Dynamics of the bottom boundary and nepheloid layers in a coastal upwelling system (NW Iberia)

PI34A-2506

Villacieros-Robineau N.[1] (nvrobineau@iim.csic.es), Zúñiga D.[1], Barreiro B.[1], Alonso-Pérez F.[1], de la Granda F.[2], Froján M.[1], Collins C.A.[3], Barton E.D.[1] and Castro C.G.[1]

[1]Instituto de Investigacións Mariñas (IIM-CSIC, SPAIN), [2] BSH, Hamburg (Germany), [3] Department of Oceanography, Naval Postgraduate School, Monterey (USA).

Field study and objectives

Based on ADCP and sediment trap measurements (75m depth, RAIA station, yellow star) from Nov 2008 to Apr 2010 , wave numerically propagated time series and 15 cross-shelf hydrographic surveys, we have analyzed the seasonal hydrodynamics of the Bottom Boundary Layer (BBL) and its effects on the generation and modulation of Nepheloid Layers (NLs, particulate matter "clouds") in the NW Iberian margin, a highly hydrodynamic region marked by an upwelling-downwelling seasonal pattern, by the IPC and ICC currents and by strong continental inputs from rivers.

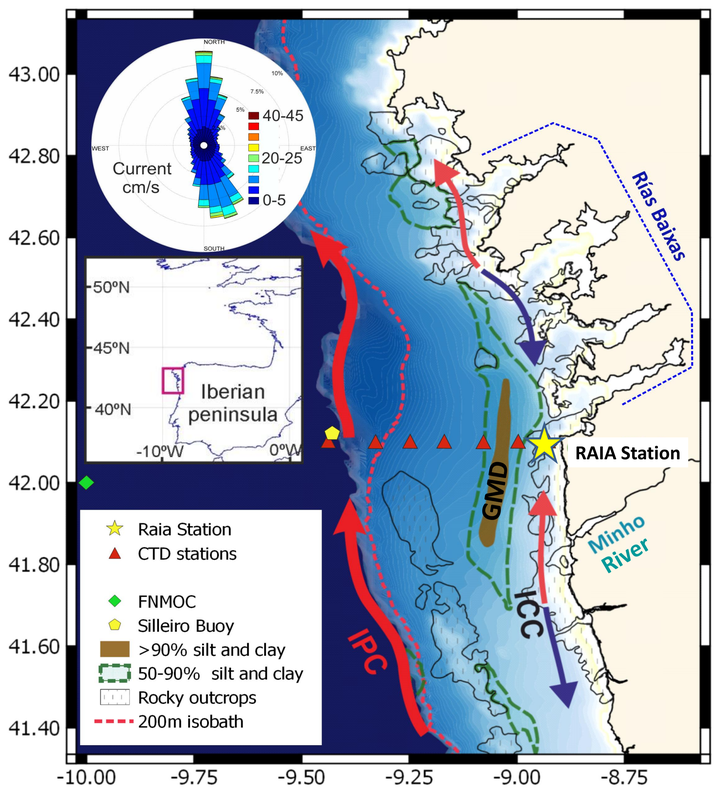


Figure 1. Study area. **IPC** is Iberian Poleward Current attributed to the interaction of the meridional density gradient with the continental shelf and slope (red thick arrows), **GMD** is Galician Mud Depocenter and **ICC** Inshore Coastal Current which flows southwards during upwelling events (blue arrows) and northward during downwelling events (thin red arrows). Adapted from Dias et al. (2002) & Lantzsch et al. (2009).

Hydrodynamics of the bottom boundary layer (BBL) at the inner shelf: RAIA station

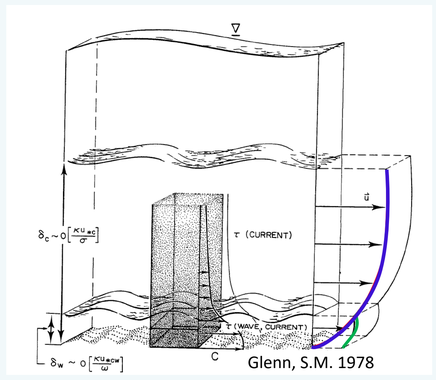
METEO & HYDROGRAPHIC CONDITIONS

Downwelling seasons were more energetic than upwelling seasons in winds (a), runoff (b), waves (d) and currents (e).

BOTTOM SHEAR STRESS

Total bottom shear stress is the combination of current and wave shear.

Figure2 . BBL **current (blue)** and **wave (green)** profile.



High levels of bottom shear stress (f) in the inner shelf occurred mainly during downwelling events in the downwelling seasons, when there was a coupling between stormy waves (d) and intense current events (e).

There was no clear dominance (f) of **waves (green)** or **currents (blue)** and **co-dominance events (red)** were frequent.

RESUSPENSION AND NEPHELOID LAYER DEVELOPMENT

Shear stress promoted high resuspension events that favors the generation of Bottom Nepheloid Layers (**BNLs**) whose vertical extent was confirmed by means of the ADCP backscatter signal (g) and total mass particulate fluxes registered by a sediment trap (h) moored at 35 m above the bottom.

RAIA station is representative of a **High Resuspension Inner Shelf Area (HRISA)**

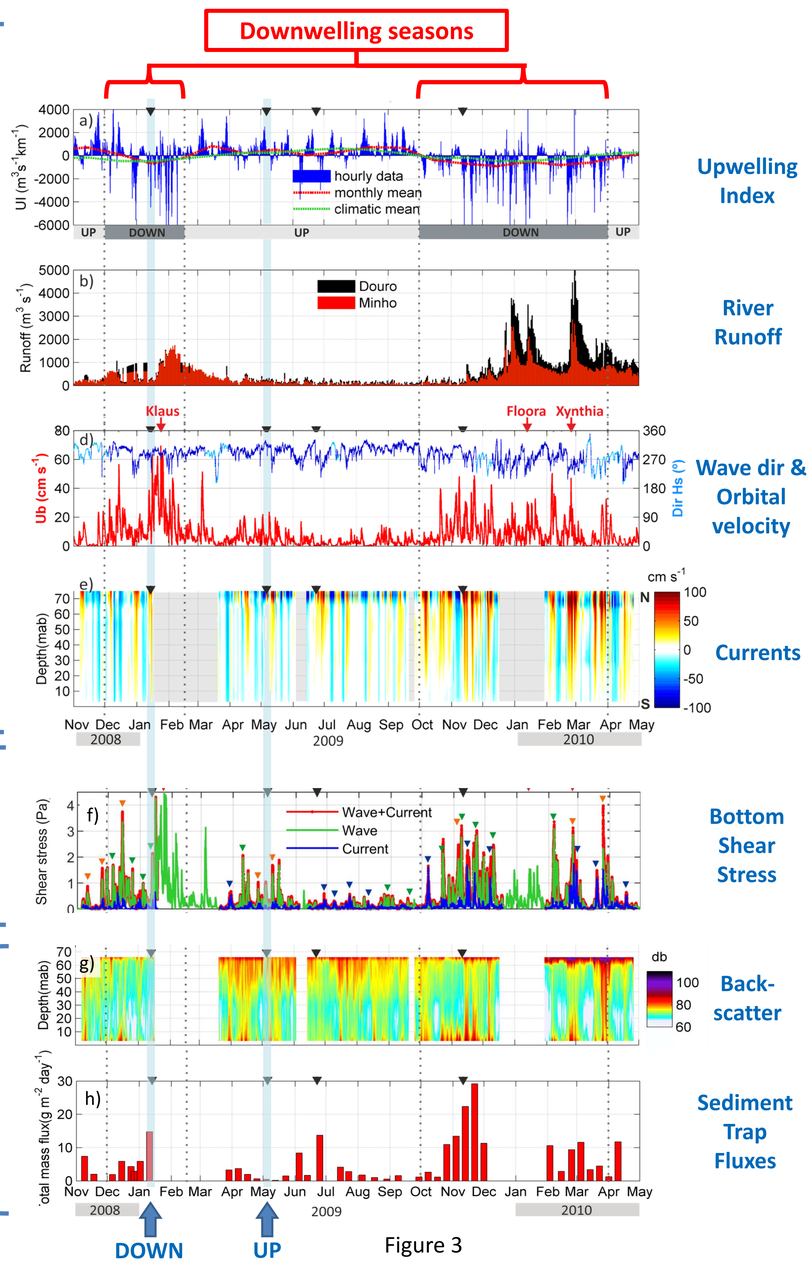
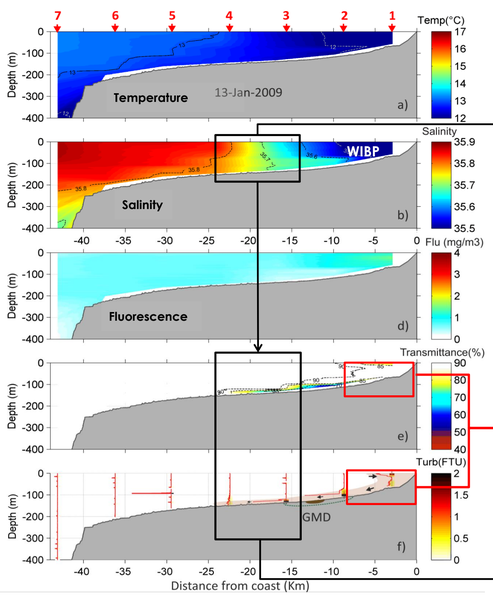


Figure 3

Nepheloid layers behavior under different oceanographic conditions: Downwelling vs. upwelling

DOWN in Figure 3



Thermohaline front

High resuspension events

BNL development

BNL and SNL confinement

NO BOTTOM OFFSHORE EXPORT

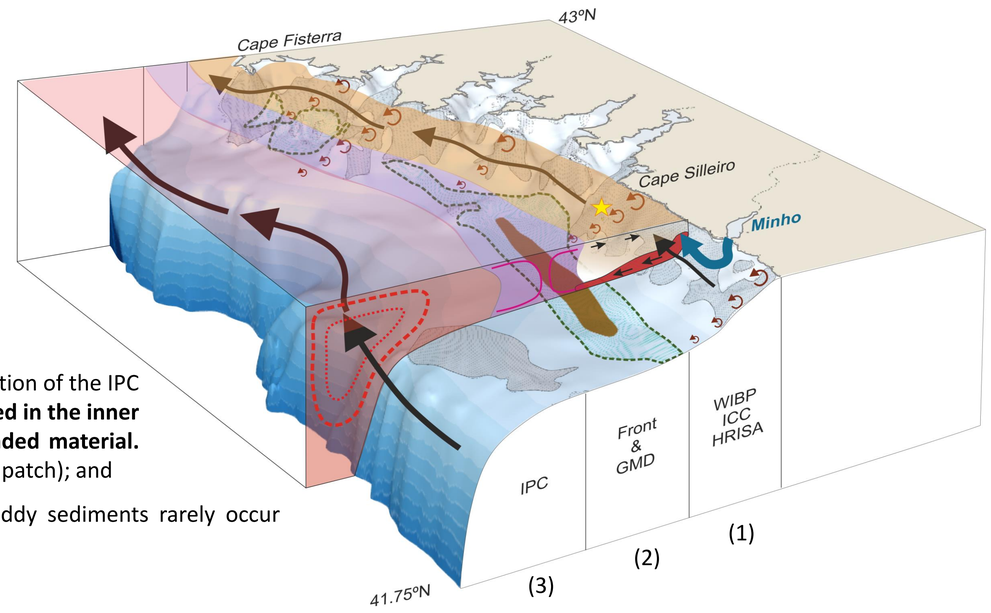
Downwelling conditions
Conceptual model

Three different zones can be identified:

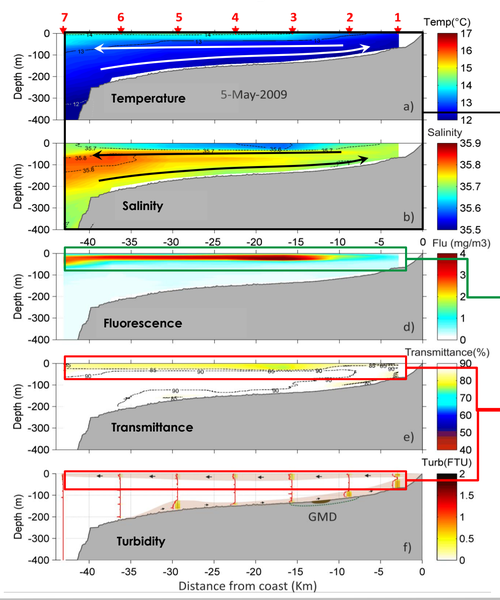
(1) the **High Resuspension Inner Shelf Area (HRISA)** extending offshore to the boundary marked by a **thermohaline front** result of the confluence of ocean and river waters. High resuspension events promote **well-developed BNLs (red area)** that are **advected northward** by the **ICC** (thin black/brown arrows). West Iberian Buoyant Plume (**WIBP**, yellow/orange area) generated by **Minho** (blue arrow) **and Douro** rivers runoff limits the vertical extension of BNLs.

(2) an intermediate zone affected by the **thermohaline front,** result of the interaction of the IPC advected waters with the low saline water lens of the WIBP. **BNLs were confined in the inner shelf by this front, pointing to the absence of offshore export of resuspended material.** This zone is also characterized by the **Galician Mud Depocenter** (**GMD**, brown patch); and

(3) an outer shelf **area influenced by the IPC** (black thick arrows) where muddy sediments rarely occur probably due to slope currents and internal waves.



UP in Figure 3



Positive circulation pattern

High biological productivity

SNL development

NO BNL development

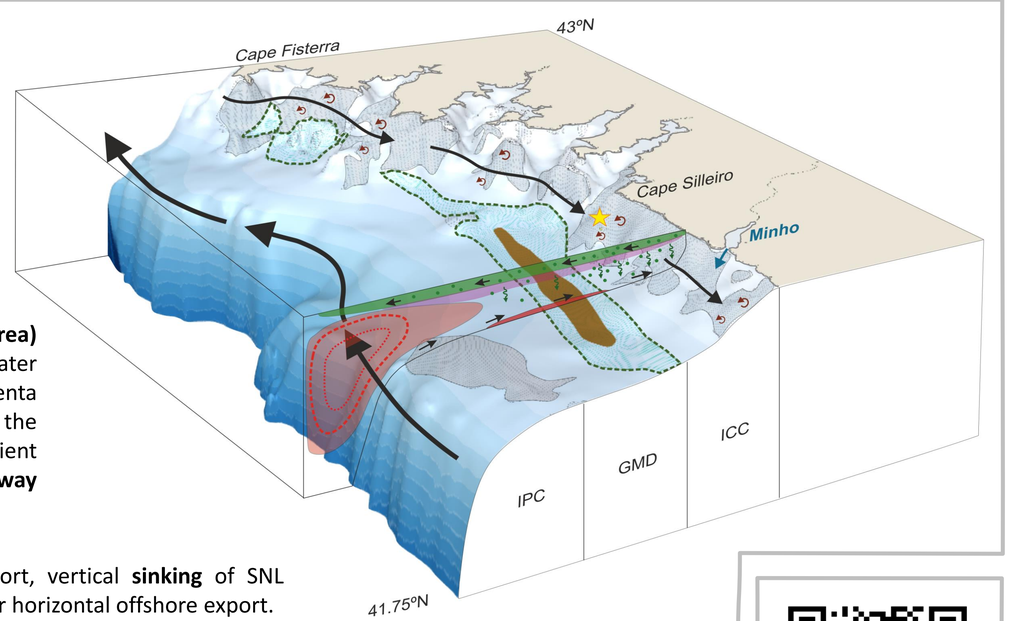
OFFSHORE EXPORT BY INCIPIENT UPWELLING FILAMENTS

Upwelling conditions
Conceptual model

During the upwelling season, due to the low energy condition, **only thin BNLs were developed (red near bottom area)**.

In contrast, **Surface Nepheloid Layers (SNLs, green area)** of **biogenic origin** are well developed in the upper water column above the high stratification layers (magenta area). These **SNLs are transported offshore** through the across shelf (small black arrows) as part of incipient upwelling filaments. **This is a probable export pathway for particulate matter.**

If there is a **relaxation** of offshore Ekman transport, vertical **sinking** of SNL **particulate matter** (small green circles) **is favored** over horizontal offshore export.



References: Lantzsch et al.(2009). Sedimentary architecture of a low-accumulation shelf since the Late Pleistocene (NW Iberia). Marine Geology, 259(1-4), 47–58. Dias et al.(2002). Sediment distribution patterns on the Galicia–Minho continental shelf.Progress in Oceanography, 52(2-4), 215–231. Glenn, S.M. (1978). A continental shelf bottom boundary layer model: the effects of waves, currents, and a moveable bed. University of Rochester, USA.

Acknowledgments: This contribution has been funded by the Spanish Government through CAIBEX project (CTM2007–66408–C02–01/MAR, CTM2007–30809–E/MAR, CTM2008–05305–E/MAR), i-SMALL project (CTM2014-56119-R) , and Juan de la Cierva-Formación fellowship (FJCI-2017–34290), and by the European Union FEDER project MarRISK (0262_MarRISK_1_E).

Reference: Villacieros-Robineau et al. (2019). Bottom boundary layer and particle dynamics in an upwelling affected continental margin (NW Iberia). *JGR-Oceans*, 124, 9531-9552. https://doi.org/10.1029/2019JC015619