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Subj: ONR Grant: N00014-15-1-2630
"SWIFT Observations winds, waves and boundary layer over the inner shelf"

Encl: (1) Final Report including publications for "SWIFT Observations winds, waves and boundary layer over the inner shelf" with accompanying SF 298.

Enclosed please find the Final Report with publications and corresponding SF 298 form for the subject grant. These documents constitute the Final Technical Report and deliverables for ONR Grant N00014-15-1-2630.

cc: ONR Seattle – Robert Rice and Naomi Roberson
Naval Research Laboratory Code 5596
Defense Technical Information Center
Office of Sponsored Programs – UW Closeout
APL-UW Grants and Contracts Closeout Coordinator

Final Report

SWIFT Observations winds, waves and boundary layer over the inner shelf

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http://www.apl.washington.edu/innershelf

MAJOR GOALS

The long-term goal was to understand the dynamics of the Inner Shelf region of the coastal ocean, with intent to improve the skill of numerical forecast models and the interpretation of remote sensing products. This project made detailed in situ observations of physical processes in support of this goal, including wind forcing, surface wave motions, boundary layer dynamics, and turbulence.

OBJECTIVES

The specific objectives of this project were to use SWIFT drifters to:

1. Understand overlapping surface and bottom boundary layers, including effects of surface waves,
2. Understand convergence at fronts and internal wave packets, and
3. Address the space-time variations of these processes.

APPROACH

The approach focused on field observations of physical processes throughout the Inner Shelf region. Observations used SWIFT drifters, which measure winds, waves, current profiles, and turbulence in a surface-following reference frame. Ancillary measurements within the scope of the project include shipboard surveys, moorings, and shore-based meteorological stations.

WORK COMPLETED

A major field experiment was completed in September-October 2017 in the vicinity of Pt Sal (central California Coast). A total of approximately 2000 hours of SWIFT data were collected, using 8 drifters deployed and recovered across 23 days of operations spanning two intensive periods. The drifter operations were coordinated with groups from Scripps and the Naval Postgraduate School, such that drifter 'swarms' would be available for joint analysis. Figure 1 shows the tracks of SWIFT deployments throughout the domain.

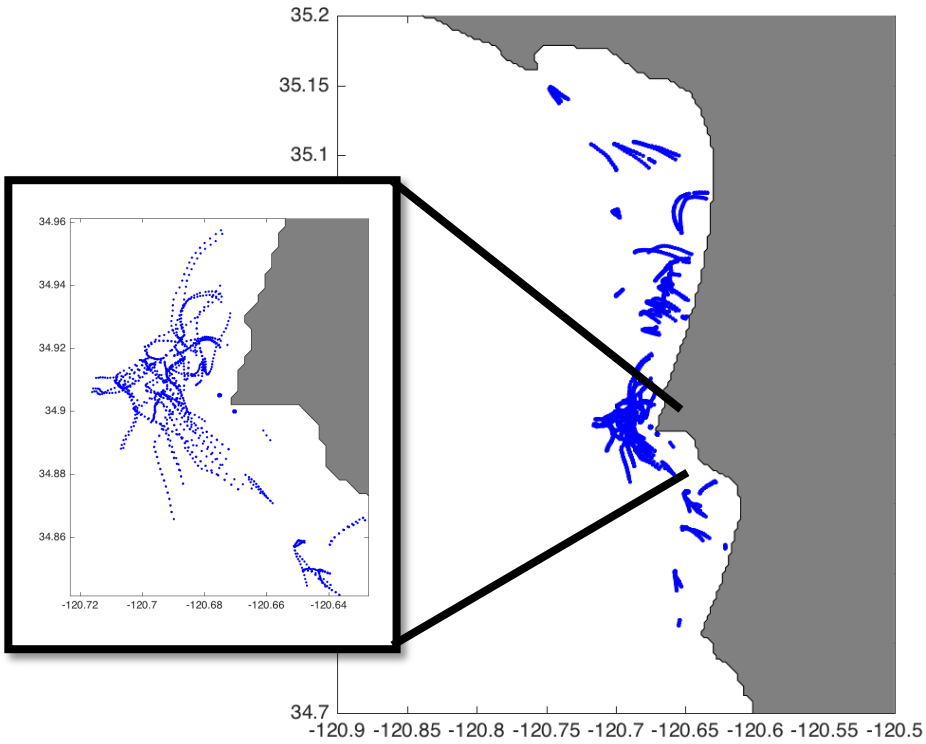

Figure 1. SWIFT tracks during the Inner Shelf experiment, including a zoom view around Pt Sal.

Shipboard transects of Acoustic Doppler Current Profiler (ADCP) data and Conductivity-Temperature-Depth (CTD) tows were collected during each of the 23 days. These ship surveys were coordinated with the other ships and the aerial remote sensing. Figure 2 shows an example of a shipboard ADCP section in the region of strong laterl shear just downstream of Pt Sal.

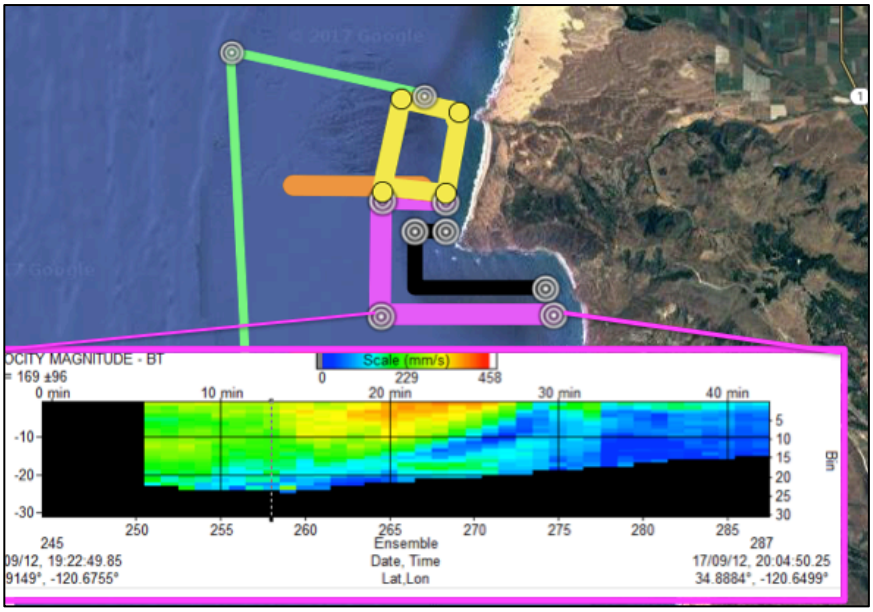

Figure 2. Shipboard ADCP transect south of Pt Sal. Colored lines in the map are the tracks of coordinated surveys by other research vessels.

Finally, five moorings were in place for the 45 days, spanning the full experiment. The mooring locations and configurations were also coordinated with the larger group. Figure 3 shows a time series of significant wave heights measured by the moorings.

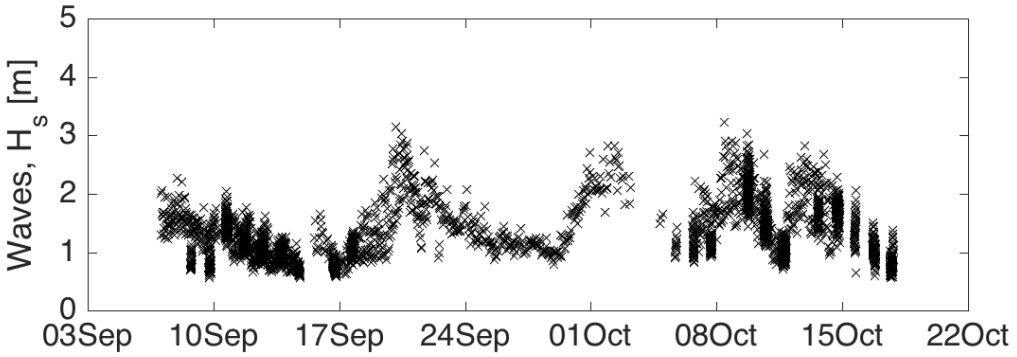

Figure 3. Signficant wave heights measured by APL-UW moorings.

All collected data have been reviewed, and quality-controlled 'level 2' have been posted for collaborative use. The SWIFT drifter data show strong downwelling vertical velocities in convergence zones (fronts and internal wave packets), as well as clear boundary layer signals. The drifter and mooring data show strong flow separation and turbulence generation in the vicinity of the Pt Sal headland.

RESULTS

Data processing has supported the following results:

1. Strong downwelling is observed inconvergence zones associated with fronts.
2. Headlands (such as Pt Sal) cause flow separation, recirculation, and turbulent dissipation.
3. Surface and bottom boundary layer scan overlap and interact.

Figure 4 shows an example of downwelling at a front, as part of collaborative processing of drifter swarms with Scripps investigators Matt Spydell and Falk Feddersen. Convergence is calculated from the combined tracks of the Scripps drifters, and downwelling is observed from the current profilers onboard the SWIFT drifters. This example is illustrated using aerial infrared imagery provided by collaborators Chris Chickadel and Melissa Moulton.

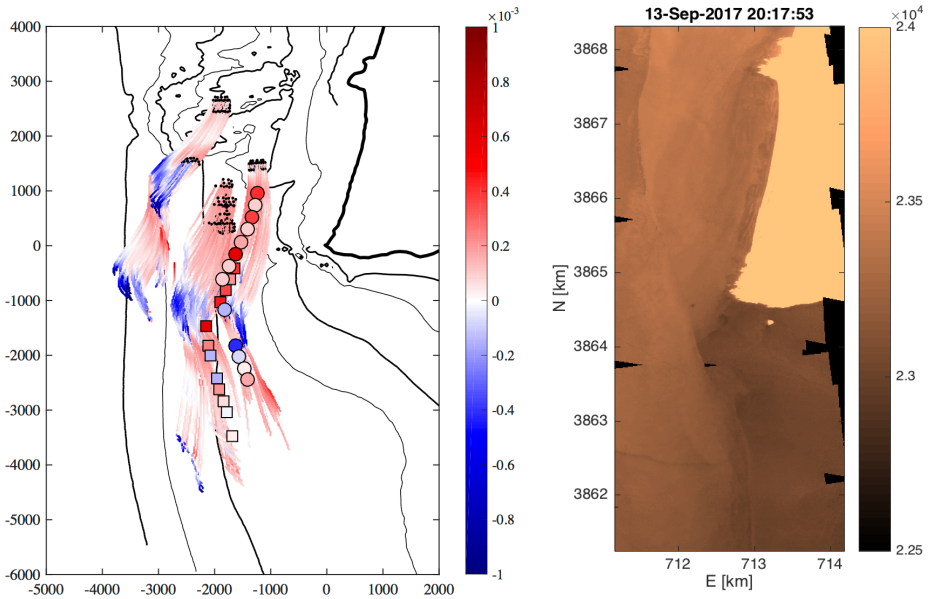

Figure 4. Estimates of convergence and downwelling (left panel) at a front, along with aerial infrared imaging of the front (right panel). Collaborative results with Matt Spydell, Falk Feddersen, Melissa Moulton, and Chris Chickadel.

Figure 5 shows an example of the vertical structure of the downwelling and turbulent dissipation rate profiles at the same front shown in Figure 4. Both the downwelling and the turbulent dissipation are strongest in the upper meter. This thin surface layer is difficult to observe via conventional shipboard or moored approaches, yet this layer controls most remote sensing signals. Work is ongoing to parameterize these effects for inclusion in forecast models.

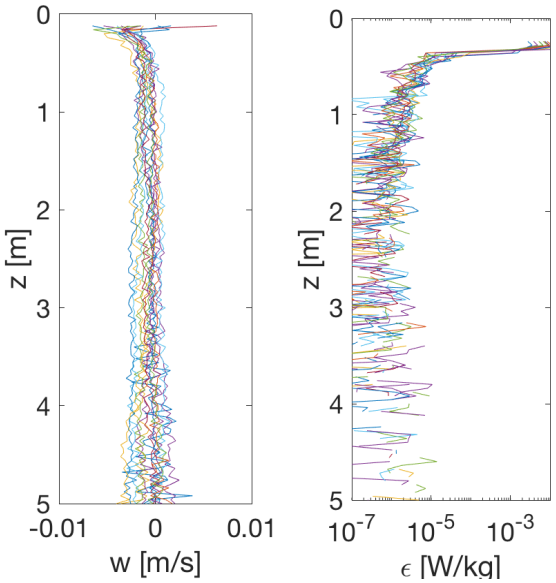

Figure 5. Profiles of downwelling velocity (left panel) and turbulent dissipation rate (right panel).

IMPACT/APPLICATIONS

This project has advanced capabilities in measuring waves, shear, and turbulence from autonomous drifting platforms. In particular, results may be applied to improved inferrences from remotely sensing signatures at the ocean surface, such as slicks, fronts, and wave fronts.

RELATED PROJECTS

A DURIP award in FY 17 provided support for a new version of SWIFT buoys used in the observational campaign.

PUBLICATIONS

- Zippel, S., G. Farquharson, and J. Thomson, Turbulence from breaking surface waves at a river mouth, J. Phys. Oceanog.,48, (2018). [published, refereed]*
- Zippel, S. and J. Thomson, Surface wave breaking over sheared currents: observations from the Mouth of the Columbia River, J. Geophys. Res., 122 (2017). [published, refereed]*
- Guerra, M. and J. Thomson, Turbulence Measurements from 5- beam Acoustic Doppler Current Profilers, J. Atmos. & Ocean. Tech., 34 (2017). [published, refereed]**
- Moghimi, S. , J. Thomson, T. Ozkan-Haller, L. Umlauf, S. Zippel, On the modeling of wave-enhanced turbulence near-shore, Ocean Modeling, 103 (2016). [published, refereed]*

* Based on RIVET / DARLA data collection (prior ONR support), but publication support by present ONR Code 322 support.

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13. SUPPLEMENTARY NOTES

14. ABSTRACT

This project was to understand the dynamics of the Inner Shelf region of the coastal ocean, with intent to improve the skill of numerical forecast models and the interpretation of remote sensing products. This project made detailed in situ observations of physical processes, including wind forcing, surface wave motions, boundary layer dynamics, and turbulence. The specific results of this project were to use SWIFT drifters to:

1. Understand overlapping surface and bottom boundary layers, including effects of surface waves,
2. Understand convergence at fronts and internal wave packets, and
3. Address the space-time variations of these processes.

These results and the related data products have been shared with the research community.

15. SUBJECT TERMS
Ocean surface waves, coastal zone, currents, turbulence.

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