Marine Mammals & Arctic Oil and Gas Operations: Monitoring and Mitigation of Effects

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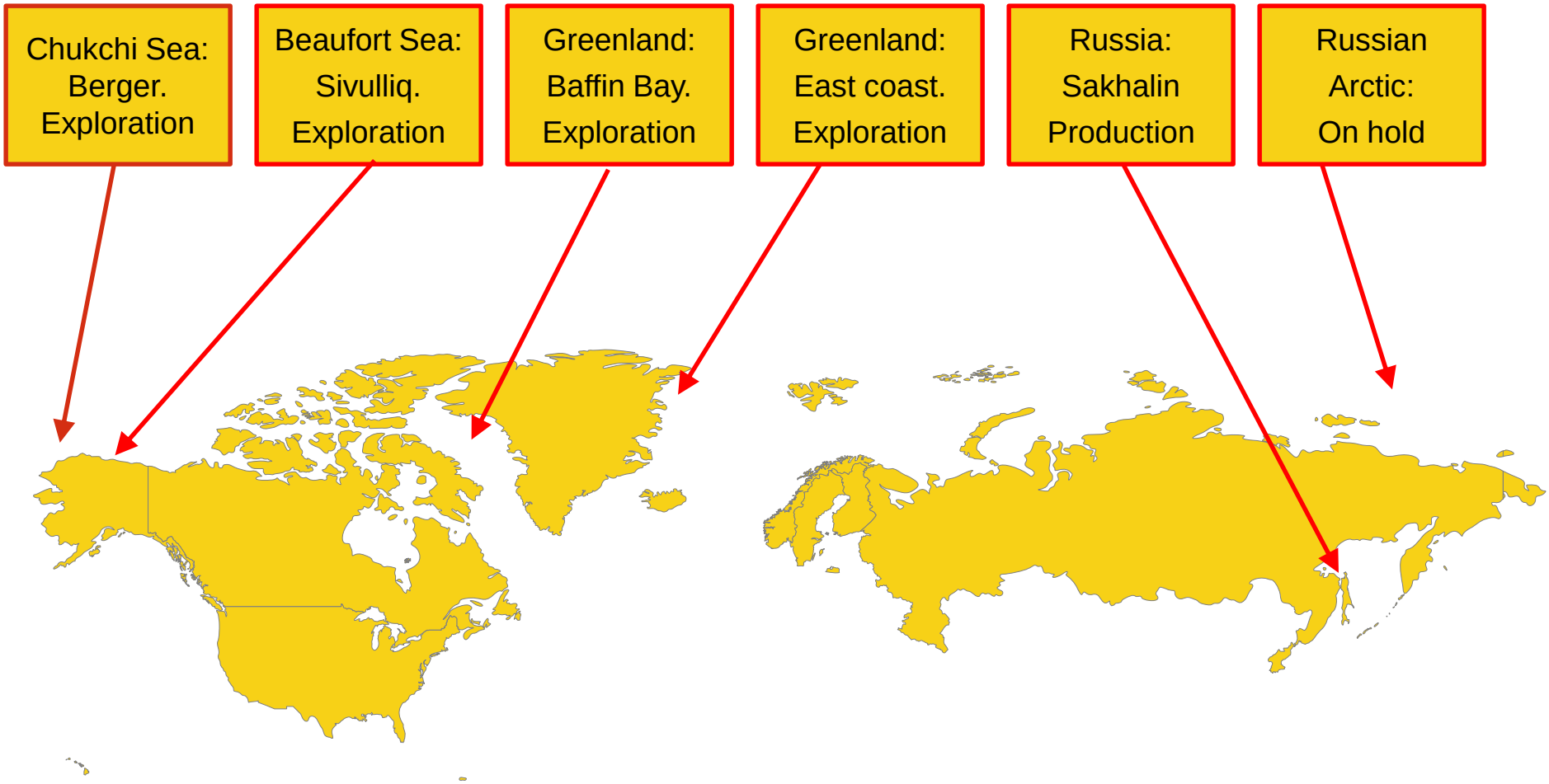
- Greeneridge (Susanna Blackwell)
- Joint study program partners (Conoco, Statoil)
- Many others

Overview presentation

- Shell in the Arctic: where do we operate
- Marine Mammal monitoring & mitigation programs – why do we do it?
- Case studies
  - Greenland
  - Alaska
- Conclusions

Shell in the Arctic



Why Marine Mammal Monitoring & Mitigation

- Sound can impact marine mammal populations triggering need for risk assessment. Increased understanding of impacts on marine mammal populations.
- Requirement to design and implement mitigation plans to minimize disturbance to marine mammal populations and indigenous hunt.
- Concerned stakeholders and regulators over (protected) species and areas.
- Comply with regulations/permit requirements, internal/international standards.
- Science based decision making vs. precautionary approach.

Marine Mammal Monitoring Framework

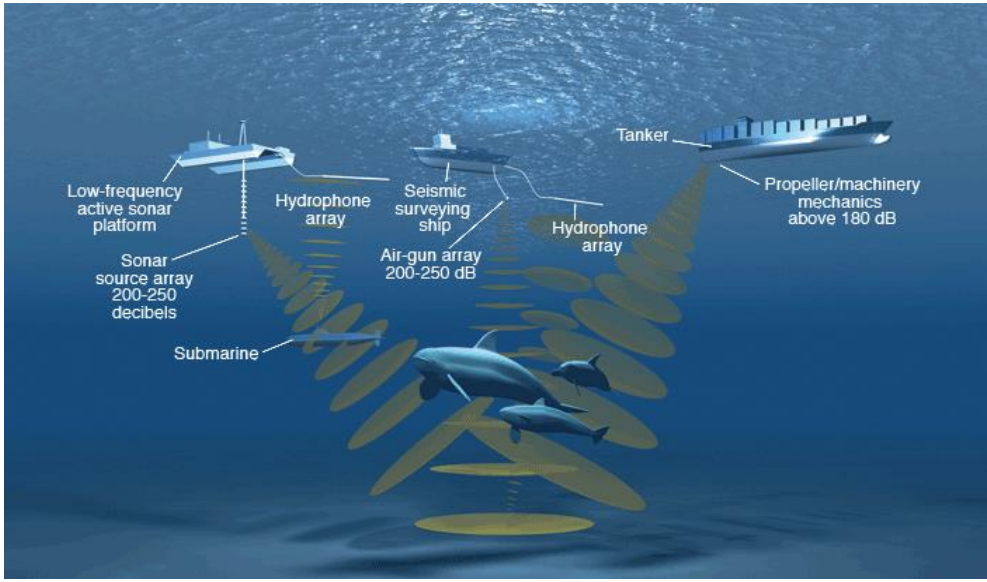
Marine sound - background

Source → Path Way → Receiver

Marine sound - background

Main data needs:

- Sound levels of specific activity
- Frequency
- Type of sound (continuous vs. pulsed)
- Duration
- Rise time
- Depth

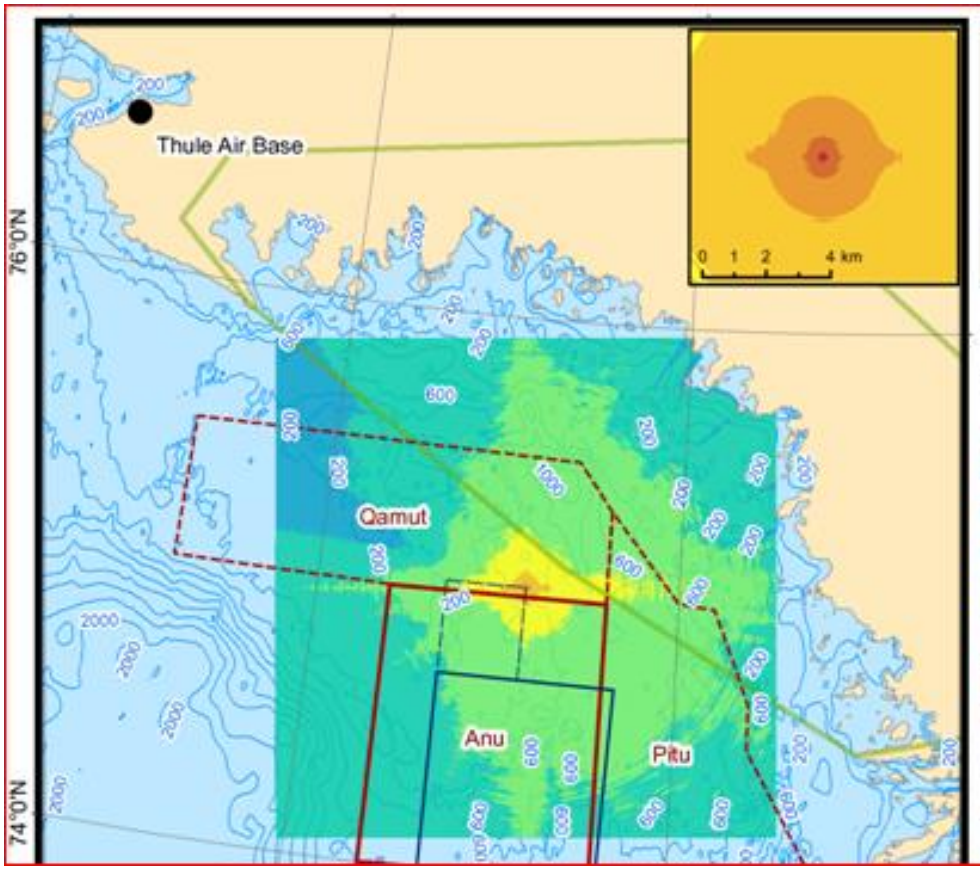


Source → **Path Way** → **Receiver**

Marine sound - background

Main data needs:

- Source loudness
- Source frequency
- Source directionality
- Depth of source
- Bathymetry
- Water sound speed profiles
- Directionality
- Bottom type



Source → **Path Way** → **Receiver**

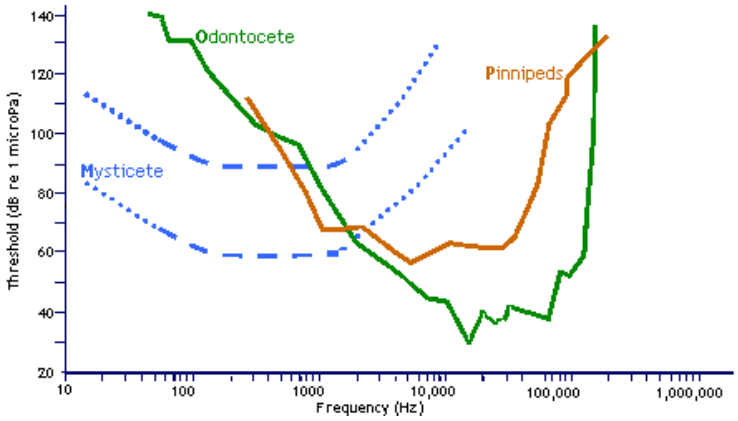
Marine sound - background

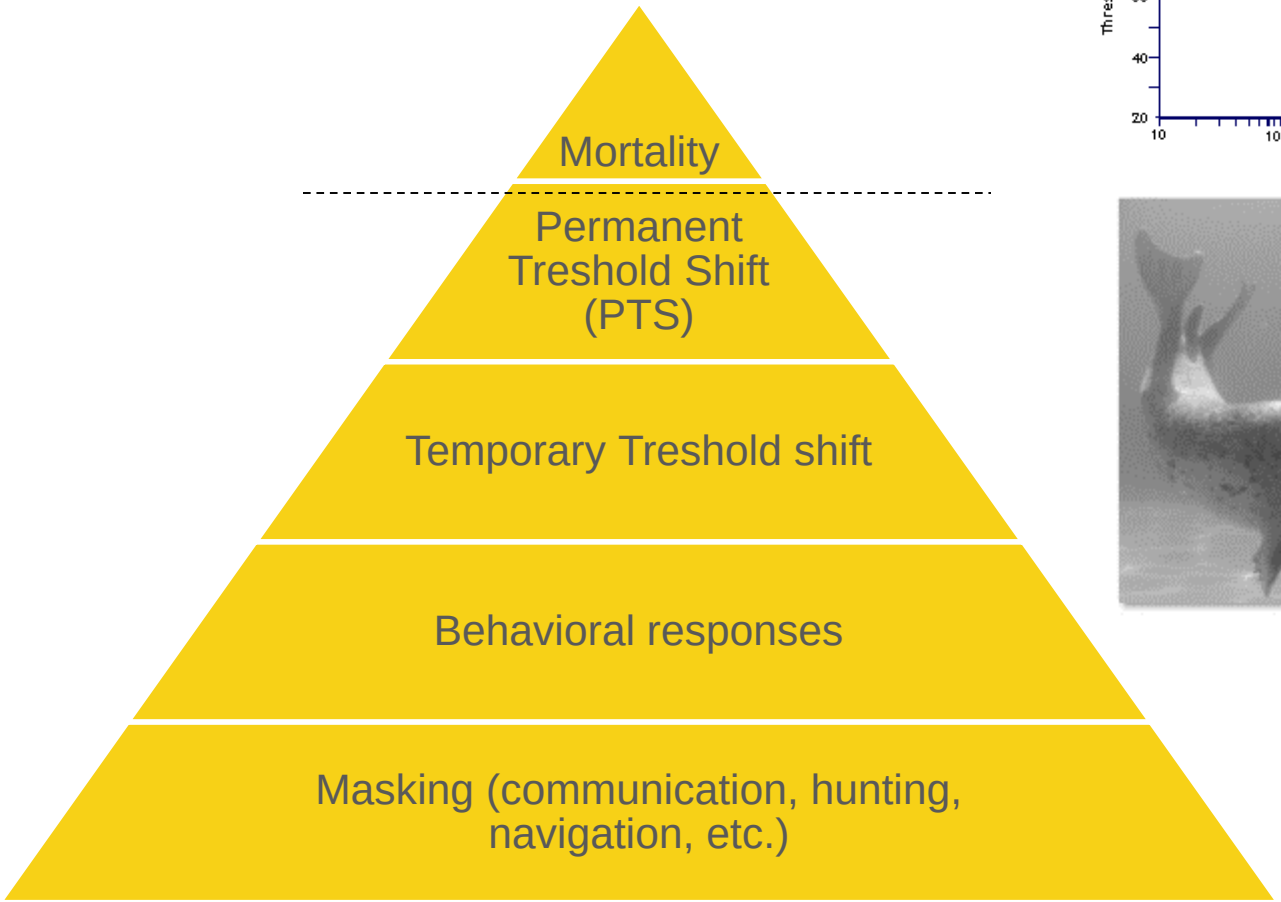
Main data needs:

- Species present
- Species distribution and abundance
- Seasonal variation & migration patterns
- Hearing functionality of species
- Acoustic thresholds for injury
- Acoustic thresholds for behavioral changes
- Masking
- Population status
-Population effects
- Effective mitigation measures

Source → **Path Way** → **Receiver**

Marine Sound - impacts



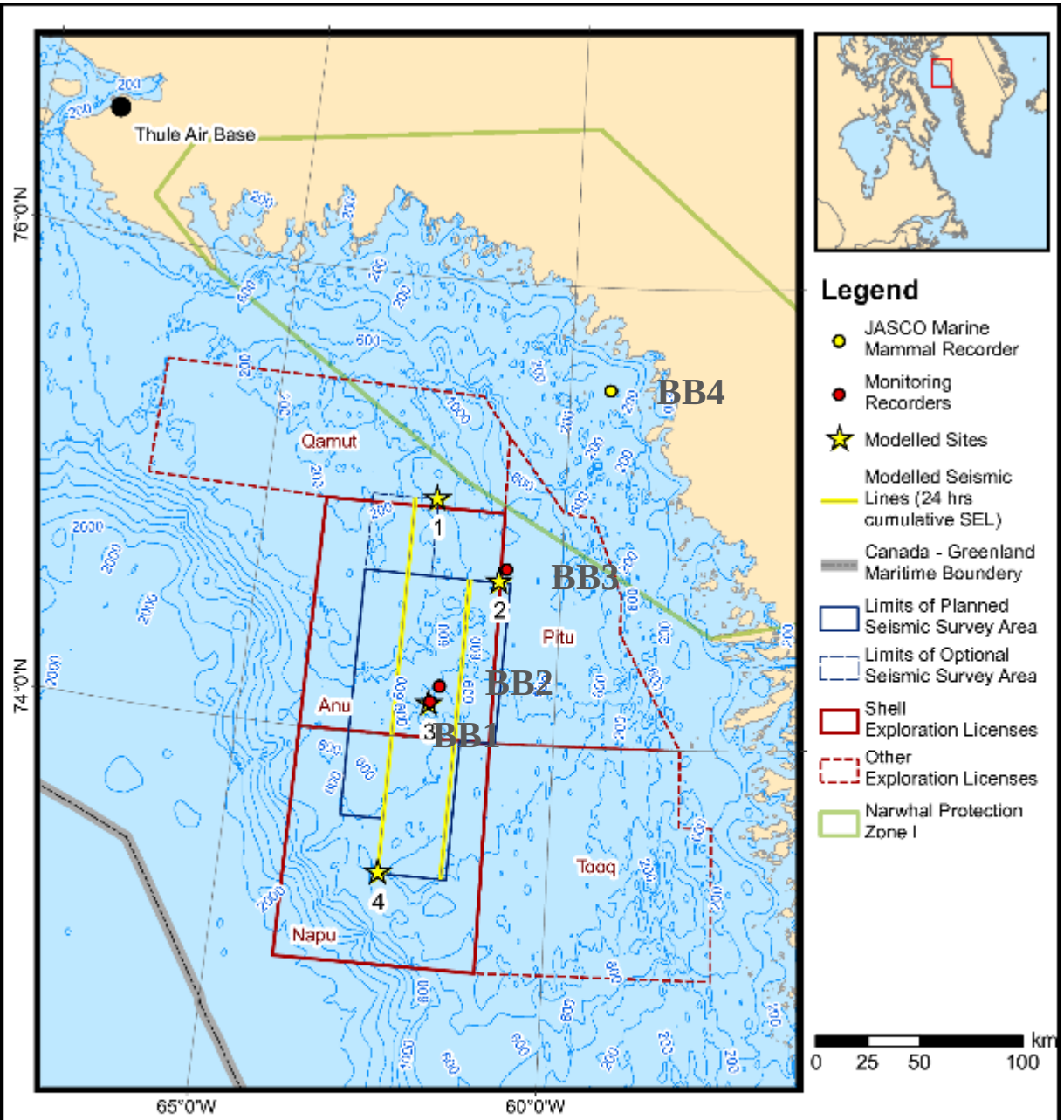


Case study

Baffin Bay - Greenland

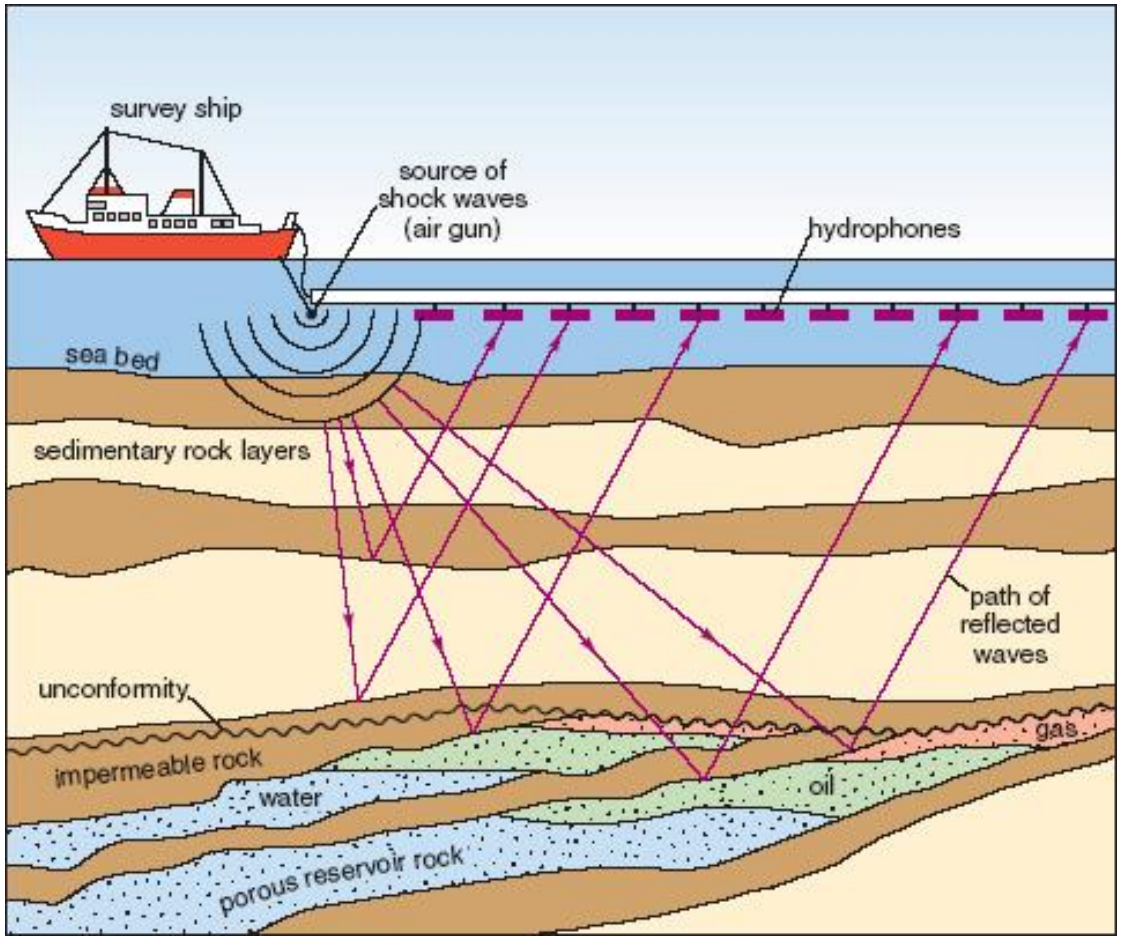
2012 Acoustic monitoring program

Baffin Bay - 2012 3D survey acoustic program



- 2 seismic vessels
- 33 guns - 3480 in^3
- 3 mooring with 3 hydrophones (100, 200, 400m.)
- 1 recorder in Melville Bay (Jasco)

Baffin Bay - 2012 3D survey acoustic program

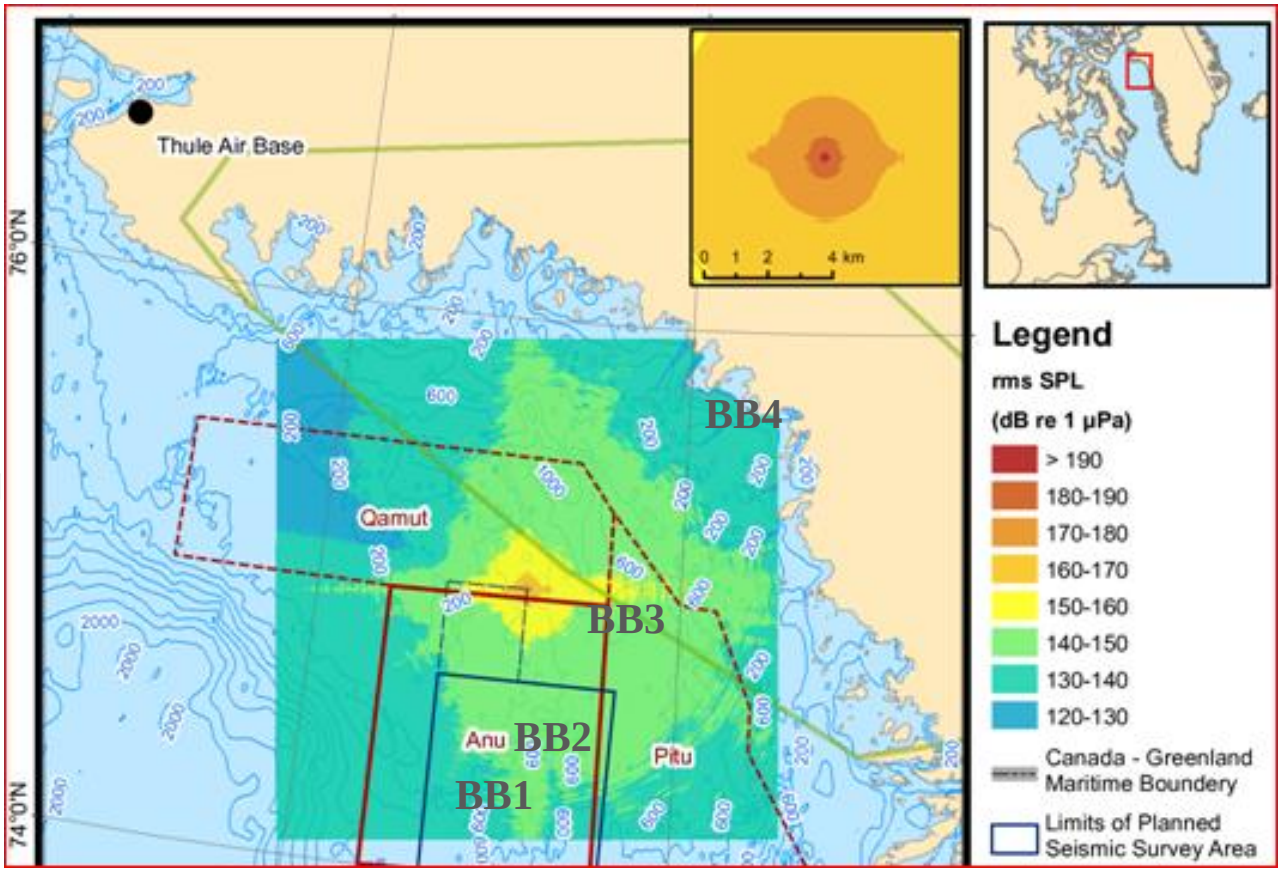


- 2 seismic vessels
- 33 guns - 3480 in^3
- 3 mooring with 3 hydrophones (100, 200, 400m.)
- 1 recorder in Melville Bay (Jasco)

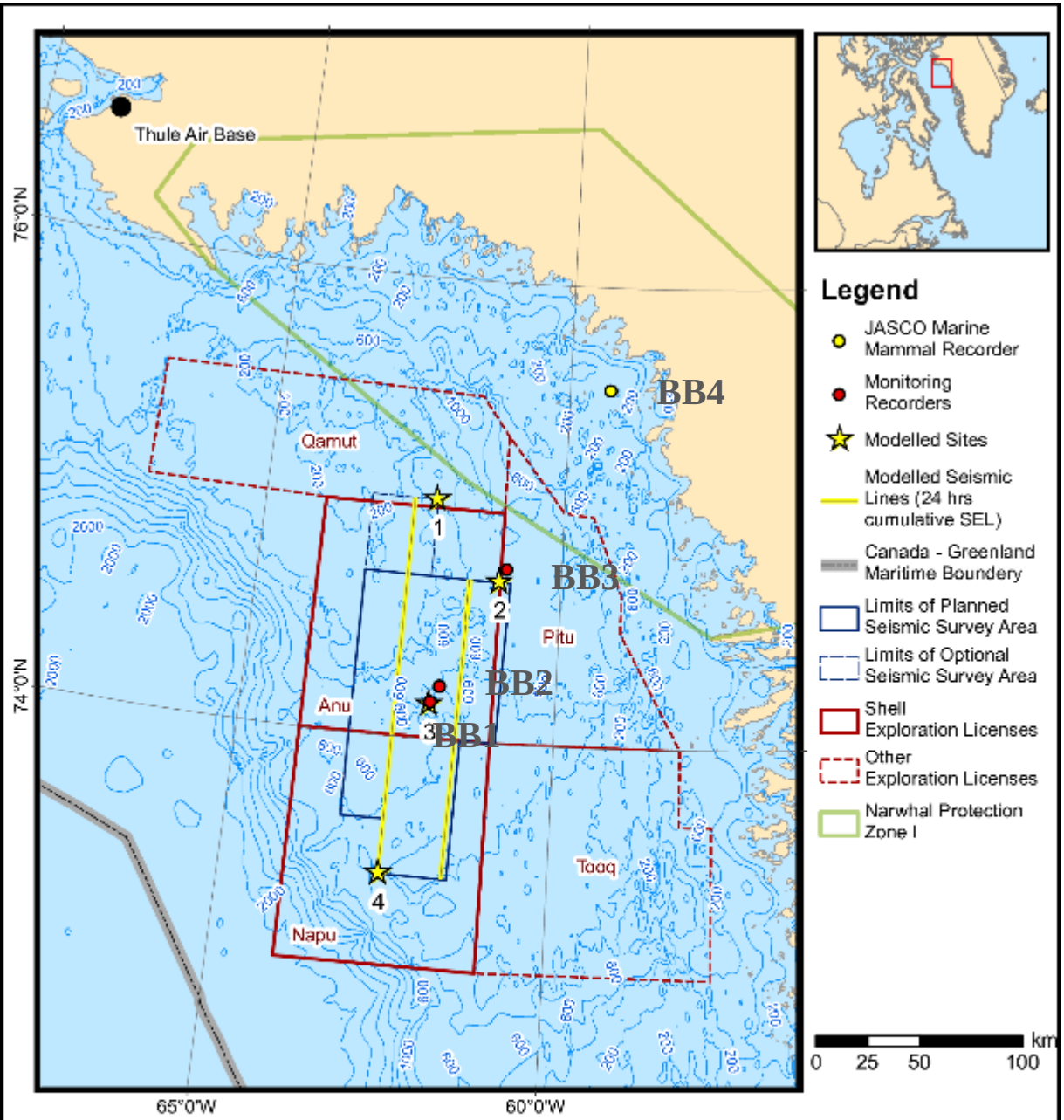
Baffin Bay - 2012 3D survey acoustic program

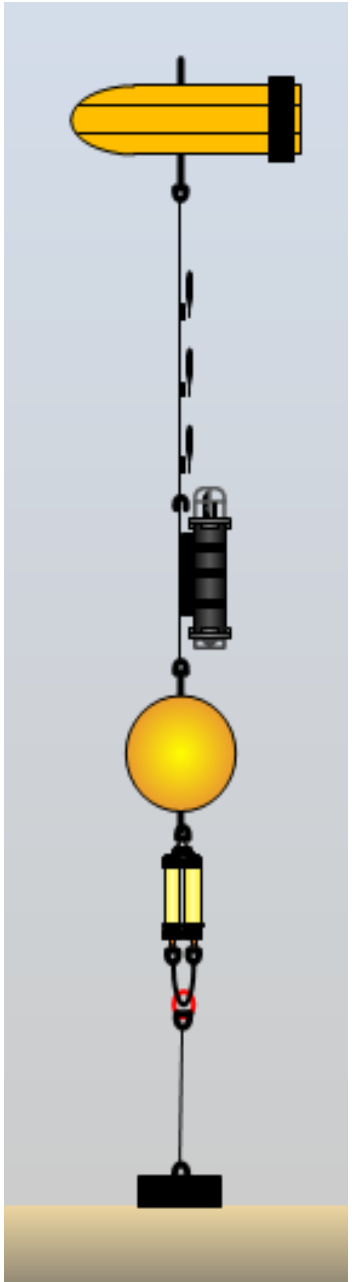
Mitigation measures:

- Acoustic propagation modeling studies
- Marine Mammal Observers
- Passive Acoustic Monitoring
- Shut-down criteria
- Ramp-up procedures
- Seasonal closure



Baffin Bay - 2012 3D survey acoustic program





Baffin Bay - Objectives

Objectives

The purpose of the acoustic monitoring program was to obtain a better understanding of :

1) ambient and anthropogenic sound levels and sound propagation in arctic waters.

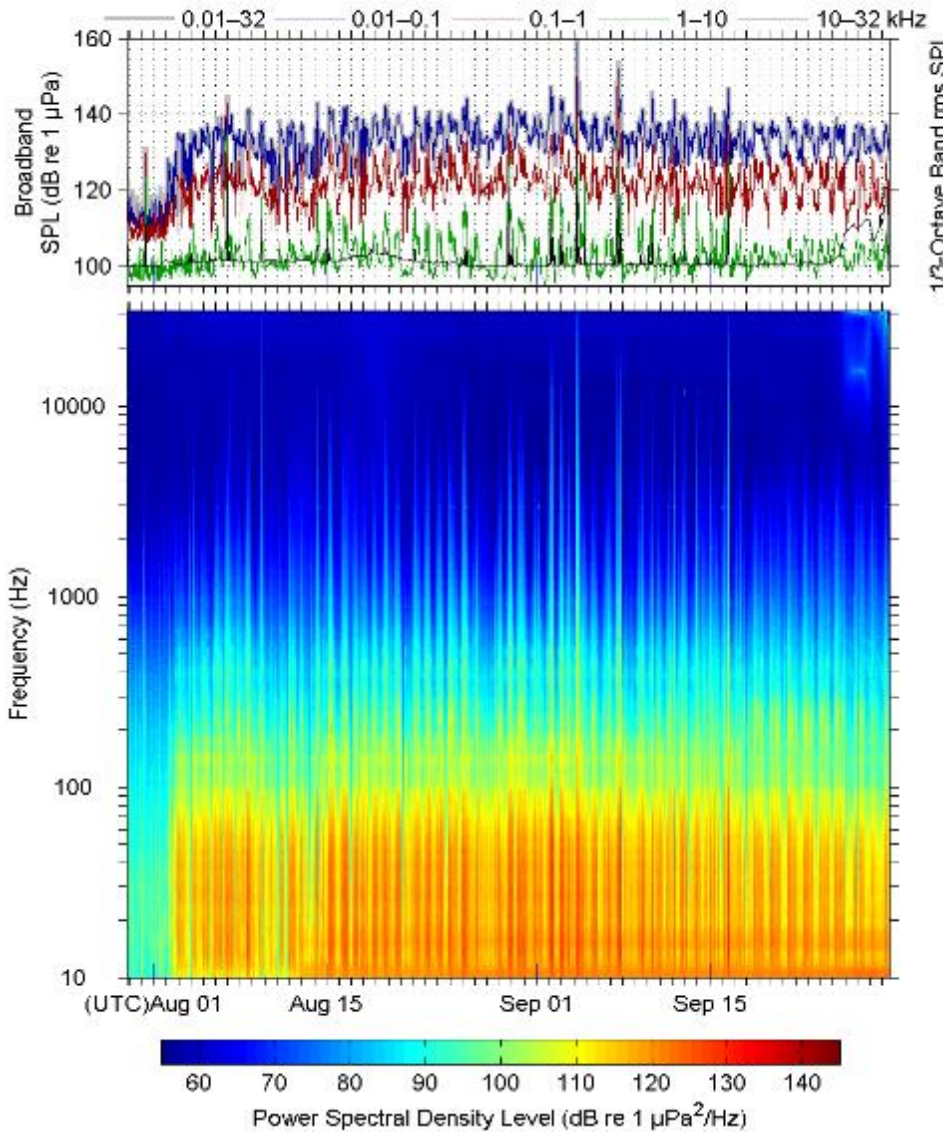
2) possible exceedance of sound level criteria for injury.

3) presence of marine mammal species within and adjacent to the license areas.

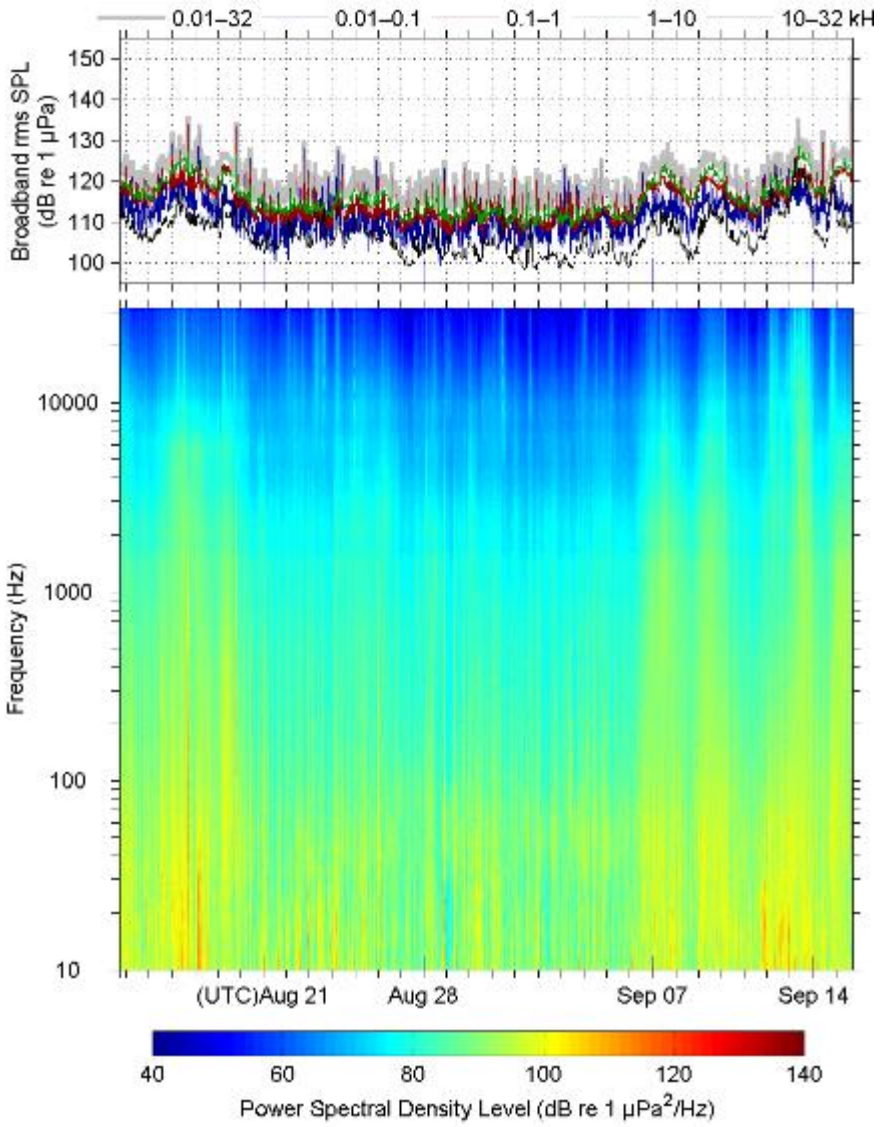
Additionally: Danish Centre of Environment & Greenland Institute of Natural Resources conducted industry-funded studies on (i) Acoustics, (ii) Distribution and abundance of narwhal (aerial surveys) and (iii) Impact on narwhal hunt.

Baffin Bay - Results

BB1



BB4 – Melville Bay

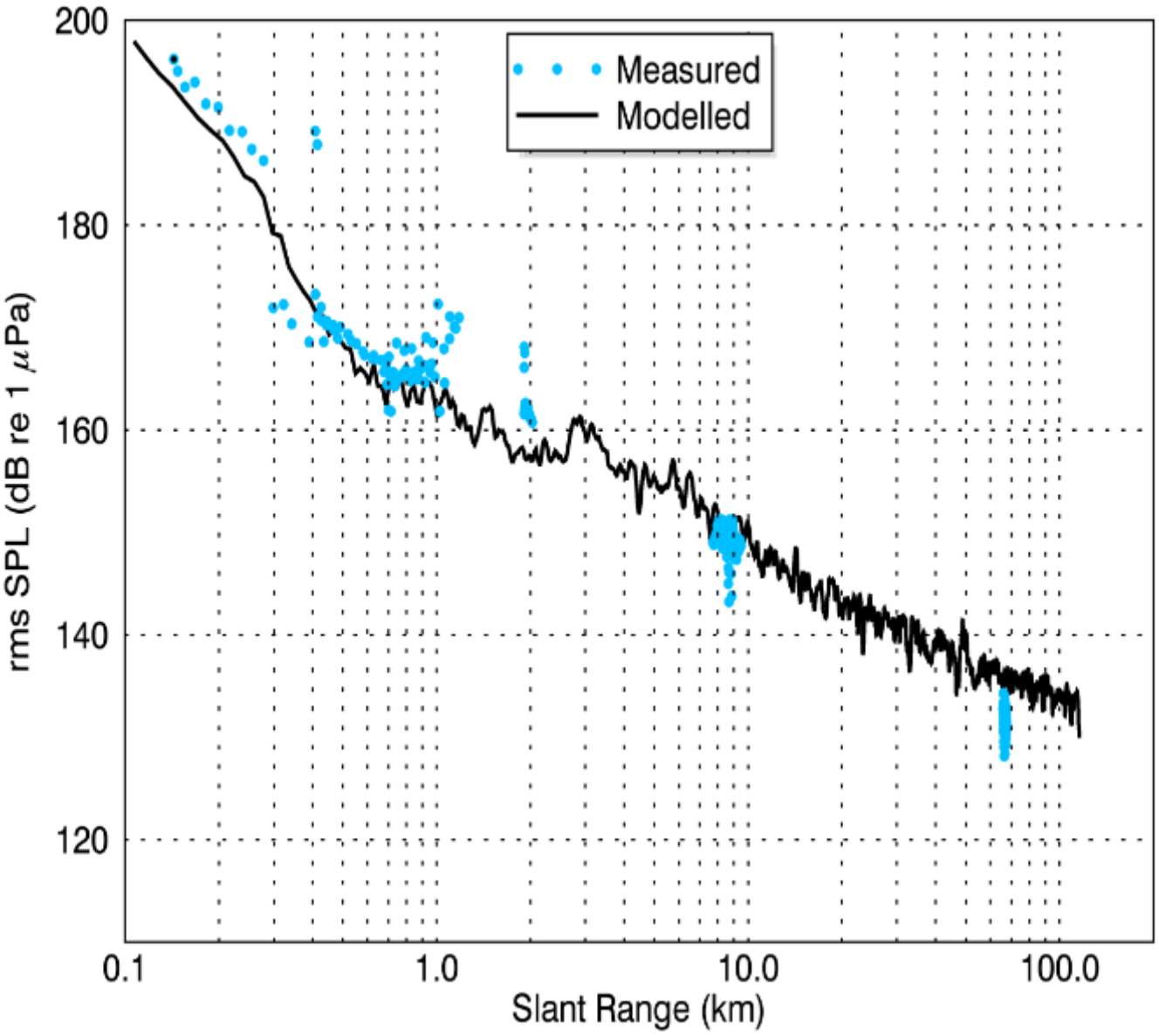


Baffin Bay - results

Table 1. Median 1-min rms SPLs, recording durations, and duration of ambient vs anthropogenic sound at each measurement location.

Station	Depth	Total		Ambient		Anthropogenic (Vessels and seismic)	
		Minutes	Median 1-min rms SPL (dB re 1 µPa)	Minutes	Median 1-min rms SPL (dB re 1 µPa)	Minutes	Median 1-min rms SPL (dB re 1 µPa)
BB1	100	89059	132.8	964	110	54964	134.1
	200	89059	133.1	5423	109	51436	134.7
	400	89059	132.5	7911	111.3	44340	135.0
BB2	100	91171	132.8	803	112	54498	134.3
BB3	100	92936	130.2	1716	108	46246	130.2
	200	92936	129.9	6531	107	41463	131.5
	400	92936	130.1	16428	109	34728	133.8
BB4 (Melville Bay)	100	45180	116.5	20782	119.3	7509	113.8

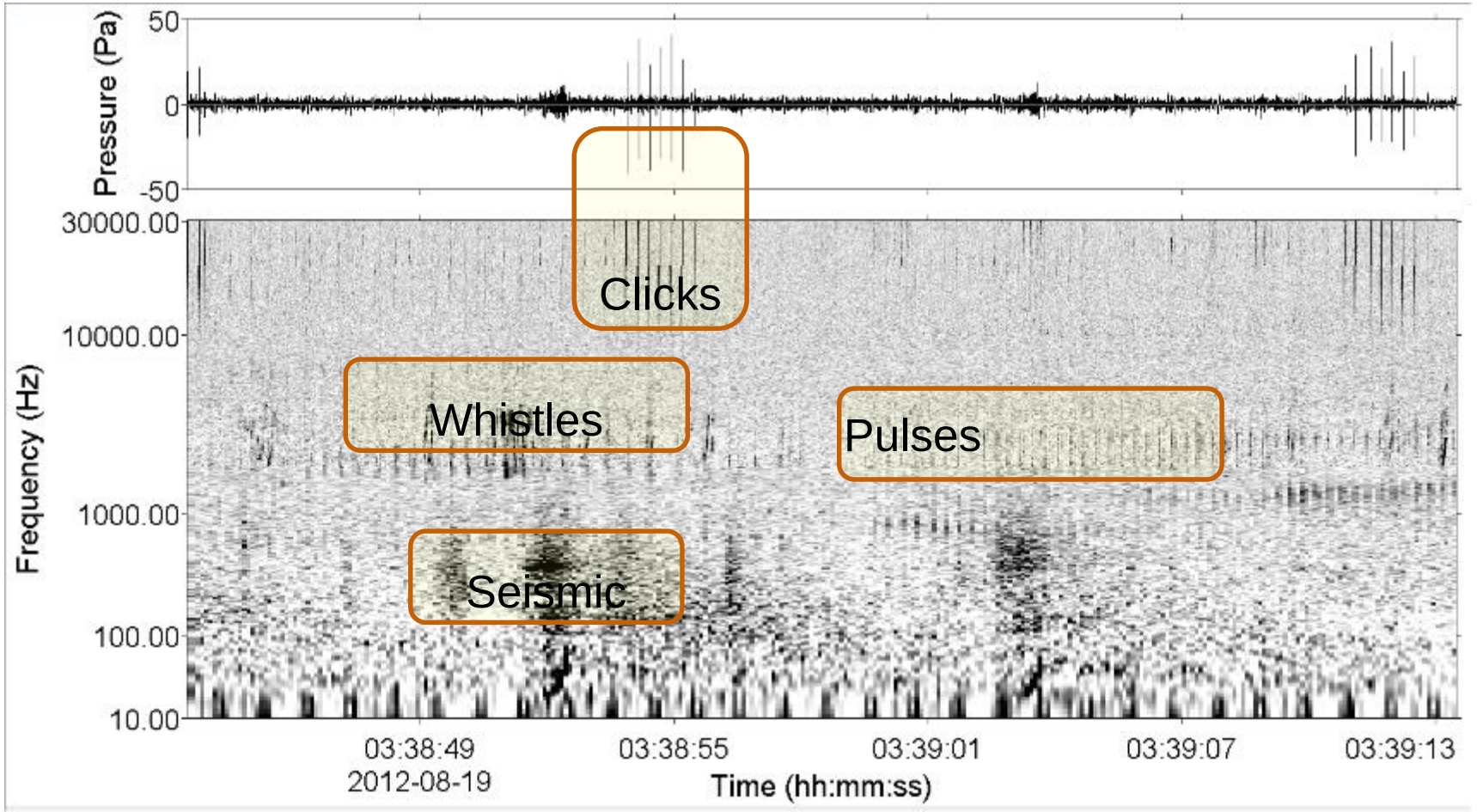
Baffin Bay – results: Measured vs. modeled sound levels



Baffin Bay – results: marine mammal detections

Within the license areas there were detections of sperm whale, narwhal, fin whales*, bearded seals*

On Recorder in Melville Bay: narwhal detections and ice.



Baffin Bay – Conclusions

1) Sound levels within the license areas were elevated by ~20dB. Within Melville Bay, ice is dominant sound source.

2) Propagation conditions off the coast of Greenland are complex, and propagation modelling must be performed at high fidelity to fully capture the dynamic environment.

3) Conclusion from independent study (WHOI) that Jasco propagation model is fairly accurate despite poor data input to the model.

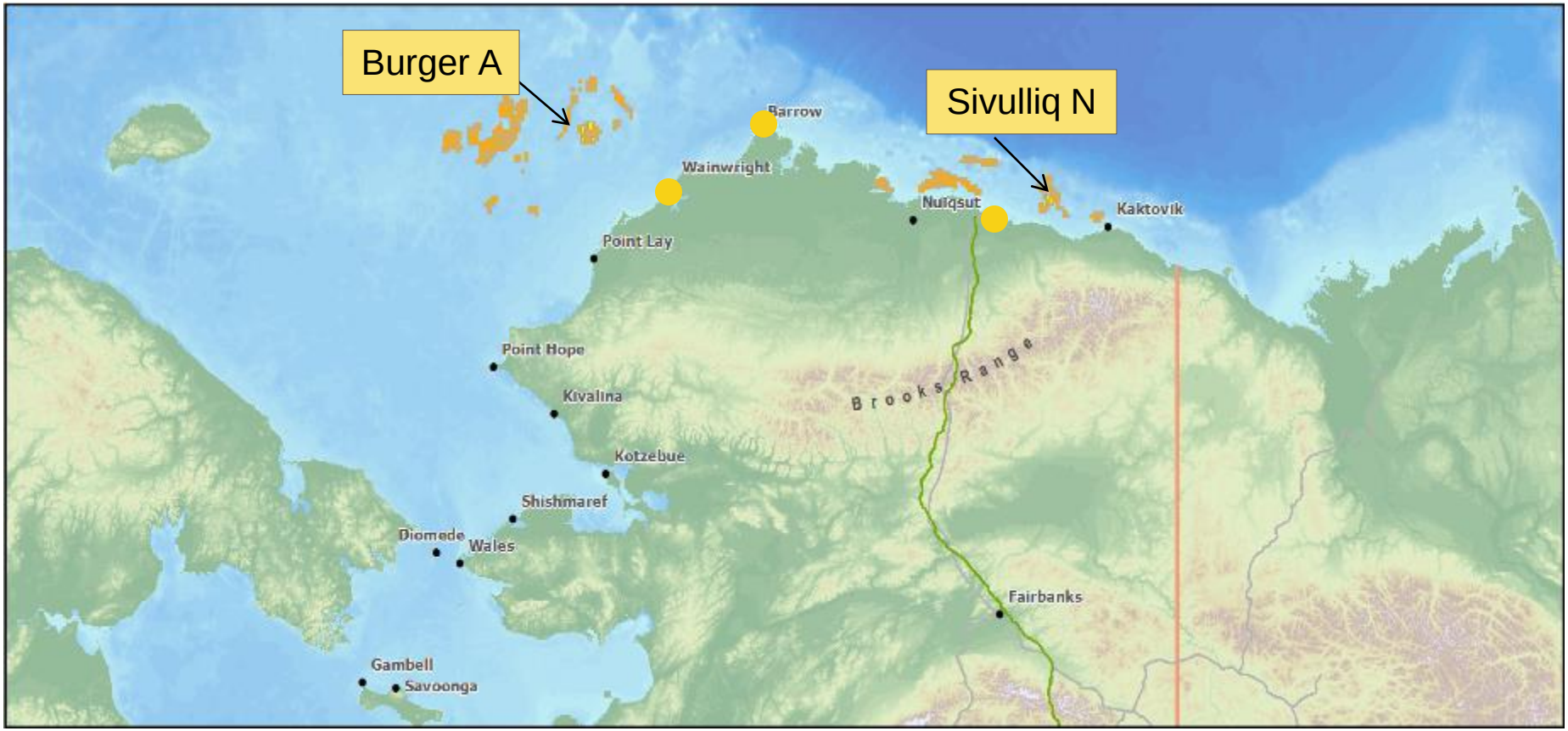
4) No evidence of short-term impacts on narwhal population or the hunt.

5) Results of science programs are used by DCE and GINR to advise on further development of regulations.

Case study:

Chukchi & Beaufort Seas

Shell's Drilling Program

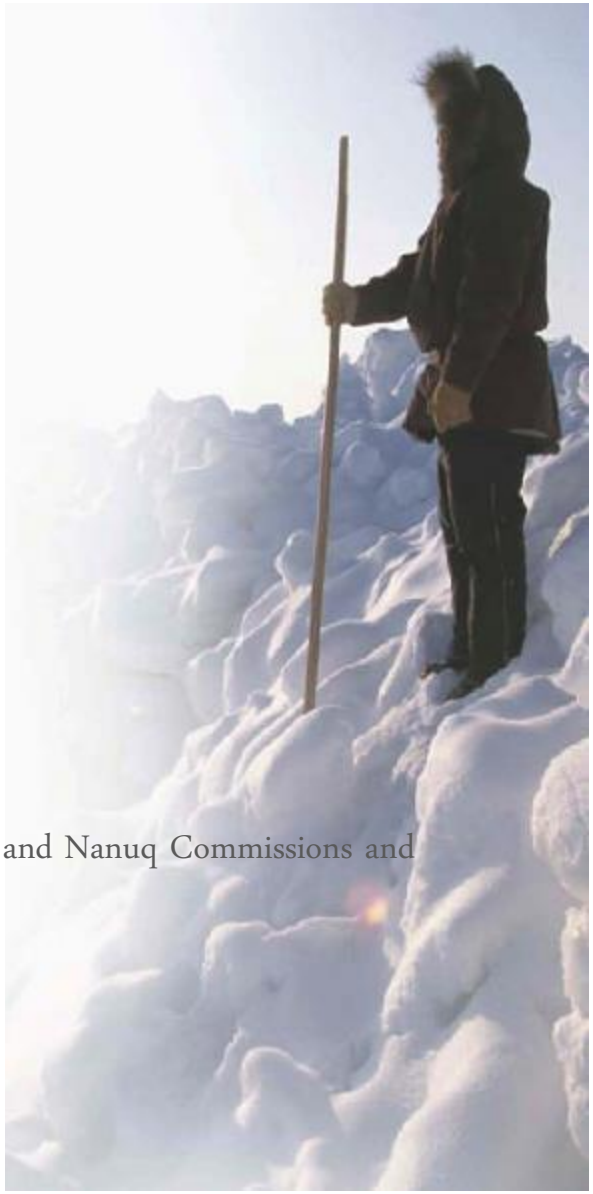


Future activities Shell in Alaska

- 2015 – planning for a drilling program in Chukchi Sea at Burger site
  - Drilling rigs:
    - Noble Discoverer
    - Transocean's Polar Pioneer
  - Fleet of support vessels, similar to 2012
    - Anchor handlers, ice management, oil spill response, supply & towing
  - Ninth Circuit – Lease Sale 193

Safeguards

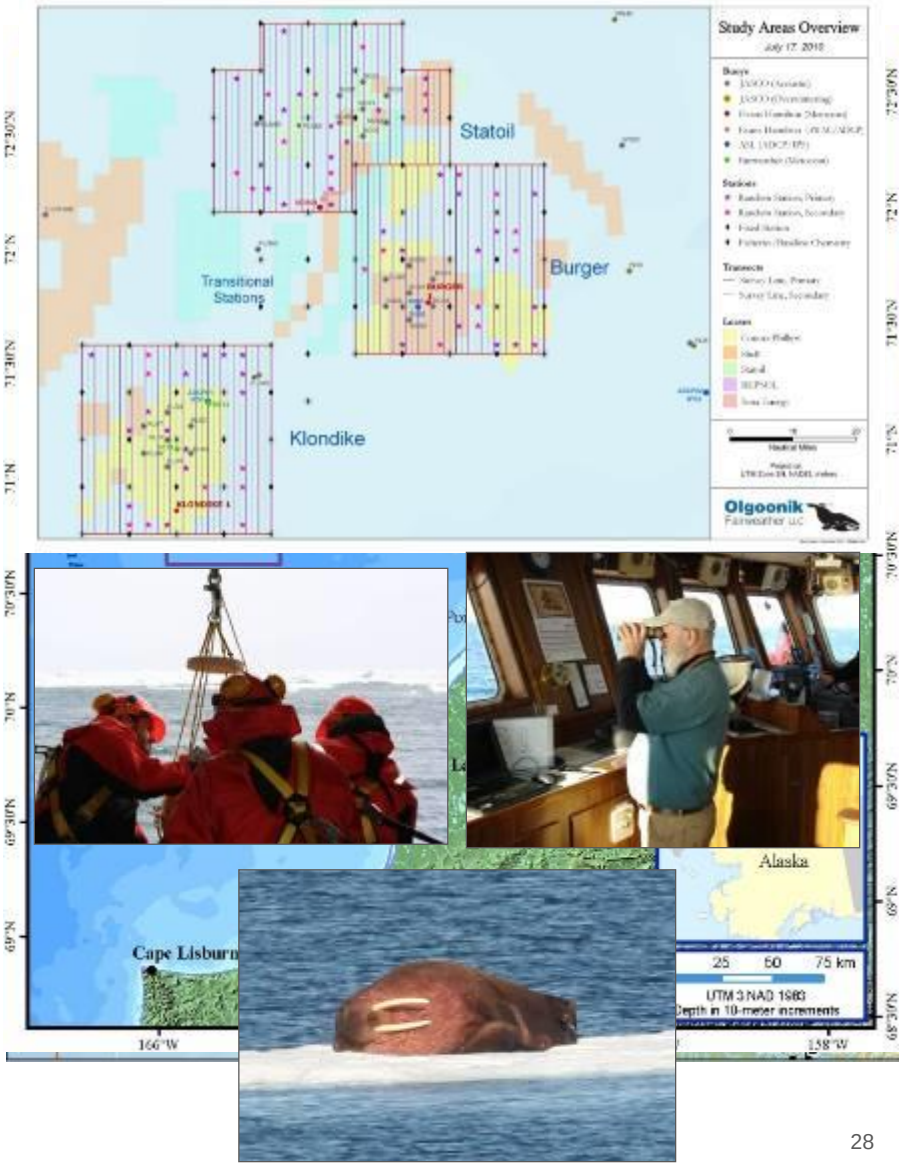
- Whaling Blackout as appropriate
- Communication Centers activated during vessel activity
- Subsistence Advisors in coastal villages
- Protected Species Observers on all Shell assets
- Community Liaison Officers in coastal villages
- Advanced Data Acquisition Manager (ADAM) tracks all vessels offshore and aviation assets as well as weather data points
- PSO weekly sightings interactive web map.
- A real time ice and weather forecasting system
- Collaboration and Communication with AEWC, Beluga and Seal Committees, Walrus and Nanuq Commissions and hunters



Alaska: Marine Mammal monitoring programs

Chukchi Sea Lease Areas and Baseline Studies

- Jointly funded by ConocoPhillips & Statoil
- Operated by native corporation
- Three areas of top priority
- Subject to intensive interdisciplinary study each year since 2008
  - Physical oceanography
  - Benthos
  - Plankton
  - Acoustics
  - Fishes
  - Marine Mammals
  - Marine Birds

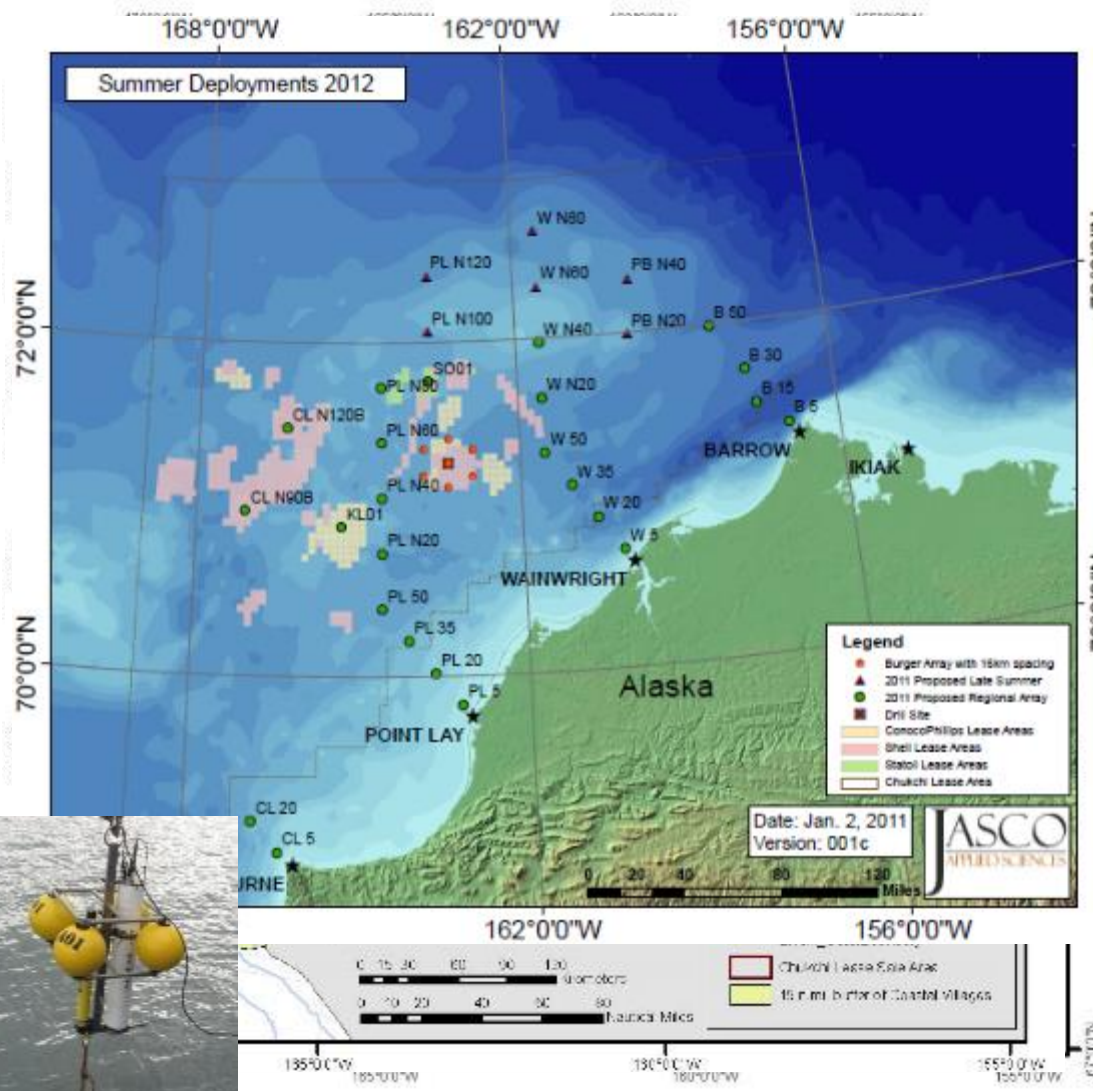


www.chukchiscience.com

Marine Mammal Observations

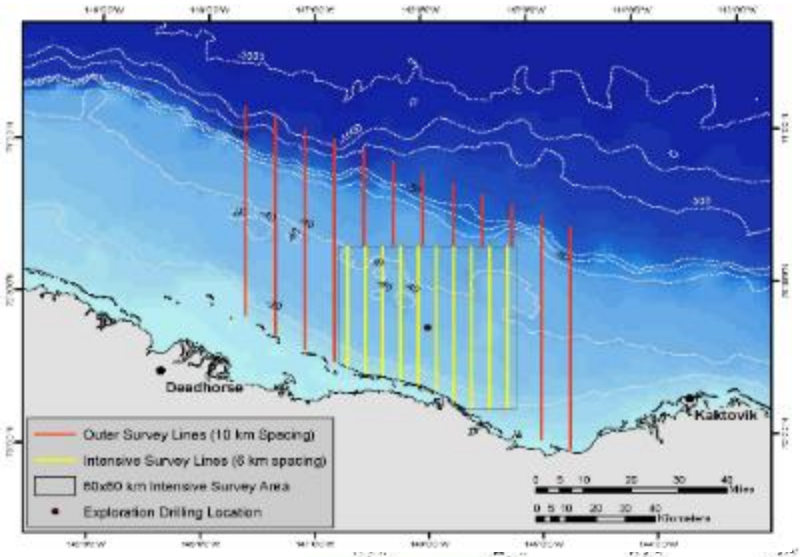
Triad of Information

- Vessel based observations
  - PSOs on sound source vessels (drill rigs, ice management, anchor handlers)
  - Integrated biologist/local knowledge staff
- Aerial observations
- Acoustics
  - Open water since 2006
  - Year around since 2007

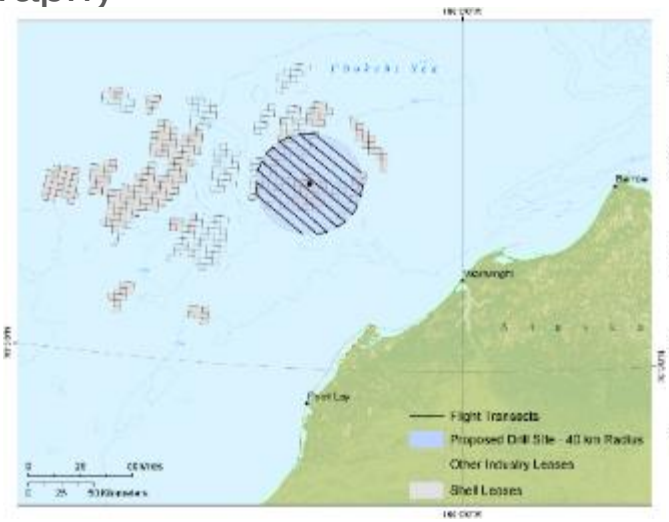


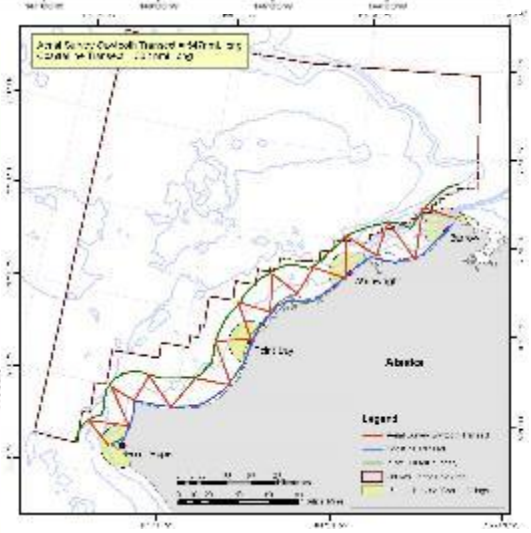
Aerial Program

- Offshore overflights in the Beaufort
  - Manned flights w/ photography
  - Stratified sampling strategy



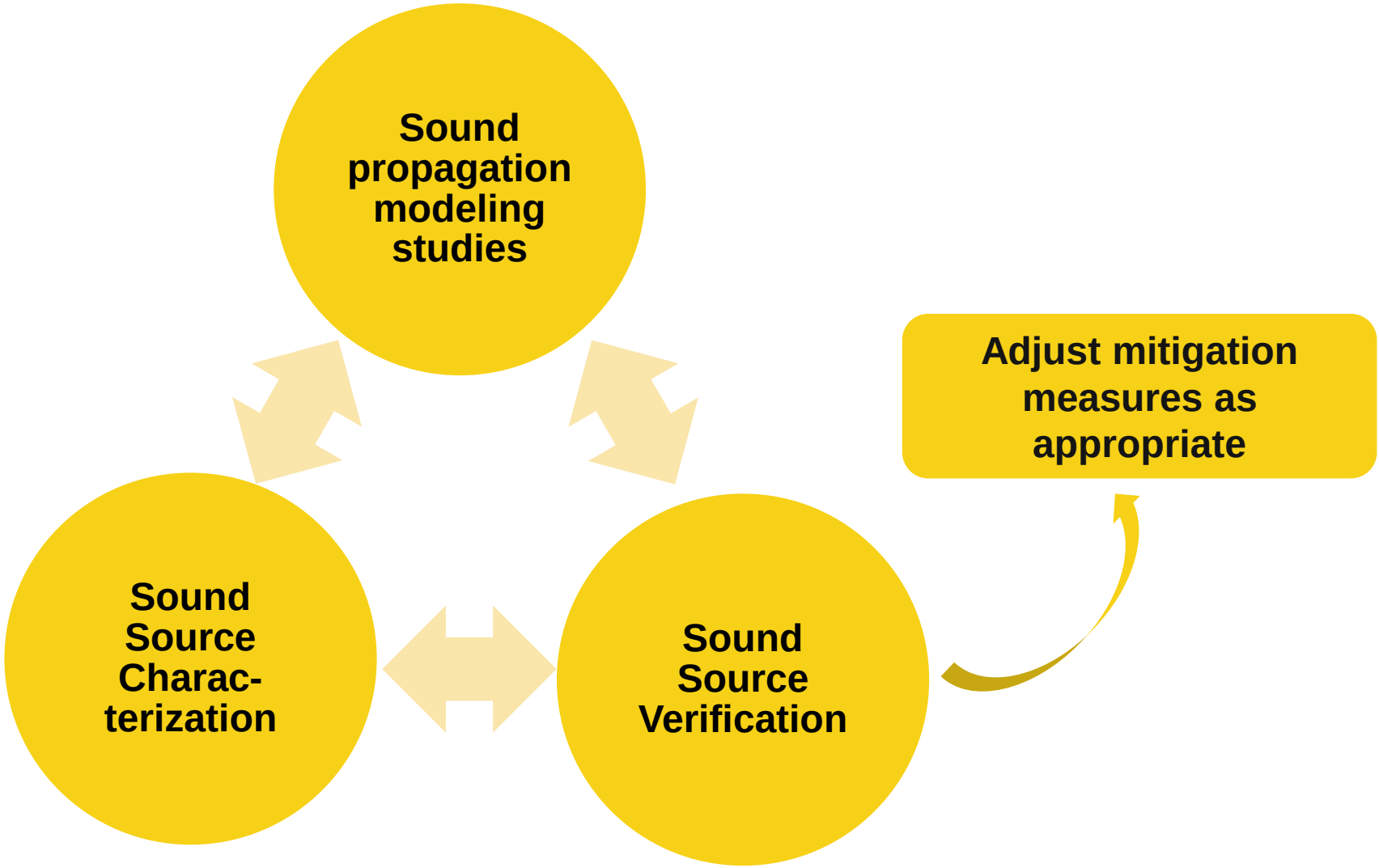
- Chukchi nearshore
  - Sawtooth pattern
  - Manned flights w/ photography





- Chukchi Burger prospect
  - Photographic survey
  - Manned aircraft
  - No PSOs

Activity-specific Acoustic Programs



Key questions

Occurrence:

- What is the distribution and seasonal abundance of marine mammals in the Chukchi and Beaufort Seas? Vocal characteristics of species.

Exposure:

- What are the ambient sound levels throughout the region?
- What is the extent and propagation of anthropogenic sounds from exploration operations?
- What are the capabilities and accuracy of efforts to model soundscapes and potential exposure levels?
- What data are needed to improve the ability to model soundscapes of the operational area?
- What are the modeled and measured sound levels received by marine mammals?

Key questions

Responses:

- What behavioral responses do marine mammals exhibit to industrial operations?
- At what distances and sound levels do marine mammals exhibit these responses (context)?

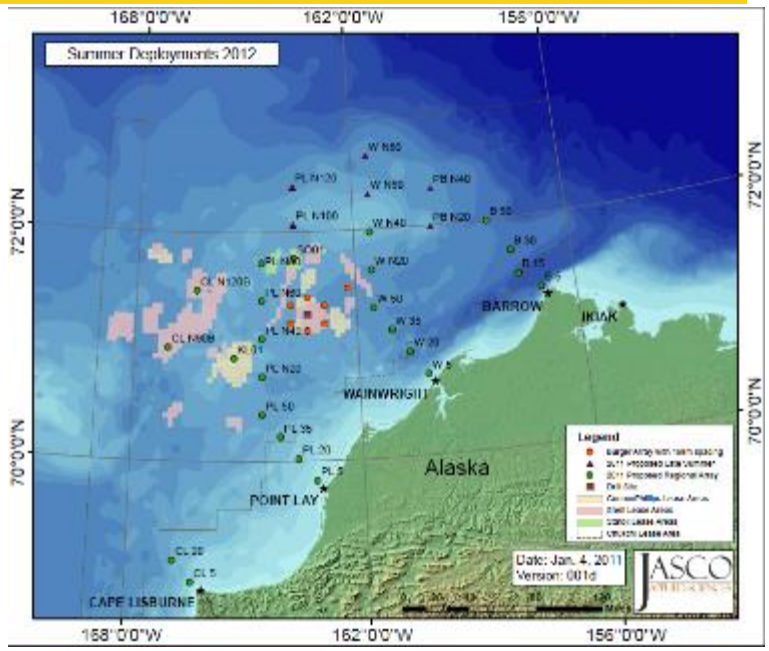
Consequences:

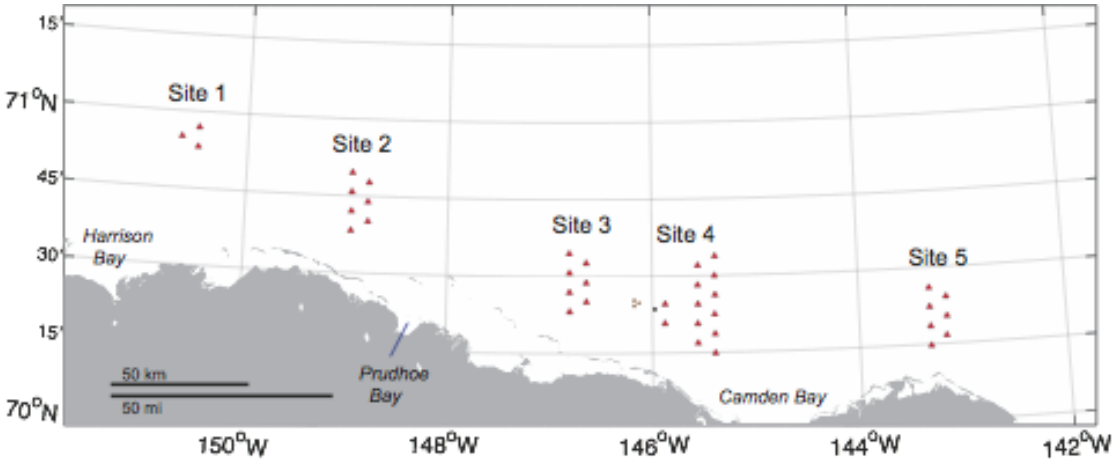
- Do seismic/drilling activities impact populations of marine mammals in the Chukchi and Beaufort Seas?
- Are there biologically significant impacts to individual animals?
- Do seismic/drilling activities offshore impact the availability of marine mammals to subsistence hunters?

Acoustic monitoring

Bowhead distribution – Regional arrays

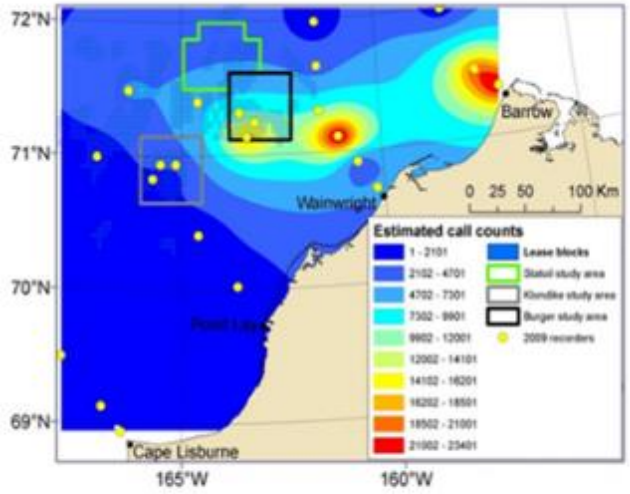
- Acoustic recorders deployed in the Chukchi & Beaufort
- Localization capability
- Goals
  - Understand effects of industry sound on the distribution and behavior of marine mammals.
  - Understand patterns of distribution and movement



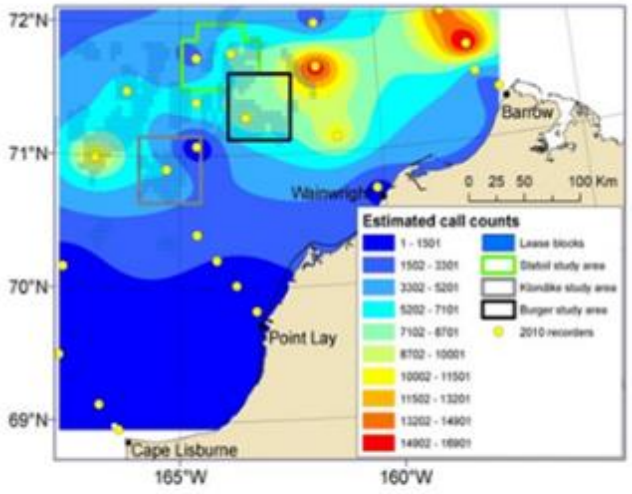


Bowhead distribution – Regional arrays

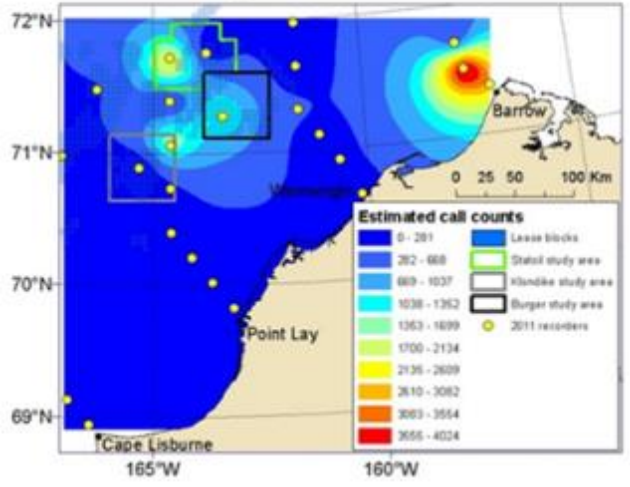
5 Aug to 15 Oct 2009



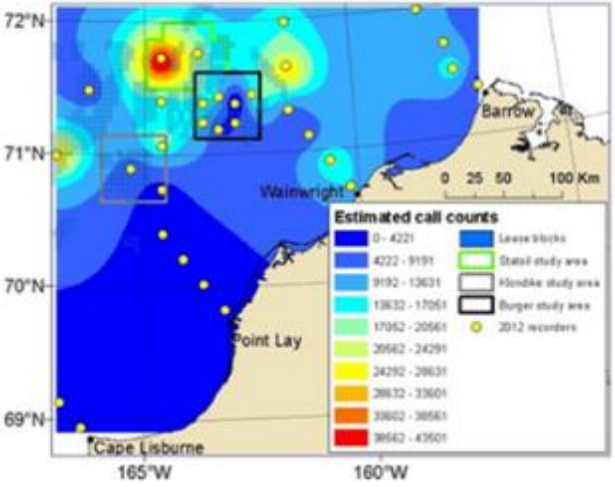
25 Jul to 15 Oct 2010



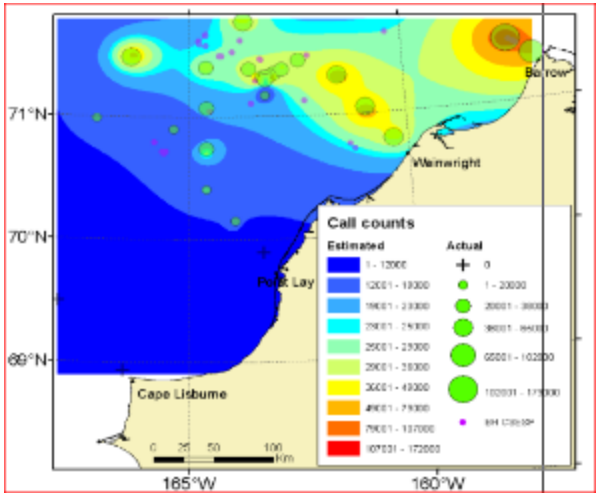
16 Aug to 12 Oct 2011



8 Aug to 13 Oct 2012



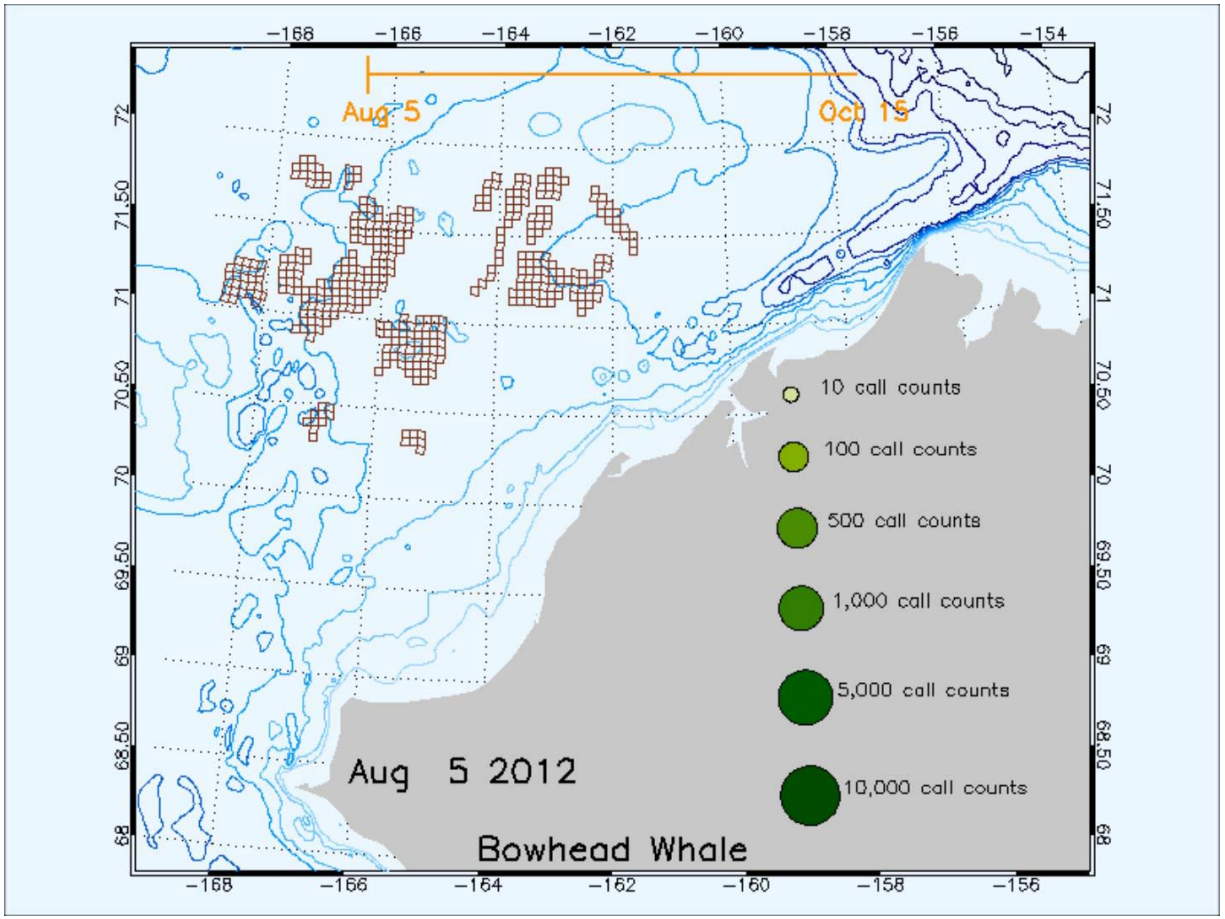
5 Aug to 11 Oct 2013



- Most calls detected north of 71°N, which is consistent with satellite tagging and aerial surveys.
- Distribution is more variable than in the Beaufort Sea.

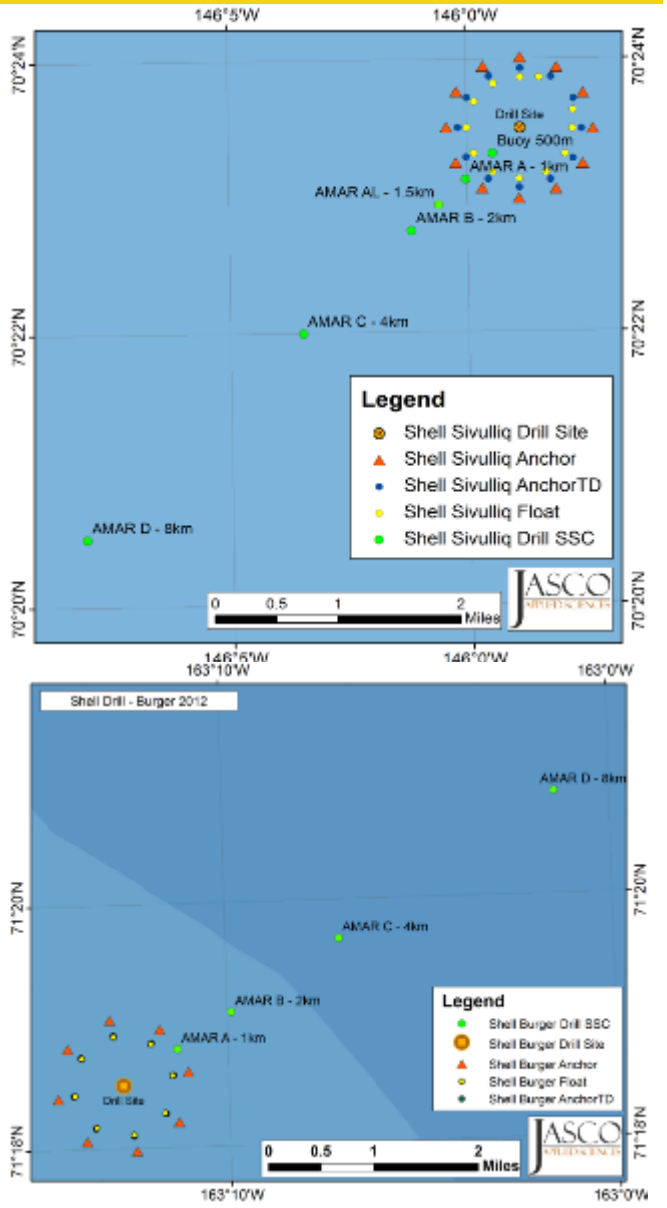
Bowhead distribution – Regional arrays

- Highest call counts in April/May (spring migration) and in Oct/Nov (fall migration). Fewer calls detected in summer months.
- Main fall migration corridor seems to pass north of ~70.5°N



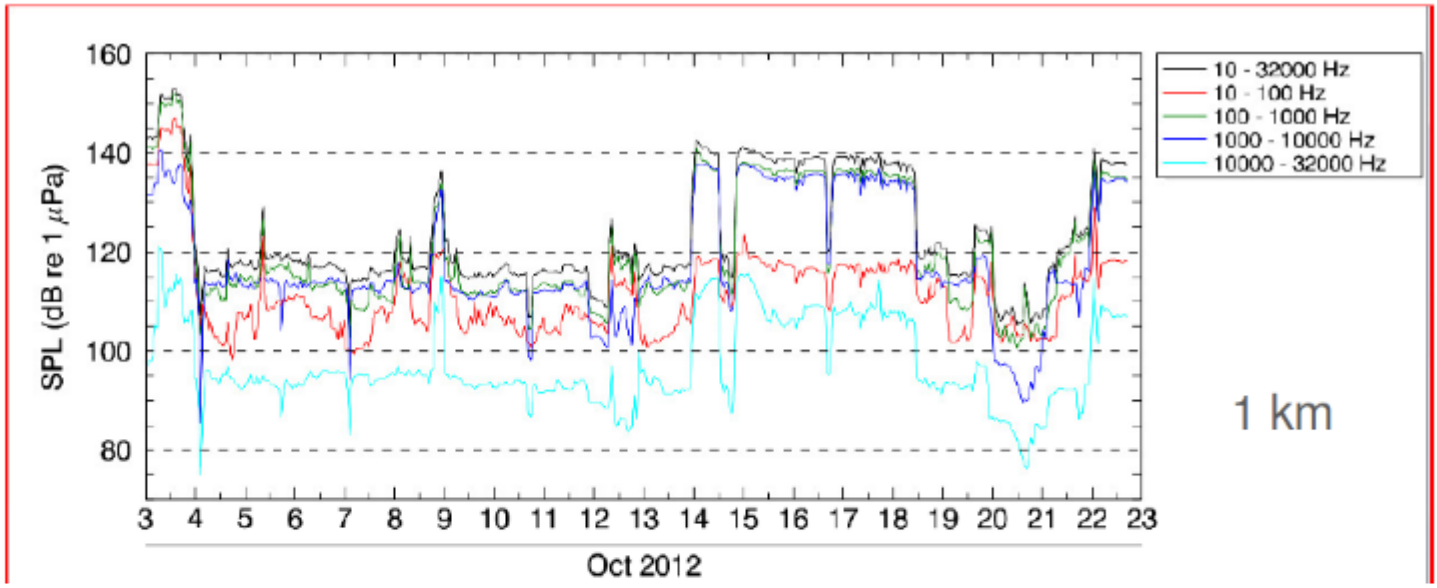
Acoustic monitoring of 2012 drilling program

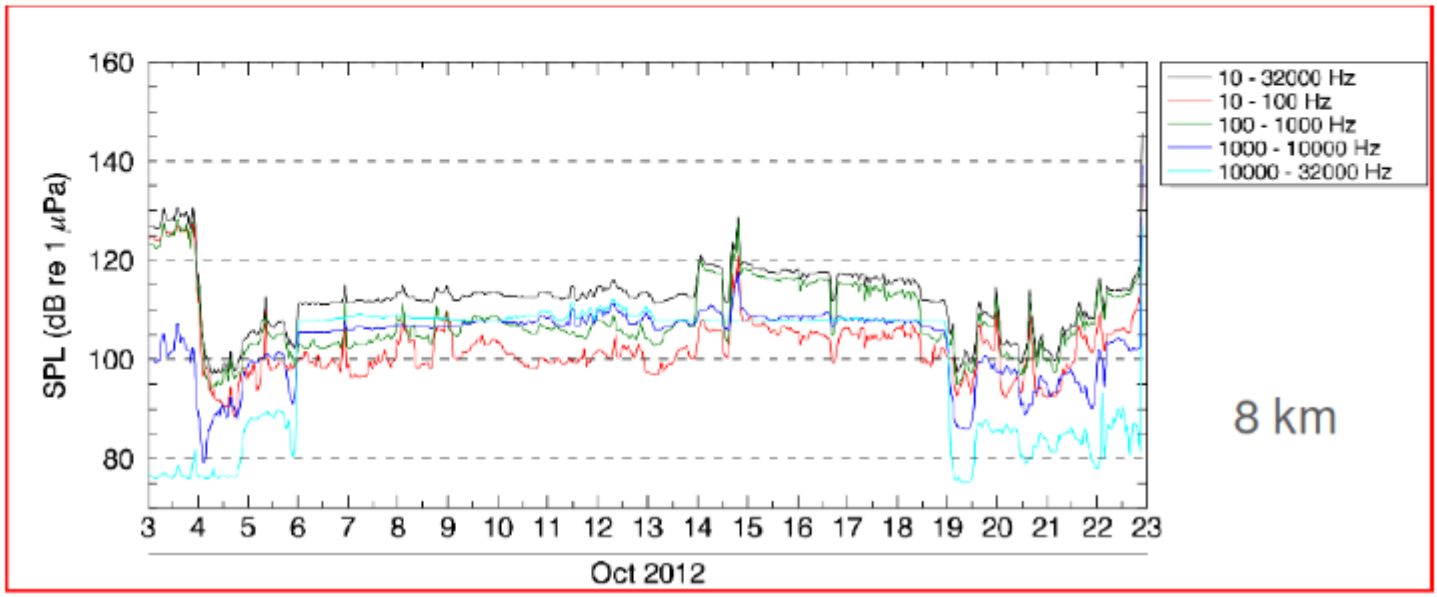
- Monitor and evaluate drilling related sound levels and propagation
- Collect distribution and movement information through call data
- Based upon learnings since 2006



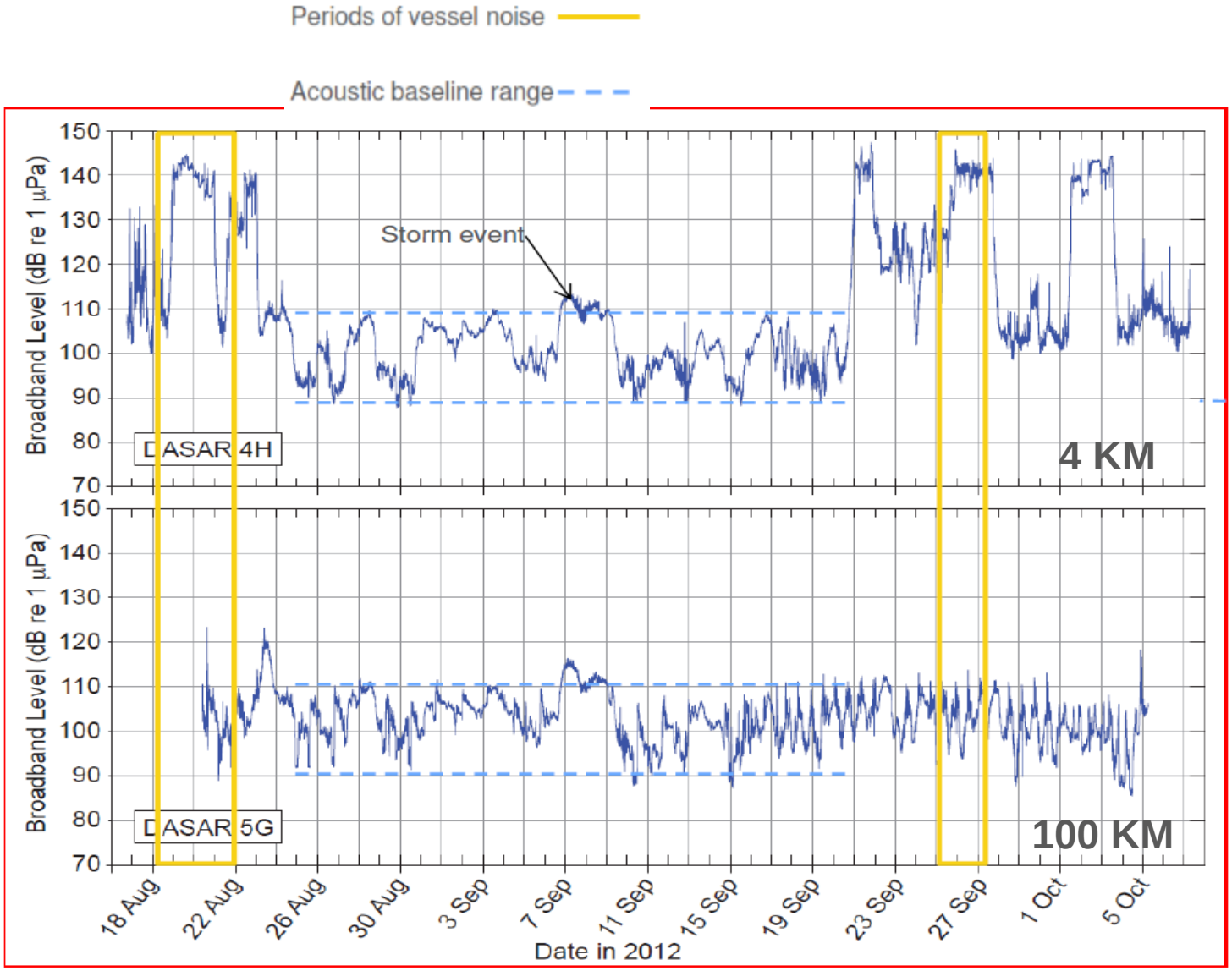
Data from recorders 1 km and 8 km from drillsite

- Drilling mud line cellar is relatively loud
  - Mostly noise from bit on rock
- Drilling itself relatively quiet
  - About 120 dB
  - Drops to 110 dB by 8 km (5 mi)
- Significant drop off of noise in first 5 miles
- Periodic vessel noise drops out quickly



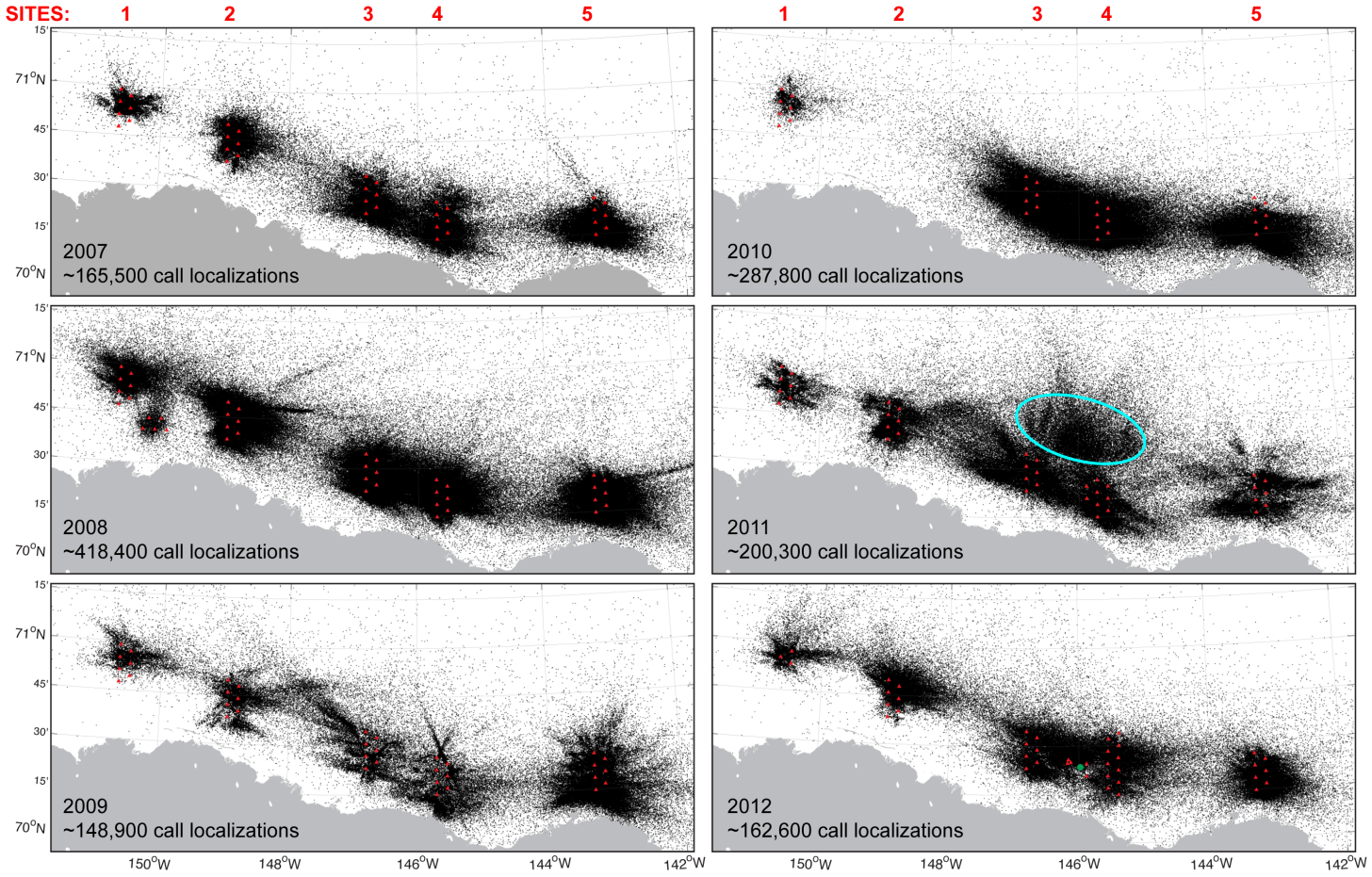


Data from recorders 4 km and 100 km from drillsite



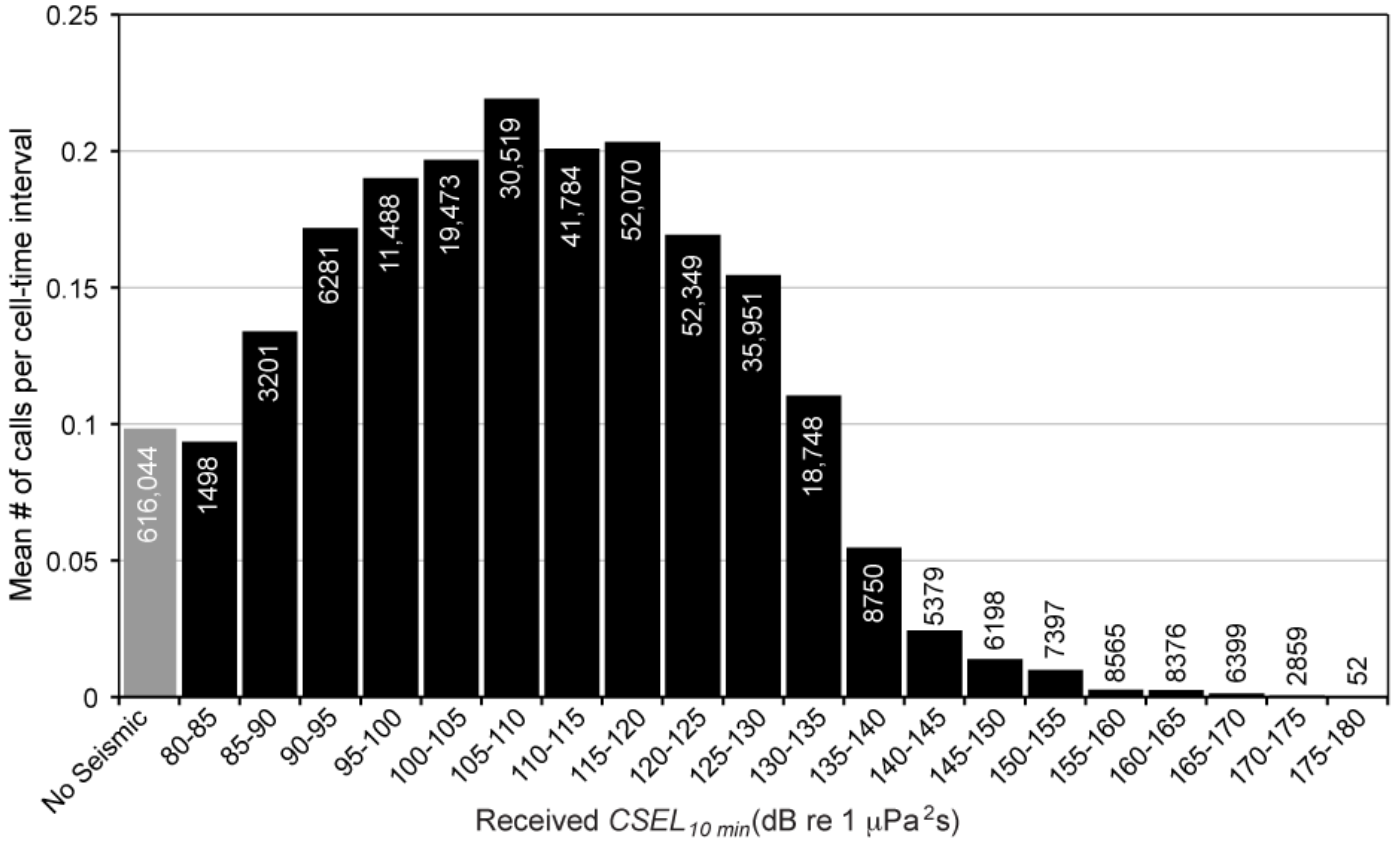
Shell 4MP Results: Bowhead Migration Corridor

- No evidence of migration corridor displacement in the Beaufort Sea.
- Bowhead occur well within the 120 dB re 1 µPa zone. Localized avoidance dependent on whales' activity states; feeding whales more tolerant.



Effects of seismic on calling rates

- Bowhead calling rate increase in presence of low level airgun pulses (<110 dB SEL)
- Bowhead calling rates decrease in presence of louder airgun pulses (>110dB SEL)



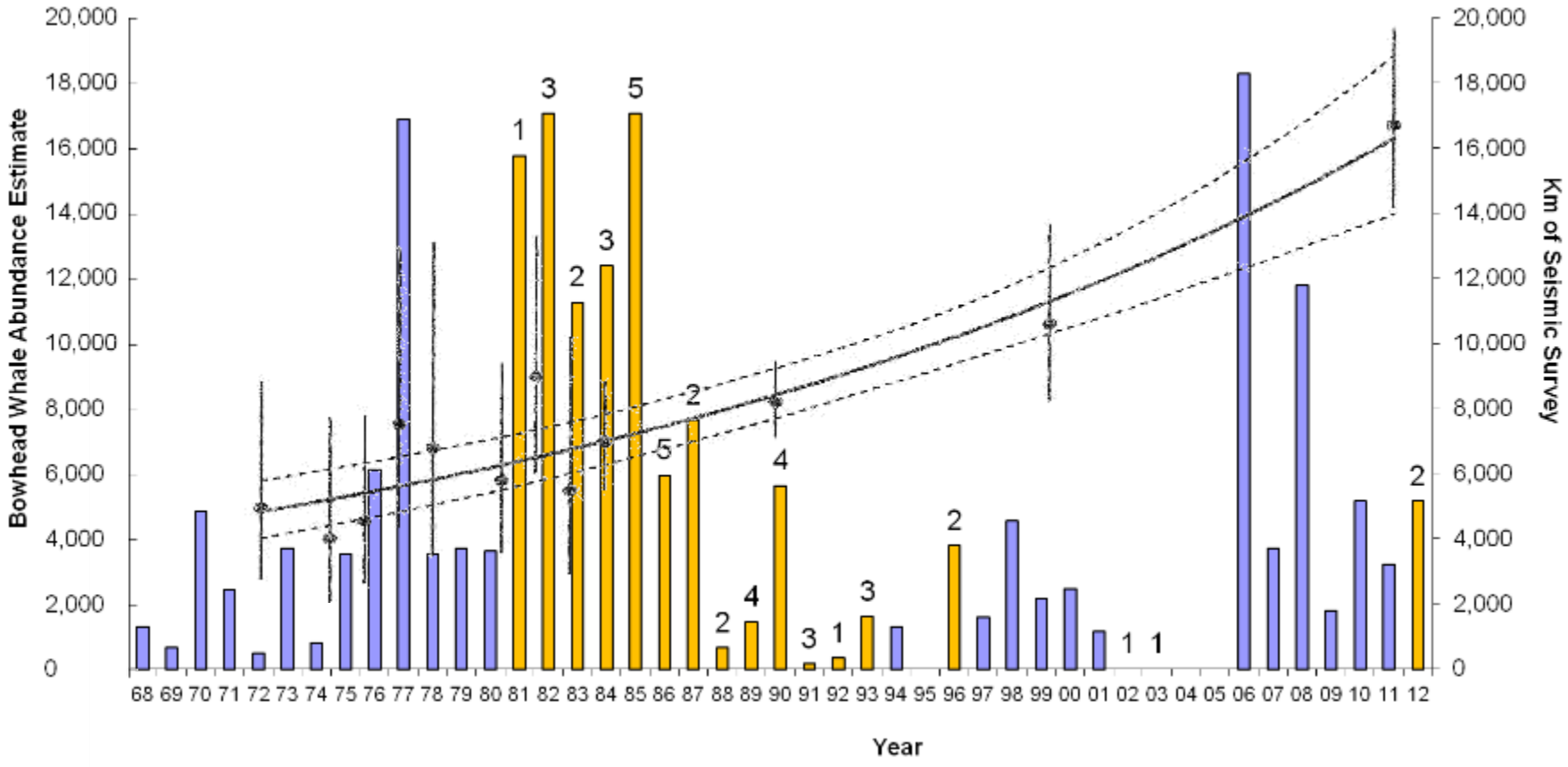
Effects of seismic on dive cycles

- Behavior studies indicate that whales avoid close approach to activities
- Analyses of behavior data indicate that whales spend less time at the surface and dives are longer near seismic
- The result is that aerial surveys that do not account for the change in behavior may underestimate the number of whales and may overestimate deflection

Probability of detecting a bowhead whale during periods with and without seismic survey operations.

Category	Undisturbed	Seismic
Non-calf	0.180	0.155
Mother	0.203	0.152
Summer	0.210	0.202
Fall	0.176	0.107
Traveling	0.152	0.120
Socializing	0.259	0.163
Feed shallow	0.225	0.185
Feed deep	0.164	0.145

OCS Historical Seismic, Wells, and Bowhead Abundance



(Abundance Estimate: Givens et al. 2013. Paper SC/65a/BRG01 presented to the Scientific Committee of the International Whaling Commission, June 2013)

Bowhead monitoring conclusions

- Bowhead whales show behavioral response to industry activities,

  include changes in calling behavior, dive cycle and localized avoidance.

- Responses are context specific.

- Population is growing at healthy rate with no apparent relationship to industry activity.

Conclusions

Overall conclusions

- Exploration activities are a large contributor to the acoustic sound scape, potentially impacting on marine mammal populations. Can be managed with correct mitigation measures.

- Industry is a significant funder of marine mammal research translating into extensive (peer-reviewed) knowledge of populations and impacts.

- Investment in environmental science programs results in fact-based decision making vs. pre-cautionary approach.

- There are numerous arctic science and biodiversity programs. Arctic is a well studied place.

Thank You

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Shell Alaskan Arctic Offshore Exploration Activity

Year	Chukchi	Beaufort
2006	3D Seismic	Shallow Hazards Survey
2007	3D Seismic and Shallow Hazards Survey	3D Seismic and Shallow Hazards Surveys
2008	3D Seismic and Shallow Hazards Surveys	3D Seismic and Shallow Hazards Surveys
2009	Shallow Hazards Survey	-
2010	Shallow Hazards Survey	Shallow Hazards Survey
2011	-	-
2012	Exploration Drilling	Exploration Drilling
2013	Shallow Hazards Survey and Well Maintenance	-
2014	-	-