Arctic Acoustic Ecology

From Concepts to Actions

S O A R Acoustic Working Group – Christopher Clark (Cornell), Catherine Berchok (NOAA), Susanna Blackwell (Greeneridge), Dave Hannay (JASCO), Josh Jones (SIO), Kate Stafford (APL)

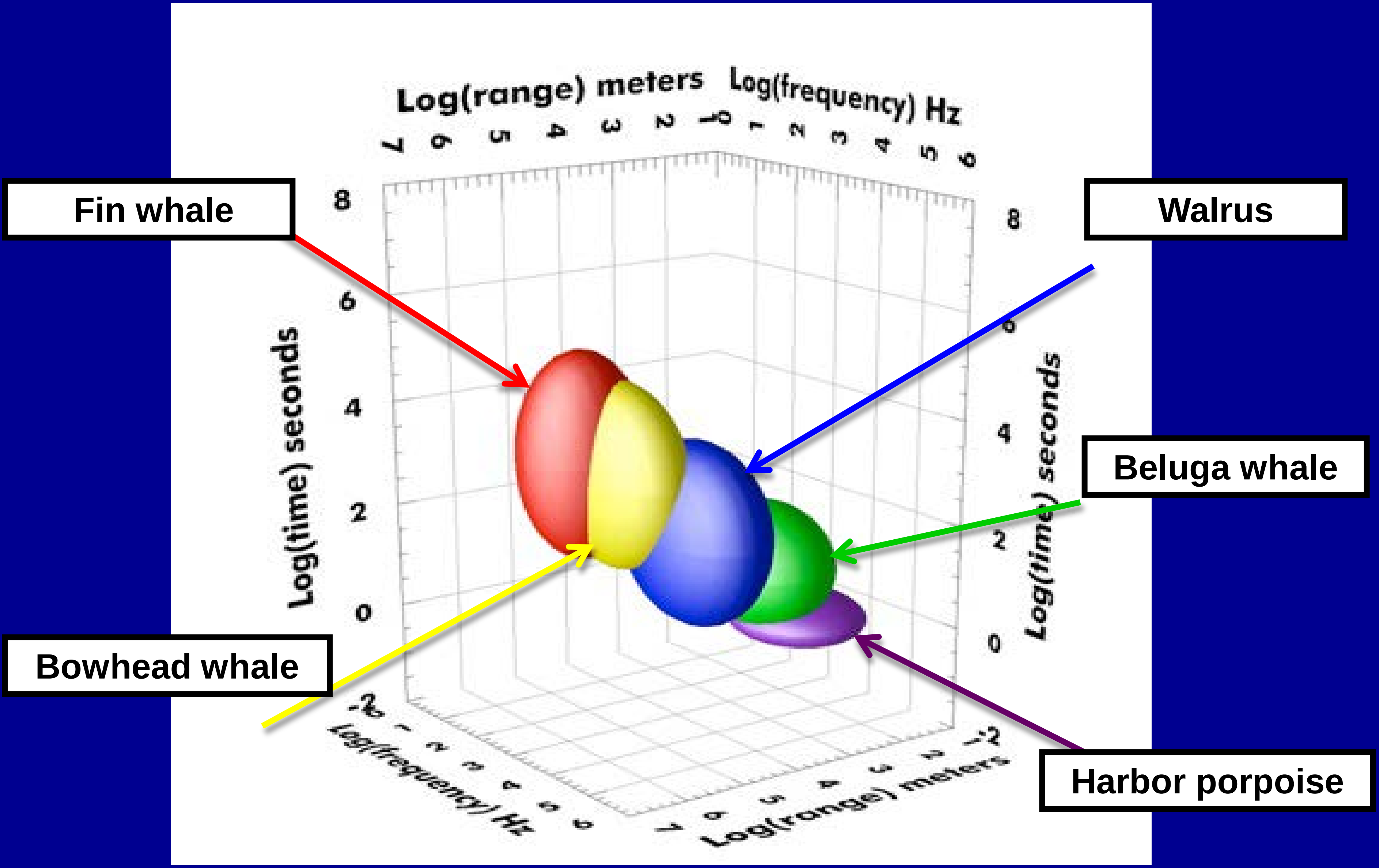
PacMARS-SOAR Open Workshop: January 20, 2013

Outline

1. **Concept of Acoustic Ecology**
2. **Data and data products reality**
3. **Acoustic Group Proposal**
4. **Acoustic Working Mtg – status and products**

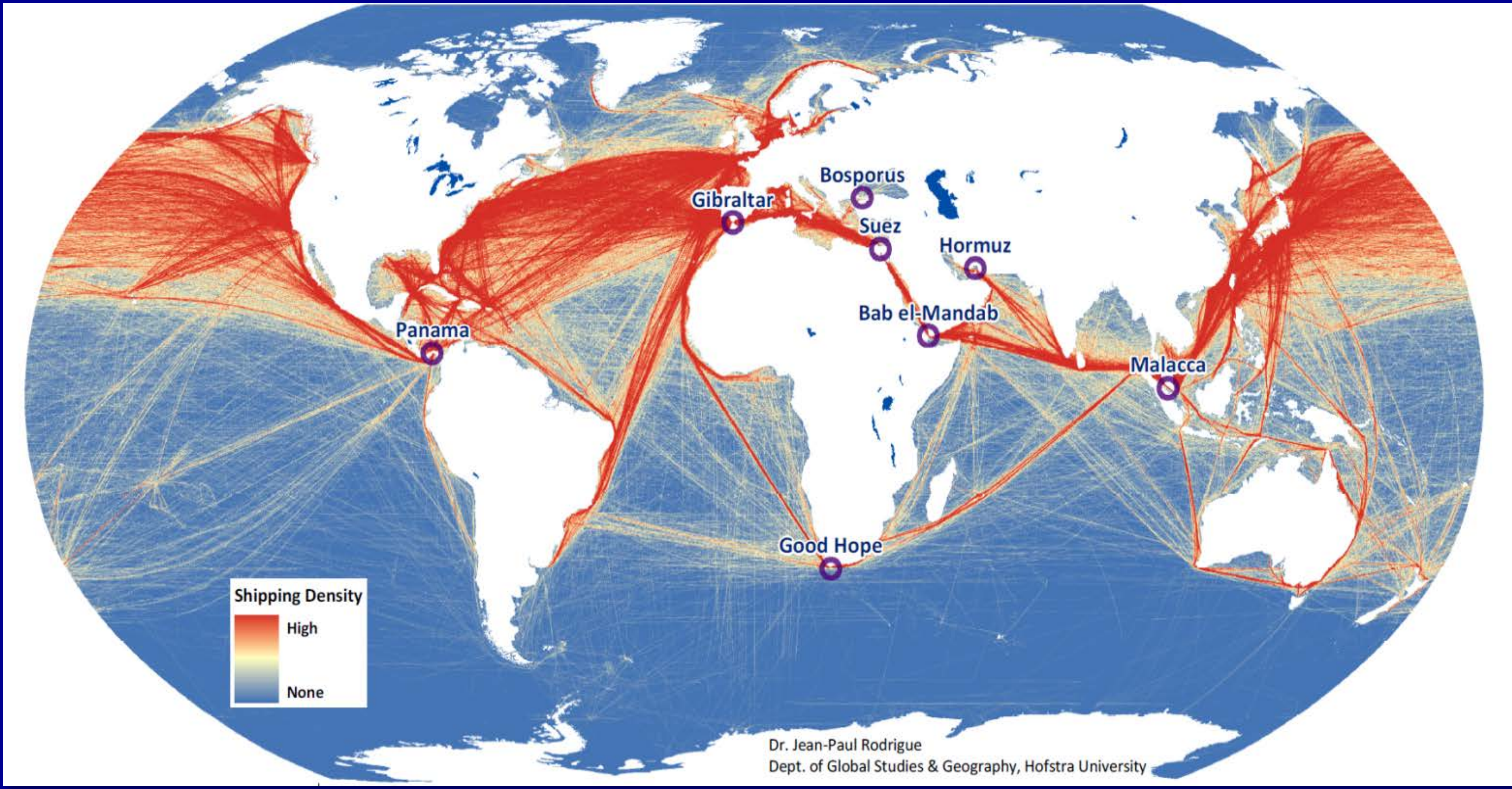
“Fortunately, nature has a few big places beyond man's power to spoil -- the ocean, the two icy ends of the globe, and the Grand Cañon.” John Muir, 1902

Concept: Different Marine Mammals** Occupy Different Acoustic Niches, i.e., Acoustic Habitats

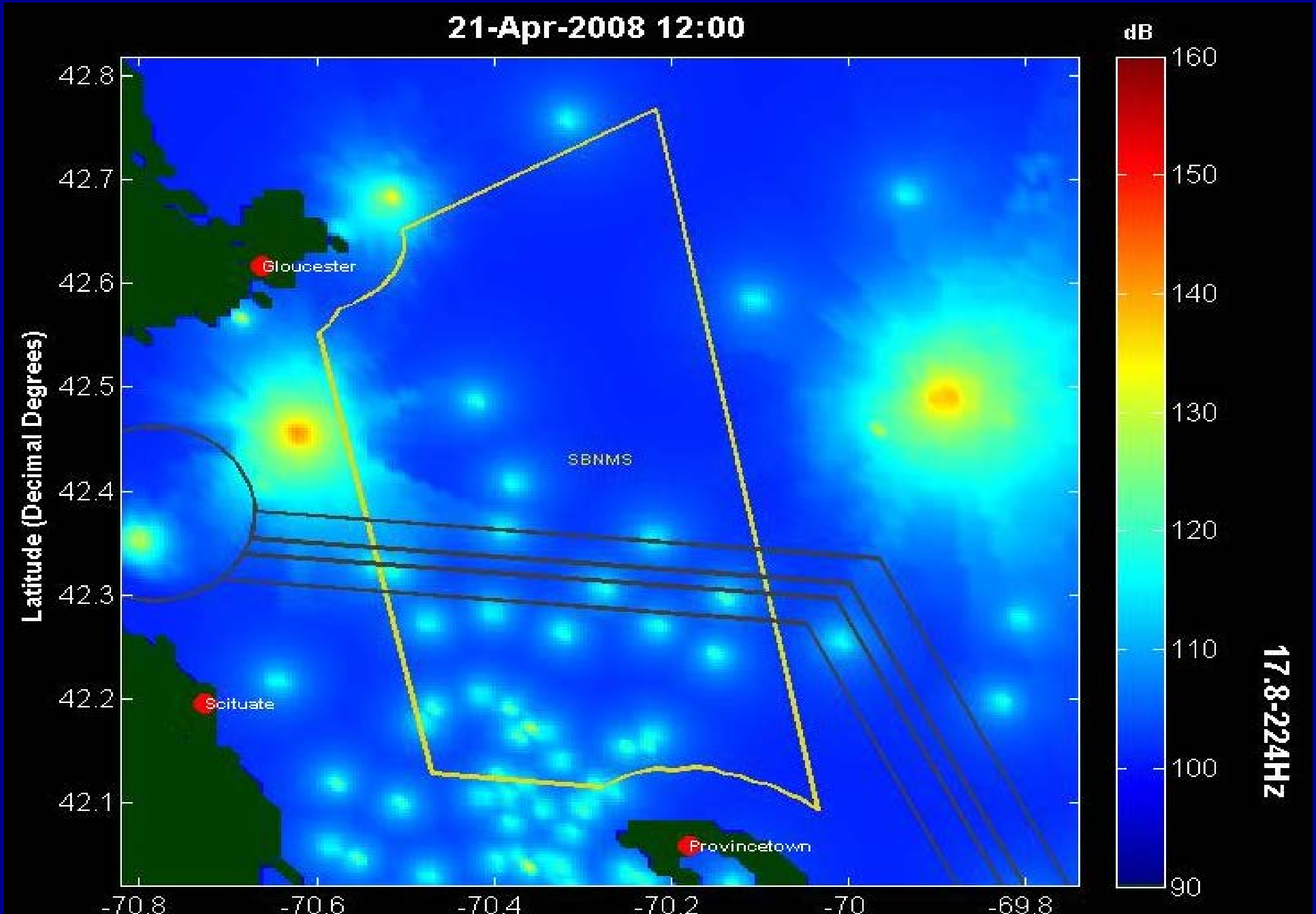


** With apologies to all marine vertebrates, marine invertebrates (*oh my!*) and humans (*really?*)!

Global Commercial Shipping Traffic
96% of world's commerce

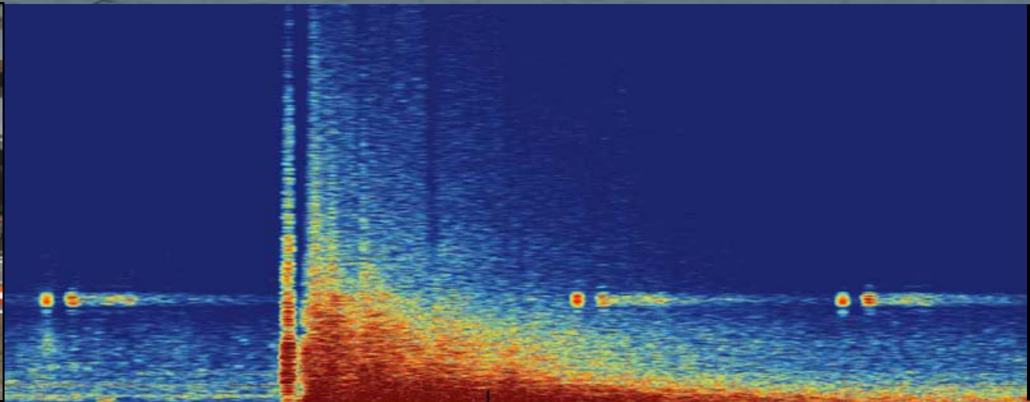


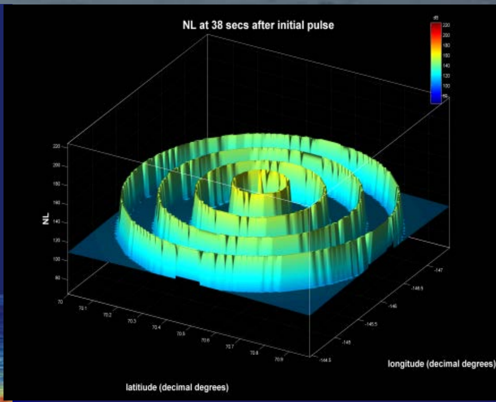
We can now dynamically map the spatio-temporal-spectral features of marine mammal acoustic spaces: whales and anthropogenics.



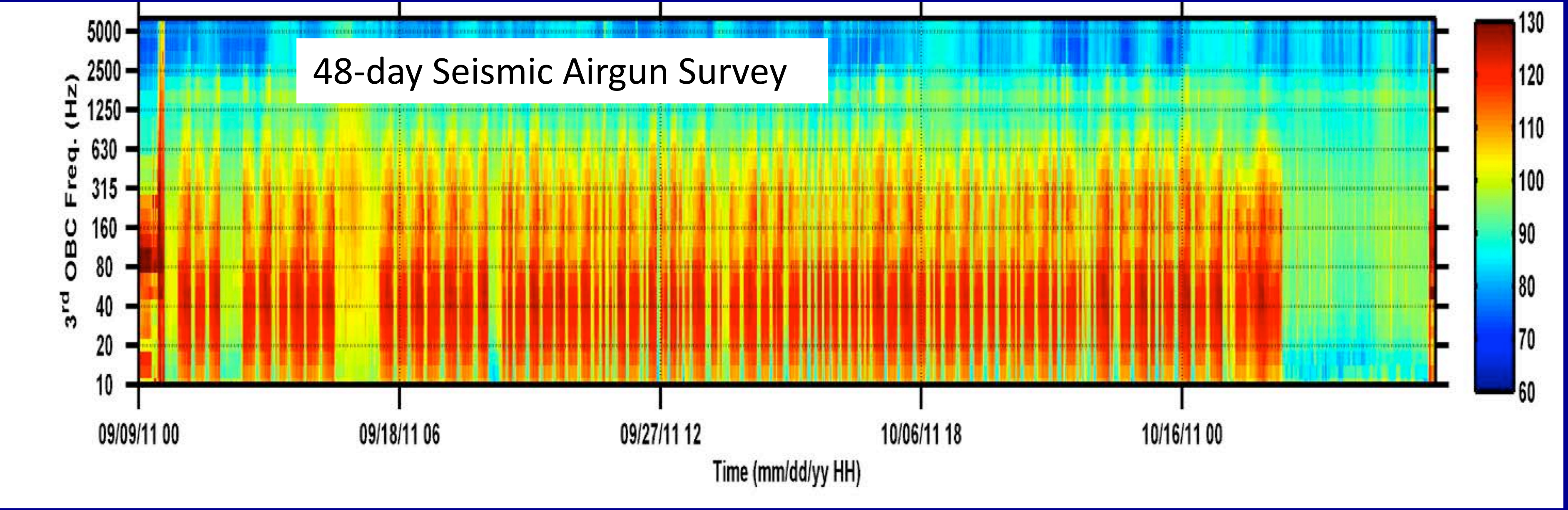
Clark et al. 2009, Ellison et al. 2011, Morano et al. 2012, Hatch et al. 2012

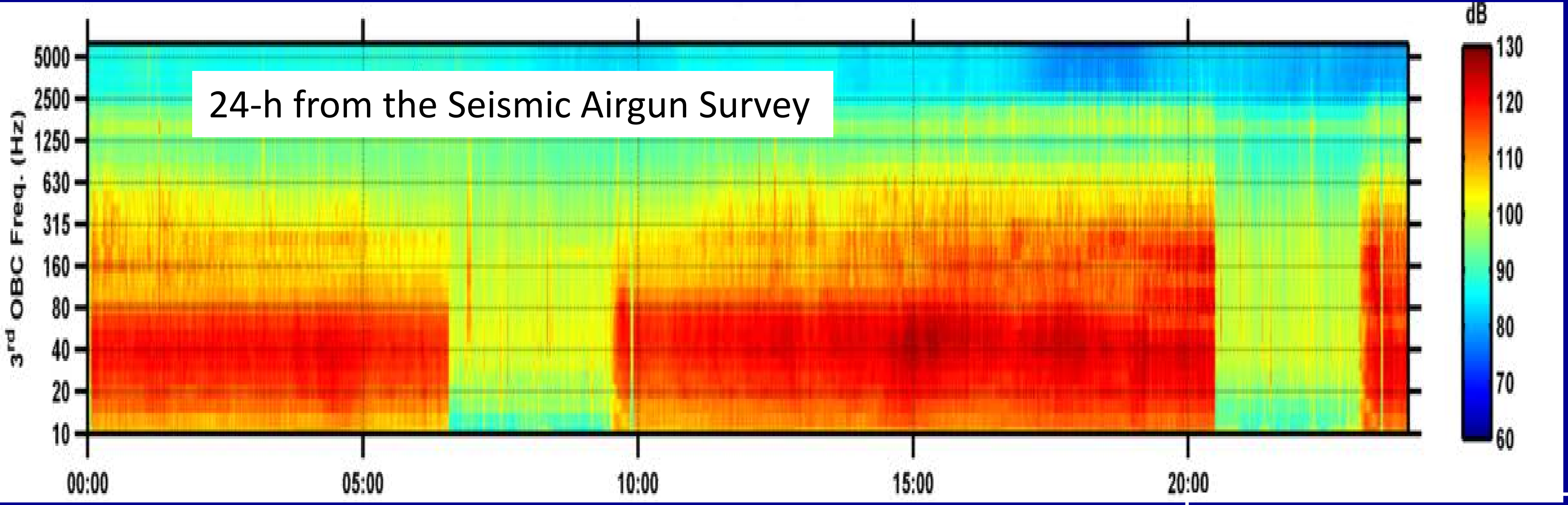
Energy Exploration, Development and Operations
Very High Noise Levels, Large Areas, Long Times





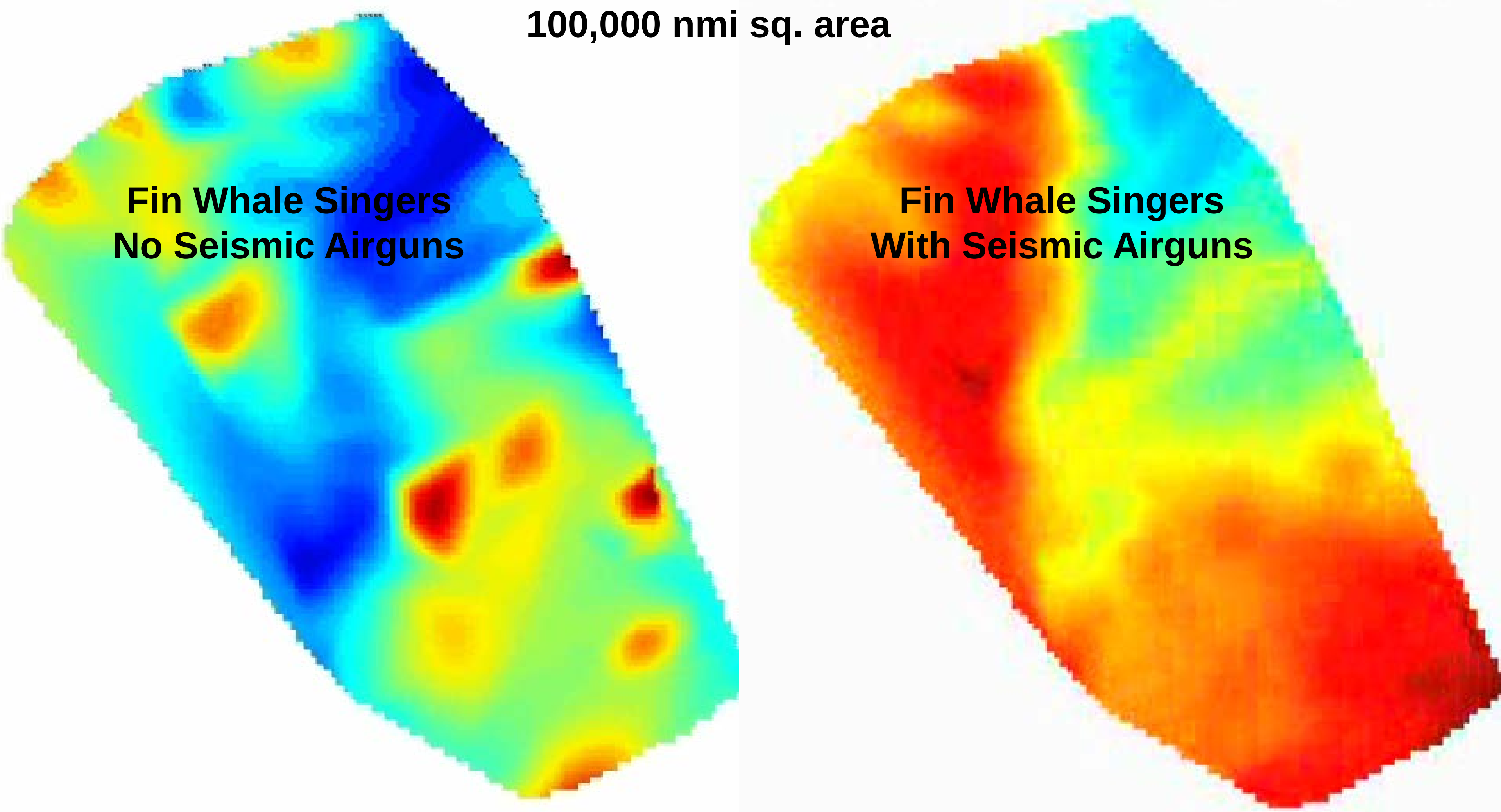
Influence of Oil & Gas Seismic Airgun Array Exploration on Acoustic Habitat



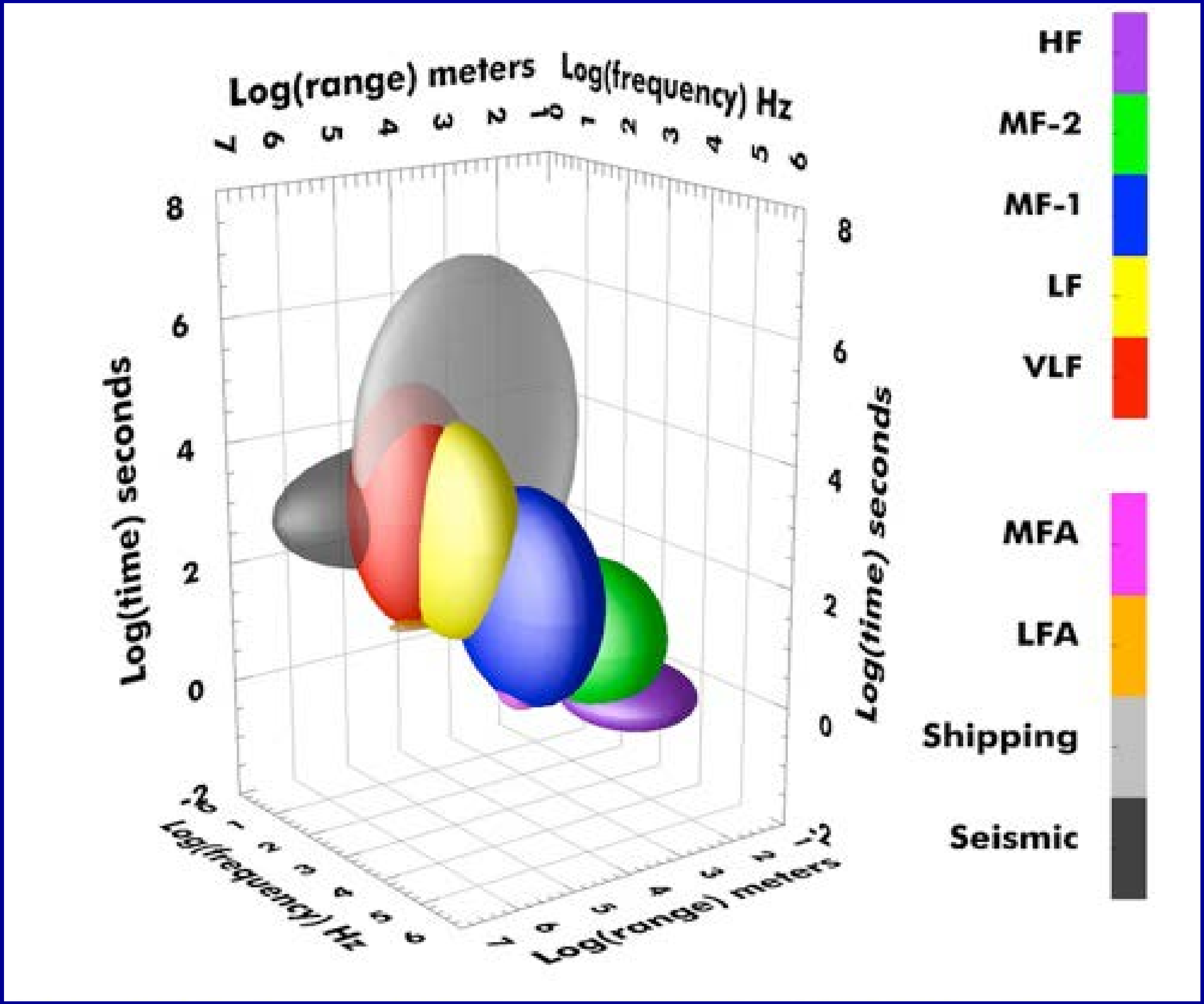


Clark and Ponirakis, in prep

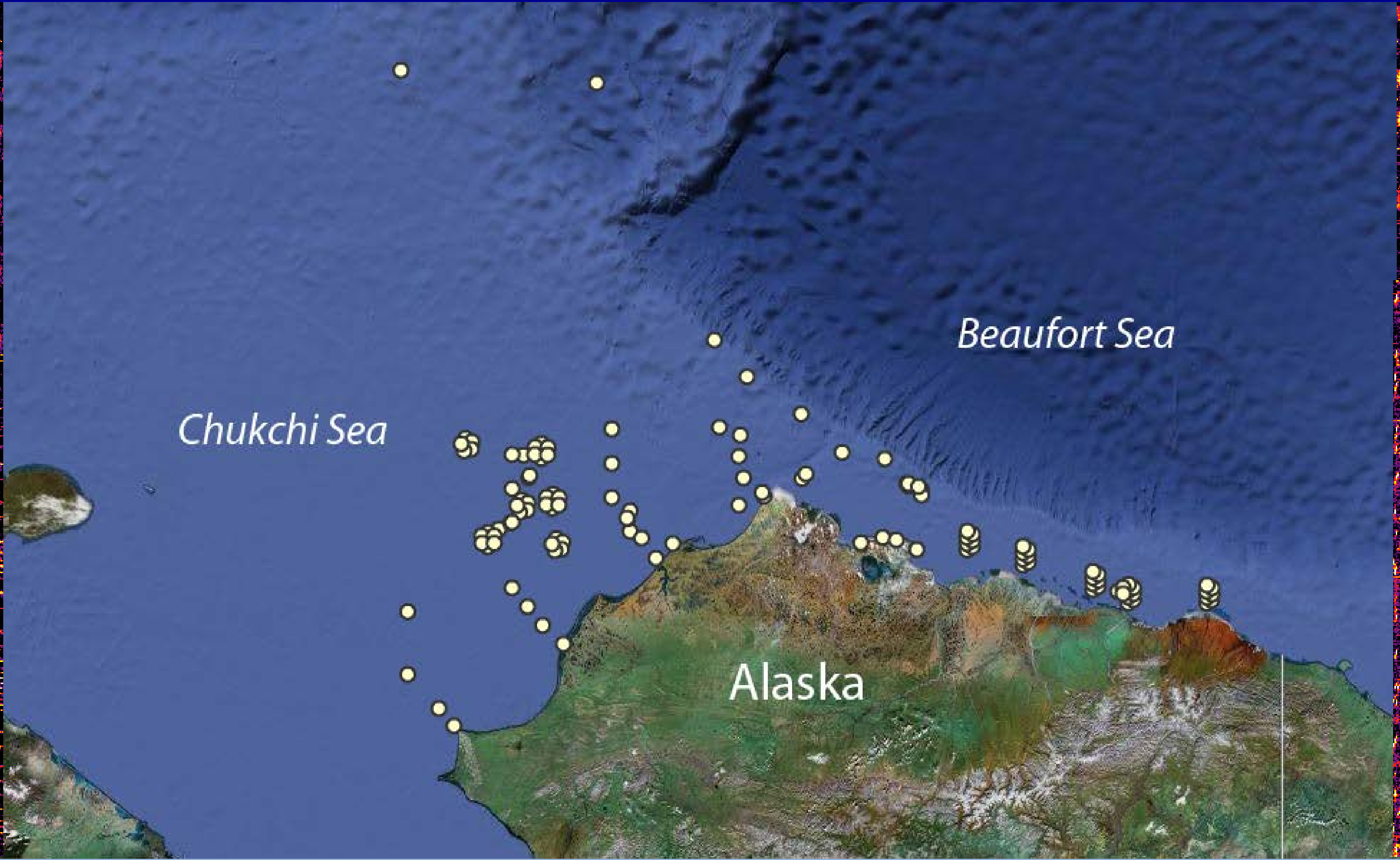
Seismic acoustic footprints can occupy large spatio-temporal portions of marine mammal acoustic habitats. Scales of present influences are basically unknown. Ex., 20-22Hz spectral band = fin whales engaged in male reproductive display



Marine Mammal & Anthropogenic Acoustic Spaces



There are considerable amounts of passive acoustic recorded data from throughout the Chukchi and Beaufort Seas. For example, 135 recorders in one year alone.



Comparing marine mammal acoustic habitats in Atlantic and Pacific sectors of the High Arctic: year-long records from Fram Strait and the Chukchi Plateau

Sue E. Moore · Kathleen M. Stafford · Humfrey Mellin
Catherine Berchok · Øystein Wiig · Kit M. Kovacs ·
Christian Lydersen · Jackie Richter-Menge

Some data have been analyzed and some results published.

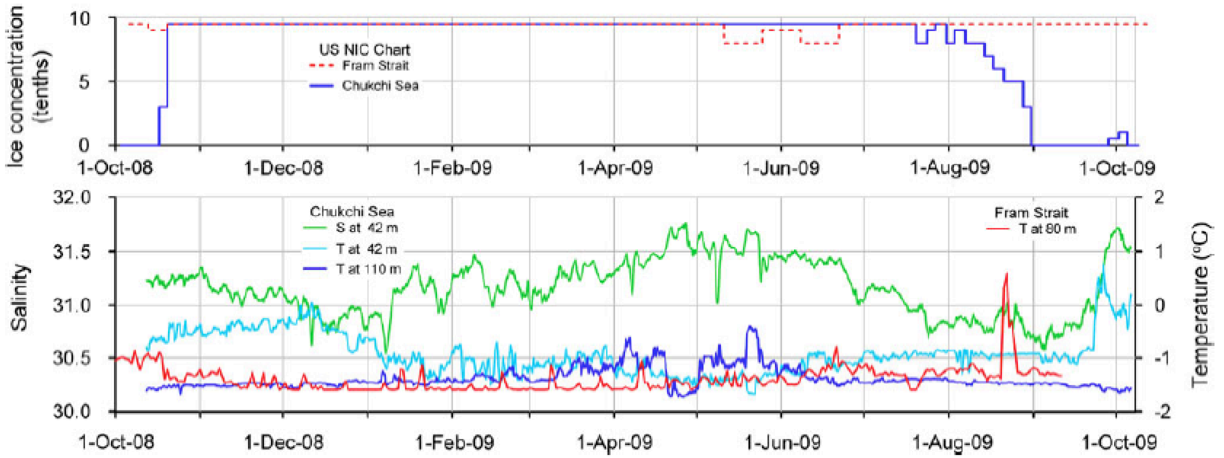
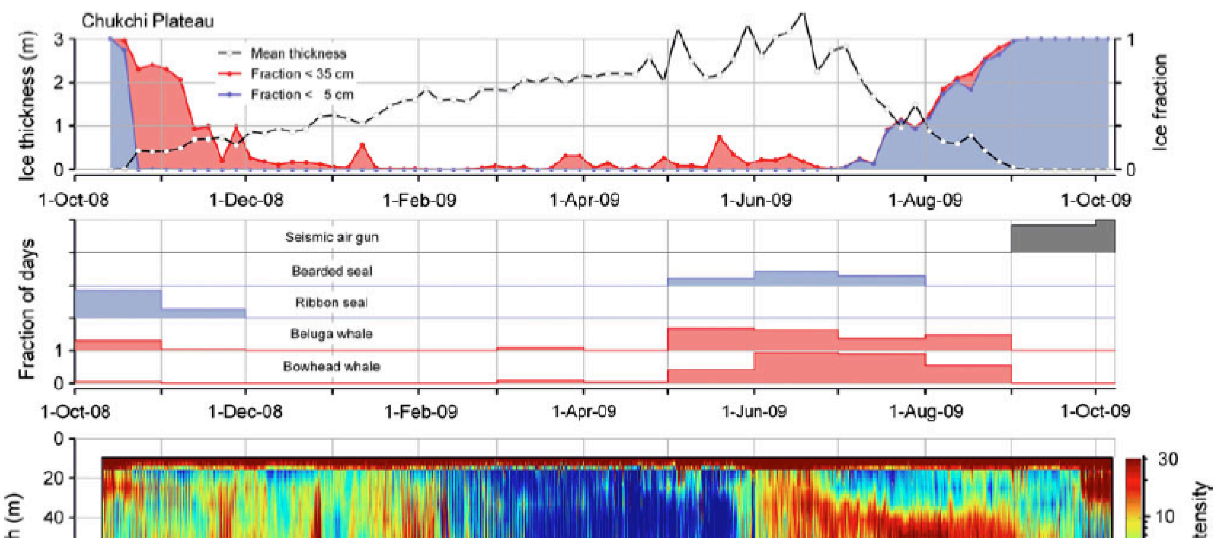


Fig. 3 Sea ice concentration (**a**) and temperature/salinity (**b**) at the mooring sites. Ice concentration is that linked to the ice-chart polygon overlying each mooring (http://www.natice.noaa.gov/products/weekly_products.html). Salinity and temperature were measured by SBE37 (Sea Bird Electronics) at 42 m depth on the Chukchi mooring and deeper temperatures measured by the AURAL-M2 on both moorings



But these efforts are spasmodic and represent a very small portion of the data and potential synthesis products. Hence we are maintaining an inadvertent culture of disservice to the Arctic ecosystem and cultures.

Underwater ambient noise on the Chukchi Sea continental slope from 2006–2009

Ethan H Roth,[a] John A. Hildebrand, and Sean M. Wiggins
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Donald Ross
2404 Loring Street, Box 101 , San Diego, California 92109

Acoustic data reveal ecosystem level changes in noise during the summer-fall season.

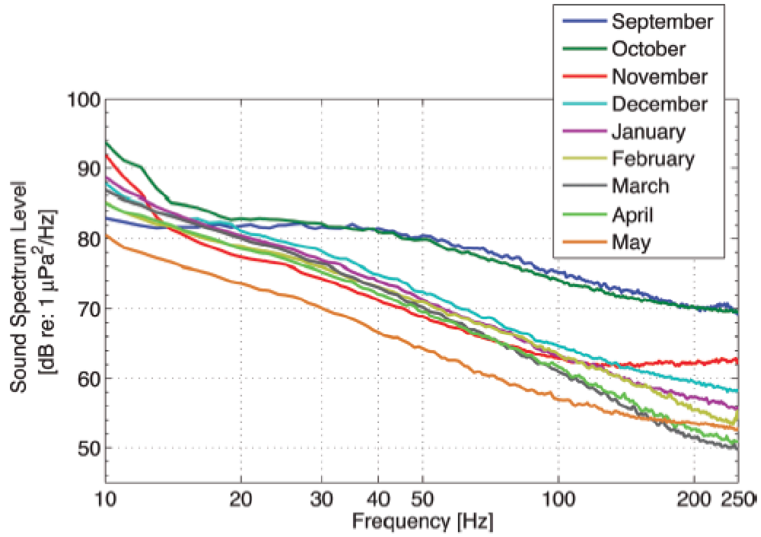


FIG. 2. Mean monthly sound spectum levels from September 2006 to May 2007. Each monthly average is based on 200-s samples, selected when no transient signals are present.

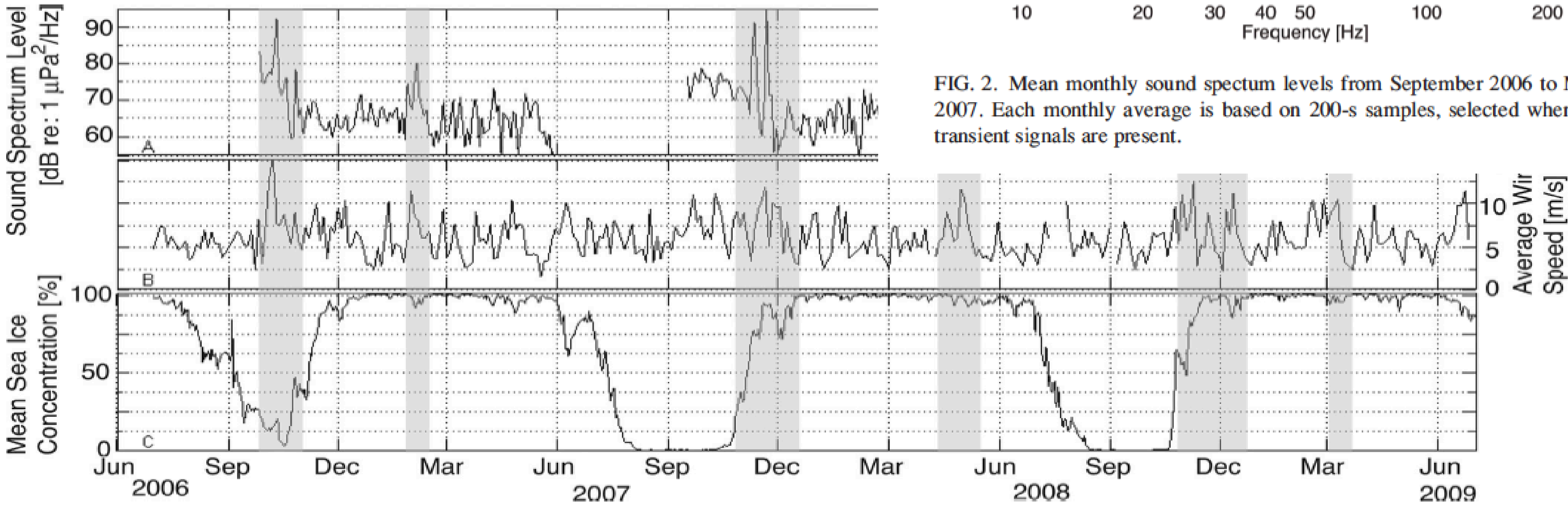
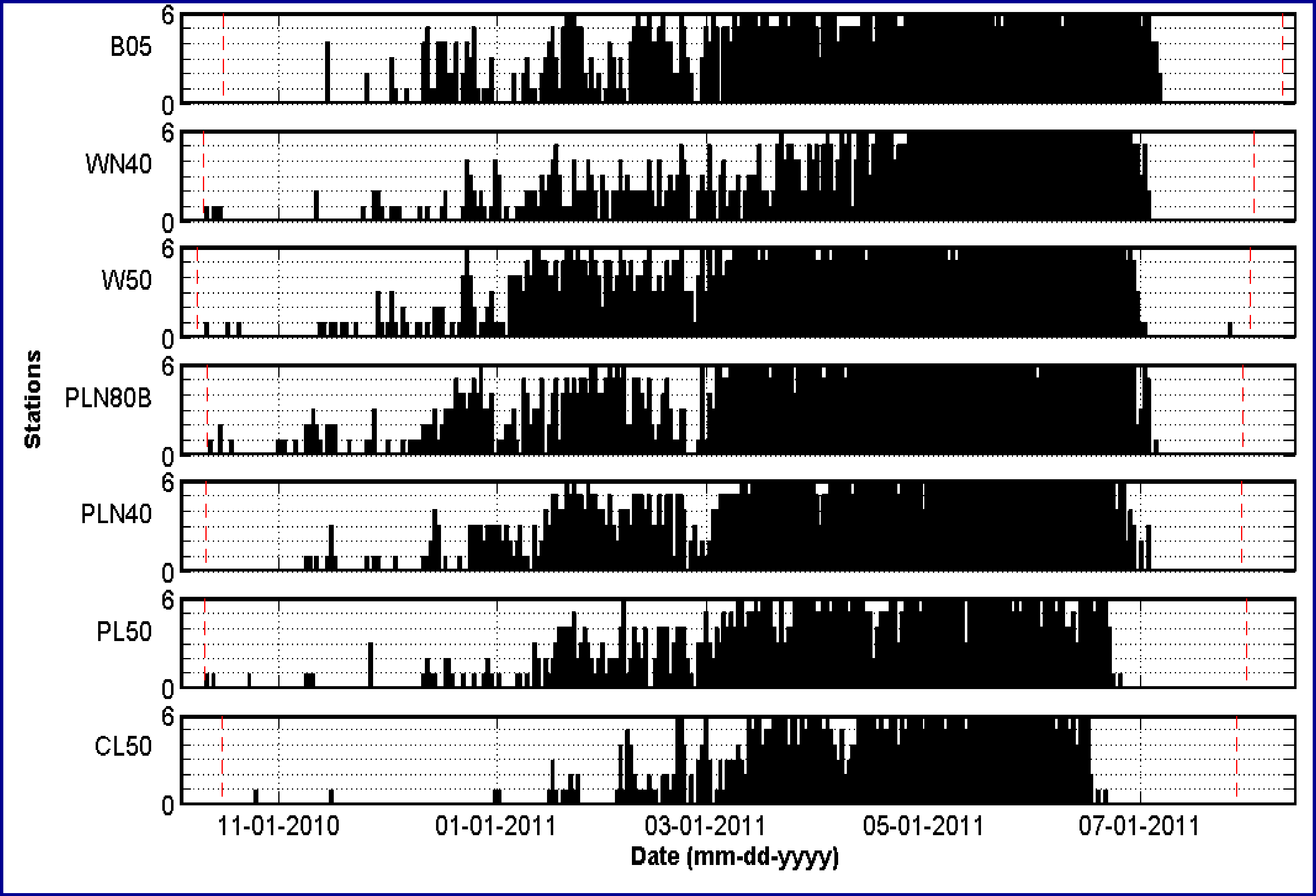


FIG. 5. (a) Time series of mean sound-pressure spectrum levels at 100 Hz, (b) three-day averaged wind speed values from the weather station in Barrow, Alaska, and (c) the percentage of sea ice cover from AMSR-E for a 100 nm radius centered on the instrument site. Shaded periods of time show correlations between significant ambient noise and weather events.

Bearded Seal acoustic detections, 2010-2011

Number of 4-h periods per day per recorders with bearded seal acoustic detections.

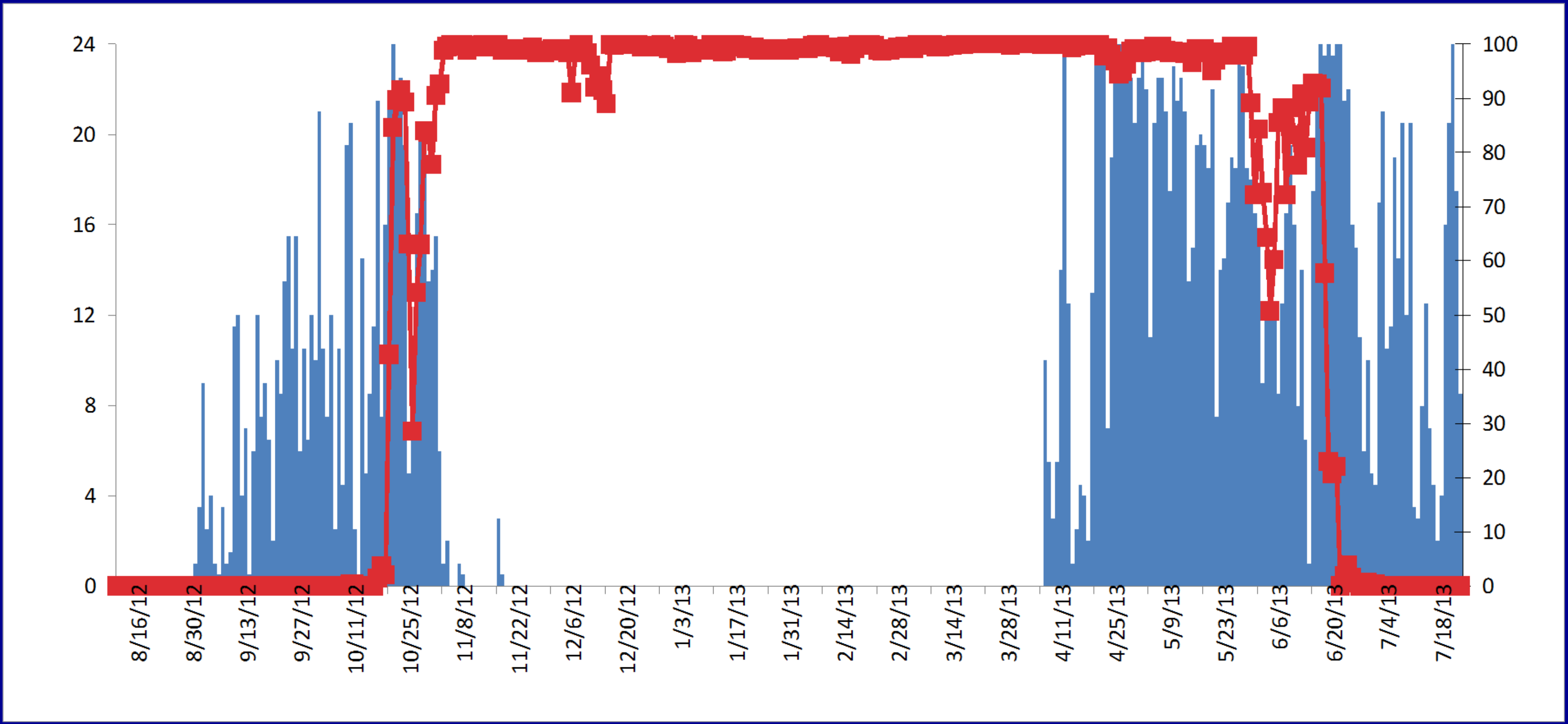


Source: Delarue et al., 2012

Chukchi Sea Environmental Studies Program

Bowhead whale acoustic detections, 2009-2010

Number of bowhead whale acoustic detections per hour, per day for one recorder relative to ice cover. (Courtesy K. Stafford, NOPP)



Proposal from the March 2012 meeting:

What sound environments do bowheads encounter in the Chukchi and Beaufort Seas?

Objective:

The objectives: map spatial and temporal variability of the acoustic environment encountered by bowhead whales and the occurrence of acoustically active bowheads per 12h, in the Beaufort and Chukchi Seas over a 1-year period, summer 2009 through summer 2010.

Challenges:

Agree on the data

Agree on the analysis

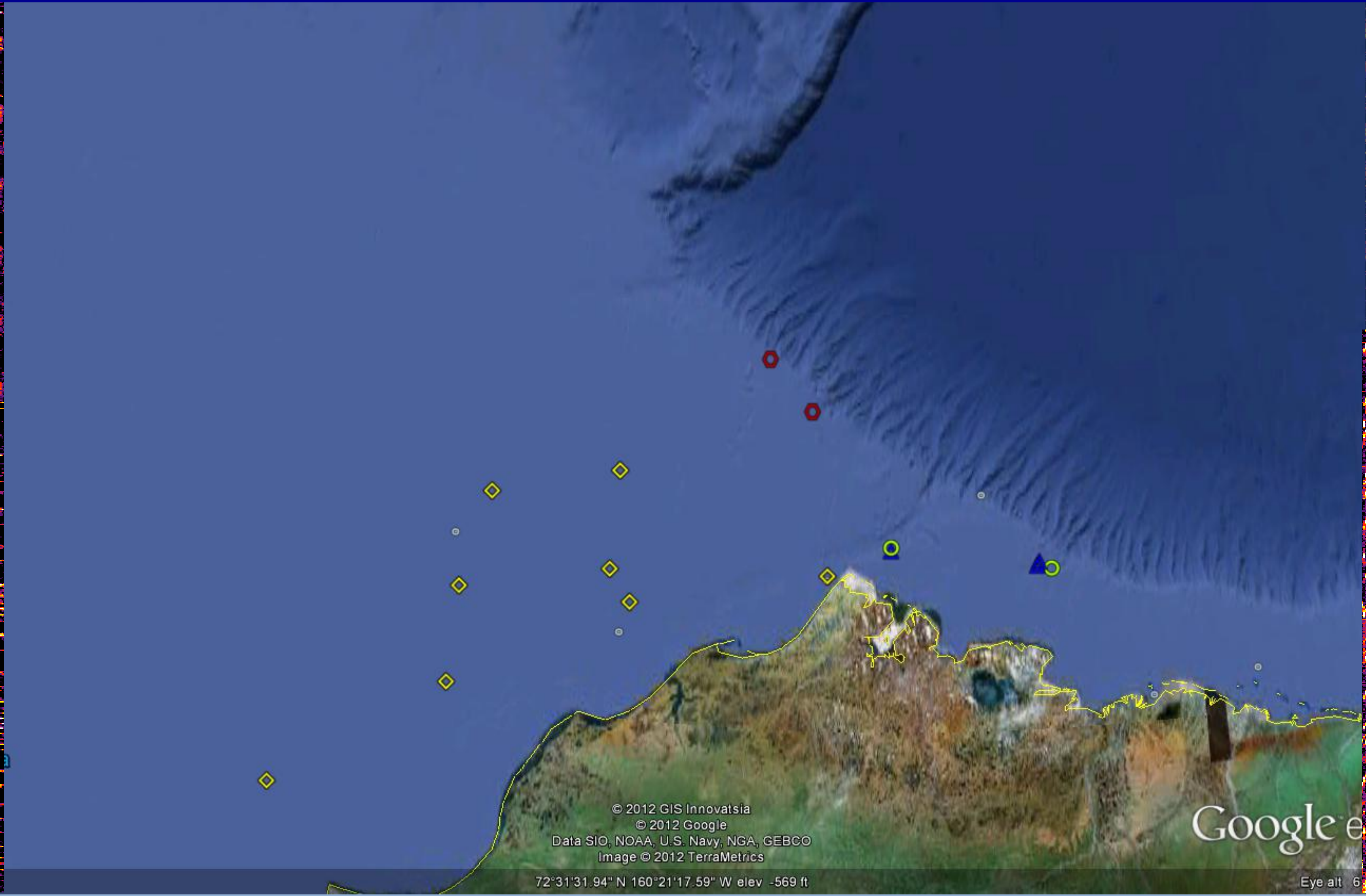
Avoid objective and data processing creep

When in doubt and resources are scarce, keep it simple and simpler, and reduce

Prior to Acoustics Working Meeting, Cornell Bioacoustics, 6-9 Nov 2012

1. Obtained copies of the raw data – multiple TB in different formats, different sampling rates, different sampling schemes = *ugly*!
2. Staged the raw data – *sounds simple, but it's not*!
3. Converted all data to standard format and sampling rate – *ugh*.
4. Pre-processed the raw data to provide all with "vistas" – *processed data tripled data size, but we started to have fun!*

Data: Overwintering Acoustic Recorders: summer 2009 --summer 2010
N = 15 Acoustic Recorders



During the Acoustics Working Meeting

1. Reviewed the initial data analysis products – *great to have them available at start.*
2. Cogitated on data quality, spatial & temporal scales
3. Revised and iterated through our objectives multiple times *- the staging of data and tools allowed for multiple analysis revisions and data products tuning.*
4. Wrote a summary and started an outline for publication

Outcome from the Acoustics Working Meeting, Cornell Bioacoustics, 6-9 Nov 2012

A year in the acoustic world of Western Arctic bowhead whales

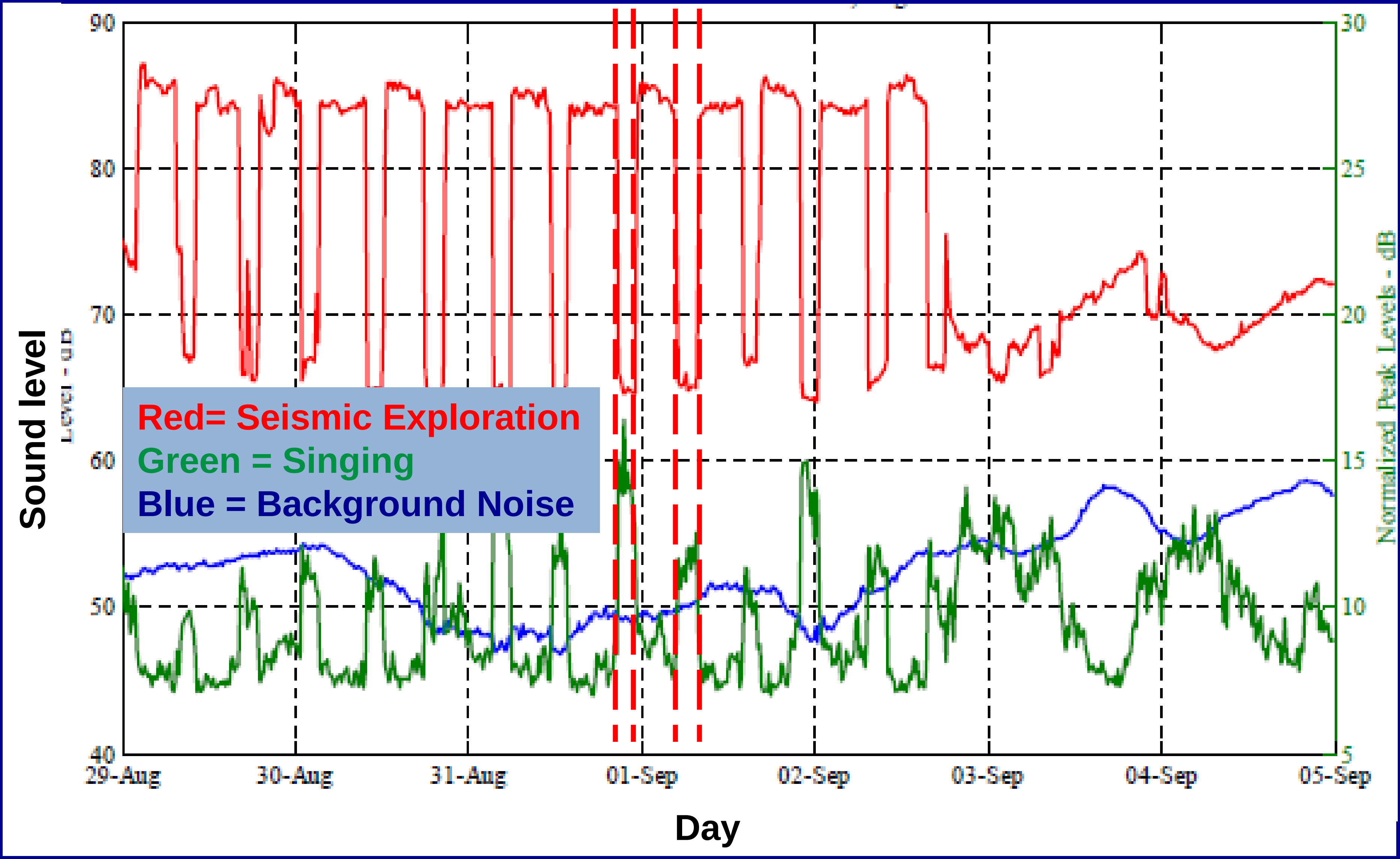
Christopher Clark, Catherine Berchok, Susanna Blackwell, David Hannay, Josh Jones, and Kate Stafford (Lori Quakenbush and John Citta)

Marine mammals in the Western Arctic experience a highly variable acoustic environment throughout the regions that they inhabit throughout the year. We analyzed data to describe and quantify the acoustic occurrence of bowhead whales, *Balaena mysticetus*, and the spatial-temporal variability in their acoustic environment for a one year period, summer 2009 to summer 2010, from a widely distributed set of seafloor acoustic recorders (n ≈ 15) along a 2300 km transect. The results map spatial and temporal variability and average noise levels for the acoustic environment encountered by bowhead whales as they occur in the Beaufort and Chukchi Seas during their fall 2009 and spring 2010 migrations. ***The motivation is to begin the exploration of linkages between physics, productivity, marine mammal distributions and sound-generating activities over ecologically appropriate scales.***

Comment: ***Often within big structures there's an illusion of movement because time doesn't stand still, and everyone is "busy.". How fast are we really moving relative to reality*?**

Onward

Is all this noise a problem? Seismic "on" = Whale Singing "off"
Is this response example "biologically significant"?



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Evidence that ship noise increases stress in right whales

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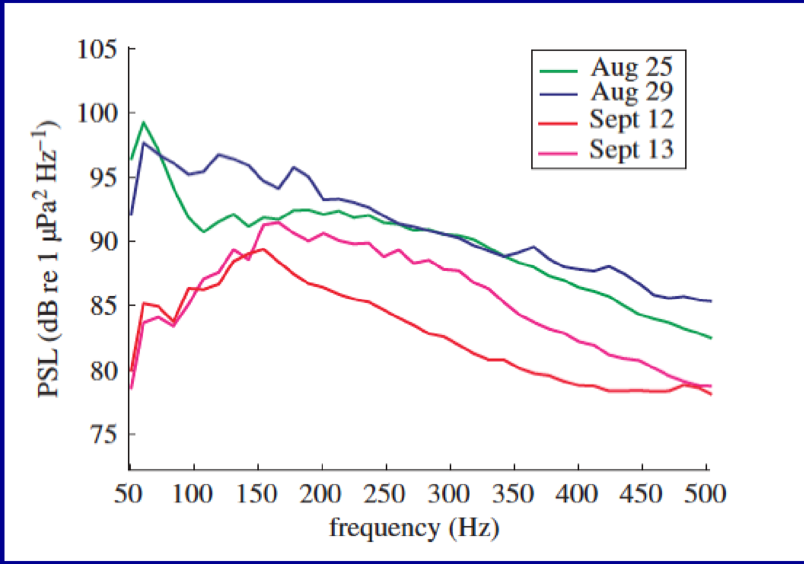

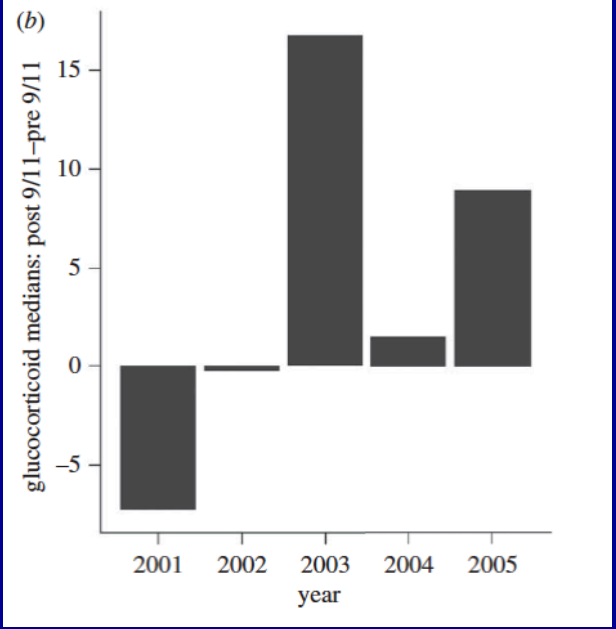

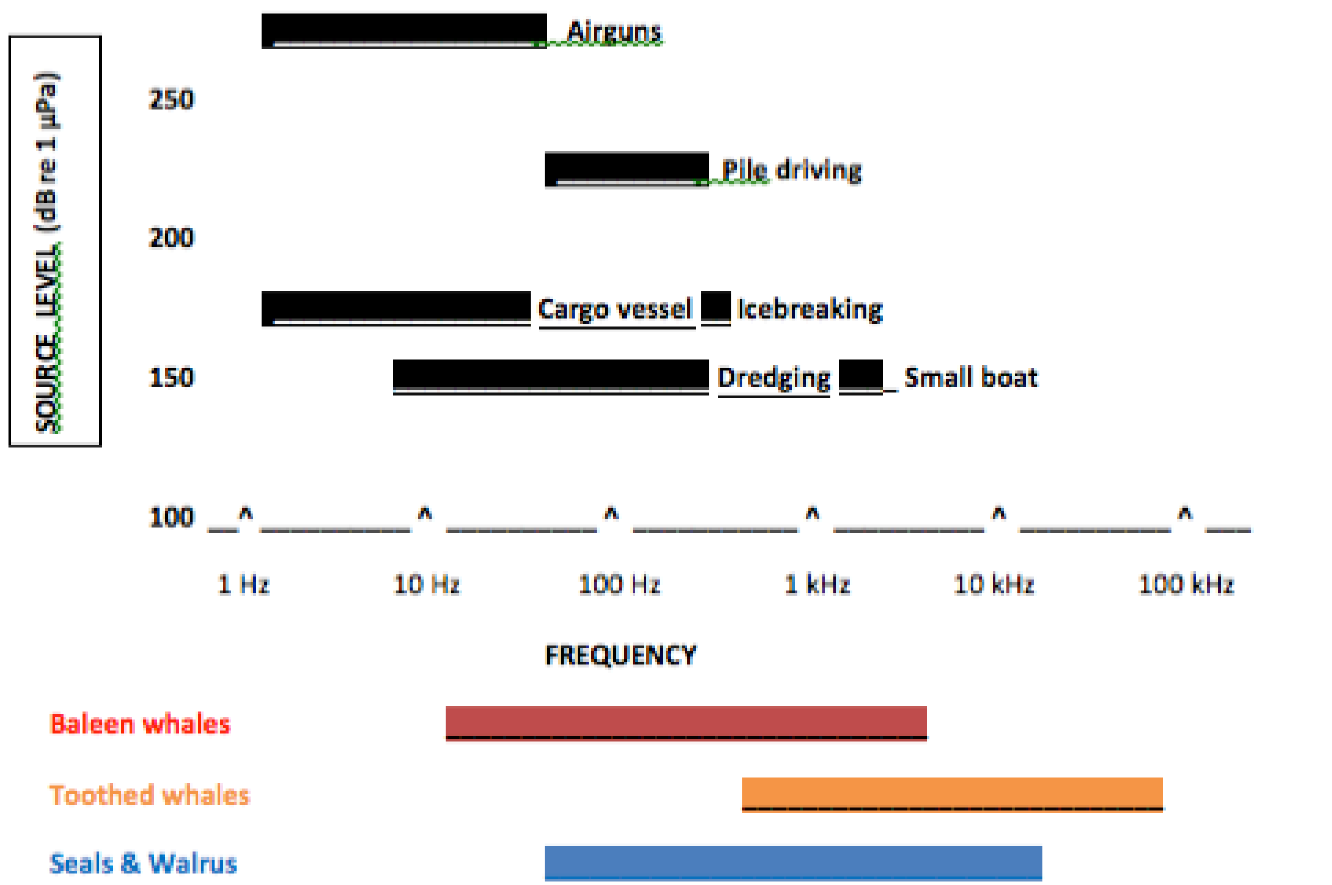

Figure 1. Approximate frequency bands and source levels for common offshore activities in the Arctic (Hildebrand 2009; Greene 1995), relative to frequencies used by Arctic baleen and toothed whales, seals and the walrus.

Moore et al. BioSci, 2012

Acoustic Footprint from Oil & Gas Exploration (e.g., seismic airgun survey: 100,000 sq. nmi).