Announcing a Call for Proposals for a Departmental Research Initiative (DRI) to be supported by the Office of Naval Research (ONR), entitled

Non-Linear Internal Waves Initiative (NLIWI)

Beginning in Fiscal Year 2005

This announcement contains (1) the goal of this DRI, (2) the background and a general overview of the motivation behind this initiative, (3) more specific guidance concerning desired proposal scope, (4) the proposed project timeline and funding, (5) requirements for proposal submissions, and (6) links to additional information.

(1) Goal

ONR's Physical Oceanography (PO) program is interested in receiving individual or team proposals on the study of the generation, propagation and modal transformation of non-linear internal waves (NLIW). The goal of this Departmental Research Initiative is to achieve the basic science understanding that leads to a predictive capability that will be able to tell when and where non-linear internal waves will occur and what effects they will have on the hydrodynamic and acoustic environment. ONR-PO is particularly interested in observational studies that reveal a better understanding of the processes by which NLIWs undergo modal transformation. Additional areas of interest are the use of remotely sensed variables, together with models, that can reproduce and predict the generation and structure of these waves, their evolution during propagation, and the processes controlling dissipation. The program is interested in the use of remote sensing and modeling to create a predictive system for NLIWs.

(2) Overview

Introduction

Internal waves are a ubiquitous feature of the oceans. In the deep waters of the open ocean, internal waves interact only weakly with the oceanic environment. In the shallow waters of littoral zones, internal waves can reach amplitudes much greater than those found in the open ocean. These large amplitude waves are governed by nonlinear dynamics, and they interact strongly with their environment. This includes interactions with surface waves, rendering surface patterns of large-amplitude internal waves frequently observed in airborne and satellite imagery. Nonlinear internal waves (NLIWs) also have a profound influence on the acoustic properties of the water column. In many regions, NLIWs occur seasonally, with a regular frequency associated with the tides. They are perhaps the most significant naturally occurring perturbation to acoustic transmission in the littoral oceans. NLIWs are known to have a number of pronounced consequences with Naval relevance:

(1) Hydrodynamics: NLIWs produce large amplitude displacement and velocity fluctuations relative to the background environment.
(2) Low frequency acoustics: The temperature anomalies associated with NLIWs significantly modify the sound channel in littoral waters.
(3) High frequency acoustics: Turbulence generated by the passage of NLIWs results in thermal and salinity microstructure that scatters high frequency sound.

Background

Starting in the 1970s, important work on NLIWs was conducted in enclosed bays, inlets, and fjords. These studies demonstrated the outstanding features of NLIWs, including their ability to radiate long distances despite the marked levels of dissipation that occur in their wake. Synthetic Aperture Radar imagery has revealed the wide spread occurrence of NLIWs in littoral waters. Often, NLIWs are classified as either waves of elevation, in which deep water is displaced upward, or waves of depression, in which surface water is displaced downward. The hydrodynamic and acoustic properties of these waves differ, and the processes controlling whether NLIWs occur as waves of elevation or depression are ambiguous. A major milestone in our awareness of the influence of NLIW on acoustics occurred during ASIAEX in the late 1990s. Acoustic surveys revealed enormous NLIWs generated by tidal forcing at the Luzon Straits in the South China Sea. ASIAEX observations indicated that waves can evolve from one class to the other as they propagate into regions of varying depth. This implies an important role for “modal conversion,” a process by which waves evolve in spatial and energetic structure as they encounter changes in depth. Additionally, “wave-wave interactions,” occurring between the spectral components of a wave packet, also act to modify the overall structure and properties of the waves.

Theoretical methods and modeling approaches exist for examining these conversion processes. However, most frameworks rely on numerous assumptions and approximations. In particular, NLIWs are often modeled as “weakly nonlinear,” in that the wave solutions are sought by adding successive corrections to the linear physics. The reliability of these treatments has been challenged. While many approximations are justified during the initial development of a wave, they fail to characterize the wave at later phases of evolution. Assessments of the fully evolved state of NLIWs have relied on field observations. Unfortunately, observational information is generally limited to either a spatial snapshot, or temporal snapshot of an evolving system. Our incomplete understanding of the joint temporal/spatial evolution of NLIWs as they undergo modal conversion and wave-wave interactions severely limits our current predictive capability.

Predicting where and when NLIWs occur, and understanding their effects as they evolve, is a challenge that is closely coupled to questions surrounding the fundamental wave physics. Specific questions relevant to prediction include: What determines whether NLIWs radiate as waves of elevation or depression? Do the wave properties change in a predictable way during modal conversion and wave-wave interactions? Over what distance will the waves impact the acoustic field? For waves generated along topography, what are the important topographic height and length scales? What modal interactions favor waves of elevation versus waves of depression? What aspect of wave-wave interactions determine the life span of the waves? What is their relation to internal tides?

Expected Scope

The goal of the Non Linear Internal Waves DRI is to address these fundamental physical questions. ONR seeks to construct an integrated study involving observational, theoretical, and modeling approaches as needed. The following areas are of interest: have been identified as part of this DRI:

- **Generating a holistic view of non-linear internal waves from generation to decay along the wave path.**
- **The holistic view includes the variability of acoustic transmission in the regions affected by the non-linear internal waves**
- **Theories to explain the processes that govern generation, modal conversion, and dissipation**
- **Field experiments to test those theories and help generate and support the holistic view.**
- **Theories to link the detailed (internal structure) of the waves to the surface signature.**
- **Models and theories to predict the occurrence of NLIWs**
- **Identification of data needed to support a prediction system for NLIWs**

Summary

(3) Proposal Scope

The NLIWI DRI will be primarily managed by the Physical Oceanography (322PO) program at ONR with significant collaborations with the Ocean Acoustics (321OA) program. In order to leverage resources, ONR has identified two geographic regions of interest, the New Jersey shelf and the. Western Pacific margin-Luzon Strait and west of the Luzon Straits.

New Jersey Shelf Opportunity: In the period between May and October, this region is a prodigious source of NLIWs, which radiate shoreward from the shelf break where they are generated by tides. The extensive and flat continental shelf in this region is. provides a prime field opportunity for monitoring wave-wave interaction processes, as the waves will be undergo minimal modal conversion, although modal conversion has also been observed (Orr, 2004). The 321 OA team is currently planning for the next cycle of the shallow water acoustics program. This cycle is planned for the period of FY05-FY07, with FY06 planned as an intensive field period. The is a call for planning letters to the OA program calls for or a shallow water acoustics study focused on a domestic based field site along the Mid-Atlantic Bight off New Jersey.
http://www.onr.navy.mil/sci_tech/ocean/321_sensing/pl_oa_05.asp

Acoustic resources in shallow water would be ideally located to capture the late-term evolved state of waves. This is one opportunity to leverage resources for field-work, understand the interaction of NLIWs with acoustic transmission, and to work in a region where there is a degree of historical knowledge about the generation and general propagation characteristics.
ftp://acoustics.whoi.edu/users/jlynch/SW2006/SW2006Workshop.zip

Proposals to the NLIWI DRI might utilize this region and framework to address questions related to the wave-wave interaction, the predictability, and the dissipation of NLIW's. We also suggest that this field site is an excellent candidate region to utilize new technology to address these scientific questions. After years of investment by ONR, the community has mature observational technology, such as acoustic backscatter systems, profiling systems (for in-situ sampling) and autonomous platforms for detailed surveys; these components are expected in this type of field study. We also encourage the use of newer platforms and devices (such as gliders and other networks of platforms) to give both temporal and spatial information on the evolving wave field and its affects on acoustic transmission.

The Western Pacific Margin –Luzon Straits and west of Luzon Straits Opportunity: The goal of this field experiment would be to capitalize on the initial knowledge of the ASIAEX program (http://www.oal.whoi.edu/ASIAEX01/), and provide complimentary process physics information to the existing acoustic understanding of the region. In FY05, there is a cooperative ONR field study to characterize the seasonal NLIW climate In this region. We anticipate a more comprehensive field study in FY07 in this region. There are good opportunities to study the evolution of NLIWs as they radiate over the varying bathymetry of the Luzon Straight. Modal conversion and wave-wave interactions are both active in this region, providing a good opportunity to observe both processes at one site. The research challenge is the separation of their relative contributions as they occur simultaneously and operate in an area where strong currents and high amplitude NLIW's have been observed. The Ocean Acoustics program plans to co-locate a small study in this region in FY07.

The DRI Composition

It is anticipated that awards will be made to individual PI efforts and small teams of investigators rather than one or two large multiple-investigator, comprehensive proposals. Proposals that indicate potential links and synthesis with other complementary proposals are encouraged. Proposals that anticipate leveraging

against additional resources or experiments are encouraged, but should be as specific as possible concerning the nature of the observations or work that would be utilized, including references to the leveraged efforts if available.

Field investigators should propose to one site (NJ) or (Westpac-Luzon Strait). A limited amount of supplementary work can be considered for the FY05 pilot. Investigators should indicate the connectivity between the remote sensing and modeling and/ or indicate their connectivity to data, field observations, and modeling/theoretical studies.

(4) Project Timeline

A general proposed timeline, subject to change by the consensus of project participants once funding decisions have been made, is as follows:

FY05	FY06	FY07	FY08	FY09
Spring field experiment in The Luzon Strait area; Meeting and planning other experiments	Field experiment in NJ; theoretical work; model diagnostic work; remote sensing	Second WESTPAC field experiment; data analysis; model, theory	Data analysis; modeling; continuing work on remote sensing-model	Continued data analysis; synthesis and publication of results

Available funds will not be divided evenly among years, with higher levels of funding expected during field years. Participants must recognize the need for flexibility when developing research plans and operating budgets, and are requested to consider the overall budget limitations considering that researchers from many different fields are necessary to achieve the objectives of this DRI.

(5) Specific Proposal Requirements

There will not be a call for planning letters for this initiative. Some planning letters submitted to the core Physical Oceanography program have been asked to prepare proposals for the NLIWI effort, but were not given any additional guidance outside of that presented in this document. It is anticipated that many related core efforts will be asked to join efforts with this DRI.

Full proposals are due no later that **July 15, 2004**. Proposals should be submitted through ONR's Hopper system via the following link: http://onroutside.onr.navy.mil/aspprocessor/prop322/

Format
Proposals must adhere to ONR standards (http://www.onr.navy.mil/02/how_to.asp)

Content
Proposals should include: Introduction and Background (be brief and relevant), Objectives, Technical Approach, Linkages and Collaborations, References, PI Qualifications, Full Budget (do not send separate budget files), Budget Justification, Cover Page, Certifications. PI's that are new to ONR or are just entering the field are encouraged to send copies of some relevant publications and a full curriculum vitae, separately.

Questions may be addressed to
322_PO@onr.navy.mil

If you are having trouble reaching us by email, please call (703) 588-2578 or (703) 696-7237 and explain that you are trying to reach a program officer and that your email access is being blocked. We apologize for this temporary inconvenience.

(6) Links to additional information

Williamsburg Workshop
NLIWI Workshop (this web site)
Ocean Acoustics Call For Planning Letters (See text above)
ASIAEX Home Page (See text above)