelfth Current, Waves and Turbulence Measurement (CWTM)* (pp. 1-5). IEEE.