Internal waves on the South African continental shelf: A heuristic approach

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Location: UMR MARBEC (Sète) and UMR LOPS at UBO-IUEM (Brest)

Level: M2

Duration: approximately 6 months

Requirements:

A background in physical oceanography
Good knowledge of R/ Matlab/ Python and unwillingness to learn
Good writing skills in English

Project Description:

The RESILIENCE (fRonts, EddieS and marIne LIfe in the wEstern iNdian oCEan) cruise took place onboard the R/V *Marion Dufresne* from April 19th to May 24h 2022 in the South-West Indian Ocean (Figure 1). The aim of the cruise was to investigate the fine scale biophysical coupling within fronts of mesoscale eddies (Ternon and Noyon, 2023). The cruise was divided into leg 1 that sampled the central Mozambique Channel from April 25th to May 1st, and leg 2 that was conducted along the South African coast from May 2nd to May 17th.

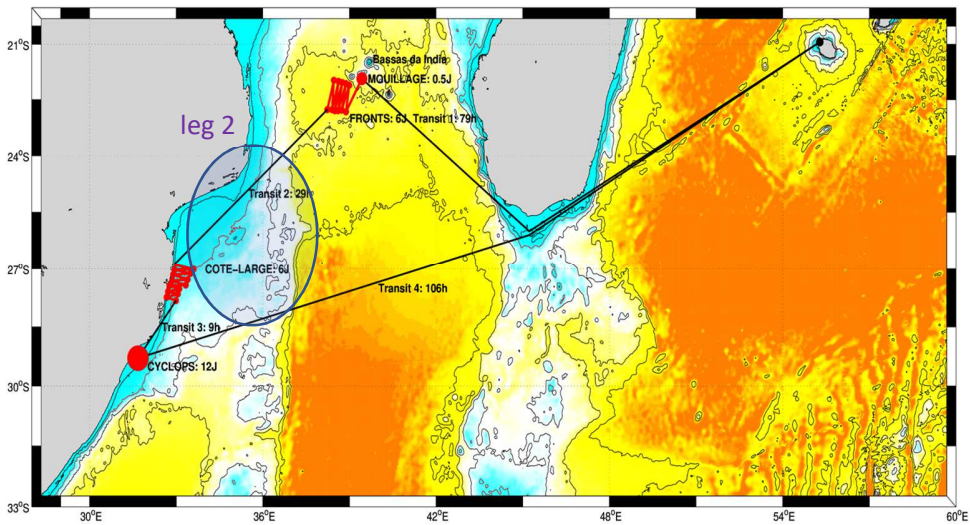

Fig. 1 *General map of the RESILIENCE cruise with the location of leg 2 operations.*

The presence of internal waves is ubiquitous over the continental slope. They can induce important displacements of the thermocline and strong currents. Their frequency and wave length obey the dispersion relation and depend on the stratification and the physical process that led to their generation. Most commonly, their generation takes place when the barotropic tide hit the steep topography of the continental slope. However, other mechanisms may also play a role (Fearon et al. 2020). When breaking, internal waves may induce intense turbulent mixing, and therefore play an important role on primary production by uplifting nutrients towards the surface (Gentil et al. 2021).

Because vertical stratification has a strong effect on the backscattering of acoustic layers, internal waves can be observed in the acoustic signal (Sandstrom et al. 1989), as shown by the multi-frequency acoustic dataset collected during leg 2 of the RESILIENCE cruise (Figure 2).

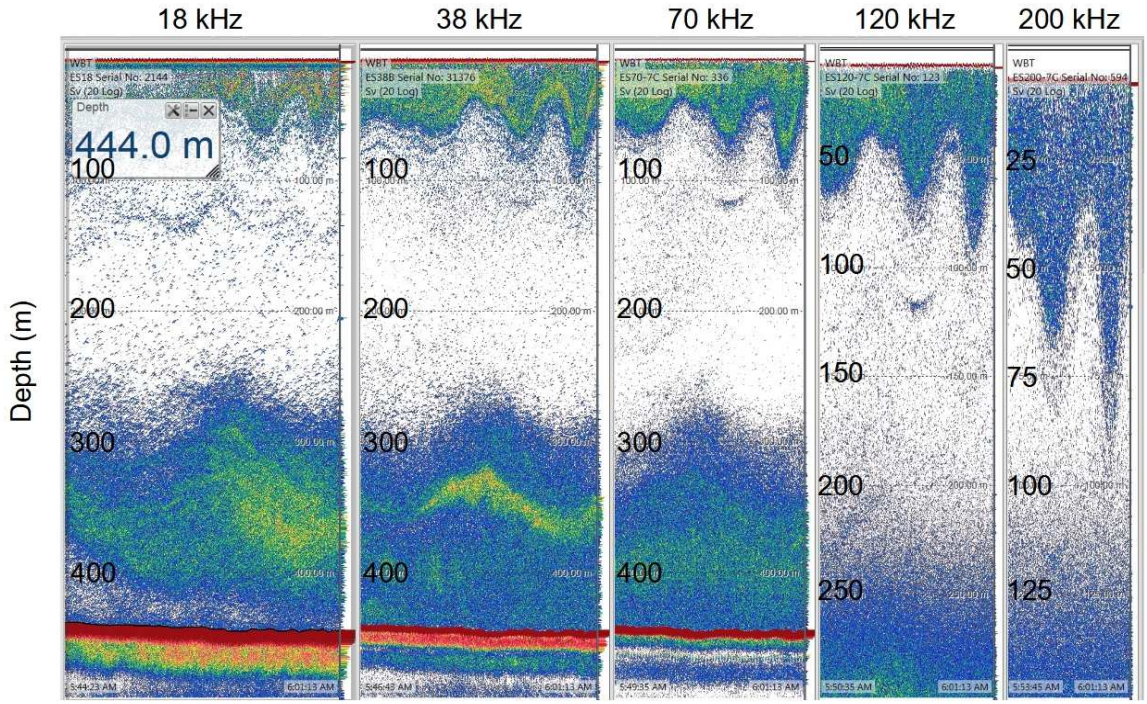

Figure 2 Example echograms (graphical representation of the acoustic data) at the 18, 38, 70, 120 and 200 kHz frequencies. Internal waves (seen as horizontal displacement of marine organisms caused by currents) are visible between the surface and 100 m depth.

Project aim:

The proposed study aims at : i) using all available data to detect the presence of internal waves during leg 2, all along the continental slope of South Africa's east coast; ii) characterise their signature in terms of thermocline displacements, currents, and potential effects on marine ecosystems (chlorophyll distribution, phytoplankton & zooplankton communities).

Project activities:

1) The student will get his hand on the acoustic dataset collected with a SIMRAD EK80 ship-borne echosounder during leg 2 and look for internal wave events. This acoustic dataset has already been processed using Matecho software to remove noise, attenuated signals and surface saturation. The data has also been echo-integrated in s_A (m^2 nmi^{-2}; proxy of microzooplankton and micronekton biomass) and S_v (dB re ^{1} m^{-1}; proxy of density) at vertical and horizontal elementary sampling distance unit of 0.5 m high layers at a threshold of −90 dB.
2) The student will use all the available environmental data (bathymetry, satellite image, TSG, and FerryBox) to provide the synoptic and dynamical context associated with each internal wave event detected in the acoustic data set (position relative to the shore, to the Agulhas Current and to the mesoscale features).
3) The student will collocate the hydrological (CTD, MVP) and hydrodynamic (ADCP) data collected during the cruise to characterize the signature of the internal waves in terms of thermocline displacement, current velocity, physical mechanisms that led to their generation. If available by then, other environmental variables such the oxycline and nutracline depths will be diagnosed.
4) Internal waves detected in the acoustic data nearby the wire-walker and ADCP mooring will then require particular attention. This mooring provided a 14-day time series of temperature, salinity, and current vertical profiles at 60m depth off Durban. This time series will be analysed to detect internal waves and their characteristics.
5) Using echograms made up of the five acoustic frequencies, the student will carry out sensitive studies to best detect the upper and lower limits of the biological layers of interest and investigate whether internal waves modulate the structuring of biophysical layers. If time permits, biological layers will be characterised by the Escore algorithm to determine the composition of the acoustic groups and their evolution with respect to the internal waves.

References

Fearon, G., Herbette, S., Veitch, J., Cambon, G., Lucas, A. J., Lemarié, F., & Vichi, M. (2020). Enhanced vertical mixing in coastal upwelling systems driven by diurnal-inertial resonance: Numerical experiments. Journal of Geophysical Research: Oceans, 125, e2020JC016208. https://doi.org/10.1029/2020JC016208

Gentil, M., Floc'H, F., Meunier, T., Ruiz-Angulo, A., Roudaut, G., Perrot, Y., Lebourges-Dhaussy, A., 2021. Internal solitary waves on the NW African shelf: A heuristic approach to localize diapycnal mixing hotspots. Continental Shelf Research. 104492. https://doi.org/10.1016/j.csr.2021.104492

Sandstrom, H., Elliot, J.A., Cchrane, N.A., 1989. Observing groups of solitary internal waves and turbulence with BATFISH and echo-sounder. J. Phys. Oceanogr. 19, 987–997.

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