Project title “Hydrodynamic and Internal Tide Processes at Losin Pinnacle and their relationships with Coral Reef- Thailand”

Preparing manuscript title “Hydrodynamic and Biological Features of Losin Pinnacle-Thailand with Fully Developed Vortex Shedding”

Project member

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Purposes

To examine and describe hydrodynamics features including current field, fluctuation of seasonal pycnocline in relationship with a fully developed vortex shedding and biological features of the remoted small but important pinnacle namely “Losin Pinnacle” situated in the Gulf of Thailand.

Methods

This study utilized available resources from both the Faculty of Fisheries, Kasetsart University (FOF-KU) and the Center for Marine Environmental Studies, Ehime University (CMES-EU). The FOF-KU gathered field observation data and secondary data, e.g., bathymetry, flow velocity, profiles of water temperature, salinity, water density, turbidity, chlorophyll-a concentration and dissolved oxygen. Additional, long-term data water temperature and water level were collected using data logger. At CMES-EU, a concept of two-dimensional hydrodynamic model were discussed using unstructured grid and the first version of the model was produced using DFLOW FM model. The model was calibrated and validated against measured data aiming at reproducing a local hydrodynamic feature of the pinnacle with effects of local wind.

Results

Measurements indicate that the Losin Pinnacle is a small formation, approximately 700 meters long and 450 meters wide, oriented along the northwest-southeast axis. It features two crests: one submerged and the other permanently above the sea surface. The pinnacle has an average depth of 12-15 meters, surrounded by water at approximately 45 meters depth (Figure 1). In August and September, a pycnocline (formed by thermocline and halocline) is observed at around 25 meters depth (Figure 2). The upper water layer is characterized by higher temperatures, lower salinity, reduced turbidity, and higher dissolved oxygen content. Highest chlorophyll-a concentration are at the boundary between the upper and lower layer water. The pycnocline fluctuates rapidly in vertical position, as recorded by both profiling measurement and by the data loggers (Figure 3). Temperature fluctuations were measured at datalogger deployed at 13-meter and 26-meter depths, with the most intense variations occurring from April to May and again in July. Frequency analysis reveals that temperature fluctuations occur at tidal frequencies, with periods of about one hour.

To model tidal effects, we implemented a two-dimensional hydrodynamic model covering the entire Gulf of Thailand, with a refined grid resolution of approximately 5x5 meters around the Losin Pinnacle. Simulated flow fields during strong ebb tides are shown in Figure 4. The model reveal development of Fully Developed Vortex Shedding (FDVS) at the lee side. We hypothesize that rapid fluctuations of pycnocline are associated to turbulence generated by the FDVS. Tidal and FDVS-induced mixing around the pinnacle likely contribute to nutrient enrichment, cooling of the upper water layer, and the creation of a distinct hydrodynamic and water quality environment, making the pinnacle a unique oasis in the surrounding oligotrophic waters. These fluctuations vary throughout the year due to monsoonal dynamics and the formation and dissipation of the pycnocline in the Gulf of Thailand (Figure 5).

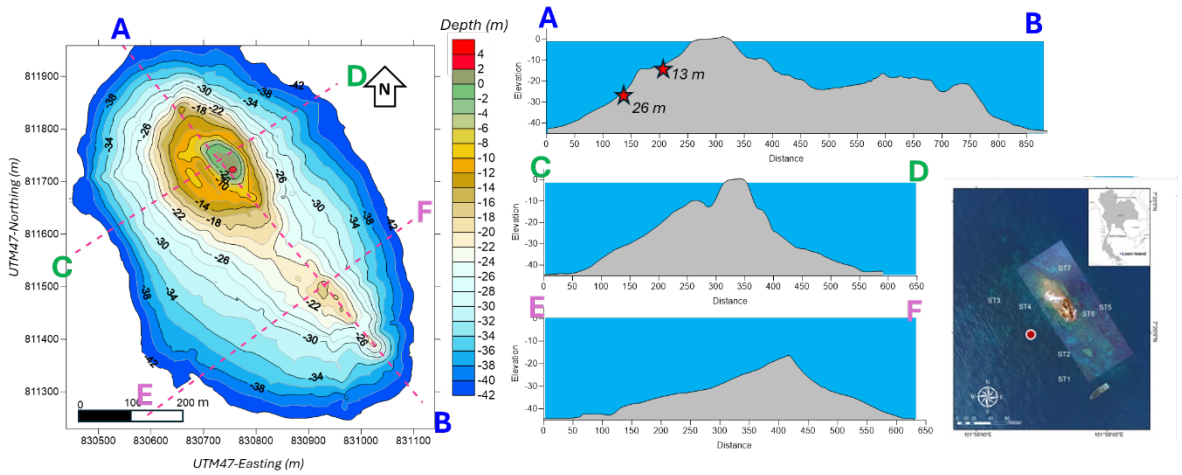

Figure 1 Location and bathymetry of the Losin Pinnacle, Thailand.

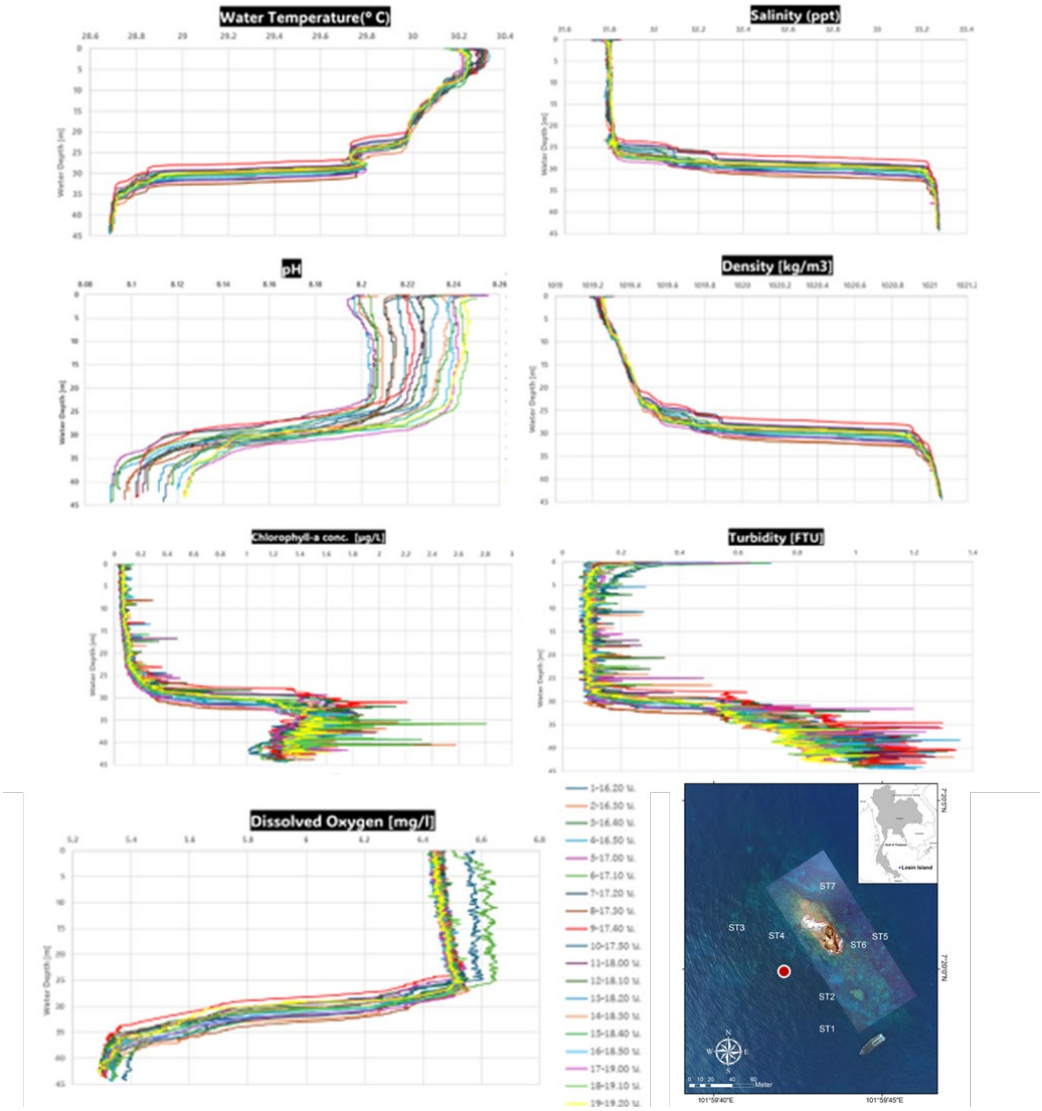

Figure 2 Every 10 minute profiles of measured multi-parameter CTD during 22 August 2024 field measurements

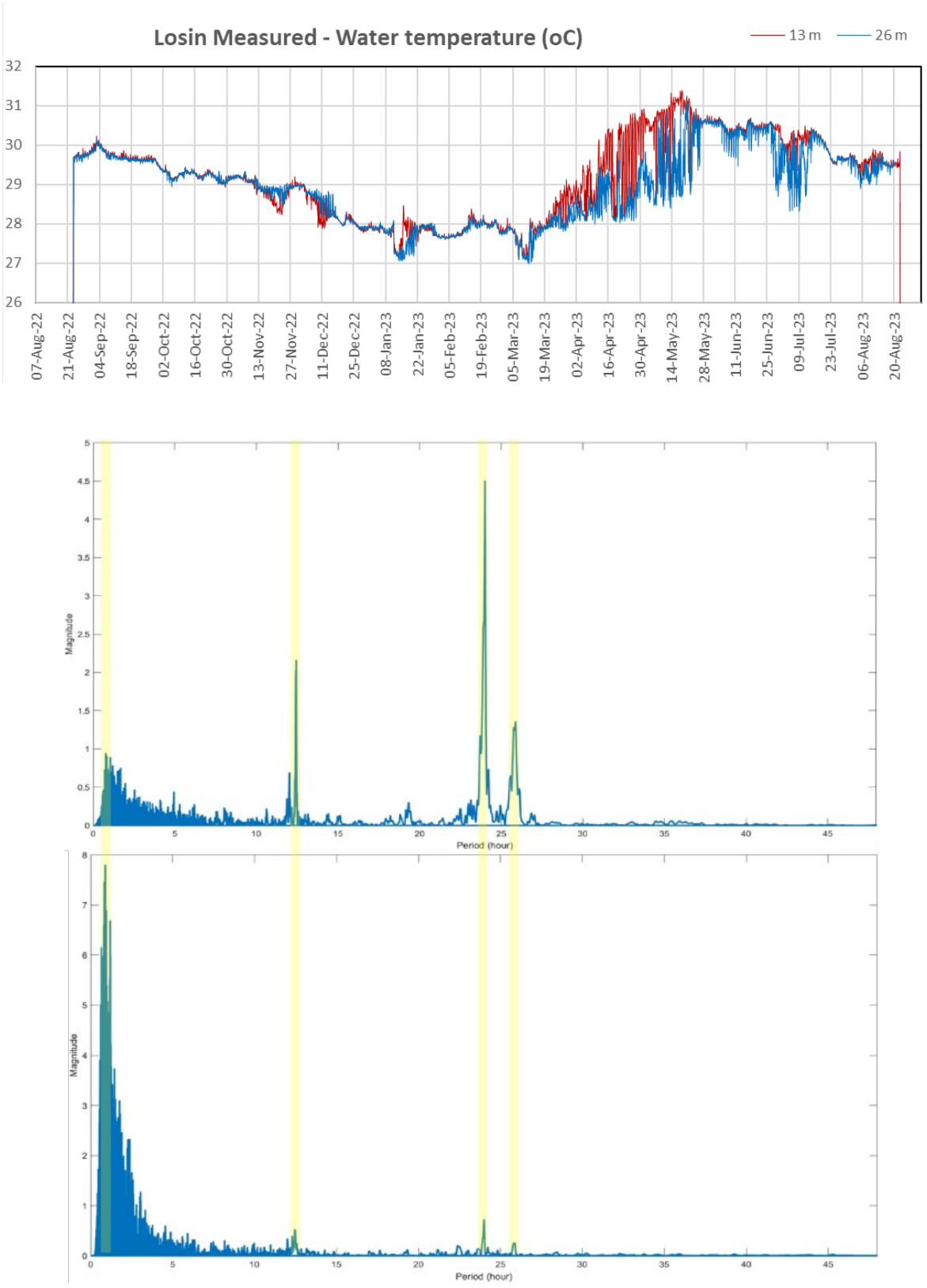

Figure 3 Time and frequency domain of a-year-long measured water temperature deployed at 12 and 26 meter depth at Losin Pinnacle, Thailand

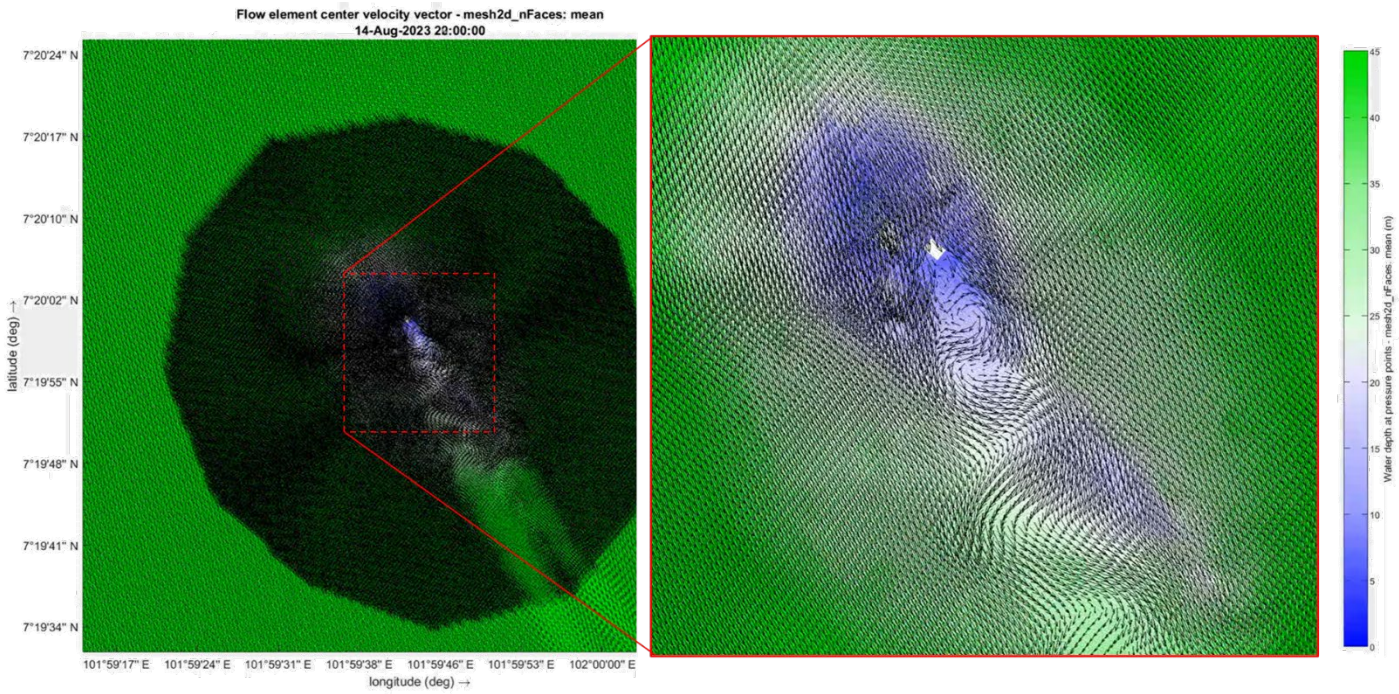

Figure 4 High resolution simulated flow field around the Losin Pinnacle showing fully developed vortex shedding.

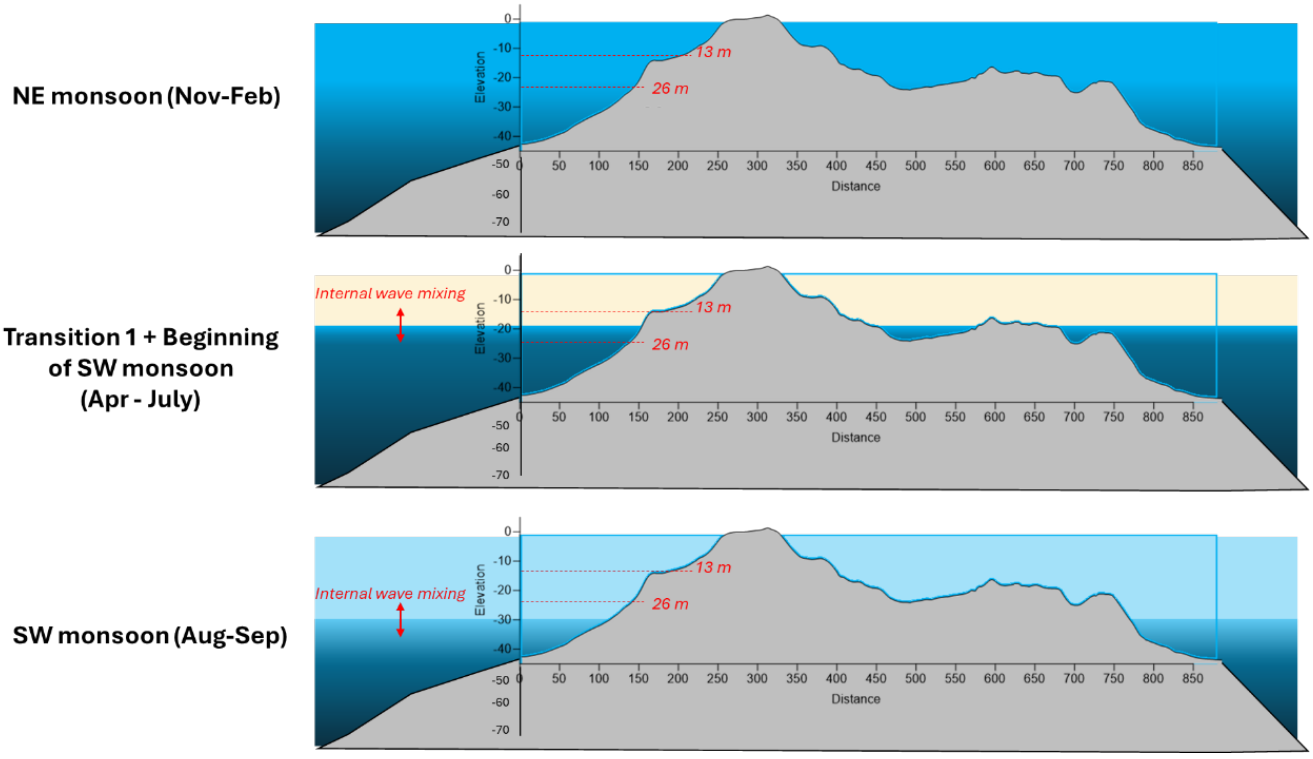

Figure 5 Illustration showing seasonal stratification and fluctuation of the thermocline at Losin Pinnacle, Thailand.

Future Challenges

The Fully Developed Vortex Shedding (FDVS) can significantly impact fluctuations in the thermocline, halocline, and pycnocline. A three-dimensional hydrodynamic model, incorporating density variations and non-hydrostatic assumptions, is essential for a detailed analysis of this mechanism. Understanding this process will enhance our knowledge of local dynamics around small pinnacles or obstructions in free-surface flows and their broader remote effects.
