The Windy Islands Soliton Experiment (WISE)

Steven R. Ramp
Department of Oceanography, Code OC/Ra
Naval Postgraduate School
Monterey, CA 93943-5122
phone: (831) 656-2201 fax: (831) 656-2712 email: sramp@nps.edu

Grant #: N0001406WR20285

LONG-TERM GOAL

The long-term goal is to enhance our understanding of coastal oceanography by means of applying simple dynamical theories to high-quality observations obtained in the field. My primary area of expertise is physical oceanography, but I also enjoy collaborating with biological, chemical, acoustical, and optical oceanographers to work on interdisciplinary problems. I collaborate frequently with numerical modelers to improve our predictive capabilities of Navy-relevant parameters in the littoral zone.

OBJECTIVES

The objective of this grant is to observe the ocean variability in the northeastern South China Sea for a period of one year. Previous work suggests that this variability stems from the wind-driven mesoscale, the Kuroshio Current intrusions, the tides, and very large amplitude non-linear internal waves. The internal waves are associated with the tidal bore which originates somewhere near the Luzon Ridge and propagates WNW across the deep basin to the Chinese continental shelf and slope. The seasonal variability and the impact of the Kuroshio Current interactions on the wave generation and propagation problem has been previously unknown. In addition to the problem's inherent scientific interest, understanding and predicting the wave behavior (and associated acoustic perturbations) is of strong Naval tactical value as well.

APPROACH

A transect consisting of six subsurface moorings was deployed across the northeast sector of the South China Sea (Figure 1) from April 2005 to June 2006. The moorings each sampled current, temperature, and salinity using a variety of sensors, and observed the presence (or not) of the large-amplitude internal waves as the internal tide passed by. The moorings also sensed the position of the Kuroshio Intrusion, when present, to observe its impact on the internal wave problem. Acoustic sensors were deployed by collaborating investigators Profs. Ching-Sang Chiu and Ben Reeder on moorings B1 and B2 (Figure 1) to observe the impact of the ocean variability on the low-frequency trans-basin acoustic propagation. The Luzon Strait mooring must resolve the tidal flux and mesoscale variability in the strait, and sampled for six months at a time. All other instruments must sample rapidly (order 2 minutes) to resolve the high-frequency internal wave field. Battery and memory limitations then dictated that the instruments be serviced every three months. This work was done from the Taiwanese research vessel OCEAN RESEARCHER 1 during cruises in April, July, and October 2005 and February and June 2006. Deep CTD casts were also done during these cruises to map the ambient

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
30 SEP 2006		**00-00-2006 to 00-00-2006**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
The Windy Islands Soliton Experiment (WISE)	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Naval Postgraduate School,Department of Oceanography,Monterey,CA,93943**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**5**	

stratification in the water column. Additional related studies using floats, drifters, hull-mounted sonars, and satellite remote sensing were also done by collaborating investigators. The numerical modeling team is using several different approaches suitable to a wide range of spatial and temporal scales to synthesize the observational results into a coherent picture of the ocean variability.

WORK COMPLETED

The field work for WISE commenced in earnest during FY05 and continued during FY06 with cruises during October 2005, February 2006, and June 2006. The array during this time consisted of a mooring in the Luzon Strait between Batan and Itbayat Islands, two in the deep basin, and one on the continental slope. (The two moorings originally planned by Taiwan on the continental shelf were abandoned because of equipment losses due to heavy fishing in the area.) During the October and February cruises the entire moored array was recovered and re-deployed, and the array was recovered for the final time during June 2006. Data return from the four moorings was excellent and the desired one-year time series of the variability in the northeastern SCS have been obtained. The preliminary results were presented at the NLIWI planning meeting in Kona, Hawaii during February 2006, which was organized by the PI. Several oral presentations have also been given (see publications section).

RESULTS

The results obtained so far can be understood by partitioning the processes observed into four important geographical subregions namely the two ridges (Luzon and Heng-Chun), the deep basin, the continental slope, and the continental shelf.

- The ridges: The internal tide, and sometimes NLIWs directly, is generated at the eastern (Luzon) Ridge. Some enhancement of the internal tide is possible via interaction with the western (Heng-Chun) Ridge.

- The deep basin (2500 m – 3500 m): This region is characterized by free propagation, accompanied by some non-linear steepening of the internal tide, with little or no bottom interaction.

- The continental slope (2000 m – 500 m): This is an important transformation region. The incoming transbasin waves, usually solitary, split into packets of waves in this region. New NLIWs are also generated by the shoaling of the internal tide, which were absent in the deep basin. All these waves are depression-type waves.

- The continental shelf (less than 200 m): The transformation to elevation waves occurs here, usually in water less than 120 m deep. New NLIWs are also locally generated at the shelf break, which interact with the true transbasin waves.

The temporal variability is still being studied, but we can fairly say that the occurance of the waves depends critically on the strength of the barotropic tide in the Luzon Strait and the strength of the stratification along the propagation path. The latter varies seasonally, and perhaps also according to the position of the Kuroshio Intrusion. The waves were generated year-round, but were decidedly weaker during the winter (December through February) months (Figure 2). Within each spring/neap tidal cycle, there were no waves for about four days around neap, the strongest waves were generated just before and after spring tide, and weaker or no waves were generated right at the strongest spring

tide. This generation cycle will be the subject of a follow-on investigation. Our working hypothesis is that the flow is under hydraulic control at the eastern sill, which can potentially explain many of the phenomena observed.

IMPACT/APPLICATION

The study areas, both the Chinese continental shelf and the deep basin leading to the Pacific Ocean south of Taiwan, are presently areas of high tactical interest to the Navy. The ASIAEX results have already lead to improved situational awareness by U.S. operators in both offensive and defensive ASW postures. It is anticipated that the WISE transect will extend the utility of these results from the spring to the entire calendar year and lead to a predictive capability to account for internal wave impacts on sonar performance and waterspace management.

TRANSITIONS

Transitions to SUBPACFLT are anticipated as the results become available. This transition process represents a follow-on to WESTPAC tactical oceanography symposium held at Pearl Harbor during February 2004.

RELATED PROJECTS

Nonlinear internal waves in the Monterey Bay were also observed during the Adaptive Sampling and Prediction (ASAP) program during August 2006, funded by a DoD MURI grant. These data will be analyzed during FY2007-2009. A related NSF CMG grant to model the SCS waves was also obtained (Lead PI is Prof. Woo-Young Choi, NJIT).

PUBLICATIONS

Ramp, S. R., C.-S. Chiu, F. L. Bahr, T.-Y. Tang, and Y. J. Yang, 2006: Characterizing the nonlinear internal wave field in the northeastern South China Sea. Presented at: 2006 Ocean Sciences Meeting, Honolulu, HW, February 2006.

Ramp, S. R., T.-Y. Tang, Y. J. Yang, C. Villanoy, F. L. Bahr, and Y.-T. Chang, 2006: Tidal Currents in the Luzon Strait. Presented at 2006 NLIWI Workshop, Kona, HW, February 2006.

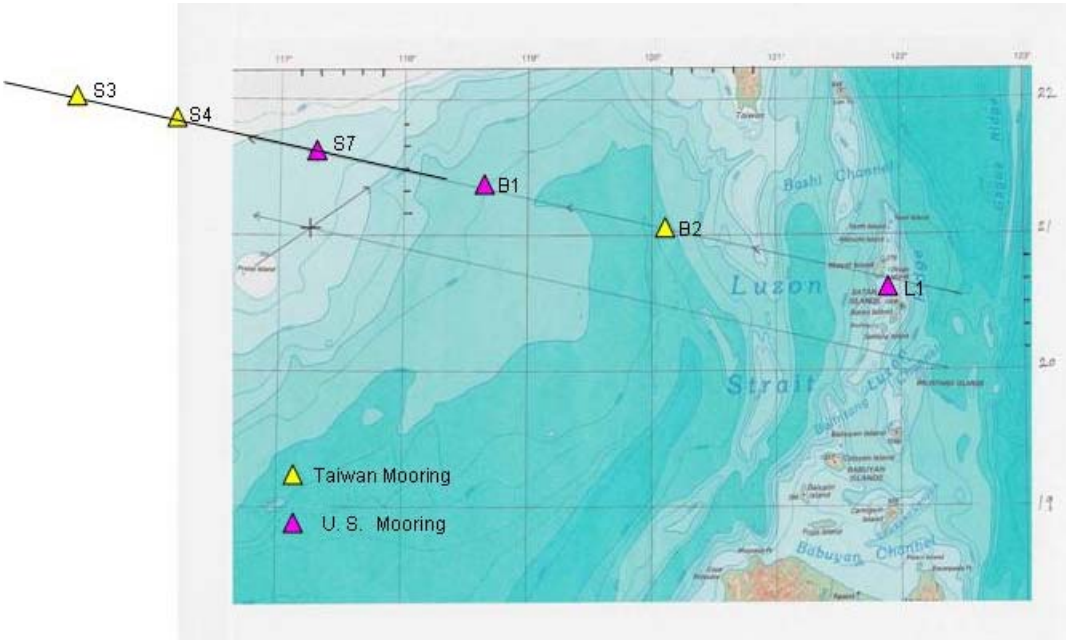

Figure 1. A schematic drawing of the WISE mooring transect. The moorings sampled velocity, temperature, and salinity at internal wave frequencies, which required three-month service intervals. The effort was shared by the U.S. and Taiwan as indicated. The work was conducted from the Taiwanese research vessel OCEAN RESEARCHER 1.

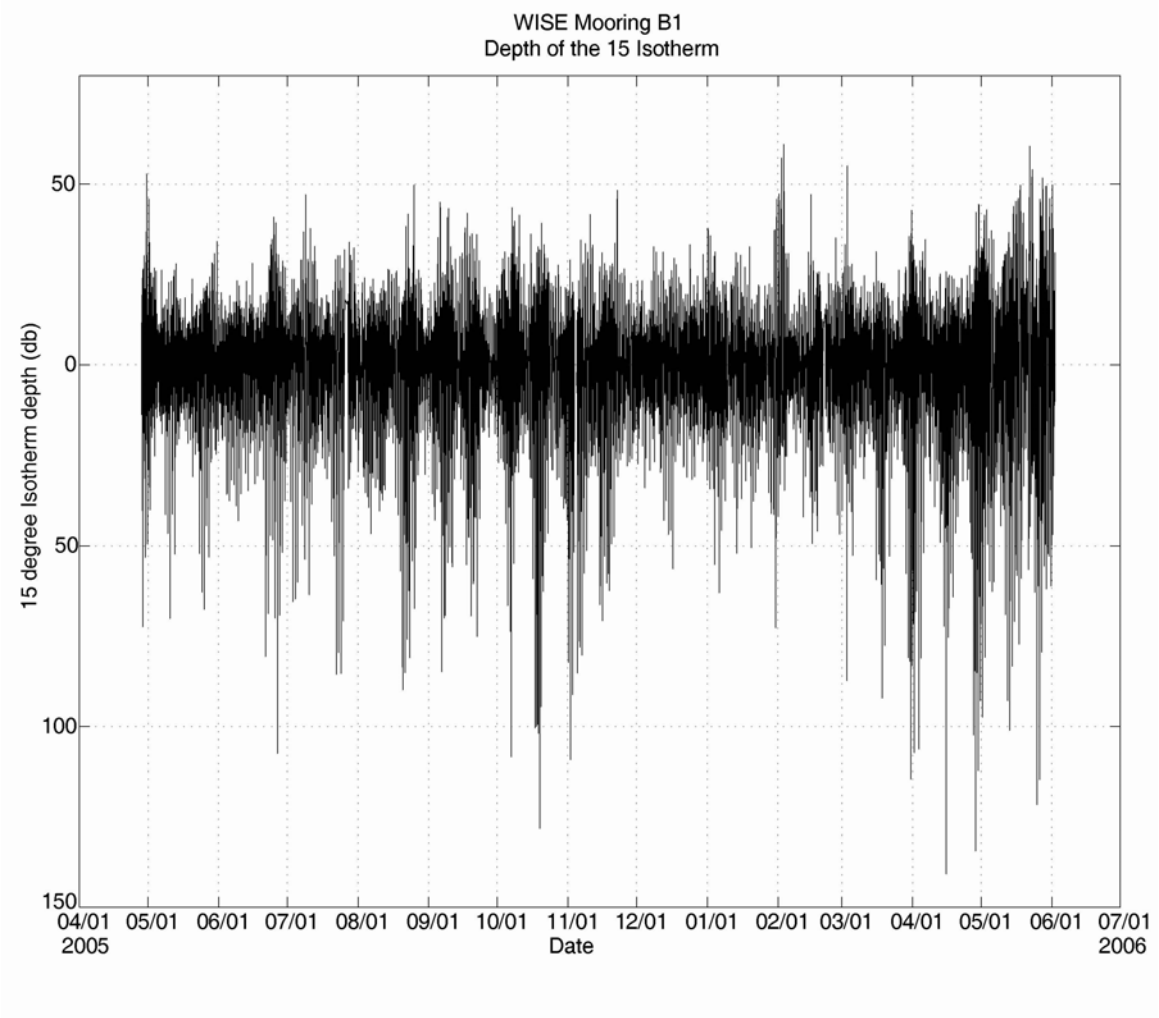

Figure 2. The depth of the 15°C isotherm at mooring B1 (see Figure 1 for location) at 2500 m depth in the South China Sea. The data have been high-pass filtered, thus the 0 starting depth. The large displacements are due to the passing nonlinear internal waves. Note the much smaller waves during the December 2005 through February 2006 time frame. The tides at the generation site were unchanged during this time.