Seamount-Induced Physical and Biological Variability In Sulawesi Sea

PPMI Program, Utama Unggul Schematic

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Abstract

Understanding how flow–topography interactions regulate biogeochemical processes over short timescales remains a key challenge in tropical oceanography. This study investigates physical–biological coupling over Seamount A (872 m summit depth) in the Sulawesi Sea using shipboard Acoustic Doppler Current Profiler (ADCP) measurements and paired day–night Conductivity Temperature Depth (CTD) observations collected during the OceanX 2026 expedition. Three-dimensional de-tided ADCP velocity profiles reveal pronounced vertical shear across the seamount, characterized by strong eastward surface residual currents at 20 m, northeastward veering at 200 m, and a reversal to predominantly westward flow at 300–600 m. Paired day–night CTD casts during Leg 2 demonstrate consistent nighttime shoaling of the deep chlorophyll maximum (DCM) and elevated depth-integrated Chlorophyll-*a*. These findings indicate that shear-driven vertical mixing over complex seamount topography enhances upward nutrient supply into the euphotic zone. This study will continue over a three-year research plan analyze the data observation, hydrodynamic modeling, biogeochemical, and fisheries modeling.

Keyword: Seamount, Biological Process, Diel chlorophyll maximum, Sulawesi Sea.

Introduction

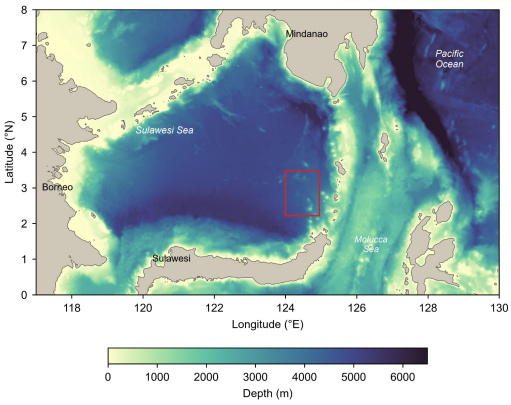
The Sulawesi Sea is a dynamic semi-enclosed basin within the Indonesian Throughflow (ITF) that transports water masses from the Pacific Ocean into Indonesian waters. This region is characterized by strong currents, complex bathymetry, and water mass transformation, which influence physical and biogeochemical variability (Gordon et al., 2010; Sprintall et al., 2014; Koch-Larrouy et al., 2015).

This study provides new insights into physical-biological coupling in tropical regions, particularly within the Sulawesi seamount ecosystem. Specifically, it highlights the role of seamount-induced current dynamics and vertical mixing in regulating diel chlorophyll variability over short timescales. These findings are important for understanding biogeochemical dynamics influenced by complex topography and strong current circulation (McGillicuddy, 2016; Mahadevan, 2016; Lévy et al., 2018).

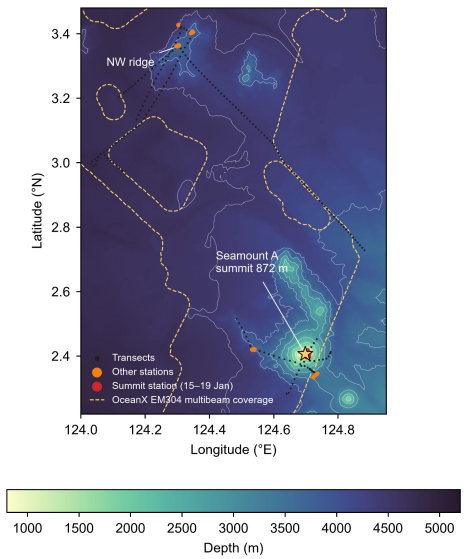
Research Method

This study was conducted in the Sulawesi Sea (Picture 1), a deep marginal basin in northern Indonesian waters. Specifically, the observations focused on Seamount A and Ridge E in the central Sulawesi Sea (Picture 2), along with several surrounding seamounts (Seamounts A–D and F–G). Rising from a ~4,000 m basin floor to a summit at ~900 m depth, Seamount A acts as a topographic obstacle that triggers physical processes such as vertical mixing and local upwelling.

These observations covered 21 casts during day and 14 casts in night time during Leg 2 across Seamounts A–D, F–G, and Ridge E. Current velocity profiles were recorded using two hull-mounted ADCP using a wideband Simrad EK80 echosounder.



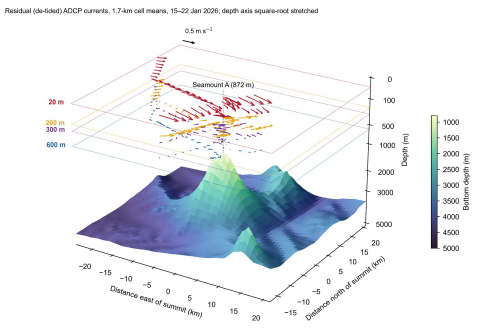
Picture 1. Bathymetry of the Sulawesi Sea (red box indicates the study area) and (b) Seamount A (872 m summit) and NW ridge with survey transects and stations coverage



Picture 2. Seamount A (872 m summit) and NW ridge with survey transects and stations coverage

To quantify water-column phytoplankton biomass, depth-integrated Chlorophyll-*a* was calculated by vertically integrating the quality-controlled, smoothed Chlorophyll-*a* profile from the surface to 150 m depth using the trapezoidal rule:

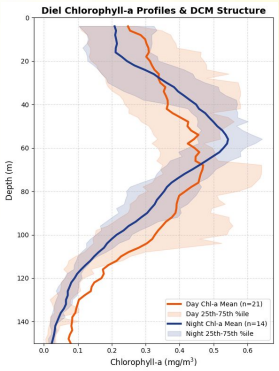
$$Chl_{int} = \int_{0\,m}^{150\,m} Chl(z)dz$$



Picture 3. Three-dimensional distribution of residual shipboard ADCP horizontal velocity vectors over Seamount A during 15–22 January 2026.

Discussion & Result

As shown in Picture 3, the surface residual current at 20 m (red vectors) flows predominantly eastward. At 200 m depth (yellow vectors), the residual flow veers toward the northeast. In contrast, the deeper residual currents at 300 m (purple vectors) and 600 m (blue vectors) display a consistent vertical pattern, flowing predominantly westward.



Picture 4. Diel chlorophyll-a profile and DCM structure during day and night CTD casting

Regime	Casts	Mean DCM Depth (m)	Peak Chl-a (mg/m^3)
Day	21	66.6 ± 21.1 m	0.598 ± 0.177
Night	14	55.6 ± 18.9 m	0.617 ± 0.103

As illustrated in Picture 3, the nighttime CTD profiles exhibit a shallower DCM and higher peak as well as depth-integrated Chlorophyll-*a* (0–150m) compared to daytime casts. These results indicate that shear-driven vertical mixing over the seamount enhances upward nutrient transport from the nutricline into the euphotic layer, promoting DCM shoaling and elevated phytoplankton biomass.

This study will continue over a three-year research plan. In the first year, work focuses on analyzing the oceanographic and fisheries observation data. Then, the second year will focus on hydrodynamic modeling in the Sulawesi Sea, while the third year will address biogeochemical and fisheries modeling.

Conclusion

This study demonstrates physical–biological coupling driven by seamount-induced current dynamics and vertical turbulent mixing in the Seamount A ecosystem of the Sulawesi Sea during leg 2. Paired day–night CTD casts show that fine-scale mixing regulates short-timescale chlorophyll variability, evidenced by nighttime shoaling of the DCM and elevated depth-integrated Chlorophyll-a. The substantially stronger positive correlation between mixing and integrated Chlorophyll-a at night highlights that shear-driven upward nutrient supply and governs biogeochemical dynamics over tropical seamounts.

Acknowledgment

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