Ocean Noise and Marine Life:
Improving understanding & management of anthropogenic noise impacts

Jason Gedamke
Ocean Acoustics Program
NOAA Fisheries Office of Science and Technology
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To survive and reproduce, animals need to:

- Attract mates
- Defend territories or resources
- Establish social relationships
- Coordinate feeding
- Interact with parents or offspring
- Avoid predators or threats

Communication is essential.
Communication exists in many forms.
Over large distances in water, most forms of communication are not practical.

Sound, however, travels exceptionally well underwater.
**Sampling schedule**
13 min recorded starting each hour
4kHz sampling rate

Logger 1: ~500km from survey
1860m depth

Logger 2: ~1500km from survey
1600m depth

Logger 3: ~2900+km from survey
1100m depth
Seismic (5x speed)
Ocean Soundscapes

Natural Physical
- Lightning
- Stormy sea
- Lava flow
- Mountains

Natural Biological
- Shrimp
- Whale
- Seals
- Underwater plants
Ocean Soundscapes

Natural Physical

Natural Biological

Man-made sounds

[Images of ships, oil rigs, wind turbines, and a submarine]
Anthropogenic Ocean Noise

Currently:

• Human activities produce noise, potentially chronically, and over very large areas
• More human activities in more coastal and ocean areas means noisier waters

➤ Ocean noise is a growing global problem for marine ecosystems

Environmental Impact:

• **Acute**: Intense noise events can have adverse physical and behavioral impacts that affect health and fitness

• **Chronic**: Rising background noise limits marine animals’ communication range and ability to sense their environment

Modified from McDonald et al. (2006)
Zones of Noise Influence

- Injury
- Hearing Loss
- Masking
- Behavioral disturbance
- Audibility

Adapted from Richardson *et al.*, 1995
Fin whale recorded 1500km from survey

No seismic (5x speed)

Seismic (5x speed)
Loss of Communication Space

Hatch, Clark, Van Parijs, Frankel and Ponirakis (2012) Conservation Biology
Anthropogenic Ocean Noise

Current Noise Management:

• Mainly activity by activity
• Relatively short term, small scale
• Thresholds for high intensity, transient sources
• Difficulties due to ambient noise variability (natural & anthropogenic)
• Heavy emphasis on marine mammal impacts

Goals for Future Noise Management:

• Cumulative footprints from multiple source types
• Ecologically-relevant scales (space & time)
• Addressing chronic lower intensity sources
• Incorporating ambient noise variability
• Emphasizing impacts to a variety of marine animals and habitats
Ocean Noise Strategy

Phase I—CetSound
(Cetaceans & Sound)
Phase I-CetSound

2010 multifaceted NOAA commitment:
• Developing tools & soliciting stakeholder input
• To help comprehensively address cumulative impacts of human-induced sound

• **CetMap**: new tools to map cetacean density, distribution & important areas; provide context for impact analyses
• **SoundMap**: new tools to map noise & contributions from multiple sources

Symposium (May 2012):
• Share products, talk about *potential* management applications, & solicit input from multi-stakeholder audience

Website: cetsound.noaa.gov
CetMap

- Cetacean Data Availability Analysis
- New Density Modeling
- Biologically Important Area Identification
- Mapping and Public Accessibility to Products
SoundMap

- Chronic, regional to ocean-basin scale sound fields associated with multiple source types
- More comprehensive representations of local sound fields associated with shorter-term exemplar “events”
Cumulative Chronic Low-Frequency Noise: Gulf of Mexico Example

Predicted average annual summed noise contributions from:

- Merchant shipping
- Cruise and large passenger vessels
- Support of O&G platforms
- G&G airgun survey activity
Ocean Noise Strategy

Phase II—Ocean Noise Strategy Roadmap
Phase II: Ocean Noise Strategy
10 Year Vision

The ONS is an initiative to guide NOAA towards a more comprehensive and effective understanding and management of ocean noise impacts

Science: NOAA and federal partners are filling critical knowledge gaps and building understanding of noise impacts over ecologically-relevant scales.

Management: NOAA’s actions are integrated across the agency and minimizing the acute, chronic, and cumulative effects of noise on marine species and their habitat.

Decision Support Tools: NOAA is developing publically available tools for assessment, planning and mitigation of noise-making activities over ecologically-relevant scales.

Outreach: NOAA is educating the public on noise impacts, engaging with stakeholders and coordinating with related efforts internationally.
Ocean Noise Strategy Roadmap

Website: cetsound.noaa.gov

Purpose

• Summarize status of science and management of noise impacts on protected marine taxa
• Provide robust support for need to better address acoustic habitat and chronic/cumulative effects
• Outline broad recommendations for better addressing noise impacts through NOAA science and management activities

Content

• Executive Summary
• 1- The NOAA Ocean Noise Strategy and Managed Species
• 2- Acoustic Habitat and NOAA ’s Ocean Noise Strategy
• 3- Enhancing NOAA ’s Ability to Characterize Aquatic Soundscapes
• 4- NOAA Ocean Noise Strategy Implementation Case Studies
• Appendices

ONS Leads: Jolie Harrison (NMFS-OPR), Leila Hatch (NOS-ONMS), Jason Gedamke (NMFS-OST)
Ocean Noise Strategy Phase III: Transition to Implementation

NMFS has issued (Nov. 2016)
• Policy Directive Highlighting Strategy Goals
• Procedural Directive initiating Office-specific work plan development

Implementation Actions:
• Flagship Projects
• Initiate execution of ONS Roadmap recommendations
• Support for IMO guidelines
• Vessel noise characterization study
• Predictive sound mapping tools
• Support port noise monitoring activities
• Noise metrics

<table>
<thead>
<tr>
<th>Primary Goal</th>
<th>Recommendation</th>
<th>Key Chapters</th>
<th>Additional Goals</th>
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</thead>
<tbody>
<tr>
<td>Management:</td>
<td>Expanding types of, scopes of, and coordination among NOAA authorities to address noise issues</td>
<td>1,2</td>
<td></td>
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<tr>
<td>Identification and utilization of a full range of NOAA authorities to better manage the impacts of noise on trust resources</td>
<td>1,2</td>
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<td>Development of national guidance for acoustic impact thresholds and other management tools</td>
<td>1</td>
<td></td>
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<td>Increased use of programmatic approaches through MMPA and ESA to allow for better consideration of multiple activities, longer timeframes, and acoustic habitat impacts</td>
<td>1,2</td>
<td></td>
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<td>Improving management effectiveness for acoustic habitat through incorporation of place-based authorities as they relate to species or habitat focused goals</td>
<td>2</td>
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<td>Utilization of National Marine Sanctuaries to develop increased capacity for preserving, restoring, and maintaining natural acoustic habitats, as well as the protected species associated with them, through new management measures, regulations, dedicated scientific research, and outreach programs</td>
<td>2</td>
<td>Science; Outreach</td>
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<td>Expansion of existing international partnerships with regulated agencies and industries to promote use of quieter technologies</td>
<td>2</td>
<td>Science; Outreach</td>
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<td>Science and Monitoring:</td>
<td>Development of comprehensive and forward-looking science plans identifying most effective and efficient means to address critical data needs for understanding noise impacts on protected species and acoustic habitats</td>
<td>1,2,3</td>
<td>Management</td>
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<td>Establishment of a NOAA-led long-term, standardized listening capacity across the agency</td>
<td>3</td>
<td>Management</td>
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<td>Development of an archival database to house NOAA passive acoustic metadata, raw data, and outputs of standardized data analysis routines</td>
<td>3</td>
<td>Tools</td>
<td></td>
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<td>Enacting monitoring requirements for compliance processes that reflect comprehensive science goals, and further identifying actions that may be taken at different scales to address varying resources and capabilities</td>
<td>1</td>
<td>Management</td>
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<td>Tools and Services:</td>
<td>Development of processes and tools to compile, geospatially depict, and analyze marine species distributions, soundscapes, and NOAA-permitted/authorized activities for use in risk assessment, mitigation development and planning.</td>
<td>1,2,3,4</td>
<td>Management; Science; Outreach</td>
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<td>Developing NOAA ‘in-house’ capacity for predictive sound field and sound exposure modeling</td>
<td>1,3</td>
<td>Management; Science; Outreach</td>
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<td>Standardization of data analysis routines and output metrics for soundscapes measurements</td>
<td>3</td>
<td>Science; Outreach</td>
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<td>Outreach, Collaboration, and Stakeholder Engagement:</td>
<td>Further development of outreach programs to support the activities outlined above</td>
<td>1,2</td>
<td>Management; Science; Tools</td>
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Ocean Noise Strategy

Flagship Projects
Assessing long-term trends and changes in underwater soundscapes

Low frequency noise in the N. Pacific (US West Coast)

McDonald et al., 2006

Andrew et al., 2011

Low frequency noise in the Atlantic

Širović et al., 2016
NOAA Noise Reference Station (NRS) Network

Low frequency, long-term passive acoustic monitoring

Long-term deployment of calibrated recording packages to allow comparison between and within sites over time

Addressing needs:
- Characterization and comparison of soundscapes broadly across US waters
- Empirical validation of predictive soundscapes
- Assessment of long-term trends and changes in soundscapes
Deployment Configurations

Deep-water mooring

Shallow water lander
NOAA Noise Reference Stations (NRS)

Long Term Spectrograms of NOAA NRS data in-hand (as of 9/2016)

NRS01, 10/2014-10/2015

NRS02, 10/2014-07/2015

NRS03, 10/2014-07/2015

NRS04, 10/2014-07/2015

NRS05, 10/2014-09/2015

NRS06, 8/2014-10/2015

NRS07, 8/2014-10/2015

NRS08, 6/2014-2/2015

NRS09, 10/2014-9/2015

Dominant noise contributors:
- Anthropophony
- Biophony
- Geophony

NOAA Fisheries
NOAA Noise Reference Stations (NRS)

Monitoring long-term soundscape trends in U.S. Waters: The NOAA/NPS Ocean Noise Reference Station Network

Samara M. Haven, Jason Gedamke, Lella T. Hatch, Robert P. Dziak, Soffie Van Parijs, Megan F. McKenna, Jay Barlow, Catherine Berchok, Eva DiDonato, Brad Hanson, Joseph Hazen, Madia Hohn, Danielle Lipton, Haru Matsunoto, Christian Meining, David K. Middelton, Sue E. Moore, Erin M. Oleson, Melissa S. Saldevilla, Holger Klänck

NOAA Fisheries

U.S. Department of Commerce | National Oceanic and Atmospheric Administration | NOAA Fisheries
Potential Expanded PAM Network Sites

Network of 30 sites:
- 23 existing incl. NOAA, BOEM, Navy, NPS sponsored instruments*
- 7 new sites

*3 existing sites (Am. Samoa, Saipan, Wake) not shown

Criteria:
- Longevity—min. 3+ years
- Spatial Coverage
- Data Quality
- Data Access
Public Archive for Passive Acoustic Data

Data Ingest to Archive

- Metadata fields based on Tethys schema, can import metadata records from Tethys AND export to Tethys
- Create ISO-compliant metadata and Digital Object Identifiers (DOIs)

Carrie Wall, Project Lead & Charles Anderson, Data Manager
Public Archive for Passive Acoustic Data

Map Viewer and Data Delivery

- NMFS and NCEI joint project to provide long-term PAM data archive

- 7 NRS stations archived to date—seen on the map viewer where data can be queried and requested

- Information shown for each station reflects the metadata provided using data submission tool

https://www.ngdc.noaa.gov/mgg/pad/

Carrie Wall, Project Lead & Charles Anderson, Data Manager
Summary

- Underwater sound, both natural and anthropogenic, travels great distances. Marine life relies heavily on sound to communicate and sense their surroundings.

- Sound from human activities can have a wide range of potential impacts on marine life, of varying severity, and over short to long time scales.

- NOAA Fisheries OST’s Ocean Acoustics Program undertakes a range of activities encouraging research within and outside NOAA, interprets current science for use in management, and promotes collaboration and education on ocean noise issues.

- NOAA’s recent Ocean Noise Strategy initiative aims to improve NOAA’s ability to understand and manage impacts from Ocean Noise on our trust resources over the next decade.
  - Phase I—CetSound
  - Phase II—ONS Roadmap outlining long-term goals & recommendations
  - Phase III—Implementation actions (e.g. Office workplans, Flagship Projects)