

# **International Workshops On Shallow-Water Acoustics**

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## **LONG-TERM GOAL**

The long-term goal is to formulate and conduct a collaborative international experiment in the seas of China. Such an experiment will focus on studying the physics and variability of sound propagation and scattering that are unique to the coastal waters of the Asian Pacific region.

## **OBJECTIVES**

The FY98 objectives were:

1. To identify the outstanding research topics in shallow-water acoustics which are of common interest to all participating countries and which might form the basis for a collaborative US-Asia experiment in the seas of China.
2. To assess the scientific approaches and logistic issues for such an experiment.
3. To assess the available technology to support the field effort.
4. To identify potential sites for the experimental program and investigate the environmental conditions.
5. To recommend a plan of action that will lead to a comprehensive international experiment in 2000.

## **APPROACH**

The approach was to hold a series of international workshops, inviting top-notch underwater acousticians and acoustical oceanographers from seven different countries including China, Japan, Korea, Singapore, Taiwan, Russia and the USA, to jointly investigate the scientific, engineering and logistic rationales that might form the basis for a comprehensive shallow-water acoustic experiment, develop common or complimentary experimental objectives, identify international resources, and formulate a plan for the coordination and execution of the experiment.

## **WORK COMPLETED**

Two International Workshops were organized. The Phase I Workshop was held in San Francisco on December 8-9, 1997. The Phase II Workshop was held in Seattle on June 27, 1998. Two technical reports were generated and distributed to the participants. The reports summarize the presentations, discussions and findings of both the Phase I and Phase II Workshops, respectively.

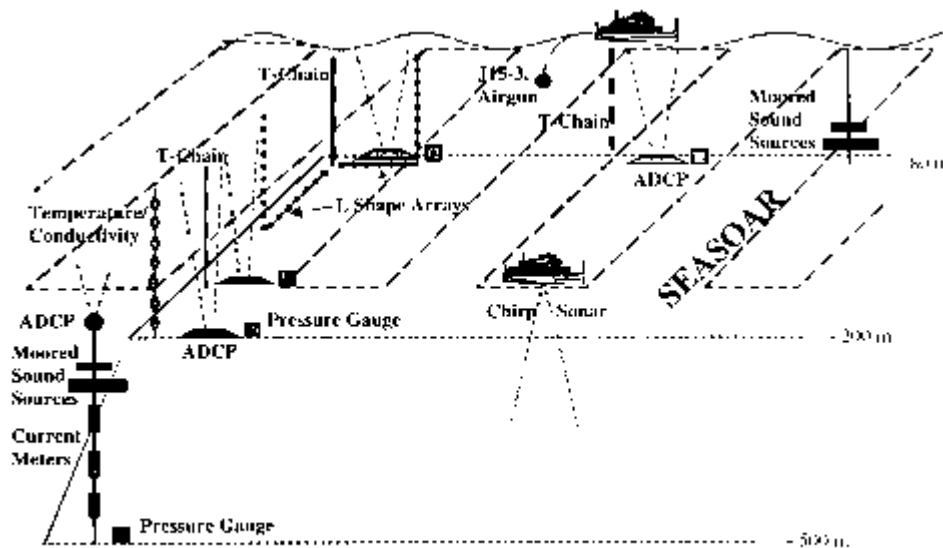
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## RESULTS

The Phase I Workshop featured a series of short presentations by the representatives of the different countries on their research interests, and what resources they might be able to contribute to a collaborative experiment if it were to take place in 2000. A group discussion on potential sites, research vessels, surveying and moored equipment, and scientific issues was also carried out. The Phase I workshop shows that acoustics clearly unifies many diverse interests of ocean scientists; geological, physical, biological and chemical. Each of these has distinct roles in the propagation of sound energy in the ocean, and inversely acoustical techniques provide powerful means for understanding properties and processes in each of these areas of ocean science. Bottom interaction acoustics is one of the many good examples: Acoustical techniques are the only efficient means of exploring the composition and structure of the sea floor over any sizable area. Inversely the interaction of acoustic energy with the bottom is one of the most significant factors in determining the acoustic wavefield in shallow water. Bottom scattering and reverberation and sub-bottom inversion techniques were identified as principal interest by several of the participants. While a site for the experiment was not selected at the Phase I workshop, several locations were proposed and discussed. The amount of equipment available to the participants was formidable. It was clear that a very well designed experiment could be mounted, an experiment which would provide a wide range of observations on space and time scales that would be difficult for any individual country to achieve. The discussion of a collaborative international experiment was continued in the Phase II Workshop. The Phase II Workshop resulted in the establishment of a comprehensive list of experimental objectives and a preliminary experimental configuration. The objectives include:

1. Understand sound propagation along and across multiple fronts.
2. Investigate the scattering effects of the linear and non-linear internal waves.
3. Examine the acoustic effects of a strong fresh-water plume.
4. Investigate the forward scattering properties of bottom inhomogeneities.
5. Understand the geological and acoustical signature of stratigraphy produced by river sedimentation.
6. Investigate directional reverberation in an inhomogeneous medium (ocean and bottom).
7. Investigate properties of the coastal ambient noise field.
8. Investigate higher frequency coastal acoustics ( $f > 1000$  Hz).
9. Investigate horizontal array coherence, as well as vertical and temporal coherence.
10. Can we learn to model and predict these effects?

The schematic of the preliminary design is shown in Figure 1. It is important to note that this preliminary design was developed based only on resources that can be made available by the Naval Postgraduate School, Woods Hole Oceanographic Institution and Naval Research Laboratories. Thus, the inclusion of the international assets as well as assets from the other US institutions will greatly enhance the present experimental objectives and design, making it the most comprehensive shallow-



*Figure 1. A preliminary sampling plan for the US-Asia Coupled Shallow-Water Acoustic and Oceanography Field Experiment.*

water acoustic experiment in present days. The Phase II Workshop also focused on site selection issues, narrowing the many previously discussed site options to only two choices. Based on scientific merits, the group's number one choice was the northern shelf of the South China Sea, with the shelf of the East China Sea selected as an alternate site. A plan of action was generated, calling for:

1. an international experiment to be carried out in April 2000,
2. our Chinese colleagues to apply to the appropriate Chinese authority for permission to conduct a collaborative scientific experiment in the South China Sea location,
3. each participating institution to provide a written summary of their research interest and resource commitment for the international experiment to the workshop organizers,
4. the Phase III workshop to be held in the near future to further coordinate the experimental effort.

## IMPACT/APPLICATIONS

The San Francisco and Seattle International Workshops on Shallow-Water Acoustics will lead to a collaborative international experiment in the seas of China. Such an experiment will allow for the measurement of a comprehensive data set to study the physics and variability of sound propagation and scattering in the Asian Pacific shallow waters.

## RELATED PROJECTS

These FY98 International Workshops continue the efforts that was initiated at the 1995 ONR USA-China Conference in Shallow-Water Acoustics (Chiu and Denner, 1997) and the 1997 International Conference in Shallow-Water Acoustics (Zhang and Zhou, 1997). They represent the important steps toward the formulation of a large-scale international experiment in the Seas of China.

## **REFERENCES**

Chiu, C.-S. and W. W. Denner, ``Report of the Office of Naval Research USA-China Conference on Shallow-Water Acoustics, December 19-21, 1995," NPS Technical Report NPS-OC-97-001, January 1997.

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## **PUBLICATIONS**

Chiu, C.-S. and W. W. Denner, ``Report on the Office of Naval Research International Workshop on

Shallow-Water Acoustics, San Francisco, CA, 8-9 December 1997," NPS Technical Report NPS-OC-98-002, March 1998.

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