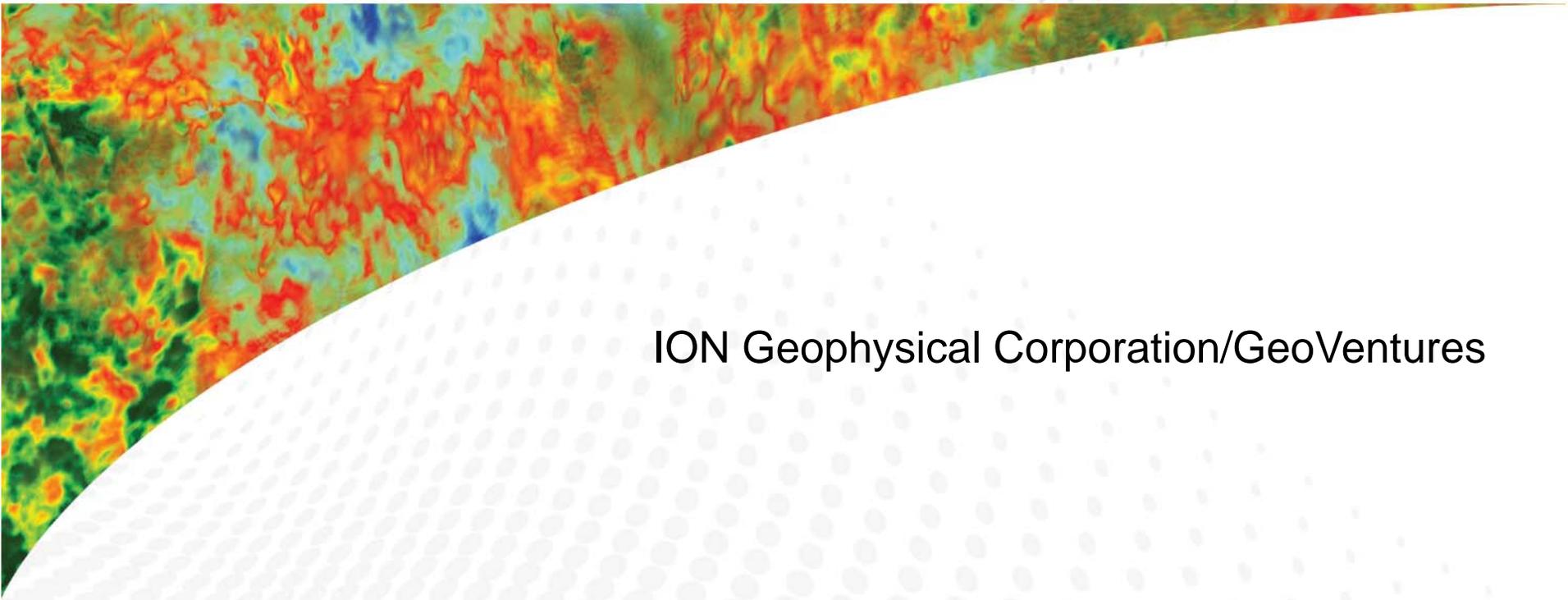




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A large, colorful geophysical data visualization, likely a seismic tomography or resistivity tomography image, showing complex patterns of red, orange, yellow, green, and blue. The image is partially obscured by a white curved shape that separates it from the text below.

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Seismic and Icebreaker Vessels Used in 2012



Geo Arctic – Seismic Vessel

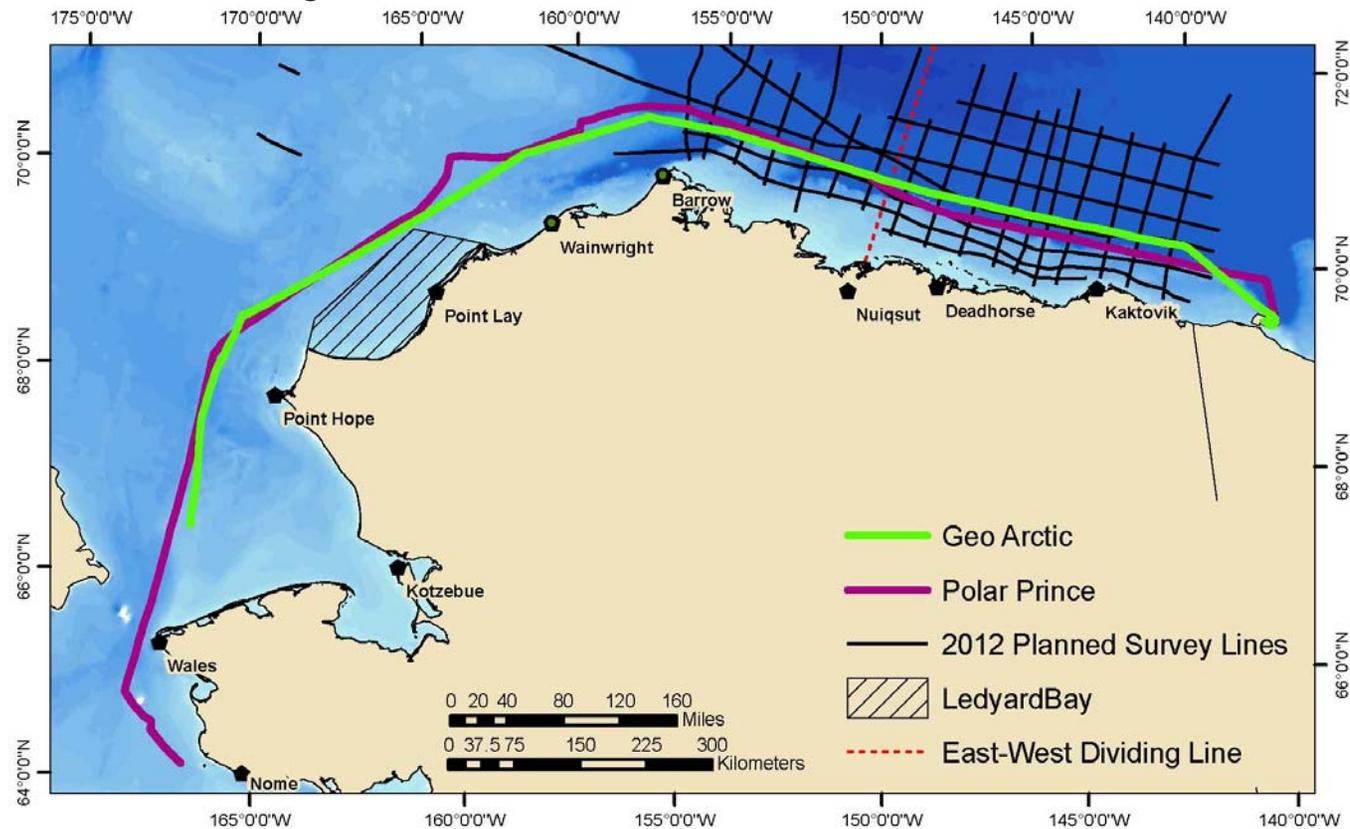
- Airgun Array
 - Permitted = 4450 in³
 - Used = 4380 in³
 - Mitigation Airgun = 70 in³



Polar Prince – Icebreaker

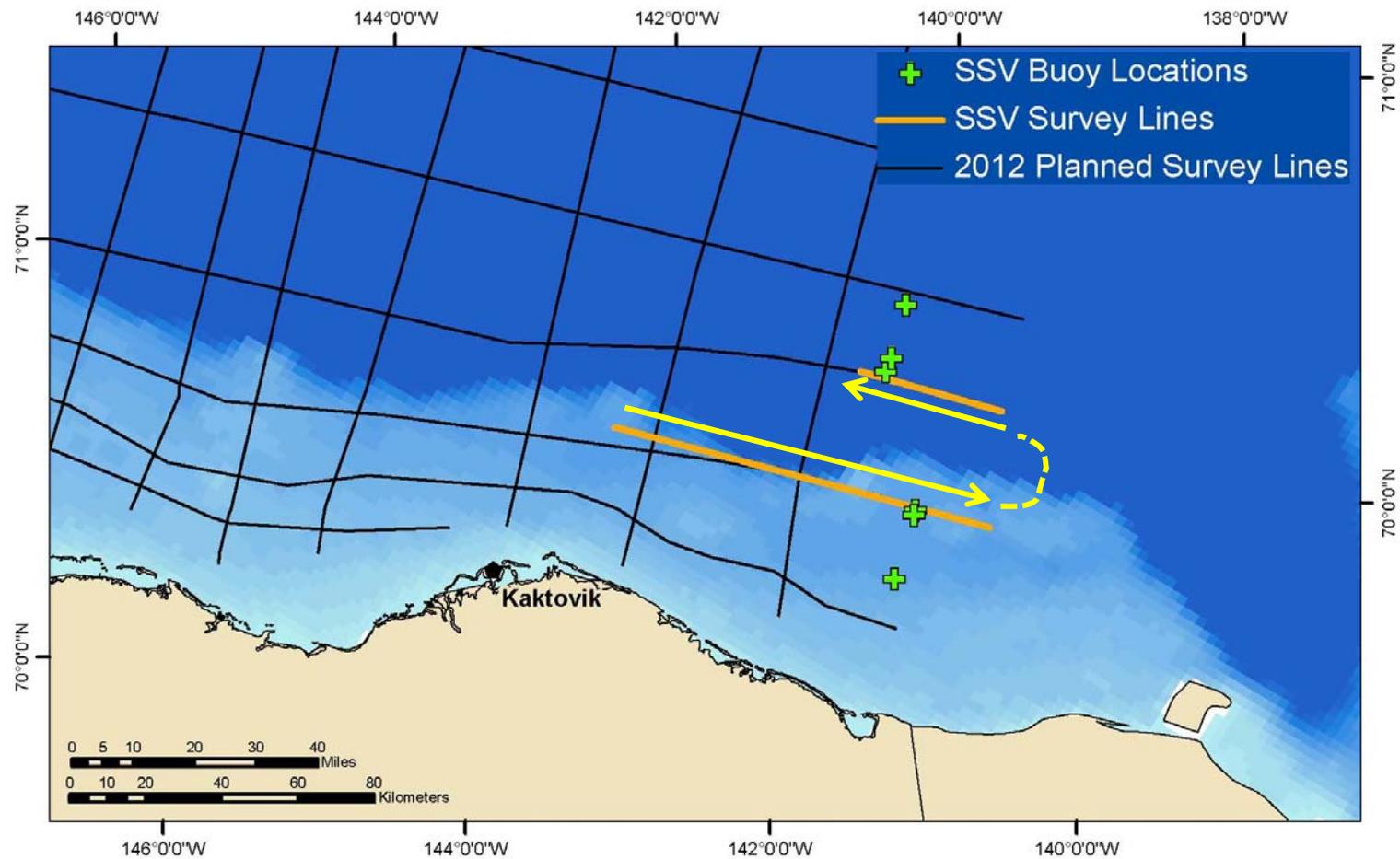
2012 Transit Timeline

- October 7 – 10th – Vessels mobilized in Nome
- October 11th – Departed Nome
- October 11-15th – Transited to Herschel Island – Remained more than 40 miles from shore during transit
- October 12th – Received BOEM G&G Permit
- October 15-18th – Took on additional fuel at Herschel Island



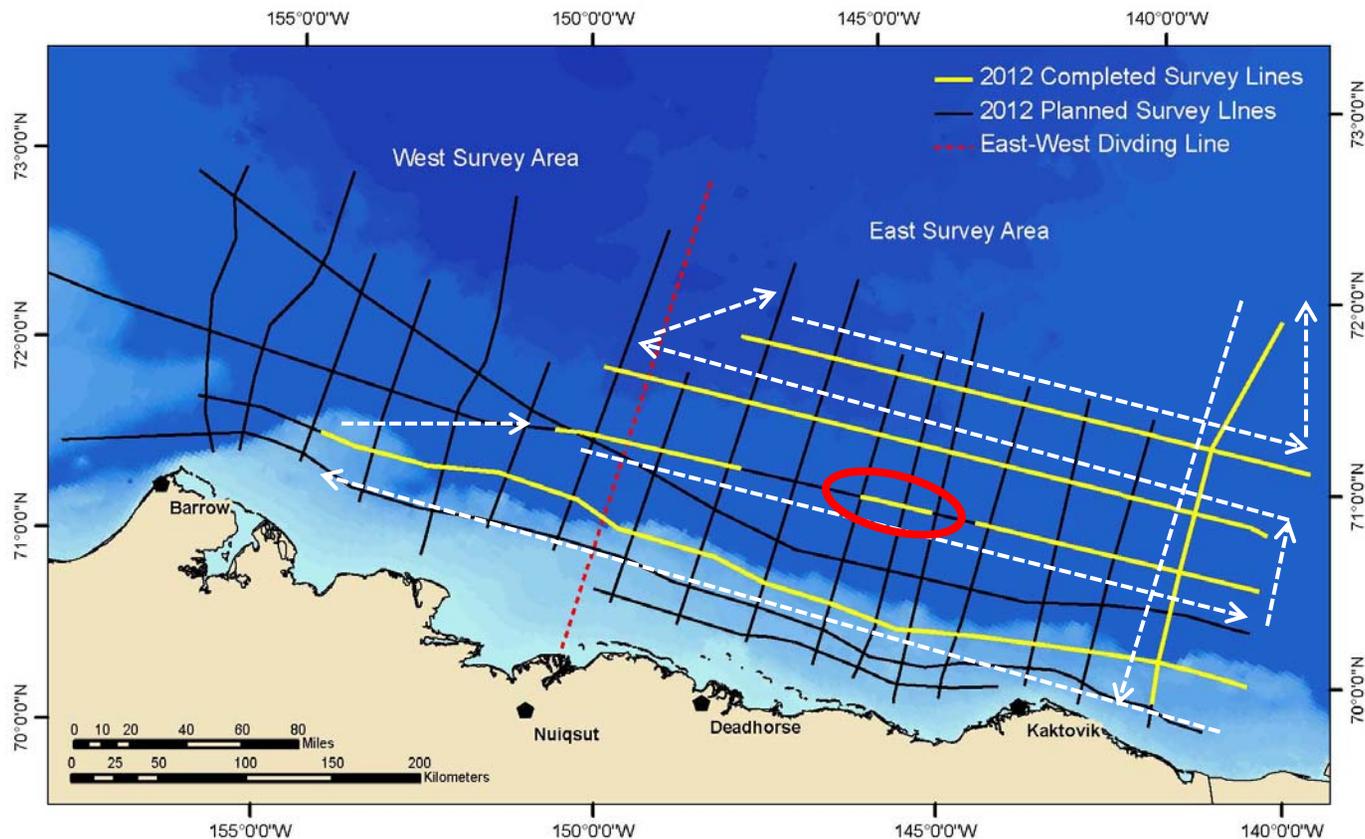
2012 SSV Location and Timeline

- October 17th – Received IHA from NMFS and LOA from USFWS
- October 19th – Transit to SSV location in Eastern U.S. Beaufort Sea
- October 20-23rd – Conducted SSV at shallow (50 m) and deep (500-1000 m) sites



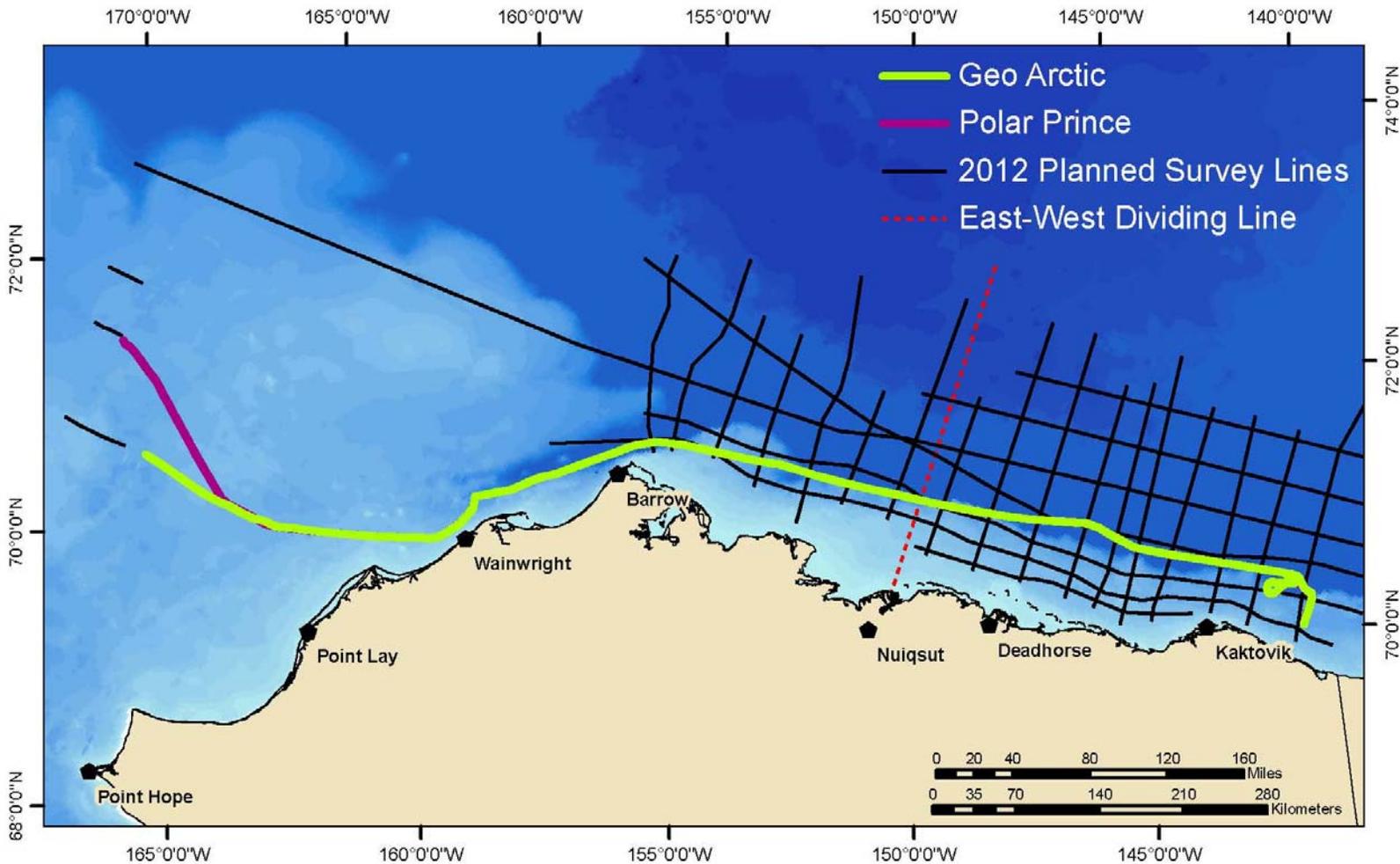
2012 Beaufort Seismic Timeline

- October 24th – Started seismic data collection
- October 30th – For ~6.5 hours the 2 “spare” airguns in the array were unintentionally fired resulting in a total discharge volume of 4880 in³ instead of the intended 4380 in³. This was reported to BOEM, NMFS and USFWS.
- November 9th – Completed seismic data collection in the Beaufort Sea



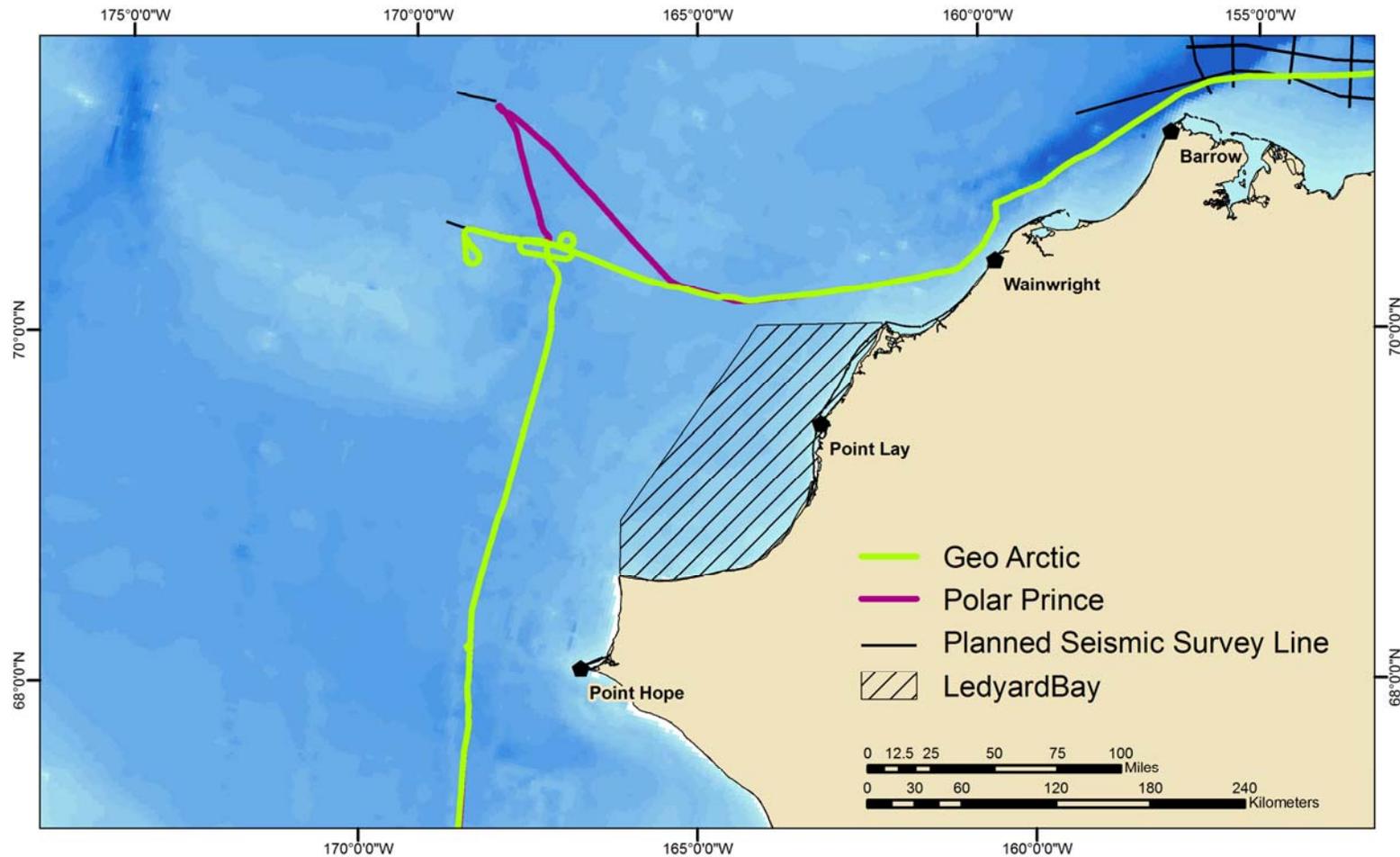
2012 Transit Timeline

- November 9-13th – Transit to Chukchi Sea.
 - Airguns and streamer cable were retrieved for the transit



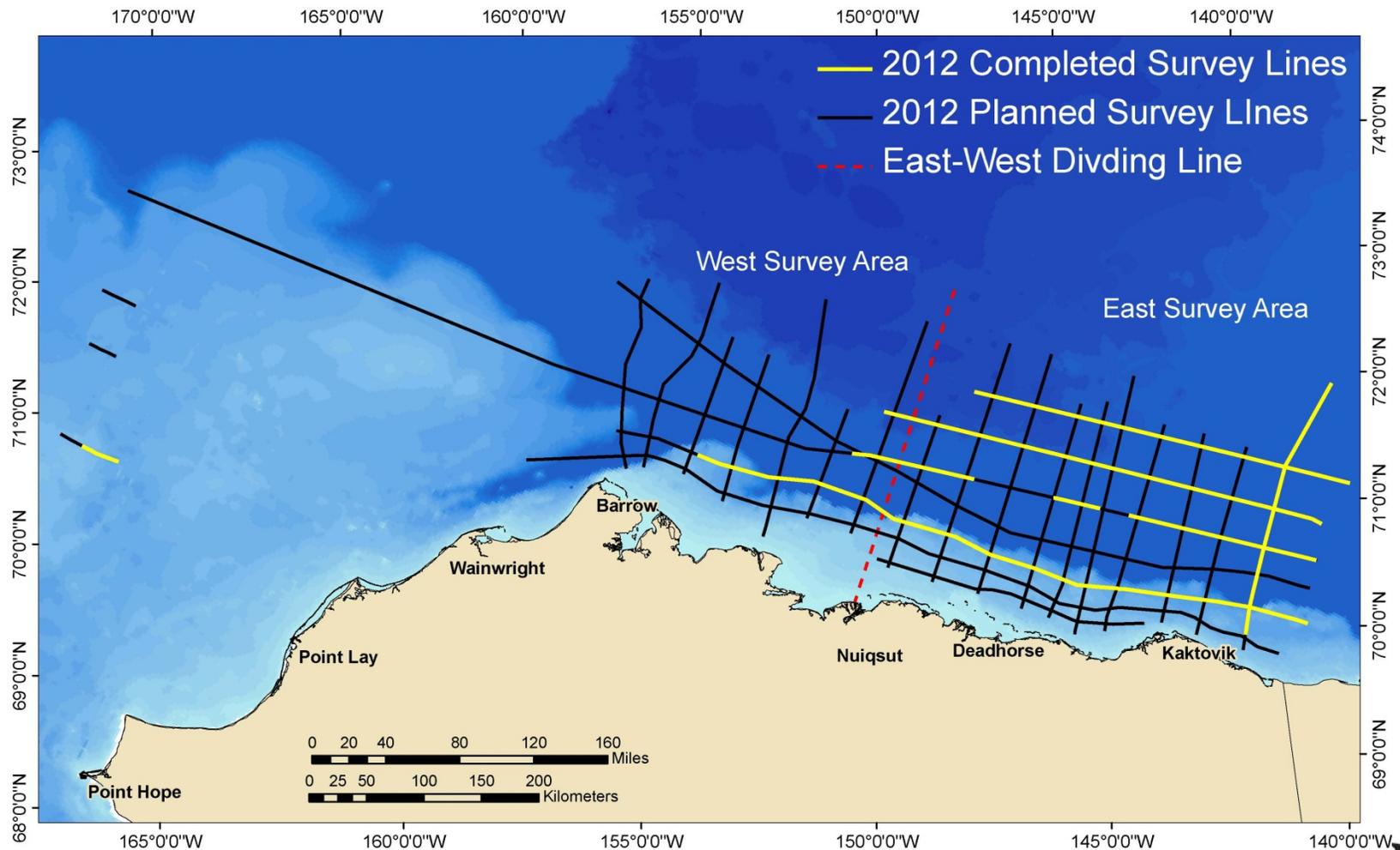
2012 Chukchi Seismic and Transit Timeline

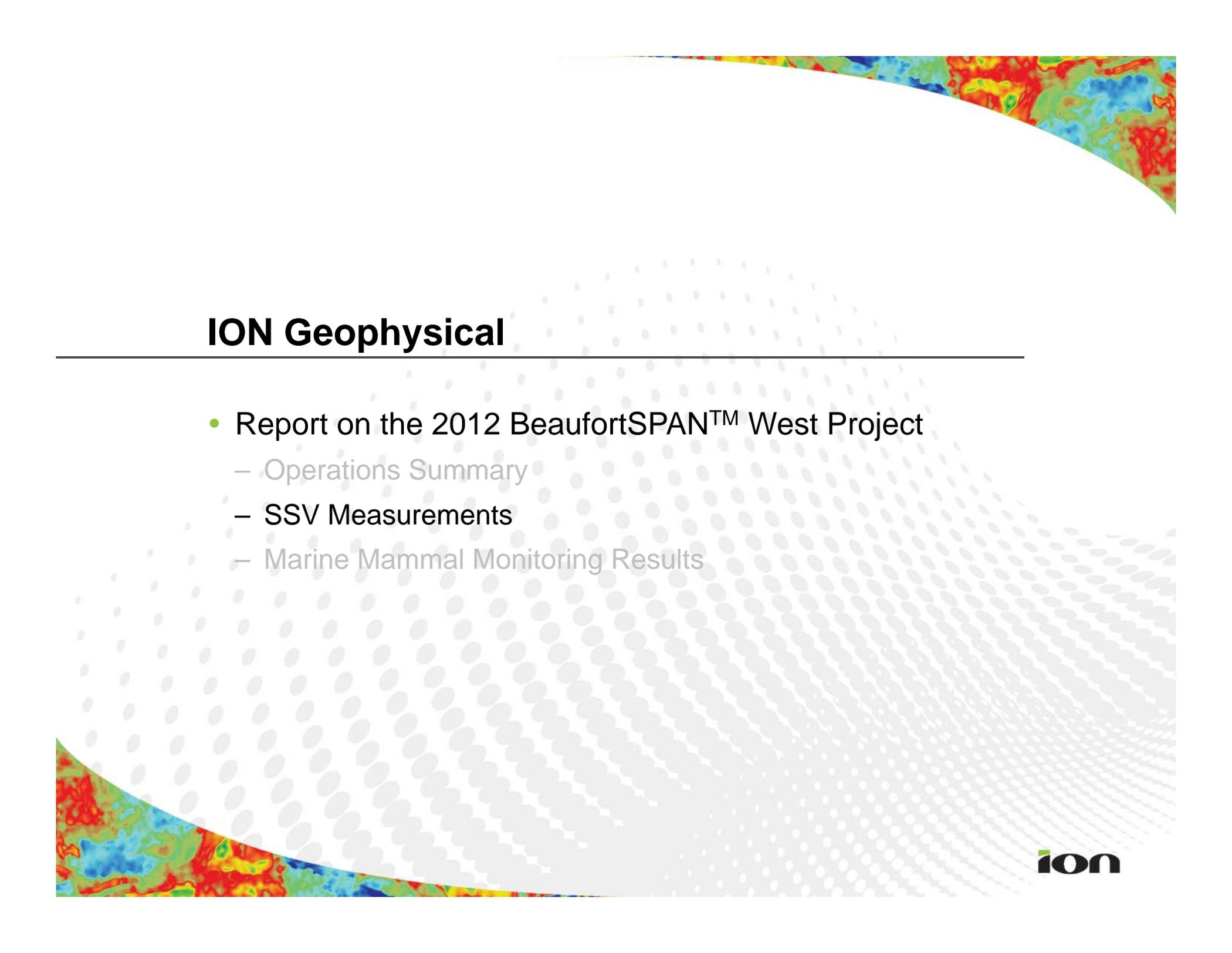
- November 14–15th – Collected seismic data in central Chukchi Sea
- November 15th – Ended seismic data collection
- November 15–20th - Transit to Dutch Harbor
- November 20th – Arrived Dutch Harbor and demobilized vessels



2012 Seismic Survey Line Completed

- 7,242 km of transect lines were planned in 2012
- A total of 1,844 km transect lines were surveyed (25%)



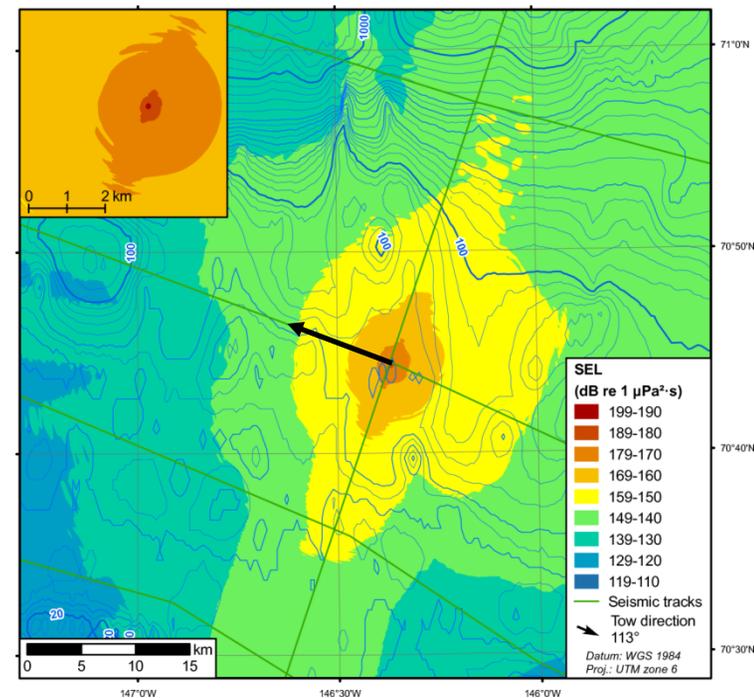


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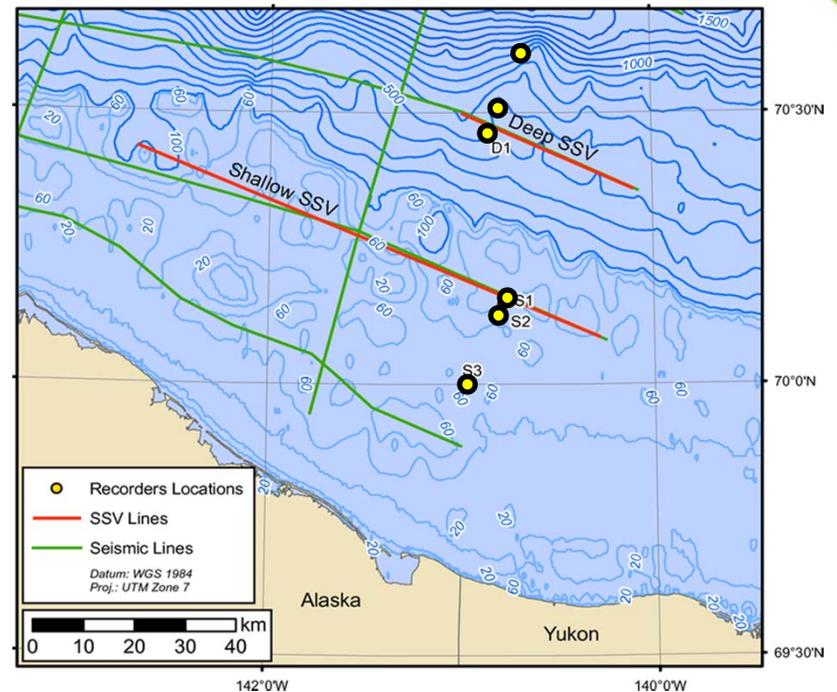
Sound Source Verification

- Purpose is to verify through field measurements the zones surrounding the airgun array over which sound levels remain above potential effects thresholds
- Thresholds applied by NMFS for this project were:
 - Level-A takes
 - cetaceans: ≥ 180 dB re 1 μPa
 - pinnipeds: ≥ 190 dB re 1 μPa
 - Level-B takes
 - all: ≥ 160 dB re 1 μPa (rms)
- Model-based estimates of the threshold distances are used until the SSV measurements are available

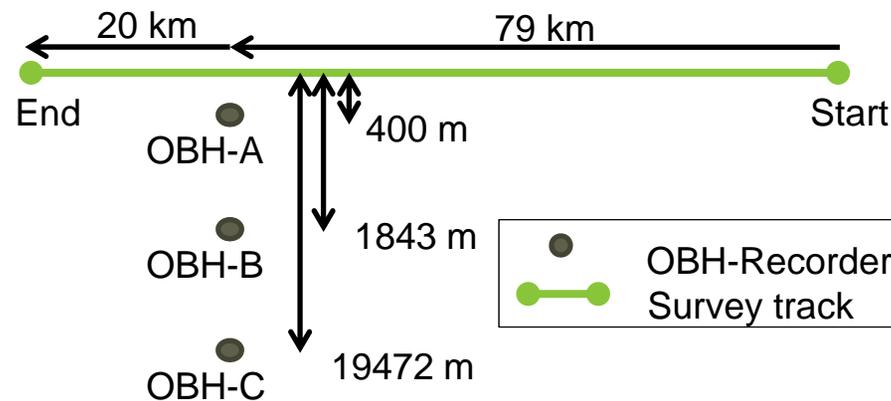
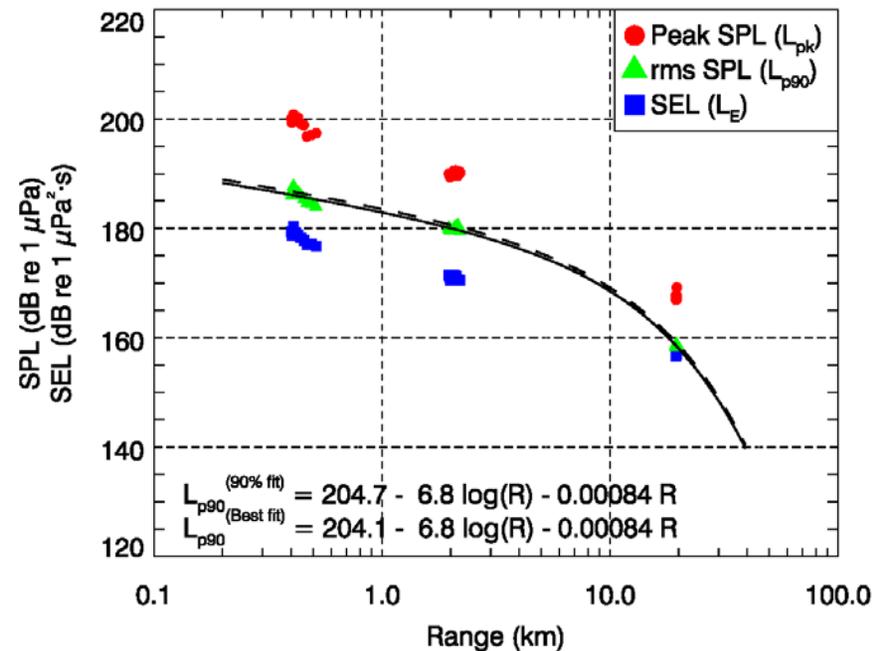
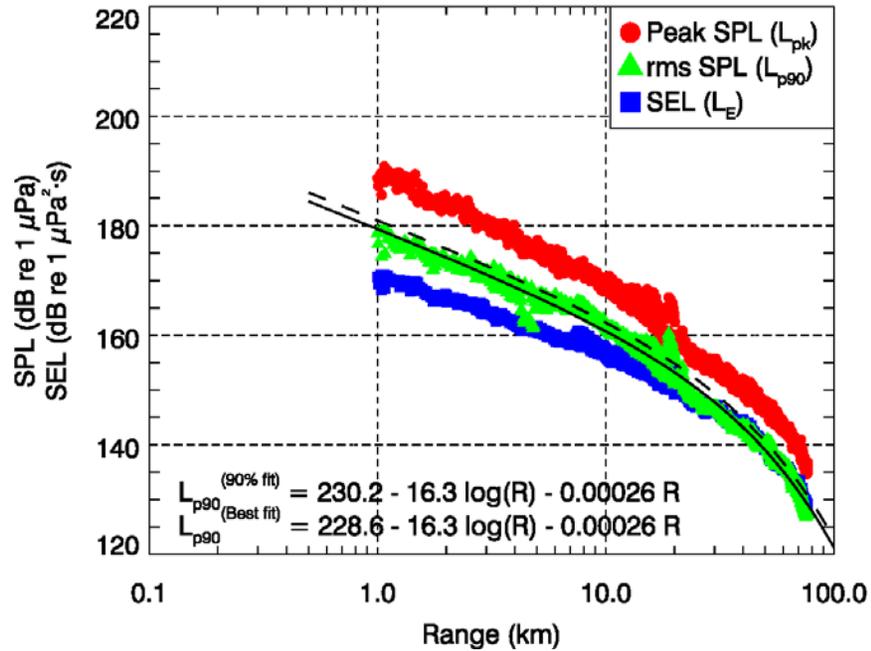


Measurement Locations and Geometry

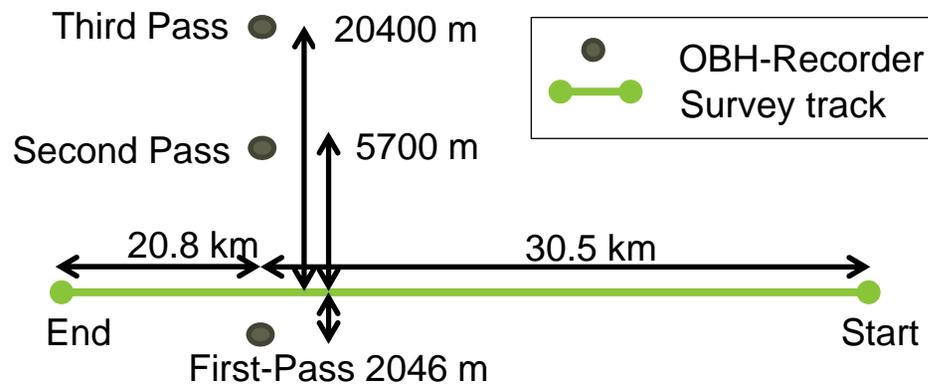
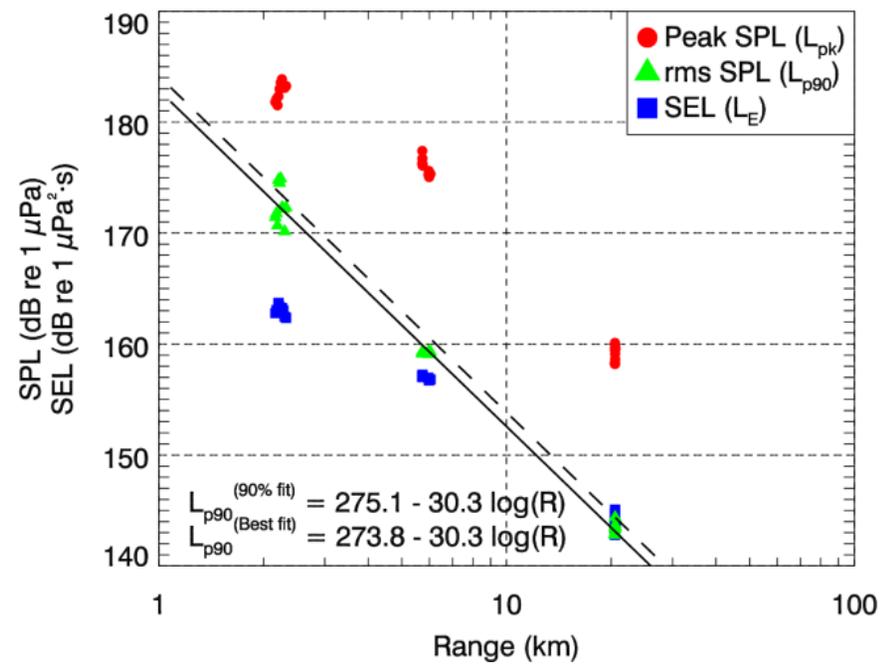
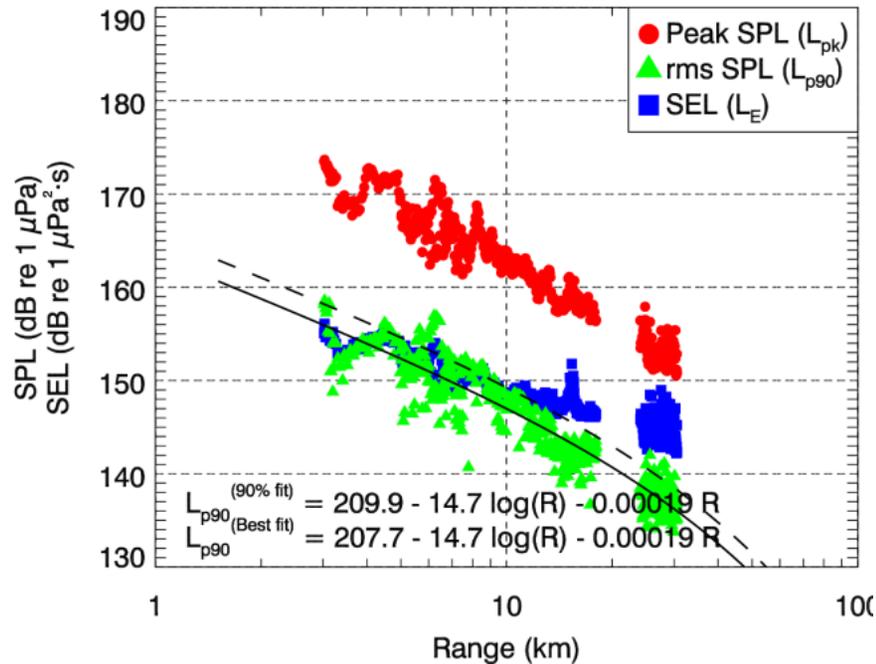
- Sound propagation is strongly influenced by water depth in water less than a few hundred meters
- SSV measurements were performed at the eastern end of ION's survey lines, in 50 m (shallow) and 500 m (deep) water depths
- Shallow-site acoustic recorders were deployed on the seabed at three distances off the survey line
- A deep-site acoustic recorder was suspended at 50 m depth beneath a surface float. Three separate seismic survey passes were made with a different distance sampled each pass



Shallow-Site Measurements (4380 in³ airgun array)



Deep-Site Measurements (4380 in³ airgun array)



Measured Threshold Radii

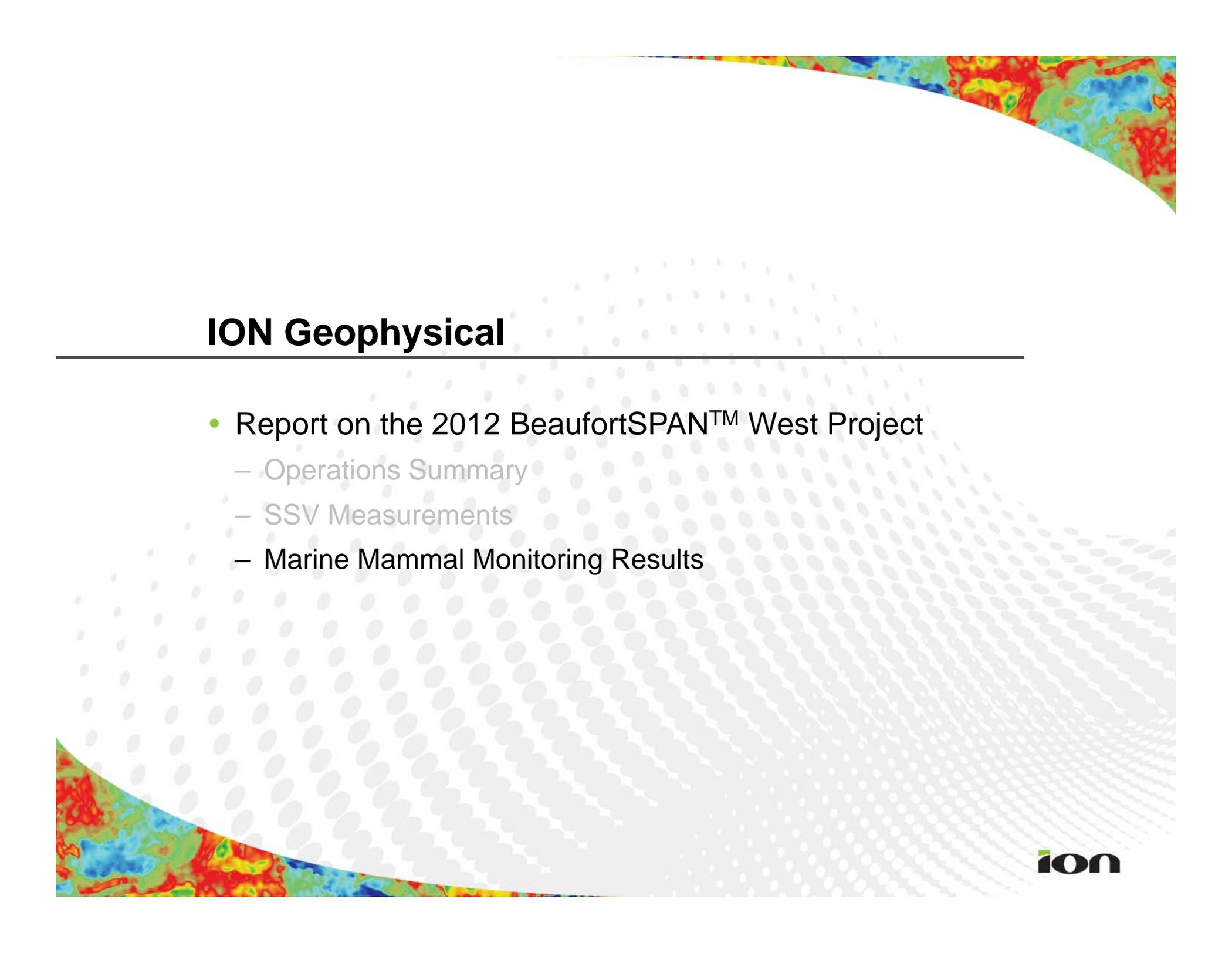
- Threshold radii distances based on 90th percentile fits
- The reported values are the maxima of broadside and endfire (forward and aft) measurements

Received Sound Level (dB re 1µPa rms)	Distance to Threshold Level (m)		
	Final Results		
	Water Depth (m)		
	<100	100-1000	>1000
190	287	395	395
180	2,290	1,250	1,250
160	18,700	6,260	6,260
120	109,000	131,000	131,000

Comparison of Threshold Radii

- During preparation of the 90-day report we noticed an error in the field report values at the shallow site for the 190 and 180 dB re 1 μ Pa sound threshold radii.
- The field report levels were too low. As a result, the exclusion zones implemented by PSO's during surveys in water depths below 100 m were too small.

Received Sound Level (dB re 1 μ Pa rms)	Distance to Threshold Level (m)					
	Field Results			Final Results		
	Water Depth (m)			Water Depth (m)		
	<100	100-1000	>1000	<100	100-1000	>1000
190	210	420	420	287	395	395
180	832	1,300	1,300	2,290	1,250	1,250
160	17,450	6,000	6,000	18,700	6,260	6,260
120	105,000	91,000	91,000	109,000	131,000	131,000

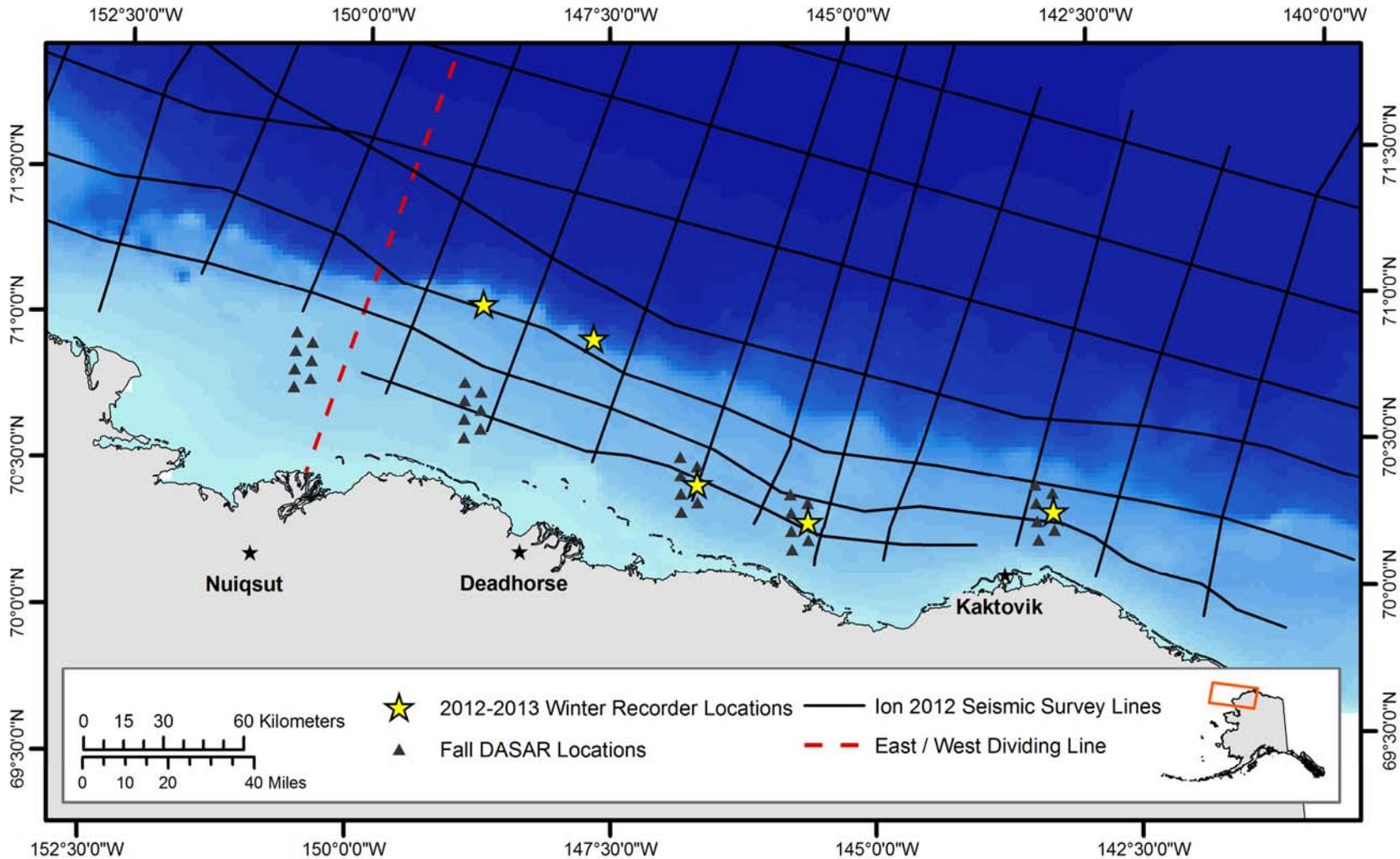


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Other Acoustic Monitoring

- Over-winter recorders deployed in the Beaufort Sea



Other Acoustic Monitoring

- Over-winter recorders deployed in the Beaufort Sea
 - Deployed October 3-7
 - Will be retrieved in July or August of 2013

- Seismic streamer noise records
 - Intended to look at vessel sounds produced when working in various ice conditions
 - They were collected throughout the survey period
 - Currently being analyzed by Greeneridge Sciences

Marine Mammal Monitoring

- PSO on both vessels
 - 5 PSOs on *Geo Arctic*
 - 4 PSOs on *Polar Prince*
- Area around source vessel was monitored by PSOs for 30 minutes prior to airgun start
- Ramp-up procedures were used
- Power down and shut down procedures for marine mammals within safety radii were in place.
 - No marine mammals were observed within field-season safety zones during seismic activity

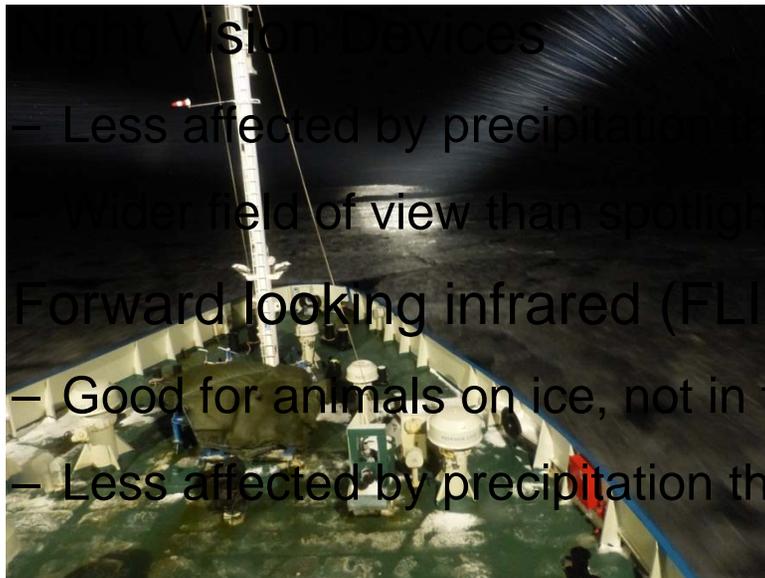


Marine Mammal Monitoring Tools

- Big-eye binoculars on *Polar Prince*
 - Used on 8 of 39 Days (20%)
- Use of large spotlights for monitoring
 - Primarily used for ice scouting by vessel crew
 - Narrow field of view, but out to 1 km
 - One polar bear detected

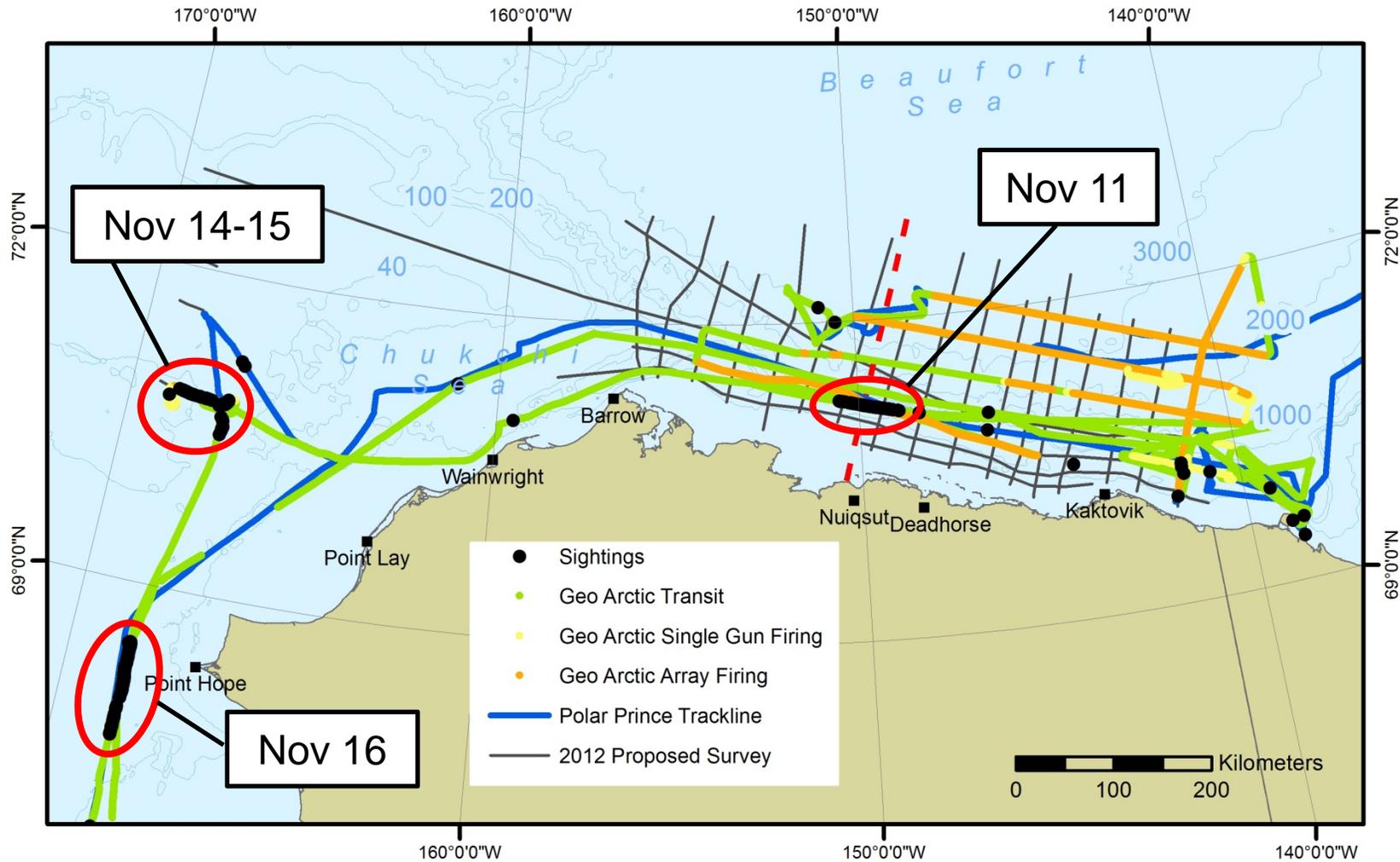


- Night vision devices (NVDs)
 - Less affected by precipitation than spotlights
 - Wider field of view than spotlights
- Forward looking infrared (FLIR) camera on *Polar Prince*
 - Good for animals on ice, not in the water (except walrus)
 - Less affected by precipitation than NVDs



Marine Mammal Observations

- All Sightings



Marine Mammal Observations

- All Sightings by Location

Species	Beaufort Sea		Chukchi Sea		Total	
	Sightings	Individuals	Sightings	Individuals	Sightings	Individuals
Odontocetes						
Beluga	1	125	0	0	1	125
Mysticetes						
Bowhead whale	0	0	39	86	39	86
Unidentified M. Whale	1	1	2	4	3	5
Pinnipeds						
Ringed seal	25	101	18	26	43	127
Unidentified Seal	72	81	85	140	157	221
Bearded seal	8	9	26	84	34	93
Walrus	0	0	179	1728	179	1728
Unidentified Pinniped	0	0	2	5	2	5
Fissiped						
Polar Bear	0	0	13	14	13	14

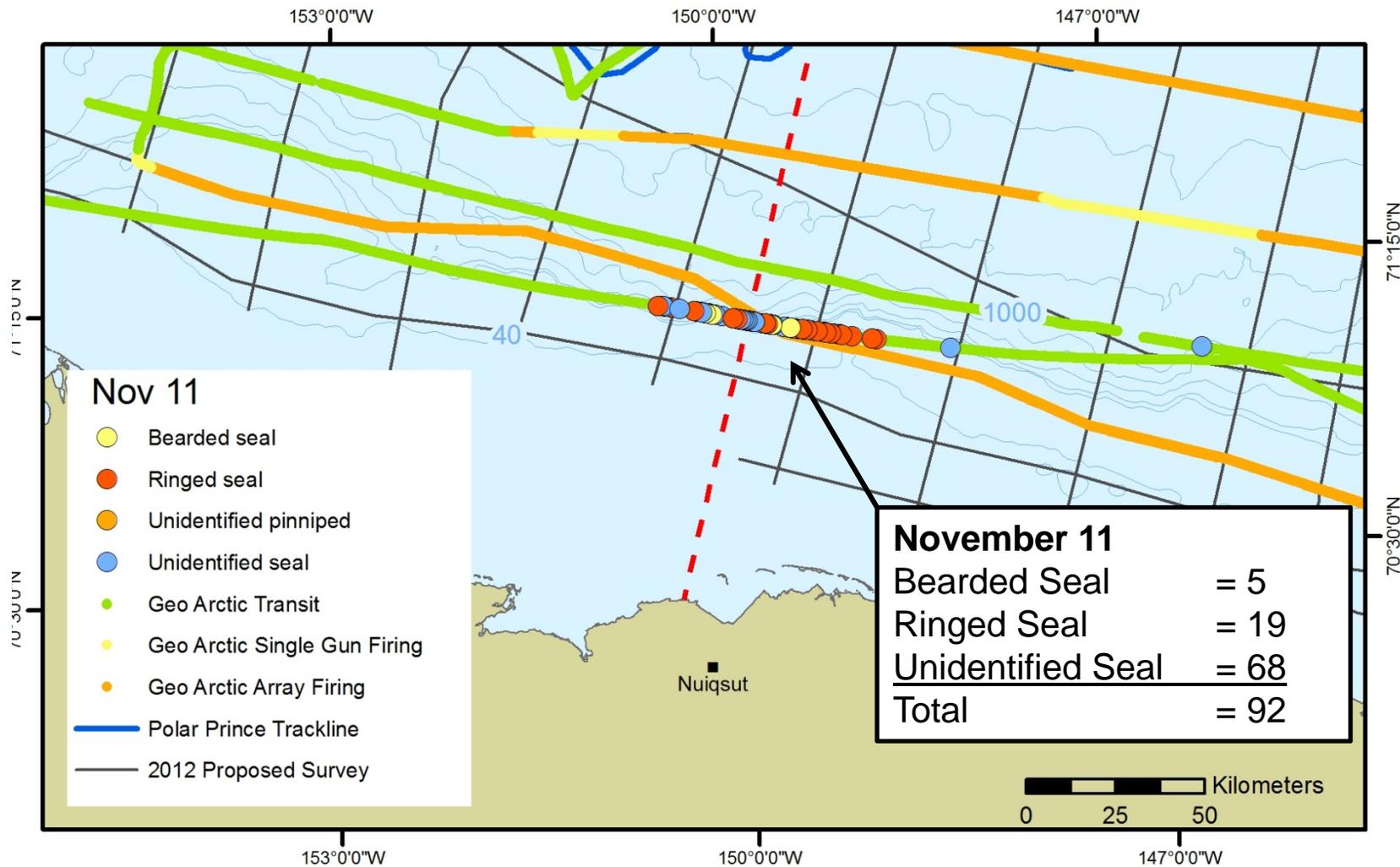
Nov 14 & 15

Nov 11

Nov 16

Marine Mammal Observations

- Beaufort Sea Sightings



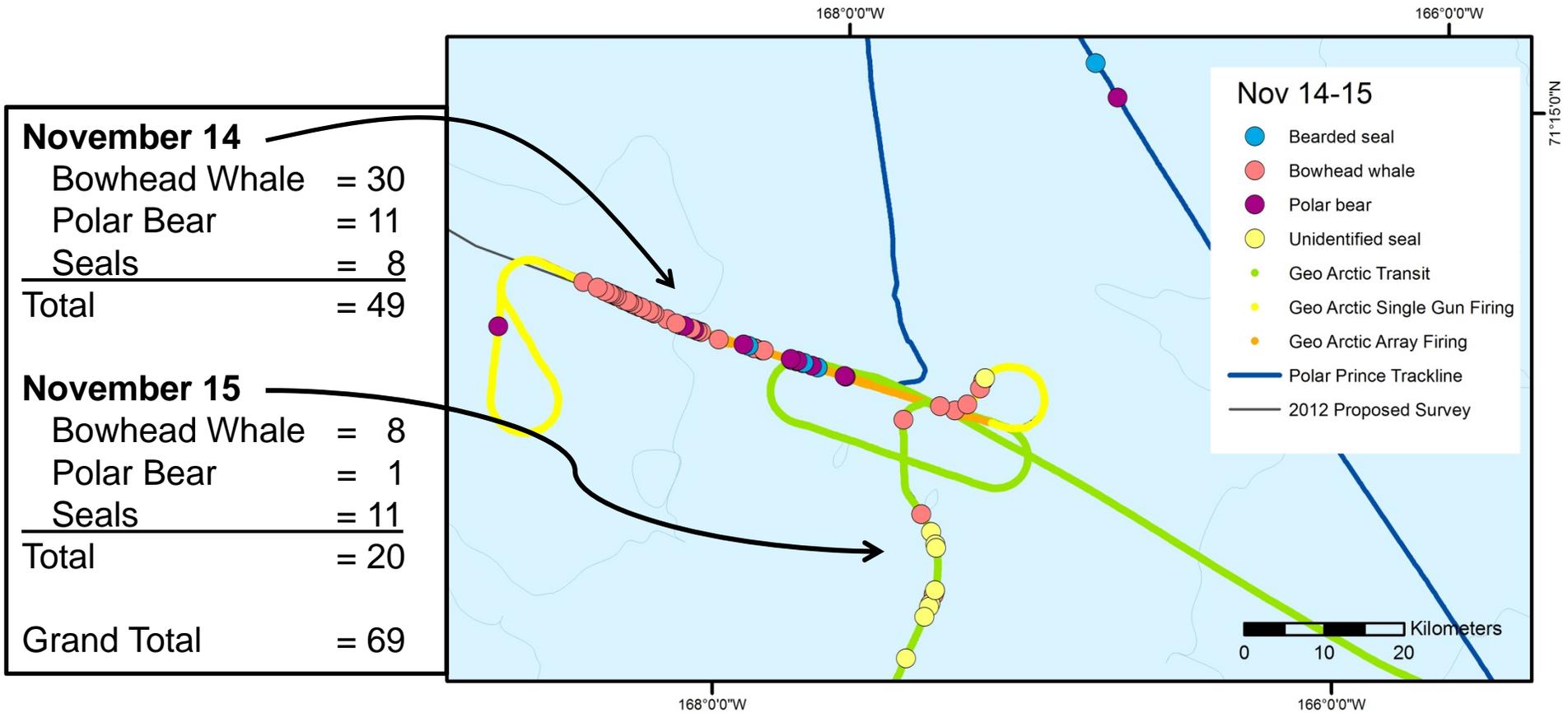
Marine Mammal Observations

- Beaufort Sea Sighting Conditions



Marine Mammal Observations

- Chukchi Sea Sightings



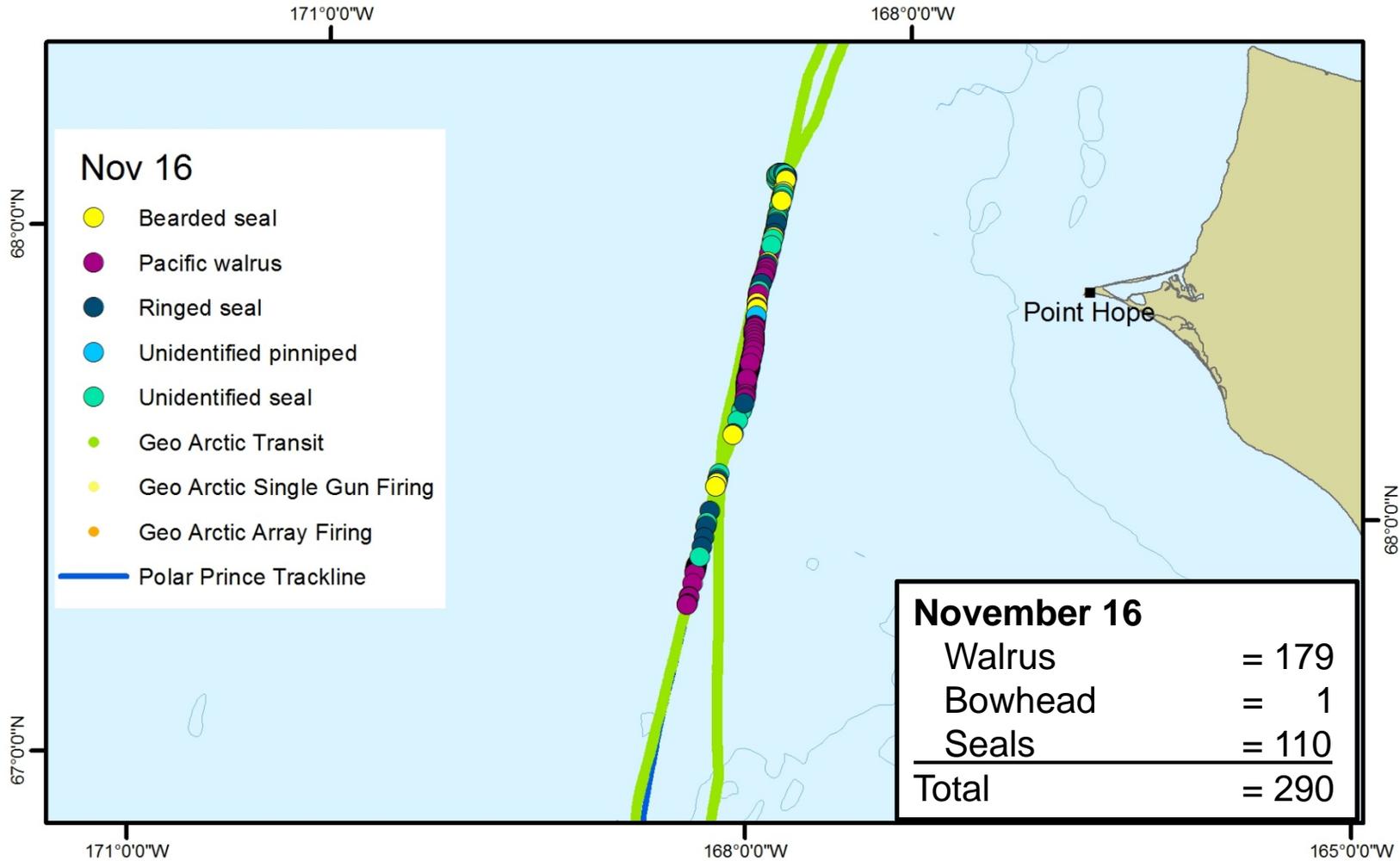
Marine Mammal Observations

- Chukchi Sea Sighting Conditions



Marine Mammal Observations

- Chukchi Sea Sightings



Marine Mammal Observations

- Chukchi Sea Sighting Conditions

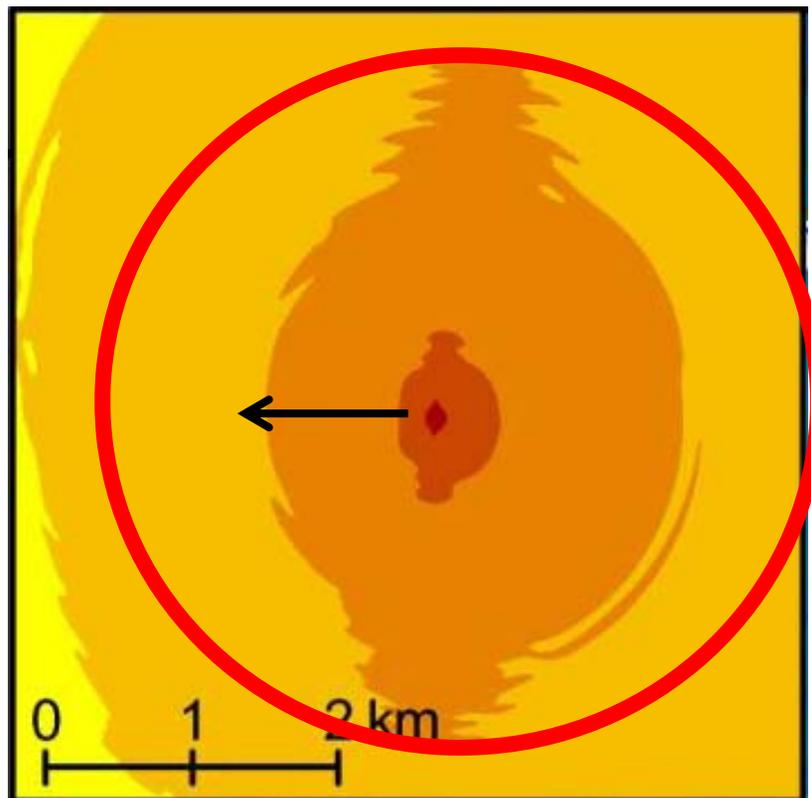


Bowhead Whales Exposed to Seismic Sounds >180 dB

- November 14th
 - Full airgun array operated throughout the daylight period
 - 30 bowhead whale sightings of 64 individual whales
 - Closest distance of whales to the airguns ranged from 870 m to 6,000 m
- Safety Zones
 - The 180 dB safety zone was 832 m
 - However, final analysis of the airgun measurements determined the 180 dB safety zone should have been 2,290 m
- 7 Bowhead sightings of 10 individuals occurred within 2,290 m
 - Received sound levels at these animals likely varied between
 - 176.3 and 182.2 dB SPL (rms)
 -

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- 180 dB Safety Zone



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- 7 Bowhead sightings of 10 individuals occurred within 2,290 m
 - Received sound levels at these animals likely varied between
 - 176.3 and 182.2 dB SPL (rms)
 - M-weighted cumulative SEL (CSEL) injury threshold analysis

M-Weighting Analysis

- 10 bowheads may have been exposed to sound levels near or slightly above 180 dB re 1 μ Pa. These exposures were evaluated using a newer criteria for level-A take.
- An expert panel developed alternate noise exposure criteria specifically for evaluating marine mammal takes. They published a preliminary set of recommendations in 2007

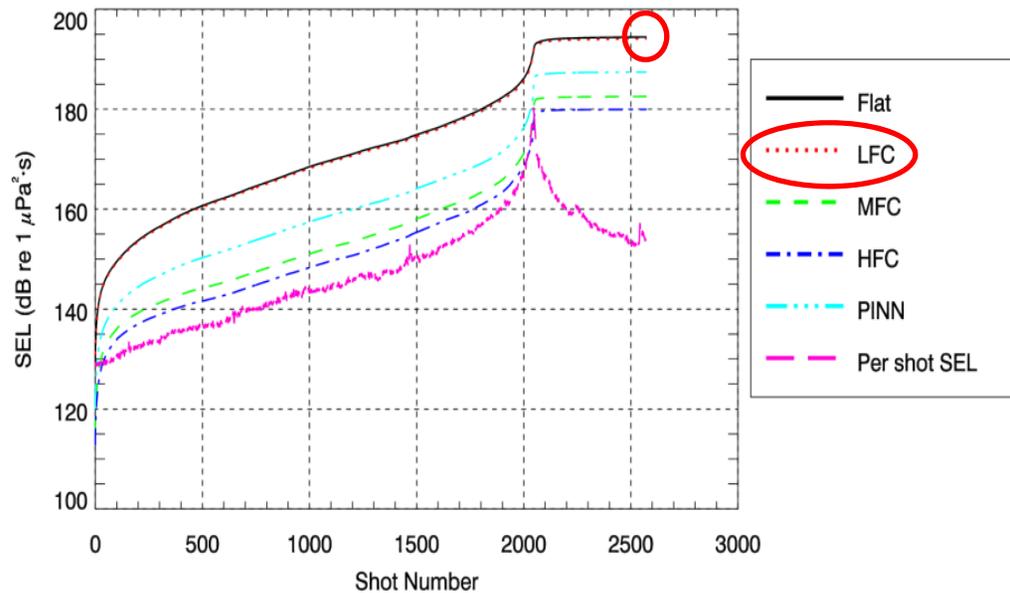
Southall et al., (2007) Marine Mammal Noise Exposure Criteria: Initial Scientific Recommendations. Aquatic Mammals, Volume 33, Number 4

- The recommendation for level-A takes suggests using Sound Exposure Level (SEL) criterion instead of the root-mean-square criterion. The new thresholds also account for specific hearing sensitivities of the exposed species (M-weighting)

Cumulative M-Weighted SEL

- Cumulative M-weighted SEL was computed over the entire SSV track from all airgun impulses received at each of the three recorders

400 m recorder



Distance off seismic survey line	Cumulative SEL (dB re 1 $\mu\text{Pa}^2\cdot\text{s}$)				
	Flat-Weighted	Low Frequency Cetaceans	Mid-Frequency Cetaceans	High Frequency Cetaceans	Pinnipeds Underwater
400 m	194.4	194.1	182.5	180.0	187.4
1844 m	190.9	190.5	179.2	176.7	183.9
19479 m	183.1	183.0	174.8	172.0	179.4

Cumulative SEL Threshold Distances for Level-A take

Hearing Group	cSEL Threshold M-Weighted	Distance to threshold
Low-Freq Cetaceans	198 dB re 1 $\mu\text{Pa}^2 \text{ s}$	114 m
Mid-Freq Cetaceans	198 dB re 1 $\mu\text{Pa}^2 \text{ s}$	N/A
High-Freq Cetaceans	198 dB re 1 $\mu\text{Pa}^2 \text{ s}$	N/A
Pinnipeds	186 dB re 1 $\mu\text{Pa}^2 \text{ s}$	735 m

Marine Mammals Observed within Safety Radii

- Direct observations within final safety zone radii

Cetaceans ≥180	Seals ≥190	Polar Bears ≥190	Pacific Walrus ≥180
10	0	0	0

- Safety zone distances

Received Sound Level (dB re 1µPa rms)	4380 in ³ Array			70 in ³ Airgun		
	Water Depth (m)			Water Depth (m)		
	<100	100-1000	>1000	<100	100-1000	>1000
190	287	395	395	24	23	23
180	2,290	1,250	1,250	94	74	74

Marine Mammals Observed within Disturbance Radii

- Direct observations within final 160 dB radii

Number of Individuals Observed within 160 dB re 1 μ Pa (rms)			
Cetaceans	Seals	Polar Bears	Pacific Walruses
64	2	0	0

- Disturbance zone distances

Received Sound Level (dB re 1 μ Pa rms)	4380 in ³ Array			70 in ³ Airgun		
	Water Depth (m)			Water Depth (m)		
	<100	100-1000	>1000	<100	100-1000	>1000
160	18,700	6,260	6,260	1,360	741	741

Estimated Numbers within Disturbance Radii

- *Estimated* numbers of marine mammals *potentially* exposed to seismic sounds ≥ 160 dB re $1\mu\text{Pa}$ (rms) in the Beaufort Sea
- Based on densities calculated during Seismic and Non-seismic periods in the Beaufort Sea

Species	Estimated No. Individuals						Requested Take	
	Seismic Densities			Non-seismic Densities			Mean	Max
	Mean	LCL	UCL	Mean	LCL	UCL		
Cetaceans								
Bowhead Whale	0	--	--	0	--	--	285	1,136
Unid. Mysticete Whale	0	--	--	36	14	100	--	--
Total Cetaceans	0	--	--	36	14	100	5,404	22,435
Seals								
Ringed Seal	0	--	--	548	177	1,686	60,574	91,244
Bearded Seal	0	--	--	131	9	1,945	93	377
Unid. Seal	0	--	--	430	145	1,261	--	--
Total Seals	0	--	--	1,110	457	2,690	60,711	91,807

Estimated Numbers within Disturbance Radii

- *Estimated* numbers of marine mammals *potentially* exposed to seismic sounds ≥ 160 dB re $1\mu\text{Pa}$ (rms) in the Chukchi Sea
- Based on densities calculated during Seismic and Non-seismic periods in the Chukchi Sea

Species	Estimated No. Individuals						Requested Take	
	Seismic Densities			Non-seismic Densities			Mean	Max
	Mean	LCL	UCL	Mean	LCL	UCL		
Cetaceans								
Bowhead Whale	3,233	1,365	7,658	174	67	454	285	1,136
Total Cetaceans	3,233	1,365	7,658	174	67	454	5,404	22,435
Seals								
Ringed Seal	0	--	--	0	--	--	60,574	91,244
Bearded Seal	0	--	--	0	--	--	93	377
Unid. Seal	0	--	--	3,257	1,422	7,461	--	--
Unid. Pinniped	1,053	804	1,380	0	--	--	--	--
Total Seals	1,053	804	1,380	3,257	1,422	7,461	60,711	91,807

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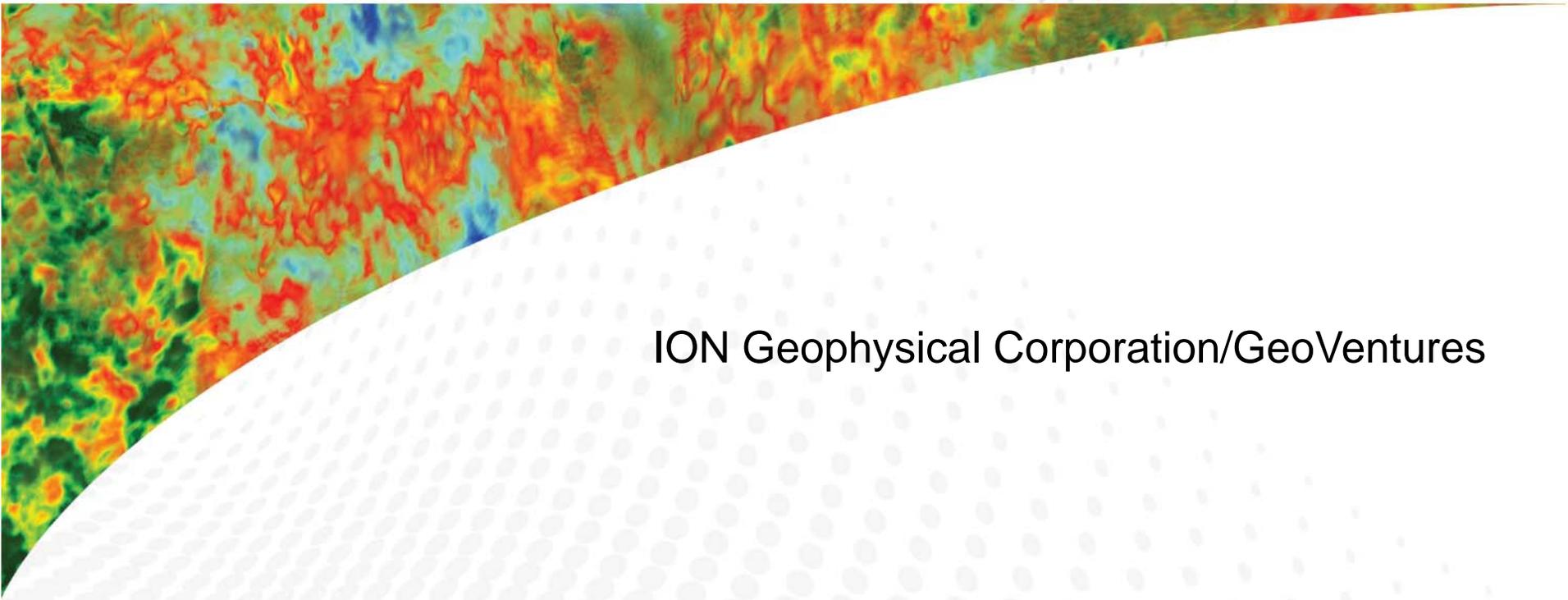
- ION does not plan to operate in 2013
- Questions?





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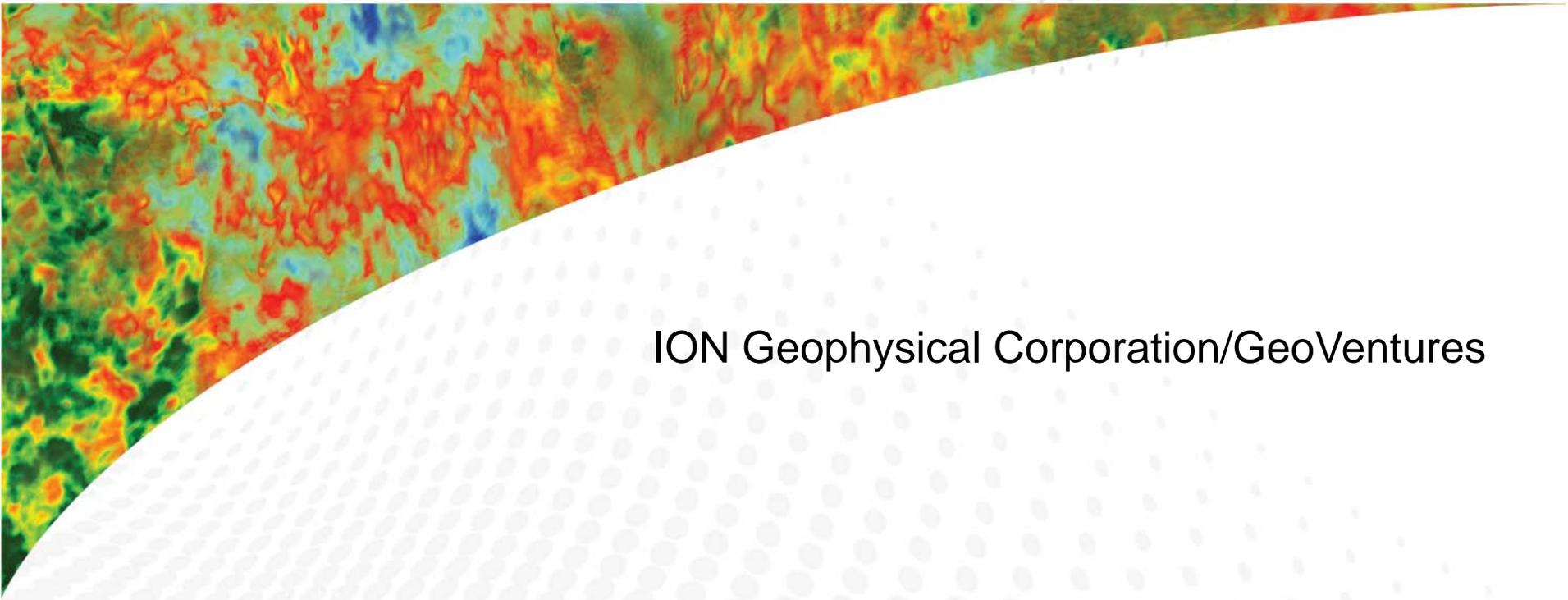
A large, colorful geophysical data visualization, likely a seismic tomography or resistivity map, showing complex patterns of red, orange, yellow, green, and blue. The image is partially obscured by a white curved graphic element that sweeps across the bottom of the slide.

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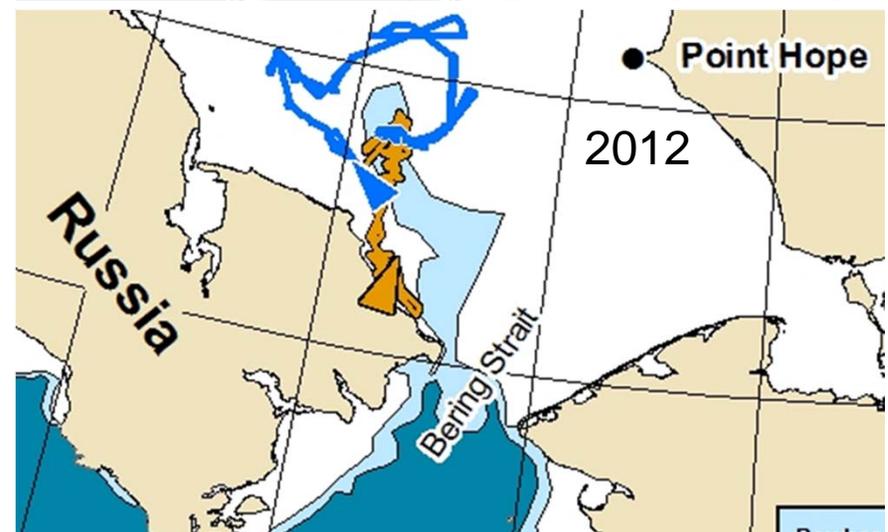
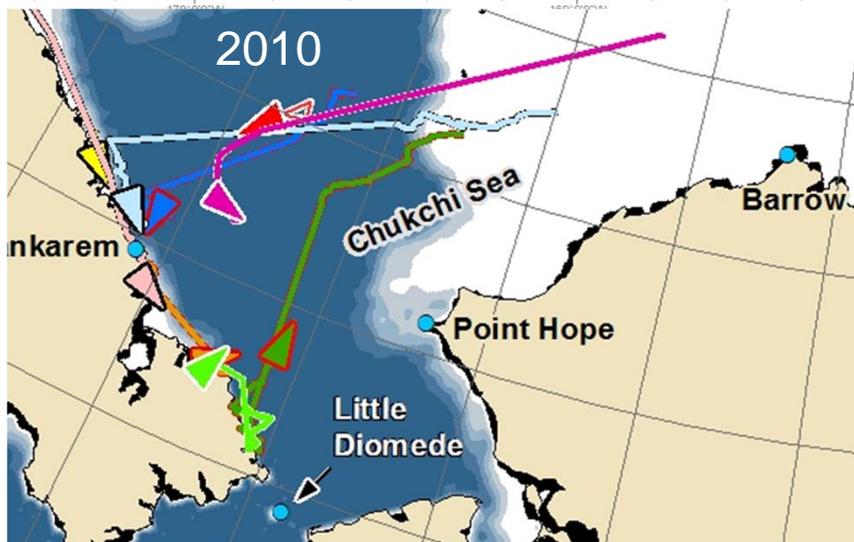
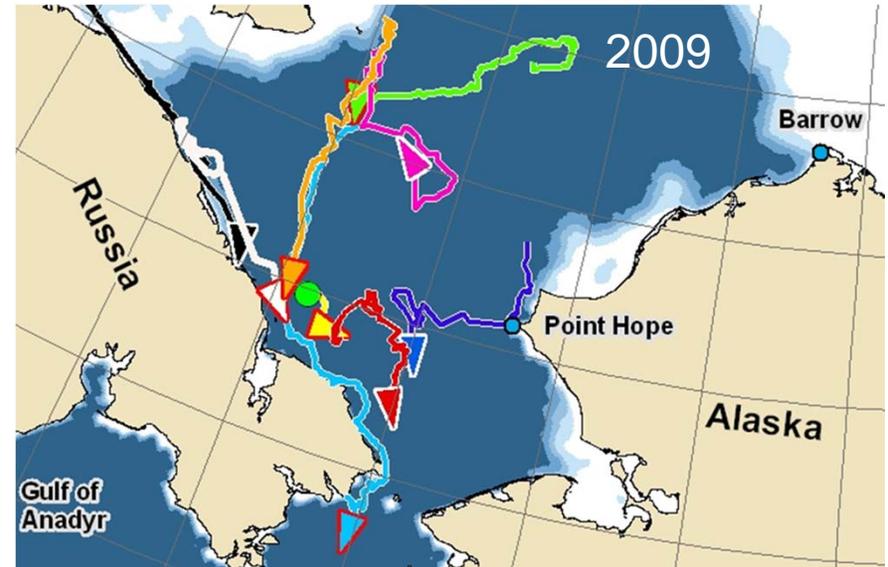
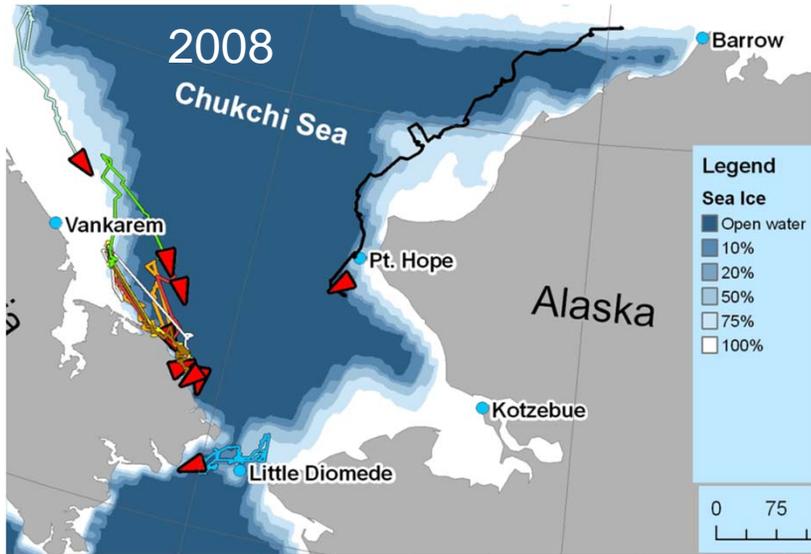
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November Bowhead Locations from GPS-Satellite Tags

- Mid- November Satellite Tagged Bowhead Locations



Comparison of FLIR and NVD Observation Effort

Device and Precipitation Type	Effort (km)	Number of Sightings	Mean Visibility Distance (m)	Visibility Range (m)	Mean Light Intensity (fc)	Mean Cloud Cover (%)
<u>FLIR</u>						
Fog	18	0	500	500	0.05	90
Snow	310	1	378	100-2000	0.02	89
Mixed	9	0	332	300-500	0.17	98
None	357	0	712	200-6000	0.14	66
<i>FILR Totals</i>	695	1	539	100-6000	0.08	78
<u>NVD</u>						
Fog	18	0	1000	1000	0.05	90
Snow	342	0	329	100-1000	0.02	88
Mixed	9	0	216	200-300	0.17	98
None	426	1	459	150-1000	0.12	65
<i>NVD Totals</i>	796	1	394	100-1000	0.08	77

Comparison of 4380 in³ and 4880 in³ radii

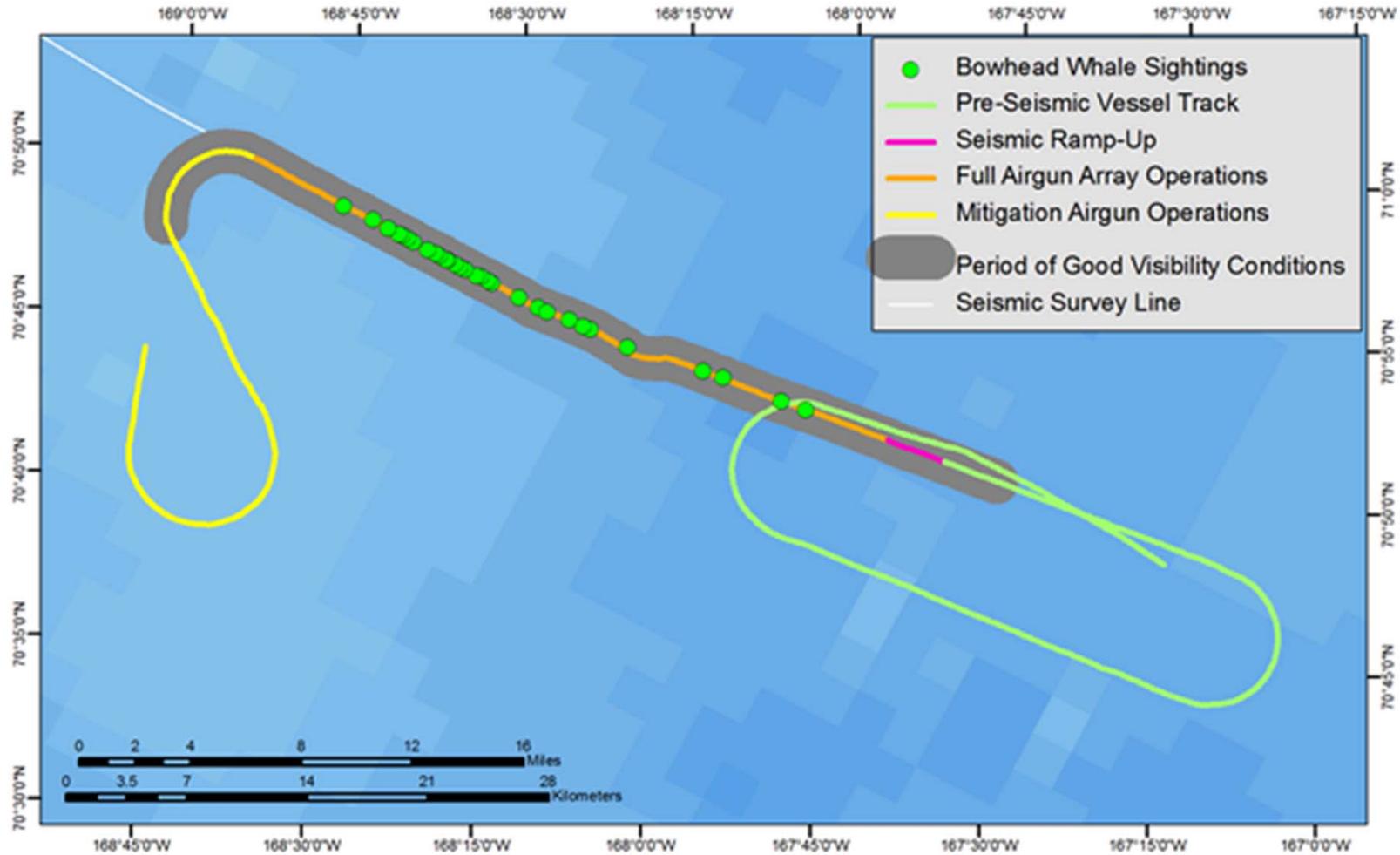
Received Sound Level (dB re 1μPa rms)	Distance to Threshold Level (m)					
	Measurements (4380 in ³)			Modeling (4880 in ³)		
	Water Depth (m)			Water Depth (m)		
	<100	100-1000	>1000	<100	100-1000	>1000
190	287	395	395	317	426	426
180	2,290	1,250	1,250	2,460	1,340	1,340
160	18,700	6,260	6,260	21,800	8,050	8,050
120	109,000	131,000	131,000	>109,000	>131,000	>131,000

Bowhead Whales Exposed to Seismic Sounds >180 dB

Sighting ID	CPA Distance (m)	Clockface Position of Sighting	Clockface Heading of Whale(s)	Direction of Travel	Estimated Received Sound Level - dB (rms)			
					Endfire 90%	Broadside 90%	Endfire 50%	Broadside 50%
POL201267	1532	12:00	9:00	perpendicular	177.9	181.8	176.3	181.2
GEO2012105	913	2:00	10:00	across bow and away	181.7	183.8	180.1	183.2
POL201268	870	9:00	9:00	perpendicular	182.1	184.0	180.5	183.4
GEO2012108	1360	3:00	5:00	parallel and away	178.8	182.2	177.2	181.6
POL201272	1313	2:00	3:00	perpendicular	179.0	182.4	177.4	181.8
POL201276	1362	1:00	9:00	across bow / perpendicular	178.8	182.2	177.2	181.6
GEO2012115	1899	10:30	12:00	parallel	176.3	180.8	174.7	180.2

Estimated Numbers within Disturbance Radii

- Chukchi Sea observations and estimated densities



Estimated Numbers within Disturbance Radii

- Chukchi Sea observations and estimated densities

