Processes in Marginal Seas
-and-
ASIAEX Project Management

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: ramp@oc.nps.navy.mil

Ching-Sang Chiu
Department of Oceanography, Code OC/Ci
Naval Postgraduate School
Monterey, CA 93943-5122
phone: (831) 656-3239 fax: (831) 656-2712 email: chiu@usw.nps.navy.mil

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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 their predictive capabilities of Navy-relevant parameters in the littoral zone.

OBJECTIVES

The objective of these two closely-related grants is to plan, execute, and analyze the data from a multi-national oceanographic field program in the East and South China Seas to investigate how the complex littoral environment (i.e., its water column, boundary, sediment and sub-bottom structure and inhomogenities) affects the ray paths, mode structure, propagation loss, and temporal and spatial (both vertical and horizontal) coherence for low-to-intermediate frequency (50-4000 Hz) acoustic transmissions in shallow water

APPROACH

The objectives were addressed via an intensive field program in the East and South China Seas called the Asian Seas International Acoustics Experiment (ASIAEX). The ASIAEX main field program consisted of two distinct experiments; a reverberation experiment in the East China Sea (ECS) with mainland China and Korea, and a volume interaction experiment in the South China Sea (SCS) with Taiwan and Singapore. The goal of the reverberation experiment was to *Develop models that can predict the mean reverberation level and fluctuations using measured environmental parameters*. The

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14. ABSTRACT
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 their predictive capabilities of Navy-relevant parameters in the littoral zone.

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goal of the volume interaction experiment was *to understand acoustic propagation through shallow water when strong oceanic variability is present*.

Professors Ramp and Chiu both served two roles for ASIAEX, as principal investigators and project managers. As the International Science Coordinator and Associate Coordinator, they handled the logistics, political matters, research vessel clearances, and planning workshops for the entire program. They also participated in the East China Sea pilot study aboard the R/V ROGER REVELLE during spring 2000 and the South China Sea volume interaction experiment aboard the Taiwanese research vessel OCEAN RESEARCHER 1 during April 2001. Professor Ramp was one of the lead physical oceanographers for the U.S. team and Prof. Chiu one of the lead acousticians. Other key individuals involved in the SCS portion of the program (our most immediate collaborators) include James Lynch, Tim Duda, and Glen Gawarkiewicz of WHOI; Marshall Orr and Steve Wolf from NRL; and David Tang and Joe Wang from NTU.

WORK COMPLETED

Field Work: The ECS pilot study was successfully completed from the R/V REVELLE during April 2000. The SCS pilot study was also completed during spring 2000 from the OCEAN RESEARCHER 1. The ASIAEX main field programs in the South and East China Sea were completed during spring and summer 2001. Approximately 35 principal investigators from 18 major institutions participated in the work at sea. The resulting data set, collected over 108 days on eleven cruises aboard six research vessels in two marginal seas, is the largest and most comprehensive of its kind ever collected, and will serve to advance the state of the art in understanding acoustic propagation in shallow water. Some results from the SCS spring 2001 cruises conducted from Taiwanese research vessels are highlighted here. For additional information on the ECS 2001 program, see the annual report by Peter Dahl (APL/UW). For more information on the SCS SEASOAR cruises and acoustics work, see the annual reports by Gawarkiewicz (WHOI), Chiu (NPS), Lynch (WHOI) and Orr (NRL). The Low-Cost (LOCO) moorings are discussed in the annual report by Duda (WHOI).

Planning: A first-look data analysis workshop was held in Maui, Hawaii during 31 October – 2 November 2001. This was mostly for all the investigators to report what they collected to establish a baseline to move forward from. This meeting was organized by the international coordinator with outstanding technical suppport from Mrs. Beverly Kuhn of ONR. The coordinator also participated in a second meeting held during January 2002 in Seattle, WA, primarily for the mainland Chinese. This meeting was hosted by the Applied Physics Laboratory, University of Washington. Considerable time and effort was also expended during the grant period planning the final ASIAEX International Symposium in Chengdu, PRC, to be held 14-18 October, 2002. The PI hosted Dr. David Tang from the National Taiwan University at NPS for the month of July, to work on manuscripts with Drs. Ramp, Chiu, and Gawarkiewicz (WHOI).

Analysis: FY02 was primarily an analysis year and much has been accomplished. A manucript on the circulation in the Ulleung Basin during June 1999 was submitted for publication (see list). A second manuscript on the ECS 2000 pilot study was also completed (see list). Several other manuscripts on the SCS main field program are in advanced preparation in collaboration with many co-authors. Oral presentations were presented at the ASIAEX principal investigator's meeting in Maui, Hawaii; the AGU Ocean Sciences Meeting in Honolulu, Hawaii; and at PACSUBFLT headquarters in Pearl Harbor, Hawaii (see lists).

RESULTS

New results are conveyed here that were not included in previous annual reports (see FY00 and FY01 CDs). Without doubt, the most energetic motions observed during ASIAEX 2001 were the strong, highly nonlinear internal waves or solitons. These were the most energetic solitons ever observed anywhere in the world. The waves appeared in groups related somehow to the phase of the barotropic tide in a way not yet fully understood. At other times there were no waves arriving at all. The wave packet arriving May 6 was the first in one of these "groups" and thus provided the cleanest signal as it propagated up the slope into shallower water (Figure 1). The waves exhibited a complex evolution during this time. The bottom forced the large amplitude peaks to shorten and broaden. New waves appeared either from other (local) sources or by wave fission. Finally, elevations waves developed out of a broad region of deepened thermocline caused by the depression waves running together. A statistical analysis was performed on all the waves to determine their origin (Figure 2). The large amplitude (> 50 cm s^{-1}) waves all came from near the Batane Islands (Phillipines) in the Luzon Strait. The smaller (25 – 50 cm s^{-1}) waves had two sources; the Luzon Strait and Dongsha Island (Pratis Reef). The ultimate source of all the waves is likely the Batane Islands, with some of these waves refracted northward as they impinge upon Pratis Reef. A theoretical effort continues to understand, model, and predict these fascinating wave motions.

IMPACT/APPLICATION

The ASIAEX program is a follow-on to the New England Shelfbreak Primer experiment and as such will advance the state of the art in shallow water acoustic propagation prediction. The 2001 field program used more sophisticated acoustic sources and arrays, multiple towed vehicles, and alongshore as well as across-shore array configurations to better elucidate the subtle relationships between the water column variability, bottom and sub-bottom structure, and acoustic propagation loss. The ASIAEX analysis will lead to improved detection, location, identification, and targeting in the littoral zone. The large dramatic buoyancy changes induced by tidal bores and internal solitons have direct operational impacts on submarines in shallow water. The knowledge / predicatablity of these features has found immediate use at PACSUBFLT.

TRANSITIONS

Profs. Ramp and Chiu have briefed the fleet three times so far on the impacts of the environment on East and South China Sea operations. They briefed CAPT Will Jordan and CDR James Hart of COMSUBPAC during February 2001 and ADM Sullivan and Dr. Schuster from N77 (ASW) during August 2001. Most recently, Profs. Chiu and Ramp traveled to Pearl Harbor during September 2002 to meet again with CDR. Patrick Cross USN, staff oceanographer for PACSUBFLT for a SECRET brief to operators. This brief was very well received. The information provided has been incorporated into the pre-brief for embarking submarine leaders.

RELATED PROJECTS

None

PUBLICATIONS

1. Ramp, S. R., F. L. Bahr, C. J. Ashjian, and L. D. Talley, 2002: The upper-ocean circulation in the Ulleung Basin during June-July 1999. *Deep-Sea Res. II*, submitted.

2. Ramp, S. R., C. S. Chiu, F. L. Bahr, Y. Qi, P. Dahl, J.Miller, and R. Zhang, 2002: The Shelf-Edge Environment in the Central East China Sea and its Impact on Low Frequency Acoustic Propagation. *IEEE J. Ocean Engineering*, submitted.

3. Ramp, S. R., C. S. Chiu, J. F. Lynch, T. Duda, T. Tang, Y. Yang, N. R. Pettigrew. Moored Observations of internal solitons in the Northeastern South China Sea. Presented at: AGU Ocean Sciences Meeting, Honolulu, HW. 11-15 Feb., 2002.

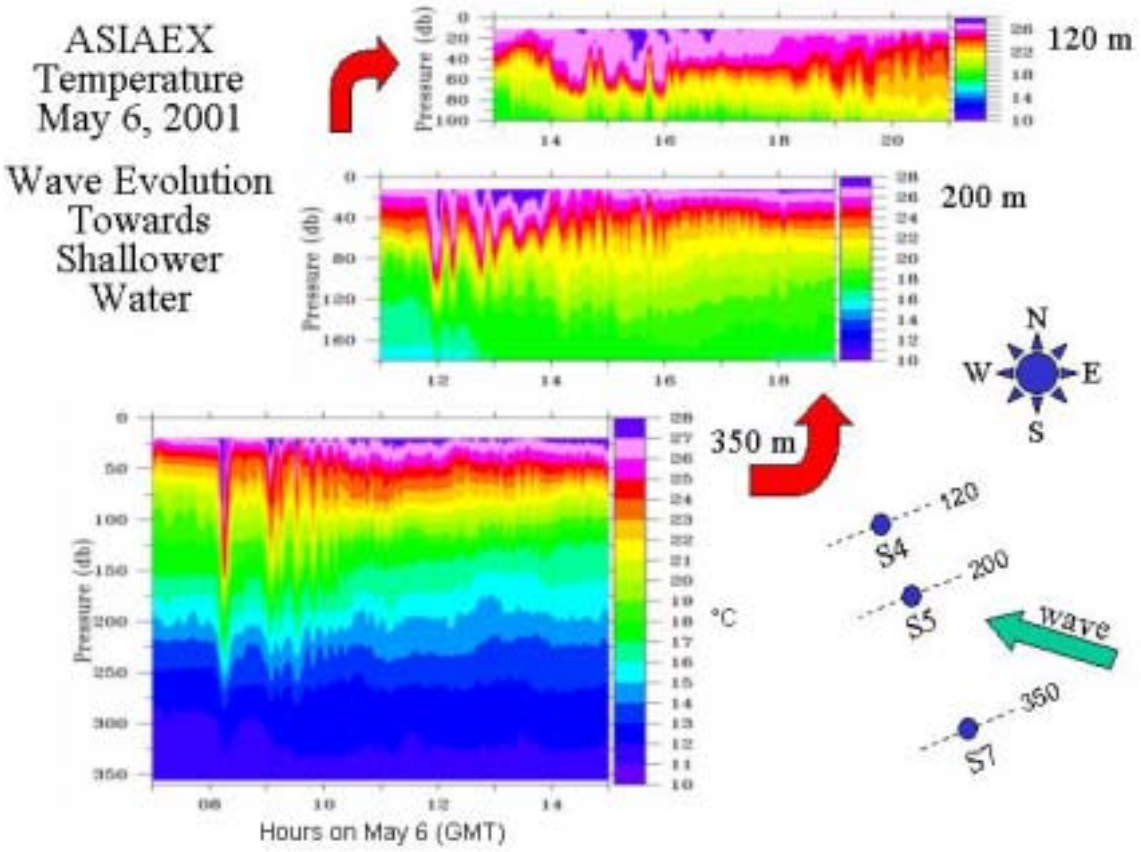

Figure 1. Evolution of an internal soliton running up onto the continental shelf from the ESE in the South China Sea. The bottom forces the large amplitude peaks to shoal and broaden, and spawns a new wave (the second one in the middle panel). Elevation waves grow out of the depressed thermocline at the 120 m depth.

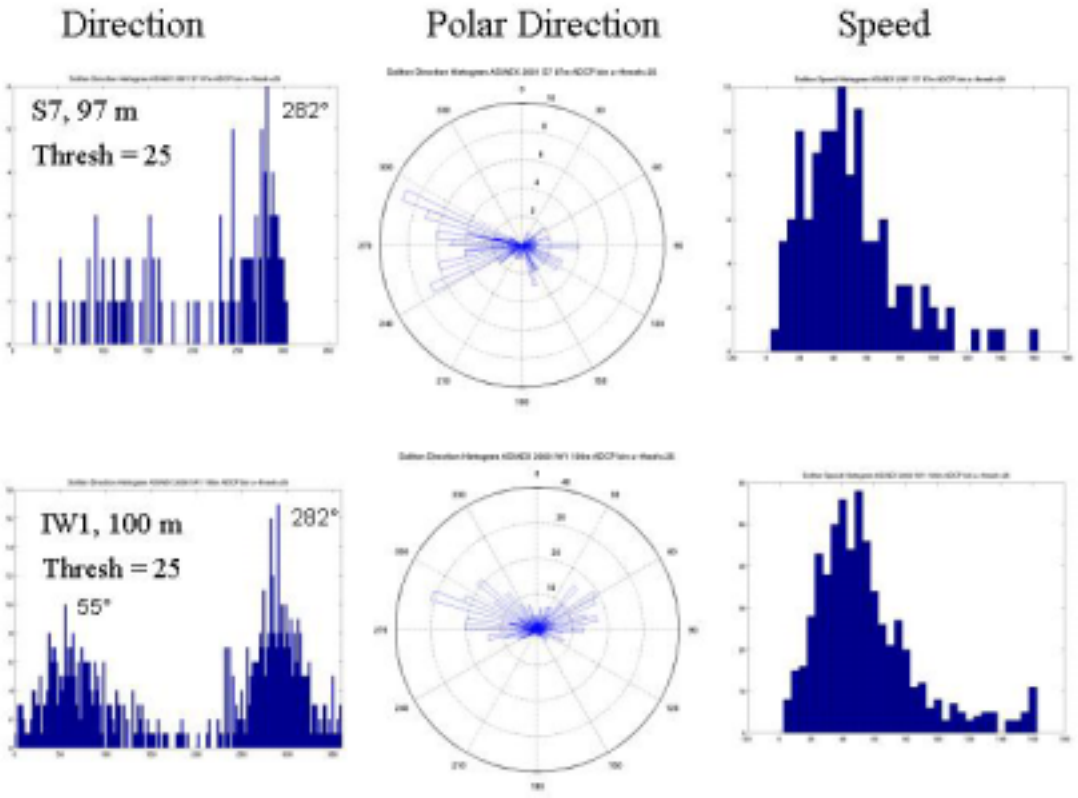

Figure 2. Speed and direction histograms for all the solitons observed at site S7 during spring 2001 and IW1 during spring 2000. All waves with orbital velocities greater than 25 cm s^{-1} are shown. The bimodal direction distribution indicates two sources, one near the Batane Islands in the Luzon Strait, and a second near Dongsha Island (Pratis Reef).