



OCEAN OBSERVATION AND SOUND IN THE MARINE ENVIRONMENT:

Toward an International Quiet Ocean Experiment

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ALFRED P. SLOAN FOUNDATION



Ideas about an International Quiet Ocean Experiment

Jesse Ausubel (SLOAN Foundation)

March 2010

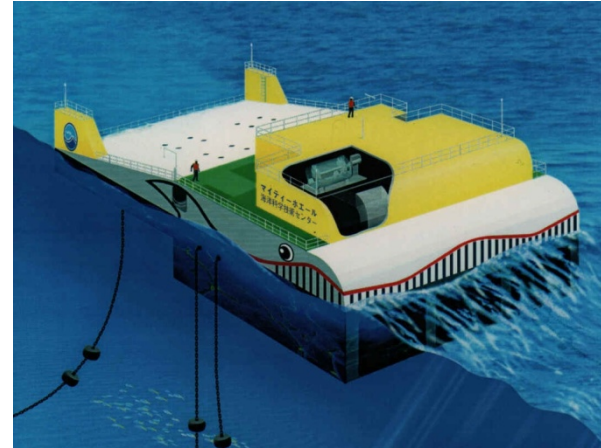
Ocean Crowding

More uses, more users



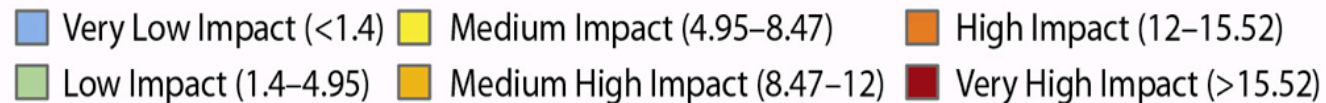
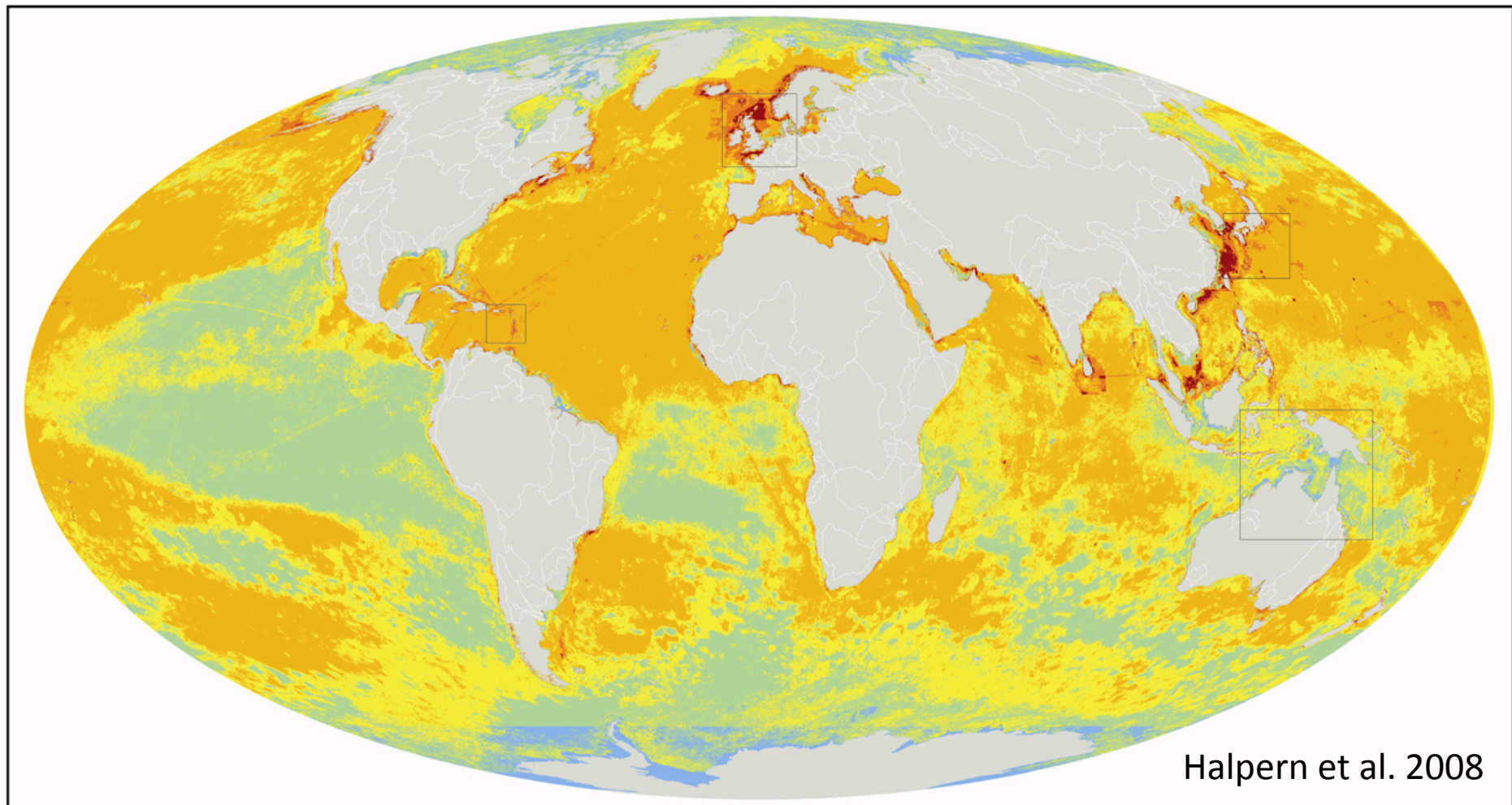
Drilling derricks

Wave energy machine (concept)

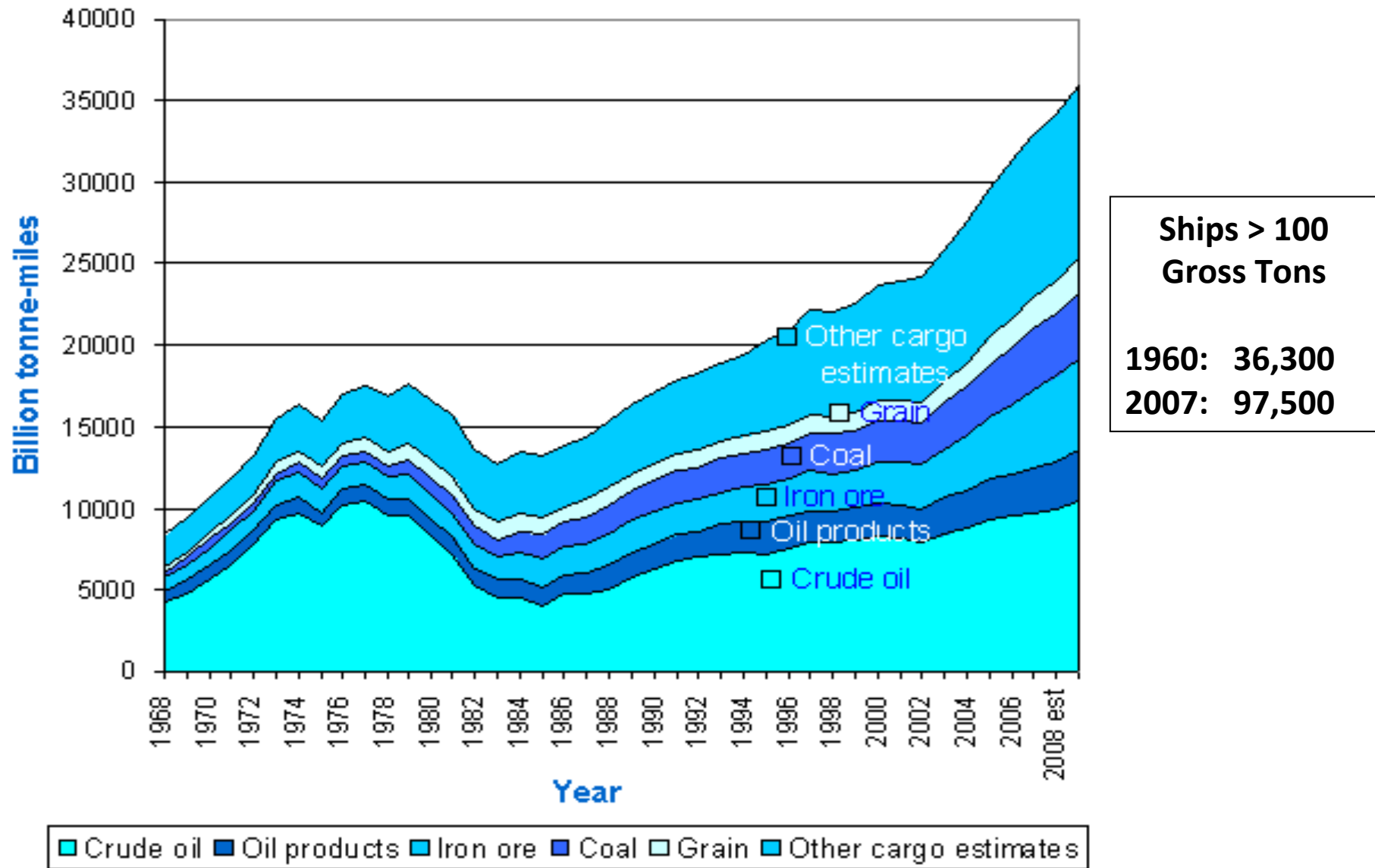


Collective impact of all uses:

Majority of surface oceans now experience high impact from mix of coastal & maritime activities



Crowding: Growth in Maritime Transport



Source: <http://www.marisec.org/shippingfacts/worldtrade/volume-world-trade-sea.php>



International Quiet Ocean Idea



- Oct 2010: Rhode Island (SCOR, SLOAN, POGO)
- What do we know about underwater noise?
Ambient & anthropogenic.
- What do we know about impacts on fauna?
- How do we study the effects?
- We study the addition of a little bit of extra noise to an already noisy environment, or an already noise-impacted animal.



International Quiet Ocean Idea



- Could we treat the subject with silence rather than noise?
- How? Where? What sources? For how long?
- Feasible on a large scale?
- Small scale? Where are the opportunities?

New initiative

REGULAR ISSUE FEATURE

An International Quiet Ocean Experiment

BY IAN BOYD, GEORGE FRISK, ED URBAN, PETER TYACK, JESSE AUSUBEL, SOPHIE SEEYAVE, DOUG CATO, BRANDON SOUTHWALL, MICHAEL WEISE, REX ANDREW, TOMONARI AKAMATSU, RENÉ DEKELING, CHRISTINE ERBE, DAVID FARMER, ROGERGENTRY, TOM GROSS, ANTHONY HAWKINS, FENGHUA LI, KATHY METCALF, JAMES H. MILLER, DAVID MORETTI, CRISTIAN RODRIGO, AND TOMIO SHINKE¹

ABSTRACT. The effect of noise on marine life is one of the big unknowns of current marine science. Considerable evidence exists that the human contribution to ocean noise has increased during the past few decades: human noise has become the dominant component of marine noise in some regions and noise is directly correlated with the increasing industrialization of the ocean. Sound is an important factor in the lives of many marine organisms, and theory and increasing observations suggest that human noise could be approaching levels at which negative effects on marine life may be occurring. Certain species already show symptoms of the effects of sound. Although some of these effects are acute and rare, chronic sublethal effects may be more prevalent, but are difficult to measure. We need to identify the thresholds of such effects for different species and be in a position to predict how increasing anthropogenic sound will enhance the effects. To achieve such predictive capabilities, the Scientific Committee on Oceanic Research (SCOR) and the Partnership for Observation of the Global Oceans (POGO) are developing an International Quiet Ocean Experiment (IQOE), with the objective of coordinating the international research community to both quantify the ocean soundscape and examine the functional relationship between sound and the viability of key marine organisms. SCOR and POGO will convene an open science meeting to gather community input on the important research, observations, and modeling activities that should be included in IQOE.

INTRODUCTION

Does the noise made by humans harm marine life? At present, we can offer only preliminary answers to this important question, for only a few species. We

know that the ocean has become more industrialized and that the noise levels associated with human activities have increased (NRC, 2003). For example, in areas where measurements have been

made, anthropogenic noise in the ocean has been increasing across much of the frequency spectrum (Andrew et al., 2002; McDonald et al., 2008), and especially at lower frequencies (< 500 Hz; Frisk, 2007). Increases in noise from human activities add to the many natural sources of sound in the ocean, such as waves breaking, rain, and ice movement, and the sounds of the marine animals themselves (Figure 1). Given the spatial and temporal complexity and variability in all sound sources, the relative contribution of anthropogenic noise is not always readily distinguishable.

The combined effects of temperature and pressure in the deep ocean create a sound channel by which acoustic waves can be transmitted over large distances, sometimes hundreds of kilometers, and often much further. The complex pathways taken by this sound affect the final received levels, but if they are averaged through time at the receiver, they provide an integrated signal defined by the relative locations of all the sound

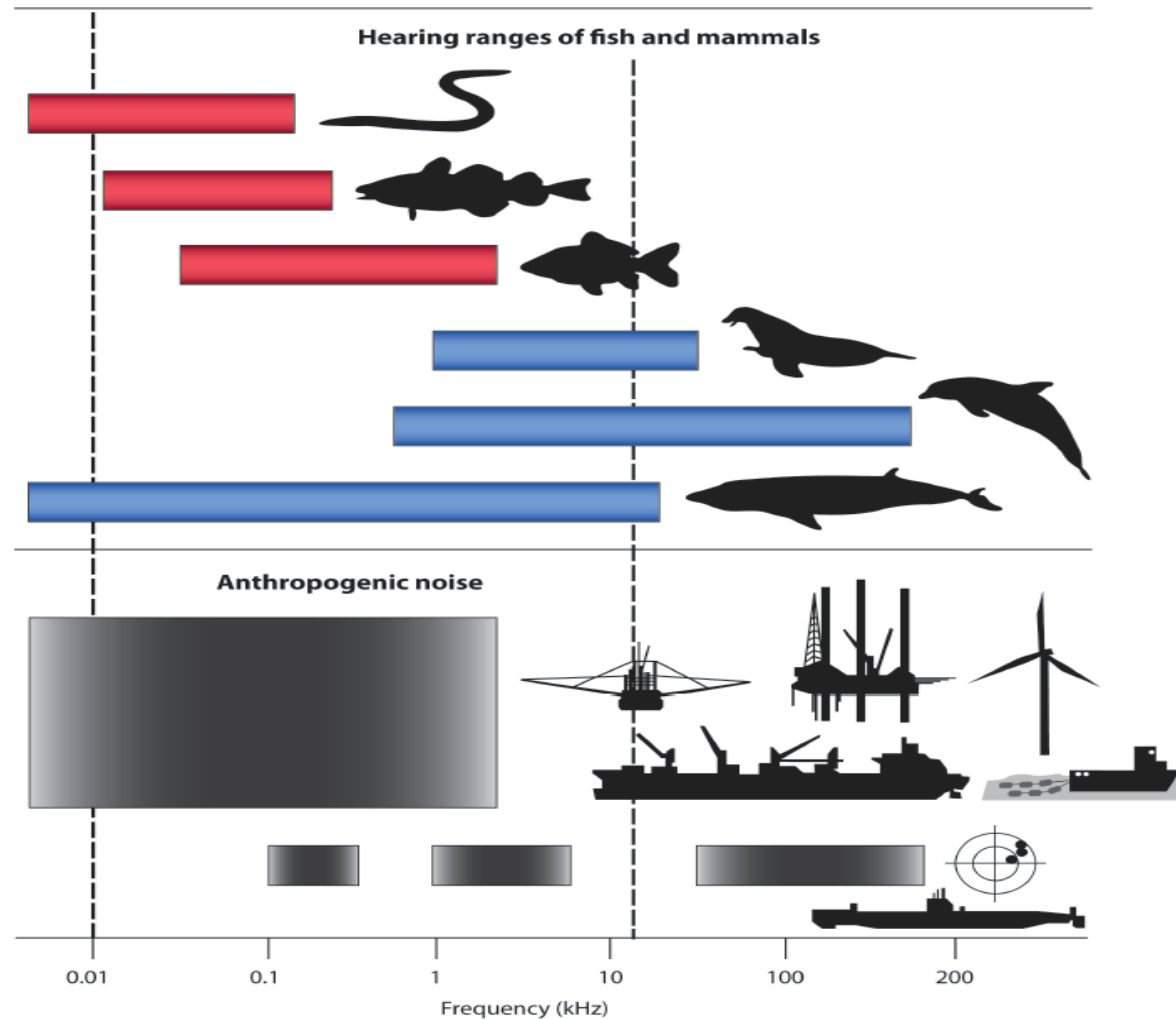
¹The authors of this article were the attendees at a meeting, held at the University of Rhode Island from October 27–29, 2010, to discuss the feasibility of conducting an experiment to examine the effects of sound on life in the ocean.



The problem: Industrialization of oceans keeps adding sound



Human additions of sound overlap full range of animal uses of sound in the ocean

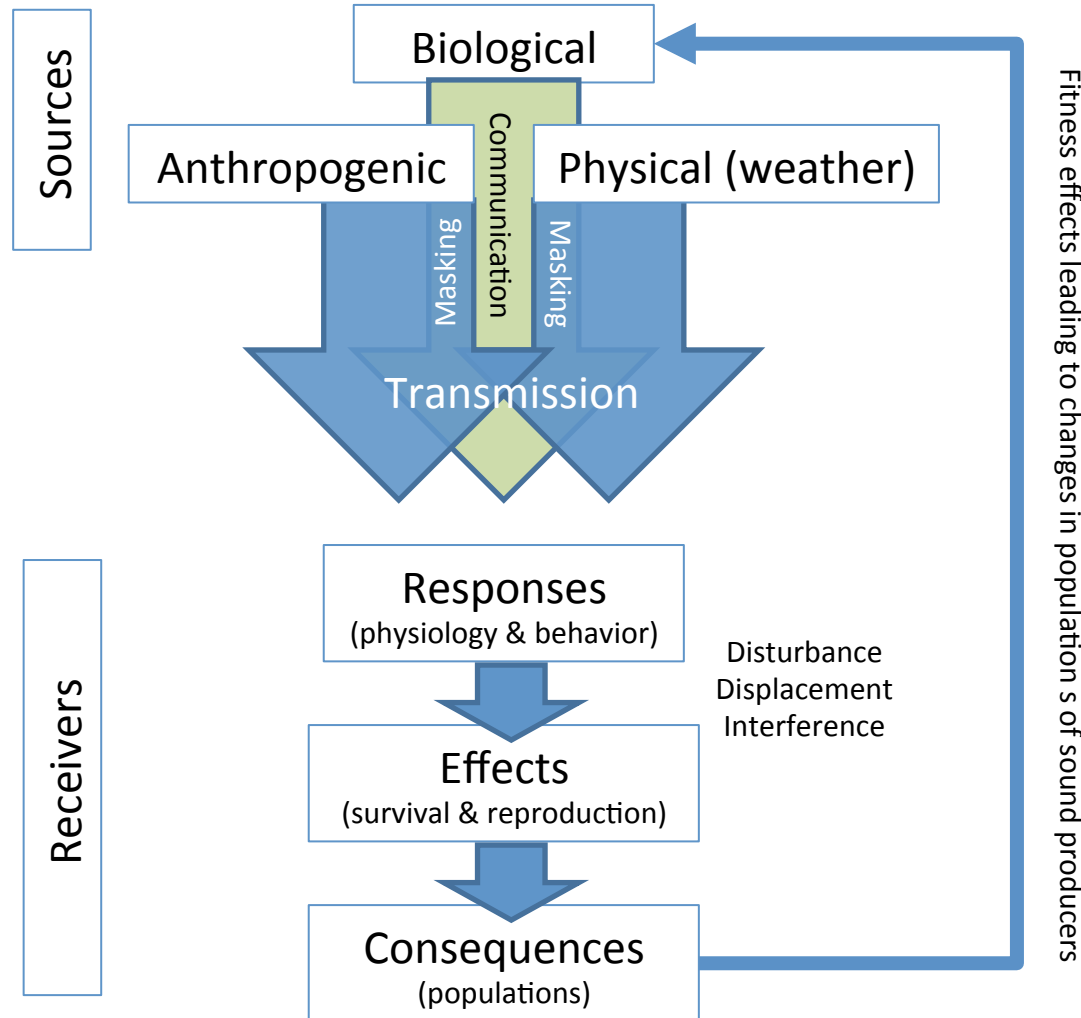




A model of the problem



Population
Consequences of
Acoustic
Disturbance





State of knowledge & policy



- Some evidence of increasing anthropogenic sound levels (worst cases are bad);
- Some evidence of biological effects;
- High uncertainty in current knowledge, future trends and significance of effects – worst cases have serious implications for the ocean;
- High uncertainty combined with potentially serious consequences lead to a precautionary view taken within legislation.





Goals



- To ensure that measurement of sound is an integrated part of global ocean observation
- A community-based approach to research that includes industries and other stakeholders
- Mitigation that minimises economic impact & leads to innovation improving economic performance

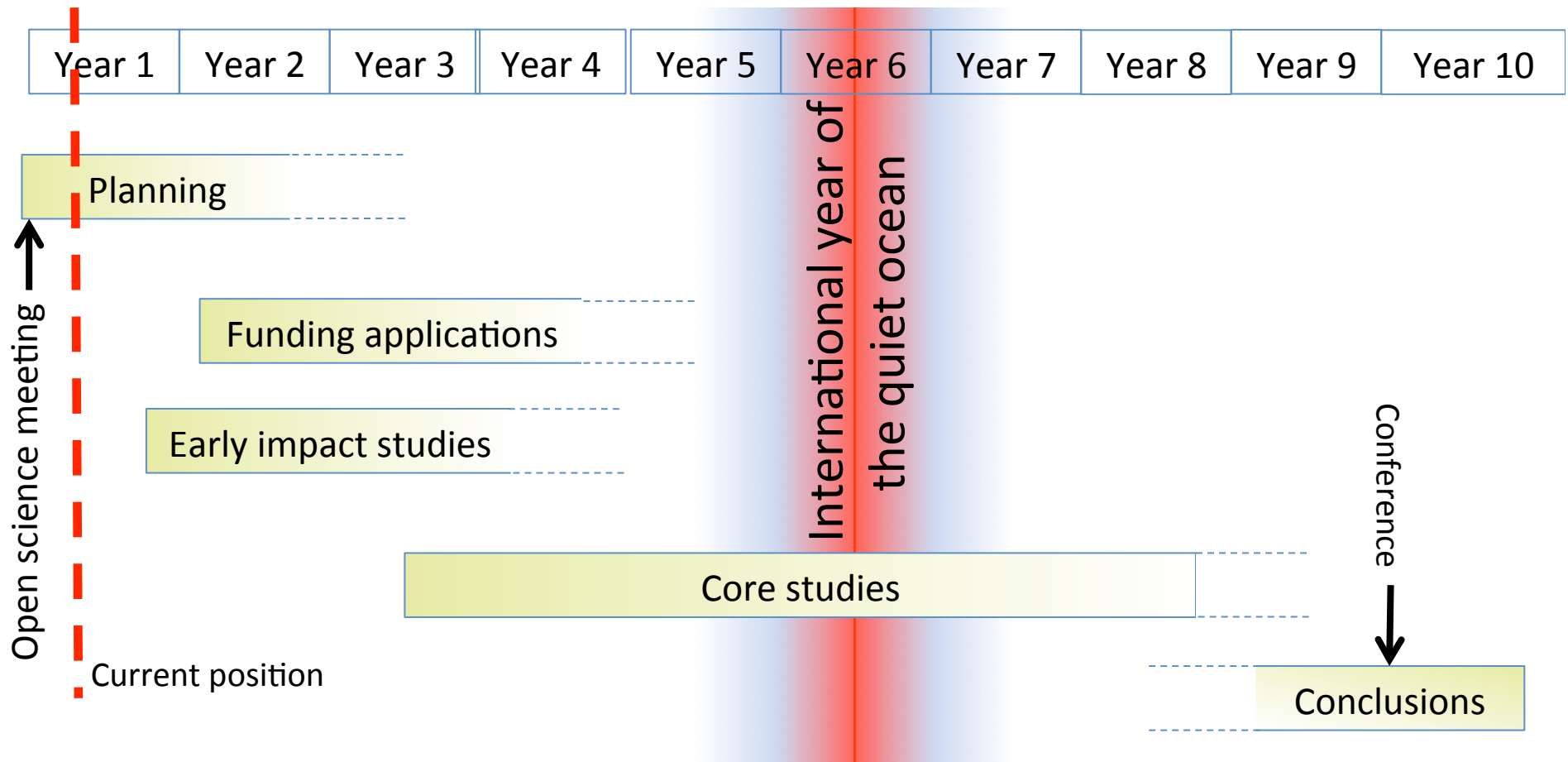




International Quiet Ocean Experiment



IQOE Time Line





International Quiet Ocean Experiment



Emerging questions

- Levels and distribution of anthropogenic sound in the ocean
What is current state?
- Trends in anthropogenic sound levels across the global ocean
How is state changing?
- Effect of anthropogenic sound on viability of important marine animal populations
What are consequences?
- Global ocean soundscape before humans industrialized
How does the present differ from past?
- Future effect of sound on marine life
Should we be concerned?



International Quiet Ocean Experiment



Emerging work streams

- Trends in anthropogenic sound
- Ocean observing systems (physical and biological)
- Data management and standards (DMAC)
- Acoustic and biological modelling of soundscapes
- Regional experiments
- Economic consequences
- Engagement with industries (WOC)
- Public engagement (e.g. citizen science website)



International Quiet Ocean Experiment



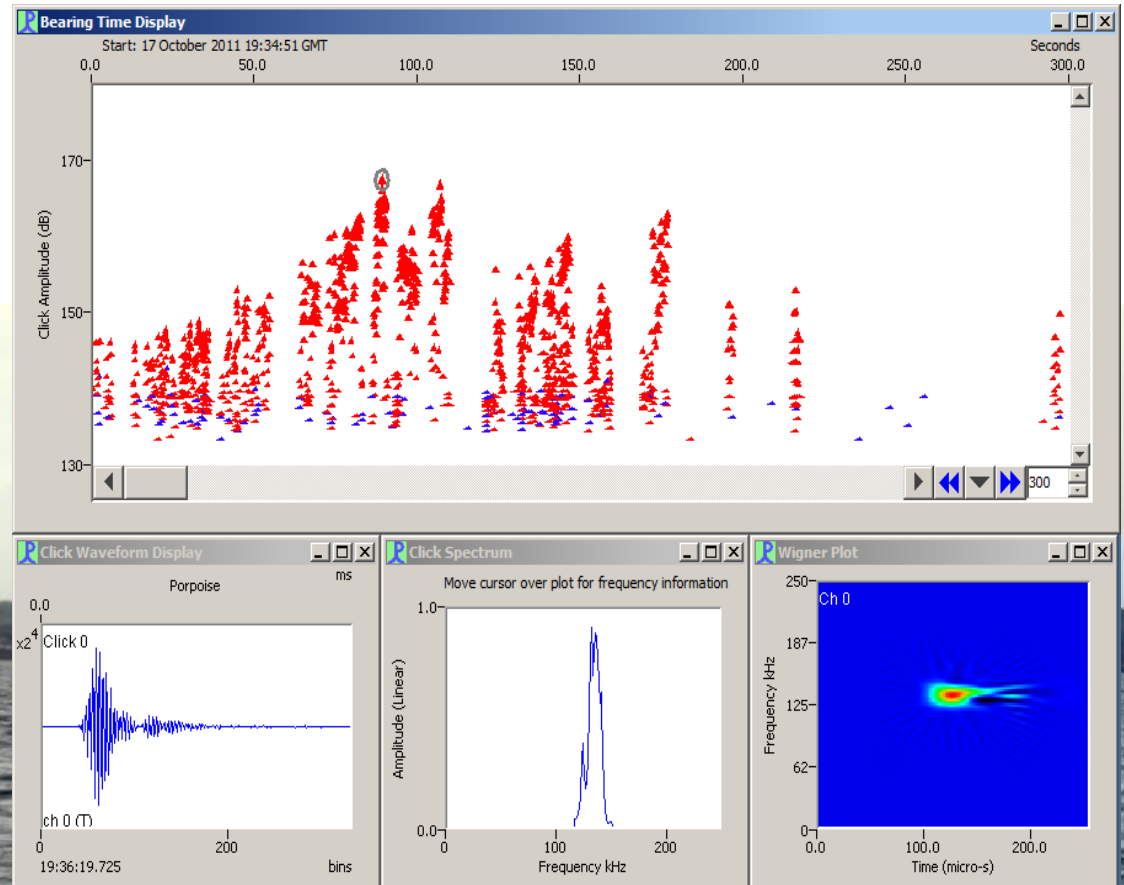
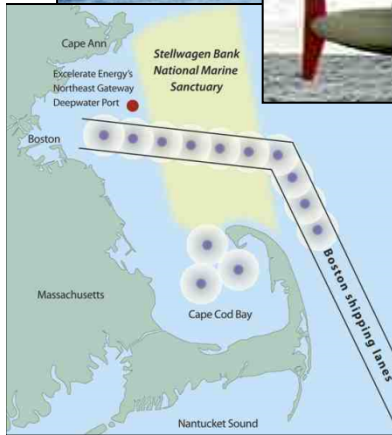
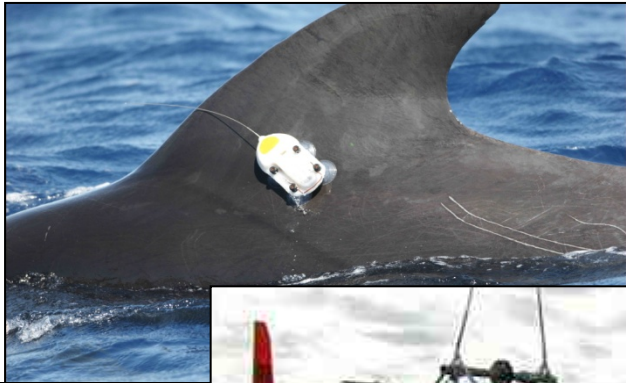
Science plan (Table of Contents)

- Executive Summary
- Introduction and overview
- Theme 1: Ocean Soundscapes
- Theme 2: Defining the effects of sound on marine organisms
- Theme 3: Observing sound in the ocean
- Theme 4: Industry and regulation
- Implementation

To be published on <http://AquaticAcousticArchive.com> by April 2012; or email C.Erbe@curtin.edu.au

New observing systems

- Cabled observatories (Neptune, Venus)
- Moored or drifting surface buoys
- Gliders & animal-borne
- Ad-hoc subsurface moorings/loggers



Data delivery and management (<http://listentothedeep.com/>)

Lido
CENTRE FOR THE DEEP OCEAN ENVIRONMENT

LISTENING TO THE DEEP OCEAN ENVIRONMENT

Listen on Site

Presentation

Partners

Bioacoustics

Listen on Site

Sound Library

Statistical Analysis

Making Sense of Sounds

Contact

Observatories

Loading locations
Loading data
locations
Locations data
loaded :

Europe

- East Sicily
- Iberian margin
- Norwegian Margin
- Black Sea
- Porcupine
- Azores
- Nordic Sea
- West-Mediterranean Sea
- Ligurian Sea
- Eastern Mediterranean

North America

- Folger Passage
- Barkley Canyon
- Barkley Slope

Asia

- Kushiro OBS 1
- Kushiro OBS 2
- Kushiro OBS 3
- Hatsushima

playing
low
quality

Welcome to the Salish Sea hydrophone network

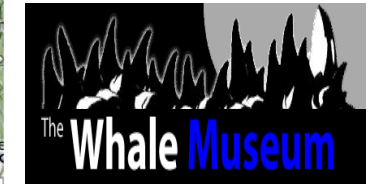
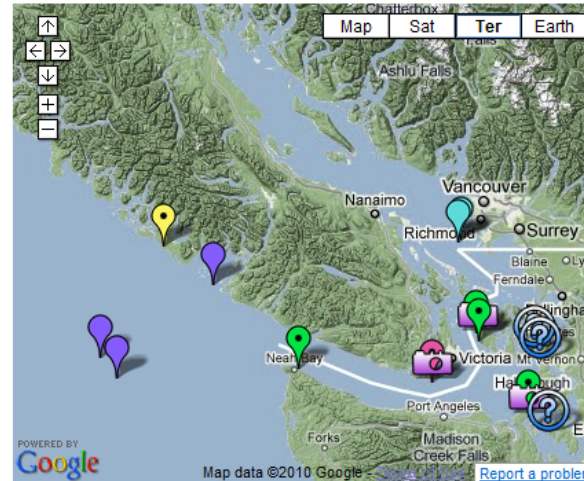
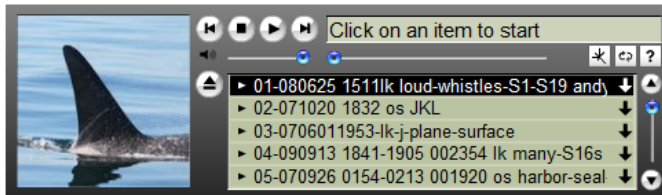
<http://orcasound.net/>

A growing coalition of scientists, educators, and citizens are working together to expand a regional hydrophone network in the Salish Sea. This site is part of the [SeaSound Project of The Whale Museum](#) and is an experiment in sharing real-time underwater sound. The goals are to monitor the critical habitat of endangered southern resident killer whales to detect orca sounds and measure ambient noise levels.

Listen live via the links in the table or in the pop-up description you get by clicking the green markers on the map. For some hydrophones you can also watch live video from nearby (by clicking on the camera icons). The other icons show other hydrophones in the region that have not yet been networked.

2010 listening challenge: Help notify researchers when orcas are in the Salish Sea. If you hear killer whales please [email detection@orcasound.net](mailto:detection@orcasound.net) or [log your observations](#) in a collaborative Google spreadsheet. Use the [Salish Sea sound tutor](#) to learn to tell which pod is present based on the calls they use most often. Use [web cams and other real-time sensors around the Salish Sea](#) to figure out what else you might be hearing.

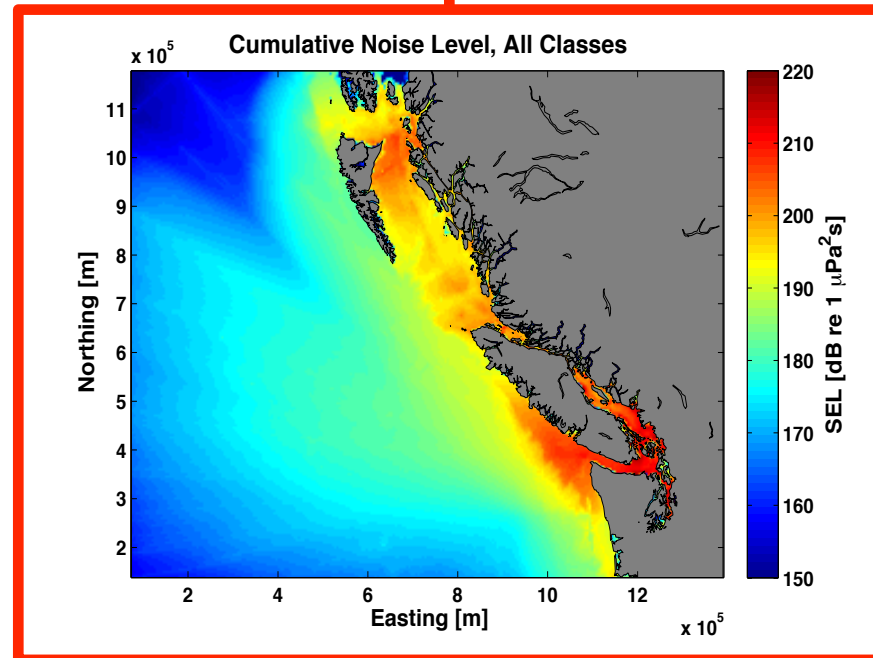
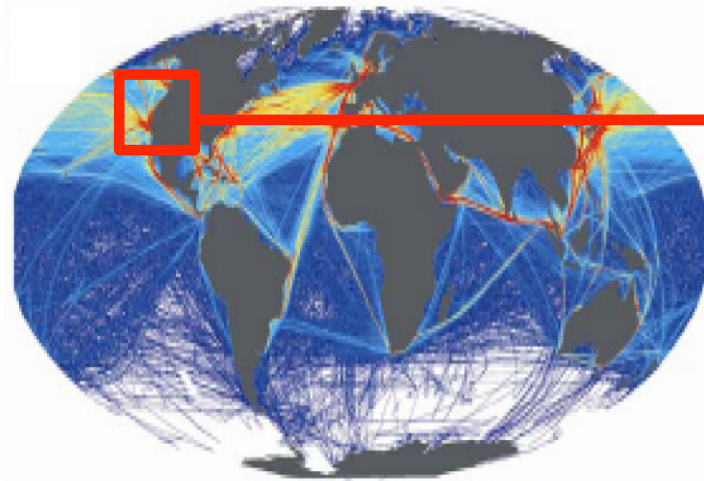
If you don't hear anything interesting live, you can hear archived sounds in the "greatest hits" player below, or via the sound archive links in the table.



Click on the links in this column to listen to underwater sound from each location. (If the link doesn't work, see the listening guidance below.)	Follow links in this column to explore archived sounds and details about the hydrophone location.
<p>Listen to OrcaSound on San Juan Island</p> <p>Watch live video from ~300m south of the OrcaSound hydrophone (offline July 09) (courtesy of the Center for Whale Research)</p>	<ul style="list-style-type: none"> • Site description and sound archives • History and research results
<p>Listen to Lime Kiln State Park on San Juan Island</p>	<ul style="list-style-type: none"> • Site description and sound archives
<p>Listen to Port Townsend Marine Science Center</p> <p>Watch live video from the Port Townsend Towercam (located a few km to the south of the hydrophone; KX-HCM280A Panasonic Network Camera with West-East presets: 8 = Keystone; 3 = Point Hudson; 5 = Marrowstone Point)</p>	<ul style="list-style-type: none"> • Site description and sound archive • Port Townsend Marine Science Center • Port Townsend Ferry Camera • Port Townsend - Keystone Ferry Locator
<p>Listen to the Seattle Aquarium</p>	<ul style="list-style-type: none"> • Site description and sound archive • Seattle Aquarium • Real-time ferry locations



Outcome example: World Map of Anthropogenic Ocean Sound





Citizen Science

- Build cheap miniature acoustic recorders
- That can be controlled with a mobile phone
- Write app for sound logging & analysis (automatic detection & classification)
- Let users upload *.wav & photos (incl. GPS) to AquaticAcousticArchive.com
- Involve public in analysing data



International Quiet Ocean Experiment



Achievements so far

- Initial planning workshop, Rhode Island (Oct 2010)
- Steering Group, Fort Lauderdale (Feb 2011)
- Publication of Oceanography article (May 2011)
- Creation of A3 web site (C.Erbe 2011)
- Open Science Meeting, Paris (Aug 2011)
- 1st draft Science Plan (Dec 2011)



International Quiet Ocean Experiment



Planning phase activities

Year 1 Q1	Year 1 Q2	Year 1 Q3	Year 1 Q4	Year 2 Q1	Year 2 Q2	Year 2 Q3	Year 2 Q4
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Science plan review

↑ Application submission to Sloan Foundation

Planning committee active

↑ Data management and standards workshop

Communications plan and web site

International outreach and liaison

↑ Soundscapes workshop

↑ Experimental planning workshop

↑ Trends workshop

Funding proposal submissions

IQOE executive established and functional



International Quiet Ocean Experiment



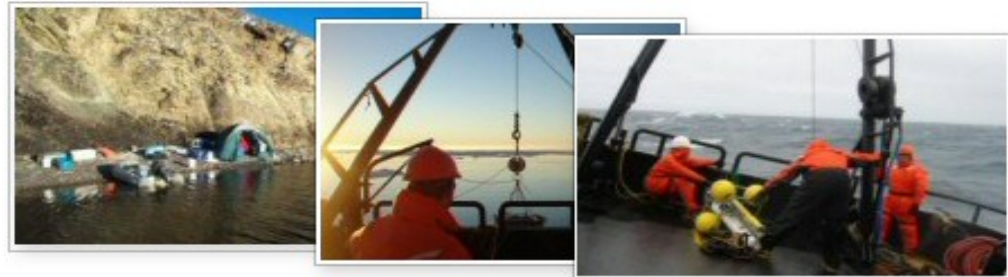
Web site



<http://AquaticAcousticArchive.com/>

Christine Erbe (Curtin University)

- Literature Library
- Metadata Library
- [Marine Mammal Species](#)
- Live Observatories
- Equipment & Hardware
- Software Tools
- Upcoming Events



Welcome to the Aquatic Acoustic Archive. This site is a resource library containing searchable references to publications on

- ✓ Underwater Acoustics
- ✓ Ambient Noise
- ✓ Anthropogenic Noise
- ✓ Sounds Made by Marine Animals



International Quiet Ocean Experiment



Planning committee expertise

- Ocean acoustics
- Biological oceanography
- Behavioural biology (fish acoustics)
- Behavioural biology (marine mammal acoustics)
- Ocean observation systems (fixed arrays)
- Ocean observation systems (mobile)
- Acoustic propagation modelling
- Marine industry
- Media relations and contacts



International Quiet Ocean Experiment



International

Quiet

Ocean

Experiment

WHO?

- global stakeholder community
- global participation
- multicultural, for everybody

WHAT?

Monitor, investigate, understand, appreciate sound & its effects; Lessen negative impacts

WHERE?

Local => regional => global

HOW?

- discovery
- understanding
- science

Conveying
a
complex
message
in simple
ways
that
can be
understood