

Rapid evolution: progress and trends in ocean noise mitigation

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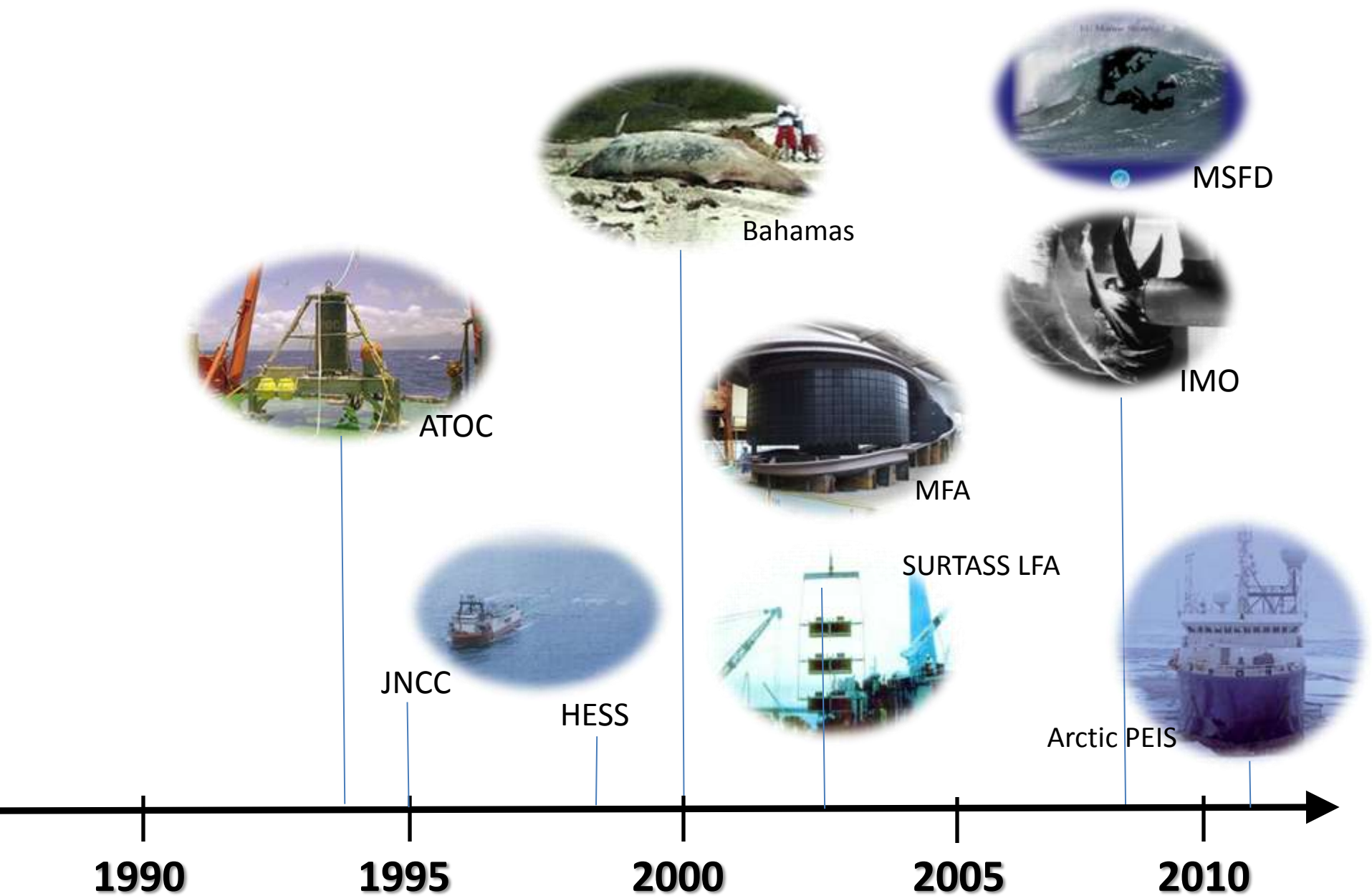


Rapid Assessment of Ocean Noise in Canada's Pacific – Vancouver – February 2012

Overview

An extremely generalized
history

Focal events in ocean noise mitigation



Primary focus for mitigation: “near-field” operational measures



Seismic



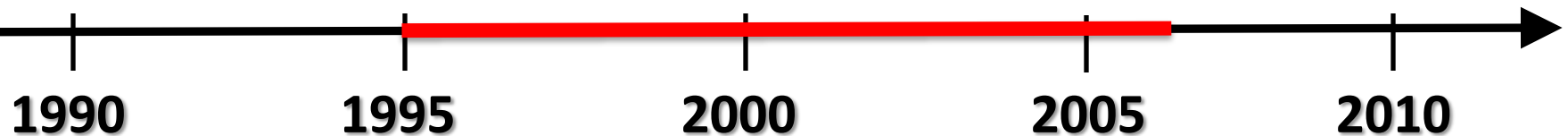
MFA sonar

- Reducing “near-field” exposures (safety zones and/or ramp-ups)
- Monitoring for “near-field” mitigation and impact detection
- Obtaining compliance with environmental laws (environmental assessments and permits)

N.B.: generally no mitigation for shipping



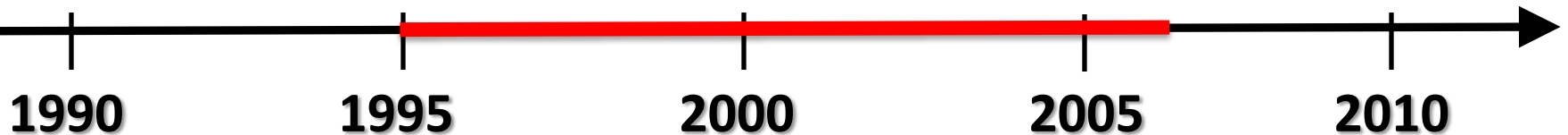
Shipping



But...

- Rise in concern over **chronic ocean noise**
- **Inappropriateness of “near-field” targeted methods** to some noise sources (esp. ships)
- Emergence of **complimentary approaches** in marine conservation (Marine Spatial Planning, Marine Protected Areas)
- Increasing use of **programmatic environmental assessment** to reduce regulatory burden [regulation]
- Increasing investment and industry interest in **noise reduction and alternative technologies**, due in part to regulatory pressure

= Beginnings of a paradigm shift?



Shifting focus for mitigation: habitat and technology

- **Habitat-based management** (e.g., exclusion areas, ATBAs, shipping lane consolidation and revision, MPA management)
- **Technology-based noise control** (e.g., quiet ship design, technological alternative for seismic airguns, attenuation systems for piledrivers)
- **Multi-sector cumulative noise management** (region- or population- based)

N.B. Does not displace “near-field” mitigation



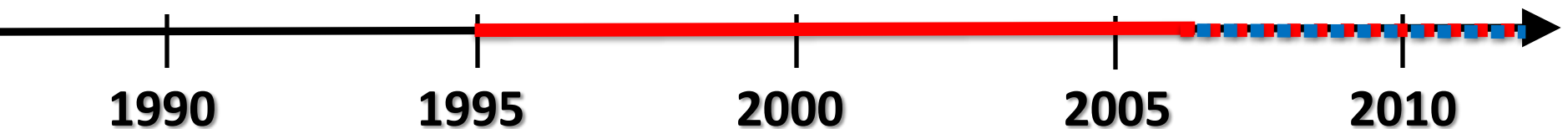
Arctic PEIS



MSFD



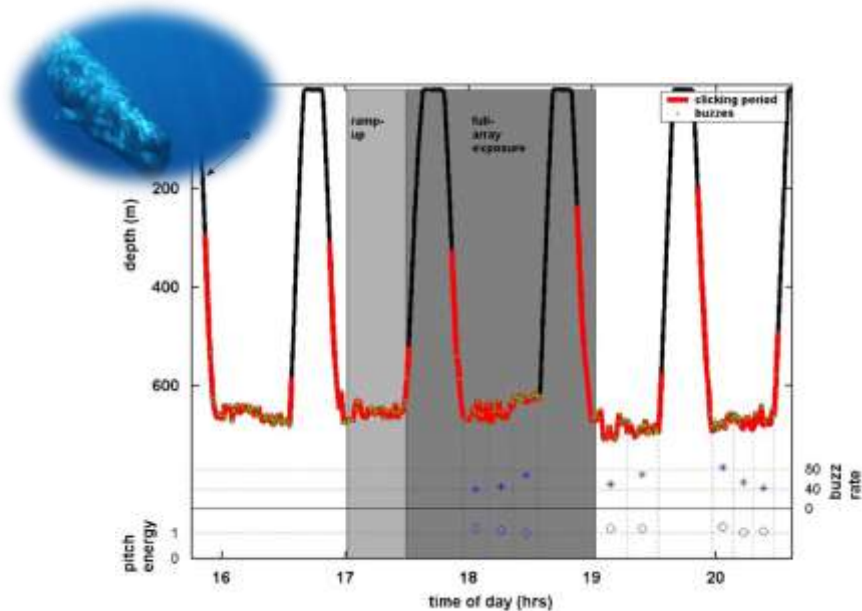
IMO



Mitigation of near-field exposures

Ramp-up (soft start)

Ramp-up (soft start)



whales
=
birds?

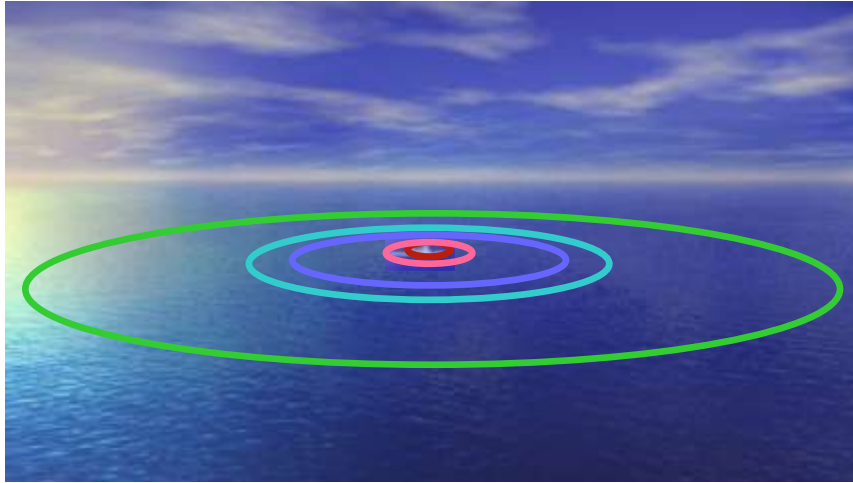


- Some animals will not abandon important habitat = thus ramp-up clearly not effective for some species/ applications (SWSS 2002-04, Parsons et al. 2009)
- Unclear where effective at reducing near-field impacts vs. adding more noise into environment
- Some new efforts to test effectiveness (JIP)

Mitigation of “near-field” exposures

Safety zones

Safety zones



Norway

U.S.

Canada (for non-baleens)

Italy

Australia

MFA sonar shut-down zones c. 2008

- Core concepts, but variability in details of radii and other protocols by sector, state, and region (see above for MFA sonar)
- Sound-source verification to determine safety zone radii
- Controversy over radii (Gedamke et al. 2011, Lucke et al. 2009)
- Complex protocols – not just about setting radii (pre-monitoring, stop/start, etc.)

Habitat-based management

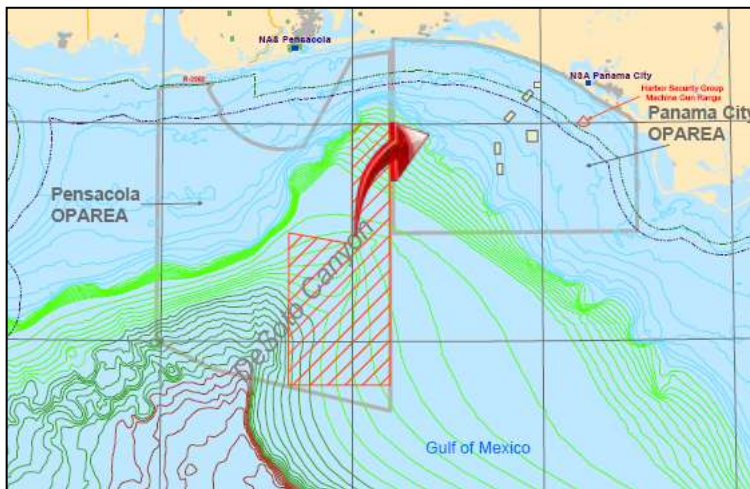
Exclusion areas and siting measures

Exclusion areas and siting measures



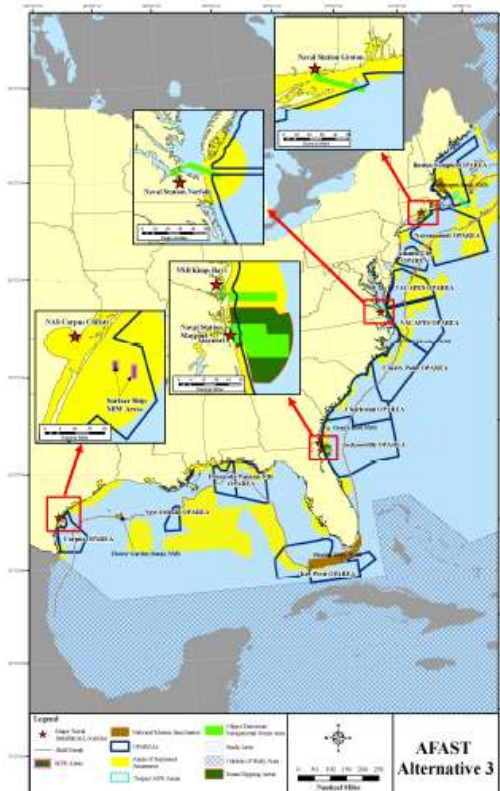
“Hotspot” driver

Exclusion areas are broadly established on a sector-by-sector basis, or habitat is avoided on a project-by-project basis, to reflect known “hotspots” (i.e., habitat important or risk elevated due to other factors or both)



U.S.: Navy relocated major exercise to avoid DeSoto Canyon (sperm whales)

Exclusion areas and siting measures

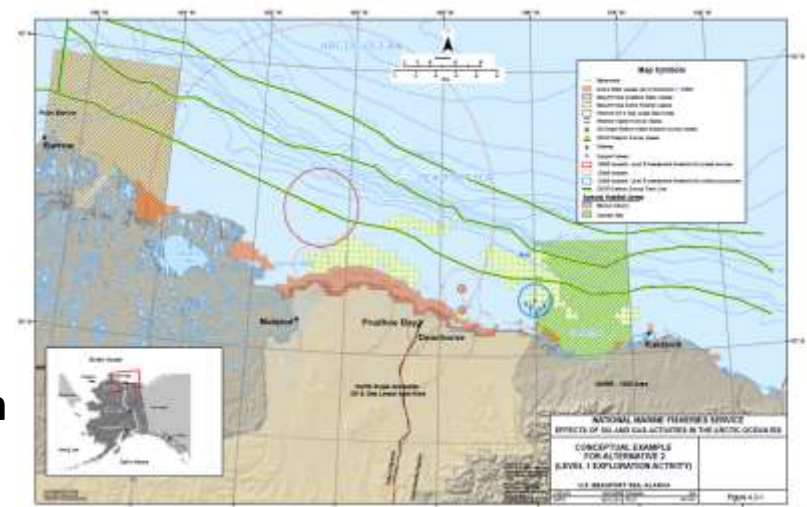


U.S.: Atlantic Fleet sonar training (2009-2014), alternative 3

Programmatic assessment driver

Programmatic approach to environmental assessment or permitting process allows *consideration* of sector-wide exclusions or siting measures on a regional basis

U.S.: Arctic oil and gas exploration (2012-2017), alternative 4

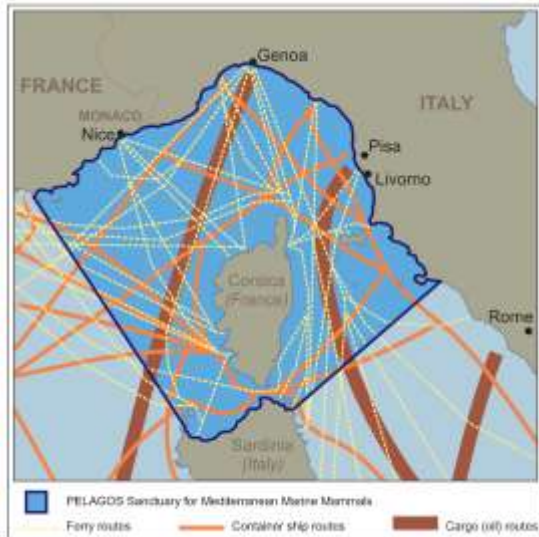


Exclusion areas and siting measures



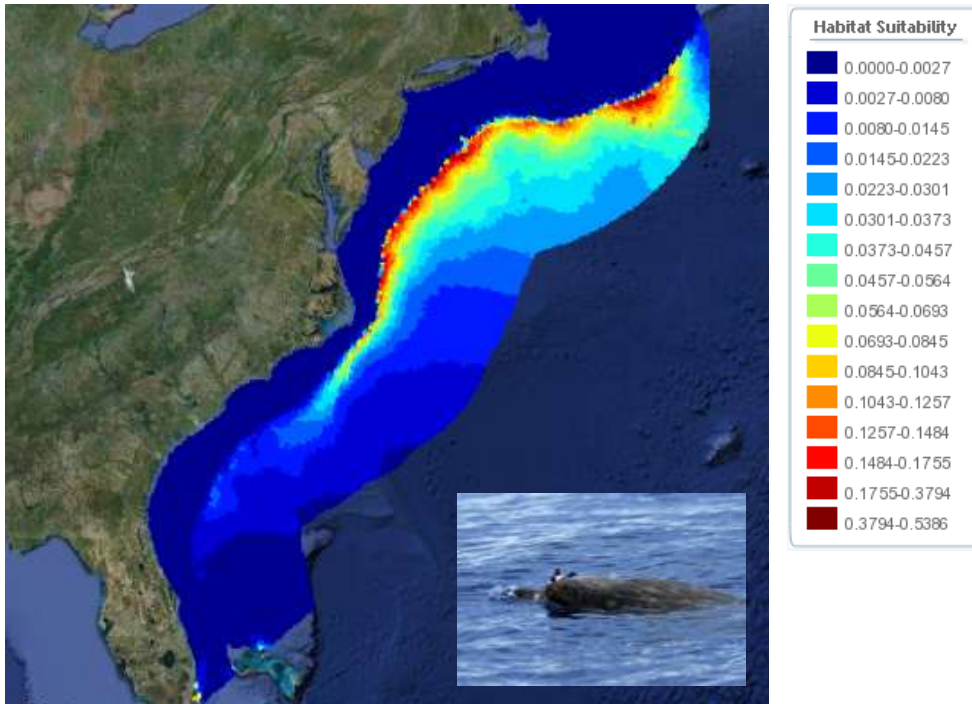
Marine Protected Area driver

Marine Protected Area designation provides an important impetus and a vehicle for noise assessment and management, *but* some Marine Protected Areas may not be large enough to manage some types of anthropogenic noise (Agardy et al. 2007; Hoyt 2011)



Pelagos Sanctuary: work with IMO to consolidate/resite shipping lanes and/or reduce vessel speeds?

Exclusion areas and siting measures



U.S.: Navy used predictive modeling to establish siting alternatives/ exclusion areas for Atlantic Fleet sonar training

Bases used in various jurisdictions

- Habitat important for feeding, breeding, migrating, or even resting
- Observational data (visual, acoustic tags, etc) → site-specific behavior
- Survey data → population densities
- Correlation with oceanographic features (banks, seamounts, fronts, steep canyon walls)
- **Predictive habitat modeling**

Technology-based noise control

Quiet ship design

Slides from: Scholik-Schlomer, A.R., Bergmann, T., Hatch, L., Jasny, M., Metcalf, K., Southall, B., Weilgart, L., and Wright, A. (2011), Reducing underwater noise from large commercial ships, presentation at Society for Marine Mammalogy Biennial Conference, Tampa, Florida.

Solution: Ship Quieting



- The largest source of noise from large ships is **propeller cavitation**
- Cavitation noise is wasted energy
 - Reduction has possible ancillary benefits of reducing fuel consumption, air emissions, and maintenance costs
- Navies and researchers have long used ship-quieting techniques
 - Techniques must be adapted for commercial applications

The Goal: Hamburg Statement (Okeanos Workshop)

International Workshop on
Shipping Noise and its Effects on
Marine Mammals - Foundation for the Sea
Hamburg, Germany, 21st-24th April 2008

Statement of Participants

A diverse group of stakeholders from around the world was convened with expertise in the areas of underwater acoustics, naval architecture, marine engineering, ship building, marine mammal bioacoustics, marine mammal ecology, noise control, marine mammals, international maritime law, and marine mammals. Marine mammals are acoustic specialists and depend on sound for survival (e.g., communicating, navigating, finding food and mates, avoiding predators). For example, blue and fin whales produce intense low-frequency sounds in the 10-300 Hz band. The ambient noise level in this band (10-300 Hz) has been doubling approximately every decade. **drastically reducing these ranges. Although the**

There is a relationship between commercial shipping and the amount of underwater noise. Given that unlike chemical pollution, noise does not persist in the environment. Thus, if a source of noise is reduced, the noise level in the water is immediately reduced. **There are favorable opportunities to eliminate the impacts of shipping noise on marine mammals.**

To achieve this goal, specific initial global action that will reduce the contributions of shipping noise to the ambient noise level in the 10-300 Hz band is needed.

The engineering tools and methodologies currently available are sufficient to reduce radiated noise from ships, or can be developed with limited effort. **For this reason, the goal can be achieved immediately.**

The widespread application of technical and operational noise reduction measures applied on an individual ship basis would lead to the 3 dB reduction in ambient noise within a decade and would result in an overall increase in potential communication/hearing ranges for marine mammals. It was clearly recognized that shipping noise is a trans-boundary, international issue. All participants called for the coordination of action at the international level, i.e. by the International Maritime Organization and its members.

¹ In sound level terms, a doubling in the power of sound is measured as 3 dB, while a ten-fold increase is measured as 10 dB.

“[W]e call for initial global action that will reduce the contributions of shipping to ambient noise energy in the 10-300 Hz band by 3 decibels in 10 years and by 10 decibels in 30 years relative to current levels. This goal would be accomplished by reducing noise contributions from individual ships.”

- Hamburg Statement (2008)

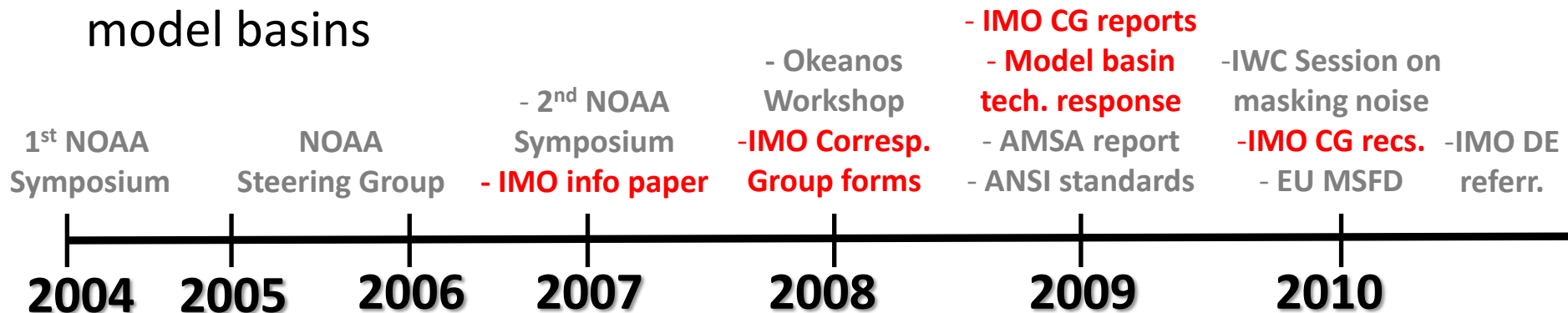
*IWC Scientific Committee subsequently endorses this goal (JCRM 2009, Suppl.)

Recent Observations: Small Improvements are Possible & Can be Significant

- Reducing noise by 6 dB from the loudest 16% of all vessels → 60% reduction in ensonified area
- Merchant ships currently differ by 40 dB between quietest and noisiest vessels → room for improvement
- Recent technological assessments suggest reduction of cavitation levels by 6-10 dB is currently feasible → greater reductions require further research
- Modeling basin studies/optimization for large commercial ships likely <2% of total vessel cost → insignificant relative to anticipated fuel savings

Vessel-quieting efforts for commercial ships: Moving to the IMO

- **2007:** U.S. submits an information paper on knowledge & concerns re: shipping noise & masking of marine animal communication
- **2008:** U.S. petitions Marine Environmental Protection Committee (MEPC) of IMO to form a correspondence group (CG); Approved & U.S. chairs
- **2009:** MEPC CG reports focus on technical/practical aspects of vessel-quieting (prioritization), based on input from worldwide model basins



MEPC CG Recommendations (2010/2011)

Focus Areas for Quieting*:

- **Propulsion**

- Propeller design/modification to reduce cavitation

- **Hull Design**

- Flow noise reduction

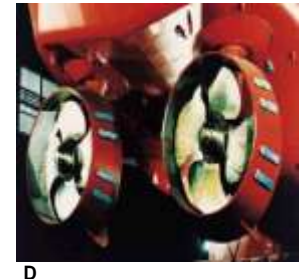
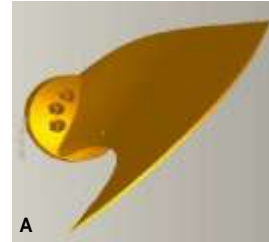
- Hull/propeller optimization to reduce wake field

- **On-Board Machinery**

- Damping, mounts, & equipment isolation

- **Operational Modifications**

- Speed & load variations; Maintenance



In priority order

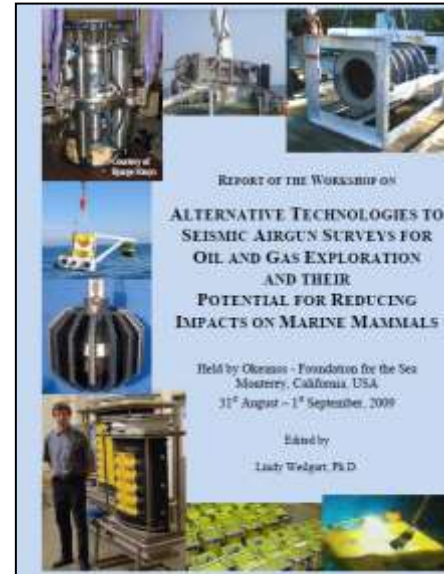
Other Mechanisms for Implementation of Ship-Quieting Technology

- Regional Noise Requirements
 - EU Marine Strategy Framework Directive
 - Recently passed requirements to maintain “good environmental status” → including underwater noise (monitoring specifically required for 2 frequencies [63 & 125 Hz] targeting shipping noise)
- Country-specific requirements by port and/or flag states
- Financial Incentives
 - Incentive-based regulations & tax breaks
 - Market incentives (e.g., fuel efficiency, “Green” company certifications)

Technology-based noise control

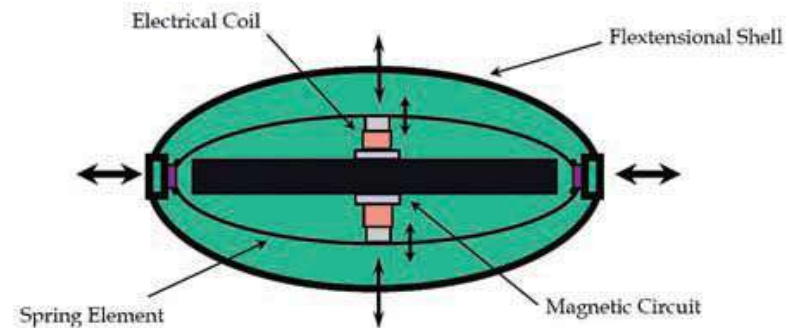
Alternative technologies for seismic exploration

Alternative technologies for seismic exploration



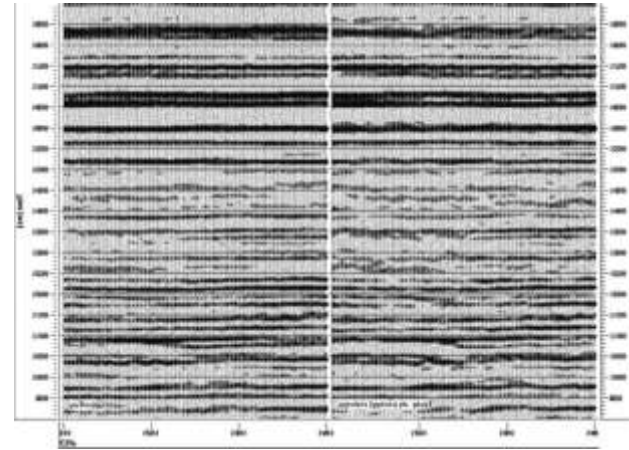
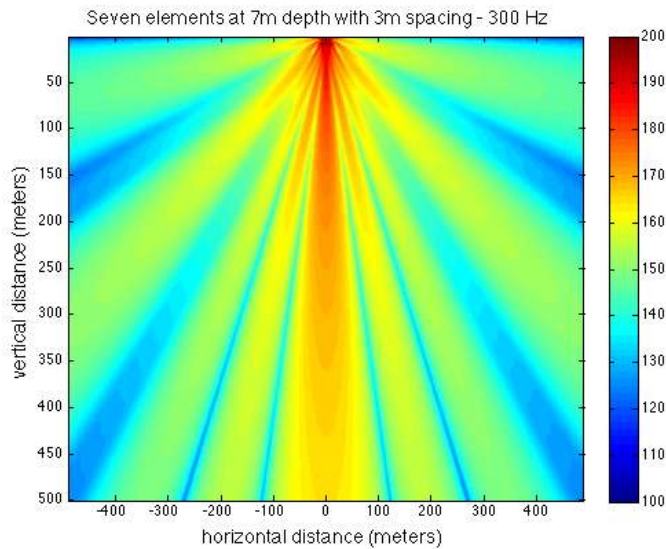
- Airguns produce a great deal of “waste” sound and generate peak levels substantially higher than needed for offshore exploration
- Quieter technologies are either available now for commercial use or can be made available within the next three to five years c. 2010 (controlled acoustic sources, non-acoustic sources, fiber-optic receivers)
- Governments should accelerate development and use of these technologies through both R&D funding and regulatory engagement

Vibroseis 2G



- Marine vibroseis uses a vibrating source rather than an impulsive source
- Vibroseis has been used on land for decades, but the first generation of marine vibroseis, developed in the '80s and '90s, had unreliable hardware
- Geo-Kinetics and PGS have developed a working electromagnetic vibroseis array that appears far more reliable than the first generation; JIP has commissioned development of two systems from other vendors; Defence Research and Development Canada is developing another

Vibroseis 2G



- Vibroseis has **several potential environmental advantages** over airguns: reduced risk of TTS/ injury since highest RL = ~ 196 dB; no output above 100 or 200 Hz except harmonics; effective source level 30+ dB lower
- Vibroseis has **one primary environmental disadvantage** in being continuous or nearly continuous, but airgun pulses also spread over time
- Some tests have demonstrated **data quality** equivalent to airguns
- **More work is needed to confirm environmental benefit and demonstrate value to operators; regulatory engagement is essential – U.S.?**

Technology-based noise control

**Best available control
technologies for piling**

Control technology for piledriving



- Source reduction technology: vibratory piledrivers instead of impact piledrivers
- Noise attenuation technology: e.g., bubble curtains, cushion blocks, cofferdams, temporary noise attenuation pile design
- Europe has the most experience from Dutch, British, Norwegian offshore wind projects; also U.S. from bridge/ port construction and retrofits



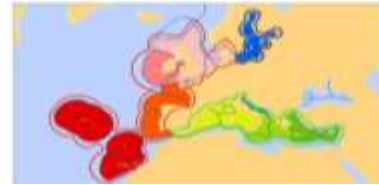
Source: Evans ed. 2008 (ECS workshop); Laughlin 2007 (WADOT Mukilteo); Reyff 2009 (CALTRANS Bay Bridge)

Future practice

Multi-sector cumulative
noise management?

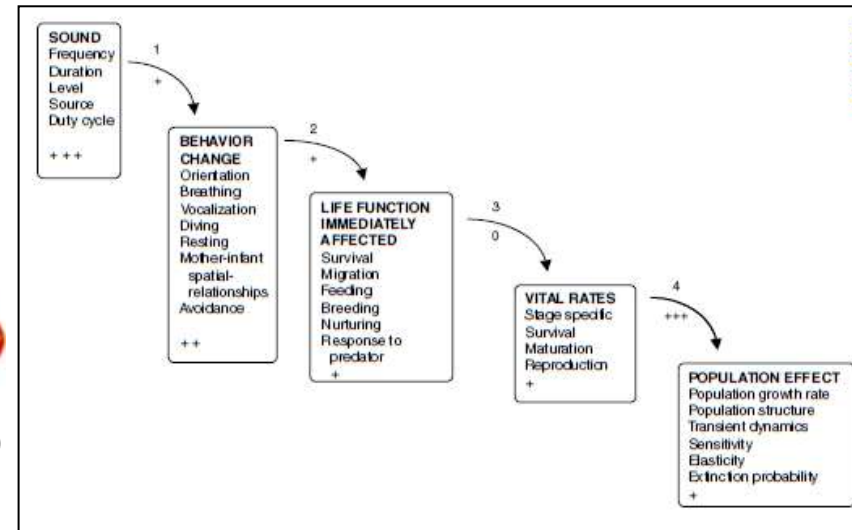
Synthetic, multi-sector cumulative noise management?

Commission Criteria	Commission Indicator
11.1 Distribution in time and place of loud, low and mid frequency impulsive sounds	Proportion of days and their distribution within a calendar year over areas of a determined surface, as well as their spatial distribution, in which anthropogenic sound sources exceed levels that are likely to entail significant impact on marine animals measured as Sound Exposure Level (in dB re $1\mu\text{Pa}^2\cdot\text{s}$) or as peak sound pressure level (in dB re $1\mu\text{Pa}_{\text{peak}}$) at one metre, measured over the frequency band 10 Hz to 10 kHz (11.1.1)
11.2 Continuous low frequency sound	Trends in the ambient noise level within the 1/3 octave bands 63 and 125 Hz (centre frequency) (re $1\mu\text{Pa}$ RMS; average noise level in these octave bands over a year) measured by observation stations and/or with the use of models if appropriate (11.2.1).



Regional management: MSFD

Source: DEHRA; NRC 2005



Population-based management: PCoD

Conclusion

What constitutes “best practice” for ocean noise mitigation and management?

- Generally consists of operational measures to reduce “near-field” risk and (increasingly) habitat-based mitigation, with technology-based mitigation emerging as critical for several major noise sources
- Often project-based, but increasingly relies on programmatic processes such as EIAs that better allow for non-operational mitigation and management of cumulative impacts
- Generally sector-specific, but possibly evolving towards synthetic, multi-sector regional (MSFD/ U.S. noise mapping) and population (PCoD) management

Thank you!

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