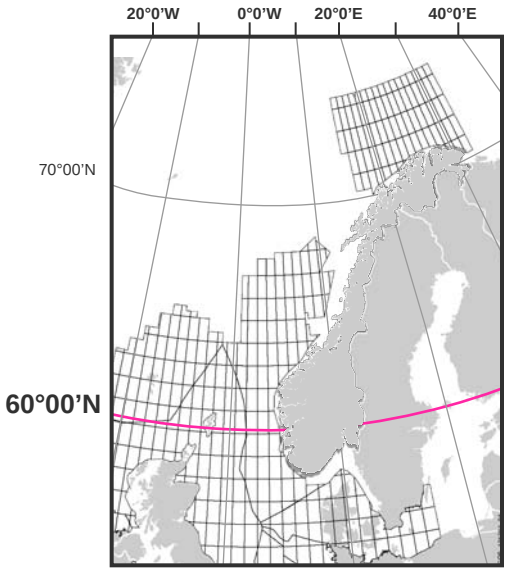
2010 Statoil Seismic Survey

Open Water meeting, 7 March 2011 , Anchorage

Karin Berentsen, Statoil Alaska

Photo: Emily McCabe

Norway – Alaska 60°00’N



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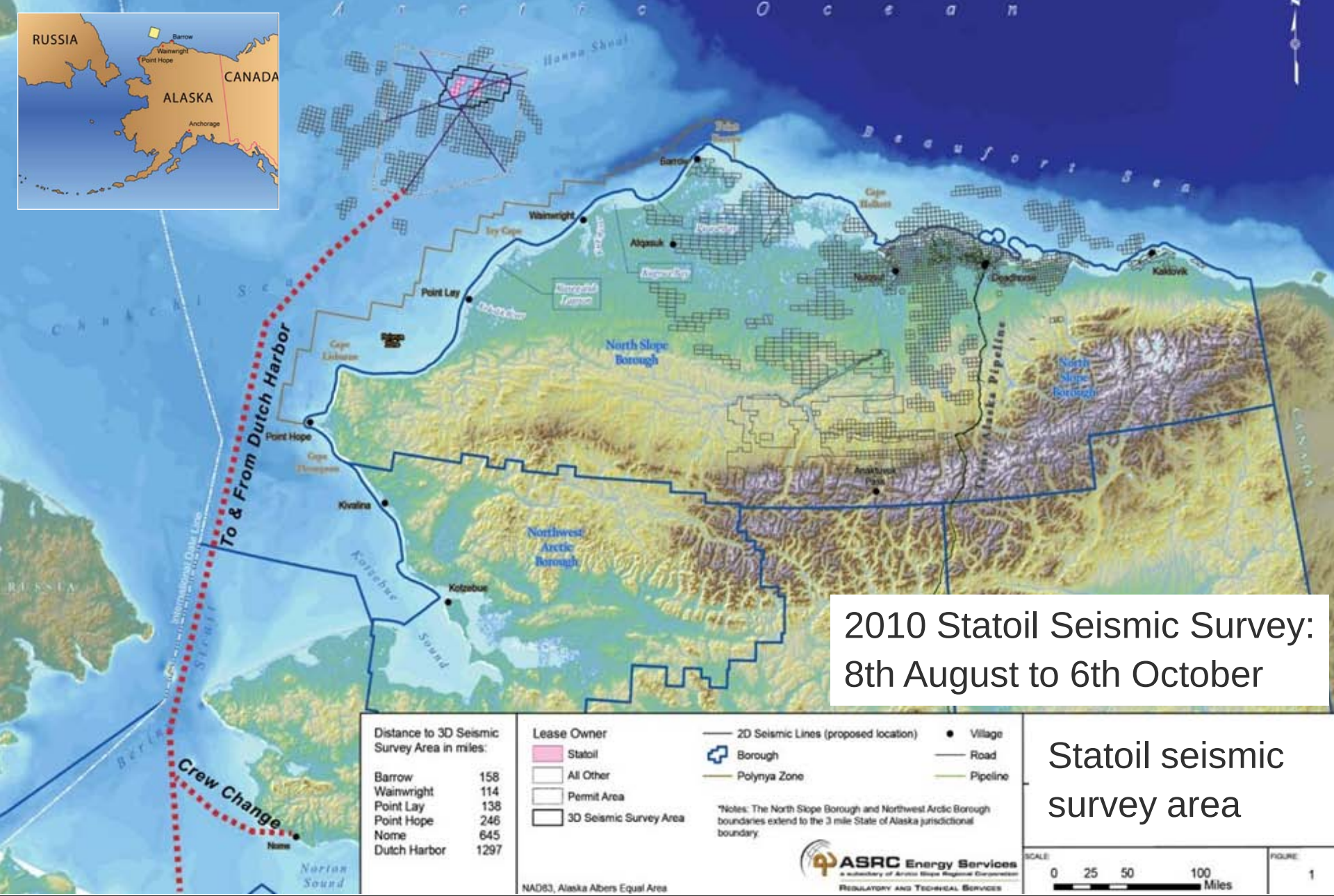
RUSSIA
Barrow
Wainwright
Point Hope
CANADA
ALASKA
Anchorage
Arctic Ocean
Beaufort Sea
Barrow
Wainwright
Point Lay
Atqasuk
Nuiqsut
Deadhorse
Kaktovik
North Slope Borough
Trans-Alaska Pipeline
Point Hope
Kivalina
Northwest Arctic Borough
Kotzebue
To & From Dutch Harbor
Crew Change
Nome
Norton Sound
2010 Statoil Seismic Survey:
8th August to 6th October
Distance to 3D Seismic Survey Area in miles:
Barrow 158
Wainwright 114
Point Lay 138
Point Hope 246
Nome 645
Dutch Harbor 1297
Lease Owner
Statoil
All Other
Permit Area
3D Seismic Survey Area
2D Seismic Lines (proposed location)
Borough
Polynya Zone
Village
Road
Pipeline
*Notes: The North Slope Borough and Northwest Arctic Borough boundaries extend to the 3 mile State of Alaska jurisdictional boundary.
ASRC Energy Services
Regulatory and Technical Services
NAD83, Alaska Albers Equal Area
SCALE:
0 25 50 100 Miles
FIGURE:
1
Statoil seismic survey area

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Stakeholder Engagement

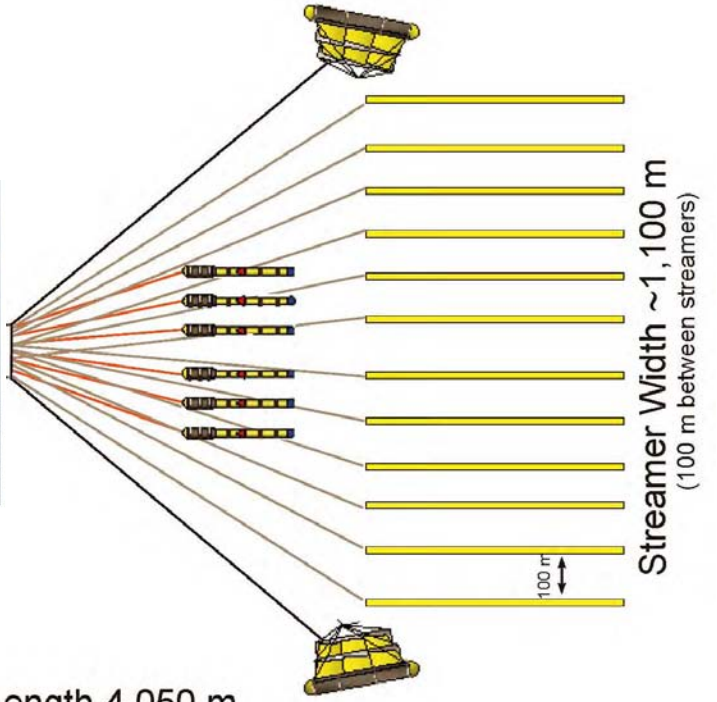
- *October & November, 2009* - Community and Leadership Meetings Barrow, Wainwright, Pt. Lay, Pt. Hope, and Kotzebue
- *October & December, 2009* - NSB Planning Commission Meeting, NSB Wildlife Department meeting
- *January, 2010* - Plan of Cooperation Meetings in Barrow, Wainwright, Pt. Lay, Pt. Hope
- *February, 2010* – AEWC mini convention
- *April, 2010* – Open Water Meeting and meetings with marine mammal co-management groups
- *December* – NSB Planning Commission and Wildlife Department, and AEWC

2009 – 2011 ongoing meetings with:

- Mayor Itta and the Mayor's office, and other stakeholders
- Agencies: NMFS, MMS/BOEMRE, U.S. Fish and Wildlife Service, and EPA

The Seismic survey

M/V GEO CELTIC



Environmental support vessels

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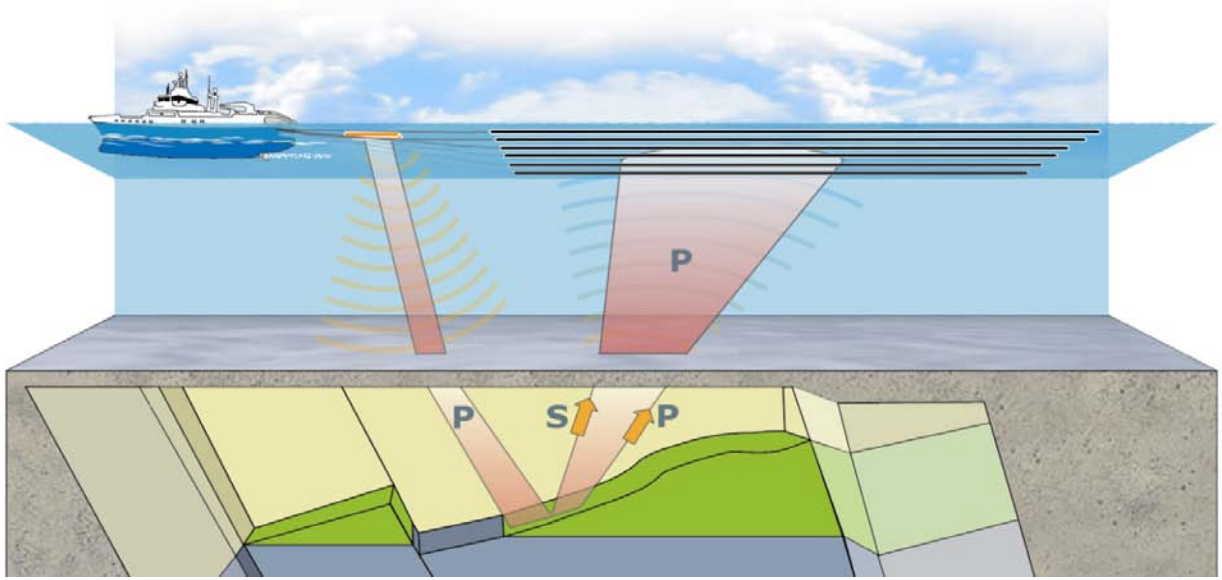
Purpose of the seismic survey

- Seismic reflection data enables us to image the subsea geology
- Existing seismic data were old, sparse and of inadequate quality
- Modern data are required to understand the complex geology
- The acquired data is being used to make decisions on further exploration



Statoil's Survey Vessels

M/V Geo Celtic

Geo Celtic

- Seismic Survey Vessel
- 5 Marine Mammal Observers (MMOs) including 2 Inupiat Observers

Tanux 1

- Primary Support Vessel for the Geo Celtic
- Typically forward of & within one mile of the *Geo Celtic*
- Small boat operations - support
- Safety Zones –assist monitoring
- 4 MMOs per crew

M/V Norseman 1

- Primary scouting vessel
- Most of the time 'zig-zag' scouting to monitor the safety radius for whales/walrus
- Support vessel with 24-h watches (reduced as darkness increased)
- 4 MMOs per crew

Survey – General:

- 2 Inupiat MMOs per crew on each vessel - 1 crew change
- 24 - hours watches - 4 hour observation shifts
- MMOs onboard during survey and transit to and from the prospect area

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2010 Statoil Seismic Survey - Preparations

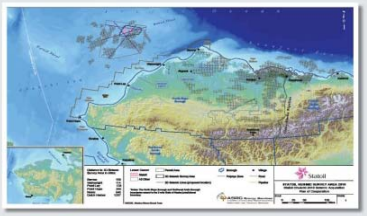
Environmental Evaluation Document :

- Survey area is mainly 100 miles offshore
- Main conclusion: Not expected to conflict or interfere with the community's Subsistence harvest or the availability of whales, seals, polar bear, or Pacific walrus
- **Cumulative Effects Analysis included**
- **Permits applications** with preliminary Incidental Harassment Take Estimates

Permits:

- **IHA**: The Incidental Harassment Authorization of Marine Mammals (Whales, seals); National Marine Fisheries Service (NMFS)
- **G&G permit**; MMS (now BOEMRE)
- **LOA**: Letter of Authorization for polar bears and Pacific walrus; US Fish and Wildlife Service (USFWS)

Measures to reduce impact



Survey Area

The survey area is located far offshore and will not interfere with subsistence activities.

Statoil will prepare a polar bear interaction plan that addresses food and waste management, personnel training, and safety and communication regarding polar bears.

Ice Management

Ice conditions (radar, satellite imagery) in the project area will be monitored during the seismic survey in order to minimize survey time and activity close to the ice edge.

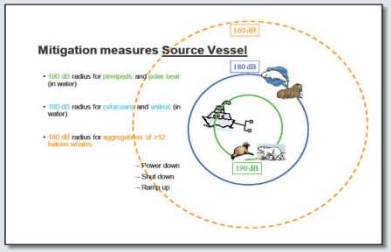
Communication & Call Center

Statoil will, together with Shell and ConocoPhillips, operate a Search and Rescue (SAR) helicopter and shore communication and call centers to improve the area's emergency systems.

Marine Mammal Monitoring

Vessels operated by Statoil will take every precaution to avoid harassment of marine mammals, including whales, seals, walruses or polar bears in the water when a vessel is operated near these animals.

- Marine Mammal Observers (MMOs) will be employed on all 3 vessels.
- An additional (third) vessel has been contracted primarily to assist with marine mammal observation.
- Scientific and Inupiat MMOs
  - 5 on source vessel until mid-August, then possibly 3 or 4
  - 2 or 3 on support vessels



Mitigation Procedures

- Establishment of safety radii through sound source verification measurements of airgun array.
- In the established exclusion or safety zone, power down, shut down, and ramp-up procedures will be in place.

Environmental Baseline Monitoring

Statoil is participating in environmental baseline monitoring with Shell and ConocoPhillips. This includes:

- Seabed and water sampling and analysis over old drill sites
- Fixed seabed acoustic recorders to monitor marine mammal activity in the Chukchi Sea.
- Ecological studies of Chukchi fish populations.

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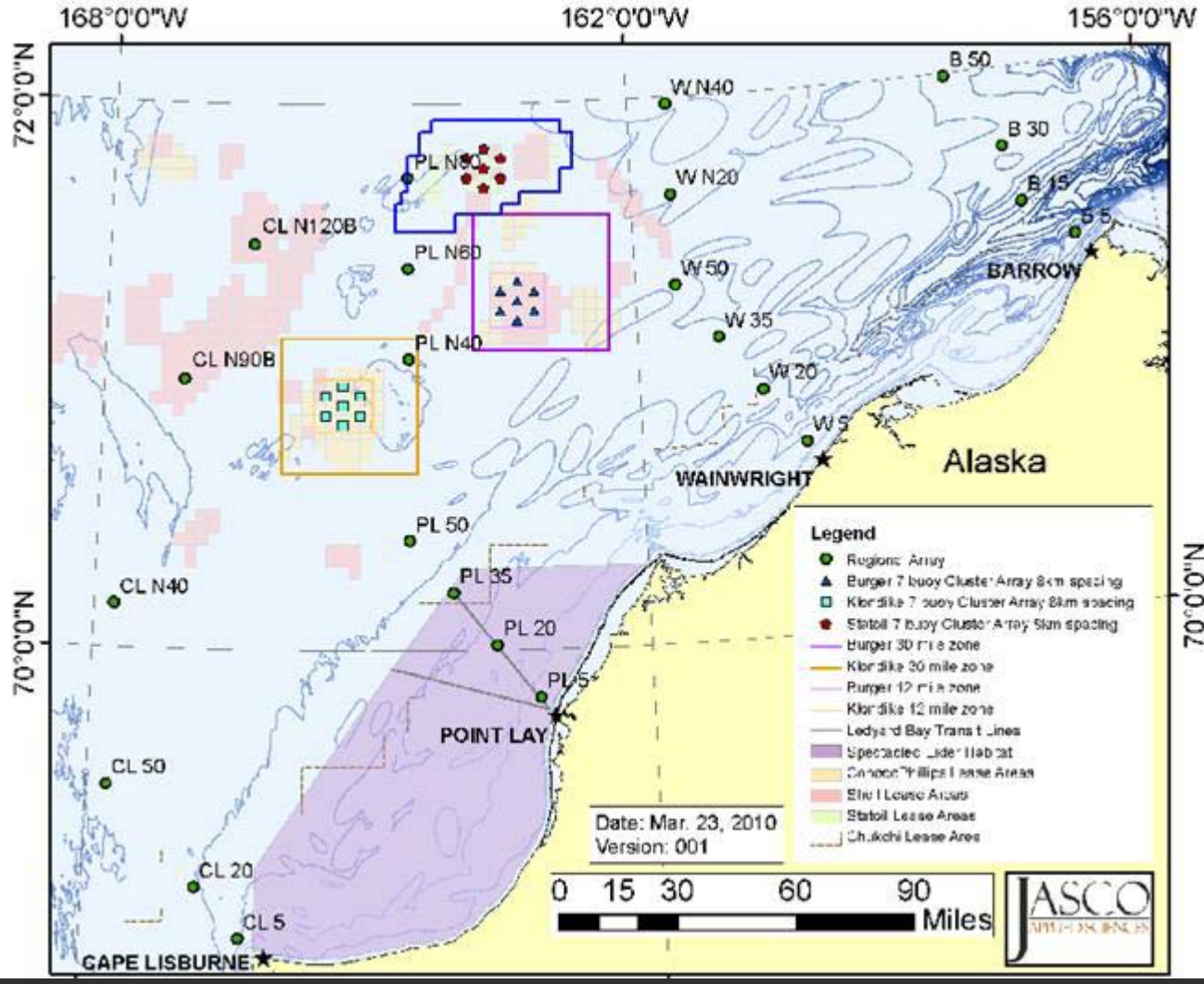
2010 Science Survey
Operated by Olgoonik-Fairweather

- Sponsored by
  Shell, CPAI and Statoil



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2010 Seismic Survey

- Survey Start 8th August 2010
- Demobilization 6th October 2010

- **What did we see?**

Photo: Bill Tracey Sr. , Point Lay

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Next –
90 Day Report

Karin Berentsen
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Tusen takk!

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Photo: Emily McCabe

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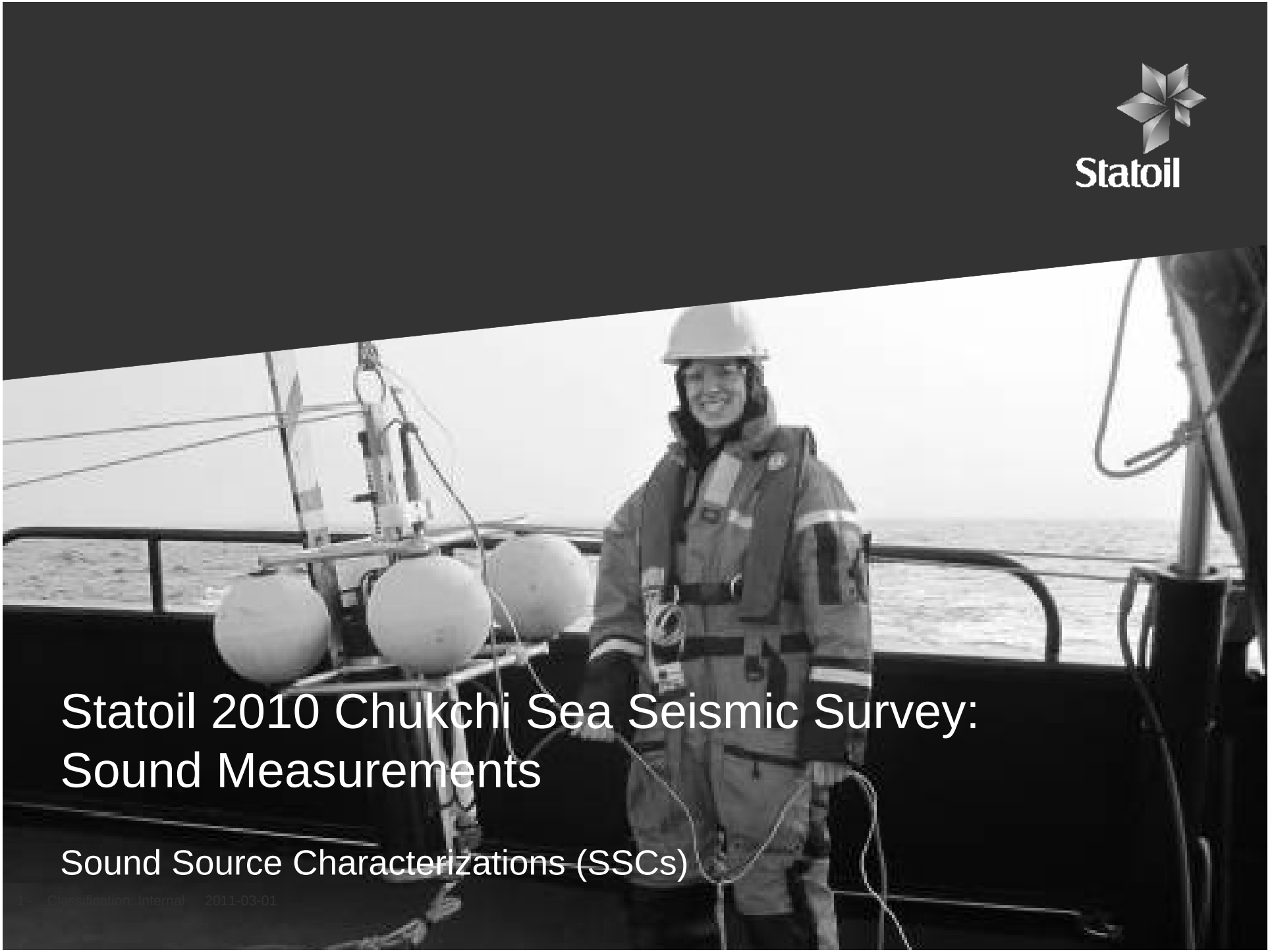
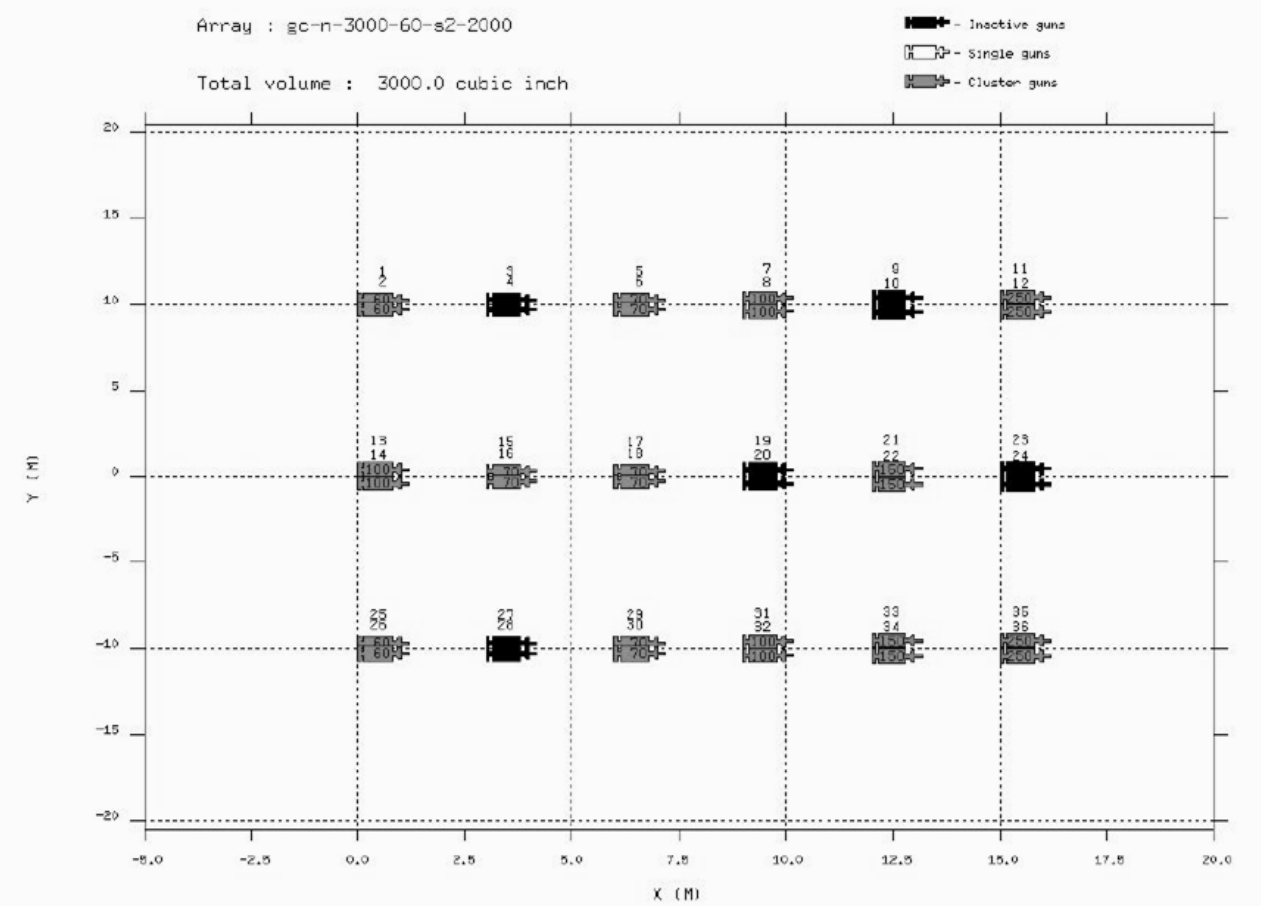


Statoil 2010 Chukchi Sea Seismic Survey: Sound Measurements

Sound Source Characterizations (SSCs)

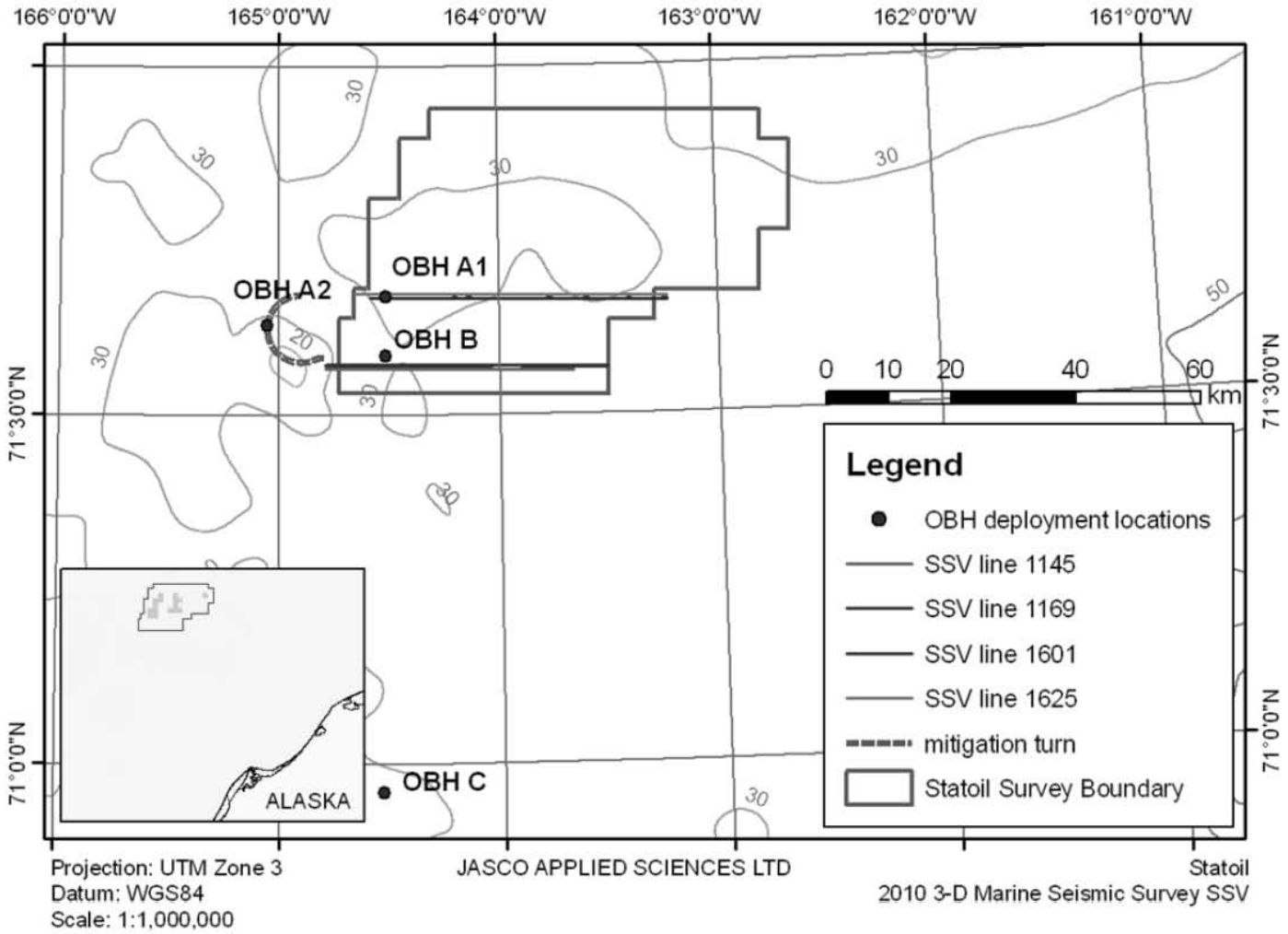
Sound Source



Full Array =
26-airguns, 3000 in^3

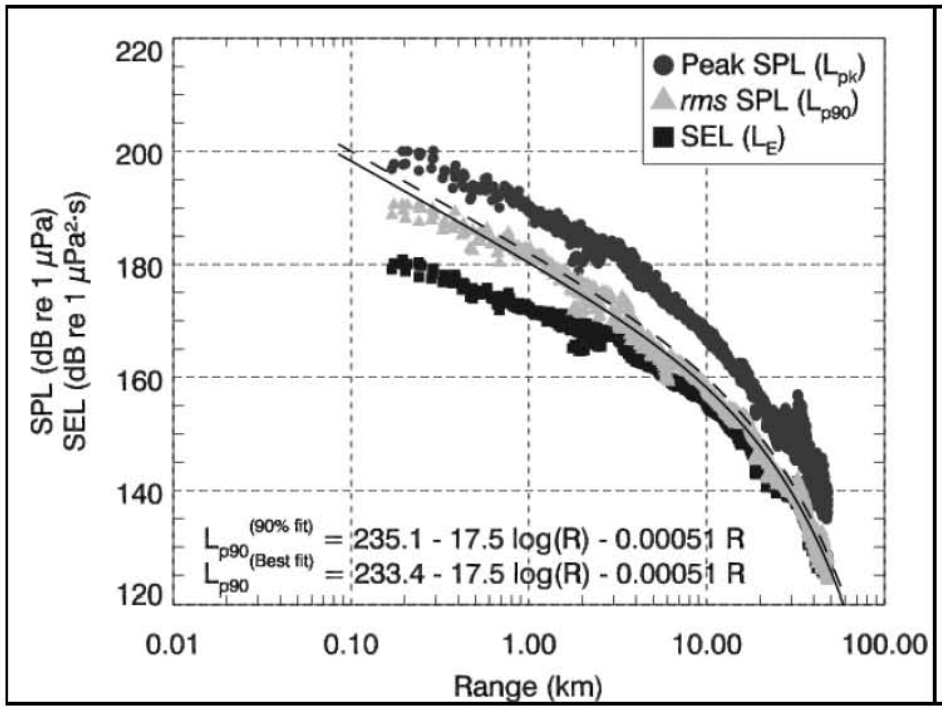
Mitigation Gun =
Single 60-in^3 airgun

SSC Measurement Locations

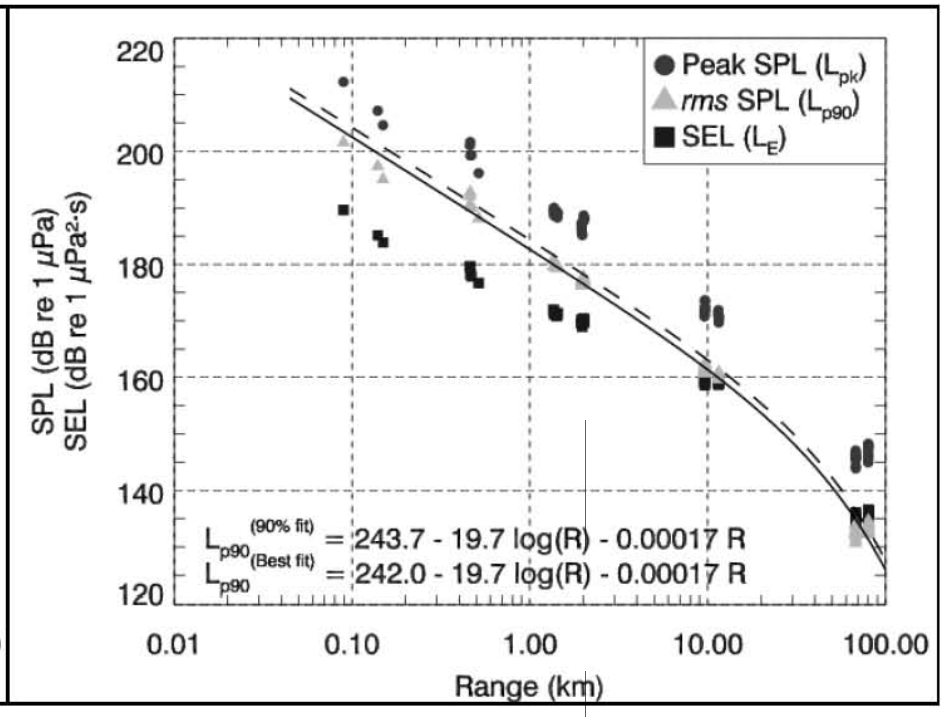


Measurement Results

Endfire



Broadside



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Safety Radii (in meters)

Full Airgun Array

Received Level (dB re 1 µPa rms)	Pre-Season Modeling Results	Field Season Measured Radii	Final Measured Radii
≥190	700	430	520
≥180	2,500	1,600	1,600
≥160	13,000	16,000	13,000
≥120	70,000-120,000	130,000*	130,000*

Mitigation Airgun

Received Level (dB re 1 µPa rms)	Pre-Season Modeling Results	Field Season Measured Radii	Final Measured Radii
≥190	75	13	13
≥180	220	68	68
≥160	1,800	1,500	1,500
≥120	50,000	26,000*	26,000*

2010 Chukchi Sea Marine Mammal Monitoring and Mitigation Program

- Provide marine mammal observers (MMOs) to visually monitor the occurrence and behavior of marine mammals near seismic survey operations.
- Implement appropriate mitigation measures.
- Collect data on current distribution and relative abundance of marine mammals in the eastern Chukchi Sea during the open-water season.
- Use marine mammal observations to estimate exposures of animals to seismic sounds.

Survey Vessels

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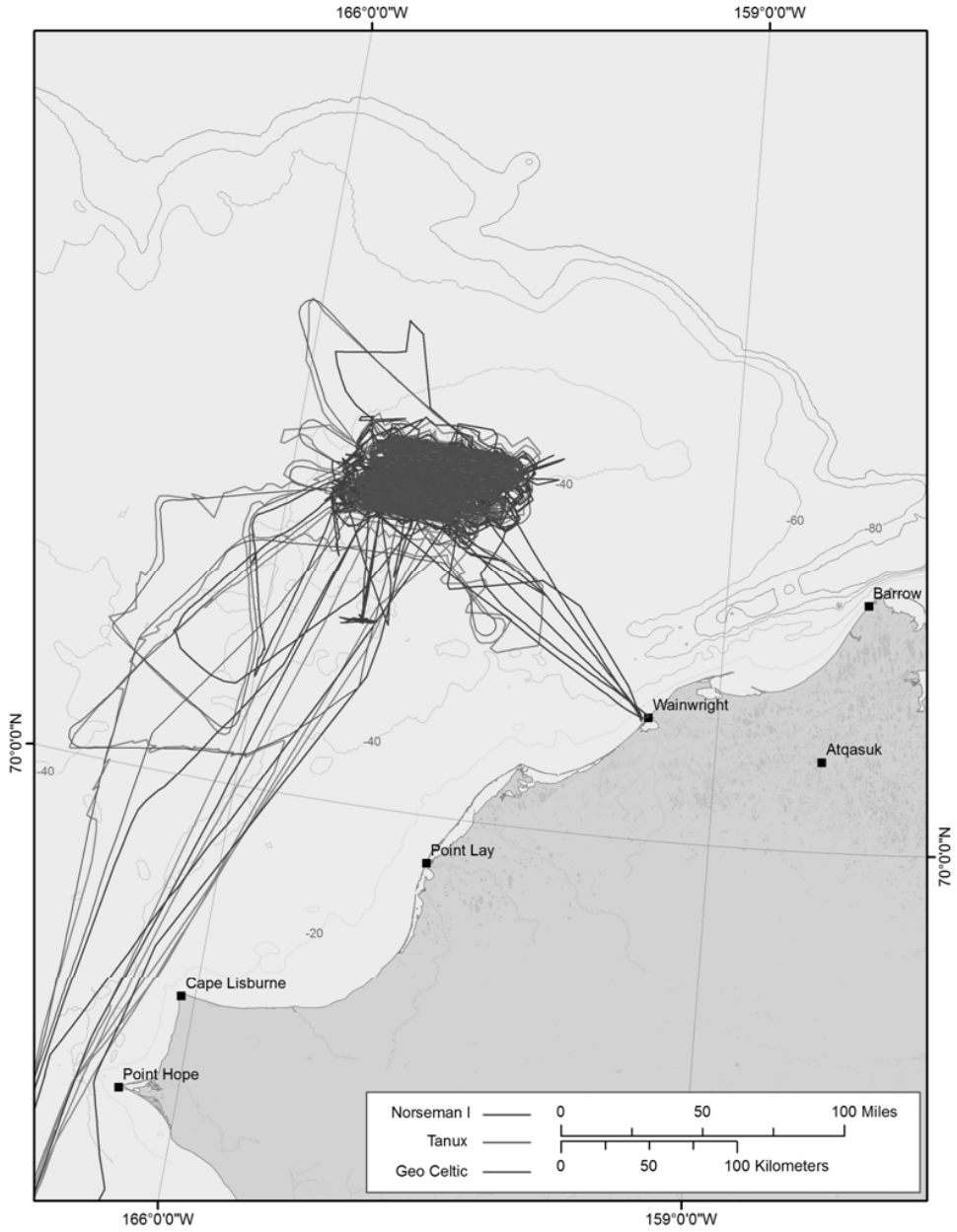
Vessel Tracklines and Watch Effort

- Seismic Activity
  - 20 Aug. through 1 Oct.
  - 8,069 km of seismic
    - 5,387 km of full array
    - 2,681 km of mitigation airgun
- MMOs on watch for 28,080 km
  - 3,187 km during darkness



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Marine Mammal Monitoring

Permit Watch Requirements:

- At least 1 MMO on duty on the Source vessel during all daylight seismic operations and during nighttime power ups
- 2 MMOs on duty 30 min before / during all full ramp ups, and as much as possible during other survey operations

2010 Actual Watch Statistics:

- Requirement met, plus at least 1 MMO remained on watch during **99%** of nighttime seismic operations and for **99%** of nighttime periods
- Requirement met, plus 2 MMOs on watch for **22%** of total nighttime and **62%** of total daytime periods

Cetacean Sightings (number of individuals)

Species	*Geo Celtic*	Monitoring Vessels	Total
Bowhead Whale	0	5 (6)	**5 (6)**
Gray Whale	1 (1)	4 (9)	**5 (10)**
Minke Whale	4 (5)	0	**4 (5)**
Unidentified Mysticete Whale	7 (10)	9 (10)	**16 (20)**
Unidentified Toothed Whale	1 (3)	0	**1 (3)**
Unidentified Whale	0	1 (1)	**1 (1)**
Total Cetaceans	***13 (19)***	***19 (26)***	**32 (45)**

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Estimated numbers of cetaceans *potentially* exposed to sounds ≥ 160 dB re 1µPa (rms) in 10-dB categories based on seismic and non-seismic densities:

Exposure level in dB re 1µPa (rms)	Number of individuals exposed		Exposures per Individual
	based on non-seismic densities	based on seismic densities	
≥160	28	18	21
≥170	16	10	11
≥180	10	7	5
≥190	8	5	2

Seal Sightings (number of individuals)

Species	*Geo Celtic*	Monitoring Vessels	Total
Bearded Seal	53 (56)	69 (72)	**122 (128)**
Ribbon Seal	0	1 (1)	**1 (1)**
Ringed Seal	17 (18)	16 (17)	**33 (35)**
Spotted Seal	1 (1)	4 (4)	**5 (5)**
Unidentified Pinniped	19 (25)	26 (31)	**45 (56)**
Unidentified Seal	57 (63)	97 (98)	**154 (161)**
Total Seals	**147 (163)**	**213 (223)**	**360 (386)**

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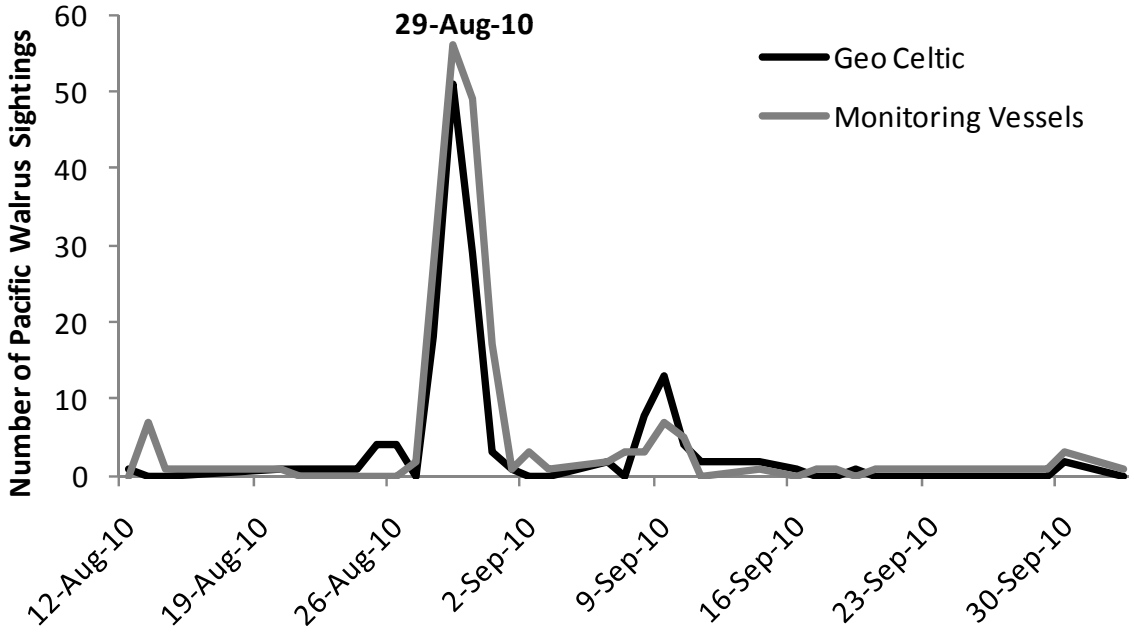
Estimated numbers of seals *potentially* exposed to sounds ≥ 160 dB re 1µPa (rms) in 10-dB categories based on seismic and non-seismic densities:

Exposure level in dB re 1µPa (rms)	Number of individuals exposed		Exposures per Individual
	based on non-seismic densities	based on seismic densities	
≥160	1206	2180	21
≥170	686	1240	11
≥180	451	816	5
≥190	351	652	2

Pacific Walrus Sightings (number of individuals)

Species	*Geo Celtic*	Monitoring Vessels	Total
Pacific Walruses	150 (352)	196 (690)	**346 (1042)**



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Estimated numbers of Pacific walrus *potentially* exposed to sounds ≥ 160 dB re 1µPa (rms) in 10-dB categories based on seismic and non-seismic densities:

Exposure level in dB re 1µPa (rms)	Number of individuals exposed		Exposures per Individual
	based on non-seismic densities	based on seismic densities	
≥160	96	793	21
≥170	339	451	11
≥180	223	297	5
≥190	178	237	2

Numbers of marine mammals observed within threshold safety radii in 2010:

Number of Individuals and Exposure Level in dB re 1µPa (rms)		
Cetaceans ≥180	**Seals ≥190**	**Pacific Walrus ≥180**
0	10 (10)	40 (21)

- **Full Airgun Array**
  - **≥ 180 dB distance = 1,600 m**
  - **≥ 190 dB distance = 520 m**
- **Mitigation Airgun**
  - **≥ 180 dB distance = 68 m**
  - **≥ 190 dB distance = 13 m**

Mitigation Measures Implemented:
Power Downs

Number of Power Downs		
Cetaceans	**Seals**	**Pacific Walruses**
1	9	29

- **Full Airgun Array**
  - **≥ 180 dB distance = 1,600 m**
  - **≥ 190 dB distance = 520 m**
- **Mitigation Airgun**
  - **≥ 180 dB distance = 68 m**
  - **≥ 190 dB distance = 13 m**

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Mitigation Measures Implemented:
Shut Downs

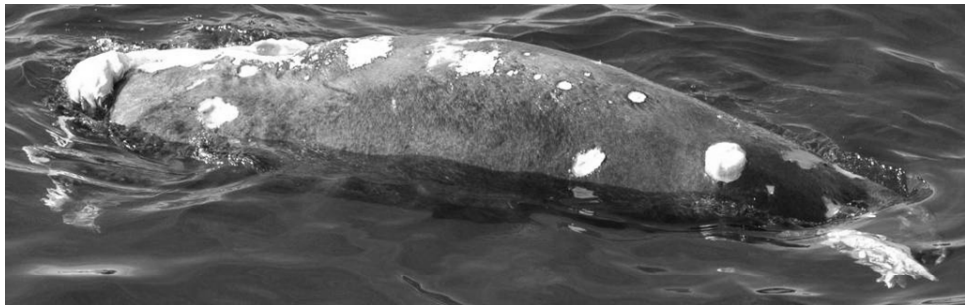
Sighting ID	Species	No. Individuals	Date	Initial Behavior	Reaction to Vessel	Distance to Airguns at First Detection (m)	CPA to Airguns (m)
GEO2010999	Pacific walrus	1	21-Aug	DE	--	--	--
GEO201080	Pacific walrus	3	25-Aug	SW	LO	2567	230
GEO2010101	Pacific walrus	1	28-Aug	SW	NO	739	739

- **Full Airgun Array**
  - **≥ 180 dB distance = 1,600 m**
  - **≥ 190 dB distance = 520 m**
- **Mitigation Airgun**
  - **≥ 180 dB distance = 68 m**
  - **≥ 190 dB distance = 13 m**

Marine Mammal Carcasses

9 Carcasses Were Observed:

- 1 unidentified mysticete whale
- 2 unidentified whales
- 3 Pacific walruses
- 1 unidentified pinniped
- 1 unidentified seal
- 1 unidentified marine mammal



Marine Mammal Carcasses

Date	Species	Vessel Activity	Comments
11-Aug	Unidentified Mysticete Whale	Pre-Seismic Survey **	Advanced decomposition ventral side at surface
14-Aug	Pacific Walrus	Pre-Seismic Survey	Moderate decomposition, missing head, birds present
14-Aug	Unidentified Seal	Pre-Seismic Survey	Small carcass, decomposed and discolored
15-Aug	Unidentified Pinniped	Pre-Seismic Survey	Advanced decomposition, missing head, birds present
15-Aug	Unidentified Whale	Pre-Seismic Survey	Small whale 3-5 m in length, advanced decomposition, throat pleats visible
17-Aug	Pacific Walrus	Pre-Seismic Survey	Floating on back, pink/peach color to exposed skin
21-Aug	Pacific Walrus	Mitigation Airgun Firing	Airgun shut down, USFWS contacted, carcass older than 72 hr, seismic began 16 hr previous to sighting
6-Sep	Unidentified Whale	To Nome for Crew Change **	Small whale, very decomposed, noticeable odor
17-Sep	Unidentified Marine Mammal	To Nome for Crew Change **	Highly decomposed, mostly blubber, bubbly texture

** Observed Outside of Survey Area

Thank you

Statoil 2010 Chukchi Sea Seismic Survey: Marine Mammal Monitoring

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2010 Statoil Seismic Survey

Infrared (IR) camera for marine mammal observations in the Chukchi Sea

Jürgen Weissenberger, PhD, Statoil

Karin Berentsen, Alaska Regulatory Compliance Manager, Statoil

Classification: Internal 2011-03-07

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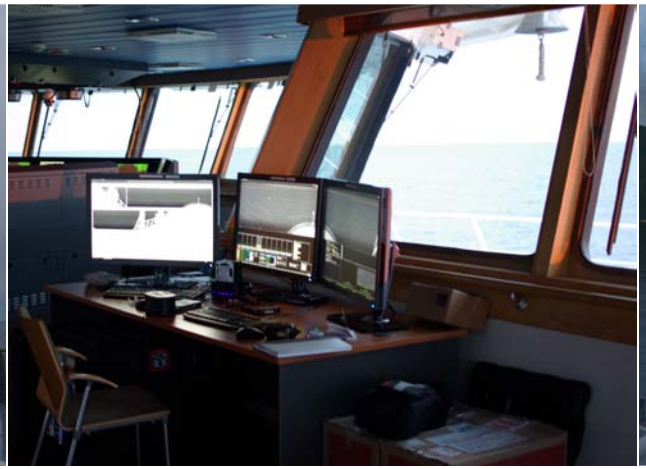
The Infrared (IR) Camera



Camera that is sensitive to temperature differences

Continuous in operation
12 August – 4 October

Manned 3-4 hours per night

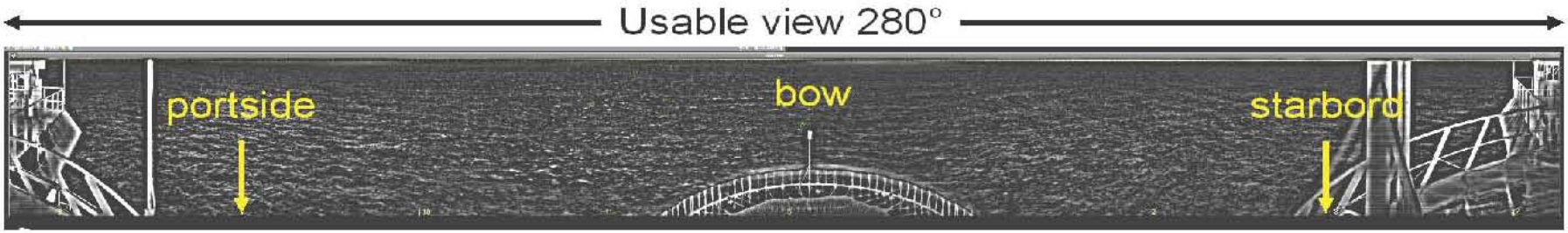
High technology IR camera

IR camera with 360° view; test had 280 °

Mounted 24.5m above sea level

No Equipment in the water

5 pictures per second (can see a whale blow]



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Classification: Internal 2011-03-07

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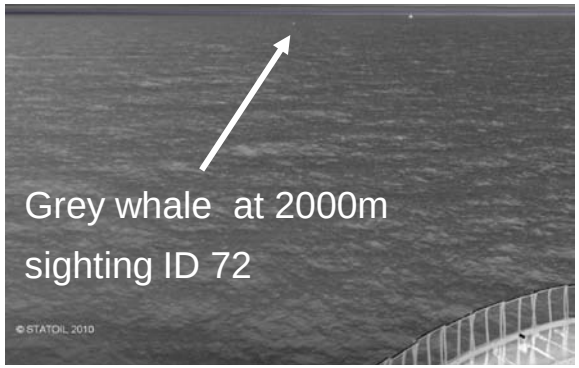
Observations made:

Whales:

Blows of big whales visible up to 2000m (grey whale)

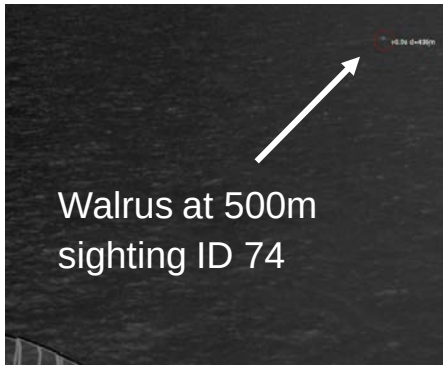
Blows of smaller whales (dall's porpoise) up to 500m



Walrus:

New knowledge:
Walrus has a IR signature when swimming on surface; visible up to 1500m

Weather: Hampered by fog, bad visibility and sea state as for visual observations



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IR - Camera

Preliminary observations

- Early Phase Research initiative
- IR camera developed for other tasks
- Not fine tuned for marine mammals
- Correlation to MMO protocol ongoing
- Final results to be published

- Wide ”horizontal” coverage and auto detect
- Day and night observations
- Limited resolution in long distance
- Provides opportunity to analyse Marine Mammal movements

IR - Camera

Conclusions

- Early Phase Research Initiative
- Weather dependant:
  Observations hampered by bad weather (fog, bad visibility and sea state)
- Manual adjustments needed
- Unstable software

- ***Main Conclusion:***

  IR camera is not ready for inclusion in any mitigation requirements

Thank you

IR camera for marine mammal observation

Jürgen Weissenberger

Karin Berentsen,
Statoil Alaska
kbe@statoil.com

www.statoil.com

Acknowledgements:

Fugro Geo Team for support on board Geo Celtic

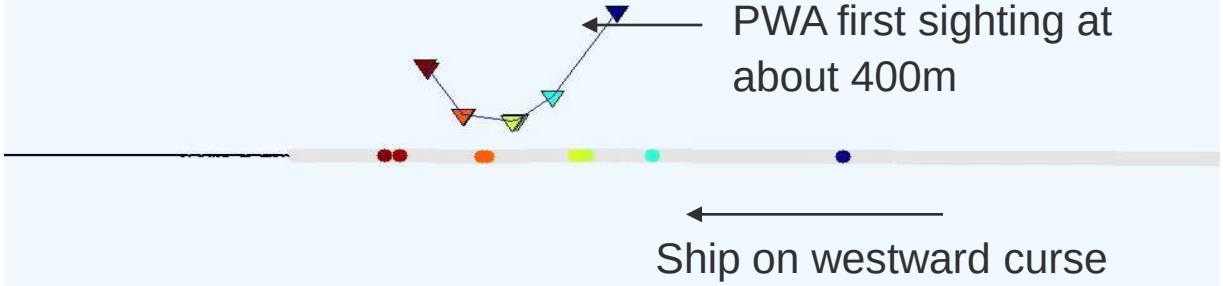
LGL and all **MMO's** for providing observational data and for active participation in the project

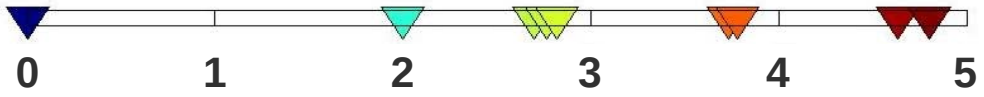
Alfred Wegener Institute for Polar and Marine Research for software and software support

RDE Defence Industry for IR camera and trouble shooting

164° 34'W 164° 33'W 164° 32'W

MMO observation PWA 94 (Pacific walrus)
Wind force 2
Visibility 10
Activity: SH (mitigation gun running)





Time since first detection (min)

Round dots:
Course plot for ship movement;

Triangles:
Animal sighting (PWA track nr)

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Passive Acoustic Monitoring in the Chukchi Sea, Sept – Oct 2010

Bruce Martin, Eric Lumsden, Julien Delarue, Fred Campaigne
JASCO Applied Sciences.
Jon Kåre Hovde, Statoil
Darren Ireland, LGL

Project Objectives

Investigate the ability of a directional towed array to detect & localize *arctic* marine mammals using PAM.

Answer questions:

- How does noise impact ability to detect mammals by PAM?

- What factors are driving the noise? Ship self noise? Towed array flow noise? Environmental Noise?

- Under what conditions does PAM provide additional capability compared to MMOs?

- What additional technological developments are required to deliver effective arctic PAM?

The Arctic PAM Challenge

Low Frequency (<1 kHz) calls from bowhead whales, walrus, ice seals.

Bowheads migrate through the Chukchi in fall; Don't expect high numbers until late september

Walrus migrate out of area in fall

Bearded seals year round residents

Beluga occasional in the area in fall, moving out to Bering sea for the winter.

Low frequencies overlap with seismic, shipping and ambient noise complicating detection and localization.

Methods – Towed Array

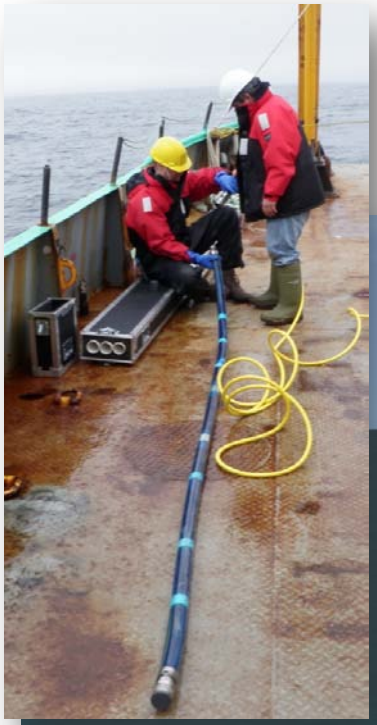
Directional towed array technology designed to provide bearings from a single call.

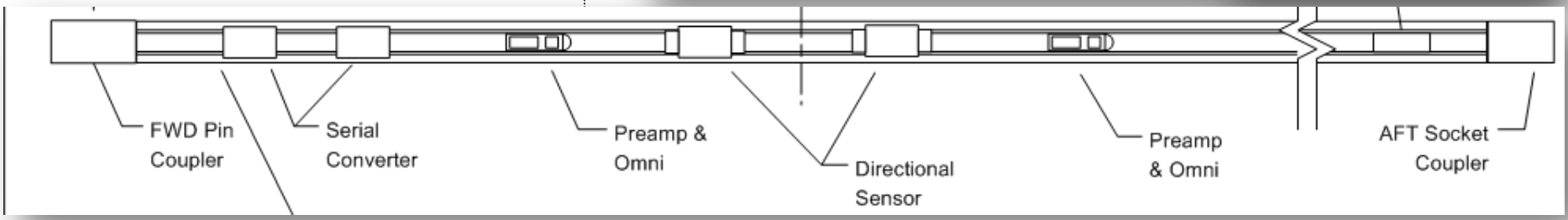
Components:

- 400 m tow cable
- Forward Acoustic Module
- 400m Neutrally Buoyant tow cable
- Aft Acoustic Module
- 16 m rope drogue

Software: PAMGUARD, JASCO's SpectrogramPlotter

Tow vessel Norseman I





Tow Tracks and Fixed Array

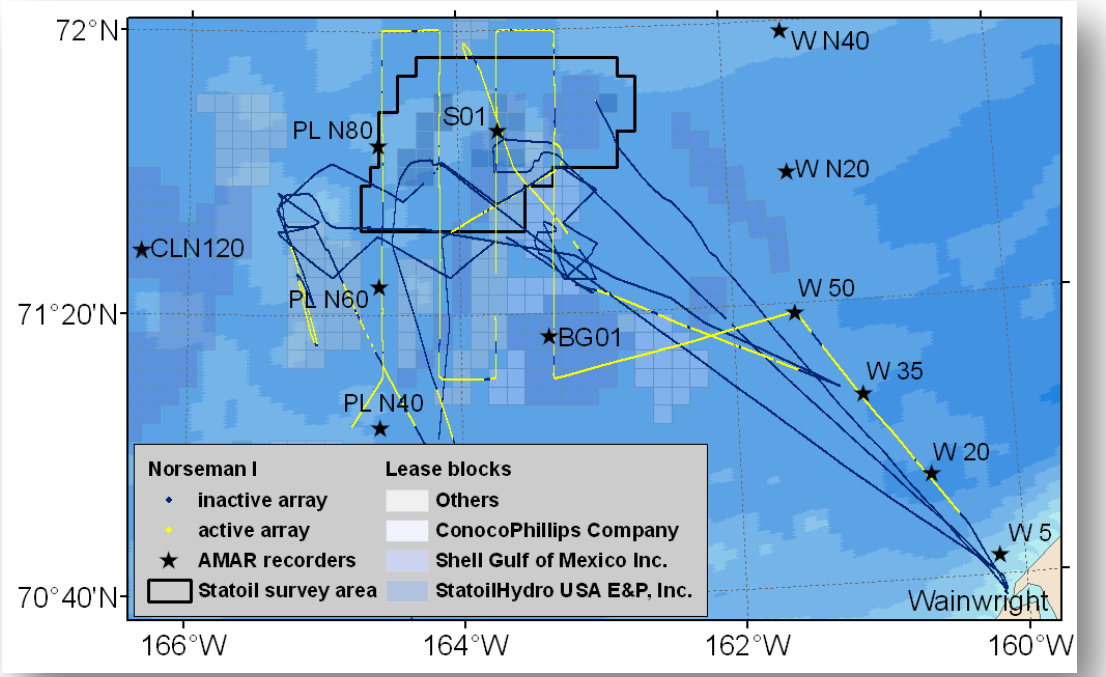
Trial designed to compare PAM detections to a fixed array

JASCO had 7 element autonomous recording arrays at the Statoil, Burger and Klondike Chukchi prospects

Geo-Celtic was conducting seismic survey in the area to 30 Sept with flip-flop 3000 in^3 airgun array & 60 in^3 mitigation gun.

Norseman I - Night-time tows 27 – 30 Sept; 24-hr tows 1 – 3 Oct.

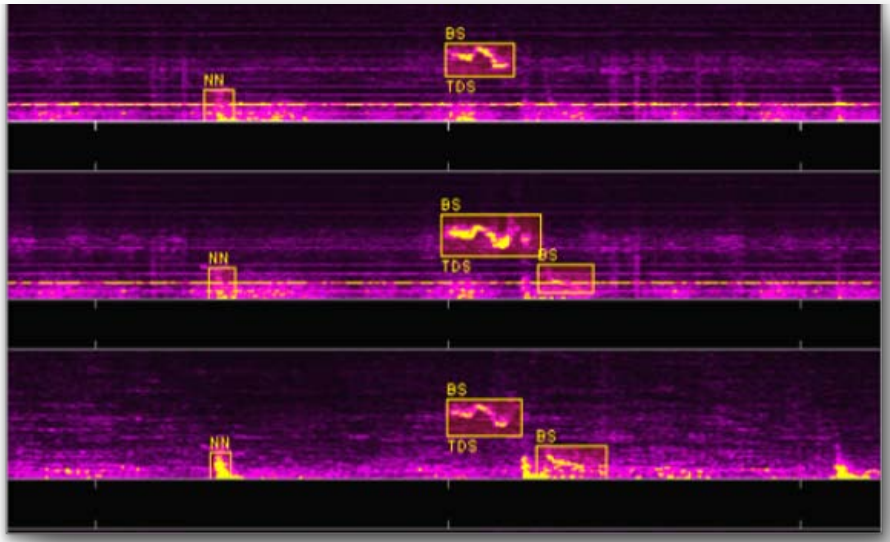
90 hours of recorded data (113 hours tow time)



PAM Data Processing

Manual Analysis

- Reviewed all data
- Created annotations for all mammal detections
- Gave times for localization.

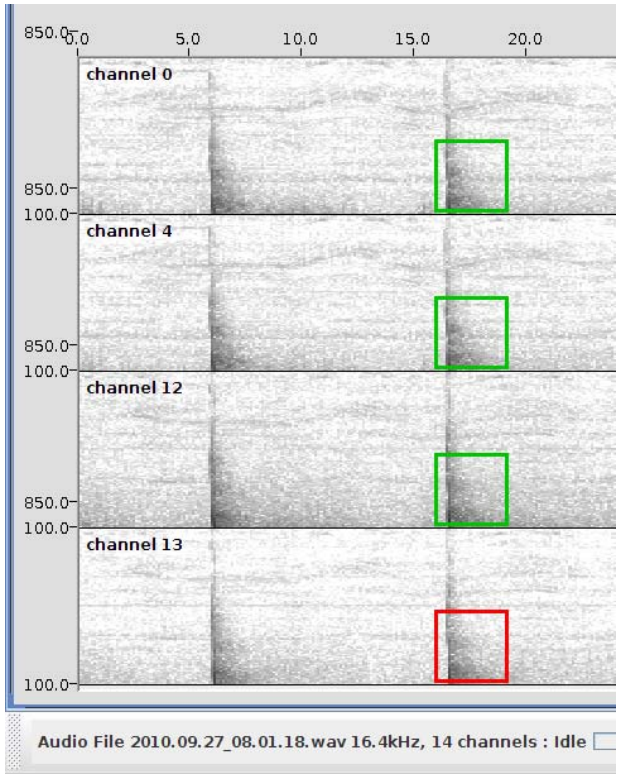


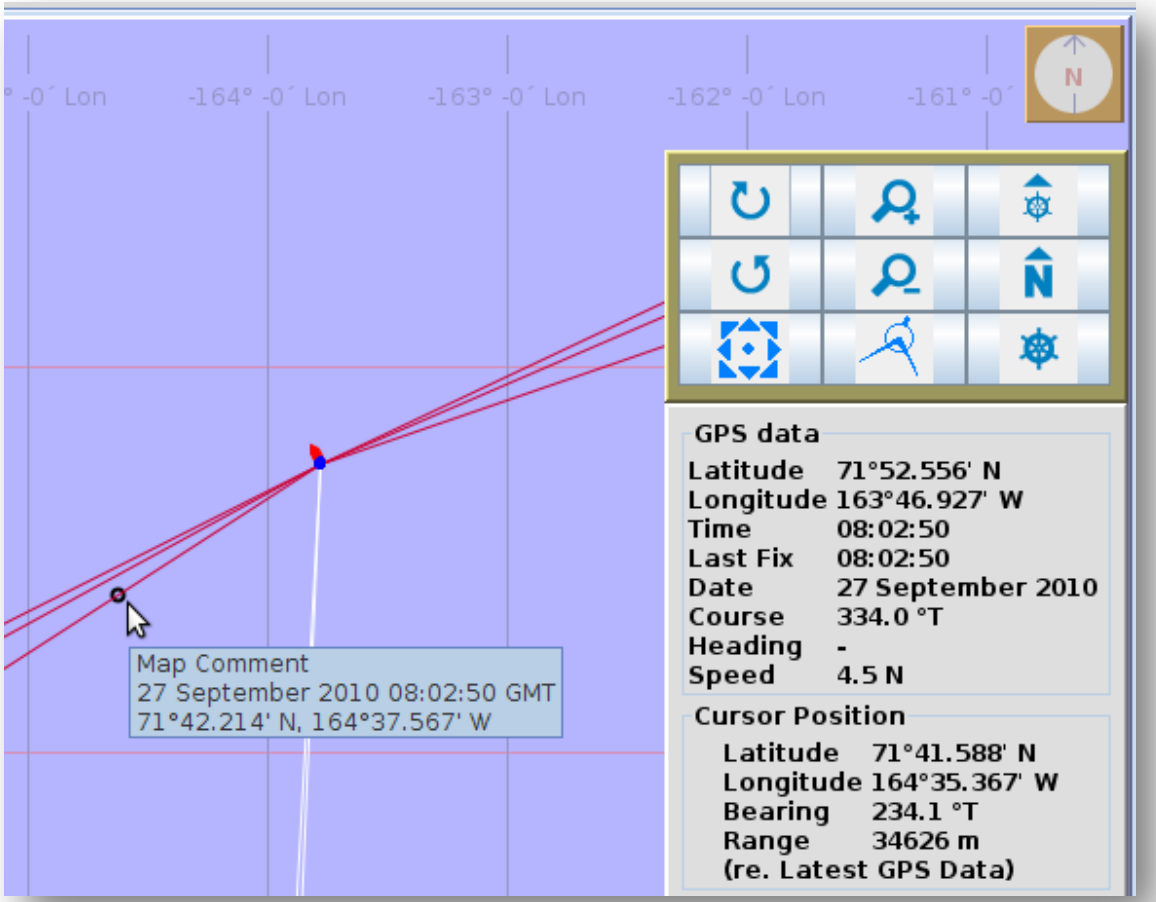
Localization

- Could not reliably configure PAMGUARD detectors to find mammal events due to ship, seismic, and array noise.
- Developed manual tools to select data for localizers.
- Need strong SNR to get good results. No tools in PAMGUARD to frequency filter before TDOA to eliminate out-of-band noise.
- Added phase based localizer for omni's and dipoles to PAMGUARD
- Used simulated and seismic data to validate localizer performance.

Directional Processing Validation

Geo-Celtic at 34.6 km from Norseman I





Fixed Array Processing

Bowhead Detection

- Manual analysis of 2009, 2010 data identified 6000+ bowhead calls.
- Trained a random forest classifier
- Characterized it's performance against manual analysis
- Provide call counts at stations S01, BG01, W35, WN20, PLN40, PLN60, PLN80, KL01, PL50

Localization

- Time align AMARs recorders
- Correlate bowhead detections between recorders.
- Perform TDOA processing, apply eccentricity constraints to ensure accurate results.
- Accuracy of 2 km for this period.
- Insufficient calls with accurate locations to provide useful data.

Results – PAM Summary

Fair - Poor weather conditions; Beaufort Scale 3 - 5 during operations (3 – 9 foot seas)

Detected bowhead, walrus, bearded seal and beluga

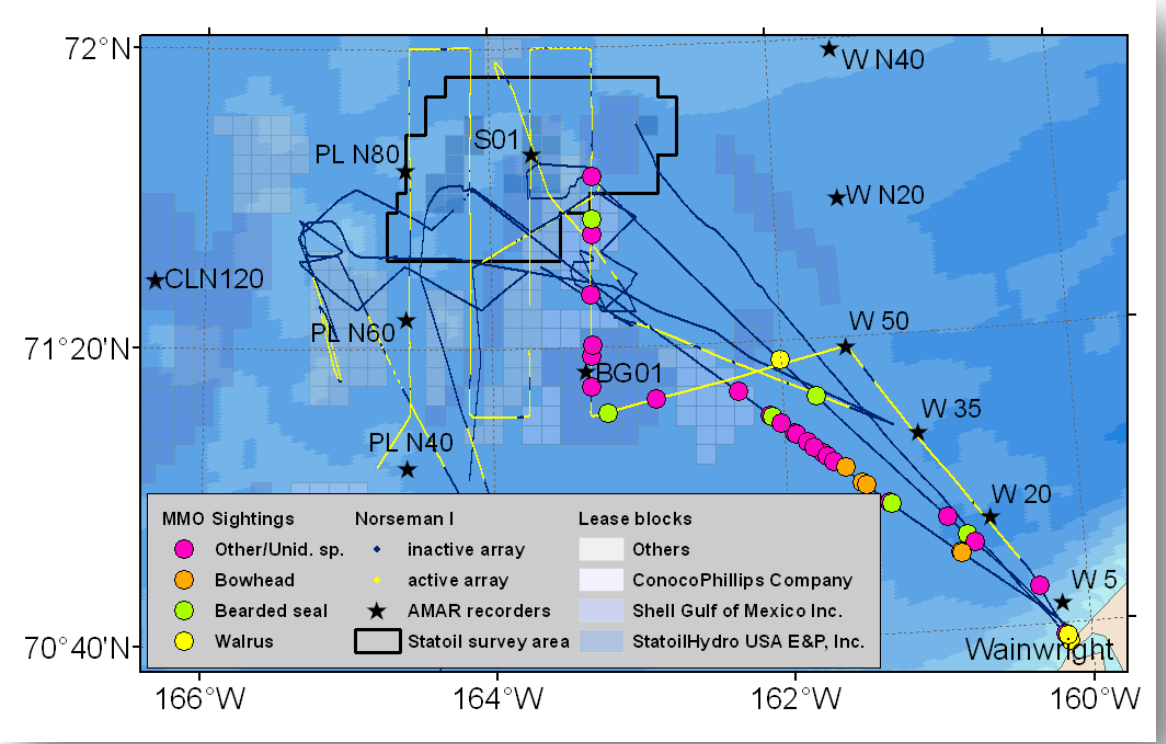
Sept 27 – 30 array towed at night, ship conducted 10 knot MMO transects during the day.

Oct 1 – 3 array towed 24-hours.

No concurrent MMO and PAM detections – MMO and PAM operations overlapped 1/3 of the time.

Circles are MMO sightings

Triangles are PAM Detections



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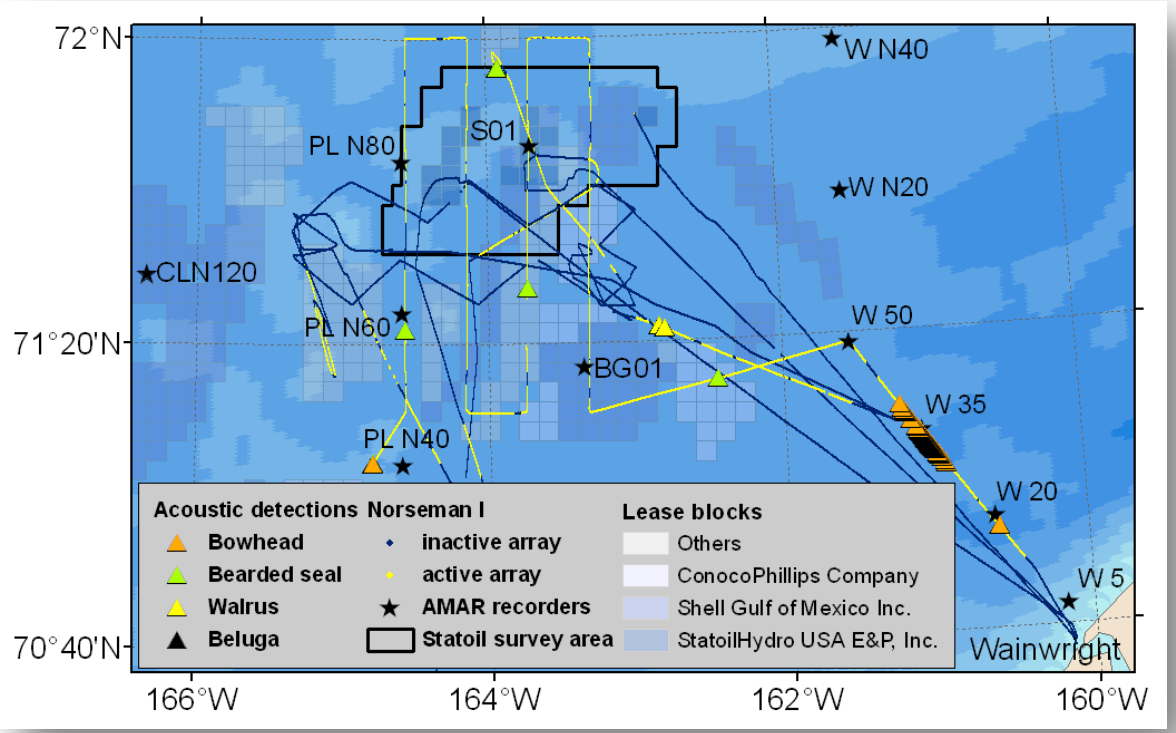

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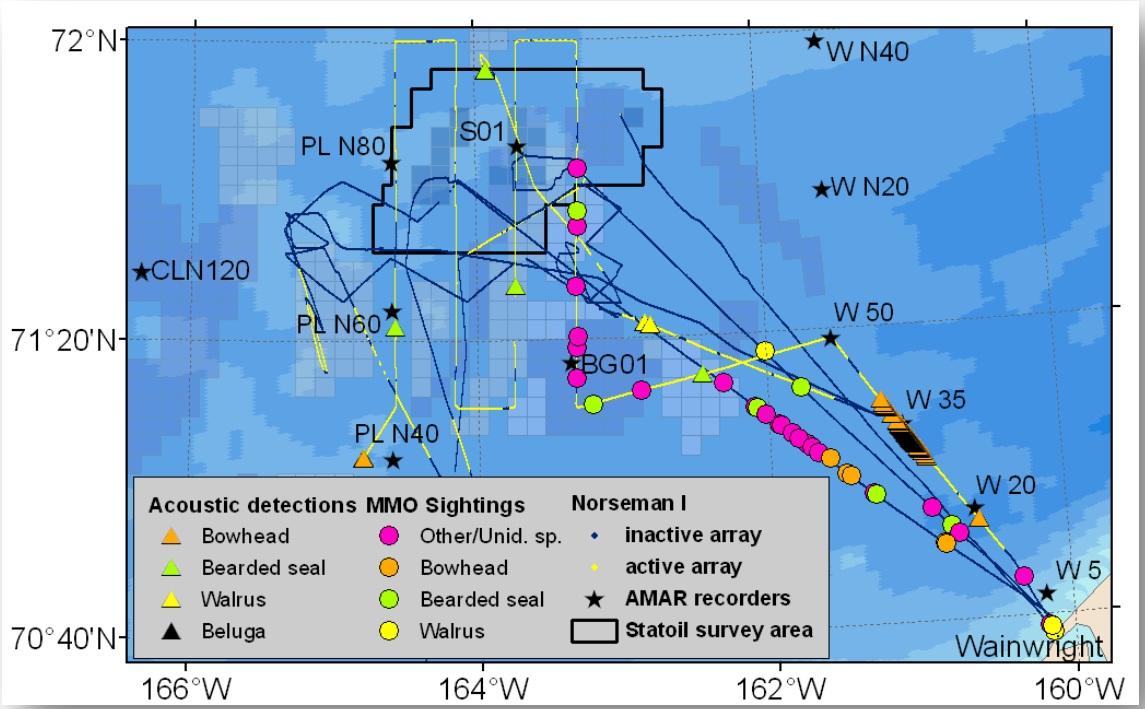
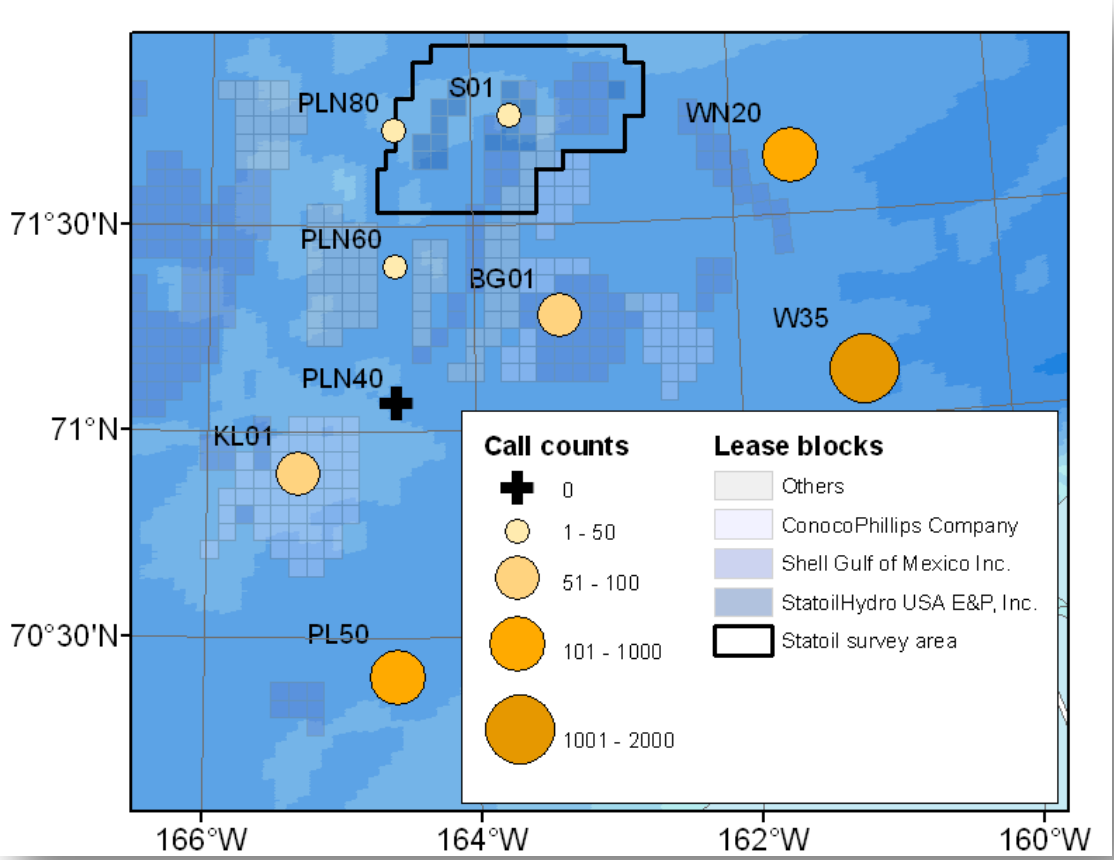


Fixed Array Summary

Bubble plot of total calls for the period 27 Sept – 3 Oct.

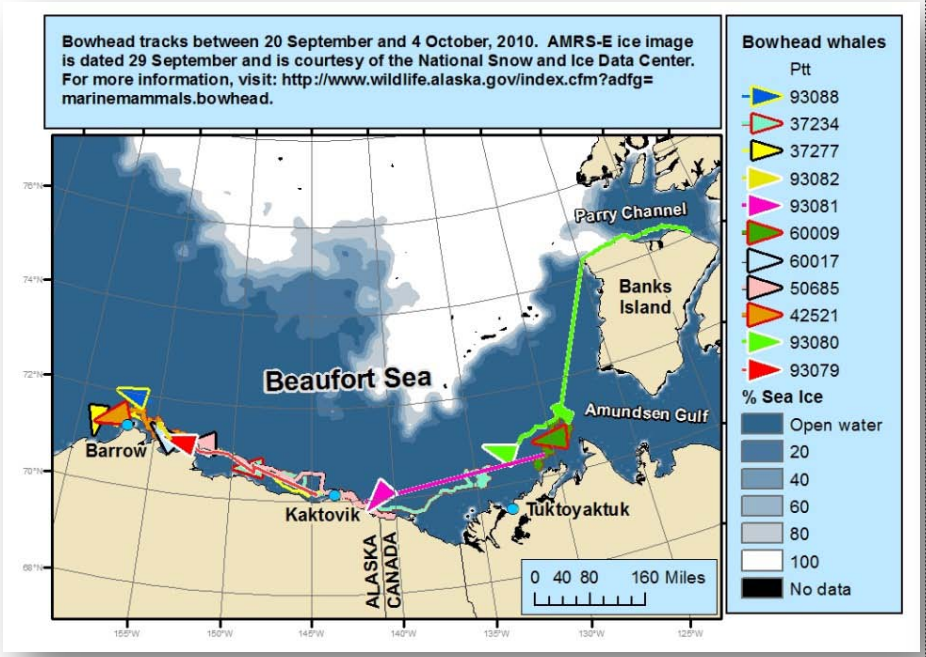
Most detections were east of the study area.

Only showing bowhead detections in these plots

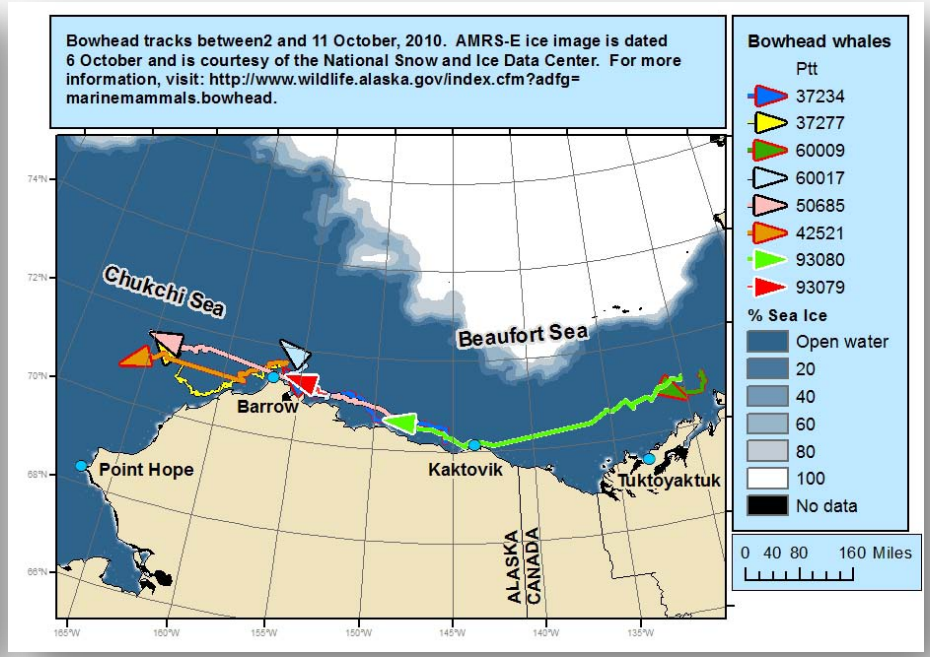


Bowhead Satellite Tagging Program Results

20 Sept – 4 Oct



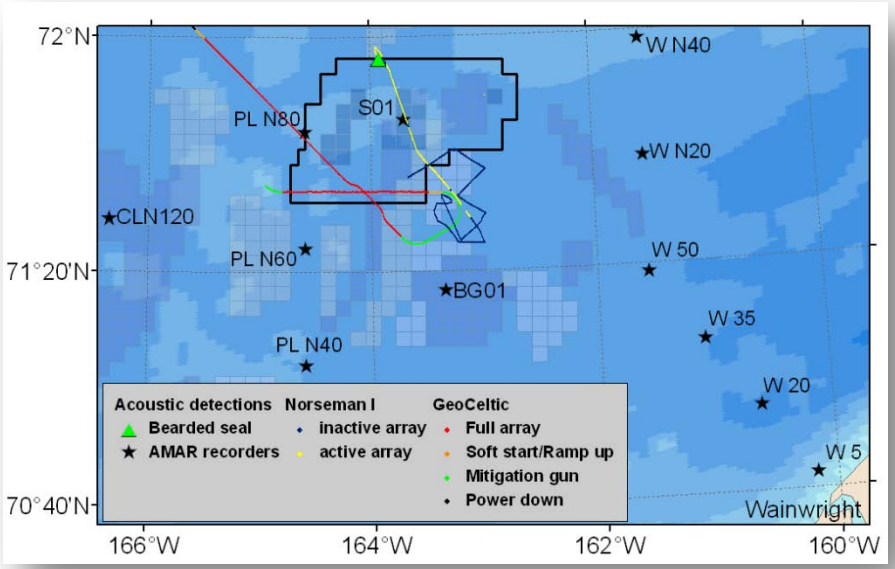
2 Oct – 11 Oct



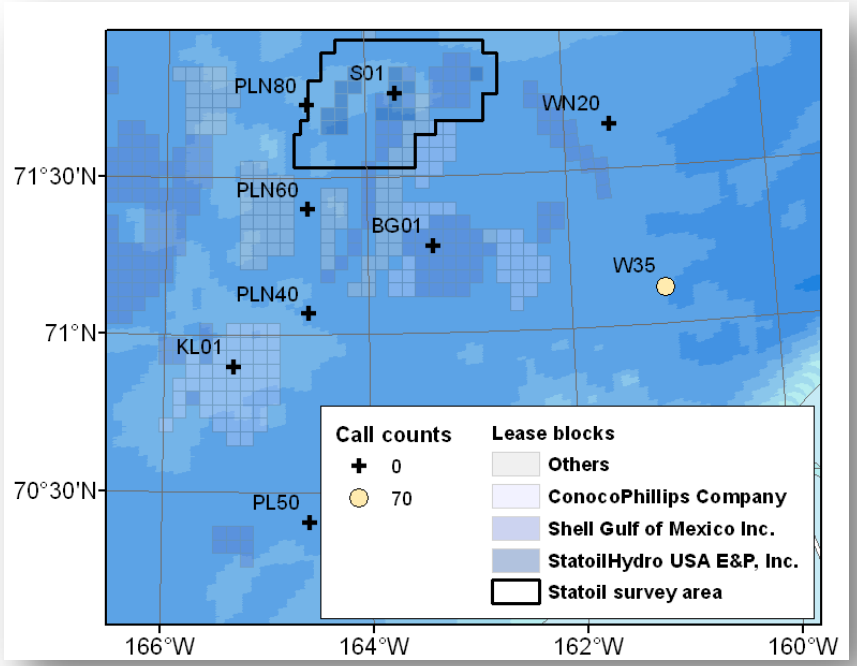
27 Sept 2010

PAM

- Norseman I transitted through Statoil array overnight.
- BF Scale 3-5, building to 8.



Fixed Array

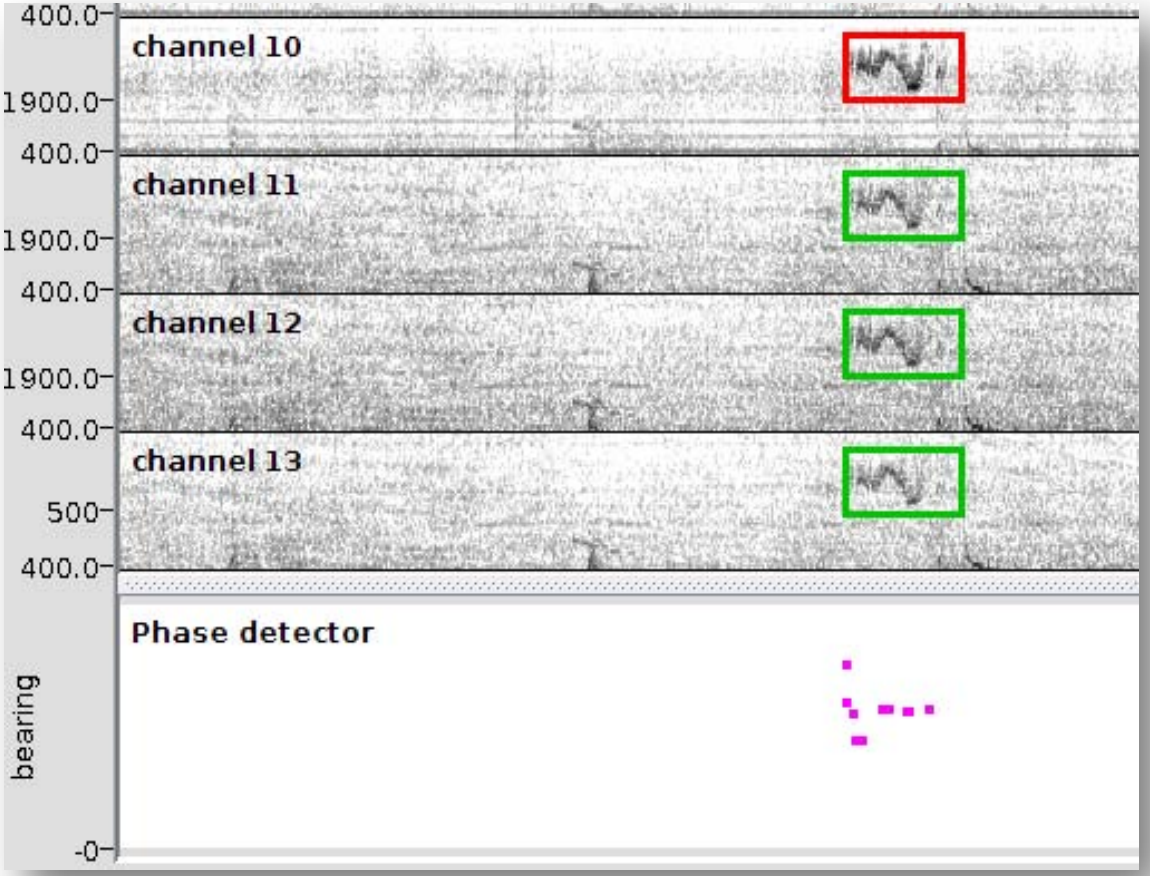


Bearded Seal Detect / Localize

Phase Detection on Channel 10 (directional) versus 11 (omni)

Detection in band for dipole sensor.

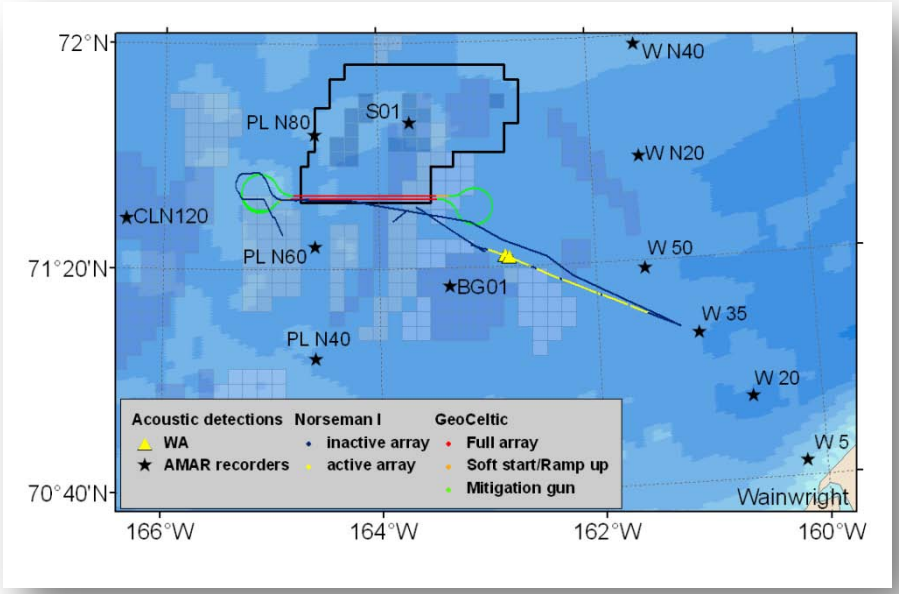
Cluster of bearings indicates good localization.



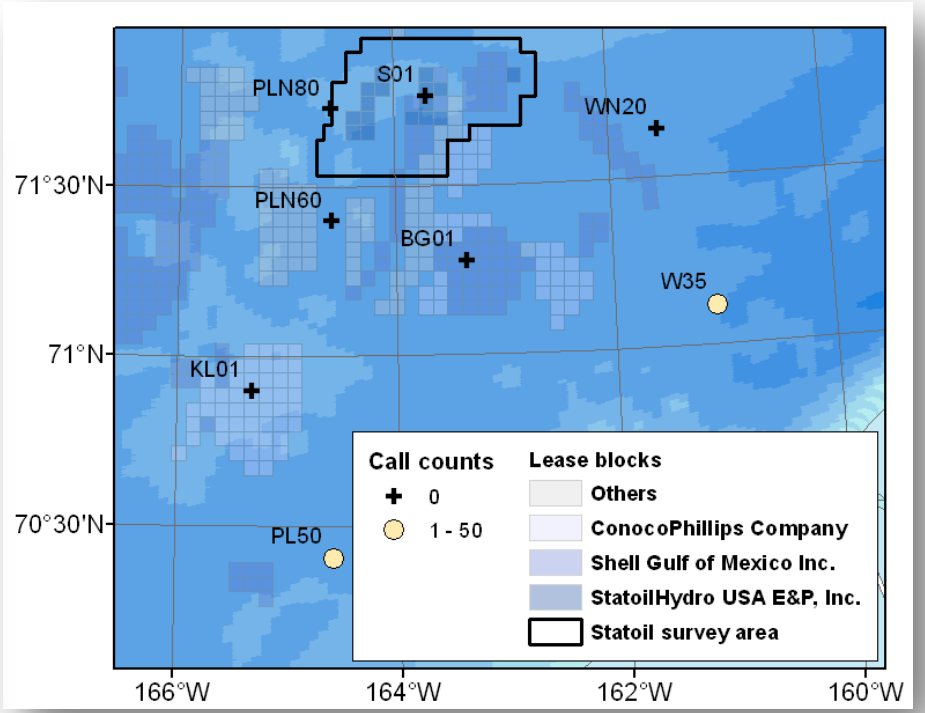
29 Sept 2010

PAM

- Norseman I tows array back from W35 to edge of Burger array.
- BF Scale 3-4



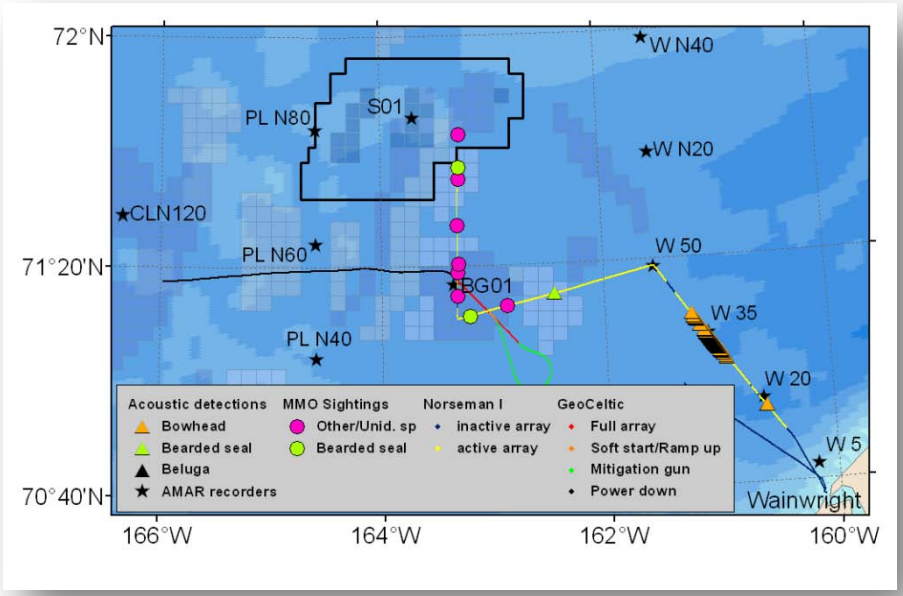
Fixed Array



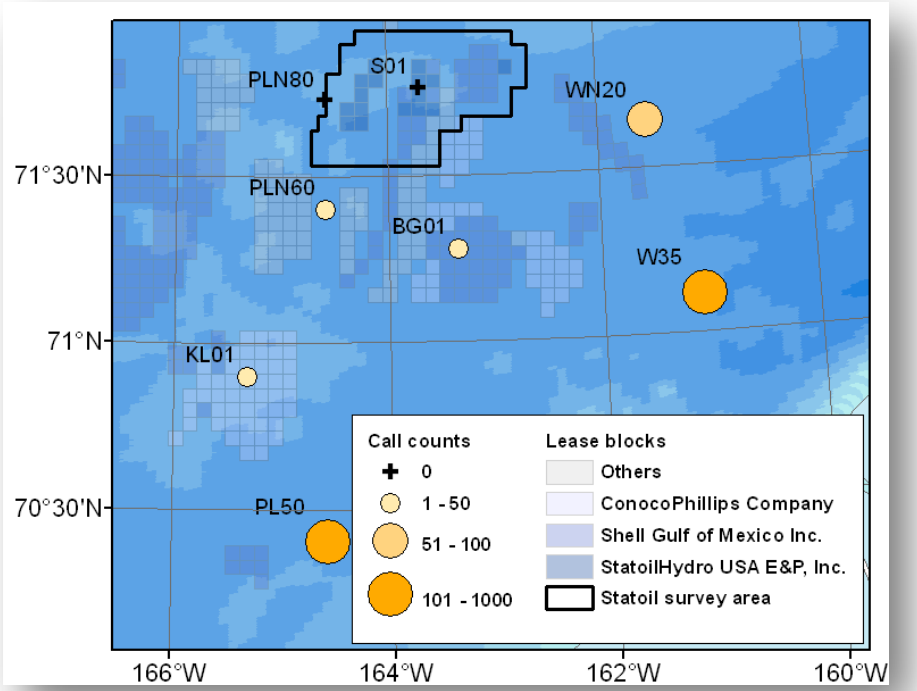
1 Oct 2010

PAM

- Best day – full day tow up the W line, then transit to Burger array.
- BF Scale 3-5
- WW, BH, BS detections.



Fixed Array

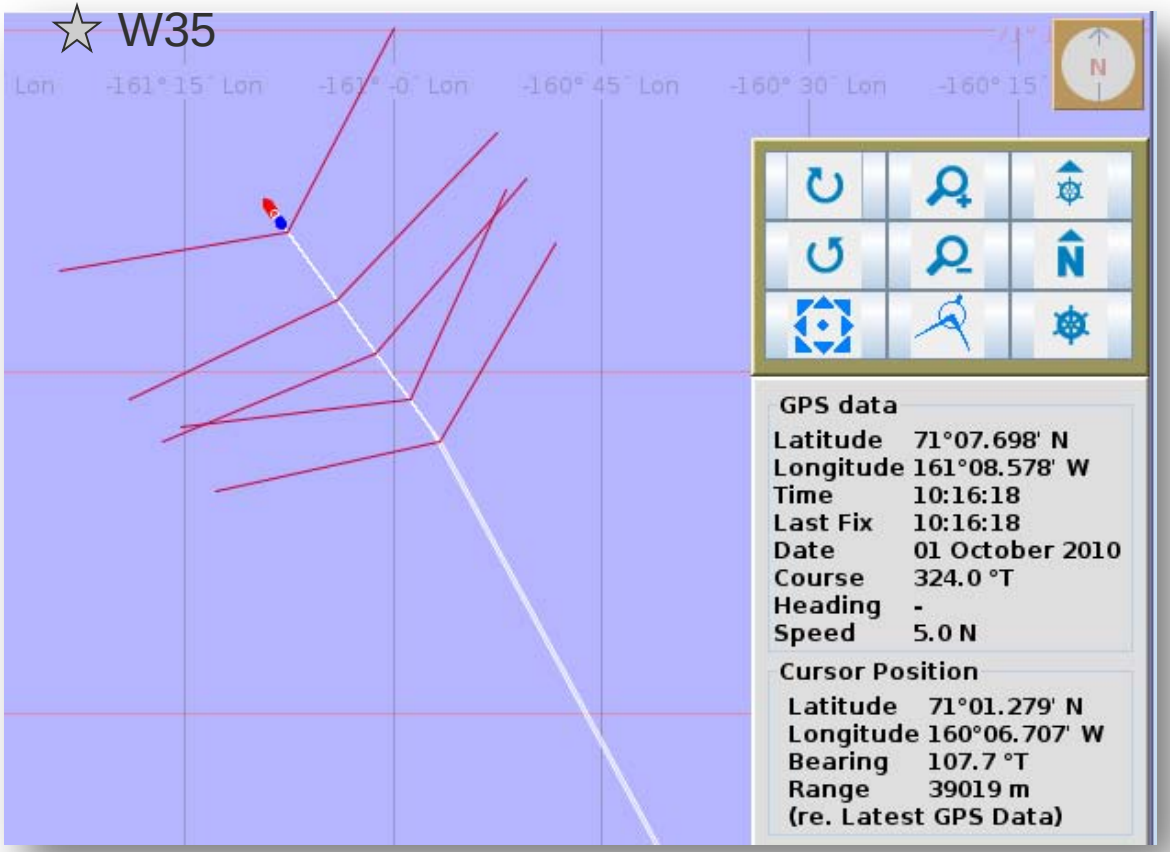


PAM Bowhead Localization

Bowhead track from 1 Oct. Correlates with W35.

TDOA localization only from aft module; Forward module TDOA is locking onto ship noise.

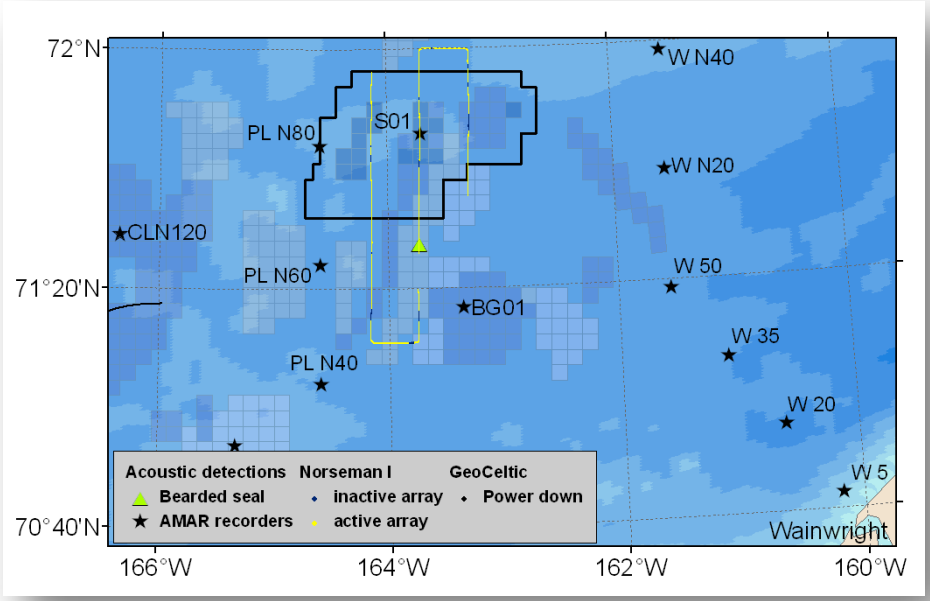
Demonstrates that localization is possible at these low frequencies in presence of ship noise in some cases – software / algorithm changes required to get forward module to localize.



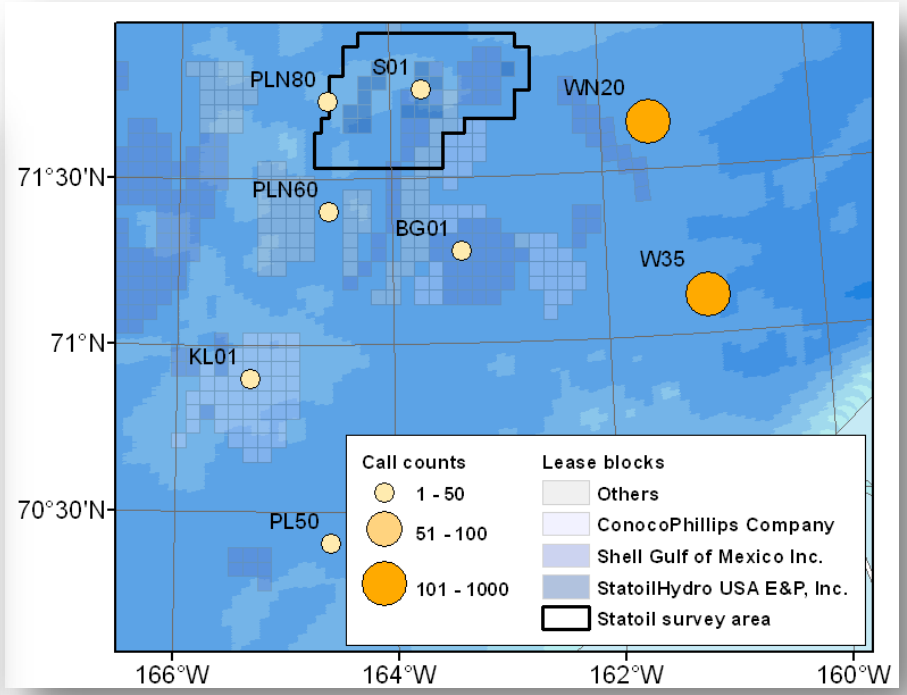
2 Oct 2010

PAM

- Full-day ‘S’ pattern through Statoil / Burger arrays.
- BF Scale 2 - 4



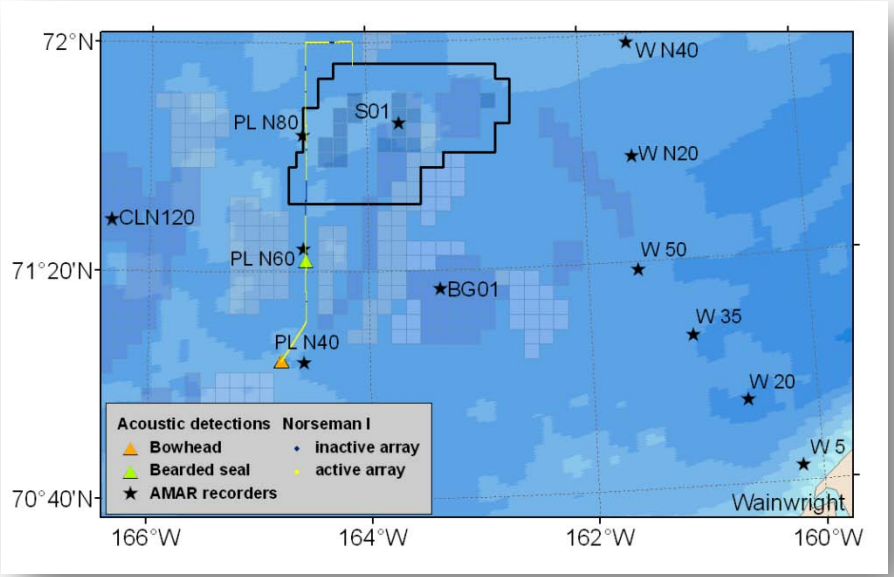
Fixed Array



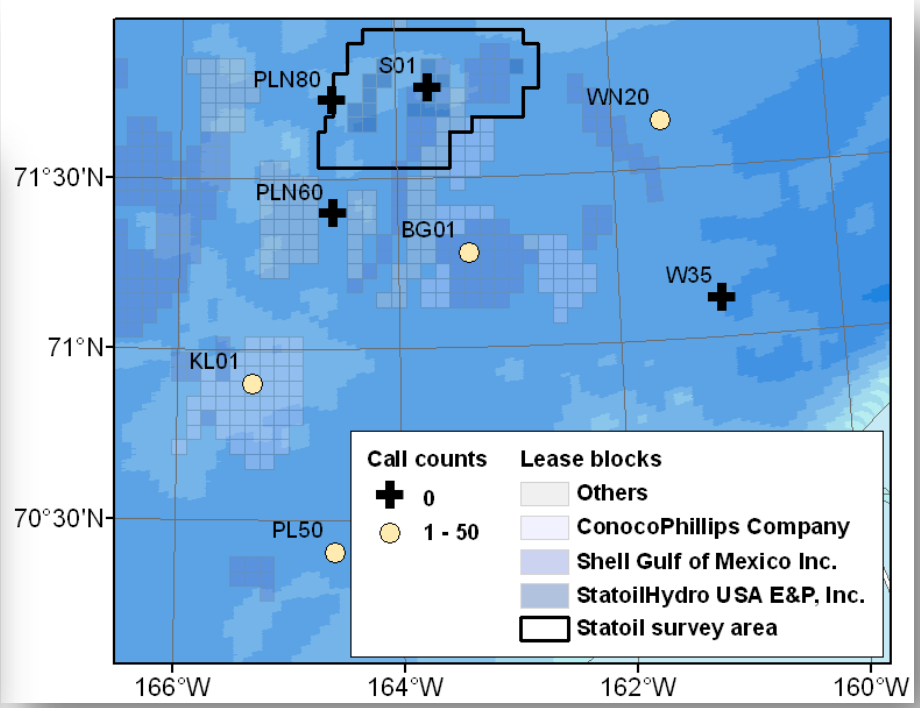
3 Oct 2010

PAM

- Transit down Point Lay Line.
- Recover at 01:00 4 Oct due to weather
- BF Scale 3-6, building to 9



Fixed Array



Discussion – Bowhead Detection

MacDonnell, Delarue, Vallarta and Martin, AMSS 2011:

Avg SL = 144.3±4.6 dB re 1 µPa

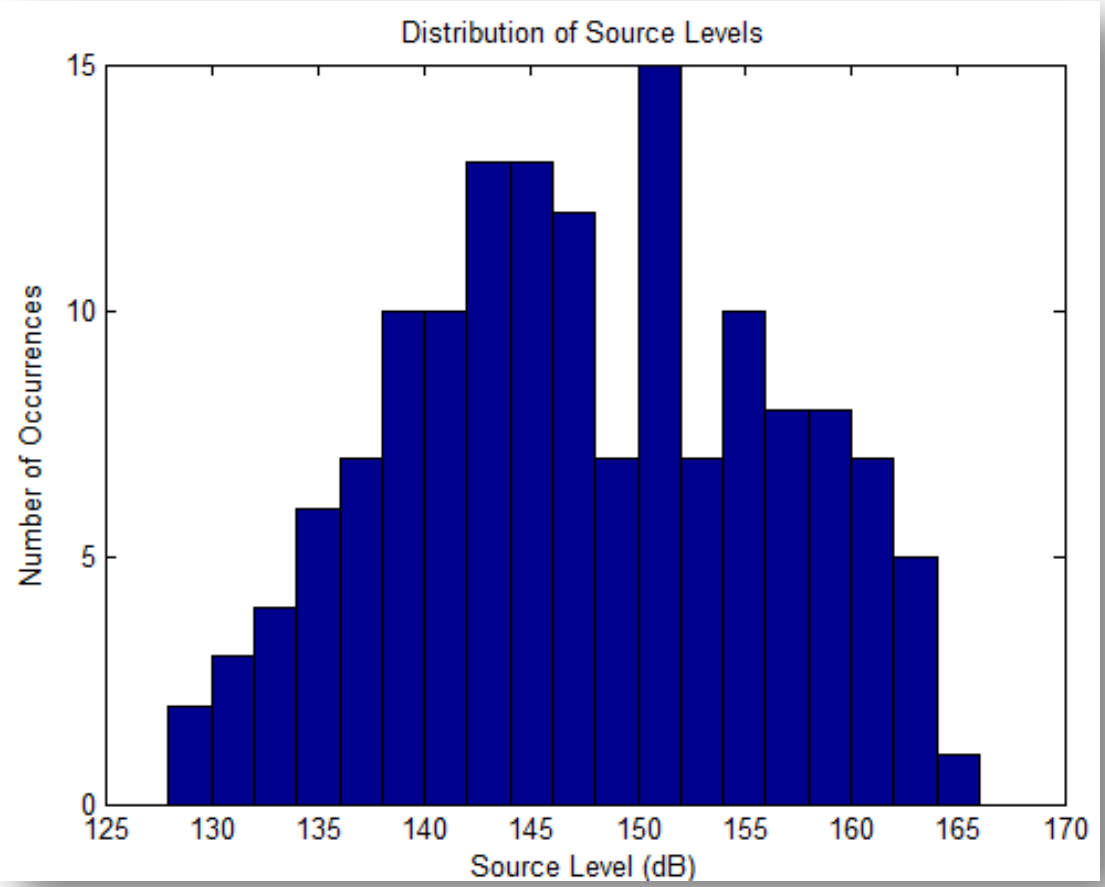
Max SL = 164.4 dB re 1 µPa

Min SL = 129.7 dB re 1 µPa

Avg center frequency = 145 Hz

Average bandwidth = 53 Hz

Average length of call = 1.01 seconds



Discussion – Measured Noise

Computed SPL in band 115 – 175 Hz

WN20 used as a surrogate for ambient levels (some seismic was present)

Range of 1 minute average values in a 10 minute span.

Date (UTC)	Ship's Speed, kts	NB Cable Length	BF Scale	Fwd Omni SPL	Aft Omni SPL	WN20 SPL
23:31 1 Oct	4.7	200	2	94.4 - 95.9	99.2 - 100.8	77.1 - 82.2
03:00 2 Oct	5.7	200	2	96.2 - 97.4	100.1 - 101.2	72.3 - 76.3
18:57 2 Oct	4.2	200	4	100 - 103.7	103 - 104.2	89.9 - 93.5
09:40 28 Sep	4.7	200	4-5	104.1 - 106.3	102.9 - 104.6	98.3 - 113.8 (s)
07:15 28 Sep	5.6	200	4-5	103.2 - 105.9	103.2 - 105.6	96.1 - 98.4 (s)
06:35 27 Sep	6.3	200	4	102.2 - 103.6	101.4 - 102.8	88.4 - 90.2
20:00 2 Oct	6.9	200	4	101.1 - 102.8	99.7 – 103	88.6 - 90.5
07:08 29 Sep	4.2	400	4	98.9 - 103.5	100.1 - 100.9	96.4 - 99.6 (s)
07:15 29 Sep	5.6	400	4	99.7 - 101.9	100.1 - 101.5	94.5 - 96.8 (s)
07:24 29 Sep	8.6	400	4	100 - 106	99.4 - 103.7	94.3 - 99.5 (s)

Discussion – Effect of Layback

Laying back should reduce noise. Using a band of 90z-225 Hz 3 dB noise improvement can be demonstrated. Not conclusively shown with 115-175 Hz.

Date (UTC)	Ship's Speed, kts	NB Cable Length	BF Scale	Fwd Omni SPL	Aft Omni SPL	WN20 SPL
23:31 1 Oct	4.7	200	2	94.4 - 95.9	99.2 - 100.8	77.1 - 82.2
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09:40 28 Sep	4.7	200	4-5	104.1 - 106.3	102.9 - 104.6	98.3 - 113.8 (s)
07:15 28 Sep	5.6	200	4-5	103.2 - 105.9	103.2 - 105.6	96.1 - 98.4 (s)
06:35 27 Sep	6.3	200	4	102.2 - 103.6	101.4 - 102.8	88.4 - 90.2
20:00 2 Oct	6.9	200	4	101.1 - 102.8	99.7 – 103	88.6 - 90.5
07:08 29 Sep	4.2	400	4	98.9 - 103.5	100.1 - 100.9	96.4 - 99.6 (s)
07:15 29 Sep	5.6	400	4	99.7 - 101.9	100.1 - 101.5	94.5 - 96.8 (s)
07:24 29 Sep	8.6	400	4	100 - 106	99.4 - 103.7	94.3 - 99.5 (s)

Discussion – Sea State Impact

Sea state is driving up ship's noise as the ship pushes through the waves. Norseman I is an older vessel, always cavitating.

Date (UTC)	Ship's Speed, kts	NB Cable Length	BF Scale	Fwd Omni SPL	Aft Omni SPL	WN20 SPL
23:31 1 Oct	4.7	200	2	94.4 - 95.9	99.2 - 100.8	77.1 - 82.2
03:00 2 Oct	5.7	200	2	96.2 - 97.4	100.1 - 101.2	72.3 - 76.3
18:57 2 Oct	4.2	200	4	100 - 103.7	103 - 104.2	89.9 - 93.5
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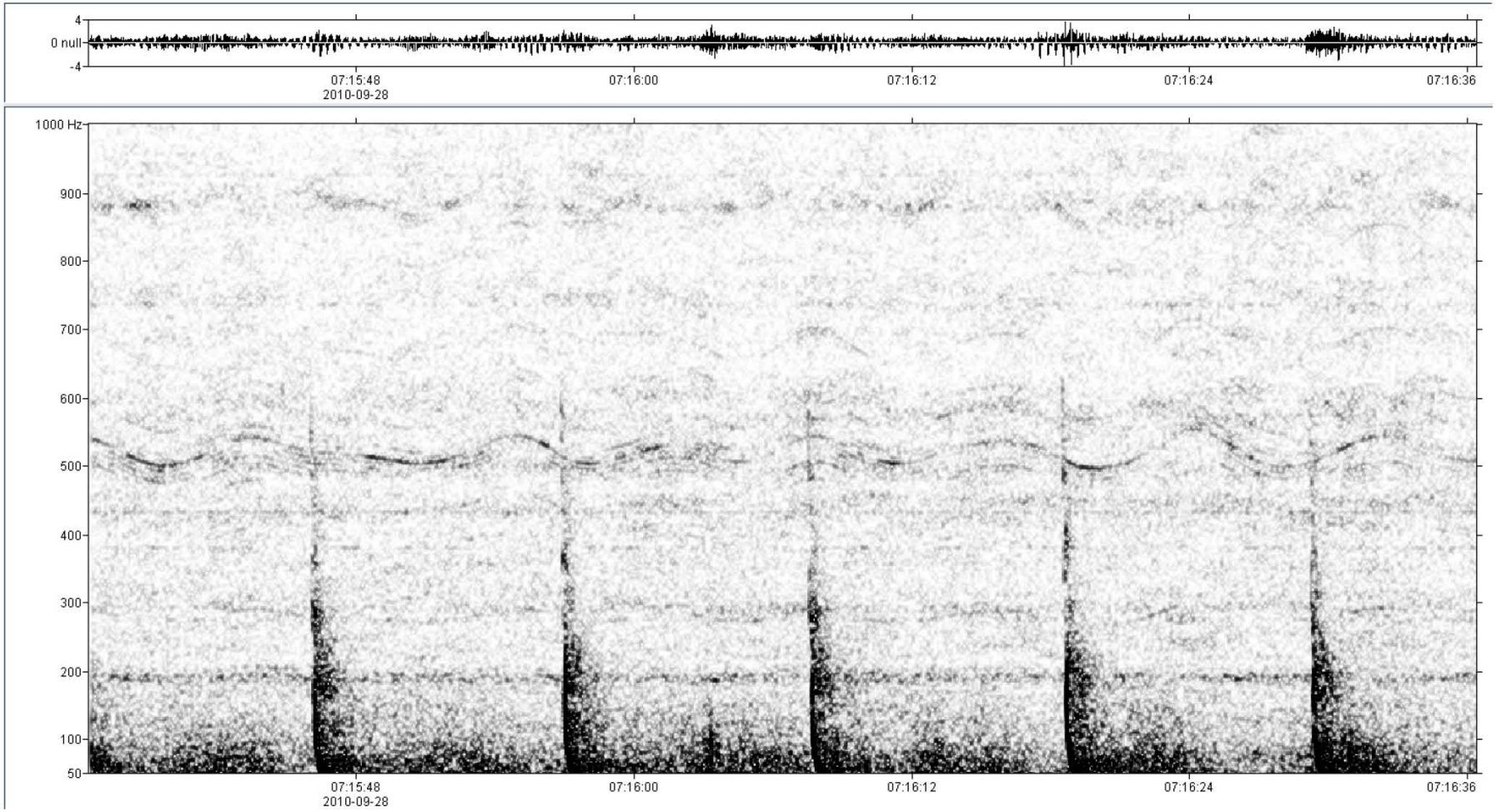
20:00 2 Oct	6.9	200	4	101.1 - 102.8	99.7 – 103	88.6 - 90.5
07:08 29 Sep	4.2	400	4	98.9 - 103.5	100.1 - 100.9	96.4 - 99.6 (s)
07:15 29 Sep	5.6	400	4	99.7 - 101.9	100.1 - 101.5	94.5 - 96.8 (s)
07:24 29 Sep	8.6	400	4	100 - 106	99.4 - 103.7	94.3 - 99.5 (s)

Effect of sea state – BF 4-5, following seas

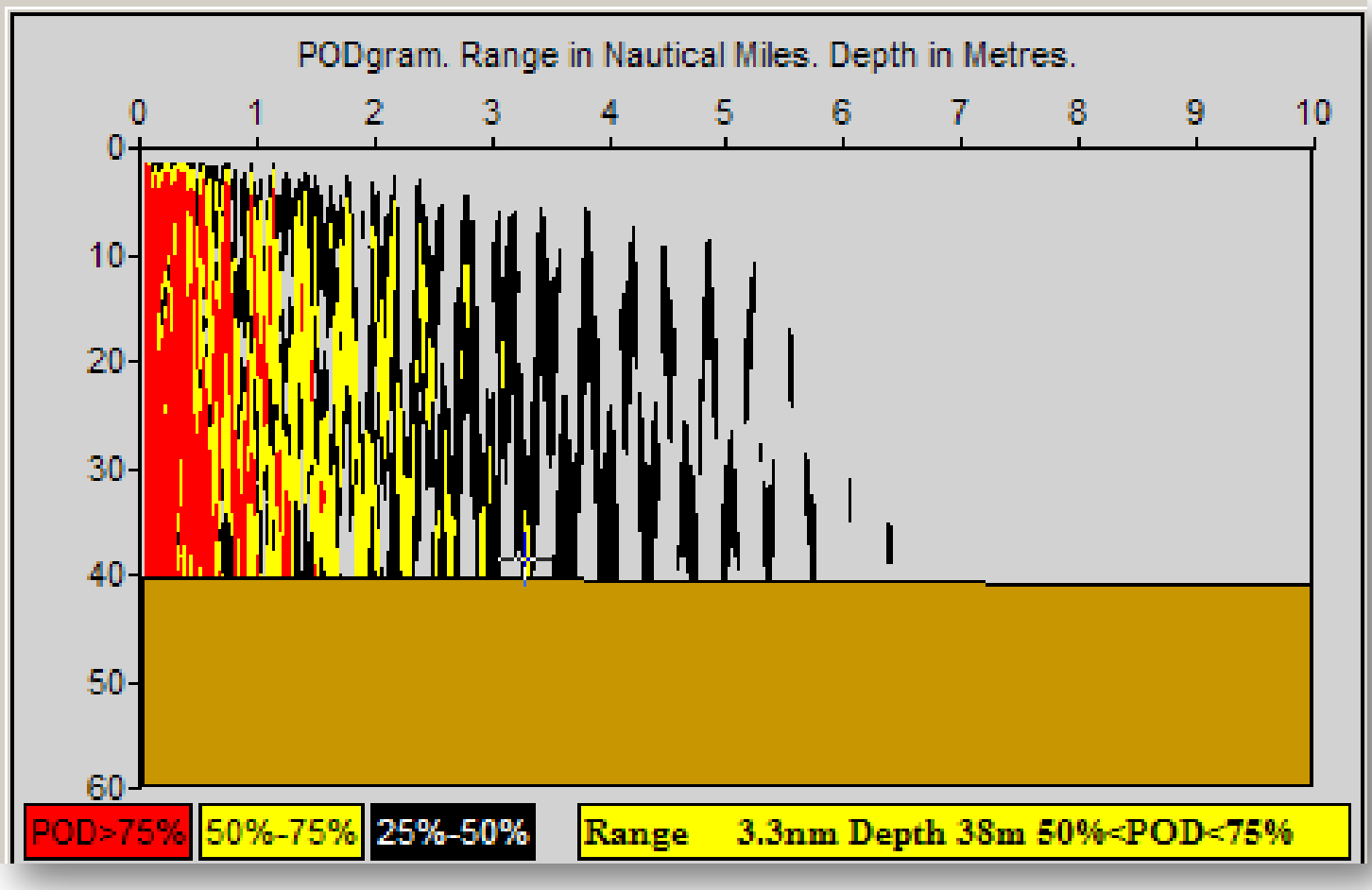


Range Predictions

145 (median) & 155 (25th percentile) dB Source Levels;
115 – 175 Hz, 1 sec;

Sandy – silt bottom; Down-slope radial

Various noise levels



Detection Ranges

Bowhead Call Source Level	Tow Vessel Noise Level	Detection Range
145	96	2 nm
145	100	1 nm
145	104	0.5 nm
155	100	4 nm
155	103	3 nm
155	106	2 nm

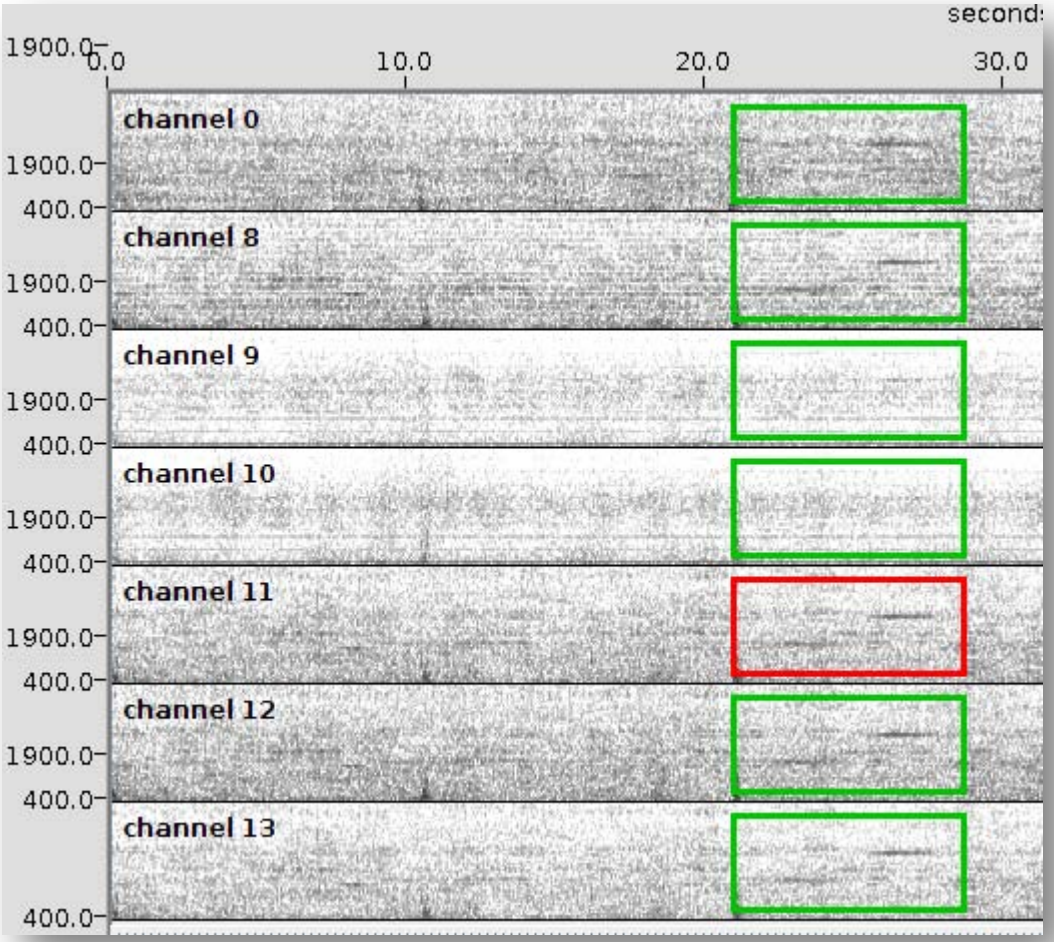
Discussion – Directional Sensors

Demonstrated bearing performance. What about detection?

Pump on Norseman I changed from ~600 Hz to ~ 1000 Hz.

Visible on the omnidirectional sensors (0, 8, 11, 12, 13)

Suppressed on directional channels (9, 10), even though it is in the peak response band for those sensors.



Discussion – System Improvements

- Evidence that sensor mounting can have as much as 3 dB effect on noise levels – need to be very particular in array construction.
  - Isolate sensors from hose walls
  - Longer neutrally buoyant cables
  - Improved drogue isolation and perhaps length
- Sensors:
  - Better wiring and noise / ground isolation
  - Lower the ‘Q’ on the directional sensors and provide a sensor with a lower resonance to better match bowhead frequencies
- System / Software:
  - PAMGUARD needs significant work to truly support auto-detect and localize.
  - Bring manual tools & phase localizer JASCO developed into the main repositories
  - Add filter – before – correlate to TDOA localizers.

Conclusions

Did we answer the questions?

- How does noise impact ability to detect mammals by PAM?

- What factors are driving the noise? Ship self noise? Towed array flow noise? Environmental Noise?

- Under what conditions does PAM provide additional capability compared to MMOs?

- What additional technological developments are required to deliver effective arctic PAM?

- 1. PAM trial ended before main bowhead migration arrived in trial area.
- 2. Results indicate that increased sea state leads to increased vessel noise for small – medium sized vessels. Detection ranges against strong bowhead calls of 4 nm in BF 2, 2 nm in BF 5 for speeds between 4 and 8.3 knots.
- 3. Next Slide.
- 4. Further research is warranted. Hardware and software improvements required before trial. Trial should evaluate performance at MMO transect speeds.

Under what conditions can PAM augment MMOs? It depends …

- Need to know tow platform's source level
- Need to know target species call frequency, bandwidth, source level
- Need to know target species call rate.
- What zone are you trying to clear?
- Need the right array, software, and settings to match
- Sample Scenarios:
  - 180 dB Zone: Sperm whale clicks when towed from seismic platform – YES
  - 180 dB zone: Dolphin whistles when towed from a support platform – YES
  - 180 dB zone: clear before ramp up using seismic spread against cetaceans – YES, IF right array and seismic platform
  - 160 dB Zone: monitor for cetaceans – difficult – would need a support platform on the leading edge of the zone – plus the mammals have to keep calling (120 dB CSEL effect)

Acknowledgements

Captain Paul Tate & Crew of the Norseman I

JASCO Field Crew – Eric Lumsden & Stephen Turner

LGL Visual Observers – Sarah Case, Leslie Curran, Nova Mongoyak, & Justina Christensen

Fugro Geoteam - Sigbjørn Vigeland

ENI - Clive Hurst

Thank you

Passive Acoustic Monitoring in the Chukchi Sea, Sept – Oct 2010

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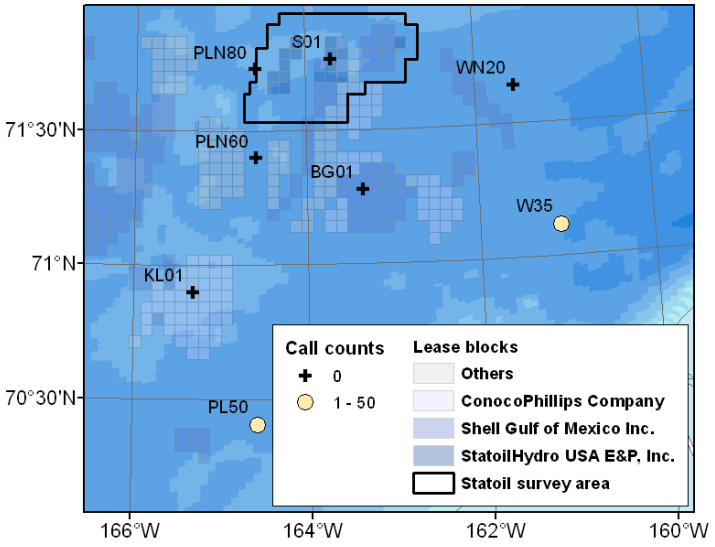
Statoil

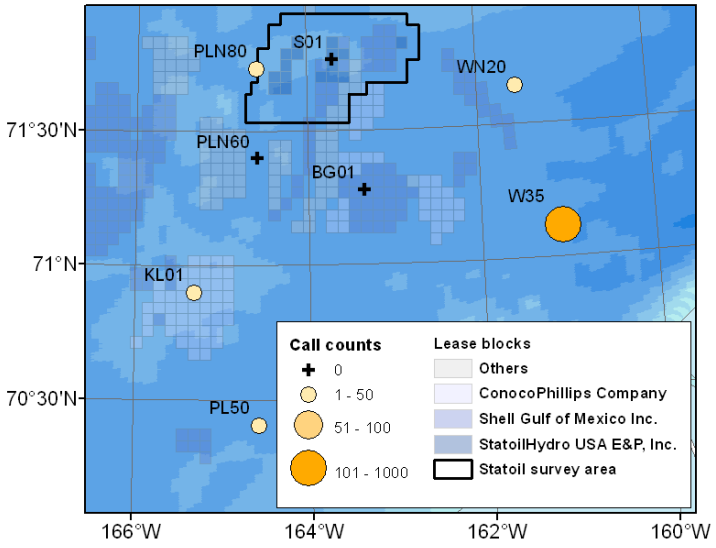
SUPPORTING MATERIAL

Fixed Array, 28 & 30 Sept

28 Sept



30 Sept

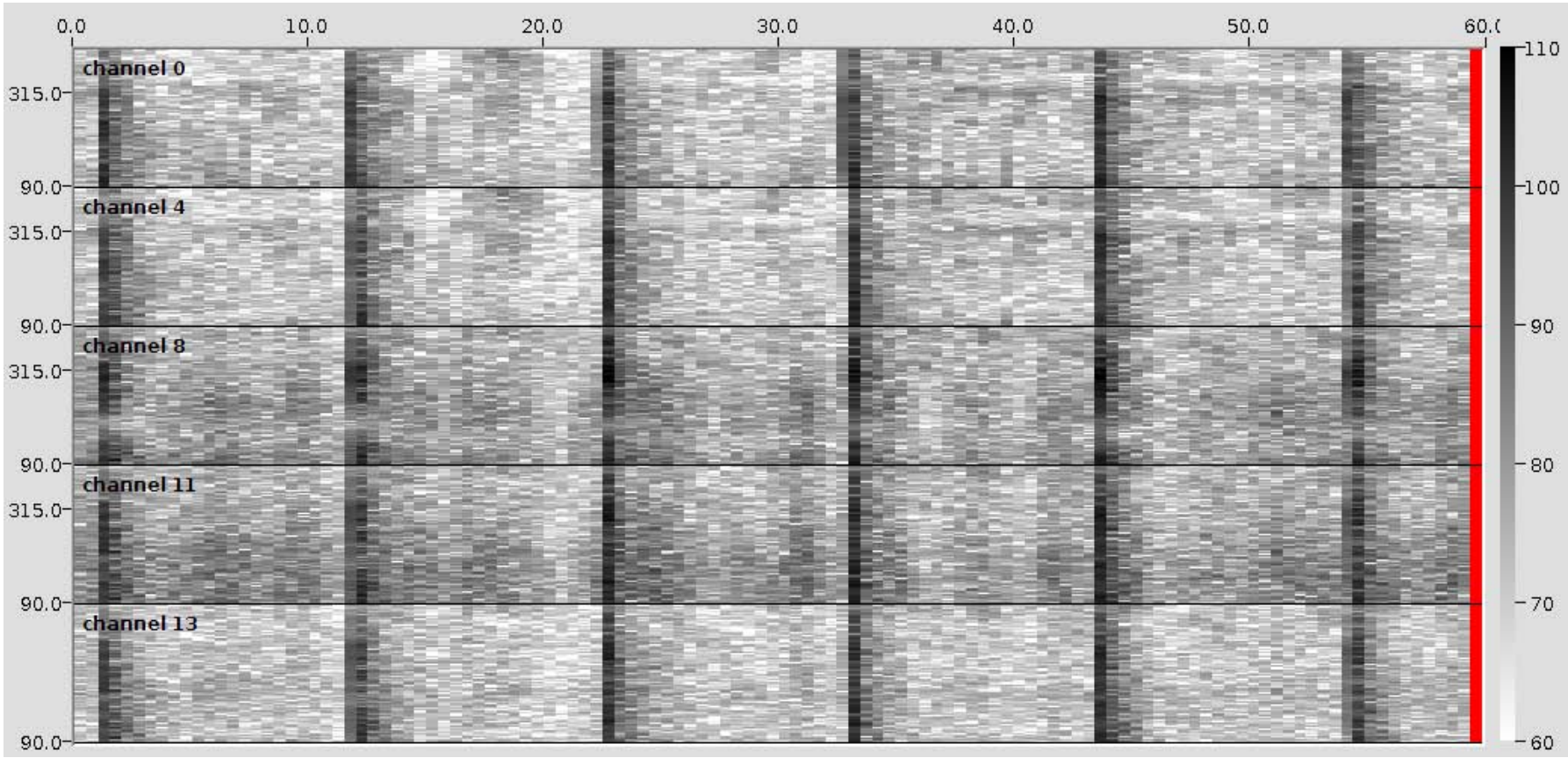


90 – 225 Hz Levels

1 sec FFT; 50% overlap;

0 & 4 are fwd module M8's

8 = aft module M8, 11 = single M15 on dipole, 13 = summed dipole Omni's.



Explain Phase Processing

Explain P-R

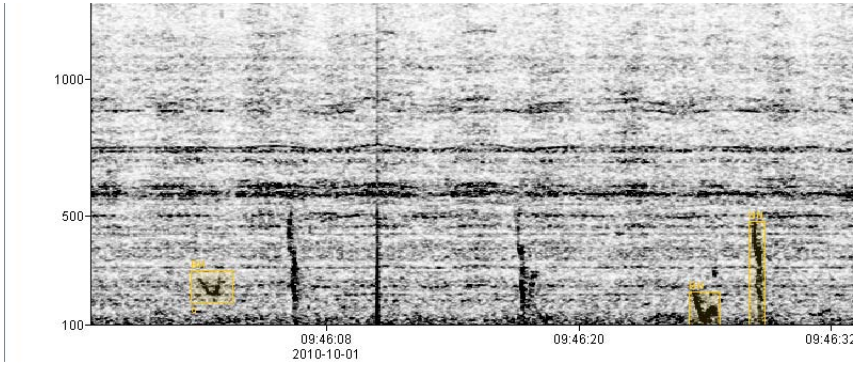
Sample Walrus Calls

PAM

Fixed Array

Sample BH Calls

PAM



Fixed

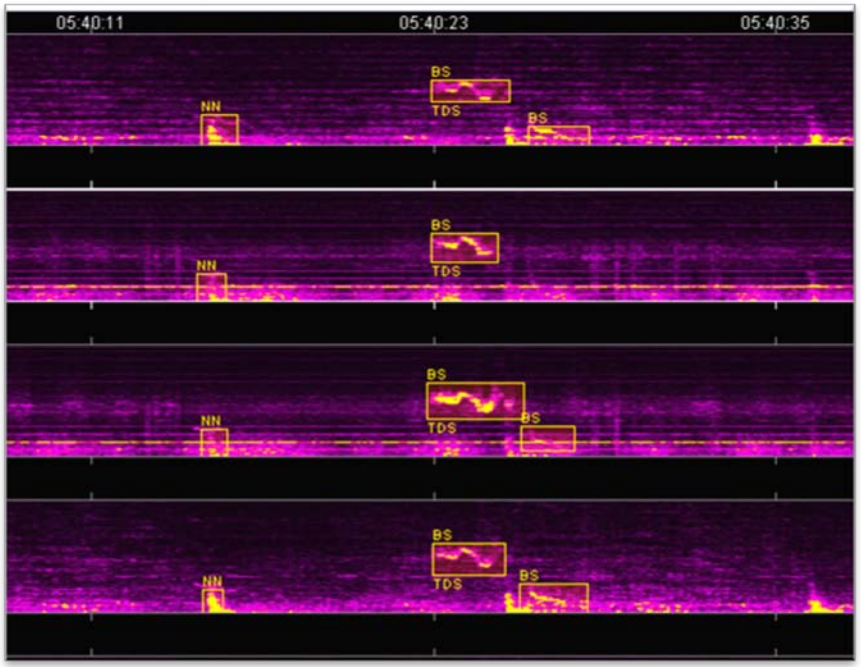
Sample Beluga Calls

PAM

Fixed

Sample Bearded Seal Calls

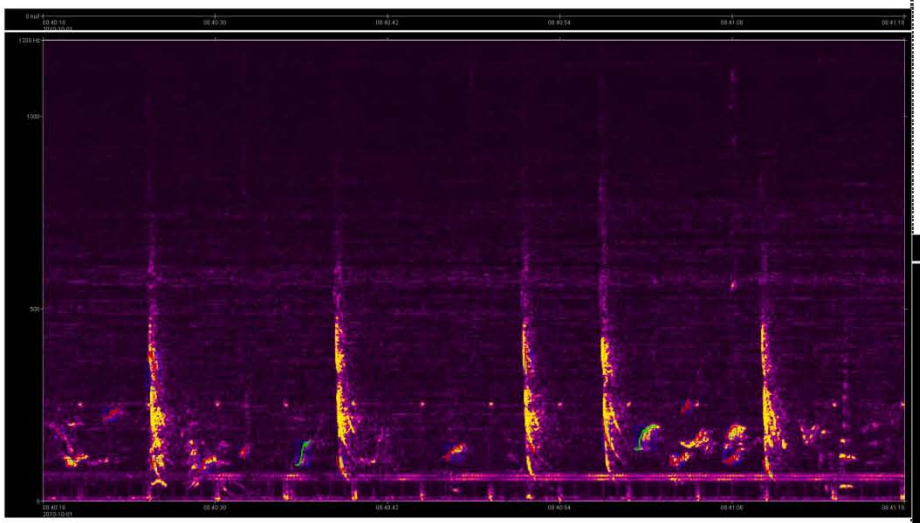
PAM



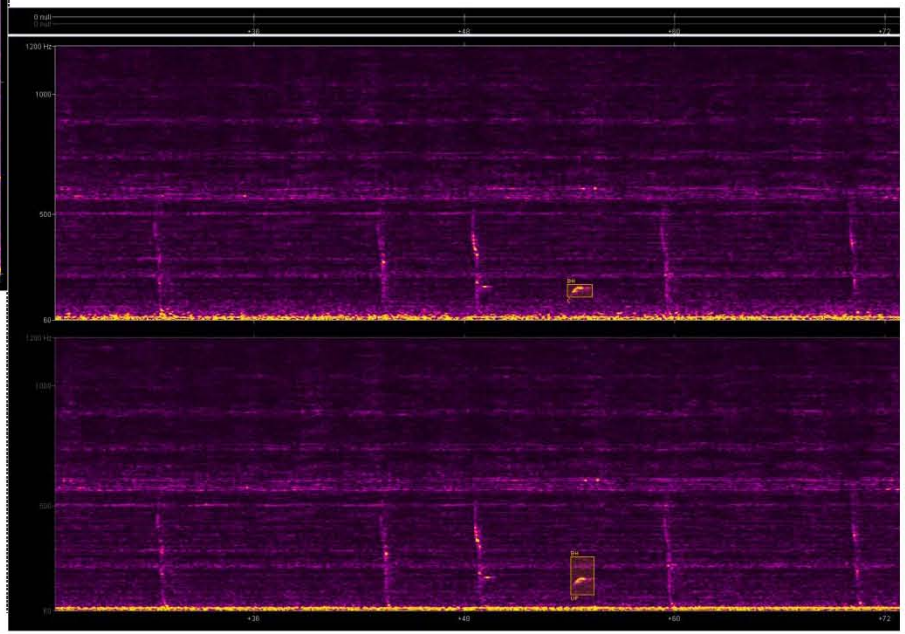
Fixed Array

PAM and W35 Alignments on 1 Oct

W35



PAM

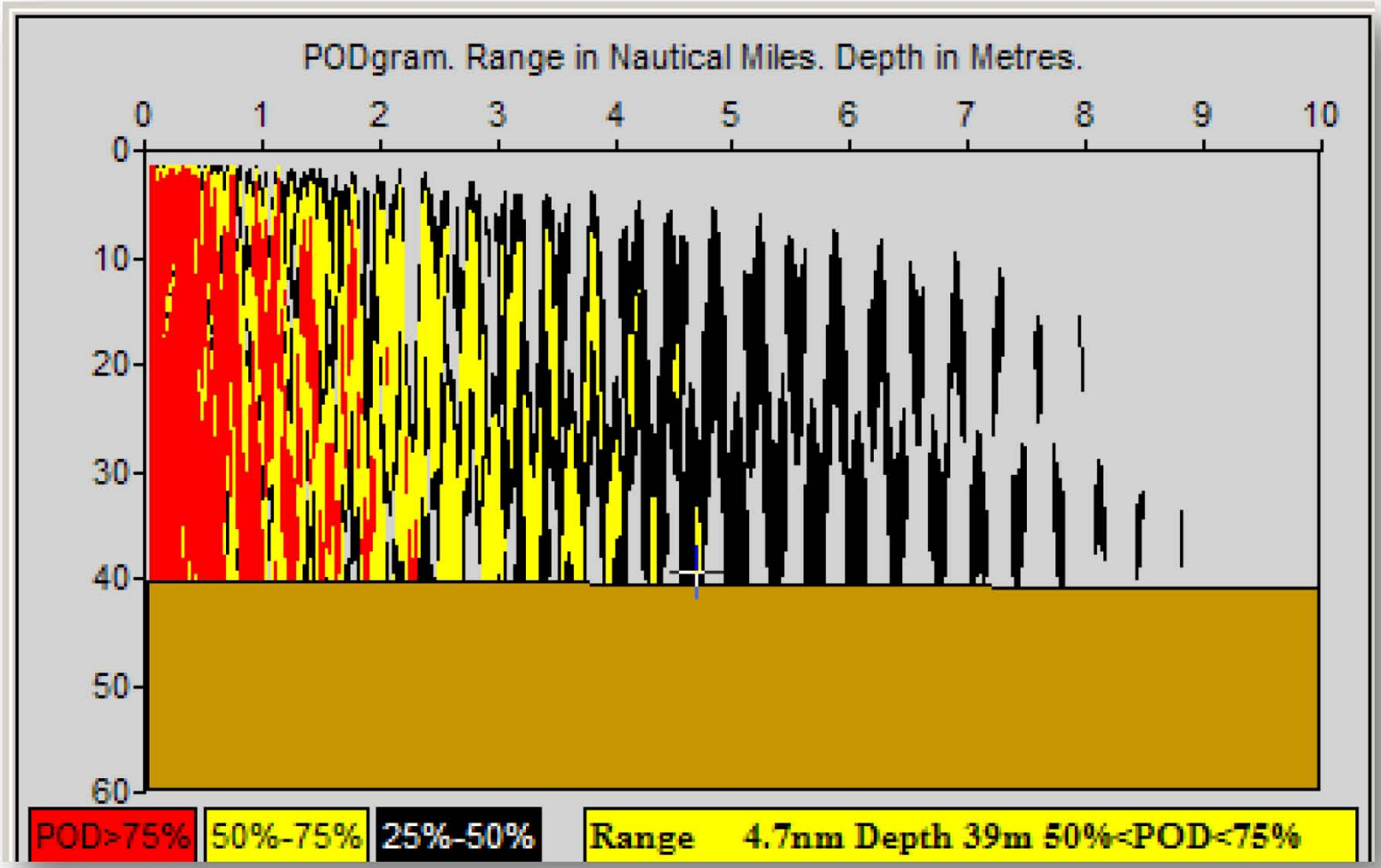


Range Prediction
100 dB Noise

155 dB Source Level, 89 – 225 Hz, 1 sec;

Sandy – silt bottom; Down-slope radial

96 dB noise → 4 nm

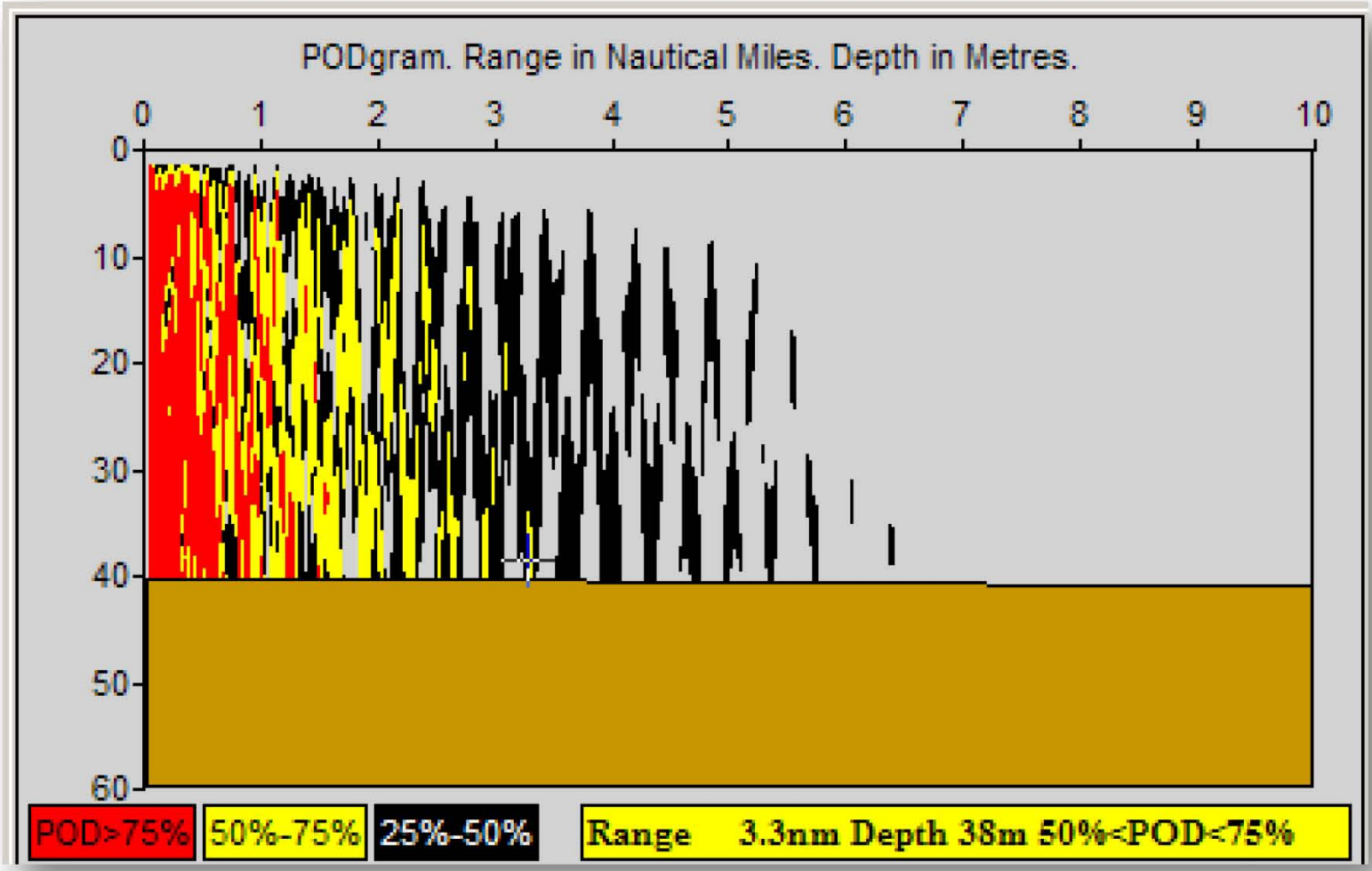


Range Prediction 103 dB noise

155 dB Source Level, 89 – 225 Hz, 1 sec;

Sandy – silt bottom; Down-slope radial

103 dB noise → 3 nm



Range Prediction 106 dB

155 dB Source Level, 89 – 225 Hz, 1 sec;

Sandy – silt bottom; Down-slope radial

106 dB noise → 2 nm