**SESSION A**
**Biologically Significant Effects of Sound Exposure:**
**Baseline Data and Assessment**
**Brandon Southall**

Summary Notes:

**(1) <u>Basic Biological Research for Representative Marine Mammal Species</u>**

**Many reports have listed areas where we are missing important *basic* physiological, behavioral (baseline), density/distribution, and longitudinal life history data for representative marine species (such as common species) and key species (ESA-listed and sound sensitive species, i.e., those that seem to react to sound at comparatively lower received levels or are historically more likely to be associated with strandings).**

- **What are the most important basic biological data needs for better understanding and management of biologically significant effects of exposure to sound that need to be met in the next 2-3 years?**
    - **Why?**
    - **Who should perform these studies, what are the cost estimates and how will they be funded?**
    - **How long is it likely to take to meet these most important data needs at a level of resolution/certainty required for management, i.e., can they be accomplished with one discrete study or will they necessitate long-term governmental support to be useful to management (show variation over seasons/larger areas etc.)?**
    - **If these essential data gaps were not bridged in the near future due to lack of funding or governmental investment, what are some options for resource agencies to manage species conservatively in the face of the specific types of uncertainty that these data gaps generate?**

**If there are other important issues under this topic, please address those also.**

*TABLE 1*
**Why:**

- Recommendation to reconsider the definition of status of a population (i.e., to include physiological information in addition to the standard distribution and relative abundance data.) (***Group Consensus***).
- Baseline data must include basic information about the species and the habitat (including the acoustic ecology).
- One must consider the variability of the data as well. Context.
- Concentrate research and resources on transition areas, such as the Arctic, subarctic, naturally loud areas with very little anthropogenic sound sources, areas that will become critical in the near future and coastal and nearshore environments.

- We don't know the cumulative / chronic effects of sound on MM health (reproductive, immune, body status). For noise, i.e., sub-lethal impacts, we don't have a focused effort to determine these impacts. Follow the example of research conducted for bycatch and take reduction teams.
- Using emerging technologies and available resources to collect the required baseline data. More efficiencies of using the existing ocean observing systems, linkages with existing observatories, neutrino research, national agreements, piggy-backing on industry, sharing/coupling with offshore renewable energy infrastructure. (***Group Consensus***).

**Who**

- Baseline studies: NOAA is a logical choice. However, much data exists that have not been shared nor integrated. Critical to identify barriers and enable sharing of data.
- **Long-term:** National Marine Sanctuaries are a good point to start, existing, many are close to the Navy range complexes. Navy and NOAA can conduct comparative studies that could produce ill good quality baseline data. A good joint project for NOAA/Navy.
- **Short Term**: Create linkages with existing ocean observatory or health assessment initiatives (e.g., Canada's NEPTUNE, NSF's Oceans Observatory Initiative, NOAA's Health and Stranding Workshops/Program). There is no cost to use existing systems, leverage funding from multiple sources, create and sustain national and international partnerships.

**How long:**

- There will be an ongoing need for research. Climate change will affect animals' responses to the next stressor, no one study at one time will do. Need to find synergies with other efforts to achieve this data synthesis.
- Long-term studies, critical to start research now for long-term studies. Important to set up the proper budgetary framework to ensure the longevity of the long-term study.

**Managing species under Data Poor Circumstances:**

- The precautionary approach is the reality that we are currently operating.
- Need more baseline data. (***Group Consensus***).
- Cannot do research/management serially; move forward in parallel
- The group found it difficult to answer this question.

*TABLE 7*

- Detailed stock assessment information in the most areas before you can determine whether effects are biologically significant
  - Employ additional research tools such as:
    - Photo-ID
    - Biopsy
    - Tagging
    - Passive acoustic monitoring
  - Help expand knowledge of behavioral ecology
- Why?
  - Most current stock assessments state that data old and needs to be updated

    - Limited info with respect to deep water species
    - Navy and NOAA rely too much on survey data for population/stock structure
    - Don't have good grasp of societies of animals – they are social creatures
- Who should perform these studies, what are the cost estimates and how will they be funded?
    - Some regulatory agencies with conservation mandates must get funding to complete mission
    - 3rd party funding sources to discretely fund and direct studies to avoid appearance of impropriety
        - Come up with new entity or work with existing sources?
        - Recommend feasibility study to review agency/industry funding vs 3rd party funding mechanism and offer solutions (MMC guidance?)
    - Regulatory decisions should not be based on research funded solely by the entity with a vested interest in the outcome = **non consensus item**
        - **No consensus** because as a practical matter very little research would get funded
    - With respect to funding – source matters because of public perception
- How long is it likely to take to meet these important data needs at a level of resolution/certainly required for management, i.e., ca they be accomplished with one discrete study or will they necessitate long-term governmental support to be useful to management (show variation over seasons/larger areas etc.)?
    - 5-10 years "baseline"
    - Replete cycles periodically for long-term monitoring
        - If these essential data gaps were not bridged in the near future due to lack of funding or governmental investment, what are some of the options for resource agencies to manage species conservatively in the face of the specific types of uncertaintly that these data gaps generate?
    - Start out with precautionary principle in the absence of data to avoid harm
    - Adaptive management when more data becomes available – which can be either more or less conservative

**(2) <u>Standardized Marine Mammal and Sound Database(s)</u>**

**There have been many discussions about creating a standardized marine mammal database and requiring that all parties/agencies holding permits or authorizations be required to electronically enter any data collected into that government-run database. This data could then be systematically archived, analyzed, and made available to resource managers, researchers, and the public. Without getting into a discussion of who should fund this and which government agency would house it (although, with the intent of informing these issues) please consider the following:**

- **What are some of the logistical needs to make this happen (e.g., data clearance/proprietary issues, communication among agencies with access to data and/or expertise in managing data etc.)?**
- **As a potential user of this database, how would you use this resource if it existed (e.g., all visual sightings made during construction projects in Puget**

**Sound over 10 years, sound source verification data from Arctic oil and gas seismic vessels) in research and/or environmental impact assessment contexts?**

- **How could these types of data be integrated with (or used in meta analyses with) more standardized or systematically collected data to inform understanding of distribution, abundance, and/or behavior?**
- **In light of your responses to the last 3 bullets, list the high-priority issues that need to be taken into consideration in the development of a standardized database to maximize its utility.**
- **Some government agencies may have existing but currently under-utilized datasets that could be made available to aid in the analysis of biologically significant effects of sound exposure. List any these datasets (of marine mammal data) that you are aware of, by agency, and indicate what type of data (e.g., basic information on distribution or abundance, data on potential effects, sound source characterization data) is contained in the dataset, as well as the general format and standardization of raw and metadata. What needs to happen to make the data more readily available (e.g., are certain protocols existing, or necessary to design)?**

**If there are other important issues under this topic, please address those also.**

- The group does not believe that one global, standardized database – though desirable – is feasible at this time. Rather, multiple, more specialized databases could be linked through a central portal.
- Central portal would act as 'gateway' in providing access for approved users – to safeguard data usage – to multiple databases that may exist for different purposes.
- The group identified three high-priority front-end issues:
  - The effort should be government sponsored, and responsibility should be jointly shared by, at minimum, NOAA, Navy, and BOEM.
  - Multiple working databases exist that cover portions of the needed information, but including them all would not be feasible; an important part of start-up would be to identify which databases best cover certain sectors and should be included in the holistic product.
  - The agency or agencies in control of the portal would need to be responsible in a gatekeeper capacity to both provide standards for databases accessible through the portal as well as for datasets to be included in individual databases.
- This effort requires significant financial and logistical commitment. Long-term commitment should be provided by government to support portal and databases. This could be accomplished through cooperative agreements involving government, academia, and industry.
- There are logistical necessities on both ends. Databases accessible through a central portal must have a "user's guide" or business rules for how data are to be entered or managed, and should have standards for establishing hierarchy of data quality.

- Partner databases should have standardized ground-rules for agreement with data providers regarding timelines for making data accessible and for validating and vetting data that is provided. Data collectors should provide some minimally processed data, i.e., a product, such that misuse of data is minimized.
- Such a resource would be primarily used in three ways: 1) environmental impact analysis; 2) looking at longer-term trends in the context of the impacts of anthropogenic activities, possibly in regard to marine spatial planning; and 3) real-time management of critical areas.
- There are a wide variety of datasets available. Under-utilized datasets would be identified through an initial vetting process in which the 'gateway' agency would pre-qualify existing databases to become part of the overall system based on need.

**(3) <u>Predictive Tools for Density/Distribution Estimation</u>**

- **What existing tools (or tools in development) can be effectively used to estimate/predict marine mammal density and distribution for under-surveyed areas of the world's oceans? What oceanographic, biological, and other environmental features (if any) are effectively considered in these predictive tools?**
- **Can we systematically identify specific sets of circumstances in which the use of these sorts of tools would be expected to be either more or less likely to result in accurate results?**
- **What should be done to achieve standardized applications and acceptance for these tools?**
- **What are the pros and cons of incorporating such tools into a standardized national system that would be applied in management decisions (such as the one contemplated for housing all marine mammal monitoring data).**

**If there are other important issues under this topic, please address those also.**

Tools that exist

- Aerial & vessel transect (visual and acoustic) including Towed arrays
- shore surveys
    - Opportunistic data, including "platforms of opportunity" sighting programs and Seismic surveys
- Tagging (satellite)
- Habitat modeling, satellite data, and existing predictive models using remote sensing and sighting data, Seawhifs, NOAA buoys
- stationary acoustic sensors
- OBIS seamap

Circumstances when more/less likely to lead to accurate results

| More likely | Less likely |
|---|---|
| Nearshore | offshore |
| Observer data while in transit with acoustic source | Observer data while in transit with acoustic source |

| | |
|---|---|
| off | on |
| "Trained" MMOs | Opportunistic sightings |
| Datasets with more sightings | Datasets with less sightings |
| Non-cryptic species | Cryptic species |
| Good baseline data | Lacking baseline data |

In some cases, predictive models might be better than existing data.

Achieve standardized applications and acceptance

- Predictive models need to be cross-checked before use for management purposes
- blind comparison between predictive models for quality control
- What is required by statute vs. what industry will voluntarily do
- For acceptance, known species information from areas that have been surveyed, require prediction in unknown area, then follow-up with physical survey to verify
- Standardized training program for protected species observers

Pros & cons of incorporating into national system – does this mean standard database or standard tools?

CONS

- Some large databases not accepted by peer-review as a dataset
- lacks quality control; no standardization for monitoring, information, database, etc; methodology varies for surveys
- Much data is collected, no one to analyze
- Money exists to create databases, not to maintain
- There will always be a variety of non-compatible databases

PROS

- Worthwhile to have data in centralized database with set standards
- Some existing databases (OBIS) that could be expanded
- Can bin data based on differing confidence

**(4) <u>Behavioral Response Research for Representative Marine Mammal Species</u>**

**As we can see by looking at the Southall et al. (2007) compilation of data, we are missing important pieces of information showing how specific marine mammal groups (representative marine species: such as common species and key species: such as ESA-listed and sound sensitive species) respond to specific types of sound sources/activities (not to mention in different contexts or at what different received levels).**

- **What are the most important specific behavioral response to anthropogenic sound data needs for better understanding and management of biologically significant effects that need to be met in the next 2-3 years?**
    - **Why?**
    - **Who should perform these studies, what are the cost estimates and how will they be funded?**

    - **How long is it likely to take to meet these most important data needs at a level of resolution/certainty required for management, i.e., can they be accomplished with one discrete study or will they necessitate long-term governmental support to be useful to management (areas achieve threshold sample sizes, repeat experiments, alter ecological/environmental conditions etc.)?**
    - **If these essential data gaps were not bridged in the near future due to lack of funding or governmental investment, what are some options for resource agencies to manage species conservatively in the face of the specific types of uncertainty that these data gaps generate?**
- **How should representative species best be used for predicting the behavioral responses of other species based on the information we have in-hand? For example, should this concept be based on taxonomy, hearing sensitivity (by frequency), or similarities in life history?**
- **What are the most important laboratory/captive based experiments and/or theoretical modeling (i.e. no field component) projects needed, and why?**

**If there are other important issues under this topic, please address those also.**

Primary concern regarding behavioral response research is the *conservation of a population.*

Behavioral effects identified as most important for survival and reproduction:

- *Displacement*
    - short-term or long-term?
    - critical habitat involved?
    - to where are animals displaced?
- *Disruption of social bonds*
    - taxonomic variability
- *Acoustic isolation*
    - masking
    - reproductive success
- *Chronic sound*
    - levels and limits of habituation
    - habituation vs. tolerance
    - measurable effect in lab settings
- *Short-term high-energy responses*
    - alarmed responses (strandings, tail slaps, etc.)

**Why?** Impact on reproduction and survival
**Who?** No limit, but needs to be interdisciplinary
**How long?** 5 years minimum just to develop an introductory understanding

**Important points:**

- We're at the <u>very beginning</u> of understanding behavioral responses
- Behavioral effects are all context-specific (i.e., species, geographical location, season, etc.)

- One particular behavior may not be important; we need to address cumulative effects
- Great variability between species (and even among species)
- Caution when using the term “representative marine species”
- Long-term research needed to fully understand behavioral responses
    - Research driven by funding, litigation, needs of regulators, etc.
- Verification of field research extremely necessary
- Prioritizing applied research is an integrative process
    - Focus on: species with known data; high-risk populations and locations

*TABLE 8*

**Recommendations**

Baseline research

- Expand beyond the 2-3 year horizon regarding the baseline data (stock assessment and range for all US waters), ongoing collection recommended instead
- NOAA and USFWS need to be the lead agencies collecting baseline data from the subject areas identified in the n-dimensional space
    - n-dimensional space: Social structure (group size), phylogeny, foraging ecology, functional hearing groups, sensitive/shy species-cryptic, predator-prey dynamics, migratory behavior, conservation status (population size, size of range, stock trends, legislative protection)
    - Increased directed funding to stock assessments, distribution, behavioral ecology, predictive habitat modeling, targeted tow-array work,…
- Existing sources to consider
    - NOAA’s Ecological Passive Acoustic System
    - NRC 2000 report
    - NPS approach—Soundscapes
    - Population models based upon ecological factors
- This baseline data is necessary for marine spatial planning, ecosystem-based management, and natural resource damage assessment process.
- With proper funding, existing data could be standardized, published, and made available at low cost
- Streamline funding requirements, permitting, and interagency commitment to a unified set of goals
- Increase opportunities for communication between researchers and managers
- Propagation modeling would be helpful for setting the scene

Applied research

- 2-3 year time horizon for directed research is appropriate
- Navy, BOEM, NOPP, and industry, in coordination with USFWS and NOAA, conduct targeted research focused on anthropogenic noise and biologically significant effect issues
- Connect to existing permit and research programs
- Specific studies
    - Compare noise types: broadband continuous, pulsive, narrow band, etc.

    - Bottom-up studied derived from species that are data rich to support larger-scale mutivariate field studies

General Discussion

- Difficulty in defining "representative species"
    - Sometimes default to species which already have a lot of data (i.e. the low hanging fruit) and those that are species of concern (ESA, MMPA)
    - Potential grouping categories: Phylogeny, functional hearing, behavioral sensitivity
    - Behavioral sensitivity is more meaningful for management/ESA issues while phylogenic makes sense scientifically (given recent data connecting phylogeny to functional hearing)
        - Selection criteria for species could be based on: ESA-listed species, phylogenic group even if you don't know that they are sensitive already, species that make up the large proportion of the takes, species where you have a big body of data for, range, level of exposure
- Group by certain factors (e.g. behavior, hearing, life history characteristics) instead of just by level of endangerment---use this to generate an n-dimensional space to characterize species

Baseline Data

- Need for baseline data especially on abundance, distribution, and movement patterns
- 3 categories of research: Basic research on density/distribution, behavioral ecology (through small # of animal observations), behavioral responses to sound (e.g. to form behavioral risk function)
- Which should come first, space designation or looking at the species movement as a whole?—general sentiment that it should be a combination of both but many agencies admitted that their research is generally space driven
- Need to mandate that agencies collect baseline data not just scramble to get information on a project by project basis—NOAA and USFWS need to be responsible for this with other agencies as appropriate
    - Budget to complete this work via passive acoustics is in the tens of millions of dollars
- Defining the n-dimensional space

**(5) <u>Non-Behavioral Responses to Sound</u>**

- **Should there be an increased focus on the effects of noise stress and immune function studies? If yes, keeping in mind both acute and long-term exposures, what are the most important studies that should be conducted and why?**
- **What are the most important data gaps in our understanding of how to best assess specific types of non-auditory tissue damage in animals exposed to**

**anthropogenic sound? Why and, separately, will they directly inform current management decisions?**

**What are the most important data gaps in our understanding of how to best assess auditory tissue fatigue/damage in animals exposed to anthropogenic sound? Why and will they directly inform current management decisions?**

**If there are other important issues under this topic, please address those also.**

*TABLE 1*

**Should there be an increased focus on the effects of noise stress and immune function studies? If yes, keeping in mind both acute and long-term exposures, what are the most important studies that should be conducted and why?**

- Non-behavioral data can be more objective than behavioral data. More tractable data sets.
- Most important work: immune function assays, reproductive function, metabolomic assays, cardiac rate, gene expression or gene regulation related to stress.
- Quantifying the relationship between the stressor and the stress response can be difficult.
- SPAWAR is conducting a lot of this research already. We should take advantage of these data sets.

**What are the most important data gaps in our understanding of how to best assess specific types of non-auditory tissue damage in animals exposed to anthropogenic sound? Why and, separately, will they directly inform current management decisions?**

- Most important data gap is not having the appropriate baseline data. However, we not only need good quality baseline data, but it is critical to have the justification studies as well.
- Creating partnerships to fill the data gaps is important.
- Transfer studies would help bridge the data gap. The challenge is to compare captured animals to free-ranging pelagic animals, applying the same biomarkers.
- The group agreed that the use of existing technologies would help fill these data gaps, such as D-tags.
- Captive studies (e.g., looking at physiological parameters), may provide an adequate control.

**What are the most important data gaps in our understanding of how to best assess auditory tissue fatigue/damage in animals exposed to anthropogenic sound? Why and will they directly inform current management decisions?**

- The number of animals studied and small sample sizes. Many animals are overtrained.
- Multiple impulse exposures are also problematic for determining impacts to anthropogenic sound.
- Piscine studies are also important for baseline habitat assessments and predator / prey studies. Important for indirect affects analyses.

**(6) <u>Biologically Significant Impacts</u>**

**What is a biologically significant impact (to an individual or a population)? How is it quantitatively identified?**

- **How do we realistically and consistently determine which effects may be discounted as insignificant in a decision-making context?**
- **How well do the NRC recommendations regarding effects on foraging, survival, and reproduction match the available data on behavioral effects? Are these the correct criteria for the determination of biologically significant impacts?**
- **Are there particular contextual factors about sound exposure (e.g., similarity of sounds to those of predators) that are more likely to result in biologically significant impacts?**

**If there are other important issues under this topic, please address those also.**

Consensus: "At the level of individual animals, changes in current and expected future reproductive success would determine biological significance; at the level of populations, changes in growth rate (lambda or r), variance in growth rate, etc. would determine biological significance. In both cases, the magnitude and direction of the change are biologically tractable; whether the change exceeds some management threshold is a policy decision."

*Note: The two converge at smaller populations; as the species becomes closer to an endangered status.

Point of Discussion

- Measures of population abundance are valuable but not explicitly necessary; we can measure proxies of population status (calving rates, mortality, juvenile to adult survival, etc.). What is needed is a comprehensive or in-depth assessment of the population, essential biological parameters and its trends (Note--there are feasibility issues that need to be considered—'contextual' in terms of species biology for example)
- It's important that we incorporate both acute and chronic effects in the analysis of the impact. For example, repetitive acute events will have chronic effects.

*Contextual factors that are more likely to result in significant impacts?*

Points of Discussion

- Relevant to the population
    - Size: Small population loss of an individual may be determined to be significant whereas in a larger population this loss may be 'insignificant'.
    - Insular/localized population: Does it spend all of its time in proximity to a given acoustic stressor, versus a population with a large distribution/range.

    - Whether the population is already 'stressed': Is prey availability high/low (El Nino/La Nina); other anthropogenic stressors such as sounds, contaminants, directed harvest, fisheries take/bycatch, competition, or predation risk.
- Relevant to the individual
    - Life history stage (juvenile vs mother with a calf, vs a male, etc.)
    - Immune status
    - Behavioral status (migrating, breeding, feeding, etc.)

*What do we need to improve these evaluation processes?*

- Point of Discussion: **"Is it not worth it to spend some money to evaluate those species that have existing technologies to evaluate at this time?"**
- If we focus our assets on a species with existing models, we can then maybe apply to other parameters or to some extent species. Some technologies and modeling practices apply now, some need Improvement, some need development.
- ***"Multiple lines of evidence in an integrated framework are essential.***
- ***Not just tagging…Not just genetics…Not just acoustics…it's the whole package."***
- Tremendous opportunity for determining parameters for a population or species ala BRS. Augmented through time set the stage to address biological significance on multiple species

*TABLE 10*

- Things that determine biological significance impacts:
    - Acute effects (strandings, etc.)
    - Additional activities and conditions would include cumulative impacts
- Critical seasons and habitat of species
- Duration of activities and overlap with critical season or habitats
- Any affects on reproduction or survival
- Psychological impacts (disagreed)
- Acute effects (strandings, etc.)
- Masking (insofar as it effects foraging, reproduction, survival, etc.)
- How do we determine which effects are insignificant?
        - You would need to conclude it had no effect on reproduction and lifespan distribution.
    - Best tool is a long-term, broad study of a population of known individuals (monitoring). Without this, data is not reliable.
    - Because it could take so long to determine a population effect is insignificant, precaution in management decisions is essential.
- How well do Are the NRC recommendations on effects on foraging survival and reproduction the correct criteria for determination of biologically significant impacts?

        - The group decided yes. Even masking should be evaluated in terms of broader behavioral effects.
- Contextual factors about sound exposure likely to cause biologically significant impacts?
        - Contextual factors can cause significant impacts including acute responses, or long-term effects such as habituation or sensitization. Impacts can also depend on the particular marine mammal species.
- Other issues -- Tools for regulators to address these issues were difficult to identify.
- Brief discussion of question 2 re standardized marine mammal data bases
        - All publicly funded sighting and effort data from surveys needs to be made available through (NOAA and BOEMRE)

DETAILED NOTES

SESSION A

**(1) <u>Basic Biological Research for Representative Marine Mammal Species</u>**

**Many reports have listed areas where we are missing important *basic* physiological, behavioral (baseline), density/distribution, and longitudinal life history data for representative marine species (such as common species) and key species (ESA-listed and sound sensitive species, i.e., those that seem to react to sound at comparatively lower received levels or are historically more likely to be associated with strandings).**

- **What are the most important basic biological data needs for better understanding and management of biologically significant effects of exposure to sound that need to be met in the next 2-3 years?**
    - **Why?**
    - **Who should perform these studies, what are the cost estimates and how will they be funded?**
    - **How long is it likely to take to meet these most important data needs at a level of resolution/certainty required for management, i.e., can they be accomplished with one discrete study or will they necessitate long-term governmental support to be useful to management (show variation over seasons/larger areas etc.)?**
    - **If these essential data gaps were not bridged in the near future due to lack of funding or governmental investment, what are some options for resource agencies to manage species conservatively in the face of the specific types of uncertainty that these data gaps generate?**

*TABLE 1*

**Why?**

- Dave M. last slide, understanding the health of the population, tend to define status of an individual in density and numbers, distribution and abundance
- **Recommendation to reconconsider the definition of status of status of a population and this needs to be considered part of the baseline,**
- We focus on quantitative, not a bad thing, need to focus on the qualitative, health, reproductive status, immune status, health parameters/indices (blubber thickness, demographics, health assessments, reproductive hormones in fecal samples, hormonal assays from blood)
- Consider the context
- What do we know and where do we start,\
- Important biological need is what the baseline data,

**Who should perform these studies, what are the cost estimates and how will they be funded?**

- 

**How long is it likely to take to meet these most important data needs at a level of resolution/certainty required for management, i.e., can they be accomplished with one discrete study or will they necessitate long-term governmental support to be useful to management (show variation over seasons/larger areas etc.)?**

- This is ongoing
- Climate change will affect animals responses to the next stressor, no one study at one time will do
- Health and Stranding Workshop, this discussion will link into their previous efforts,
- Try to find synergies with other efforts to achieve this data synthesis

**If these essential data gaps were not bridged in the near future due to lack of funding or governmental investment, what are some options for resource agencies to manage species conservatively in the face of the specific types of uncertainty that these data gaps generate?**

- Learning what needs to be done in the long-term, but the recommendations will be more short-term,
- Understand what the acoustic problems are before we can link to population
- What are the assaults on the population?
- Baseline data, what is the measure of variability within the data, you might have a response, but is it negative, biologically significant.
- Importance of habitat is important to assess, is the response do to exposure, or to a lack of resources in the area,
- **Baseline data must include basic information about the habitat, important to assess the acoustic reality of an area, ambient analysis first before making coastal associations. Baseline acoustic budget first, then layer the anthropogenic impacts over this for coastal assessments**
- Need to set the direction for obtaining sound budgets in the environment, obtain baseline data on the physiological condition of the animals,
- Questions of significant biological affects, some things are measuring at a lower resolution than others,
- If there is a response, we are good at measuring responses comparatively but not good at interpreting data, especially when the animals leave the study area, plays into evaluation of biologically significant effects, this could be a research project
- If the animal responds and the impact disrupts normal functions, this constitutes harassment, we have to use the precautionary approach and assume it is a bad thing
- If you increase the risk for certain populations for ship strikes, if you lower your ships, signal-to-noise ratio could influence the

- Habitat, one of the strengths of the MMPA is that it talks to the impact of the healthy environment**, defining the baselines for habitat** is consistent with the tenets of the MMPA, habitat baseline is the most important data
- Should we focus on hotspots, concern that today's hotspots are not tomorrow's hotspots,
- Provide a framework to provide info for identifying hotspots, anthropogenic hotspots,
- A lot of our work is identifying vulnerable areas, Arctic is high on the list, are there other areas that are vulnerable to several impacts, but are data poor.
- We face the same in countries outside the US. Trying to acoustically map, use the sensors from geophysicists to focus on marine mammals, calibrate what should be done in hotspots, develop the tools and technologies, to develop acoustic budgets. We can now make comparisons for future studies.
- Cost: use efficiencies of exisiting platforms to convice the scientist to use for conducting assessments,
- More efficiencies of using the existing ocean observing systems, linkages with existing observatories, neutrino research, national agreements, piggy-backing on industry, sharing/coupling with offshore renewable energy infrastructure
- Europeans are now using windmills to track this, you will have noise generated by the platform, you will need to take this into account, will not invalidate the information, will limit the range of detection of vocalizing animals,
- Habitat: qualifying predator/prey interactions, affects of sound on prey species and its effects on predators,
- Do we understand the effects of MFA on stranding effects, are these hotspots that we should concentrate, we need more cases to understand the trend with the five stranding events,
- A UME are these areas that we should focus? Have been focused on offshore environments and deep diving species, sublethal effects of chronic multiple species of noise, too focused on military and oil and gas, ignoring inshore environmental.
- Globally the effects the effects of sound on marine mammals are less than than incidental take of MM in commercial fishing, look at the body count,
- Roger Gentry's slide on MM deaths to sound vs commercial fishing
- We don't know the cumulative effects of sound on MM health (reproductive, immune, body status)
- For noise, sublethal impacts, we don't have a focused effort such as those for bycatch and take reduction teams,
- Concentrate on transition areas, subarctic, really loud areas with very little anthropogenic effects, in addition to nearshore environments, some of these environments area very loud, put the acoustic environment into a proper context,
- The Arctic and subArctic is a key area, a new area, an area with priority focus research areas,
- Research into exposure analysis, *but we need the baseline data first, using emerging technologies and available resources, we have good longitudinal data*

*on multiple populations affected by different stressors* and comparative data to start these approaches, we have these resources to build upon

- Baseline studies: NOAA is a logical choice, but if the Navy is doing this research, should it be incumbent on the stakeholder, much data exists that cannot be shared, cannot be integrated,
- *Long-term: Are the NMS a point to start, existing laboratories, many are close to the Navy range complexes, concurrent studies in both the Range complex and the NMS. Comparitive studies, will give a good baseline, good joint project for NOAA/Navy*
- *Short Term: Good opportunity to link with NSF OOI with no cost to use existing systems, NEPTUNE Canada is giving excellent results, at very little cost. Ask for funding to conduct pilot studies in areas without these observatories.*
- Do not ignore the cost of analysis and data overload of other species, data storage, these costs must be factored into a budget
- Partnerships are important, no one group is the centerpoint, transparency is important, how to identify these partnerships and data sharing opportunities is key,
- A lot of the questions have been applied, rather than academic, the trajectory is on the right direction.
- Europe: Able to run analysis, available tools if they get data stream in real time, once they know the ambient noise, they can conduct better analyses.
- Issues with permits with existing research on directed research on marine mammals, working with military, filtering out sensitive data,

*TABLE 3*

- From research perspective, start with what species are you interested in? drives some of research
- Also need to look at effects on fish, squid, prey items. Short term, long term. Advantage of monitoring prey abundance – NMFS already monitors for commercial fisheries.
- for beaked whales, information on deep water currents for use in predictive models as opposed to currently available surface information.
- Fisherman can estimate location of target species based on environmental data
- NMFS doesn't often use environmental data in assessments
- Need predictive tools to look at population level effects
- Should be more conservative when data are lacking – sub-populations may be affected to greater extent. Need to know what animals will be affected before assuming affects to species.
- Sub-species designations are not always in the best interest of the community that uses the resource [disagreement here]. Taxonomic "grey area" (e.g. Southern Resident killer whales) in defining species. Question of what you are trying to protect – species, sub-species, individual?

*TABLE 4*

- The group raised questions that need to be answered with baseline data: What species are out there? Where are there and why are they there?
- The more data we have, the more predictive modeling we can do in similar areas (with field verification)
- Need for long-term acoustic data collection within a set location (e.g. Naval ranges)
- Need more methods of identifying species
- There is lots of focus on data-gathering and the accumulation of data, but then what happens?
    - How does/how should data get assimilated and applied?
    - Equal investment is needed between the data and the model
    - Need to integrate all the existing databases into a centralized location
- Need for collaboration of resources among agencies, academics, institutions, etc.
- A basic science approach is the best way to answer all the unanswered questions – give researchers the money to go and do studies and they'll discover "nuggets" of information naturally
    - This isn't practical and isn't how funding is distributed
- There is a need to properly identify the problem we're trying to solve and adequately voice the problem to the general public (and funders) to get them excited/involved
- Group agreed that actually creating a "list" of answers to all these questions isn't possible, especially in a single afternoon

*TABLE 5*

Bullet 1:

- Basic distribution studies.
- Habitat utilization: how are the animals using the habitat
    - This provides a better idea of acoustic disturbance
- Reproductive rates and mortality rates
- Species specific data (ranges)
- Different responses to sound at depth as opposed to surface (while foraging)
- Behavioral and stress responses at surface and depth
- Shipping noise, habitat degradation (passive)
    - How do species capture their prey?, does shipping noise (etc) effect the hunting tactics
    - Sensory utilization of the environment
- Level of ambient noise
    - Animal may be less vocal if more quiet
- Prey species and how affected by shipping noise

Bullet 2

- We will perform these studies

- We advocate joint funding from all stakeholders to fun these studies
- Studies should be conducted over open file-sharing
- Funded by whoever wants the data
- In addition to data sharing, there needs to be places where the data is managed, ie OBIS

Bullet 3

- Most all of these are going to be long-term studies, particularly
    - Habitat utilization
    - Basic distribution
    - Reproductive levels
- Some studies could be shorter term particularly those with very little data collected previously
    - Prey species studies…

Bullet 4

- European countries are collecting their data together so all data areas are covered (ie distribution, abundance)
- Do no harm first
- Use best available data (NEPA)
- Management action: do nothing

*TABLE 7*

- Stock assessments
    - NOAA needs more funding for regular studies
    - Structure/populations dynamics
    - Seasonality
    - Needed for quanitifying impacts
    - Limited info with respect to deep water species
    - Most current stock assessements state that data old and needs to be updated
    - Navy and NOAA rely too much on survey data for population/stock structure
        - Need to invest in long-term studies to address impacts on populations
        - Additional research tools include:
            - Photo-ID
            - Biopsy
            - Tagging
            - Passive acoustic monitoring
        - NOAA Needs to prioritize stock or populations to focus resources
            - Where are navy conducting exercises?
            - Where are seismic studies?
            - Gulf of Mexico (in hindsight)

            - Internal challenges to dedicating resources within respsonsible agencies must be dealt with
- Example: AMAPPS
    - Multi agency action across seasons using multiple platforms
    - Detailed info on finer scale sites
    - Broad distribution info on species
- Reality of getting better research
    - Recommend broadening of data gathering capabilities above what we have already
    - Don't have good grasp of societies of animals – they are social creatures
    - Help expand knowledge of behavioral ecology
    - Need to make decisions on particular species – prioritize because we can't study everything
        - Prioritize locations as starting point, and then species (listing status?)
- Funding
    - Concerns with funding my outside entities because of restrictions on use of data (liability issues)
    - NRDA funding process
    - Chain of custody issues
    - How do you get user groups to contribute to research before a disaster?
        - Agencies can motivate to some degree or collaborate
            - Ex. studies program
        - JIPs – Joint Industry Program
            - Industry funded and controlled
        - 3rd party contributory entity that distributes funding
            - Industry contributes to fund proactively, but does not control distribution
            - Goal: Collect baseline data in case disaster happens, even if it does not, but then you have it if it does
            - Would this require legislation
            - 3rd party decides what gets funded
        - Examples of existing 3rd party funding sources
            - NOPP – National Oceanagraphic Partnership Program
                - Needs to be "tweaked"
                - Not distributed in prioritized way discussed
                - Agencies have not identified priorities
                - Government mechanism – need to be independent
                - Could be opened up
            - NFWF- national fish and wildlife fund
                - Mixed experiences
                - Mechanisms establishing it don't seem capable of dealing with restrictions on giving and receiving funds
                - Long-term process to apply to receive funds
                - Funding for graduate student studies effective

        - With respect to funding – source matters because of public perception
    - Baseline data and sources of funding/research
        - Recommend navy and others look down the line to get correct baseline data
        - Navy funding studies for baseline data in study areas of concern
            - Problem: Contracts may prohibit researcher access to data
            - How far in advance of Navy activities?
                - Ex. Guam – little info and funding to determine what is there before exercise conducted
        - Who owns data if Navy funds research?
            - Goes both ways – sometimes Navy can't get access to data from studies they funded
    - Outside funding and ownership of data
        - Who owns data if study funded by 3rd party?
            - Concerns that researcher won't be able to use data collected
            - Concerns that 3rd party won't have access to data collected by researcher
        - Contract should provide timeline for researcher who collected data to use it before it becomes available to anyone
        - Independent data collection and write up by researcher, and available to anyone within a specified time period
        - Can regulatory agencies require research to be conducted in open and transparent way?
            - ESA section 7 terms and conditions
            - MMPA mitigation and monitoring
    - Datagaps: How to identify and address?
        - What do managers do in light of limited data
        - Disconnect between science and managers needs to be improved
        - No feedback mechanism for prioritizing in decision making process
            - Needs to be built into process
        - Need more transparency about what federal agencies are doing
            - Look at Gulf of Mexico today
                - Place where someone knows who is doing what and where they are doing it
        - MMC role
            - First agency to look for guidance
            - Can MMC or another agency provide oversight?
            - Get info on anthropogenic activities (noise)
            - Identify priority marine mammals based on anthropogentic database
            - Coordinate to make sure efforts are not duplicated
        - Don't reinvent the wheel if mechanism already exists – just push: MMS Example: Multipurpose Marine Cadastre Planning
            - Inventories human activities – shipping lanes, platforms

            - Marine habitats
        - Addressing datagaps has logical tie-in to Marine Spatial Planning initiative
    - NMFS and Navy reporting
        - NMFS requires Navy to keep track of sonar activities that do not provide useful data on impacts
        - Needs to be better effort on industry or navy to detail record of where sound sources used and when
        - Navy and contractors need to draft contract that includes terms providing contractors with access to secure data and go though security clearance
        - Data collected and maintained must be collected in robust fashion
        - In terms of seismic – nav tapes provide where shots occur
            - Know exactly where and when
            - Need to evaluate data for lease sales
- Why important to stop talking and start taking action: GoM
    - More preventative and less reactive
    - Need to get this done before another disaster occurs
    - Concerned about keeping momentum moving forward
    - Will GoM be the event that pushes agencies to fund stock assessments?
    - Opportunities to fix and improve things and hope that if GoM can't get changes then nothing will
    - Worst case scenario analyzed in NEPA documents has occurred and cannot be disregarded
- Arctic example
    - Agency uncomfortable with permitting industry action
    - What does agency need to know?
        - Anthropogenic activities
        - Collect baseline data – how much is enough?
            - Need 3 years data minimum and 5 years for marine mammals
            - Need to repeat process for several cycles
- Basic data timelines
    - Researchers need to come up with appropriate metrics for data within time periods
        - Getting beyond the point of always needing to know more
        - Models and statistics provide that capabilities
    - Need to be realistic with time dedicated to research
    - Long-term studies needed for marine mammals because they live a long time
    - Concern with cumulative effects and other factors
    - What are the population level effects need to be able to identify populations?
    - Social interactions/seasonality
        - Different activities are impacted differently

    - Can there be a moratorium on research/activities until baseline studies completed?
        - Won't be able to get that for all activities, but might be able to plateau activities in certain areas
        - May be places where activities could be reduced
        - Protect areas where little activity and lots of productivity = Marine Protected Areas
- Recommendation – NOAA sanctuaries est system of MPA
    - Summarize human use – completed in CA and goal to complete elsewhere

*TABLE 9*

- Some of the costs are addressed in the JSOST report without exact figures
- Concern with the usage of "representative mm spp"-by vocalization range, threatened, or many other binning approaches; can certain spp be representative or are they actually really independent/spp specific
    - Need to define "representative species"
        - 1994 NRC report is the original source
        - what you can get to/what data you have sometimes is the default
        - focus on spp that are data rich--sometimes this corresponds with rep spp/spp of concern like N Atlantic right whales
        - raised issue of caution: case example of LFA didn't concern themselves with beaked whales when they are actually sensitive to mid-frequencies
        - a toothed whale is not a toothed whale- there are small subdivisions
        - is hearing specialty groups a good division point?
        - Phylogentic, function, sensitivity-potential division categories
        - Emerging data on connecting phylogeny to functional hearing (esp for delphinids)
        - Behavioral sensitivity is more meaningful for management/ ESA issues while scientifically phylogenic makes sense
        - Navy has to consider geographic issues too (nearshore vs offshore); low hanging fruit (ie which has a bunch of data) vs what is the right spp to use as representative (put more money into)
        - Relative shyness of animals around boats
        - Is it data gathering or lack of funding the root of the problem in getting differing spp data
            - Surprised at how little data is still known about Arctic spp
            - Lots of big data gaps still persist—general ecology, baselines, behavior
            - The "representative" ones are the most accessible
    - Are beaked whales a good spp to look into?
        - ESA listed spp, phylogenic group even if you don't know that they are sensitive already, spp that make up the large proportion of the takes (eg pelagic delphinids for navy

activity), spp where you have a big body of data for (terciops)

- Sometimes the data collected is based on where the best platforms are
- There is some **baseline** info we need to do better at across the board, not just spp specific (eg how many out there, where they are and when)
    - The higher level questions will have to come later
    - Baseline data is crucial to the foundation of other areas of research as well including climate impacts
    - Bowhead and right whales have the longest history in baseline data (bc subsistence and MMPA requirements- at least for bowheads)
        - But this population has a lot of change it is encountering w ice conditions so hard to not confound change with those other factors
        - Move away from individual's response to the whole population's response perhaps?
    - N atlantic right whale is a bad example since it is so depleted—need something that is more representative of issues facing other spp instead of showing the what we are trying to avoid/the worst
    - Point of contention—need to study both
    - Group by certain factors (e.g. behavior, hearing, life history characteristics) instead of just by level of endangerment
- Precedence is given to spp of concern (at the agencies)-ESA and MMPA
    - Political reality-will be easier to get money for sperm whales in gulf after the spill
- 3 categories of research: Basic research on density/distribution, behavioral ecology (small # of animal observations), behavioral responses to sound (eg for behavioral risk function)
- might need to look at spp based on level of exposure (MMS is headed this way too now with its research)
- captive studies to systematically check hearing capability which is not possible in the field
    - but this is complicated by the properties of certain bodies
    - there are more sensors in the arctic now than other areas
    - strong argument for passive acoustics as a tool (doesn't matter what time of day, natural and anthropogenic conditions are documented)
- this data collection takes a long amount of time (more than 2-3 years) and takes a lot of money
- CMSP can be used to motivate people to do the research (Boston TSS example)

        - Which should come first, space designation or looking at the species movement as a whole?—general sentiment that it should be a combination of both
        - MMS first looks at the space and Navy is concerned with just space too-if it goes outside, they don't care
    - Social structure, phylogeny, foraging ecology, functional hearing groups, biological sensitivity, especially sensitive/shy species-cryptic, predator-prey dynamics, migratory behavior, conservation status (pop size, size of range, stock trends, legislative protection)
    - Better, greater volumes of data creates more opportunities for research
    - The information that we have now is good enough to do mitigation?-point of contention
    - Sub-bullet #3-how long is it going to take—
        - How do you elect to spend your $-on one big study, on a specific area
        - Maybe do in captivity first and then verify in the wild (or other stepwise bridges to getting the information)—verify the kinds of methods on accessible spp and then go to inaccessible
    - NRC has addressed the issue of representative spp-temporal resolution, masking, tts, etc
    - Need to look at individuals since reduction of take is an important issue
    - CA project-picked baleen whales since there hasn't been data collected on them
    - Need to tie NMFS/other baseline collection groups to the CMSP so then you will get more funding
    - NOAA is mandated to get the baseline information Congressionally
    - Problem since projects are short term and then are over so you don't really get the baseline
        - Secondary issue of discrepancy of getting the appropriate quality/level of data
        - Need to urge groups that they need to get this baseline data
- Need to mandate that agencies collect baseline data not just scramble to get information on a project by project basis—NOAA and USFWS need to be responsible for this with other agencies as appropriate
    - Budget has been the primary problem
    - $10sM nationally get the data from passive acoustics
    - example of Atlantic research-collaboration
    - collate the information and standardizing it so it is more accessible
    - Navy, MMS, industry should be responsible for acoustic effects on MM
    - There has been a NOAA plan (ocean observatory) available for the last 5 years, it just hasn't been implemented

        - Area based with a species focus---tend to be focused around sanctuaries
    - Need a two tiered group—one for budget , and one for staffing on what needs to get done
    - GOMEX is a great example of what could be possible if we had had data
    - Acoustic observatories should be closely tied to stock assessments, etc

Costs, jsost, utililty, nrc recommendations, ecosystem based, natural resource damage assement

- Need to stop looking at the 2-3 year horizon regarding the baseline data, ongoing instead
- Behavioral ecology falls between the cracks?
- Use the NPS approach—Soundscapes--- as a model
- Half the battle is getting the $
- Ship noise falls into the Navy's purview (propagation, classification)
- Issue of pile driving for a year, how would that fall into baseline vs applied research categories
- NOAA Ecological Passive Acoustic Plan--5 years / $37M
- SLIMROD project (Navy)-id navy research priorities--- March 25
- Need greater transparency and need to the permit office to communicate more effectively so that researchers are doing what managers need to inform their decisions
- Try for a standardized application, unified set of goals across agencies

**(2) <u>Standardized Marine Mammal and Sound Database(s)</u>**

**There have been many discussions about creating a standardized marine mammal database and requiring that all parties/agencies holding permits or authorizations be required to electronically enter any data collected into that government-run database. This data could then be systematically archived, analyzed, and made available to resource managers, researchers, and the public. Without getting into a discussion of who should fund this and which government agency would house it (although, with the intent of informing these issues) please consider the following:**

- **What are some of the logistical needs to make this happen (e.g., data clearance/proprietary issues, communication among agencies with access to data and/or expertise in managing data etc.)?**
- **As a potential user of this database, how would you use this resource if it existed (e.g., all visual sightings made during construction projects in Puget Sound over 10 years, sound source verification data from Arctic oil and gas seismic vessels) in research and/or environmental impact assessment contexts?**
- **How could these types of data be integrated with (or used in meta analyses with) more standardized or systematically collected data to inform understanding of distribution, abundance, and/or behavior?**

- **In light of your responses to the last 3 bullets, list the high-priority issues that need to be taken into consideration in the development of a standardized database to maximize its utility.**
- **Some government agencies may have existing but currently under-utilized datasets that could be made available to aid in the analysis of biologically significant effects of sound exposure. List any these datasets (of marine mammal data) that you are aware of, by agency, and indicate what type of data (e.g., basic information on distribution or abundance, data on potential effects, sound source characterization data) is contained in the dataset, as well as the general format and standardization of raw and metadata. What needs to happen to make the data more readily available (e.g., are certain protocols existing, or necessary to design)?**

**If there are other important issues under this topic, please address those also.**

*TABLE _*

- A significant issue is that much data, particularly distribution information and effects data, is simply 'sitting around' in raw form, with researchers unwilling to disseminate due to concerns about potential misuse.
- Questions associated with this roadblock: how raw can disseminated data be? Should we set rules as to what can go in a database? Different institutions are more or less willing to contribute information if standards and safeguards are instituted.
- One way to overcome this difficulty is to qualify the data through hierarchical ranking of 'quality', or degree of processing.
- BOEM is currently capturing industry observer data and is databasing and making accessible; in use for programmatic EIS.
- It would be necessary to use such a data hierarchy to account for the differing types of MMO data collected, i.e., opportunistic data vs. aerial survey; raw sighting data or observations weighted by effort and conditions.
- Data sharing is an issue. We need to figure out what needs to go into an accessible database and also to figure out reasonable timelines for data access to allow researchers time for proprietary utilization.
- There is a need for some centralized observational database with protocols for regulation, a semi-real time queryable web of sites; e.g., OBIS-SEAMAP but linked to more specialized sites.
- Distributable tools for query, such as those used for Cornell bird databases, do currently exist.
- The form that individual databases might take will need to be context dependent. The priority should be distribution and density information.

- It would be worthwhile to contract someone to research all databases and methods of accessing them. We should probably be using only new data, rather than mining old sources.
- We can think of databases in two ways – opportunistic vs. historical databases, entered within 1-2 yrs and made reasonably accessible.
- A sophisticated level of analysis is required to take contributed data and derive something reasonably useful; a different type of analytical process is required for survey data as opposed to opportunistic data.
- Is it better to spit out raw sightings and effort data or to give a product such as density for blocks – and how do you deliver it? Data gatherers are reticent to have others analyze data, but would likely turn it over to those trusted entities.
- Most will need analyzed products at some level.
    - Some minimal processing done by contributor necessary at level of individual dataset
    - Requires significant input of resources, perhaps through contract
    - Often, people don't really know what they are looking for which is again difficulty with getting people to contribute data, i.e., contributors fear misuse
    - Ground rules on two ends – database accessed by portal and datasets contributed into a given database
    - Funders should require that data be made accessible to databases
    - What is the product of a given database? In terms of getting data in, there should be some validation process and screening.
    - How far back should database go? Only new data, or do we mine historical data? Is historical data relevant to management decisions being made now? Yes, in context of long-term trends, or when it is the best there is.
    - Put together what is available now before assessing what is needed from historical data; could integrate databases housing older data by reference – stranding database would be an accessible link
    - Wait and see what inventory gets you before determining what historical data is needed; alternative proposed is that where there are gaps, do not try and bring in data from older than 8-10 years, as utility of data is diminished beyond this window

*TABLE 8*

- Currently there are numerous databases supplying sound clips (e.g., for identification/educational purposes) and abundance data but none that aid in impact assessments or effectiveness of mitigation.
- Mobee Sound website: Library of species sounds
- Cornell's MaCally: Animal library huge repository
- Ocean Conservation Research: user of animal sounds for tourists pole to pole
- OBIS Seamap/OBIS USA

- BioAcoustic Research Network: in progress (not yet available) by Cornell; will be able to sort clips and utilize GIS interface

Why is a system needed –

- Difficult to find and access data
- Time consuming for researchers/staff to provide data
- Quality assurance inconsistent
- Constraints amount of data and space to store
- Integrate data with visual databases to better understand distribution, abundance and behavior.
- Allows for long term storage (e.g., can be used after PI is long gone)

SYSTEM NEEDED TO RETAIN AND USE DATA (don't invent a new system): Pick an existing system for a model; two methods (decentralized system preferred by our group)

- CENTRALIZED SYSTEM: The potentially data Interface tool suggested is OBIS USA with a system that judges quality assurance of data and gives the means to access the data. OBIS USA is a visual sighting system (geographically organized) maintained by the federal government via a USGS server has biological data for standardized input. Archive NODC will potentially maintain the system for acoustic data for retrievable data (seed bank). This would need to adhere to OBIS USA standards and contracts for research needs to be written to require acoustic data be deposited on OBUS.
- DECENTRALIZED SYSTEM: May be better to have an alternate gateway that will take the user to many different data repository. First portal would have metadata, then various filters link to repositories. Example of something in the works to hold data like BARN (Bio-Acoustic Resource Network) MMS project at Cornell
- Any system should have GIS interface
- Agencies and contractors doing studies should be required enter data to the system
- Activities requiring permits that includes monitoring of acoustic data should be required to be entered into the data system
- Example protocol (currently for visual sighting data): Submit data to OBIS USA- data quality assurance test conducted- OBIS USA sends data to NODC for storage- NODC classifies data (e.g., opportunistic vs. survey vs. monitoring; hobbyist vs. Agency). User can flag suspicious data.
- Challenges: potential volume of data; only as good as those that import it (data quality issues)

DATA CLEARNACE AND PROPRIETY ISSUES:

- Publicly available especially if government sponsored data base. Via Requirements through Journals, and can be a requirement. Biological acoustic data should be required from industry where permits. Timing: If there is a question of fishing and whaling using data for harvest, then possibly 2 to 3 year delays before public available.

**(3) <u>Predictive Tools for Density/Distribution Estimation</u>**

- **What existing tools (or tools in development) can be effectively used to estimate/predict marine mammal density and distribution for under-surveyed areas of the world's oceans? What oceanographic, biological, and other environmental features (if any) are effectively considered in these predictive tools?**
- **Can we systematically identify specific sets of circumstances in which the use of these sorts of tools would be expected to be either more or less likely to result in accurate results?**
- **What should be done to achieve standardized applications and acceptance for these tools?**
- **What are the pros and cons of incorporating such tools into a standardized national system that would be applied in management decisions (such as the one contemplated for housing all marine mammal monitoring data).**

**If there are other important issues under this topic, please address those also.**

*TABLE 3*

**What's the role of stock assessments?**

- Past looking at individual effects, in future need to look at effects to population.

**Should that be the starting point?**

- SARs are derived from available information, including predictive tools.

**What tools exist?**

- Line transect surveys (fisheries driven in NMFS)
  - Baseline data missing for many areas & species
  - Cost of line transects relative to other tools? Vessels and aircraft primary costs. East coast has money for (right whale) surveys. Real time surveys are monitoring, not research.
  - Navy marine mammal program can conduct activities at lower cost than charters because flights and ships are already out
    - But hard to get MMOs, etc on platform – contracts are logistically easier.
  - Value of line transects depends on location and species for useable datasets – need other options. E.g., little value to beaked whale surveys

because chance of seeing them is very low. Also don't know what stock animals belong to in visual surveys.

- Arctic surveys –strong population data for bowheads. NOAA developed model to translate pop data to movements of animals & estimate acoustic takes
    - Population data from shore-based monitoring (20+ years of data)
    - To strengthen population estimates for bowheads, using acoustic surveys done by oil companies – bowheads silent during seismic surveys – acoustic surveys done when seismic surveys are absent could help. Surveys provide presence/absence data
    - Use long-term satellite Tagging data to understand movement of species and help refine population estimates

- Satellite tags one of best tools for info on where species are when we can't see them. Expensive, hard to deploy, small sample size. As more are used, higher sample size.
- Rigt whale seasonality gives opportunity to focus effort during known seasons. Other environmental sampling concurrent (e.g. zooplankton) – need to be used with other species? In remote areas, detailed species information doesn't exist. Satelites can measure chlorophil, but with cloud cover can't get data. In deep water, also lacking data.
- Offshore data more difficult to get, deep water data more difficult to get
- Need to count exposure rates with no density estimates – how to do this? What information to use?
- Lack money, time, manpower to get population density estimates for all locations
- Passive acoustic monitoring requires call rates, need to associate vocal behavior with animal behavior, how it's associated with movement. 3 methods to estimate densities of beaked whales with large numbers of fixed sensors – have very good basic data on diving behavior, vocalizations and rates, group size. Understanding of vocal behavior good. Those data are needed to estimate density.
- Estimates based on visual or acoustic data vs. estimates based on bathymetry, knowledge of species in similar environmental areas – predict what species will be there.
- Use predictive habitat models
- Population estimates based on small sample sizes
- Predictive models should be ground-truthed before used for management
- Brandon's beluga example – same species in 3 circumstances, very different responses. predictions difficult to make, should be used with caution

**What predictive models exist**

- SERDP

**What do you do when you don't have data?**

  - Use SAR or habitat model when available
  - What is best available data – SAR with limited data or predictive model?
  - Density is necessary to determine number of exposures – to run models
- Monitoring results from seismic activity – some density data were obtainied during seismic activity – opportunistic. Don't always want observers to obtain scientific data, want them to mitigate. In these cases, predictive models might be better than existing data. What is required by statute vs. what industry will voluntarily do. Need a program built around this
- Has there been a blind comparison between predictive models for quality control?
- For acceptance, require prediction in unknown area, then follow-up with physical survey to verify?
- Probably unlikely to happen.
- Discussion about different species, level a and level b takes

- Observer data while in transit with acoustic source off would be useful for abundance data, but with source on might not be useful data. Opportunistic data not as good as dedicated surveys, but a good starting point.
  - Seismic
  - Coast Guard
  - Navy
- Platforms of opportunity sighting programs (coast guard) – if reporting sightings but not trained MMOs, how valuable is the data? If can't identify species but can describe what they saw, can be helpful.
- National system
- CONS
- Some large databases not accepted by peer-review as a dataset,
- lacks quality control,
- no standardization for monitoring
- methodology varies for surveys
- PROS - More data in centralized database that adheres to set standards worthwile
- Rather see original data collectors well-funded to collect and analyze data?
- Much data is collected, no one to analyze
- Protected species database program in works for mitigation and monitoring
- Would include training on how to collect data – NMFS approved protected species observers, structured differently from fisheries observer program; consistent training and data collection; uses seismic surveys as a model

- Industry driven data sets acceptable to have user fee
- How to standardize data that is used, not just data that exists?
- Standardize inputs to models
- Or standardize tools used to collect data and predict? If one tool is not applicable, move to another? Needs to be contextual and region-specific, one system won't work for all situations. Define models for regions? Or build in confidence interval when don't know? Current models have ability to create prediction that includes depths, groups of animals IF data exists to input.
- Is the community ready for standardized system? Are tools refined enough to make decisions on which ones to use? Much info can be used for distribution but not plugged into predictive models.
- Are certain parts ready for standardization – e.g., observer training. Good to have comparisons available using different methods.
- Define what acceptable margin of error is. Tiered data with differing confidence
- Standardize what "best available" is? What best method of density estimate is?
- Is more published, peer-reviewed research more useful than large dataset?
- Use hooded way frames that spreads the energy, reduces the amplitude, and coalesces it
- Hard to do with certain technologies
- Next generation marine vibroseis - experience with data processing and coding on shore and now there is examination of doing it offshore
- Looking at hydrologic vibroseis - take more and more away of having to use airguns
- Not an air gun, uses some of the new materials that are out right such as PJS
- Just finished doing liability testing and gathering seismic data
- On land, shape and gas sweeps are being used and HF and VF technologies are being used
- The technology is non-impulsive and a swept amplitude
- Masking is an issue
- Transmission times: in the North Sea it was ten seconds
- Have take the dopler component out
- The best mode would be to have ocean sensors and it is much cheaper than having boat pass through all of the time
- Combination of the source type and the way they are being operated in the field
- Seismic survey is done like a paintbush
- With multiple ships, you can see one thing, but there shadows
- Multiple ships paint multiple lines to examine different angles
- You can do it faster if you spread your sources out
- The navy uses detags - for hydrate detection and bsr signatures
- Marine vibraters do not have the same water depth requirements as airguns have
- Deep towed marine vibrator hammer

- Couple of reports focused on quieting technologies such as replacement of airguns
- Website: www.soundmarinelife.org, report on marine quieting by noise control engineering
- Has sources that industry uses
- This source is subject to behavioral criteria - fall into a new regulatory realm
- There should be no development of new technology unless you do the environmental test (behavior and physical)
- Research has not been done
- Better to use in the environment, but behaviorally it is worse
- Paradox with impulsive source and behavioral criteria
- Quieting technology should be implement if it has less of an impact on the population
- At a certain point it will be area driven
- Need a time bandwidth type calculation - what do you do on land? You have to vibrate, vibrate, and move
- You are there longer and have to look at the amplitude, time, and frequency
- One size fits all criteria will not work
- How can we do into the most efficient way?
- There are areas where that will not work
- One with the most potential in the near term - consensus
- The whole thing can get quiet if the signal is better
- Control Source Electromagnetic - use electromagnetics in the earth to detect resistively
- Receivers are on the bottom and there is a radio at the top
- Up to twelve hundred amps
- Need to know the impacts
- If the source is put deep, it could be baffled
- That something that people are less inclined to fight with
- Opens doors to new thoughts
- Not work well in company and regulation dynamics
- Competitive nature restricts discussion
- Outside of airgun potential replacements, what are some of the things that can be used to reduce area of ensonification?
- Airguns have purposeful and incidental issues - we need data and it needs to be over a long distance
- Specific quieting technology for large commercial - are they applicable, economically feasible?
- The focus is on propellers
- At the Hamburg conference, they tried to plateau the overall rise in intensity
- Coming out with a third report with recommendations on how to move forward - discussions have been focusing on propeller design
- Comes down to what model basins have been used for

- Initial beginning - are we by definition going to get efficiency with a better propeller?
- A cavitating propeller is a less efficient propeller
- There are so many operations and maintenance caviots that are difficult to figure out
- There have been workshops on how to make a navy boat very quiet
- Actual physical hardware is not that expensive
- One option to reduce impact is skin nanotechnology can be used reduce turbulence
- As the propeller cavitates, can it be designed to reduce the impacts?
- Shipping regulations will be changing and optimization of boats will be required
- On seismic ships, vibration come on and isolate it
- Sound generation business - looking for the minute, not looking for extraneous noise
- Isolation is checked by engineers frequently
- Get to a point where everyone can hear better
- If you can reduce the vibration of the equipment, the life of it can be extended
- But with the commercial fleet, their incentive is to move faster, will they put the money forward to quieting technologies?
- Incetivizing and regulating is difficult when the authority of the US is in the ports, the ships are made abroad
- Part of the inspection could be looking at the noise issues - International Maritime Organization (IMO) agreement?
- Needs to be done at the international level
- Incentivizing is fuel efficiency and maintenance cost
- Database was required by Homeland Security post-9/11 to avoid a collision
- 24-hour generated and a lot of time is spent making it an archive
- But the biggest environmental debtates are speed, routing etc.
- They relate to exposure and quieting things
- Question technological
- The technology exists, but how can it be implemented
- But they are not paying research to look at the issue
- There should be a pilot project that can demonstrate savings
- OSBAR are working on shipping noise
- Research question is interesting - World Ocean Council Meeting in Belfast - A multiindustry group examine common interests in Belfast
- Participants came from a number of areas
- With all of these resources together, a piloting project might be feasible
- Infrastructure and standards of measurements need to be established
- Past acoustic arrays are being used to measure noise from ships
- Could the insurance companies play a role?
- Shipping noise is something that needs to be addressed
- Reducing a source can increase pulse length and cycle time
- In Radar, they have a dish with a transmitter in one dish

- MEMO radar: can transmit multiple sources in the receiver
- Underwater transmission - instrument to ship, vehicle to ship
- SONAR bowies have a limited range
- People are spreading it out not be in space, but time as well
- We need more understanding about the overall benefit from transitioning from a short-duration high intensity to longer duration lower intensity and wider aperture
- Tactical SONARS will remain in 2-4.5 kilohurtz
- Helen kenor SONARS are not going to be replaced
- The amount of kilohurtz depends on what is being done
- This is a continuum of different types of SONARS
- There is not much else that produces noise other than naval ships - need to move onto to some of the other sources
- Ways to optimize operations - mid Frequency SONAR has been in place for 40 years, so it must be working well
- Other frequencies have been tried, but have not worked
- The primary advances made have been signal processing
- Sound waves, beams, and signals work pretty well
- Usually when there is a problem with equipment, there is an inventory
- Coast guard have 230 cutters - nice to know how many Dbs
- To this, you have develop noise budget over time, space, and spectrum
- UN did a study on the contributions from the various noise sources
- Need to look at type of signal, time period, and who is there
- No existing inventory
- NOAA wrote to CEQ to request a workshop on sound mapping
- Table is established to build up the sound budget - look at acute, chronic, and ambient
- Need to be relativistic
- More temporal and operational on reducing sound
- A lot of work has been compiled for the next round of permits in 2019
- Passive acoustics is looking at submarines
- No immediate triggering on acoustic detection
- **Construction / industrial activities**
- A lot of it is small companies and feasibility
- There is a reduction, but there is some variation
- Bubble curtain goes over the seismic cables to prevent the reflection
- A reduction can be done, but there is has to be small buttons and in the shape of a cloud
- The longer the linger, the better off you are
- On the seismic end, it was 40 db
- This is mobile
- Also, air from the air guns can be used to prevent lateral transmitting
- The bubbles are very tiny from air guns
- A line of air is being created when the density is different causing either an absorption or reflection

- When you talk about putting it around deep piles like windmills, bubbles will not help with that
- Some of these are categorized as construction phase
- They are broadband
- Main noises are pile driving and dredging
- Dynamic positioning is also an issue
- Muffler designs - driving a piece of steel in the ground and put a piece of wood on it
- But they are expensive and break easily - not really feasible to use economically
- Coffer dam - put a dam around the pile and remove the water
- Very suttle between sound generation amongst small and large piles
- Certain things are not going to be feasible for certain projects
- Whole category should be technologically focused

**(4) <u>Behavioral Response Research for Representative Marine Mammal Species</u>**

**As we can see by looking at the Southall et al. (2007) compilation of data, we are missing important pieces of information showing how specific marine mammal groups (representative marine species: such as common species and key species: such as ESA-listed and sound sensitive species) respond to specific types of sound sources/activities (not to mention in different contexts or at what different received levels).**

**What are the most important specific behavioral response to anthropogenic sound data needs for better understanding and management of biologically significant effects that need to be met in the next 2-3 years? Why?**

*TABLE _*

- It is important to understand the policy needs in context of population level requirements. What do these policy needs point to in terms of research needs?
- With regard to management of biological effects, we need to look at longer-term, broad-based effects at population level and decadal scale pursuant to future MSP-type needs.
- However, planning occurs now; i.e., can't undo large-scale cargo port.
- Government has ultimate responsibility, but all users have responsibility to understand the impacts of their activities – establishing this sort of infrastructure can provide long-term funding stability for this effort.
- We should turn away from a focus on specific individuals to better understand population effects.
- Money needs to be directed to collection and study of baseline data and population status and trends.
- Has there been a situation where a decision has been made based upon biological significance in relation to population level effects rather than some individual mortality? We tend to react to individual effects.

- Behavioral response paradigm is failed. We cannot approach behavioral response by looking at individual responses. Instead of asking what scientific research is necessary to inform policy, we should perhaps reverse this process and ask what are the requirements of our policy, and how can those needs inform our scientific research.
- Metric (indices) of habitat are needed; for acoustic, activity, food supply – prey distribution is possibly an important area of study.
- We should also better assess research needs in specific relation to functional group; i.e., there are much different research needs for mysticetes, odontocetes, and possibly beaked whales.

*TABLE _*

- The most difficult question to answer because behavior is so variable
    - Context-specific
- Group decided to look at kinds of responses most concerning or specifically missing in management context
- Emphasis on the fact that the primary concern of everyone at the table is the conservation of a population (i.e. responses associated to reproduction and survival)
- Displacement
    - Contextual: short-term, long-term, critical habitat involved, to where?
    - Questions of whether displacement off a migratory route is less important
    - Group raised the issue of how long research is needed to answer this type of question
- Disruption of social bonds
    - Research shows that bonds are pretty tough, but it depends on taxonomic variability
- Sensitive/vulnerable populations
    - E.g. juveniles, unhealthy animals, animals subject to increased energetic demands
    - Need to understand overall health of a population before looking at effects
    - Ex: humpback mother and calf dive data from Antarctica shows that the pair is typically in sync throughout the day; however, at night, mother spent most of her time foraging at the bottom and calf spent more time at the surface
- Acoustic isolation
    - More energy put into vocalizing due to masking
    - Should this issue be part of the displacement category?
        - Should be different because displacement describes physical and acoustic behavior
- Chronic sound
    - Behavioral responses unknown
        - Will displacement occur?
        - Will animal habituate? What are the limits of habituation?
            - Ex: rats have shown habituation to last over generations

    - This issue can be studied because it's something measurable in a lab setting
- Short-term high-energy responses to specific stimuli
    - E.g. pulses, pings
    - Sounds that produce alarmed responses
        - Strandings, sudden and lasting departure

*TABLE 5*

- Representative Marine mammal studies:
    - Sort by hearing types
        - Frequency (5 categories)
    - Habitat utilization (breeding/feeding areas)
    - Some species are not representative of all and therefore cannot be used to describe the whole
    - Flight responses across a variety of ages/genders
    - Studies of each species should be done in a variety of contexts

- Could not find consensus among the behavioral studies
    - Problem: studies not done in a comparable way, sometimes the results were contradictory.
    - A lot of the time n=1 so variability was non-existent
- Funding agency specific to the question asked

**Who should perform these studies, what are the cost estimates and how will they be funded?**

- No limitation, but research should be interdisciplinary
    - The scientific community is already narrowed down
- Representative species can't be used to predict behavioral responses for other species unless sufficient baseline data relating the two species are available.
- Some species such as beaked whales and Tursiops have similar hearing curves, but very different behavioral responses.

**How long is it likely to take to meet these most important data needs at a level of resolution/certainty required for management, i.e., can they be accomplished with one discrete study or will they necessitate long-term governmental support to be useful to management (areas achieve threshold sample sizes, repeat experiments, alter ecological/environmental conditions, etc.)?**

- 5 years minimum just to reach introductory understanding of behavioral responses
- Shortening the research timeframe limits to results; can't eliminate long-term research when studying behavioral response

- NMFS (regulator) should have ability to fund research, but right now we're relying on Navy with greater funds (we don't really care where the $ is coming from, but who controls the researcher?)
    - balance between needing accuracy of research and the cost of long-term studies
    - the requirement drives the research and the research drives the resources
        - what's the need?(realistic approach to research and funding)
            - but some results coming out of basic research (NSF)
                - but even NSF has finite amt of funding and has to allocate resources to priorities
        - needs of regulators are a major driver for what gets researched (not the specific project, but the topic)
        - litigation is a driver
- Do animals respond differently to frequency upsweeps because of the different physical aspects to it?
- Modeling done on larger scale as well as smaller scale such as inner tissues
- Tag attachment on animals in captivity will provide baseline data

**If these essential data gaps were not bridged in the near future due to lack of funding or governmental investment, what are some options for resource agencies to manage species conservatively in the face of the specific types of uncertainty that these data gaps generate?**

**How should representative species best be used for predicting the behavioral responses of other species based on the information we have in-hand? For example, should this concept be based on taxonomy, hearing sensitivity (by frequency), or similarities in life history?**

- Be cautious about using the term "representative" when discussing species behavior; one species may not really be a true "indicator species"
    - Decision makers shouldn't make assumptions across species
    - More research is needed to make comparisons
    - There is great variability between (and even among) species

**What are the most important laboratory/captive based experiments and/or theoretical modeling (i.e., no field component) projects needed, and why?**

- Energetic and animal movement
- Field data verification (coupled with modeling) is extremely necessary
- PCAD and its components
- Studying the processes of animal behavior
    - E.g. process of animal going from healthy, to stressed, to dead
    - What causes the decrease in % of pregnant females to actual births

**More general notes:**

- Social organization of different species important to consider - they may exhibit different behavioral responses and may influence what we *expect* to see (i.e. solitary foragers, group foragers, etc)
    - may be easier to study with pinnipeds (looking at haul outs)
- Are animals that hear in certain frequency bands more likely to have certain behavioral responses to sound than animals in other bands? (large # of variables)
    - groupings needed to then test for accuracy
    - subject to different types of stimuli
    - we're at the very beginning of understanding behavioral response (agreed upon take-home message)
    - balance between obtaining accurate (often times long-term) research and the cost of long-term studies
    - the needs of regulations are a major driver for what gets researched (not the specific project, the but topic)
        - litigation is also a driver

Behavioral responses ranked by effect on fitness (i.e. reproduction and survival):

- group agreed that this type of ranking is difficult due to context-specific nature of behavioral responses
- ranking not decided on, but group identified the aforementioned behavioral responses as the most important for survival and reproduction
- the ultimate priority would be based on context

Behavioral responses ranked by priority (i.e. feasibility of accomplishing research):

- Displacement – baseline data would determine length of study
- Natural history of a species must be integrated into the equation before deciding what should be studied (e.g. What will get us this farthest the fastest?)
    - Where or for what species do we have the most background information?
    - What are the threats to each species?
    - Identify high-risk groups and/or locations
    - Are ESA-listed species involved?
- Practicality is key; research in areas with existing research facilities
    - However, this means continuing to avoid certain species found in areas like the middle of the ocean; data gaps would only be exacerbated

**(5) <u>Non-Behavioral Responses to Sound</u>**

- **Should there be an increased focus on the effects of noise stress and immune function studies? If yes, keeping in mind both acute and long-term exposures, what are the most important studies that should be conducted and why?**
- **What are the most important data gaps in our understanding of how to best assess specific types of non-auditory tissue damage in animals exposed to**

**anthropogenic sound? Why and, separately, will they directly inform current management decisions?**

**What are the most important data gaps in our understanding of how to best assess auditory tissue fatigue/damage in animals exposed to anthropogenic sound? Why and will they directly inform current management decisions?**

**If there are other important issues under this topic, please address those also.**

*TABLE 1*

- I find the data to be more objective than behavioral data
- To make the link that the stress comes from the potential exposure, to quantify the relationship is difficult.
- SPAWAR is conducting a lot of this research (e.g., immune function assays, reproductive function assays, metabolomic assays), looking for opportunistic results and plugging them into assays. Take advantage of the SPAWAR dolphin data.
- Can view responses related to sublethal effects,
- A lot of the hormones are evolutionary conserved; so many assays are applicable to other species.
- Captive studies, looking at physiological parameters, captive animals give you a level of control.
- Because of longitudinal studies, you can work out certain parameters for research.
- Okeanos workshops on stress, affects of multiple stressors, synergistc effects, workshop reports.
- The most important studies are the transfer studies (challenge is to compare captured animals to free-ranging pelagic animals, applying the same biomarkers).
- Use of exisiting technologies, such as D-tags to set up a good experiment.
- Heart rate would be a good indicator as well.
- Not just having the baseline data, critical to have the justification studies.

**What are the most important data gaps in our understanding of how to best assess specific types of non-auditory tissue damage in animals exposed to anthropogenic sound? Why and, separately, will they directly inform current management decisions?**

- You could look at gene expression or gene regulation related to stress.
- Find a partnership with a molecular biologist. Strengthen

**What are the most important data gaps in our understanding of how to best assess auditory tissue fatigue/damage in animals exposed to anthropogenic sound? Why and will they directly inform current management decisions?**

- The number of animals studied, small sample size and many animals are overtrained.
- Multiple impulse exposures are also problematic.
- Fish have the ability to regenerate hair cells. Piscine studies are important for baseline habitat assessments and predator / prey studies. Important for indirect affects analyses.

*TABLE 3*

- Parabolic equation (PE) was a big advance
    - Can be do range dependence, very little calculation
- Conico and Shell went to Alaska, they were required to monitor the propagation to the model 140 level
- When they measured it, the result was different
- Disagreement over the inaccuracies of monitoring propagation models
- Areas that we do well, there is great data and the areas that we do not do well, there is bad data
- There is no good 3D modeling
- The sound tunnel will spread sourcing and this is something people do experiments
- The first to do is to decide what you want to know
- Dichotomy: what you want to know
- NOAA resource manager will look at estimation and gross process
- But the tools are poor on the other categories and some are not applicable to resource management
- The tools we have are not great cumulative resource management
- You have to look at the proper definition of the US seabed
- Most resource managers do not think of PE, but they should
- Agreement: Most people open up ESRI GIS program and make a map - this is where we need to go
- ESME is navy funded platform for integrating different types of acoustic impact assessment
- But the issue is what is the exposure to the animals
- NOAA is looking at mapping
- A good comprehensive map would start with distribution and looking at the sounds
- Then you do an overlay and integration
- The actual translation and functional consequences
- Need to where the ship was and what the source was
- With Omniphones, there is directionality of the sources
- With some sources and some frequency bands: if there are good model parameters and skill operator, it can work
- This is a process where someone is going to have to have an understanding of the sound to use these models
- At a higher, you want expertise on both sides
- There can be consequences if you do not know how to use the equipment
- Need to have a person who is coming in from an engineering angle - this will broaden the interest and knowledge
- There are theoretical sound sources and validating them to accuracy could be challenging
- Go out there, look at sources and model transmission loss
- In the petroleum industry, validation is increasing but it is weak

- If you have got inputs, there is confidence in the models
- Need information to get into the models to ensure accuracy
- A lot of wiggles in the TL - you can average over frequency and range that smooths out the curve
- Single frequency patterns are more sensitive than a third octave
- When there is roughness, the angle is different
- Oil industry is looking at seismic data, we use to throw the water column away
- Now there is 3D cubes and you can look at water currents

*TABLE 5*

- Biological significance is the basis of determining if something needs to be done..
- At what point does a certain response become significant to the population rather than just the individual.
- Do we have the baseline data to know what the effects are? (agreed)
    - There has not been baseline knowledge
    - Hearing tests of populations in different areas with varying degrees of noise to get baseline data
- Focus just on response rather than if its significant (agreed) expanded: focus at the physiology to see if that behavior is worth pursuing.
- Start at an individual then begin to expand to the population
- Stress: produced from various different things, difficult to discern whether the stress is from anthropogenic sound
- <u>Assigned Question:</u>
    - Would it be easier to asses immune function?
        - No, immune function changes can be affected by many different factors
        - Stress is used because marine mammals tend to have a more severe response to certain stressors
        - Captive animals may give inaccurate results over wild stress response
        - Stressors add up over time, making wild mammals more susceptible to a stronger response to a stressor
- Yes, we should have an increased focus… (somewhat agreed)
    - (discrepancy) Instead of increased focus, people should begin to think about how to focus on these stressors
    - Need to focus more on collecting baseline data for populations to be used for comparison and analysis
- Studies with captive animals with certain drugs to determine specific immune responses
- Suggest to bring in regional experts to aid in studies (reference to specific previous study) -agreed
- Captive animals are exposed to varying levels of sound
- ONNR met about these studies 09
- Studies in the Gulf entail catching mammals then studied, However the process of being caught induces stress in itself

    - Not completely ideal but it is a way to asses differences among different individuals in a population (ie pups, male, female, mother)
- Entangled whales have more stress, datasets available on this: stressors include nutritional and physical stress
- Drive ZODIAC up to animal and after a few hours the animal calms, it can then be tested
- Want the most data possible
- It is not known if there is non-auditory tissue damage
    - Bubble formation – have not seen studies done on other causes of this, which are needed. (disagreement)
    - Bubble formation can't be ruled out as a symptom of stress exposure
    - There have been records showing bubble formation in stranding instances, however there is no evidence that the bubble formation is a direct result of the auditory stress. (consensus)
    - Embolisms: inappropriate object; gas, fat… fatty embolists can be produced post mortem by physical damage/handling. Gas and fat are very hard to discern
- Many different tissues could be affected by stress (ie heart, skin…..)
    - Hard to relate this tissue damage to auditory stressor
- Receive level studies: too much context surrounding them
- Scientists collect data and relay it to policy planning where they make decisions if it should be pursued.
- In order to make a policy all aspects and points need to be addressed
- Other view- once a harm is reported, precautions are taken. It can then be under further review
    - Should precautions be immediately taken then reviewed, or should they be completely reviewed first then take the actions.
- How can brain studies be done non-invasively
- Hearing tests on wild animals for auditory brain response which are non-invasive and compare different populations of mammals.
- Post-mortem biopsy will tell auditory damage as well as other tissue damage
- Playbacks test the validity of models
- Tissue Fatigue:
    - Recovery times for certain levels of exposures and frequencies
    - What is the "reset" on the clock until next exposure can be initiated
    - Short and Long-term recovery times need to be recorded for various populations
    - (Discrepancy): Unethical to damage animals purposefully to study recovery time?
        - Don't purposefully damage, just study pre-existing TTS and gauge recovery time from that
        - Study animals who are already in rehab with TTS

**(6) <u>Biologically Significant Impacts</u>**

**What is a biologically significant impact (to an individual or a population)? How is it quantitatively identified?**

- **How do we realistically and consistently determine which effects may be discounted as insignificant in a decision-making context?**
- **How well do the NRC recommendations regarding effects on foraging, survival, and reproduction match the available data on behavioral effects? Are these the correct criteria for the determination of biologically significant impacts?**
- **Are there particular contextual factors about sound exposure (e.g., similarity of sounds to those of predators) that are more likely to result in biologically significant impacts?**

**If there are other important issues under this topic, please address those also.**

*TABLE A10*

- Very important question from a survival and Darwinian standpoint.
- 2 purposes to serve: population level effects, and regulatory machine (which is based on the individual). So do we look at the individual animal or the population? With ESA, if population is low enough, these could be one in the same.
- Scientific studies to find biological impact is going to take a lot a lot of research, this si different from management questions. Management question is short term, need practical solutions to protection. (goes to first bullet). Very difficult because even finding the effect is very tough. So how do you decide if its insignificant. Could we even see if something was significant?
- Practical approach would be to focus on stress, so long as it can be measured (hormones, etc.)
- On individual level this is nearly impossible.
- A positive rate of growth is not an indication of improvement. Not enough to justify discounting what we're doing as insignificant.
- AGREED: anything that effects reproduction (individual or population) is significant.
- All laws are population based, decisions are based on population.
- Traditional research, based on baseline data, still could not be enough to understand effects on marine mammals, so scientific data won't always lead to better decision-making. Even arbitrary, precautionary, limit are better than waiting for data we will never be satisfied with.
- There is always assumed to be an impact, question is what it is. clear connections between cause and effect are going to be tough.
- Critical resources, such as a particular area, location, prey etc. are all extremely important and any effect is a significant impact.
- Stress is very measurable. Chronic stress, which is usually negative. AGREE: long term stress indicators are useful examples of negative impacts. Problem is that measuring that usually creates stress on its own. Also, rates of foraging could indicate negative impacts.

- Because something so close to death usually stops reacting, behavioral responses themselves are not indicators of significant impacts. Lack of response does not indicate lack of impact.
- Most anthropogenic activities are punctuated, so behavior responses to them are useful?
- Some things, which seem precautionary, can still be detrimental.
- Seasonal avoidance is still top mitigation technique for controlling, but trading one time of year for another.
- Long term stress levels are good indication of possible population impacts; avoidance of particular seasons and areas are best mitigation. Lack of behavioural response is not singular indicator of lack of significant impact.
- Masking should be folded into foraging, survival, reproduction under first bullet because it impedes these things, leading to stress, etc. i.e. significant impact. But, what is masked, how much is masked is difficult to determine, and hence how much impact there is.
- Also, some stress is carried unknowingly and with little impact. How do you differentiate?
- What are we actually measuring when we say impacts? Comes down to measuring mortality distribution changes. How do we actually measure impacts?
- Perhaps use models to understand these at a population level? So, to do this you need very good input data, but is doable. Long term demographic changes are doable with certain species that have been studied for a long time.
- Two different questions: biological and regulatory.
- From regulatory standpoint, "harm" caused is the key. Stress, reproduction sound important. Foraging is a tougher question because depends on so much else besides just sound.
- So how do study the incremental increase in stress from a project?
- Can also identify critical life stages and more susceptible to stress related changes (end of migration, for example)
- Are there biological responses that we can observe and measure that we can use as indicators.
- Other than stranding, aborting, obvious mortality,(but these are the few instances good for short termassessment) this is difficult. Need a broader context. Can we use population behavior?
- Reductions in foraging could be measured, but have to understand context.
- To get context, need to look at a broad range of data.
- Beaked whales on AUTEC range. If you monitor and detect behavioral changes in foraging etc. but show little long term changes, that would be an insignificant impact. Don't always have this kind of ability in all cases.
- More effort should go to monitoring, which leads to better understanding of population, which leads to better understanding of what a significant impact is.
- Have to recognize limitations of this data.
- Also, cheaper to understand larger changes than individual.
- Contextual factors: 3rd bullet. Breeding, reproduction,

- We should be less concerned with short term episodic events unless they are frequent enough to affect long term (disagreed, because where do you draw of line of becoming a problem. i.e. original question) Long term study of known generations of individuals is really the only way to see significant changes.
- You really can't say what is *insignificant*, only what is significant.
- No impacts on lifetime survival or reproductions is the only way for an effect to be insignificant.
- Generally agreed, grudgingly since this is intractable. No way to realistically get enough data, so this answer is really useless.

*Table 4*

- the behavioral impacts we discussed for the group's assigned question helped lead to (quantify) biological significant impacts
    - the impacts need to affect fitness (i.e. the potential for reduced reproductivity) from a conservation point of view
    - it's a continuous process/rate; we just draw a line between impacts on individuals vs. populations (i.e. PBR)
- the temporal aspect of a sound is important (i.e. whether it's acute, chronic, repeated, etc) when considering biological significance
    - a one-time noise over a short period of time may not have a significant impact
    - is there an exposure length we can say is definitely not biologically significant?
        - The group debated over the definition of "brief"
        - Agreed that a non-repeated sound over a brief period of time, not related to any other action (i.e. a discrete event), and sublethal – could potentially be considered to lack biological significance
- Many major biologically significant events aren't known until after the fact (e.g. marine mammal strandings like the Bahamas 2000 event)

*TABLE 6*

- The EIS' touched on frameworks for determining significance or not (0 to 9). In otherwords, the document directed but didn't really didn't do anything towards it.
- Two types of significance: Acute and cumulative/long-term.
    - Acute: Did they respond immediately
    - Cumulative / Long-term: Was there a residual impact.
    - Regulatory focus now seems to be on the Acute impacts.
    - MMPA vs ESA
- Are there any chronic impacts? Are there studies focusing on that yet?
- Parsing the difference between the study of chronic vs acute studies is important and challenging. Right now, some treat all as chronic as we don't necessarily have the ability to differentiate at this point.

- Is trying to distinguish between acute and chronic effect a dead-end endeavor? How do we know we aren't seeing an acute response to a long-term exposure effect.
- One time acute impact can be less than chronic impacts for slow developing detriment.
- Toxicology model essentially looks at the acute vs. chronic response.
- How do we measure this impact? Genetic impact, reproductive impact, etc. Data collection on that is not simple if possible at all.
- How much of an impact are we willing to live with? Management decision to decide with scientific evaluation being one of the primary tools for this judgment call. Biology tells you what will happen. Management decision comes from societal value impact. PBR methodology.
- Do I or Do I Not expect an incremental change in the animals current reproduction process. Life history trait (fitness, of foraging play into it, but the focal point is survival/reproduction. Mean to an end.
- Acute is associated to individuals where Chronic is more population based.
- Necessary condition, you must have an individual impact to have a population impact. Do we all agree on that? Is it as binary as it seems?
- How do you quantify the results of these impacts? It's all a gut feeling. We are starting to get some cognizant agencies, but still a gut feeling.
- The metric isn't the same for all species as some recover quicker/better than other species.
- Is it complete – No. Is it better than doing nothing.
- Hard to capture energetics.
- Do we have a way to quantify acoustic impact? Some, but primarily theoretical.
- Figure 3.9-7 Marine Mammal Response to Spectral Anthro…. Sounds.
- Sequential raising of the bar required to publish works on biological impacts. You used to be able to publish a paper without as much pushback as you have today. Now you need to show proof of population impact.
- The lawyers and scientist never seem to agree on what the threshold should be.
- Threshold: Is the population increasing, stable, or climbing? So you can have an impact at the individual level, but if it doesn't have a population consequence..okay.
- But you can't wait for them to die off, so you must look at trends, habitat use, and utilize the in-depth knowledge, not just baseline.
- Sticking Point: Where do we draw the line on impact: 1 loss, 2 loss, etc.
- In order to quantitatively analyze effects, we'd need a comprehensive evaluation/assessment of a given species.

- Whether or not we reach PBR requirements may or may not be able to take action based on harassment of a group.
- **"Do I, or Do I not, expect, or see, an incremental change in a individual's current survival or reproductive process?"**
- Point of Discussion: **"In order to quantitatively analyze effects, we'd need a comprehensive evaluation/assessment of a given species."**
- 1 – The need for identifying the mechanism for determining the number of perturbations required to be discounted is not simple or an agreeable endeavor.
- 2 – The majority of

**SESSION B**
**Understanding and Reducing**
**Sound Generation and Propagation**
**John Hildebrand**

Summary Notes:

**(1) <u>Sound Source Identification and Review</u>**

**Please refer to the attached spreadsheet which lists: types of anthropogenic sound that contribute notably to the soundscape; U.S. acoustic data sets that can help characterize sound fields affected by these sounds (broadly, e.g., shipping lanes); the agency/organization that holds those datasets, whether or not the specific sources have been specifically characterized, and the reference:**

- **Is anything missing or incorrect?**
- **What are the most important data needs (and why?), each, for characterizing acoustically:**
    - **individual sources**
    - **understanding broad use of the source type**
- **Are there similar data sets available outside of the U.S. Government that would provide valuable sound field characterization information? Is there sufficient reason to push for releasing this data?**

- Large-Ocean going Shipping category is too broad – large ocean going is too broad (carriers, tankers, container ships) – speed of ship is important – is there a place to go to get this information (mostly in gray literature and it can be restricted – such as AIS)
- All military vessels (US and Foreign) need to be added – like support vessels and navy might be willing to release retroactively locations/types of vessels
- Break out seismic into two subsets: oil/gas and scientific
- Lloyds and IMO could provide information on all global vessels
- Need to capture mid size coastal vessels – like tugs that pull barges between NY and Boston
- There are actually three types of military sound sources: LFA, MFA, and HFA (there are actually about 600 sound sources) this list will be available in the next round of EIS's – Gene Nissen at Fleet Atlantic is compiling this list
- Sovereign foreign vessels are not required to get a permit in U.S. waters (*military context; not research)
- Need to have a fishing category that is broken down into AHD and ADD and seal bombs
- Need to add a scientific sound source category (such as Rafos floats, multibeam sonar, bottom penetrating echosounder, scientific sound source, low flying aircraft, etc)
- Need to add a category for acoustic navigation and acoustic modems
- Need to add a sub-category of harbor activities under Construction/Industrial Activities

- Recommendation: Data needs for all of these categories is where, when, how, and sound characteristics
- Recommendation: have specifications for radiated sound – an example is if a boat is going to be close to a whale it is only allowed to produce so much sound
- Recommendation: any commercial vessel should be required to carry AIS
- Recommendation: need a global ocean soundscape database compiled by cooperating federal agencies
- Table needs to be reformatted, do not have a sense of scale (spatially, how many sources there are in each category, their geographic usage)
- Question the use of chronic vs acute, these are subjective terms, need to develop a more quantitative description (ie, peak vs accumulative energy level)
- Is there a standard for the noise measurement from each individual source?
- Add: Navigation sonar, Fish finder, Tug boat operations, Ice management (ice pushing)

**(2) <u>Ambient Noise</u>**

**What acoustic datasets are available for measured ambient noise? What are the needs for longitudinal measurements of ambient noise? How should we standardize collection of that data? How do we prioritize the areas in which ambient noise measurements are most needed? What are the important uses of ambient noise data in a management context?**

*TABLE 2*

Consensus Agreed:

- Currently there are numerous databases supplying sound clips (e.g., for identification/educational purposes) and abundance data but none that aid in assessing impacts.
- A system is needed (either Centralized or De-centralized gateway) to store and access acoustic data that is also linked to visual sightings/GIS interface.
- Standards of quality assurance for data is needed and should be clarified by the gateway/server
- Agencies and contractors doing studies/permit holders should be required enter data to the system
- Journals should require data also be entered into system before publishing literature.
- The system should be publically available without restrictions

Disagreed:

- None

TABLE _

- What is ambient noise? Everything non-anthropogenic, yet recognising that in certain areas anthropogenic sources significantly contribute to the prevailing AN

spectrum, eg shipping. Everything that is not currently regulated in this area within the framework of this project.

- Acoustic data sets (raw data) available – none in any systematic format, most data not analyzed for AN that would be readily accessible. Data avail from naval arrays, SOSUS, ocean observatories (Neptune, Venus), and lots in the consulting industry, eg Cornell MARUs or JASCO AMARs or Lammers' EARs or Multielectronique's AURALs. Recommendation is for a centralized data base (global noise climatology), eg regulator could require that clients/operators make data avail for a specified period (eg raw data for 5 yrs, processed data for ever). Currently data sets are owned/managed by individual organizations. Without access to real AN recordings, extrapolate from few publications, HITS and MARVIEW (shipping) coupled with AN modeling.
    - Seismic data could be an additional source of ambient noise data
    - NW Regional Office or Northwest Fisheries Science Center has a recent memo on this topic
- Longitudinal monitoring- there is a need for historical, long term, regional seasonal/annual data to support environmental impact assessments, to compare operational noise to 'natural' ambient.
- Standardization – very difficult to do, regulator needs to make it part of the requirement that the raw data be made publically available. Minimum standard on measurement procedures + equipment, eg to reduce artifacts such as flow noise. The standard on ship noise that came out in Nov 2009 had some minimum requirements for the measurement setup. Can standardize a reporting requirement (ie, power spectrum densities averaged over specified time windows, or third octave band), also need to be coupled with noise modeling. Not practical to standardize too much, eg require broad bandwidths, high sampling frequencies (so as to have the broadest data avail for any future uses), as this will drive up costs. Data collection should remain optimized for a certain project/species/sound source.
- Prioritization of areas – different approaches possible. Eg need to look at the type of activities in an area, is there a high demand for specific areas? Oil, gas lease areas, developing ports, coastal areas where we have MM and near shore shipping, may have higher priority. Areas of high human activity (incl noise and non-acoustic stressors); or areas of sensitivity based on species at risk.
    - North Atlantic does not have same level of repeat measurements as Pacific; important to repeat and document. (Table 11)
- What are the important uses of AN data in a management context? There is a need to determine the contribution of the proposed action above the AN, need to know ambient to evaluate potential harassment on the marine environment. Long term ambient noise monitoring allows us to keep a pulse on the background conditions to alert the regulator to AN creep. Eg some regulators ask to mitigate for 120 dB SPLrms in the case of migrating baleen whales, but then AN levels are 125 dB.

**(3) <u>Quieting Technologies</u>**

**Different groups are working on ways to quiet shipping noise and quieter alternatives to seismic airguns for oil and gas surveys. Are there other activity types in which economically feasible improvements have been/could be made to reduce the amount of energy introduced into the water to accomplish the given goal (i.e., quieter ways to build a pier or detect an enemy submarine)?**

Summary Notes:

- Behavioral Significance: What will be the principle drivers on behavioral significance? Quieting addresses receive levels, but in order to affect quieting, some of the most promising technologies would have affects on duration and frequency content
- The metrics for behavioral significance would have to be taken into account to focus what quieting efforts are the priority
- Purposeful vs. Incidental: One of the goals of quieting is optimizing of different purposeful signal uses wrt animals and people relative to incidental background noise
- Incentives: Research and incentives need to be addressed in order to be advanced and obtain support
- Who pays for the research? For example: Canada charges user fees to petroleum companies and when West Africa opened up for exploration, they oversaw the collection of baseline ID and petroleum companies got as one product
- Noise budget piggy banking could be a viable option (e.g., cap and trade) (or, focusing budget on priorities)
- User fees would be used to fund research
- Seismic Technology: Alternatives to Air Guns
- Marine vibroseis development
- Vessel Quieting : IMO guideline development, higher cost applications, Navy and NOAA have both done higher cost applications
- There is a really great need for better understanding of effective measures to quiet ships and no clear research framework to support it
- Navy SONAR: Most quieting is operational constraints rather than technological adaptations or modifications
- Exploration of signal modification with lower intensity with trade duration tradeoffs
- Construction: Bubble Curtains and muffling
- Because they are temporarily constrained, a lot of the quieting ideas are operational (SONAR and construction phases)

**(4) <u>Cumulative Contributions of Multiple Sound Sources to Marine Noise</u>**

**How do we best evaluate multiple specific sources and their cumulative contributions to marine noise?**

*TABLE _*

- How do we best evaluate multiple specific sources and their cumulative contributions to marine noise?
- The physics is available, it's a bookkeeping problem that can be addressed by summing up received levels at the animal.
- On the biological level this is hugely complicated problem, it is a behavioral question that depends on several issues, including animal recovery time, habituation, sensitization, context, audiogram, stress level, etc. The science is not available to address this at this time.
- Management tools are short-term, single source constructs; management needs to define and demand the metrics (which will be informed by biological effects)

TABLE 8

- To better understand behavioral responses, one must understand:

- Source characteristics- frequency, broadband vs. tone, signal to noise ratio, particle motion (fish respond to particle motion), is source near/far, duration (SEL), signal type, etc.
- Intensity vs. duration at receiver- SEL important but is difficult to determine physiological impacts
- Behavior segregation – are animals foraging, socializing, migrating?; how is the perceiver characterizing the sound stimulus?
- Can be issues with classifying expected behaviors based on functional hearing group alone because social status may play key role: (e.g., beaked whales (typically solitary) can react must more strongly than social pilot whales but both in same hearing group according to Southall).
- Effectiveness of visual observations (i.e., Marine Mammal Observer) on a survey boat?
    - Can't localize on an animal
    - No ability to have a statistical basis
    - What is the animal behavior below the surface of the water
    - PAM should operate around source and be integrated with visual operations to give much better picture of behavioral reactions
- Any restrictions should look at cost benefit of restricting human activity; some things can be absorbed in the cost of business.

*TABLE 9*

**Recommendations**

- Baseline research

- Expand beyond the 2-3 year horizon regarding the baseline data (stock assessment and range for all US waters), ongoing collection recommended instead
- NOAA and USFWS need to be the lead agencies collecting baseline data from the subject areas identified in the n-dimensional space
    - n-dimensional space: Social structure (group size), phylogeny, foraging ecology, functional hearing groups, sensitive/shy species-cryptic,

predator-prey dynamics, migratory behavior, conservation status (population size, size of range, stock trends, legislative protection)
    - Increased directed funding to stock assessments, distribution, behavioral ecology, predictive habitat modeling, targeted tow-array work, etc.
- Existing sources to consider
    - NOAA's Ecological Passive Acoustic System
    - NRC 2000 report
    - NPS approach—Soundscapes
    - Population models based upon ecological factors
- This baseline data is necessary for marine spatial planning, ecosystem-based management, and natural resource damage assessment process.
- With proper funding, existing data could be standardized, published, and made available at low cost
- Streamline funding requirements, permitting, and interagency commitment to a unified set of goals
- Increase opportunities for communication between researchers and managers
- Propagation modeling would be helpful for setting the scene
- Applied research
- 2-3 year time horizon for directed research is appropriate
- Navy, BOEM, NOPP, and industry, in coordination with USFWS and NOAA, conduct targeted research focused on anthropogenic noise and biologically significant effect issues
- Connect to existing permit and research programs
- Specific studies
    - Compare noise types: broadband continuous, pulsatile, narrow band, etc.
    - Bottom-up studied derived from species that are data rich to support larger-scale multivariate field studies

**General Discussion**

- Difficulty in defining "representative species"
    - Sometimes default to species which already have a lot of data (i.e. the low hanging fruit) and those that are species of concern (ESA, MMPA)
    - Potential grouping categories: Phylogeny, functional hearing, behavioral sensitivity
    - Behavioral sensitivity is more meaningful for management/ESA issues while phylogenic makes sense scientifically (given recent data connecting phylogeny to functional hearing)
        - Selection criteria for species could be based on: ESA-listed species, phylogenetic group even if you don't know that they are sensitive already, species that make up the large proportion of the takes, species where you have a big body of data for, range, level of exposure
    - Group by certain factors (e.g. behavior, hearing, life history characteristics) instead of just by level of endangerment---use this to generate an n-

dimensional space to characterize species. Determine a reasonable basis for extrapolation based on shared n-dimensional features.

- **Baseline Data**
  - Need for baseline data especially on abundance, distribution, and movement patterns
  - 3 categories of research: Basic research on density/distribution, behavioral ecology (through small # of animal observations), behavioral responses to sound (e.g. to form behavioral risk function)
  - Which should come first, space designation or looking at the species movement as a whole?—general sentiment that it should be a combination of both but many agencies admitted that their research is generally space driven
  - Need to mandate that agencies collect baseline data not just scramble to get information on a project by project basis—NOAA and USFWS need to be responsible for this with other agencies as appropriate
  - Budget to complete this work via passive acoustics is in the tens of millions of dollars
  - Defining the n-dimensional space (see recommendations above)

**(5) <u>Sound Propagation Prediction Tools</u>**

**What tools are currently available (or will be available in near future) to resource managers and the public to model sound propagation? How do these tools compare in ease of use and accuracy of output? Have they been validated?**

Summary Notes:

- There is ray/gaussian beam based, normal mode, fast field/wave number integration, and parabolic equation
- Standard historical bases exist, but typically insitu measurements are required
- The quality of the output is based on the quality of the input based on data resolution ( spatial and temporal resolution)
- Running the system requires skilled operators, agencies need to have technical expertise (capacity issues), and you need an available user friendly platform (ex: AIM, ESME)
- Very good with particular types of modeling scenarios and having validated output; in others we are not such as shallow water low frequency propagation, high resolution 3D, rough scattering, reverberation; and some types (impulsive sources)
- Applicability to management scenarios: do they provide the ability to look over a broader band in a single hertz model, do they integrate how animals are truly distributed in space

- Validation: Models are consistent with each other, but they fall apart based on environmental input quality (in more heterogeneous environments, more data is needed to accurately predict propagation)
- What are the impacts that you are trying to quantify (sound is one part of this)
- Use deterministic forecasts or hindcasts; avoid averaging
- Need to invest in databases for full predictive systems

**(6) <u>Standardized Marine Mammal and Sound Database(s)</u>**

**There have been many discussions about creating a standardized marine mammal database and requiring that all parties/agencies holding permits or authorizations be required to electronically enter any data collected (which will sometimes include sound source verification information and could also include other sound source information) into that government-run database. This data could then be systematically archived, analyzed, and potentially made available to resource managers, researchers, and the public. Without getting into a discussion of who should fund this and which government agency would house it (although, with the intent of informing these issues) please consider the following:**

- **What are some of the logistical needs to make this happen (e.g., data clearance/proprietary issues, communication among agencies with access to data and/or expertise in managing data etc.)**
- **As a potential user of this database, how would you use this resource if it existed (e.g., all visual sightings made during construction projects in Puget Sound over 10 years, or the sound source verification data for seismic airguns in the Arctic) in research and/or environmental impact assessment contexts?**
- **How can we standardize source characterization and measurements (at least within certain large frequency bands) so that comparisons among sources are meaningful in the context of evaluating impacts to marine mammals?**
    - **For example, the ASA Standards Committee S12/Working Group 47 has produced a document, "American National Standard Quantities and Procedures for Description and Measurement of Underwater Sound from Ships- Part 1: General Requirements" (ANSI/ASA S12.64-2009/Part 1), and similar efforts are under way within the International Standards Organization (ISO/TC8SC2) regarding the characterization of underwater noise, specifically for merchant ships. Should the ANSI standards be adopted as a standard for sound source verification (SSV) test when vessel noise is involved? Or should we wait for the ISO standards and make a decision which one is the most appropriate to be used in addressing shipping noise? Why?**
    - **Are there other existing standards that we should consider adopting? What are the pros and cons of doing so?**
- **Are there existing datasets describing specific propagation environments (e.g., SVP, boundary condition, transmission loss spectra, etc.)? Is the information accessible to researchers and resource managers?**

- **Some government agencies may have existing but currently under-utilized datasets that could be made available to aid in the analysis of biologically significant effects of sound exposure. List any of these datasets (of sound source characterization or propagation data) that you are aware of, by agency, and indicate what type of data (e.g., basic information on distribution/abundance, data on potential effects) is contained in the dataset, as well as the general format and standardization of raw and metadata. What needs to happen to make the data more readily available (e.g., are certain protocols existing, or necessary to design)?**

Summary Notes:

- Recommendation: An interagency group needs to be tasked with figuring out how to pay for and house this type of database
- Recommendation: Create ANSI/ASA like standards to characterize sounds from airs guns and shallow water industrial activities
    - Shallow water bottom type variability makes standardization difficult
- Recommendation: There should be a requirement that ship tracks and source characteristics from oil exploration be made available for analyzing soundscapes
- Recommendation: some product from Navy's SPORTS system that documents the use of sonar be made available for analyzing soundscapes
- Recommendation: coast guard (must) compile of AIS be made available for analyzing soundscapes
- www.marview.gov – tracks AIS data worldwide (Department of Transportation); archival data (what is currently collected?)

DETAILED NOTES

SESSION B

**(1) <u>Sound Source Identification and Review</u>**

**Please refer to the attached spreadsheet which lists: types of anthropogenic sound that contribute notably to the soundscape; U.S. acoustic data sets that can help characterize sound fields affected by these sounds (broadly, e.g., shipping lanes); the agency/organization that holds those datasets, whether or not the specific sources have been specifically characterized, and the reference:**

- **Is anything missing or incorrect?**
- **What are the most important data needs (and why?), each, for characterizing acoustically:**
    - **individual sources**
    - **understanding broad use of the source type**
- **Are there similar data sets available outside of the U.S. Government that would provide valuable sound field characterization information? Is there sufficient reason to push for releasing this data?**

*Table 11*

Question: if an animal is hit with multiple types of sound with multiple types of frequencies which criteria governs takes from a modeling perspective?

General Statements:

- There are foreign navies that use our navy ranges – is this captured somewhere? Are foreign vessels subject to MMPA or ESA in our waters or on the high seas?
- Data needs for all of these is where, when, how, and sound characteristics

New/modified categories:

- Large Ocean-Going shipping category is too broad – need to break this into separate categories like bulk carriers, oil tankers, container ships because they each have different characteristics (speed and shape of ship is important) – is there a place to go to get this information (mostly in gray literature and it can be restricted – such as AIS)
- Need to capture coastal vessels – like tugs that pull barges between NY and Boston
- There should be an overall fishing category that can be broken out into subcategories rather than an aquaculture category
    - Need to add AHD (acoustic harassment devices), ADD (acoustic deterrent devices) – i.e. pingers, and seal bombs
- Need to add a scientific sound source category (such as Rafos floats, multi-beam sonar, bottom penetrating echosounder, etc)
- The seismic category needs to have two subsets: seismic and scientific
- There are actually three types of military sonars: LFA, MFA, and HFA (there are actually about 600 sound sources)
    - Jene Nissen with NAVFAC Atlantic has compiled a list that is being used in the next round of Navy EISs
- Need to add a category for acoustic navigation devices and acoustic modems
- Need to add a sub-category to the Construction/Industrial Activities category called harbor activities

Access to additional information:

- Is it possible to have access to VMS system to capture some information on fishing vessels (Coast Guard and NOAA Enforcement keep this information)
- AIS is only line of sight and then have to rely on HITS which isn't necessarily reliable – can it be regularly updated
- Is it possible to have access to Lloyds and IMO databases for insured vessels
- Military vessels that don't go active need to be added – like fleet support vessels
    - Navy might be willing to retroactively release information on locations/types of vessels

Recommendations:

- All commercial vessels should be required to carry AIS

- There should be specifications for radiated sound – an example is there should be rules for how much sound a whale watch boat is allowed to produce
- There needs to be a global ocean soundscape database compiled by cooperating federal agencies

*TABLE 12*

- Table presented seems bloated.
- Ice breakers in U.S. don't contribute significantly with only 1 U.S. Coast Guard boat.
- Missing navigation sonar.
- Ice breakers are not chronic
- Canada has 13-14 vessels
- USA has 1
- Russia has a lot
- Commercial fishing works in ice, but not chronic either.
- Add navigational sonar and fish finders.
- Inadequate knowledge on pile driving – predicting sound channel presence/absence.
- Seismic air gun field measurements can be different from modeling done due to settings used in the field.
- What is difference from chronic and acute? Unclear what is meant.
- Is chronic more frequent than acute?
- Chronic vs. acute appears to be a subjective column.
- Question: where are source level measurements made on the seismic array?
- Answer: 500 m, and 1 km then back calculate.
- Sound source list is not coherent and is unorganized.
- Unclear objective of table.
- Missing tugboat operations.
- Question: How was conclusion of acute vs. chronic made? Peak vs. accumulative energy level would be a better way.
- Google earth is not read in real time – cannot could boats in harbors using Google earth.
- Should include ice management with ice breakers.

**(2) <u>Ambient Noise</u>**

**What acoustic datasets are available for measured ambient noise? What are the needs for longitudinal measurements of ambient noise? How should we standardize collection of that data? How do we prioritize the areas in which ambient noise measurements are most needed? What are the important uses of ambient noise data in a management context?**

**Question #2 – Ambient Noise**

- What is ambient noise? Everything non-anthropogenic, yet recognising that in certain areas anthropogenic sources significantly contribute to the prevailing AN spectrum, eg shipping. Everything that is not currently regulated in this area within the framework of this project.
- Acoustic data sets (raw data) available – none in any systematic format, most data not analyzed for AN that would be readily accessible. Data avail from naval arrays, SOSUS, ocean observatories (Neptune, Venus), and lots in the consulting industry, eg Cornell MARUs or JASCO AMARs or Lammers' EARs or Multielectronique's AURALs. Recommendation is for a centralized data base (global noise climatology), eg regulator could require that clients/operators make data avail for a specified period (eg raw data for 5 yrs, processed data for ever). Currently data sets are owned/managed by individual organizations. Without access to real AN recordings, extrapolate from few publications, HITS and MARVIEW (shipping) coupled with AN modeling.
    - Seismic data could be an additional source of ambient noise data
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- Longitudinal monitoring- there is a need for historical, long term, regional seasonal/annual data to support environmental impact assessments, to compare operational noise to 'natural' ambient.
- Standardization – very difficult to do, regulator needs to make it part of the requirement that the raw data be made publically available. Minimum standard on measurement procedures + equipment, eg to reduce artifacts such as flow noise. The standard on ship noise that came out in Nov 2009 had some minimum requirements for the measurement setup. Can standardize a reporting requirement (ie, power spectrum densities averaged over specified time windows, or third octave band), also need to be coupled with noise modeling. Not practical to standardize too much, eg require broad bandwidths, high sampling frequencies (so as to have the broadest data avail for any future uses), as this will drive up costs. Data collection should remain optimized for a certain project/species/sound source.
- Prioritization of areas – different approaches possible. Eg need to look at the type of activities in an area, is there a high demand for specific areas? Oil, gas lease areas, developing ports, coastal areas where we have MM and near shore shipping, may have higher priority. Areas of high human activity (incl noise and non-acoustic stressors); or areas of sensitivity based on species at risk.
    - North Atlantic does not have same level of repeat measurements as Pacific; important to repeat and document. (Table 11)
- What are the important uses of AN data in a management context? There is a need to determine the contribution of the proposed action above the AN, need to know ambient to evaluate potential harassment on the marine environment. Long term ambient noise monitoring allows us to keep a pulse on the background conditions to alert the regulator to AN creep. Eg some regulators ask to mitigate for 120 dB SPLrms in the case of migrating baleen whales, but then AN levels are 125 dB.
- What is ambient noise – needs to be identified?
- What about reverberation? Needs to be considered.

- Ambient & shipping is LF – do we need to be species specific?
- List of ambient categories should include broad categories like wind noise.
- Wentz curves – need to be aware of the environment that the noise is in. Ex. Wind speed noise is reflective of the environment.
- What to include in "ambient" discussion – should include shipping and commercial.
- Need to consider regulator perspective: ambient is everything other than what is being regulated.
- Natural and anthropogenic categories of ambient:
    - Natural: lightening strikes, snapping shrimp, wind, and rain.
    - Anthropogenic: shipping, pile driving, fish finders.
- Shipping can be considered ambient or the source of regulation.
- Temporal component needed also – distant or close.
    - Transient or resident
- Any source can be considered ambient based on resolution over time.
- Can we model noise event – how accurate can it be without the ambient component?
- Maybe make exception for shipping – use AIS data.
- Can't deterministically tell where some ambient sources are but AIS will help for shipping. Lightening unknown source.
- Seismic
- Environmental component is lower priority.
- Categories:
    - Shipping
    - Sonar
    - Exploration
    - Environmental
- Question: what about dredging?
- Sonar not in scope of discussion of ambient but may be in if not source of regulation.
- <u>Data sets available</u>:
    - HITS – historical and temporal shipping. Ships and ship tracks – not ambient. Data translates to ambient.
    - Ambient noise models
    - SOSUS – unknown status
    - Cornell has raw acoustic data sets for different parts of the world. Data not analyzed.
        - Cornell data set has ship tracks from 2006 – 2010.
    - NEPA requirements may include some data sets
    - MARVIEW – worldwide ship tracking on U.S. Maritime Administration. www.marview.gov Tracks worldwide shipping of ships that send out a signal on AIS.
- Need a master repository for these data sets for comprehensive and systematic collection of ambient noise.
- If have details of shipping can back track the ambient noise.

- MARVIEW tracks ports, events like hurricanes and ship movements/reaction.
- DANM (Dynamic Ambient Noise Model) = ambient noise model fed by HITS database.
- Question: Does any place have an archive of noise measurements; can be source of information for archived ambient noise database.
- Question: Why does regulator need to know ambient?
    - In Australia – need to know signal excess because mitigate to signal excess, mitigate to zero signal excess.
    - NEPA – need to characterize environment baseline and this is ambient before proposed action.
    - Oil companies in Australia monitor ambient noise doe a year prior to permit request.
    - Answer to data sets available: None in any systematic format. Recommend a centralized master repository for data sets to enable a comprehensive and systematic collection of ambient noise.
        - Extrapolate information from HITS and MARVIEW
        - Cornell – Has Marine Autonomous Recording Unit (MARU) data and some SOSUS data.
- <u>Needs for longitudinal measurements:</u>
    - Establish global climatology
    - Question: How to encourage people to contribute?
        - Have workshops; publish reports.
    - Problem with snapshot view – need historical look – longitudinal record for regulatory process.
    - Longitudinal is over time.
    - Skip question for now.
    - GDEM (Generalized Digital Environmental Model Data Base) – for lat/long get sound speed profile. Good to get similar database for ambient noise.
    - NAVO (Naval Oceanographic Office) may have some databases on ambient noise.
    - Navy should have ambient noise data base since it is needed for the sonar equation calculation. Don't they? Calculating signal excess requires ambient noise. Classification issue may be a problem.
    - Question: What are physics of ambient noise?
        - Does each ship add to noise? – Yes
        - Size of ship matters, horsepower, etc.
    - Summary of Needs: to support environmental impact assessment
        - Historical
        - Seasonal
        - Regional
        - Long term
        - Annual
- <u>Standardize collection of data</u>:
    - Need centralized data

- Money is an issue; regulator should make the requirement to make the data publically available for some length of time.
- Question: does all ambient noise need to be broadband? Not necessarily.
- Snapping shrimp can clip off acoustic data so not all low frequency.
- Requirement to standardize data would be difficult.
- Need to determine how data will be processed. Raw data should be available.
- Let regulator set the standard. (i.e. monitor for a year, give details of recording requirement (ex. 5 min/hour) or whatever to create a dataset.
- Example: goal is to have a similar data set as for elevation data – can just order the data. Would be nice to have similar data source.
- Prioritize where areas where data should be collected.
    - Areas where animals at risk or areas where can do something about it.
- Question: Activity driven versus animal driven – which should it be?
- Don't like prioritization being based on status under ESA.
- Areas with higher use areas – long term consideration
- Look at number of threats on the animal
- Go where permitting – where demand exists
- Areas where there is a port – justification for moving shipping lanes, OSC (?) oil & gas leases/sales areas.
- Today may not be a priority but need to consider long term.
- Would be nice to wire the whole U.S. coast.
- Gather baseline data around the U.S.
- Coastal migrants, near shore shipping, NRW areas.
- Gray whales – West coast; bowhead whale – Atlantic; Beluga whale – West coast.
- N.W. Australia – animals at risk. Not suggesting any areas in Australia.
- Procedures to ID are not specific to geographic area - all stressors.

- <u>Management Context:</u>
    - Anything beyond proposed action is ambient.
    - Objective is to protect marine mammal in its environment, but need to put into context. Protecting/establishing criteria for commercial activity.
        - Example: Cook Inlet – noise criteria for harassment (120 dB) is below ambient (123 dB).
    - Ambient lets you know pulse on the background conditions and alerts the regulator to long term ambient noise creep.
    - Need to be careful of ambient noise creep (a steady increase in background noise.)
        - Ambient noise levels are rising to harassment thresholds.
    - Question: Does it make sense to have large company collecting monitoring data to get together to exchange data? Would have holes in coverage but would have some data.
    - Answer needs to be in the regulators court.
    - Regulator does not have the authorization/funding to support a long term database.

- Alternative is the shipping database
- MARVIEW has much information to give to the public.
- Christine Erbe will take draft summaries and fine tune them.
- OTHER POSSIBLE QUESTION:
    - What about climate change issue? Is there an effect?
    - Suggestion that acidification of ocean would change the volume attenuation because sound propagation is based on pH – absorption coefficient is affected.
    - But there is not a strong tie into the climate change.
    - Never mind this question.

**(3) <u>Quieting Technologies</u>**

**Different groups are working on ways to quiet shipping noise and quieter alternatives to seismic airguns for oil and gas surveys. Are there other activity types in which economically feasible improvements have been/could be made to reduce the amount of energy introduced into the water to accomplish the given goal (i.e., quieter ways to build a pier or detect an enemy submarine)?**

- Behavioral Significance: What will be the principle drivers on behavioral significance? Quieting addresses receive levels, but in order to affect quieting, some of the most promising technologies would have affects on duration and frequency content
- The metrics for behavioral significance would have to be taken into account to focus what quieting efforts are the priority
- Purposeful vs. Incidental: One of the goals of quieting is optimizing of different purposeful signal uses wrt animals and people relative to incidental background noise
- Incentives: Research and incentives need to be addressed in order to be advanced and obtain support
- Who pays for the research? For example: Canada charges user fees to petroleum companies and when West Africa opened up for exploration, they oversaw the collection of baseline ID and petroleum companies got as one product
- Noise budget piggy banking could be a viable option (e.g., cap and trade) (or, focusing budget on priorities)
- User fees would be used to fund research
- Seismic Technology: Alternatives to Air Guns
- Marine vibroseis development
- Vessel Quieting : IMO guideline development, higher cost applications, Navy and NOAA have both done higher cost applications
- There is a really great need for better understanding of effective measures to quiet ships and no clear research framework to support it
- Navy SONAR: Most quieting is operational constraints rather than technological adaptations or modifications
- Exploration of signal modification with lower intensity with trade duration tradeoffs

- Construction: Bubble Curtains and muffling
- Because they are temporarily constrained, a lot of the quieting ideas are operational (SONAR and construction phases)

**(4) <u>Cumulative Contributions of Multiple Sound Sources to Marine Noise</u>**

**How do we best evaluate multiple specific sources and their cumulative contributions to marine noise?**

- The physics is available, it's a bookkeeping problem that can be addressed by summing up received levels at the animal.
- On the biological level this is hugely complicated problem, it is a behavioral question that depends on several issues, including animal recovery time, habituation, sensitization, context, audiogram, stress level, etc. The science is not available to address this at this time.
- Management tools are short-term, single source constructs; management needs to define and demand the metrics (which will be informed by biological effects)
- Separate out sound sources, get baseline from there, then look to combination of others.
- Under risk assessment broadly characterize major source of noise and include in the model.
- Studies done on humans, monitor on exposure level to some threshold to determine harassment/take.
- A take is a single measurement – not single evaluation of effect on animal.
- Don't have an answer to the question.
- Issue is context driven.
- Don't have science to answer the question.
- Can make assumption, example beaked whale doesn't hear that frequency.
- HARD, HARD, HARD QUESTION.
- Possibly just add up the received levels.
- Really is a biological question – no expertise at table to answer adequately. Not a question of multiple or single sources but the biological reaction to that source.
- Fish people come at issue differently from large mammals because they can dissect a fish.
- Can put D-Tag on the whale though. Only done single source to date but could do more than one source.
- Acoustically, does not make a difference.
- No bounds on question, so don't know how to respond to it.
- Behavioral context driven.
- Animal perceives sound at different frequencies.
    - Question: are you potentially harassing animal beyond range of the animals hearing – maybe?
    - Question: Could this be considered a complicated waveform issue?

- NOAA – take on task to reduce globally in-water noise. Example wind farm, seismic and sonar. How to assess the cumulative effects? Cannot model with an acoustic model.
- Won't get to point of dosimeter, is that enough?
- Can accumulate all sound sources. Moving species need to be taken into account.
- Question: what about long term effect on animals – maybe it shortens their life – unknown.
- Two ways to look at issue: 1) Monitor received exposure level, if over threshold called a take; or 2) acoustic ecology of animal – what is going on with the animal, the big picture.
- Along migratory route may receive several pings from different sound sources. Don't know how to evaluate.
- Don't ever believe an animal will be exposed to PTS and maybe not TTS if it can avoid the source. Avoidance behavior needs to be considered.
- On physics level, it's a bookkeeping issue, just sum. But on biology level it is largely couple issues taking into account recovery time, duration of exposure, habituation, motivation, stress level, etc. Requires research audiograms.

**(5) <u>Sound Propagation Prediction Tools</u>**

**What tools are currently available (or will be available in near future) to resource managers and the public to model sound propagation? How do these tools compare in ease of use and accuracy of output? Have they been validated?**

- What tools are currently available? There is ray/gaussian beam based, normal mode, fast field/wave number integration, and parabolic equation
- Standard historical bases exist, but typically insitu measurements are required
- The quality of the output is based on the quality of the input based on data resolution ( spatial and temporal resolution)
- Running the system requires skilled operators, agencies need to have technical expertise (capacity issues), and you need an available user friendly platform (ex: AIM, ESME)
- Very good with particular types of modeling scenarios and having validated output; in others we are not such as shallow water low frequency propagation, high resolution 3D, rough scattering, reverberation; and some types (impulsive sources)
- Applicability to management scenarios: do they provide the ability to look over a broader band in a single hertz model, do they integrate how animals are truly distributed in space
- Validation: Models are consistent with each other, but they fall apart based on environmental input quality (in more heterogeneous environments, more data is needed to accurately predict propagation)
- What are the impacts that you are trying to quantify (sound is one part of this)
- Use deterministic forecasts or hindcasts; avoid averaging

- Need to invest in databases for full predictive systems
- Need improved information on sound velocity profiles, bottom acoustic parameters, wind speed/wave height, bathymetry, and characteristic of sound sources
- Can something be done to improve information on sound profiles for shallow water?
- Publicly available models for sound propagation provide reasonable results in comparison to Navy's CASS model
- How we collect information on noise is unique due to the freedom of almost anyone being able to stick an instrument in the water and collecting information - there are issues with expertise on being able to process/analyze the data
    - Something to think about is recruitment of new talent in the acoustics field and who will train them - there is a problem with losing knowledge on underwater acoustics – programs dying or people passing away
- Need to mine old datasets to get to ambient noise baselines to understand how things have changed

**Recommendations:**

- A measurement of ambient noise trends needs to be made in the North Atlantic
- Someone needs to approach the Navy to try to get Arctic acoustic measurements from the cold war era declassified

**(6) <u>Standardized Marine Mammal and Sound Database(s)</u>**

**There have been many discussions about creating a standardized marine mammal database and requiring that all parties/agencies holding permits or authorizations be required to electronically enter any data collected (which will sometimes include sound source verification information and could also include other sound source information) into that government-run database. This data could then be systematically archived, analyzed, and potentially made available to resource managers, researchers, and the public. Without getting into a discussion of who should fund this and which government agency would house it (although, with the intent of informing these issues) please consider the following:**

- **What are some of the logistical needs to make this happen (e.g., data clearance/proprietary issues, communication among agencies with access to data and/or expertise in managing data etc.)**
- **As a potential user of this database, how would you use this resource if it existed (e.g., all visual sightings made during construction projects in Puget Sound over 10 years, or the sound source verification data for seismic airguns in the Arctic) in research and/or environmental impact assessment contexts?**
- **How can we standardize source characterization and measurements (at least within certain large frequency bands) so that comparisons among sources are meaningful in the context of evaluating impacts to marine mammals?**

    - **For example, the ASA Standards Committee S12/Working Group 47 has produced a document, "American National Standard Quantities and Procedures for Description and Measurement of Underwater Sound from Ships- Part 1: General Requirements" (ANSI/ASA S12.64-2009/Part 1), and similar efforts are under way within the International Standards Organization (ISO/TC8SC2) regarding the characterization of underwater noise, specifically for merchant ships. Should the ANSI standards be adopted as a standard for sound source verification (SSV) test when vessel noise is involved? Or should we wait for the ISO standards and make a decision which one is the most appropriate to be used in addressing shipping noise? Why?**
    - **Are there other existing standards that we should consider adopting? What are the pros and cons of doing so?**
- **Are there existing datasets describing specific propagation environments (e.g., SVP, boundary condition, transmission loss spectra, etc.)? Is the information accessible to researchers and resource managers?**
- **Some government agencies may have existing but currently under-utilized datasets that could be made available to aid in the analysis of biologically significant effects of sound exposure. List any of these datasets (of sound source characterization or propagation data) that you are aware of, by agency, and indicate what type of data (e.g., basic information on distribution/abundance, data on potential effects) is contained in the dataset, as well as the general format and standardization of raw and metadata. What needs to happen to make the data more readily available (e.g., are certain protocols existing, or necessary to design)?**

General statements:

- There are 2 issues: how data is collected and where it ends up
    - How and where do you store the data?
- Government subsidized research should have data collected and archived in a standard format so that it can be shared more easily
- What are the requirements for a database: do you need the raw data or do you need scrubbed data (an example is only archiving blue whale calls instead of the whole dataset)
- There will probably be issues in regards to navies allowing data to be released due to classification issues
- What do people need data for: do management people have different needs than scientists?
- Everyone agrees this is important, but there are many nuances that have to be considered
- Need to include information on uncertainty to improve tuning capabilities of models

Recommendations:

- An interagency group needs to be tasked with figuring out how to pay for and house this type of database

- Create ANSI/ASA like standards to characterize sounds from airs guns and shallow water industrial activities
    - Shallow water bottom type variability makes standardization difficult
- There should be a requirement that ship tracks and source characteristics from oil exploration be made available for analyzing soundscapes
- Some product from Navy's SPORTS system that documents the use of sonar be made available for analyzing soundscapes
- Coast guard (must) compile of AIS be made available for analyzing soundscapes
- It is important to collect metadata for all data being included in any databases
- Agreements/mandates need to be in place so that people will make their data available to the global community
- Is there a way to come up with standards for how the data is to be collected
- There needs to be a clear understanding of the soundscape in the ocean that comes from data archived by cooperating federal agencies
- An interagency group needs to be tasked with figuring out how to pay for and house this type of database
    - Part of this needs to be to find out requirements, who the users will be, standardization of data, clearances, etc.
- Create ANSI/ASA like standards to characterize sounds from airs guns and shallow water industrial activities
- There should be a requirement that ship tracks and source characteristics from oil exploration be made available for analyzing soundscapes
- Can a product from the Navy's SPORTS system that documents the use of sonar be made available for analyzing soundscapes
- Can the Coast Guard create a compilation of AIS that will be made available for analyzing soundscapes
- Need improved information on sound velocity profiles, bottom acoustic parameters, wind speed/wave height, bathymetry, and characteristic of sound sources
- Can something be done to improve information on sound profiles for shallow water?
- Publicly available models for sound propagation provide reasonable results in comparison to Navy's CASS model
- How we collect information on noise is unique due to the freedom of almost anyone being able to stick an instrument in the water and collecting information - there are issues with expertise on being able to process/analyze the data
    - Something to think about is recruitment of new talent in the acoustics field and who will train them - there is a problem with losing knowledge on underwater acoustics – programs dying or people passing away
- Need to mine old datasets to get to ambient noise baselines to understand how things have changed
- A measurement of ambient noise trends needs to be made in the North Atlantic
- Someone needs to approach the Navy to try to get Arctic acoustic measurements from the cold war era declassified

- www.marview.gov – tracks AIS data worldwide (Department of Transportation); archival data (what is currently collected?

**SESSION C**
**Acoustic Behavioral Harassment Criteria,**
**Methodologies for Cumulative Effects Analysis, and Mitigation**
**Jolie Harrison and Leila Hatch**

## (1) Acoustic Behavioral Harassment Criteria

**Thinking outside of any boxes (i.e., do not limit thoughts based on questions below), what are some alternative methods (with their pros and cons) for structuring and implementing acoustic criteria for behavioral harassment? For example:**

- **Dose/response curve versus step function based on received level**
- **Estimating sound fields on a project-by-project basis vs. setting up standard isopleths for different activity types/depths/bathymetry**
- **If dose/response curve, how derive? – LOGIT, etc.**
- **Quantitatively, and more comprehensively, incorporating the consideration of additional contextual factors such as distance from the source, directionality/predictability of source movement (i.e., additional factors beyond received level).**
- **Classifying general categories of noise differently, for example (1) impulse; (2) non-impulse continuous (such as drilling or any source that is continuously run for an appreciable duration at one location); and (3) non-impulse transient (such as vibratory pile driving, shipping, or any source that runs intermittently or runs continuously but does not stay at one location) – OR, maybe it should be by activity type instead of these broader categories? OR, sounds classified as predators?**

**Acknowledging the large role that context of exposure plays, how should hearing sensitivity (by frequency) be quantitatively taken into account in predicting marine mammal *behavioral* responses to sound?**

**If there are other important issues under this topic, please address those also.**

**Table C-1**
**Acoustic Behavioral Harassment Criteria**

**Dose/response curve versus step function based on received level?**

- Dose function is an improvement over the step function.
- The sole use of step functions for regulatory decision-making is no longer appropriate due to the variability associated with a single number. Step functions don't represent the full range of reactions for different types of animals.
- For example, there could be a single continuous curve with several step functions binned within the curve to trigger/facilitate regulatory decision-making or mitigation. (Group Consensus).
- Also, modeling for takes by **dose response** should be a part of an exercise to get a permit.

**Estimating sound fields on a project-by-project basis vs. setting up standard isopleths for different activity types/depths/bathymetry?**

- Every project will have different source characteristics. Anytime you model, you take into account the variability of these types of inputs (depth, bathymetry, season, ship track, etc). The group recommends to estimate on a case-by-case basis.

**If dose/response curve, how derive? – LOGIT, etc.**

- Recommend the binning approach of the step function embedded within the continuous curve previously discussed (i.e., specific thresholds where the operator at sea can implement mitigation/shut-downs).
- We have to use the same metric for comparisons. Look at studies where SPL have been estimated for animals and build your best curves from those data.

**Consideration of additional contextual factors.**

- Note that the more variability you insert into the criteria, the more difficult to model/compute. Increases computation time and production time for required documents.
- The group identified five factors that should be considered: time, repetition, frequency, level, and context. For the regulators, suggest creating guidance parameters for each one.
- In the permitting phase, all parameters should be estimated. Then the regulators could assess which parameter is the most salient variable for that activity.

**Classifying general categories of noise differently**

- Consensus that it is important to consider the context, especially when considering the ambient acoustic environment. Different types of exposures may require different assessment protocols.
- Long-term events without chronic effects should be in a different class for permitting activities than short-term events.
- Difficult to determine the significance of the reaction for each of these types of sounds? Reiterate context of the situation.

*Table 6-C*

**Acoustic Behavioral Harassment Criteria**

Need to develop a matrix that (at least initially) categorizes by Species, Activity and Geographic (with sub-groups within each)

Taxa based on observed behavioral response similarities (ie, inshore dolphins, beaked whales)

Activity – ie, seismic, pile driving

Geographic - based on physical characteristics (ie, near shore, shelf) and/or where a known specific animal behavior occurs with supporting information that we can expect a different behavioral response at a specific RL than we would expect when they are not doing that behavior

Need to develop a series of step functions based on available literature that documents behavioral reactions by RL

If a data gap exists, need to pull in data from other boxes in matrix that are most representative

Literature search is the first step required to support each category, identify the data gaps then prioritize the data gaps and make recommendations for research focus

What we are attempting to do is to develop a framework for behavioral harassment that takes context into consideration

Note: there was some non-conclusive discussion about what metric to use for RL, ie, energy or SPL or another quantitative way that takes duration into effect

**(2) <u>Masking</u>**

**How can we quantify the biological (fitness) consequences of signal masking in order to understand the costs of noise interference with communication, the locating of prey, predator avoidance and hearing environmental cues in marine animals? How should we seek to manage relatively lower level (below current exposure thresholds) changes in ambient noise resulting from regular human activities that are, nevertheless, changing the acoustic ecology for marine animals that rely on sound to live?**

**If there are other important issues under this topic, please address those also.**

*Table C-2*

- **One way to approach the issue is to model net background changes in the acoustic** environment, across the range of activities, and to compare with longer-term population trends.

- Obtain an index of ambient noise on a broad range, determined simplistically through sensor-based monitoring, which can be compared with range when additional activities are added to environment. Index can be understood over seasonal and longer-term scales.
- We can then model the environment based on forecasted changes in activity levels. The obtained index and modeled changes to the environment can be compared against observed long-term changes to given populations.
- Assess how much masking is occurring based on the above and what is known about signal usage of certain species. This approach provides some understanding of 'baseline' (ambient background, including all activities over defined time scale) against which changes in activity level can be measured against what is understood about an animal (or population's) acoustic space requirements.
- 'Hotspots', or areas that currently have high levels of activity, especially shipping, can be areas where we first look to understand this. In addition to the index of background noise, we should look to understand an index of overall background activity against which to measure changes in activity.
- Biological impacts can include a) reduction in environmental perception, b) reduction in communication, c) complete masking of all signals, and d) annoyance. These then reduce reproduction and/or overall longevity/survivability.
- Management must occur under the inherent assumption that negative impacts are occurring. Understanding these impacts are not generally amenable to scientific experimentation, and waiting to observe negative population trends could result in irreversible harm, indicating a precautionary approach.
- There is a need for long-term studies. From management perspective, it is very difficult to use quantified reductions in foraging as some percentage of 'required' caloric intake, for example, to set policy or regulate activity levels. In the interim, precautionary management options include reducing noise level from ships as well as capping ambient noise. Practicability is an issue.
- The conservation status of a given species, as well as stressors other than noise (cumulative impacts should be considered), should play a role in management's risk tolerance when considering conservation of species against the backdrop of the suite of societal considerations.

**(3) <u>Cumulative Impacts Assessment</u>**

**How do we integrate information about how animals are responding to noise with information about how they are responding to the more realistic multi-stressor environments that they are exposed to either during a short-term permitted activity and/or in the increasingly urbanized coastal ocean?**

- **Context is critical, and context is not just noise, it is pollution, abundance of food, mate availability, chemical pollution, new transient vessel activity and many other things. How do we integrate noise with information about the full environment the animal is exposed to in order to evaluate effects effectively?**
- **Please recommend a framework for considering the interaction of multiple stressors (acute and chronic) in the context of conservation management decisions.**

- **What additional data can be being collected when doing marine mammal research or monitoring of sound effects that could be used to inform cumulative impact assessments? Which of these additional data collection efforts would be easy, medium, or difficult? Inexpensive, medium, or expensive?**

**If there are other important issues under this topic, please address those also.**

*Table C-3*

EPA has a great definition of cumulative impacts, includes analysis of cumulative impacts from single action and across multiple actions.

Science question is what is the effect of stressors, management question is how much is too much of an effect? To determine what is too much of an effect, extrapolate from effects measured in well-studied populations, utilize PBR framework, or use a relativistic ranking. Intrepretation need to be made by management.

Different goals – manage ecosystem (coarse level framework) in region AND manage populations (survivorship, etc.).

Need levels of analysis based on goals and available data:

- Individual level for a population where individual encounter histories are used to estimate vital rates (survivorship and fecundity) using stressors (e.g. noise, contaminants, prey availability, fishery take etc) as candidate covariates in a mark-recapture modeling framework
- Call these "models based on well-studied populations" (i.e. elephant seals, resident killer whales, Sarasota dolphins, North Atlantic right whales)
- For other populations for which inference from models based on well-studied populations are reasonable, hold all other variables constant except stressor of concern (e.g. due to proposed activity or levels in unmodeled location). In this middle ground, output would still be an increase of X% in stressor is predicted to result in y% change in vital rate
- For other populations for which inference from models based on well-studied populations are unreasonable or data are lacking, apply multivariate approach to model effect on variable with assumed relationship to vital rate (e.g. communication capability, foraging activities). In this middle ground, output would still be an increase of X% in stressor is predicted to result in y% change in behavior.
- For situations with either less data or to address ecosystem-based goals, map distribution and intensity of multiple stressors in regions or ecosystems and use qualitative framework (i.e. scenario-based frameworks, expert-based opinion) to weigh vulnerability of habitats and species overlapping those areas. Using this approach, output would be relativistic ranking of cumulative impacts (i.e. Halpern et al. 2008, Johnson et al. Biological opinions etc.)

ISSUES/RECOMMENDATIONS: Populations selected for PCAD, POLLUTION 2000+ and analyses proposed above should be the same. This would address one of the weakest parts of modeling: need to have covariate data for multiple stressors at the individual to understand synergies.

Table C-7

- How do we integrate information about how animals are responding to noise with information about how they are responding to the more realistic multi-stressor environments that they are exposed to either during a short-term permitted activity and/or in the increasingly urbanized coastal ocean?
- Recommend developing more comprehensive stock assessment reports that are more expansive and inclusive of recognized and new stressors and environmental conditions
- First, understand species and environment, then identify potential stressors, then analyze how these stressors add up cumulatively
- Benefits of having that information in one document
- Context is critical, and context is not just noise, it is pollution, abundance of food, mate availability, chemical pollution, new transient vessel activity and many other things. How do we integrate noise with information about the full environment the animal is exposed to in order to evaluate effects effectively?
- Synergistic effects of various stressors hard to understand
- Developing matrix that identifies stressors and potential connections
- Please recommend a framework for considering the interaction of multiple stressors (acute and chronic) in the context of conservation management decisions.
- Must have fundamental understanding about species
- Prioritize “unknowns” to compete the life history picture (ex. highly migratory species)
- For non-migratory, not as critical because know where they are
- Cumulative effects must deal with particular stock or population – what is their spatial domain?
- Stocks cannot be defined by political boundaries – must have global understanding of species
- Suggest matrix populated with information about species, stressors
- How to make best decisions
- Best available info
- What we would like to have – recognize limits of best available data (ex. best available = 10% of what we would like to have)
- More tentative if less; less tentative if more
- Management has to decide if unknowns are within realm of acceptable risk
- Still learning more even for species we think we know a lot about (ex. gray whales)
- Not a static environment – environment changing, and knowledge about the environment changing
- Look at cumulative in terms of adapting to the future
- For managers, how do we adapt to changing conditions
- Long-term activities need to be monitored over time

- Ex. renewable energy projects
- How can technologies be developed without holding up the industry
- Need to be explicit about areas of certainly and uncertainty because uncertainly may decrease in the future if dedicate to gather more information in those areas
- What additional data can be collected when doing marine mammal research or monitoring of sound effects that could be used to inform cumulative impact assessments? Which of these additional data collection efforts would be easy, medium, or difficult? Inexpensive, medium, expensive?
- Next workshop could try to bring in multiple disciplines – direction and prioritization comes from what identified
- Highly flexible and highly interdisciplinary
- Need to bridge certain gaps (i.e., vocabulary) but can be resolved based on experience with recent examples
- Just have to learn to communicate
- Ex. Okeanos, TOPP (Tagging of Pacific Predators)
- If any other important issues under this topic, please address those also

**(4) <u>Mitigation</u>**

- **Regarding typical basic mitigation measures (i.e. exclusion zones, monitoring of exclusion zones, power-down or shutdown within exclusion zones, or ramp-up) intended to avoid exposing animals to sound levels associated with TTS, PTS, or more severe behavioral responses:**
    - **What evidence is available indicating these measures are effective at accomplishing the goal above?**
    - **How would you design a study to evaluate the effectiveness of current mitigation measures?**
    - **Are you aware of real-time ways to improve/augment these measures to better accomplish the above goal using methods or technologies that are available today and considering the characteristics/goals of the proposed activity?**
    - **What kinds of potential effects (e.g., auditory masking from chronic sound sources) may conventional approaches miss in terms of mitigation**
    - **Based on existing evidence, what are the pros and cons of focusing mitigation measures primarily on avoiding exposure to very high levels (at close distances) that would likely be associated with more severe impacts versus avoiding other kinds of impacts that may be less immediately severe but more widespread?**
- **How do we best incorporate information about noise exposure into siting/ocean use decisions in general? For example, based on the existing evidence, what characteristics of marine mammal use would suggest that an area should be considered for limiting sound-producing activities, (e.g., breeding/calving, feeding, high density, etc.). What information exists to support the effectiveness (in terms of reducing quantity or severity of effects) of limiting activities in these scenarios?**

- **For the purposes of both better analysis and mitigation development, is there evidence of specific acoustic exposure conditions that have been linked to more adverse effects (e.g., the way that the Navy has generally characterized the steep bathymetry and multiple vessel factors that have been present in most of the stranding events that have been associated with naval exercises)? Or, if scientists suspect such an association, but supporting data are limited, how could we design a study to answer these sorts of questions?**

**If there are other important issues under this topic, please address those also.**

*Table C-4*

- **What evidence is available indicating these measures are effective at accomplishing the goal above?**
- Some evidence for baleen whale horizontal avoidance of seismic activity
- **How would you design a study to evaluate the effectiveness of current mitigation measures?**
- Ramp up: determine orientation and range of animals before and after ramp up procedures; experimental studies
- Monitoring: have multiple monitors observe/report independently (without consulting each other), compare end result, and allow scientists to assess reports
- **Are you aware of real-time ways to improve/augment these measures to better accomplish the above goal using methods or technologies that are available today and considering the characteristics/goals of the proposed activity?**
- Use of active sonar to detect animals
  - evaluate effectiveness of detecting animals within safety zone and evaluate effectiveness of limiting impacts to animals
- **For the purposes of both better analysis and mitigation development, is there evidence of specific acoustic exposure conditions that have been linked to more adverse effects?**
- When a sound source is in the center of migration corridor or in the middle of where animals want to go
- When sound associated with a direct threat (e.g. presence of killer whales in beaked whale habitat)

- **Or if scientists suspect such an association, but supporting data are limited, how could we design a study to answer these sorts of questions?**
- Ship movement towards shore, essentially herding the animals
  - tag animals and use gps to track animal and ship movement
  - test ship movement toward shore and away from shore

- **General points:**
- Monitoring data (raw data, not just reports) should be readily available to public
- Need to standardize monitoring and reporting efforts to make this most effective
- Monitoring provides basic information to determine necessary mitigation measures and needs to be done in action areas before activities (e.g. oil exploration) ever begin

- Balance of near-source real time mitigation vs long-term planning mitigation
- Need to report range and orientation of animals to vessel when observed
- Debate about whether masking is captured by behavioral risk function

**(5) <u>Monitoring Methods</u>**

**How should we design and prioritize monitoring studies, in the context of regulated activities, to both: 1) better understand the acoustic signatures and acoustic behavior of sources and species, respectively associated with the authorized activity and area, and, as appropriate and needed, 2) provide information that will help fill broader identified data gaps (background noise variation in a region, animal distribution/density in a region, response of species to sources of different types under different conditions etc.) or 3).**

- **What is the most important type of information that monitoring programs should gather? Why?**
- **Describe how the focus should shift in different circumstances (e.g., for longterm activities vs. shortterm, for activities in areas with little available marine mammal baseline information vs. areas with substantial information).**
- **Describe some methods/study designs that could be used to efficiently gather the data prioritized above (specify method, not just technology used). Estimate how long these methods take to implement (from deployment of equipment through analysis of data and finalization of reports) and compare how much they cost, grossly (low, medium, high – or some other system).**
- **Should NMFS convene a panel of experts to design a national monitoring strategy specifically targeted at filling some of the data gaps identified in this workshop? Focus of this group would be to recommend methodologies pursuant to a wide array of regulated activities that would take into consideration varying resources (money, capacity and infrastructure) among regulated parties while ensuring consistency in overall approach and goals among monitoring programs. Why or why not?**

**If there are other important issues under this topic, please address those also.**

*Table 5-C*

- **Need to establish a common language and be consistent in using it**
  - **(Research, monitoring, mitigation, baseline)**

- How should we design and prioritize monitoring studies?
- Monitoring is the process of 'looking for a change' , therefore baseline data are needed for comparison
- Baseline data collection is imperative for monitoring studies.
- Research done first gives a baseline, which then provides information on how to monitor the area
- Decide what type of baseline data currently exists and what are needed (agency collaboration)
- Acoustic Monitoring may be more cost effective and thorough

- Should be done in concert with visual monitoring

- What is the most important type of information needed?
- Region-specific research needs to be conducted to determine what techniques are most applicable to the area studied
- Acoustic monitoring would develop comprehensive baseline data and should be incorporated into existing OOS databases

- How should focus shift in different circumstances?
- It depends – context/activity specific incorporating regional variability in populations

- Methods/Study designs
- Regional, focused studies need to be done then incorporated into a nationwide ongoing study to gather a more complete baseline dataset.
- There needs to be some fine-scale study of specific populations in order to gather baseline data, which can be used to identify monitoring and mitigation strategies
- Acoustic studies are complimentary to visual monitoring and can produce extensive baseline data

- Should NMFS convene a panel of experts to design a national monitoring strategy?
- Yes
- Need to establish a common language and be consistent in using it
- Panel should include members of the groups and agencies which will be using/ regulating the data
- Monitoring studies are currently viewed as a requirement, should be viewed as a more proactive approach
- Use of AMMAPS for inter-agency collaboration and to design finer-scale acoustic studies

*Table C-8*

- **<u>Summary Discussion Points</u>**
- *How should we design and prioritize monitoring studies in the context of regulated activities to better understand acoustic signatures and behavior of sources and species in authorized activities?*
- Regulated: Monitoring for mitigation measures implemented (Navy sonar, Oil & Gas seismic, Coastal Construction) Sound signature is required of equipment, depends upon whether full power can be used or adjusted.
- **Better propagation models are needed. Focus on exercises where opportunities present themselves to gather information is a priority. Static cases preferred to dynamic exercise cases.**
- No current regulation on sound population from shipping sources.
- **Three main sources being regulated**

- **Navy sonar sources**
- **Industry sources**
- **Coastal construction**

- *All deal with a priori assumptions with regards to propagation models to establish safety zones. Coastal construction and industry required to do on site measurements as well. Academia involved in lawsuits regarding sound regulation.
- *How do we help fill broader identified data gaps (background noise variation, animal distribution/density, response of species to sources in different conditions)?*
  - **Develop a recommendation to develop a monitoring program to assess areas where coastal shipping noise signature has elevated to a point of having an environmental impact.**
  - **Better understanding of current noise budgets (anthropogenic sources) to bound the options for improvement of regulation.**
  - **Resources could/should also be utilized for stock assessments/baseline understanding of species to better analyze behavioral responses to injected noises.**
- **Recommendation is for cooperative effort in industry to establish a field of long-term analysis associated with oil industry.** Start with a surrogate site to hone the assessment process and provide baseline. Must be careful when choosing the sites for these as we must understand what the area chosen means to the animals being monitored. Example, is it a transient location.
- Simplistic Statement – **We must improve the baseline data to provide added credence to stressor analysis.** Doing this is the hard part. Coordination of info exchange seems to be much easier to accomplish than actually occurs. Cooperative Effort in the scientific community would be needed since everyone is interested in the data 'They' need, instead of what the industry/community could use. ***This would be a significant paradigm shift***.
- Must be careful not to spread the limited resources to thin amongst too many objectives. Some project focus would be more beneficial than a wider breadth of studies.
- ***Relating back to surrogate site selection, it's important the resources are allocated properly to get sound stock assessment. If you're monitoring the wrong things in the wrong spaces, this is not money well spent.***
- *Would the convening of a panel be beneficial?*
  - **Some are good at collecting data; few are good at analyzing data.**
- It would be beneficial to establish a universal strategy/framework for data collection and use of this information. Some think convening a small panel of experts, vice workshop, would help in capturing the broad nature of this subject. Others think a bottom up approach would be sufficient to establish a core set of monitoring guidelines to aid in data consistency and improved information exchange. Keeping

this focused on basic commonalities across many fields of study will make this more beneficial than trying to make this too complex.

Session C Additional Notes

- The consensus statement, with regards to Question 1, should be incorporated into the report. It clearly defines the limits for the acoustic behavioral harassment criteria and was extremely helpful to our table in framing discussions.
- Mitigation: Gray whale example – There are confounding variables. It's not just down to location of the source. You may actually be exposing a different subset of the population, e.g., younger and more sensitive animals may be more inshore and may react more. In contrast, older and/or less sensitive animals may be moving more offshore, reacting less. Conclusions from this and other such results need to be drawn carefully.
- Masking: Not enough to hear signal, need to understand and recognize what the signal is intended to convey
- Acoustic Harassment Criteria: Dose-response curve is not applicable. Response has more to do with context. Maybe dose-response works at higher energy levels. At lower levels, should look more at signal to noise ratio. Is the sound/noise detectable?

- PTS/TTS limits seem to be based mostly on bottlenose dolphins and belugas, but data from harbor porpoises seem to be placed in a separate category. Why is the apparently most sensitive animal seen as an outlier and not used to base PTS/TTS on? This is not precautionary approach.

DETAILED NOTES

SESSION C

- **Question #1 – Acoustic Behavior Harassment Criteria**

*Table 1*

- **Dose/response curve versus step function based on received level?**
- Dose function is an improvement over the step function.
- The sole use of step functions for regulatory decision-making is no longer appropriate due to the variability associated with a single number. Step functions don't represent the full range of reactions for different types of animals**.**
- For example, there could be a single continuous curve with several step functions binned within the curve to trigger/facilitate regulatory decision-making or mitigation. (***Group Consensus***).
- Also, modeling for takes by **dose response** should be a part of an exercise to get a permit.
- **Estimating sound fields on a project-by-project basis vs. setting up standard isopleths for different activity types/depths/bathymetry?**
- Every project will have different source characteristics. Anytime you model, you take into account the variability of these types of inputs (depth, bathymetry, season, ship track, etc). The group recommends estimating on a case-by-case basis
- **If dose/response curve, how derive? – LOGIT, etc.**
- Recommend the binning approach of the step function embedded within the continuous curve previously discussed (i.e., specific thresholds where the operator at sea can implement mitigation/shut-downs).
- We have to use the same metric for comparisons. Look at studies where SPL have been estimated for animals and build your best curves from those data.
- **Consideration of additional contextual factors.**
- Note that the more variability you insert into the criteria, the more difficult to model/compute. Increases computation time and production time for required documents.
- The group identified five factors that should be considered: time, repetition, frequency, level, and context. For the regulators, suggest creating guidance parameters for each one.
- In the permitting phase, all parameters should be estimated. Then the regulators could assess which parameter is the most salient variable for that activity.
- **Classifying general categories of noise differently**
- Consensus that it is important to consider the context, especially when considering the ambient acoustic environment. Different types of exposures may require different assessment protocols.
- Long-term events without chronic effects should be in a different class for permitting activities than short-term events.

- Difficult to determine the significance of the reaction for each of these types of sounds? Reiterate context of the situation.
- **Acoustic Behavioral Harassment Criteria**
- Does it make sense to have a dose function rather than a step function? **Dose function is an improvement over the step function.**
- Modeling by dose response should be a part of an exercise to get a permit.
- Separation of monitoring and mitigation. The step function is relatively simple for a management perspective. You need simplicity in situ, to hit the kill switch.
- Dose function – we calculate harassment numbers for our permit. When we model, we model with dose function, but we look at SEL as well.
- Look at Chris Clark's modeling, why don't we use his models for estimating take for permits. BS, you'd have to start by regulating shipping industry for noise.
- Let's start with the Arctic, why can't we work backwards from Chris' models.
- Separating by frequency bands, chronic, sub-lethal exposures, for long-term monitoring and regulation, you'll need this type of assessment, for short-term activities, masking may not be a concern.
- Context, must take into account the time scale of the activity.
- Chronic, sub-lethal exposures rather than acute exposures
- You have to focus on both approaches, dose response and
- Could you have dose function, linked to time duration? Long-term events without chronic effects should be in a different class for permitting activities. Different criteria for different activities. Context is important to consider, especially when considering the ambient acoustic environment.
- Arctic, it feels like it is exposed to transient acoustic events. Context of the activity needs to be integrated into the regulatory decision-making process. Quantifying the exposure, what is the impact of the series of exposures, vs. one continuous sound
- **The dosages are not equivalent, different types of exposures may require different assessment protocols.**
- How to assess the behavioral / physiological responses to acoustic insults could be a funding priority for agencies / industry.
- Most of the data that we have doesn't have the same context as the activity that requires a permit, how to translate the laboratory results to assessments/activities in the field.
- How to translate that type of information to MSP.
- The studies have to become more representative of real permitted activities.
- How to tie all of this data together, on large scales is a challenge for regulatory decision-making is a challenge.
- **There was consensus that the sole use of step functions for regulatory decision-making is no longer appropriate. Dose function is more appropriate. For example, there could be a single continuous curve with several step functions binned within the curve, (i.e., triggers to facilitate regulatory decision-making or mitigation).**
- Can take this type of approach and use in a risk assessment.

- **There is variability within a single number. Under legal scrutiny, it's easy to argue against the threshold (i.e., what is a take) because of the variability around a single threshold.**
- Step functions don't represent the full range of reactions of individual animals.
- PTS, TTS, are more repeatable number than trying to figure out behavior. Context, prior experiences, predisposition of the animal affects the response of the animal to an acoustic insult.
- Shifts in auditory physiology could
- **Trying to assess behavior of the animal to an acoustic insult based on PTS, TTS criteria, may not account for the physiological impacts to the animal (stress, immune, heart rate).**
- **How do you encapsulate this complexity into a decision-making framework, precautionary to account data paucity, consistent and tractable?**
- This may be different by region. For example the Arctic. Will different regions require different approaches?
- The problem with single RL threshold is different for different types of species.
- Southall (2008) paper does not take injury off the table; the information is unknown at this time. Problem is small sample size. Relative signal excess, onset levels may be lower in the higher frequencies.
- We have to focus on sub-lethal effects more, but not ignore acute effects.
- Characterizing a stimulus linear relationship or a curved fit, intensity vs duration.
- **Five Factors: Time, repetition, frequency, level, context. Create guidance parameters for each one.** In the permitting phase, all parameters estimated, regulators can assess which parameter is most salient variable for that activity; determine what the relevant metric is. Dosage could be determined at the permitting process. However, the law requires that this occur at the application phase of the process.
- From the modeling standpoint we could model dose curve using SEL, but we don't.
- Are we counting too many animals for take? We get take numbers that may be more than the number of areas present. How many of these animals do in fact react to x RL? The model should be representative and realistic.
- Modeling: large footprint, evenly distributed animals, creates scenario that may generate inflated take estimates. Requires refinement of models.
- For the population of mammals, how many surveyed. Eighty percent of animals we don't have data. No whale data. Anecdotal for the info that we have for whales.
- **Five factors: Time and context are the important factors. Provide a higher level of resolution of a single number with no context.**
- You could use SEL to deal with time and context.
- All of the data that we have for behavioral responses only take into account the RL. Not taking into account other factors.
- Have to determine the criteria for behavior, and then we could model SEL for Level B takes.

- Is there a situation where you would have concern for the species because of sublethal repetition, but masking isn't occurring? Need to think of Level A, compare acoustic habitat being taken over vs. other situations of sublethal effects. Answer: In a broad scale, have to follow the regulations under the MMPA for a permit.
- Layla, Focus on the acoustic habitat resources would be put to better use than focusing on Level B due to lack of data. Under the law individuals still matte under the MMPA and ESA.
- Acoustic space is less affected in the Arctic. Concerns of just using the approach
- No data for when masking becomes chronically stressful. Comes back to time scale.
- Biological significance of masking is unknown. Short-term exposures may not affect the animal. We don't know how the animal compensates for the loss of this sensory
- **A lot of the cases of masking could be partial masking. What about the cases where there is degradation of the communication channel. Is this significant, there is a psychological element to this. Affect on attention. This is an issue with humans, not on the radar screen for consideration for marine mammals.**
- Lombard effect, not receiving feedback, increase in amplitude.
- Energetic masking. Communication masking, energetic masking overlaid with other effects (e.g. attention). It's not just the effect of what's happening in the inner ear.

*Table 6*

- Need measurements of continuous noise
- Look at activity
- Current pulse and non-pulse categories are not sufficient
- Need to consider what the animal perceives
- Animals react to sound relative to context of where they are and what they have habituated to.
- Air gun survey vs. pile driving, while acoustically similar, reaction of animal will differ.
    - Context includes what the animal is subjected to anthropogenic and natural noises
    - Life cycle of the animal may also have an impact on reaction.
- Context: animal, environment and activity
- Novelty of the source needs to be considered
    - Initial reaction
    - Need to consider long term effect
    - Environmental context
- Not sure if permit can address these issues
- Activity context may not be hard
    - But, may have situation of 2 different sound sources on one platform

- IAGC has done 3-D measurements of an activity but financially cannot be done for every activity.
    - Sound source verification is not required <u>every</u> time, but it is done periodically. Did in Alaska and Gulf of Mexico.
- Suite of sources on platform, ex. Seismic arrays, engine noise, depth sounders, etc. The array will dominate; depth sounder 3 or 10 kHz; seismic array is lower frequency.
- Need to consider differences in source level, frequency, duty cycle, etc. when discussing the 'activity'.
- Put categories within the activities.
- Now just have non-impulsive and impulsive – seems like there is more than can be done in describing the activity.
- Impulsive, tonal and broadband – need duty cycle consideration.
- Tonal component needs to be considered.
    - Represent killer whale calls
- Inherently by considering activity, do consider the tonal component.
- Tonal component is a different beast all together
    - i.e. machinery on a ship
    - It is hard to get ship specifics.
- Pile driving treated same as seismic today with regard to harassment criteria
    - Need to consider stationary vs. non-stationary and predictability.
    - Not sure how to do this calculation
    - There may be more takes in an area where the activity never happened before.
- Need revision of sound characteristics and identification of data gaps.
- Takes are based on context – are they metered?
    - Ex. If pile driving occurs in an area often, does that mean that the number of takes is reduced?
    - That is not the intention of the folks at the table.
- The number of animals affected physiologically seems straight forward; it is the biological reaction that may change.
    - This can result in less takes for behavioral harassment.
- Ex. Sea lions reaction to acoustic harassment devices – aren't reacting but they are losing their hearing
- Ex. Skittish animals – need to distinguish species instead of groups
- Behavior – maybe consider social behavior
- Marine mammal register; category 1 and 2 size based.
    - Different requirements for different taxa
    - Not just cetaceans; maybe deep diving cetaceans, social species, etc.
    - Come up with some sort of matrix.
- Porpoise is a good example
- Assumptions made are important
    - Shouldn't have true assumptions if looking to capture all situations.
- Key to consider different species reaction

    - Ex. All animals surface typically heading in the same direction versus other species that surface in a zigzag formation. If the one species that typically headed in the same direction all of a sudden surfaces scattered, that would be a change in behavior.
- Novelty of exposure is hard to predict or know
    - Very hard to apply novelty to regulatory process
- Won't be able to predict individuals but location of specific groups
- Activity in a specific area
- Acoustic criteria linked to the discussion above.
- Question: What is considered behavioral harassment?
    - Is an animal's change in direction or surface pattern harassment?
    - i.e. beaked whale doesn't typically breach, but in the Med an observation was made of a beaked whale breach several times. It is unknown if a predator was present below surface.
    - The point is that observable behavior has some high energy component and unknown biological component/factor.
- Don't need to spell out verbatim what a 'take' is.
    - Significant stuff that impacts fitness is obvious, but a 'take' is more.
- Put in context of activity
    - Take into consideration the area and behavioral reaction
- Question: What do you do with this information?
    - Is it the received level that determines the threshold?
    - Or the distance from the source?
- Start with procedural process
    - Come up with more complex description of the sound source
    - Incorporate the species context
    - Then come up with a number of harassments
- Need to start with something
    - Received level
    - Specifics of sound source (the characteristics)
- Ex. Tonal up-sweep/down-sweep, etc., need to be considered.
- Ex. Fish farms – acoustic deterrent devices to keep harbor porpoises away from the nets was intended purpose. But killer whales were affected and the population in the area changed.
- Looking for "thing" that gets you in to be regulated
    - The distance component – is there some point where the range from the source eliminates the source from consideration
    - Signal excess is a factor – need to consider ambient noise
- Distance without context is difficult to incorporate
    - Perception of loudness, similarity to predator sounds, etc.
- Question: Should M-weighting be applied to behavior?
- Question: What is going on in the environment for the animal?
    - Perceived sound can be different at different times of year.
- Possible masking issue (another tables discussion question)
- Question: How to measure perceived sound?

- Answer: Measure trained animal to detect tone then lower source into background noise.
- The data is not there to address this for all species.
- Harmonics tones – two pieces
    - Context of sound
    - How well the animal hears that sound
- Question: Quantitatively, how do you consider harmonics?
    - Currently, don't regulate >200 kHz HF cutoff
    - Quantitatively assess reaction at ends of hearing range
- Question: Is there an LF cutoff?
    - What about inshore species if there are only odontocetes there?
- Step function versus dose for received level
    - Question: does it depend on data?
- Concerns with cookie cutter for dose
- If choosing matrix – building a dose
    - How to consider variability?
- Pull out context issues
- Assume 100% response then move down
- Have series of step functions for study
    - Expose animals to X and record the reaction
    - Data is lacking in this type of study.
- Matrix could be a series of step functions
    - Context
    - Activity
    - Make it animal based
- Ex. Harbors – but have several harbors with varying environmental conditions
- Need to consider every activities affect on the animal
    - Note response to activity at some level
    - Pull out all activities that feel are important (???? Not sure I got this right)
- Not a smooth curve on animal reactions but a series of step functions
- Describe more complex, real scenario to better regulate
    - Need to compile a matrix
    - N-dimensional space and fill in the boxes
- Step function is easier to do than the dose function
- Endangered species threshold differ than non-endangered
- Question: Where do you start to consider effects?
    - Who is regulated?
- Matrix will have gray boxes where there isn't data
- Matrix:
    - Species
    - Activity
    - Geographic area
- Where there are data gaps, fill in form from other boxes that are most representative
- Question: Is the step function the fall back?

    - Making a curve is difficult because data is lacking
    - May have to resort to the use of a step function
- Attempting to take context into consideration
- Question: In absence of data or low observable numbers (i.e. n=3) where does that fall in the matrix?
- Answer: Still TBD
- This is a framework to put data as collected
- NOW: Received level PTS/TTS for pulse vs. non-pulse
- MOVING FORWARD: Develop framework to take context into account
- SPL now being used for behavioral
    - Some non-conclusion discussion on time component aspect for matrix (SPL vs. energy)
    - Majority of data presented in research is presented in received level SPL
    - Question: RMS received level?
    - What should be considered? Average pulse received or highest/lowest received level
- Won't pull out separate harassment/criteria for specific behavior (feeding/breeding/etc) unless there is supporting data.
- Series of step functions should replace the risk function

**Consensus statement:** The acoustic behavioral harassment criteria are just that. It determines the level of behavioral harassment due to acoustic exposure. It does not determine the overall level of impact – that is a separate step that can consider the risks involved in any given context allowing for a certain amount of uncertainty. Thus, behavioral harassment plus TTS, PTS and injury do not completely assess total impact and physiological stress and other factors (e.g., masking) would also need to be considered.

- Behavioral harassment is the wrong thing to look at. Need to look at context.
- Dose response are appropriate at very high levels and in a small region, but could be viable to establish severity – metrics are probably energy level metrics; at lower levels must look at signal to noise ratio
- Issue with received level is that it is confounded with distance from source
- If we're talking about behavioral harassment criteria, then with no response, how can you understand necessary measures? Fundamental flaw
- Disconnect between biological impact and regulatory need to look at this
- Have to measure behavioral harassment, and how do we do that? What it means is another question…there are other impacts, and this should be explicit. How then do you determine what is harassment

Behavioral responses are not good indicators for impacts.

Dose response curves are not always free of other variables, i.e., context. Likely that signal-to-noise ratios and context are both involved. Context very important, especially at lower level exposures.

Presence of high frequencies is probably an indicator of proximity to animals in the ocean.

You need to consider (e.g., grey whales – offshore = older animals?) all variables when you interpret your results – especially when unexpected results are found.

Dose-response curves useless at lower levels. Much context below TTS level.

Some behavioral responses at SPAWAR are completely non-transferable to the wild.

What is the risk when there is no response? Need to consider salience, e.g., how salient is the signal to the animal? Decisions based on sub-optimal information (due to masking) should be assumed to also be sub-optimal. In the case of North Atlantic right whales, they may well be making sub-optimal decisions 80% of the time.

**Question #2 – Masking**

*Table 6*

- Need to go to terrestrial mammals and extrapolate
- Lots of information on terrestrial side, very little on marine side
- Terrestrial side mostly visual so the link to the marine world is not direct
- Getting more data on ambient noise relative to masking is important
    - But what does it mean?
    - Is it just annoying? Or does it have a fitness consequence?
- Question: How would you regulate that?
- Answer: Unknown

Question 3: Cumulative Impacts Analysis

- How do we integrate information about how animals are responding to noise with information about how they are responding to the more realistic multi-stressor environments that they are exposed to either during a short-term permitted activity and/or in the increasingly urbanized coastal ocean?
    - Many trying to do this kind of work for a long time and aware of how complicated this analysis is
    - Complex difficult problem
    - Practical approach ideas: Matrix with list of stressors for species in project area (ex. pollution and sea otters), species life parameters affected, projects, and adding synergistic effects

**See Andrew Wright Presentation Assessing Cumulative Impacts of Underwater Noise with Other Stressors on Marine Mammals**

- 
    - Ex. Renewable energy project in UK developed table to document what was looked at and ranking system (defined) for effects to each species
    - Complex environment makes stressors more or less significant
    - First step to identify potential stressors
        - Stressors not all anthropogenic (ex. finding prey/food, reproduction)

- Environmental factors also play a role
  - Need individual studies on life history parameters
  - From management perspective, health of population usually considered first
- Does NMFS approach allow you to consider additional suite of stressors? Yes, there are existing regs that require agencies to consider cumulative effects.
- Cumulative effects analysis usually qualitative and subject to interpretation
  - Also need to consider species that are more sensitive than others
- Ex. fur seal populations and response to changes in prey and foraging effort
- different life history strategies must be accounted for and can present extremes in plasticity
- must deal with cumulative effects differently based on what life history animal expresses in a certain area
- field in matrix would need to address this topic
- need fundamental understanding of species to understand stressors
- Context is critical, and context is not just noise, it is pollution, abundance of food, mate availability, chemical pollution, new transient vessel activity and many other things. How do we integrate noise with information about the full environment the animal is exposed to in order to evaluate effects effectively?
- Please recommend a framework for considering the interaction of multiple stressors (acute and chronic) in the context of conservation management decisions.
  - Must have fundamental understanding about species
- Prioritize "unknowns" to compete the life history picture (ex. highly migratory species)
- For non-migratory, not as critical because know where they are
  - Cumulative effects must deal with particular stock or population – what is their spatial domain?
- Stocks cannot be defined by political boundaries – must have global understanding of species
  - Suggest matrix populated with information about species, stressors
  - How to make best decisions
- Best available info
- What we would like to have – recognize limits of best available data (ex. best available = 10% of what we would like to have)
- More tentative if less; less tentative if more
- Management has to decide if unknowns are within realm of acceptable risk
  - Still learning more even for species we think we know a lot about (ex. gray whales)
  - Not a static environment – environment changing, and knowledge about the environment changing
- Look at cumulative in terms of adapting to the future
- For managers, how do we adapt to changing conditions
- Long-term activities need to be monitored over time
  - Ex. renewable energy projects
  - How can technologies be developed without holding up the industry
  - Need to be explicit about areas of certainly and uncertainty because uncertainly may decrease in the future if dedicate to gather more information in those areas
  - If write into decision a timeline for research in areas of uncertainty, able to revisit decisions in light of new information

- Current process does include cumulative effects, but fails to address synergistic effects
  - Needs to be integrated into process
  - For endangered species, recovery plans are threat based
  - May be easier to assess for populations that have been the subject of long-term studies (ex. Randy Wells study of BoDo in Sarasota Bay)
- What additional data can be collected when doing marine mammal research or monitoring of sound effects that could be used to inform cumulative impact assessments? Which of these additional data collection efforts would be easy, medium, or difficult? Inexpensive, medium, expensive?
  - Short term and long term projects needed
    - Short term projects tend to provide initiative for long-term
    - Challenges with getting funding for long-term research
    - However, long term study critical to understanding cumulative impacts
  - What players involved?
    - Goal – coordinate and cooperate
    - Cumulative impacts analysis is interdisciplinary and needs to involve difference species as well as different areas of expertise
  - Next workshop could try to bring in multiple disciplines
    - Highly flexible and highly interdisciplinary
    - Need to bridge certain gaps (i.e., vocabulary) but can be resolved based on experience with recent examples
    - Just have to learn to communicate
    - Ex. Okeanos, TOPP (Tagging of Pacific Predators)
  - Good examples of current research
    - Long term study of Sarasota Bay BoDo
- If any other important issues under this topic, please address those also
  - Be cautious of "hot" research topics and "species du jour" because may shift resources away from other important areas and duplicate effort in one area
  - Focus should be on what we know and what we don't know not what is getting the most attention
  - Cumulative effects not just limited to sound sources
  - How do you deal with different baseline conditions?
    - Ex. Southern Hemisphere less noisy than Northern Hemisphere
    - Depends on whether species are coastal or pelagic
    - How does that affect a species sensitivity?
  - Can a strategic plans identify important research areas? What can convince research on cumulative effects? Legislation?
    - One way to approach the issue is to model net background changes in the acoustic environment, across the range of activities, and to compare with longer-term population trends.
    - Obtain an index of ambient noise on a broad range, determined simplistically through sensor-based monitoring, which can be compared with range when additional activities are added to environment. Index can be understood over seasonal and longer-term scales.

- We can then model the environment based on forecasted changes in activity levels. The obtained index and modeled changes to the environment can be compared against observed long-term changes to given populations.
- Assess how much masking is occurring based on the above and what is known about signal usage of certain species. This approach provides some understanding of 'baseline' (ambient background, including all activities over defined time scale) against which changes in activity level can be measured against what is understood about an animal (or population's) acoustic space requirements.
- 'Hotspots', or areas that currently have high levels of activity, especially shipping, can be areas where we first look to understand this. In addition to the index of background noise, we should look to understand an index of overall background activity against which to measure changes in activity.
- Biological impacts can include a) reduction in environmental perception, b) reduction in communication, c) complete masking of all signals, and d) annoyance. These then reduce reproduction and/or overall longevity/survivability.
- Management must occur under the inherent assumption that negative impacts are occurring. Understanding these impacts are not generally amenable to scientific experimentation, and waiting to observe negative population trends could result in irreversible harm, indicating a precautionary approach.
- There is a need for long-term studies. From management perspective, it is very difficult to use quantified reductions in foraging as some percentage of 'required' caloric intake, for example, to set policy or regulate activity levels. In the interim, precautionary management options include reducing noise level from ships as well as capping ambient noise. Practicability is an issue.
- The conservation status of a given species, as well as stressors other than noise (cumulative impacts should be considered), should play a role in management's risk tolerance when considering conservation of species against the backdrop of the suite of societal considerations.

**Additional notes**

Only way we can do this objectively is to look at masking of signals by our standards. We could thus look at the percentage of time signals are covered. The problem is figuring out exactly how much of a signal needs to get through the information.
However, baselines will need to vary by species, even if the measurement standard is human-based.

- Frequencies are an important consideration.

- Predator avoidance might be one metric.

What are we considering to be masking? Any sort of signal loss or degradation, given that we don't yet know what parts of the signal is important.

- Net ambient noise for a given area before is a prerequisite before you do any of this.

- This is mostly a low frequency issue, dominated by shipping, though seismic also contributes.

- Masking could be assessed by change in ambient over a period of time. Time periods should be varied.

- Call amplitude and frequency is not the whole story. It's also the frequency modulation.

- Shipping is wide frequency band and continuous. Almost perfect masker!

Masking:

- Energetic masking = total sensory disruption
- Communication masking = signal disruption
- Perception masking = environmental sensing
- Sensor arrays can be used as 'virtual whales' to determine some kind of masking index.
- How do we determine how much signal is enough? Can we look at long term population health and compare to noise? Foraging success and population growth should mean that masking isn't that bad.
- One approach is to model shipping predictions against ambient noise, and compare this with biological data.
- Some masking studies could be done in captivity.
- We need to understand maturity to know whether something is being masked. Younger vs. older animals may have different experience – younger animals may be used to more noise, due to environmental changes in the same way as younger humans. However, this doesn't mean that there are no impacts.
- Certain noises you become attuned to, then if you don't hear them you assume something is wrong – we may have a generation of mammals that have learned to deal with ambient noise, are born into it as a portion of their acoustic environment which may impact how we baseline
- Impacts should be based on behavioral state at the time of exposure, but don't have to have any behaviorally obvious consequences.
- Masking is annoying. Annoyance is linked with psychological issues, raised blood pressure and associated conditions in humans.
- Environmental perception masking can be lower than communication masking, and can be annoying, generating community annoyance in humans.
- Higher sound levels are probably dose related, while lower sound levels are very context related.
- Masking is not generally amenable to scientific study.

- We need to be looking at decadal time spans. We also need to make management changes as we progress.

Masking:
- Reduction in environmental perception
- Reduction in communication
- Complete masking of all signals
- Annoyance

- Reduce reproduction
- Reduce longevity &/or increase mortality

- We can quantify foraging, and know a fair amount about right whale calving intervals. They aggregate on food patches, but if sound is down, they go on random walks to find the patches, which increases travel costs and reduces time feeding. Can we quantify caloric costs associated with shrinking and expansion of communication network? How much of a hit in foraging success can be absorbed without decrease in reproductive success?
- We can use right whales as a case study for demonstrating that noise can affect foraging, but will need to manage most other species without such information.
- Scientists need to be explicit about exactly how hard this stuff is to quantify and how long it can take.
- Assumptions should be that ALL of signal required and that ALL of foraging opportunities are needed.
- Marine spatial planning might be one option for reducing masking impacts.
- Population route is the right way to go, but it'll take time. In the meantime, we need to avoid irreversible harm. It's quite possible that any impacts from activities now may not be seen until much later.
- We need to consider cumulative impacts issues, e.g., how impacted a population is to start with, size of reduction in acoustic space.
- We can look at how much we can hear an animal's signal over a certain noise – if we can hear it, then it's not fully masked; what is the % of time we can hear an animal's sound over a certain noise?
- What's the baseline? Maybe the human hearing experience can serve as somewhat of a baseline; understanding that there is a different baseline for each species, but maybe the human ear can be a standard in the absence of data.
- What is everyone assuming that masking actually is? What are we defining?
    - Any degradation of the signal
    - Also look at duration, i.e., short-term masking and long-term, persistent masking

- Cautious about using human thresholds and experience as a baseline; comparing noise propagating thru water with that propagating through air
- What are mechanics of inner ear? Can this indicate the range of perception
- What's the baseline? there may be enough knowledge for some species to determine baseline
- Model based on increase in net level of activity; consider duration , instantaneous vs. general increase in rise time
- There are strict rules about what constitutes complete masking; not just overlap in band and level but what is the type of sound?
- Worthwhile to look at long-term issue first, growth of ambient noise, net impact of activities, over time scales from the period of the activity up to seasons and years
- Use each monitoring unit as a virtual whale to understand what that individual would experience
- In the long-term we want to come back with some sort of index of noise; ports are masking hotspots – is it based on the number of ships coming in, or dependent on level of shipping activity; elsewhere it may be addition of other activities; open ocean is ambient plus temporary activities
- How will you deal with perception side? How much of that signal can be heard, or needs to be heard?
- Overarching principle is conservation, with subsets of reproduction and survivability – these are things that masking may impact (if we could measure them)

We aren't seeking to understand all of the mechanisms but simply to safeguard these animals. How can we make it safe enough without hurting commercial activity? Once we see changes in populations it is too late, so need a precautionary guess about what changes to acoustic ecology animals can tolerate, a measure of how much % of time they must, or can, deal with a degraded signal.

**Question 3 – Assigned**

*Table 3*

- Cumulative impacts
- EIS done by Navy on dolphin relocation to Washington (not targeted to noise)
- Run into problems with definition of cumulative impacts and species response to it. EPA has a great definition of cumulative impacts, include cumulative impacts from single action and across multiple actions. If you want a scientific definition of cumulative impacts, need a way to measure it.
- Metrics – how do you evaluate cumulative impacts
- Always multiple stressors that contribute – vessels and sound, etc.
- Knowing contaminants exist doesn't equal knowing effects to fitness of animals
- Lack hard evidence on what impacts are; no framework to determine
- IWC multi-year project [POLLUTION 2000+] estimating consequences of contaminant loads. Track animals through time in heavily contaminated and less

contaminated areas. Global project. Takes into account energetic consequences, done in context where can estimate contaminant load, but still doesn't answer "jeopardy" question for ESA. Relying on EPA thresholds is not helpful.

- How do we define animals – what does a healthy animal look like? have "ideal" animal on behavioral spectrum, look at impacts of various stressors. Frameworks that lead back to behavior can be a concern, because of mandates to look at effects to habitat. Need large population, trackable study animals to follow contaminant loads, rules out many species. Might be able to create solid framework for a few species. Models don't necessarily translate to other species.
- **Cumulative impacts analysis is the weakest part of management plan. Lack of ability to synthesize what is happening in marine environment.**
- Need baseline for what the stressors are – ambient noise levels, shipping traffic, contaminants in environment. There is the beginning of a framework for evaluating multiple stressors.
- Politically, don't stop activities because there will be cumulative impacts.
- Using mark-recapture, model survivorship against a variety of contaminants. Large sample of animals in population, estimate survivorship against covariates. Difficult to do with respect to noise. Would have gross ambient level for all individuals, coarse estimate. Would be very dependent on Would need a large amount of sensitivity analysis. Could be powerful relative to another population, would know that cumulative load is higher – but what is too much. Is it more important to know how an animal is doing or a population?
- Halpern et al. Survey of population biologists, give ranking to stressors in region, stressors weighted by importance – overall habitat survey; visual ranking. could we do this with populations or species, marine mammals overall, and include foraging success, etc. Creating GIS layers of what contaminants are there and plug into model.
- Would an indicator of ecosystem health be more effective than population? Look at suitability of habitat to support individuals (within regions). Navy is moving toward looking at ocean basins
- Two different goals – manage ecosystem (coarse level framework) in region AND populations (suvivorship, etc.). Don't want to lose either framework.
- What types of data can be collected?
- Noise database – some overall received level for region using shipping noise, oil and gas
- Weakest part of modeling, even if you have the data, link to population effect. Can describe how model fit better. Output is how strong the relationship between particular variables and effect to population is. Once you have the relationship, can change other variables in survivability model. Model would show effects of contaminants on survival over and above things like age, sex, prey availability. **Science question is what is the effect of stressors, management question is how much is too much of an effect?** Use well-established modeling frameworks. Weakest point of approach is that data requirements are so strict, would be very selective. Could construct framework with right whales, Sarasota dolphins, elephant seals because know detailed life history, use to build a larger model. If you move to a new area, will be lacking a lot of data to plug into model.

In that case, use an area-based metric. Precautionary principle would apply in those situations. Use as much of what is applicable from the known populations as is possible and translate that model to species where less info is available. Will have many more species that are lacking data than those where all data are available. Modeling framework would not be limited to well known populations. If we can't even reliably estimate population densities, how can we model all of these other variables and make policy decisions based on it? Predictive step in modeling is only as good as the raw data you have to put into it and the model – better = higher confidence. With the data, estimating survivorship and reproduction, NOT predicting anything. If the model fits well, you have confidence in using the model in populations where some data are lacking. All other things being equal, change one variable (contaminant) can estimate survivorship/reproduction based on that. Then can start changing multiple variables to look at cumulative impacts. In policy, always go back to question of are other species data applicable.

- Also need stock based models
- Need three different kinds of models.
    - Individual level for a species
    - Population/stock level
    - Ecosystem level
- Need to integrate as much information about well-known populations as we can.
- Can data from one one population be translated to a different population? Is done, works better for some species than others. For populations where we can track individuals,
- Populations selected for PCAD and those selected for POLLUTION 2000+ are not the same.
- PCAD modeling – worked through elephant seal model, will be moving to right whales
- Terestrial models for these systems.
- Need thresholds for ambient noise. At what level of ambient noise will species start to have problems? Practicality – how can you enforce?
- Translation to management would include using model to determine what expected effect is (e.g. 1% drop in survivability) and for non-listed species, compare to PBR, for listed species determine if that is acceptable.
- For large populations, it would take more drastic events to see effects than in small populations. Want to retain past history in model and add new variable to evaluate effects. If natural fluctuations continue as they have, how will human activities affect that? Looking at If you see effects in the model, what is biologically significant vs. what is statistically significant?
- Can model effects to things other than survivorship and fecundity – other behavioral response metrics, for example effect of anthropogenic sound on communication that later has an affect on survivorship. Can't make transfer function
- Population/stock model can be split to two models – one looking at behavioral response and one looking at survivorship
- Goal is healthy ecosystem that supports populations

**Question 4:**

- The standard mitigation measures we have now are aimed at reducing risk of injurious exposures, rather than long-range behavioral impacts
- Typical risk-management (e.g. determine normal exposure, what's there, etc) needs to be addressed
- Broad scale conceptual impacts need to be addressed through source-based technological advancements
    - Lessen environmental footprint at the source
    - Current exclusion zones just prevent injury
- From a management perspective, it would be helpful to know what's out there in terms of mitigation - and is it working?
    - 2 categories of alternatives: geographic mitigation vs. source-based mitigation
    - Source-based mitigation not practical because the Navy's very goal is to put energy out in the water toward their target
    - NOAA often uses spatial and temporal mitigation measures
        - Problematic at times (e.g. construction can't be done around Anchorage in winter, but that's also when belugas aren't around)
- Monitoring needs to be done (e.g. photo ID, etc) in specific regions <u>before</u> activity (e.g. oil exploration) is even started
    - Monitoring feeds into mitigation measures
- Navy needs long-term regular monitoring to accurately predict what's happening (e.g., we think we know what's out there, but then a bunch of blue whales show up in a training range)
- Longer-term understanding of abundance via monitoring helps determine effectiveness of mitigation measures
    - This is difficult from a regulatory perspective
- Questions of how successful near-source, ship-based methods of mitigation are
- 500 m exclusion zone for seismic had been used by industry for years without verification that distance was correct
    - In fact, the distance is okay for deep water, but not for shallow
- Modeling should be used ahead of time (conservatively) for prediction, then field research is necessary for verification
- We don't have good criteria for impulsive sounds (no good metric from which to set limits on)
- Ramp up sounds good on paper, but there are questions about actual effectiveness (perhaps most effective with pile driving and pinnipeds?)
    - A precautionary approach
    - Little evidence for odontocetes avoiding ramp up
    - To test ramp up, you need to allow animals to come within a certain distance; then, determine if avoidance behavior occurs with ramp up
    - This is also a context-specific issue; mating grounds, foraging sites may influence how an animal reacts

- Discussion of how large airgun arrays influence animal behavior
    - Activating large arrays results in wildly different results; not a predictable, smooth increase in sound levels throughout the area
    - Sound levels and propagation also dependent on the order in which you operate the airguns
- Discussion of whether keeping a mitigation gun on during seismic surveys (even when array is off) is effective
    - Is industry use this method just to avoid other mitigation measures?
    - Remember that in busy areas of the ocean, an airgun can always be heard. So what's the effectiveness of yet another sound?
- Acoustic deterrents need to be <u>really</u> well-tested to minimize collateral effect
- Feelings in the group that regulators are currently assuming way too much when there really isn't much data to work from
- Need for matrix design to address mitigation measures for different activities
- PAM is not always most efficient/effective because it only detects sounds in certain ranges and only when an animal is vocalizing
    - Just because PAM doesn't hear a vocalization, doesn't mean animal isn't nearby
- Discussion of active acoustics as a monitoring method to prevent blade strikes with underwater turbines
    - In terms of shutdown, we aren't at the point where we can distinguish marine mammals from large fish
- Balance needed between near-source real-time mitigation and long-term planning mitigation
- There are more effective ways to do visual monitoring
    - Require independent observers, rather than industry's own crew
    - However, all the training and hiring that would go into this may take away resources from other more important needs
- Discussion about the balance between visual observers and active acoustics - what's the most efficient?
- What's the added benefit of having visual observers?
    - Need to ensure willingness of observer to accurately/directly report what they're seeing (and not be influenced by crew)
    - Study design - have multiple observers work and report independently (no discussion between each other)
        - Allow scientists to assess reports and compare notes
- Effort data, sighting data, and shutdown data needs to be in an accessible database open to the public
    - Standardization and requirement for rapid reporting is key
- We really need better sighting and technology development in order to be proactive; rather than reacting to sound that's put in the water, we could reduce noise from the beginning
- Need for early consultation with regulatory agencies and scientific community <u>before</u> application process actually begins
    - Sighting data after activity has begun needs to be more accessible and transparent (not just the monitoring reports, but the actual raw data)

    - Emphasizes need to standardize monitoring/reporting
- Range and orientation of animals to vessel – the information needed to successfully evaluate effectiveness of current mitigation measures

- Marine spatial planning (MSP) should be used determine what portion of an area should be closed/open to certain activities
    - Currently, the industry decides where they want to go independent of scientific research
    - If we can estimate monitoring/mitigation requirements ahead of time, we can better decide where to allow certain actions
    - Having these discussions when a permit is being applied for is too late from a regulatory standpoint
- GIS tool (within NOAA?) showing critical habitat would be really useful (10km x 10km)
    - But not effective unless it's done at a fine scale
    - We seem to be moving in this direction in regards to wind farm development in the Atlantic; at least at the state level
- Habitat mapping really important to developing data layers, ID data gaps, etc; this needs to be useful for management purposes
- Need to overlay sound budget map with marine mammal hot spots
    - Once we have this information and these maps, the data still has to be updated and maintained to verify efficacy
- It is difficult to mitigate for all species all the time - how do we rank them for vulnerability?
    - Look at temporal niche, site fidelity, minimum pop size, conservation status, vulnerability to noise, etc
    - Similar to environmental sensitivity index
- Importance of broader spatial planning:
    - Not necessarily to determine that activity shouldn't go forward, but to determine the level of mitigation that should be required
    - Would allow us to look at areas with high cumulative impacts, not just key habitat or vulnerable species
    - Also need to look at "cold spots," not just hot spots
- The more efficient and effective our methods of handling acoustic impacts, the more influence we can have on an international level
    - Can gain the ability to say "Look what we did here to prevent this"
- Source-based mitigation (e.g. quieting technologies) is important for shipping and seismic
- Technologies may be coming out to greatly reduce source levels and the environmental footprint
    - Potential to control source characteristics and reduce SL from airguns
- In terms of developing a regulatory framework to address marine mammal impacts: do we need to drill down further among m-weighting groups from Southall et al and create a matrix based on what we know?
- Based on limited studies and data, we need to lump animals together and extrapolate to gain insight

- Most of the data out there is from avoidance studies - What about lesser studies of foraging impacts, for example? How do we fully incorporate this?
- We need to be evaluating "take" based on previous studies rather than current threshold levels
    - Then, monitor to see what the impacts are in terms of authorizing a permit
    - NOAA needs to get away from 120, 160 thresholds

- **Question #5 – Monitoring Methods**
  **Table 6**
- Important to ID what want to do a good job of.
- Monitor appropriately:
    - Design to detect any observable reaction; before, during and after.
- Question: How to suggest methods for monitoring?
- Regulator looking to pull together integrated plan of all monitoring
    - Lot of times just standard monitoring done.
    - The gaps in the matrix can drive the monitoring requirements.
- There may be a better way to do monitoring by activity.
- Need planning tool to pull together all monitoring information.
- May be useful to focus research on geographic areas.
    - Series of things that need to be looked at, ex. Stellwagon Bank, can look at extensively and get different environmental/biological/oceanographic fields to monitor the area from their perspective areas.
- Prior to doing operational test in an area (ex. Seismic) spend a couple years doing monitoring research. Like was done in Alaska and GOMEX.
- Acoustic measurements use bottom type but seldom actually take bottom samples.
- Long term/short term monitoring
    - Question: what is monitoring report requirement? What is the temporal application?
    - Some reports start before an event
    - Monitoring varies from before an activity to being contained within an activity timeframe.
- Question: What are you monitoring for?
    - There is flexibility in the regulations.
    - Collect general information to increase knowledge.
- There is no monitoring to watch if mitigation is being implemented.
- Agree with last bullet to provide guidelines for monitoring on national scale.

***Table __***

- Design and prioritize monitoring studies?
- MMS: No monitoring studies in the GOM
    - Has funded the largest monitoring studies with bowhead whales, since 79
    - Since it has been so successful in Alaska, why not in GOM?
        - High-ups tend to answer specific questions rather than a broad monitoring study

- What would the word “monitoring” entail?
    - Bigger umbrella as a study; however you do need baseline data
- “what is monitoring and what is mitigation” –difference btwn
    - Monitoring: Are animals present
        - There needs to be parameters that describe a monitoring study
- Monitoring studies have not been popular for funding in the past because they do not want to commit to any long-term (open-ended) study
- Money is split between the basic funding of a study and the money required for ‘operation and maintenance’
- Monitoring studies and plans have been required by the navy
- Baseline data is needed for a monitoring study
- Monitoring can be frustrating by a scientific standpoint bc research is separated
- Feedback from the monitoring studies needs to be utilized more (has been improving in the past 2 years)
- Mon. is usually only done because it is a requirement, agencies should be more proactive about mon. studies
- *Monitoring needs to be more defined as by an individual or population
    - In doing so we can better assess the data collected
- Monitoring studies have been too broad, they need to answer the question asked
- *Before monitoring can be done, a baseline knowledge is required
    - Built on up-to-date baseline knowledge
- Current baseline studies being conducted in Atlantic in preparation for future desired studies
- G and G studies in GOM collect data on whales and report it to NOAA
- Visual monitoring: very limited, can only see about 10% of whales in GOM when at the surface
    - *In getting a baseline, passive acoustic monitoring studies are better to measure populations than visual monitoring. (consensus)
    - Acoustic budgets are needed to develop acoustic baselines (seasonal cycles…etc)
    - Help assess trends
- Acoustic studies can be broad (ocean-wide), or finer to specific regions/populations
    - Acoustic budgets are needed to gather baseline data on natural and anthropogenic sound

- *Problem: There is no baseline data on ambient noise in GOM
    - Need to have some sort of acoustic array spread throughout GOM
    - Provides a control to compare monitoring studies to

- If you have a region to study, get out there and gather baseline data, then invite ocean observer in .
- Needs to be much more cooperative with OOS's
- *Regional, focused monitoring needs to be done then incorporated into a nationwide monitoring study to gather a more complete baseline dataset.
- *There needs to be fine-scale monitoring of specific populations in order to identify their baseline data which can be used to set regulations in areas around specific populations
- *Acoustic monitoring studies are much more cost effective than visual and can produce extensive baseline data
    - Achilles heel: can measure presence but not absence with acoustic monitoring
    - Needs to be complementary with visual studies
- Different institutions around the country are doing separate studies like these, there needs to be more communication and cooperation between them
    - There is a nationwide information database for these studies (IOS)
- Funding by NOAA's stock assessment program
    - However, relied heavily on visual data
- Acoustic monitoring will be able to measure animal density through JIP
- Ranges can pose as good test beds for baseline data
- Everyone needs to get together first and decide what type of baseline data is needed
- Monitoring leads to baseline or vice versa? (discrepancy)
- Research gives a baseline, which tells how to monitor the area
    - After you discover what question you need to answer, monitoring is the next step
- Monitoring is "looking for change", therefore baseline data is needed to compare to
- Mitigation Is real time implication of monitoring tools
- Methodology:
- NMFS need to establish a common language and should be consistent in using it
- Panel should include the big groups of users/regulators
- Fish and wildlife service
- Identify data gaps first then decide where to go from there
- *Monitoring is viewed as a requirement, should be viewed as a more proactive approach
- AMAPS is a good place to start for inter-agency collaboration
    - Start here to plan further finer-scale studies
- Could lead to further interest in acoustic studies

- acoustic monitoring into existing OOS

**Question 6**

- Early info from Gene (BOEMRE):
    - Regulated: Monitoring for mitigation measures implemented (Navy sonar, Oil & Gas seismic, Coastal Construction) Sound signature is required of equipment, depends upon whether full power can be used or adjusted.
        - Navy Sonar in permitting process sum of sonar activities longest typical use of propagation. Navy collects sonar use data and an after action report, safety zone is outside TTS. Navy is confident in range prediction models.
        - Coastal Construction and for Oil and Gas in Arctic similar required to measure in the habitat and define safety zone at the habitat. Nearshore Beaufort Sea is different than in offshore Chukchi Sea. Bottom recorders is possible in the Arctic but not in deeper, otherwise propagation models are used.
    - Unregulated: Shipping is not regulated, should be studied. However, the impact of coastal shipping does not seems to be adversely affecting the richest area for marine mammals.
        - Monitoring program should be developed to define effects. e.g., Houston Ship Channel
- Navy protocol for during ASW exercises compared to benefit of looking closer at safety zones associated with sound producers.
- Is it feasible to do post-op acoustic analysis following an exercise? Not necessarily from a Navy perspective with regards to resource allocation and real-time acquisition burden required.
- Are there other naval events where we can put more emphasis and allocation of assets to collect data? Definitely, and some are currently being conducted (Sea trials, ISE, AUTEC, SCORE, TACTASS operations.)
- Current safety zone analysis is very conservative.
- Seismic analysis? Navy involvement small from an operational standpoint. Commercial involvement is developing.
- **Better propogation models are needed. Focus on exercises where opportunities present themselves to gather information is a priority. Static cases vs dynamic exercise cases.**
- No current regulation on sound population from shipping sources.
- **Three main sources being regulated**
    - **Navy sonar sources**
    - **Industry sources**
    - **Coastal construction**

- **All deal with apriori assumptions with regards to propogation models to establish safety zones. Academia involved in lawsuits regarding sound regulation.**
- Marine Mammal populations doing well on the West Coast. Should we be looking at the operations along the West Coast as a good baseline.
- Protective areas along the coast needs emphasis as well and should be implemented in the analysis.
- Regulation insight: If we try and regulate the noise levels for vessels entering our ports, will they go elsewhere? Most likely if quieting measures are costly.
- Vessel shape, decoupling of propulsion noises areas of focus on newer or retrofit ships to help with noise signature reduction.
- Main initiative to get the shipping industry into improving noise signature
- **Develop a recommendation to develop a monitoring program to assess areas where coastal shipping noise signature has elevated to a point of having an environmental impact.**
- **Better understanding of current noise budgets (anthropogenic sources) to bound the options for improvement of regulation.**
- Workshop planned for US analysis and discussion of sound signature status. What do we know, and where are the hot spots? (Fall timeframe)
- There is an existing concern/desire to understand where we may be causing environmental impact.
- Following major exercises, USN evaluates what level, type, and duration of sounds the environment/animal receives. This will provide insight/information on what will help further define biologically significant event.
- Research vs monitoring: Monitoring as a means of mitigation vice obligation requirement.
- **Resources could/should also be utilized for stock assessments/baseline understanding of species to better analyze behavioral responses to injected noises.**
- Industry perspective – Looking to plan for analysis of an area for a significant amount of time (20-30 year). But, how do we establish a long-term analysis field? Some seasonal analysis exists, but this leaves gaps in data and migration trends. **Recommendation is for cooperative effort in industry to establish a field of long-term analysis associated with oil industry.** Start with a surrogate site to hone the assessment process and provide baseline. Must be careful when choosing the sites for these as we must understand what the area chosen means to the animals being monitored. For example, is it a transient location. Maybe in the context of a stock assessment.

- Navy perspective – Based on current funding, getting baseline/stock assessments(background noises, animal distribution/density in a region, etc.) would have to accidental monitoring.
- Who is it incumbent upon to collect this data? Only those that want/need the data seems short-sighted.
- Simplistic Statement – **We must improve the baseline data to provide added credence to stressor analysis. Doing this is the hard part**. Coordination of info exchange seems to be much easier to accomplish than actually occurs. **Cooperative Effort in the scientific foundation would be needed since everyone is interested in the data 'They' need, instead of what the industry/community needs.** This would be a paradigm shift. Resource management is the cornerstone of this problem and working through it.
- Is there a responsibility on the noise makers to monitor for baseline assessments? Not currently. Is this implementable or cost effective. Good stewardship of the ocean may be the focused message with shared funding requirements. 80/20 split (operational/research) maybe sellable. Great opportunity to bring the NGOs into the mix as part of the problem solution vice throwing stones back-and-forth.
- **Are the resources available sufficient to evaluate what's needed for proper risk mitigation? Must be careful not to spread the limited resources to thin amongst too many objectives. Some project focus would be more beneficial than a wider breadth of studies.**
    - **Relating back to surrogate site selection, it's important the resources are allocated properly to get sound stock assessment. If you're monitoring the wrong things in the wrong spaces, this is not money well spent.**
- Where is the natural break between baseline data collection vs mitigation. One thought is this should be controlled at the agency level. Another example, what initiative does USN have to go collect this baseline data.
- Stock Assessment Improvement Plan looking to grab some of this tertiary information.
- Chicken or the Egg: Without baseline data, your mitigation analysis is less effective. But is this sufficient cause to allocate resources for baseline data collection and analysis. Hard sell.
- When data collection is mandated, why can't we get this data back for all to utilize for analysis? Or is this proprietary information? Some, but not all, agree that it's important to have a common database for information exchange. It's less intrusive, and probably easier, in the visual sightings, but still isn't fluently exchanged. But it is improving.
- **Some are good at collecting data; few are good at analyzing data.**

- Parts 2 and 3 of question 3 are somewhat repetitive to yesterday's line of questioning.
- **It would be beneficial to establish a universal strategy/framework for data collection and use of this information. Some think convening a small panel of experts, vice workshop, would help in capturing the broad nature of this subject. Others think a bottom up approach would be sufficient to establish a core set of monitoring guidelines to aid in data consistency and improved information exchange. Keeping this focused on basic commonalities across many fields of study will make this more beneficial than trying to make this too complex.**

Session C Additional Notes

- The consensus statement, with regards to Question 1, should be incorporated into the report. It clearly defines the limits for the acoustic behavioral harassment criteria and was extremely helpful to our table in framing discussions.
- Mitigation: Gray whale example – There are confounding variables. It's not just down to location of the source. You may actually be exposing a different subset of the population, e.g., younger and more sensitive animals may be more inshore and may react more. In contrast, older and/or less sensitive animals may be moving more offshore, reacting less. Conclusions from this and other such results need to be drawn carefully.
- Masking: Not enough to hear signal, need to understand and recognize what the signal is intended to convey
- Acoustic Harassment Criteria: Dose-response curve is not applicable. Response has more to do with context. Maybe dose-response works at higher energy levels. At lower levels, should look more at signal to noise ratio. Is the sound/noise detectable?

    - PTS/TTS limits seem to be based mostly on bottlenose dolphins and belugas, but data from harbor porpoises seem to be placed in a separate category. Why is the apparently most sensitive animal seen as an outlier and not used to base PTS/TTS on? This is not precautionary approach.

**Session C, Backup Notes for Plenary Discussion**
**Introduction**

- Key issues: appropriate metrics to use in behavior. Harassment criteria.
- Some felt SPL was the correct metric, others SEL.
- Models for assessing behavioral harassment should consider the five factors noted in Session C, Table 1.
- One group created a framework, for assessment criteria. Ceate a categorization method. They considered things by activity type, by taxa, and segmented them into geographic area. Took into consideration ambient noise, bottom substrate, and incorporate contextual issues into the framework.

- Another group recommended a series of step functions for a guideline to the applicant.
- Heard the need for baseline information, baseline noise budgets for assessment of masking.
- Good to assess functional consequences.
- One group discussed quantitative moving towards qualitative modeling.

**Question 1 -** 42% chose #3. No discussion.
**Question 2 -** No discussion.
**Question 3 -** 36% agreed, no discussion
Question 4 – 1/3rd in the middle most agreed. No discussion.
Question 5 – most agreed. No discussion.
Question 6 – most agreed. No discussion.
Question 7 – most agreed. No discussion.
Question 8 – most agreed. No discussion.

**Reactions:**

Suggestion missing, sightings data from seismic surveys and commercial data should be integrated into a format to evaluate impacts. More effective use of effort detail and sightings data from these surveys. Are they actually avoiding the sound sources? Create a type of database that has this type of data. The data needs to be made available (raw data, organized database, ship track, species, orientation of the species.).

The agencies are sitting on the data. It would be helpful to have the data in a format for us to analyze. It would cost less to get this data out to the community than to create a new report.

MMS has the information. Ross Compton is analyzing all of the data now.

Our group wanted to focus on stock assessment data that was not included in the introduction. Response from Jolie Harrison: We didn't make a survey question for every question, but included in the initial bullet.

Our group talked about the need for planning style mitigation, temporal/spatial. Near source mitigation, have the planning efforts addressed this? LH: We designed this workshop to address this.

Michael: Should we query the group re: spatial temporal mitigation is primary, emphasis on planning vs. later stage mitigation. This point has been made strongly in past reports. We went for the second order question – what type of planning is needed.

More accessible tools for propagation modeling. There is an area in-between, (e.g., terrestrial studies for propagation). Agree it would be nice to have a tool that would provide a standard for managers.

Spherical spreading vs. cylindrical spreading, nothing better than conducting propagation at that site.

Two messages: folks comfortable with sound propagation modeling – this is fine

Those who are further away from using tools – we need something better that leads us to a process. Reiterate capacity building.

Question to the group: During mitigation discussions, did practicality ever come up? No, it was not a topic of discussion. The question is assessing effectiveness of mitigation. This may be easy, but not effective.

- 

**Mitigation**

Applicants should think about mitigation earlier in the planning process.

Leila Hatch: Integration of technology, improve the tools, acknowledgement of the need for a skilled user, but need more solid platforms that lead to decision-making in the NOAA regulatory framework. Whether we have the infrastructure available for the manager to make a decision. Not whether or not the prop software models work.

Active acoustics for visual detection is this included within the context of visual detection.

**Monitoring**

What do you mean by focal point? For example, several activities are required to do monitoring, in a more comprehensive framework. This could be used a planning tool to guide the monitoring plan.

## SESSION C DEBRIEF NOTES

### Question 1

*Table C-1*

**Acoustic Behavioral Harassment Criteria**

**Dose/response curve versus step function based on received level?**

- Dose function is an improvement over the step function.
- The sole use of step functions for regulatory decision-making is no longer appropriate due to the variability associated with a single number. Step functions don't represent the full range of reactions for different types of animals**.**
- For example, there could be a single continuous curve with several step functions binned within the curve to trigger/facilitate regulatory decision-making or mitigation. (Group Consensus).
- Also, modeling for takes by **dose response** should be a part of an exercise to get a permit.
    - **Estimating sound fields on a project-by-project basis vs. setting up standard isopleths for different activity types/depths/bathymetry?**
- Every project will have different source characteristics. Anytime you model, you take into account the variability of these types of inputs (depth, bathymetry, season, ship track, etc). The group recommends to estimate on a case-by-case basis.
    - **If dose/response curve, how derive? – LOGIT, etc.**
- Recommend the binning approach of the step function embedded within the continuous curve previously discussed (i.e., specific thresholds where the operator at sea can implement mitigation/shut-downs).
- We have to use the same metric for comparisons. Look at studies where SPL have been estimated for animals and build your best curves from those data.
    - **Consideration of additional contextual factors.**
- Note that the more variability you insert into the criteria, the more difficult to model/compute. Increases computation time and production time for required documents.
- The group identified five factors that should be considered: time, repetition, frequency, level, and context. For the regulators, suggest creating guidance parameters for each one.
- In the permitting phase, all parameters should be estimated. Then the regulators could assess which parameter is the most salient variable for that activity.
    - **Classifying general categories of noise differently**
- Consensus that it is important to consider the context, especially when considering the ambient acoustic environment. Different types of exposures may require different assessment protocols.
- Long-term events without chronic effects should be in a different class for permitting activities than short-term events.

- Difficult to determine the significance of the reaction for each of these types of sounds? Reiterate context of the situation.
    - Table 6-C
    - **Acoustic Behavioral Harassment Criteria**
    - Need to develop a matrix that (at least initially) categorizes by Species, Activity and Geographic (with sub-groups within each)
        - Taxa based on observed behavioral response similarities (ie, inshore dolphins, beaked whales)
        - Activity – ie, seismic, pile driving
        - Geographic - based on physical characteristics (ie, near shore, shelf) and/or where a known specific animal behavior occurs with supporting information that we can expect a different behavioral response at a specific RL than we would expect when they are not doing that behavior
    - Need to develop a series of step functions based on available literature that documents behavioral reactions by RL
    - If a data gap exists, need to pull in data from other boxes in matrix that are most representative
    - Literature search is the first step required to support each category, identify the data gaps then prioritize the data gaps and make recommendations for research focus
    - What we are attempting to do is to develop a framework for behavioral harassment that takes context into consideration
    - Note: there was some non-conclusive discussion about what metric to use for RL, ie, energy or SPL or another quantitative way that takes duration into effect

**Question 2**

*Table C-2*

- One way to approach the issue is to model net background changes in the acoustic environment, across the range of activities, and to compare with longer-term population trends.
- Obtain an index of ambient noise on a broad range, determined simplistically through sensor-based monitoring, which can be compared with range when additional activities are added to environment. Index can be understood over seasonal and longer-term scales.
- We can then model the environment based on forecasted changes in activity levels. The obtained index and modeled changes to the environment can be compared against observed long-term changes to given populations.
- Assess how much masking is occurring based on the above and what is known about signal usage of certain species. This approach provides some understanding

of ‘baseline’ (ambient background, including all activities over defined time scale) against which changes in activity level can be measured against what is understood about an animal (or population’s) acoustic space requirements.

- ‘Hotspots’, or areas that currently have high levels of activity, especially shipping, can be areas where we first look to understand this. In addition to the index of background noise, we should look to understand an index of overall background activity against which to measure changes in activity.
- Biological impacts can include a) reduction in environmental perception, b) reduction in communication, c) complete masking of all signals, and d) annoyance. These then reduce reproduction and/or overall longevity/survivability.
- Management must occur under the inherent assumption that negative impacts are occurring. Understanding these impacts are not generally amenable to scientific experimentation, and waiting to observe negative population trends could result in irreversible harm, indicating a precautionary approach.
- There is a need for long-term studies. From management perspective, it is very difficult to use quantified reductions in foraging as some percentage of ‘required’ caloric intake, for example, to set policy or regulate activity levels. In the interim, precautionary management options include reducing noise level from ships as well as capping ambient noise. Practicability is an issue.
- The conservation status of a given species, as well as stressors other than noise (cumulative impacts should be considered), should play a role in management’s risk tolerance when considering conservation of species against the backdrop of the suite of societal considerations.

**Question 3**

*Table C-3*

- EPA has a great definition of cumulative impacts, includes analysis of cumulative impacts from single action and across multiple actions.
- Science question is what is the effect of stressors, management question is how much is too much of an effect? To determine what is too much of an effect, extrapolate from effects measured in well-studied populations, utilize PBR framework, or use a relativistic ranking. Intrepretation need to be made by management.
- Different goals – manage ecosystem (coarse level framework) in region AND manage populations (survivorship, etc.).
- Need levels of analysis based on goals and available data:

- Individual level for a population where individual encounter histories are used to estimate vital rates (survivorship and fecundity) using stressors (e.g. noise, contaminants, prey availability, fishery take etc) as candidate covariates in a mark-recapture modeling framework
    - Call these “models based on well-studied populations” (i.e. elephant seals, resident killer whales, Sarasota dolphins, North Atlantic right whales)
- For other populations for which inference from models based on well-studied populations are reasonable, hold all other variables constant except stressor of

concern (e.g. due to proposed activity or levels in unmodeled location). In this middle ground, output would still be an increase of X% in stressor is predicted to result in y% change in vital rate

- For other populations for which inference from models based on well-studied populations are unreasonable or data are lacking, apply multivariate approach to model effect on variable with assumed relationship to vital rate (e.g. communication capability, foraging activities). In this middle ground, output would still be an increase of X% in stressor is predicted to result in y% change in behavior.
- For situations with either less data or to address ecosystem-based goals, map distribution and intensity of multiple stressors in regions or ecosystems and use qualitative framework (i.e. scenario-based frameworks, expert-based opinion) to weigh vulnerability of habitats and species overlapping those areas. Using this approach, output would be relativistic ranking of cumulative impacts (i.e. Halpern et al. 2008, Johnson et al. Biological opinions etc.)

    - ISSUES/RECOMMENDATIONS: Populations selected for PCAD, POLLUTION 2000+ and analyses proposed above should be the same. This would address one of the weakest parts of modeling: need to have covariate data for multiple stressors at the individual to understand synergies.

*Table C-7*

- How do we integrate information about how animals are responding to noise with information about how they are responding to the more realistic multi-stressor environments that they are exposed to either during a short-term permitted activity and/or in the increasingly urbanized coastal ocean?
- Recommend developing more comprehensive stock assessment reports that are more expansive and inclusive of recognized and new stressors and environmental conditions
- First, understand species and environment, then identify potential stressors, then analyze how these stressors add up cumulatively
- Benefits of having that information in one document
- Context is critical, and context is not just noise, it is pollution, abundance of food, mate availability, chemical pollution, new transient vessel activity and many other things. How do we integrate noise with information about the full environment the animal is exposed to in order to evaluate effects effectively?
- Synergistic effects of various stressors hard to understand
- Developing matrix that identifies stressors and potential connections
- Please recommend a framework for considering the interaction of multiple stressors (acute and chronic) in the context of conservation management decisions.
- Must have fundamental understanding about species

- Prioritize “unknowns” to compete the life history picture (ex. highly migratory species)
- For non-migratory, not as critical because know where they are
- Cumulative effects must deal with particular stock or population – what is their spatial domain?
- Stocks cannot be defined by political boundaries – must have global understanding of species
- Suggest matrix populated with information about species, stressors
- How to make best decisions
- Best available info
- What we would like to have – recognize limits of best available data (ex. best available = 10% of what we would like to have)
- More tentative if less; less tentative if more
- Management has to decide if unknowns are within realm of acceptable risk
- Still learning more even for species we think we know a lot about (ex. gray whales)
- Not a static environment – environment changing, and knowledge about the environment changing
- Look at cumulative in terms of adapting to the future
- For managers, how do we adapt to changing conditions
- Long-term activities need to be monitored over time
- Ex. renewable energy projects
- How can technologies be developed without holding up the industry
- Need to be explicit about areas of certainly and uncertainty because uncertainly may decrease in the future if dedicate to gather more information in those areas
- What additional data can be collected when doing marine mammal research or monitoring of sound effects that could be used to inform cumulative impact assessments? Which of these additional data collection efforts would be easy, medium, or difficult? Inexpensive, medium, expensive?
- Next workshop could try to bring in multiple disciplines – direction and prioritization comes from what identified
- Highly flexible and highly interdisciplinary
- Need to bridge certain gaps (i.e., vocabulary) but can be resolved based on experience with recent examples
- Just have to learn to communicate
- Ex. Okeanos, TOPP (Tagging of Pacific Predators)
- If any other important issues under this topic, please address those also

## Question 4 - Mitigation

*Table C-4*

- **What evidence is available indicating these measures are effective at accomplishing the goal above?**
    - Some evidence for baleen whale horizontal avoidance of seismic activity

- **How would you design a study to evaluate the effectiveness of current mitigation measures?**
    - Ramp up: determine orientation and range of animals before and after ramp up procedures; experimental studies
    - Monitoring: have multiple monitors observe/report independently (without consulting each other), compare end result, and allow scientists to assess reports
- **Are you aware of real-time ways to improve/augment these measures to better accomplish the above goal using methods or technologies that are available today and considering the characteristics/goals of the proposed activity?**
    - Use of active sonar to detect animals
        - evaluate effectiveness of detecting animals within safety zone and evaluate effectiveness of limiting impacts to animals

            - **For the purposes of both better analysis and mitigation development, is there evidence of specific acoustic exposure conditions that have been linked to more adverse effects?**
    - When a sound source is in the center of migration corridor or in the middle of where animals want to go
    - When sound associated with a direct threat (e.g. presence of killer whales in beaked whale habitat)
- **Or if scientists suspect such an association, but supporting data are limited, how could we design a study to answer these sorts of questions?**
    - Ship movement towards shore, essentially herding the animals
        - tag animals and use gps to track animal and ship movement
        - test ship movement toward shore and away from shore
    - **General points:**
            - Monitoring data (raw data, not just reports) should be readily available to public
        - Need to standardize monitoring and reporting efforts to make this most effective
- Monitoring provides basic information to determine necessary mitigation measures and needs to be done in action areas before activities (e.g. oil exploration) ever begin
- Balance of near-source real time mitigation vs long-term planning mitigation
- Need to report range and orientation of animals to vessel when observed
- Debate about whether masking is captured by behavioral risk function

**Question 5**

*Table 5-C*

- **Need to establish a common language and be consistent in using it**
    - **(Research, monitoring, mitigation, baseline)**

- How should we design and prioritize monitoring studies?

- Monitoring is the process of ‘looking for a change’ , therefore baseline data are needed for comparison
- Baseline data collection is imperative for monitoring studies.
- Research done first gives a baseline, which then provides information on how to monitor the area
- Decide what type of baseline data currently exists and what are needed (agency collaboration)
- Acoustic Monitoring may be more cost effective and thorough
    - Should be done in concert with visual monitoring

    - What is the most important type of information needed?
- Region-specific research needs to be conducted to determine what techniques are most applicable to the area studied
- Acoustic monitoring would develop comprehensive baseline data and should be incorporated into existing OOS databases
    - How should focus shift in different circumstances?
        - It depends – context/activity specific incorporating regional variability in populations
    - Methods/Study designs
- Regional, focused studies need to be done then incorporated into a nationwide ongoing study to gather a more complete baseline dataset.
- There needs to be some fine-scale study of specific populations in order to gather baseline data, which can be used to identify monitoring and mitigation strategies
- Acoustic studies are complimentary to visual monitoring and can produce extensive baseline data

    - Should NMFS convene a panel of experts to design a national monitoring strategy?
- Yes
- Need to establish a common language and be consistent in using it
- Panel should include members of the groups and agencies which will be using/ regulating the data
- Monitoring studies are currently viewed as a requirement, should be viewed as a more proactive approach
- Use of AMMAPS for inter-agency collaboration and to design finer-scale acoustic studies

*Table C-8*

- **Summary Discussion Points**
- *How should we design and prioritize monitoring studies in the context of regulated activities to better understand acoustic signatures and behavior of sources and species in authorized activities?*

- Regulated: Monitoring for mitigation measures implemented (Navy sonar, Oil & Gas seismic, Coastal Construction) Sound signature is required of equipment, depends upon whether full power can be used or adjusted.
- **Better propagation models are needed. Focus on exercises where opportunities present themselves to gather information is a priority. Static cases preferred to dynamic exercise cases.**
- No current regulation on sound population from shipping sources.
- **Three main sources being regulated**
- **Navy sonar sources**
- **Industry sources**
- **Coastal construction**
- *All deal with a priori assumptions with regards to propagation models to establish safety zones. Coastal construction and industry required to do on site measurements as well. Academia involved in lawsuits regarding sound regulation.
- *How do we help fill broader identified data gaps (background noise variation, animal distribution/density, response of species to sources in different conditions)?*
- **Develop a recommendation to develop a monitoring program to assess areas where coastal shipping noise signature has elevated to a point of having an environmental impact.**
- **Better understanding of current noise budgets (anthropogenic sources) to bound the options for improvement of regulation.**
- **Resources could/should also be utilized for stock assessments/baseline understanding of species to better analyze behavioral responses to injected noises.**
- **Recommendation is for cooperative effort in industry to establish a field of long-term analysis associated with oil industry.** Start with a surrogate site to hone the assessment process and provide baseline. Must be careful when choosing the sites for these as we must understand what the area chosen means to the animals being monitored. Example, is it a transient location.
- Simplistic Statement – **We must improve the baseline data to provide added credence to stressor analysis.** Doing this is the hard part. Coordination of info exchange seems to be much easier to accomplish than actually occurs. Cooperative Effort in the scientific community would be needed since everyone is interested in the data 'They' need, instead of what the industry/community could use. ***This would be a significant paradigm shift***.

- Must be careful not to spread the limited resources to thin amongst too many objectives. Some project focus would be more beneficial than a wider breadth of studies.
- ***Relating back to surrogate site selection, it's important the resources are allocated properly to get sound stock assessment. If you're monitoring the wrong things in the wrong spaces, this is not money well spent.***
- *Would the convening of a panel be beneficial?*
  - **Some are good at collecting data; few are good at analyzing data.**
- It would be beneficial to establish a universal strategy/framework for data collection and use of this information. Some think convening a small panel of experts, vice workshop, would help in capturing the broad nature of this subject. Others think a bottom up approach would be sufficient to establish a core set of monitoring guidelines to aid in data consistency and improved information exchange. Keeping this focused on basic commonalities across many fields of study will make this more beneficial than trying to make this too complex.

**SESSION D**
**Improving Monitoring Techniques**
**Technology and Methodology**
**Dave Moretti**

## (1) <u>Algorithms (by category/DCLD)</u>

*Table D-11*
Summary notes:

- Statement: questions drive the requirements
- Areas that need improvement: need a better understanding of the basic biology of vocalizations and vocalization usage – this directly applies to density estimation and probability of detection
- Recommendation: use navy ranges for verification/validation/testing for promising new technologies or if can't use a navy range use a mark/recapture method with competing and independent observers (deployment of a fake whale that embody known properties (acoustic, infrared, etc))

*TABLE D-9*
Summary notes:

- There are no set of algorithms which can replace a good analyst- and this won't change in the near future
- End users need the confidence assessment along with the algorithm
- Other problems include: processing speed, verification of algorithms, confidence levels, error rates
- It is very tedious work that requires many hours to clean, process, and test

**a. What are the basic requirements?**

- Detect, localize, classify, and assess density of anthropogenic and biological sound events.

**b. Given these perceived requirements, what are the areas (by category/DCLD) that require significant improvement?**

- Detector, Classifier, Localization algorithms are very (commercially) developed whereas density algorithms are still in their infancy with very few studies.
- Localization is key for density estimates- probability of detection falls off as you extend range so knowing the range is key input.

**c. What basic data are required for development?**

- Test and training data- in all different environmental settings, behavioral states, group size, seasons—we have just a fraction of the data that is needed. For density estimations, tagged animal and visual observation is needed.

**d. What methods can be used to verify performance?**

- Training and test databases. Performance of detectors and classifiers is verified by having data from a known species. Sounds at a known location are used to test localizers.

**e. Suggested methods for data gathering?**

- Passive acoustics (variety of collection platforms), tagged animals, visual observations (simultaneous with acoustic data)

**f. Isolate current shortfalls in methods and technology.**

- As identified in b, density algorithms needs improvement. There is not a standardized database. Recordings need to be made at higher bandwidth (to include echolocation)

**g. How can the necessary data be most efficiently shared across organizations and between developers?**

- Sharing of data should be increased, potentially through the DCL workshop series that occurs every 2 years where people compete their algorithms against each other to test accuracy. Mobysoft database provides a mechanism for sharing.

**(2) <u>Processing Hardware</u>**

**a. What are the areas of need for processing hardware?**
**b. What are the current gaps in processing hardware?**

*Table D-11*

- Processing hardware: it is a battery/bandwith/size issue
- Recommendation: Need to recruit clever engineers that will think outside of the box
- Recommendation: Need to have a workshop to bring in diverse groups (researchers/industry/engineers/etc) to work on tags/platforms/hardware/etc for cross pollination – NSF has a mechanism to do this called Industry Research Grants

**(3) <u>Platforms/sensors (Fixed/Portable)</u>**

**a. Summarize the perceived requirements**
**b. Summarize the current available platforms and sensors.**
**c. What are the current gaps in processing platforms and sensors? Priorities?**

*Table D-11*

- Thinking outside of the box – there needs to be a US/International effort to revamp the satellite transmission infrastructure to increase ability to collect data

- Recommendation: need to let the community know about available datasets (examples is Glacier Bay ambient noise from NPS, BRS data from AUTEC being housed at Cornell)
- Perceived requirements: 2 sets of goals - long-term goal is health of populations that has it's own requirements and then short-term goals of monitoring/mitigation and needs to incorporate operational feasibility
    - Need baselines of effectiveness of each type of sensor
- Recommendation: Real-time processing capabilities at the recorder level
- Recommendation: using navy ranges for verification/validation/testing for promising new technologies
- Gaps in processing platforms: commercial replacements for military sonobouys and receivers (particularly the receivers)
- Recommendation: have agencies work with FAA to increase capabilities of using UAVs

**(4) <u>Information Sharing</u>**

**Suggest methods of improving the dissemination/sharing of information (algorithms/hardware/methodologies).**

*Table D-12*
Information Sharing

- Info sharing is different from data sharing. Raw data is more difficult to use and requires that a person be contactable regarding calibrations etc, so interpreted info is perhaps preferable
- Crucial that regulators require the disclosure of information. Even private data could be required to be shared on a lower level. Maybe not raw data, but some info could be required as part of lease

Organization and dissemination

- There should be a "gatekeeper" institution that ensures consistency and data integrity, plus
- Older data is digitized
- Archives and makes public information and research
- Standardizes forms of information so that best quality is maintained
- i.e. file compression standards, quality standards of acoustic and monitoring data

**(5) <u>Current/Emerging Monitoring Technologies</u>**

**What technologies are available now or near future for real-time vs. archival data collection from monitoring/mitigation systems (PAM, active acoustics, radar, infrared imaging, underwater gliders, etc.)?**

Summary Notes:

- Many available and emerging technologies are well documented in literature and recent reports

- Technologies should be carefully validated in a scientifically rigorous format before we implement them as a mitigation or management measure standard

**What systems can be used now to inform real time management and how can they be improved (i.e., make them more cost effective, more available, more efficient etc)?**

- The technologies and applications of PAM are well documented in the literature. However there are still substantial needs to improve the technology to make it more efficient, more effective and more widely available.
- Still need to address the issue of PAM data analysis: how to assimilate, integrate, and present in a way that is meaningful for management and mitigation situations.
- PAM is good at presence and absence, but now we have to develop the capability to interpret data based on a behavioral basis
- Known limitations: still do not know what that means in terms of abundance, how do we come to abundance/density data based on vocalizations, how to determine behavior via vocalization, signal-noise ratio, directionality, location, and seasonality
- PAM is a tool that is best used in concert with others technologies (aerial/vessel/tags) to provide a complete picture of what is happening in a specific location
- Gliders have the potential to provide passive acoustic and environmental data over both short to long term scales, and the potential in near-real time. Continued validation will still be needed.
- While technologies exist, we have yet to see programs that successfully integrate the modalities in order to give a multi-dimensional picture of what is going in marine mammals and the environment (examples: Boston harbor, which has real-time feedback)

**What are the most effective systems for covering long time series and large spatial scales and generating archival data to inform time/area closures or other pre-set mitigation designs and how can those be made more cost effective/available?**

- Passive acoustics is readily available and it has the capability to do the long-term and large spatial scales
- But it needs to be used in complement with other tools as well
- There are effective systems that include tagging, surveys (aerial/ship) and photo ID
- A good program that has all of the methods can be a valid time series
- Needs to be more multi-dimensional

**What are the anticipated benefits and drawbacks of using active acoustic methods for detection of marine mammals for mitigation implementation or monitoring (e.g., avoiding certain effects, but potentially creating an acoustic impact) – what are the existing studies?**

- Active acoustics is context dependent and context species specific
- A lot of studies still need to evaluate its effectiveness and impacts

- In the last 5 to 10 years we've seen a radical improvement in new technologies that have changed the way we understand the field. Therefore the development of new and emerging technologies require continued and future funding.
- We need to work out a manner in which we can more effectively integrate multiple stakeholder funds, goals and technologies to best address these issues.

DETAILED NOTES

SESSION D

**(1) <u>Algorithms (by category/DCLD)</u>**

**a. What are the basic requirements?**
**b. Given these perceived requirements, what are the areas (by category/DCLD) that require significant improvement?**
**c. What basic data are required for development?**
**d. What methods can be used to verify performance?**
**e. Suggested methods for data gathering?**
**f. Isolate current shortfalls in methods and technology.**
**g. How can the necessary data be most efficiently shared across organizations and between developers**

*TABLE 9*

- Assumes that passive acoustic monitoring is the best source and that algorithms are the way to id the most important events (since humans can't look at it all)—though this might be a necessary evil
- How much sound into the water and the impacts on the animals (for their permits) –that is the Navy's charge; but other agencies might have different charges
- NMFS has used acoustics as a tool for stock assessments—e.g. of healthy coral reefs
- MARAD has a set of NEPA requirements that they could share with researchers
- Factors to consider: detection rates, error (false alarm), accuracies of estimates
- Sometimes algorithm use/selection reliant on what people are comfortable with as opposed to what is the best methods
    - Typical process is to take established algorithms from other labs
- Processing 10x-300x which makes a big difference in processing large volumes of data---accuracy is another problem
- We don't know all the variety of sounds that animals make (and our knowledge varies by species)—so it's still a process of discovery
- We might need some national database for all the different sounds that each species makes
    - Mobysoft-database to collect representative calls---but not very extensively used?
    - "there are no blessed data sets"---or standardized data sets
    - the quality of the data varies tremendously in different databases (esp concerning methods of collection)
- Biggest need is the test and training data to put into the algorithms (gave example of not knowing about the Gulf but being expected to interpret the data post-spill)
- Problems of calls being very short duration—need to already know where the calls are located to test out the algorithms (very difficult labeling problem mechanically)

    - Never have 100% truth—don't have that verification---always in a process of discovery
- General discussion on algorithm generation/verification
    - having an expert looking at the data along with the programmers is very helpful
    - confidence levels---very critical for the end user (which can be interpreted by an expert but should be made more available/transparent)
    - there are no set of algorithms (auto-detection) which can replace a good analyst—and this won't change in the near future
    - it is very tedious work to test out the algorithms—especially cleaning up the data (and more senior people won't do it anymore since they don't find it interesting)
- if you record the acoustic data, then you can repeat the experiment many times over (as opposed to just visual data collection)
- verification: tagged animal, visual observations, net tows to verity the presence and behavior of whales
    - visual surveys are far from perfect (though many assume they are much better than they actually are)
- data sharing: they do but there could be more
    - workshop (DCL series) are very helpful (2 year cycle)- people apply their algorithms to training data to see which most accurately captures them (pseudo competition)
    - suggestion of making greater use of Mobysoft and other sharing platforms
- there are things we know, things we know we don't know and things we don't know we need to know (Rumsfeld reference)

DCLD
Detectors-anthropogenic, biologic
- different classifiers/detectors for different species and different locations

Classifier-What species did it come from
Localization-Try to get it within a certain area with a certain amount of error
Density
- Customers are really interested in that for population/migration
- Not many researchers have actually done this---only a couple of papers on it, need ancillary data (eg probability of an animal making a call); still in its infancy/early stage of development---the rest are very commercially developed
    - Tag data helps to improve this area of research
    - Localization is key for density estimates---probability of detection falls off as you extend range so knowing the range is key to input into models

**(2) <u>Processing Hardware</u>**

**a. What are the areas of need for processing hardware?**
**b. What are the current gaps in processing hardware?**

**Question 2:**

**General statements:**

- Processing hardware: it is a battery/bandwith/size issue

**Recommendations:**

- Need to recruit people from outside of the marine mammal field to think outside of the box to solve problems
    - Part of this could be to have a workshop to bring in diverse groups (researchers/industry/engineers/etc) to work on tags/platforms/hardware/etc for cross pollination – NSF has a mechanism to do this called Industry Research Grants

**(3) <u>Platforms/sensors (Fixed/Portable)</u>**

**a. Summarize the perceived requirements**
**b. Summarize the current available platforms and sensors.**
**c. What are the current gaps in processing platforms and sensors? Priorities?**

**General statements:**

- JIP just put out a report on this topic
- Technology drives the research
- There is a lot of data that exists, but it is proprietary and is not shared - need to work on making data available

**Needs/Requirements:**

- There are 2 sets of goals that have separate requirements – the long-term goal of the health of populations and then short-term goals of monitoring/mitigation that needs to incorporate operational feasibility
    - Need to come up with baselines for the effectiveness of each type of sensor
- Need to collect long-term baseline data – can use embedded technology like navy ranges/oil fields, but also need transient abilities
    - Create collaborations with oil/gas industry, navy, and vessels of opportunity to be able to use there technology/infrastructure to collect data
- Need government subsidies to help with costs of satellite data transmission because the market is not large enough to keep costs down
- There are needs to be a commercial replacement for military sonobouys and receivers (particularly the receivers)

**Recommendations:**

- Thinking outside of the box: creating a multi-national effort to revamp the satellite transmission infrastructure to increase ability to collect data
- Real-time processing capabilities at the recorder level
- Let the community know about available datasets (examples is Glacier Bay ambient noise from NPS, BRS data from AUTEC being housed at Cornell)

- Use navy ranges for verification/validation/testing for promising new technologies

**(4) <u>Information Sharing</u> Suggest methods of improving the dissemination/sharing of information (algorithms/hardware/methodologies).**

**General statements:**

- Need to increase data sharing between navy/industry/federal agencies/researchers
- OBIS-SEAMAP (Duke University) gave all data to OBIS-USA (USGS) through 2008

**Other Notes:**

- Suggest methods of dissemination/sharing of information (algorithms/hardware/methodologies).
- If there are other important issues under this topic, please address those also.
- In Australia, any govt funded work must be made available on a public website.
- Info sharing is different from data sharing. Raw data is more difficult to use and requires that a person be contactable regarding calibrations etc, so interpreted info is perhaps preferable.
- Web based description of algorithms with contacts.
- Proprietary data is a bigger issue maybe. How do you get companies to share this info. So regulator must require the disclosure of this information. Even private data could be required to be shared in a lower level. Maybe not raw data, but some info could be required as part of lease.
- Basically, government must require that information be shared and made public.
- As far as older stuff, that's a bigger challenge. Stuff that isn't digital already is tough to get hands on. MMS used as example. NOAA should be in charge of this.
- Need to digitize and update older stuff, should have a gatekeeper, someone in charge of organization of data old and new in a way that the public can access.
- Issue of compression. Making public is easiest if data is compressed, but this could lower the quality. Original data vs compressed data. Need to save things in the highest possible XXX for that time period.
- Need standardization of acoustic and monitoring data. A uniform form.

**(5) <u>Current/Emerging Monitoring Technologies</u>**

**What technologies are available now or near future for real-time vs. archival data collection from monitoring/mitigation systems (PAM, active acoustics, radar, infrared imaging, underwater gliders, etc.)?**

**General statements:**

- Questions drive the requirements
- Basic requirements: real-time processing, automation, classification to lowest level possible (example is to identify to stenella spp instead of stenella frontalis)
- Areas that need improvement: need a better understanding of the basic biology of vocalizations and vocalization usage

- What's available to us as far as remote sensing from satellites? If google earth, why not something for us?

- BOEMRE has encouraged contracted companies to use passive acoustic monitoring.
- Specifically targeted satellites (a day, an area) is useful, but searching around technology doesn't exist. Essientially looking through a straw. How do you process the ocean?
- Meagan, Columbia has looked at using planes for monitoring, but FAA has shut down for different reasons.
- Radar, IR, LIDAR have been proffered for monitoring, but technology needs to advance.
- Active acoustics is a feasible alternative in particular for non-vocalizing animals and animals that don't spend any significant time at the sea surface, but adds extra sound into the ocean and hence requires its own impact considerations.
- Active acousticshas lots of potential, but need to make sure that it doesn't have a negative impact. Maybe go higher frequency, outside the range of most animals, though those frequencies don't travel far enough.
- EM band radiation or microwave might work, does have the high resolution that is so useful.
- Really need something to scan rapidly over a broad area. Radar is too low resolution while picking up too many extra things. False alarms are a problem.
- Emerging technologies could be a solution to this problem, eg EM waves.
- Australia has RFPs for combining methods, eg start passive monitoring and once a group of animals is detected, switch over to active, or limit active to certain times, places, etc. A combo of passive and active would be very effective detecting vocalizing & non-vocalizing animals. Requests for active systems seem to be on the rise.
- Need to integrate the visual data with the acoustic work, integrate photo i.d. and visual monitoring with the acoustic data. This is not just for ecological and behavioral research but the visual side is needed to validate the acoustic data. Need Integration of acoustic and visual observations and eg data from tags.
- New technologies are going to require coordination with other agencies that might not be immediately apparent (e.g. using unmanned aerial vehicles getting FAA approval to fly over the open ocean)

**What systems can be used now to inform real time management and how can they be improved (i.e., make them more cost effective, more available, more efficient etc)?**

- Passive acoustic monitoring- marine autonomous recording units (MARU), sonabuoy
- Gliders are pretty popular- emerging technology
    - Put passive acoustic sensors on these systems (cost effective, long term)
    - They do generate some noise so have to be careful with that

- Interest in measuring the Doppler shift of sound to determine the direction of motion of a cetacean
- Infrared imaging is being used by German researchers especially in the Arctic given the difference in temperature (makes visualization much easier)
- Need to use power efficient hardware since you want the sensors to be able to stay out in the field for extended periods of time
- Hardware that you put into phones is an emerging technology to help with the data collection/transfer since they are able to operate with small amount of energy
- Unmanned aircraft monitoring of marine mammals and the impacts of noise--- but still needs to be proven and compared with manned aircraft surveys (NOAA)
    - IR or visual sensors
    - NOAA is outfitting the Global Hawk to deploy drop sondes--- potentially could put acoustic sensors on it that could transmit data for a bit?
- Can you use IR for blow detection?
    - Not if there is wind (which disperses it too quickly)
    - And not good if you want species detection
    - German navy is working on this technology as well
- Can use multispectral sensors to detect a humpback that is submerged up to 40 ft (recent study)--- but that is subject to water clarity (need low turbidity); does better with sea state (up to Beaufort 5)
- Cabled arrays could get real time data, though this is quite expensive
    - Referenced an acoustic cable like is used in fish tracking
- Current technology---Manned aircraft—could be improved through monitoring specifically addressing the mitigation requirements (instead of formulating it independently)
- Auto-buoys are being used
- Wave glider for acoustics- surface float and a submerged wing with hydrophone so you get continuous satellite communication; basically self-sustaining since it has solar panels; Liquid Robotics is the development company
- Issue of duration of tags---not as easy as with fish when you can imbed it internally; many marine mammal tags last only a few days if they are giving very high resolution data
    - The higher the frequency of the acoustic tag—the shorter the monitoring range
- Tags can be used to aid in real-time management---but do we do this? yes for Right Whales but not in Alaska/Arctic
    - Need to build up this capability so that managers can incorporate this data in real time

**What are the most effective systems for covering long time series and large spatial scales and generating archival data to inform time/area closures or other pre-set mitigation designs and how can those be made more cost effective/available?**

- Buoys are the most cost effective at this time but we are moving towards gliders, etc

- Gliders are really good for picking up the "perceived sound level" as in how the animals are receiving the sound---they could track the animal or the activity of the Navy in real time as opposed to the limitation of stationary stations
- NOAA program, ships of opportunity, which will pick up data
    - Sometimes cruise ships will take on a scientist to collect information during the trip in exchange for a few talks to the other passengers
- Impacts monitoring typically uses aerial surveys for time-area closures
- Ultimately everything is not cost-effective; argument that the most cost effective data is that which we already have (i.e. the unreleased data that the Navy has)
    - Need to find those "hidden" archives

**What are the anticipated benefits and drawbacks of using active acoustic methods for detection of marine mammals for mitigation implementation or monitoring (e.g., avoiding certain effects, but potentially creating an acoustic impact) – what are the existing studies?**

- Drawbacks –if you are trying to protect the animals, then you can't use noise because that hurts them; detection range is pretty limited with active acoustics as well
    - Right whales come into harms way as opposed to diving when alarmed with active acoustics
- Consensus that it is a bad thing

**Recommendations:**

- Use navy ranges for verification/validation/testing for promising new technologies or use a mark/recapture method with competing and independent observers (can use a fake whale of known properties (acoustic, infrared, etc))
- Have agencies work with FAA to increase capabilities of using UAVs

**Session D, Backup Notes for Plenary Discussion**

- One participant noted that we are sending data through a "cocktail straw." Consider replacing some of these links. If you focus on infrastructure, you will open up a world of opportunities. Scientific revolution (similar to bioinformatics or genomics).
- Recruitment outside of the field.
- Groundtruthing data. Comparative tests of technology.
- Data sharing should be a part of the regulation or permitting exercise.
- UAV for monitoring. FAA requirements must be resolved.
- Active acoustics needs significant validation.
- Prey mapping and health of the life field (oil industry).
- Collaborations are a force multiplier.
- **Prioritization:**
- 1 – Information sharing
- 2 – Current and emerging technologies
- 3 – Platforms / sensors

- **Question 4** – depends on where you are from, as an academic, we have no funds. (Number 4 is not likely). Shocking that1/3 will say that it's likely to fund analysis of existing data.
- The first bullet, technology drives the science, would like to say that technology enables the research. We have science questions that the technology enables us to answer. It is important to make this distinction.
- JH: bullet related to active acoustics. Is there a discussion of balancing the importance of detection vs. putting more sound into the environment? Examples: seismic surveys, turbine use repellent. There should be some balance of the use of active acoustics. Answer: Many vessels use echosounders, you can get more data from the ones in use. You can do modifications on the processing side to analyze this type of data.
- The idea if you use an active acoustic sound source as a mitigation. There is an implication that sound is additive or cumulative. In most cases, they are operating at different frequencies. All sound sources should be considered equally in terms of risk.
- Design a signal with minimal impact, use higher frequencies which could be absorbed more. With AA there is a measurable deterrent effect. In contrast, organizations using existing mitigation with no empirical evidence that single mitigation airguns are effective.
- Weighing the cost/benefit with adding active acoustics should be applied to the use of a single mitigation gun.
- Geoacoustic mapping, cannot accomplish without putting sound into the water.