

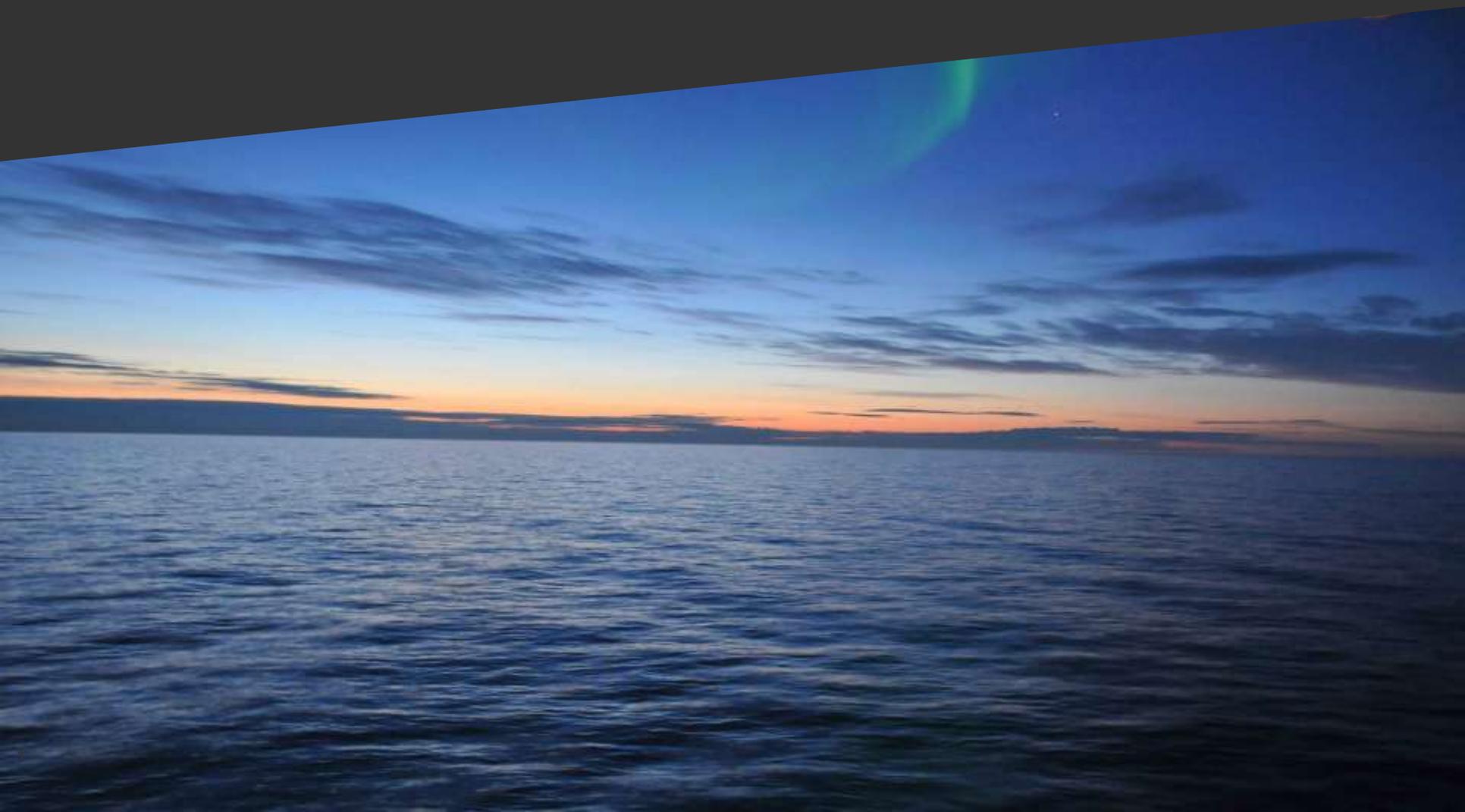
Chukchi Sea Site Survey and Soil Investigation 2011

Open Water Meeting – Anchorage March 2012

Roy Wollvik, Principal Engineer, Statoil



Statoil



Vessels Used in 2011 Season

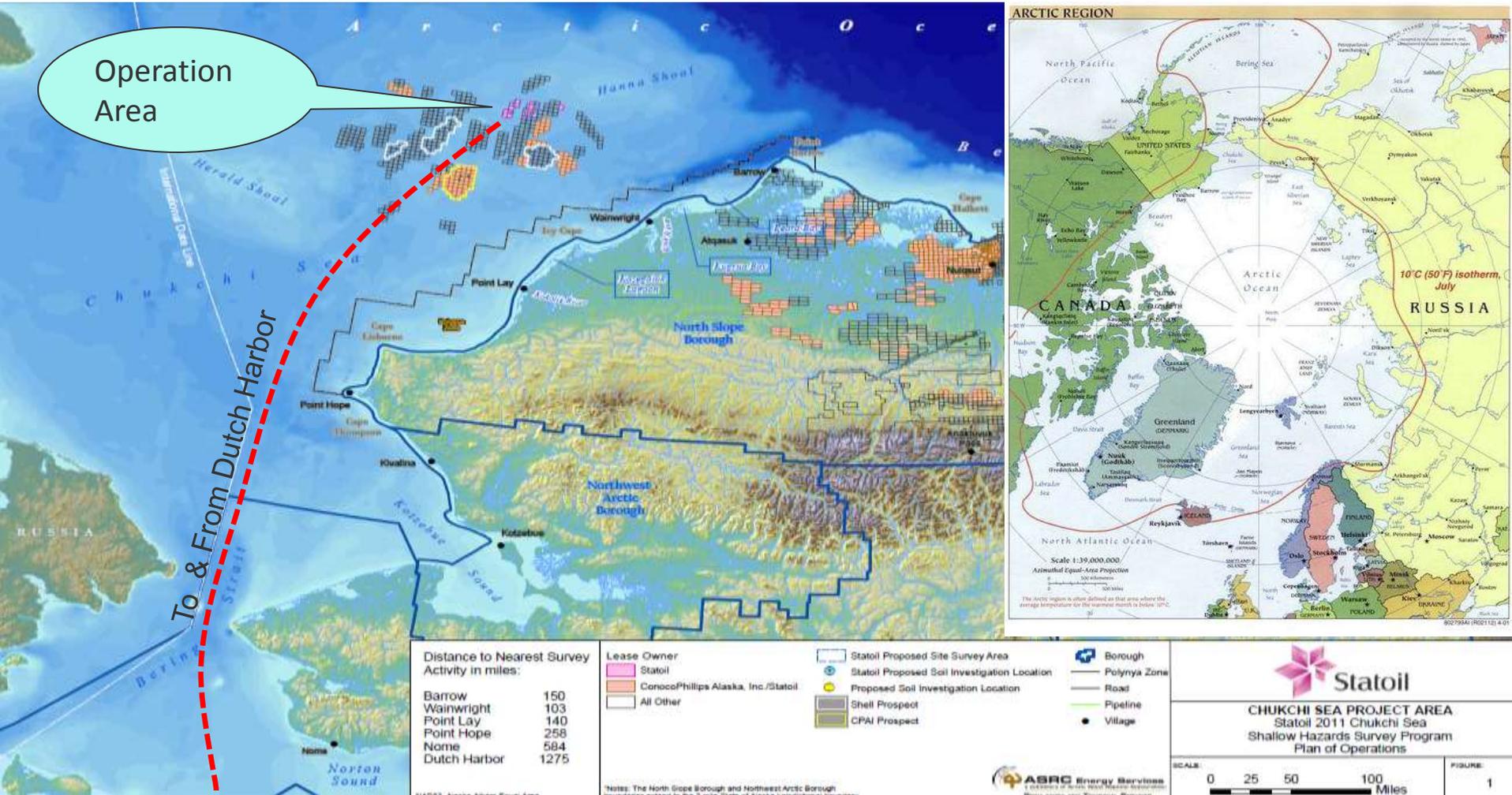


Site survey by MV Duke

Soil investigation by Fugro Synergy



Chukchi Sea, a Remote Location





M/V Duke (former Polar Duke)

- Contractor: CGG VeritasGardline Ltd
- Seabed Mapping and Shallow Seismic
- Built in Norway 1983/2007
- Ice strengthened
- 219 feet with space for 50 persons
- 11.5 knot cruising speed
- Mobilized in Dutch Harbor 1st Aug
- Demobilized 25th Sept

Site Survey by MV Duke

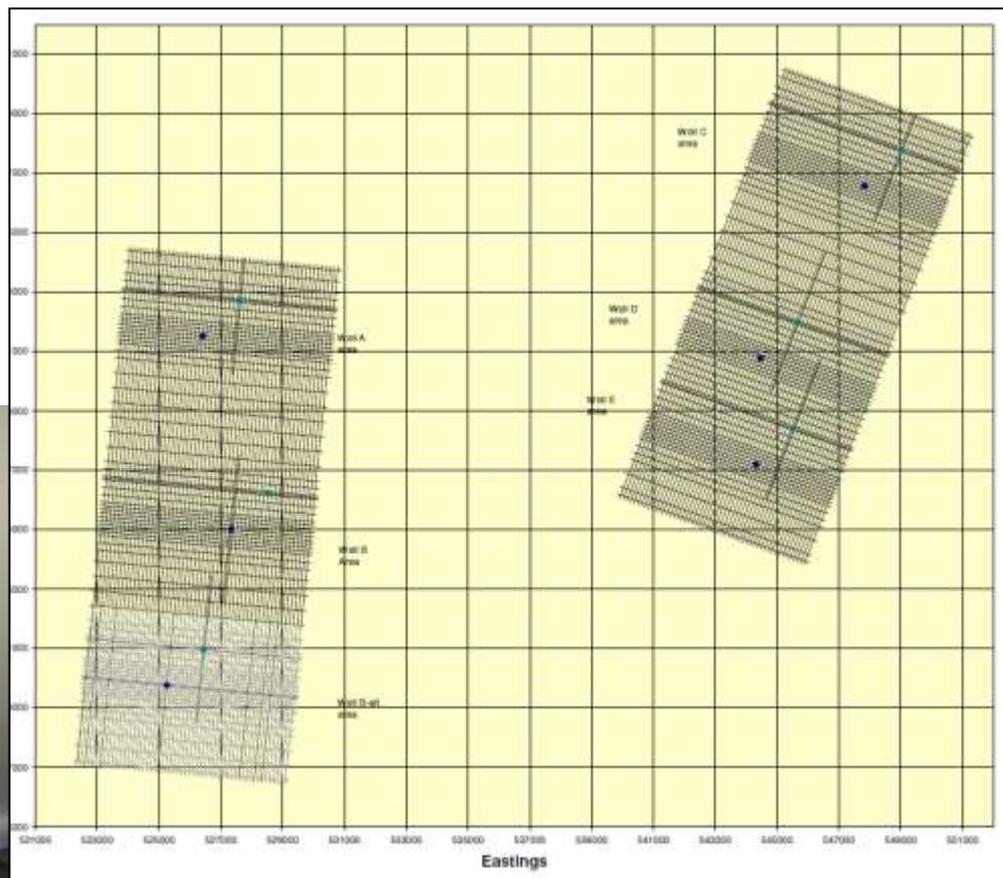
2011 Site Survey Scope of Work

- Investigate drilling well locations
- Collect data from
 - Side Scan Sonar
 - Multibeam Echosounder
 - Shallow Seismic
 - Sub Bottom Profiler
- Collect data to support shallow gas investigation
- Mapping seabed topography



2011 Site Survey Scope of Work

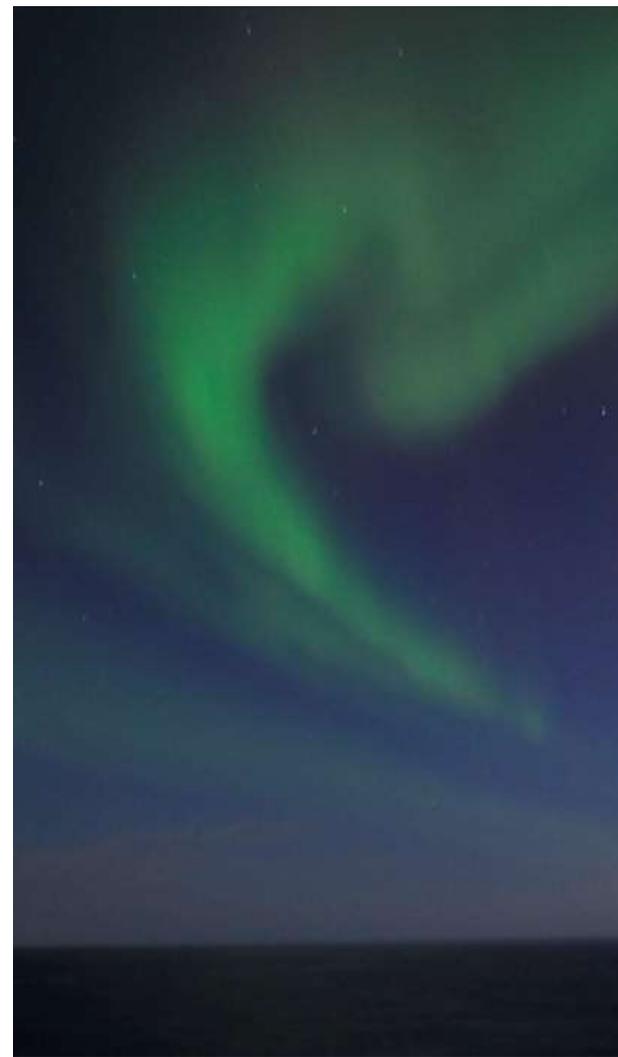
- Planned Survey areas
 - West area: 11 x 4.3 miles
 - East area: 9.7 x 4.1 miles
- Covers the planned drilling locations



2011 Site Survey Scope of Work

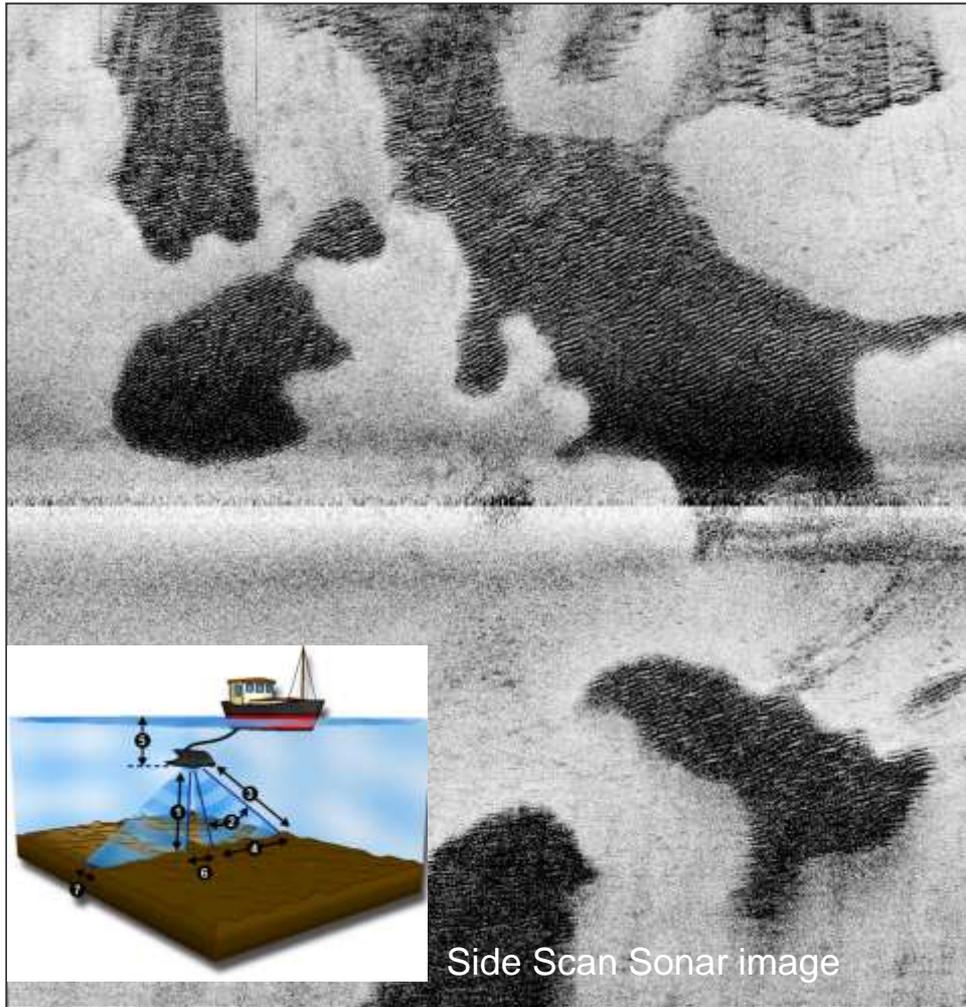
- Sound sources:
 - 10 cu in Mini Airgun for the UHRS streamer
 - 40 cu in Airgun for HRS streamer
 - SBP 300 Sub Bottom Profiler
 - Side Scan Sonar
 - EA 500 Single beam echo sounder
 - EM 2040 Multibeam echosounder
 - USBL subsea positioning system for positioning SSS towfish

Sound Source Verification test performed

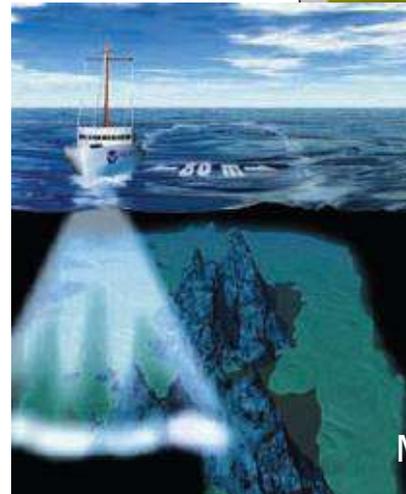


Data Examples and Methods

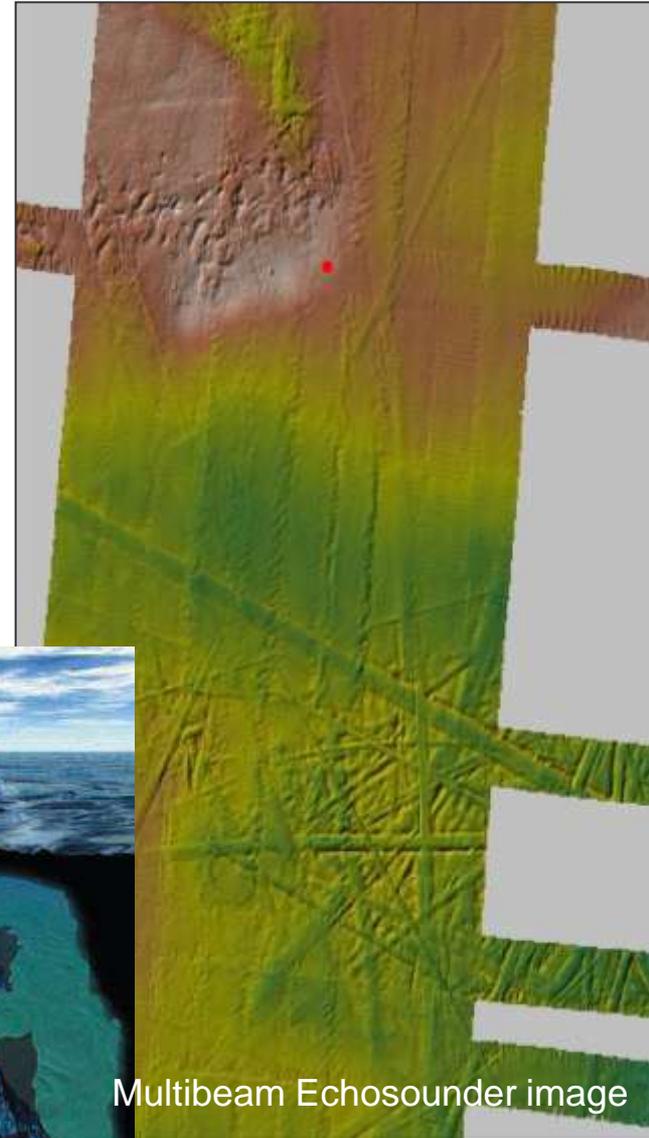
Side Scan Sonar and Multibeam Echo Sounder



Side Scan Sonar image



Multibeam Echosounder image

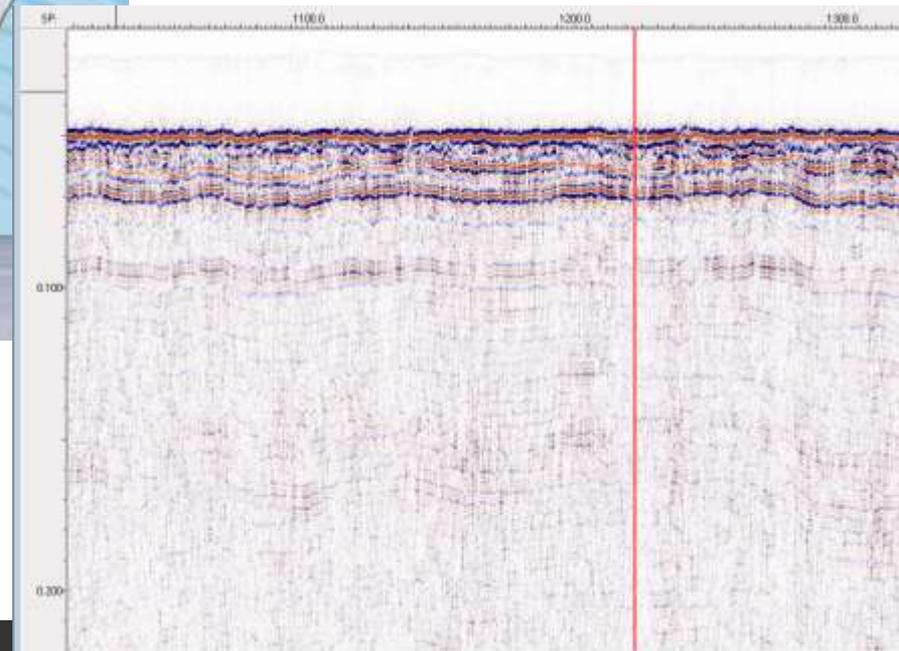
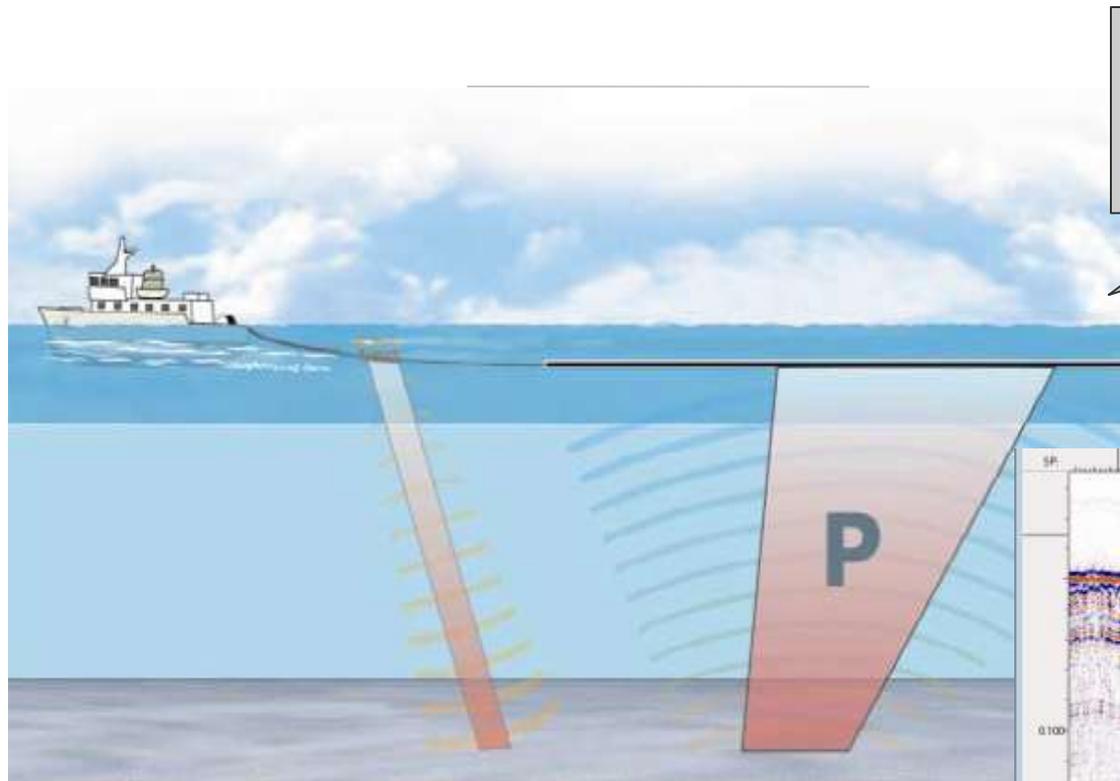


Data Examples and Methods

2D Shallow Seismic and Sub Bottom Profiler

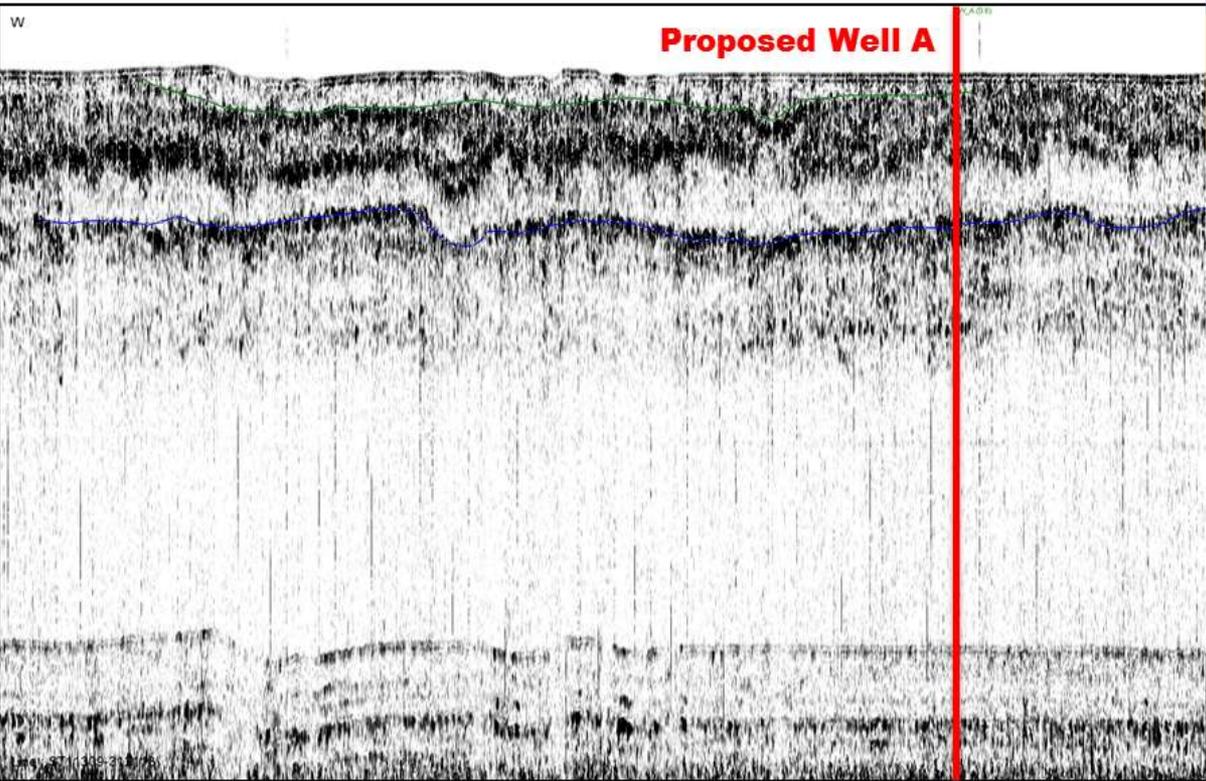
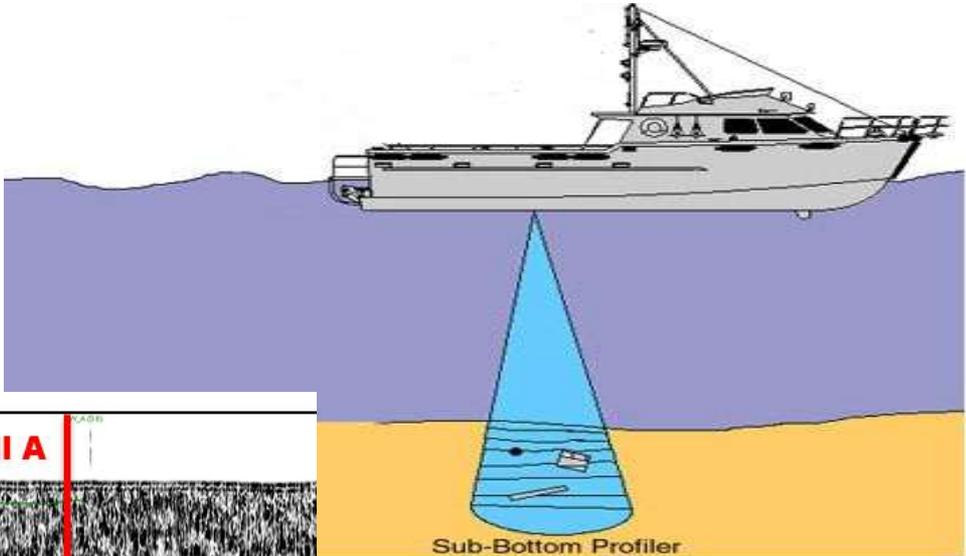
HRS streamer = 600m

UHRHS streamer = 150m



Data Examples and Methods

2D Shallow Seismic and Sub Bottom Profiler



Summary Site Survey

- 1,600 line miles of survey were completed
- 55 days in field (including transit)
- All necessary data were collected
- Complied with all regulatory requirements

MV Duke in
moonlight



- 
- Contractor: Fugro
 - Soil Investigation Vessel
 - Built in Norway 2008
 - Ice strengthened
 - 340 feet with space for 70 persons
 - 15 knot cruising speed
 - Mobilized 31st Aug in Dutch Harbor
 - Demobilized 30st Sept in Dutch Harbor

Soil Investigations by Fugro Synergy

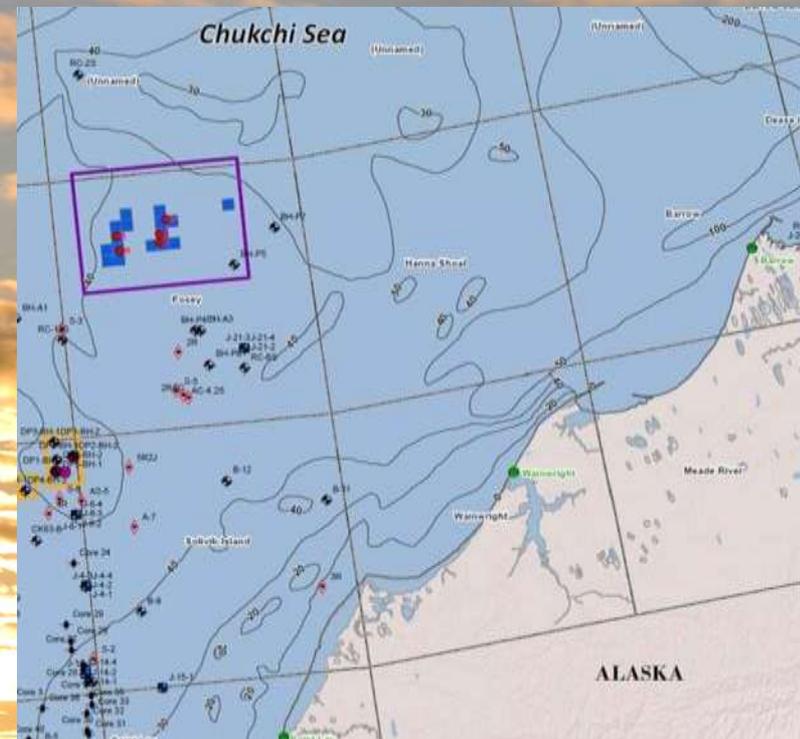
Scope of Work

Purpose of soil investigation

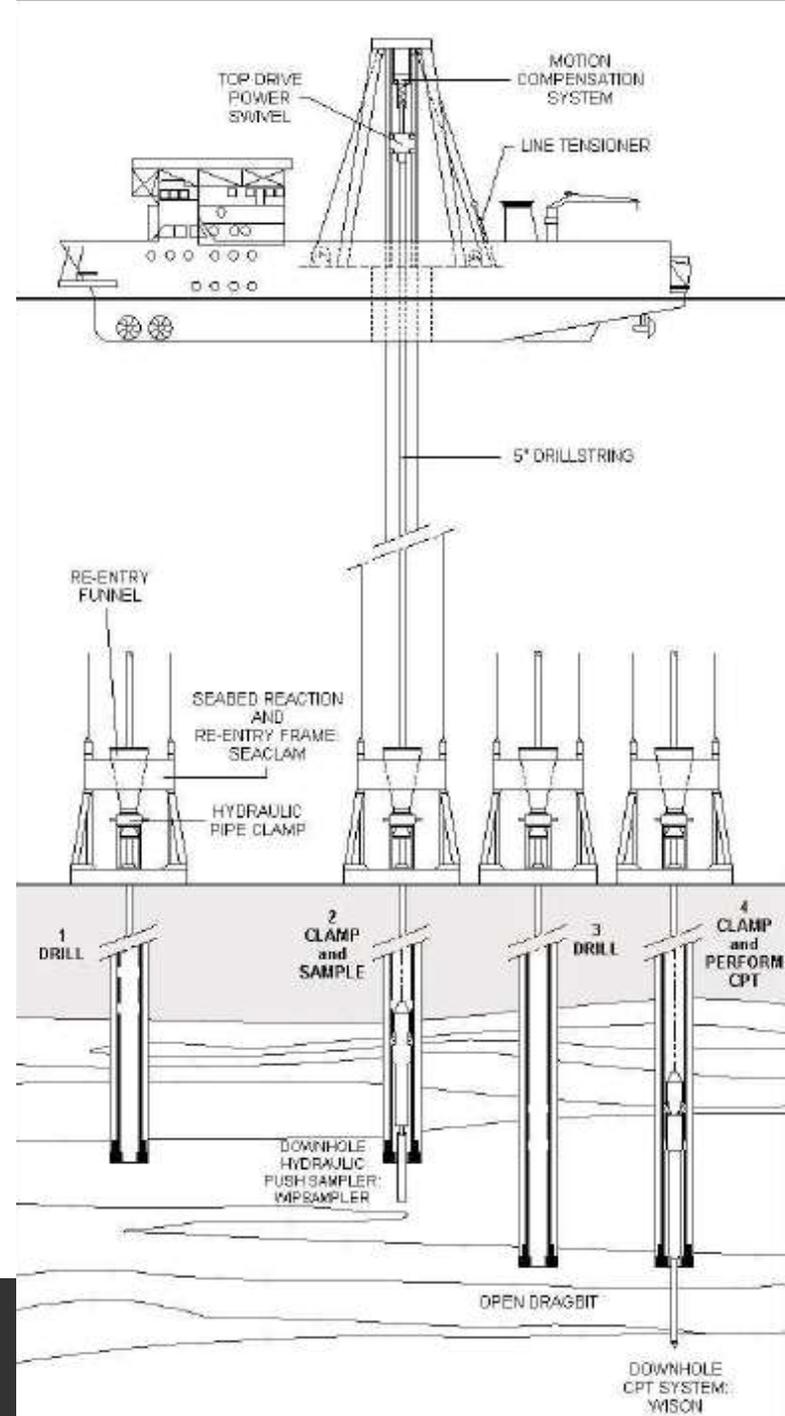
- Document soil conditions
- Collect quality soil data

Scope

- 5 locations with 3 boreholes at each location
- Push sampling and Cone Penetration Testing (CPT)
- Sound Source Verification test
- Temperature measurements



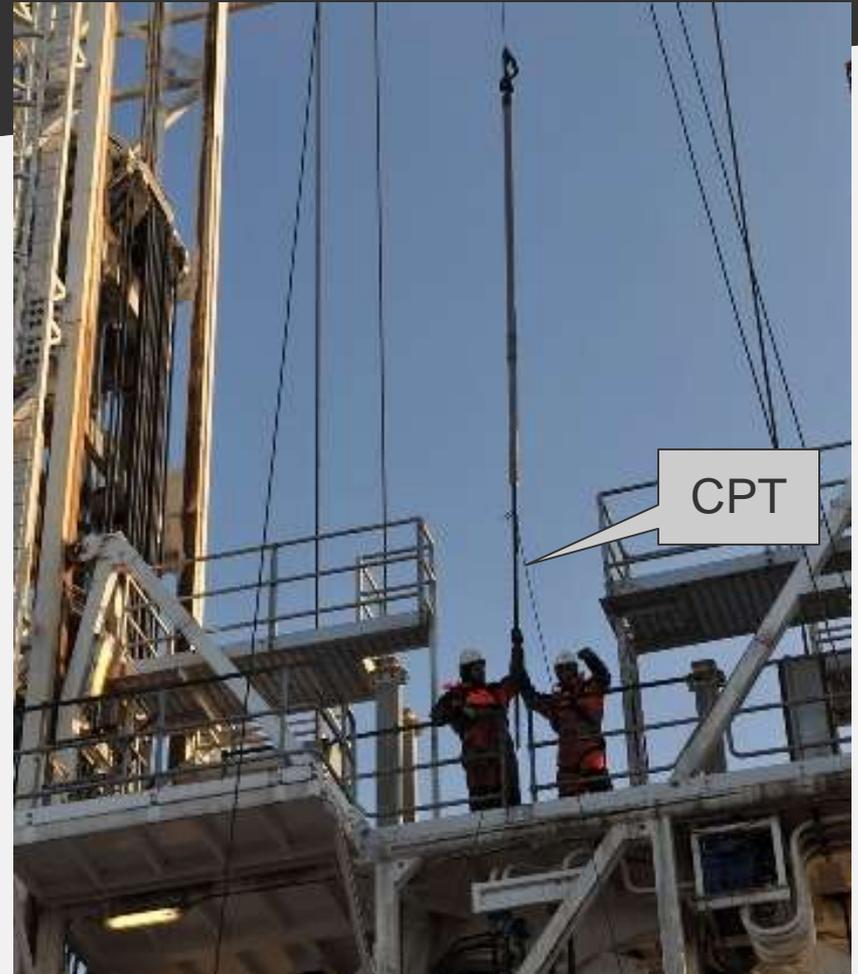
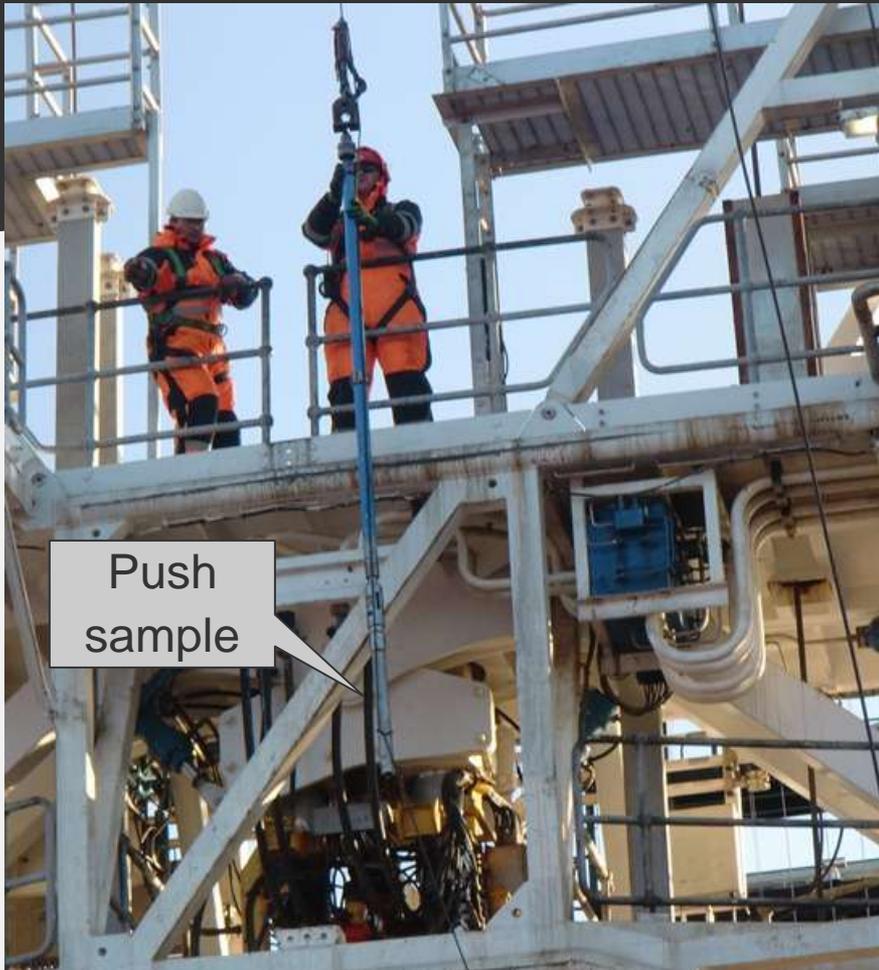
Coring Operations



Coring Operations



Sample Recovery



Sample Recovery



Sample Recovery

From Soil Investigation



Summary Soil Investigation

- In total 1,460 feet were cored from all 5 locations
- 30 days in the field including transit
- Detailed knowledge of soil conditions were obtained with geotechnical testing in combination with geophysical sub-bottom profiles
- No unexpected soil conditions were encountered
- Complied with all regulatory requirements



Health, Safety and Environment

- No accidents on either vessel (49,000 man hours)
- Work conducted to avoid conflict:
 - Communication center protocol
 - Utilize MMOs on both vessels
 - POC meetings (were held Oct & Nov 2011)
 - Sound Source Verification (results are presented in the 90-day report issued Jan 2012)
- 3 port calls to Wainwright and 1 to Nome for medical, personal emergency, or safety reasons



Quyanakpak
Thank you

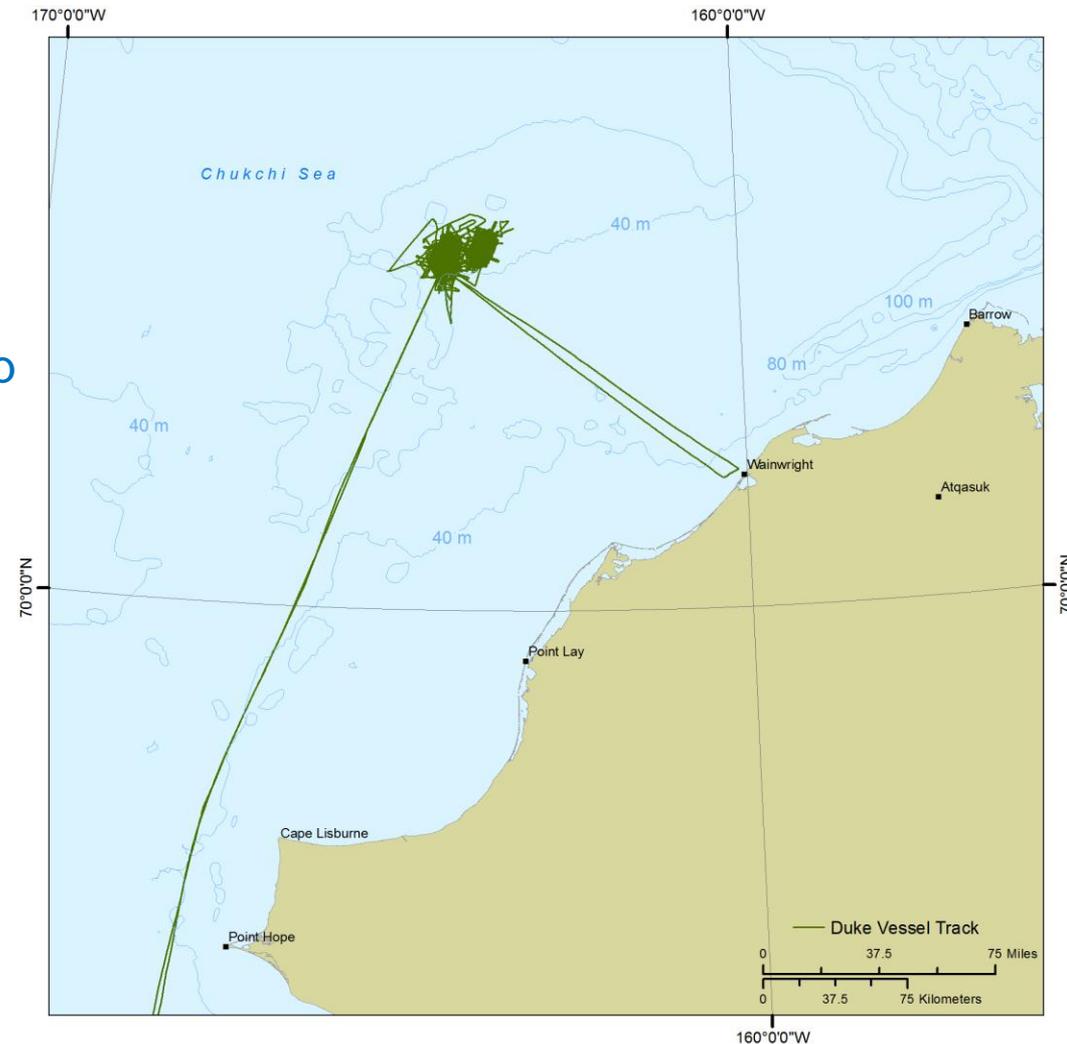


5 MMOs onboard Duke and
4 onboard Fugro Synergy



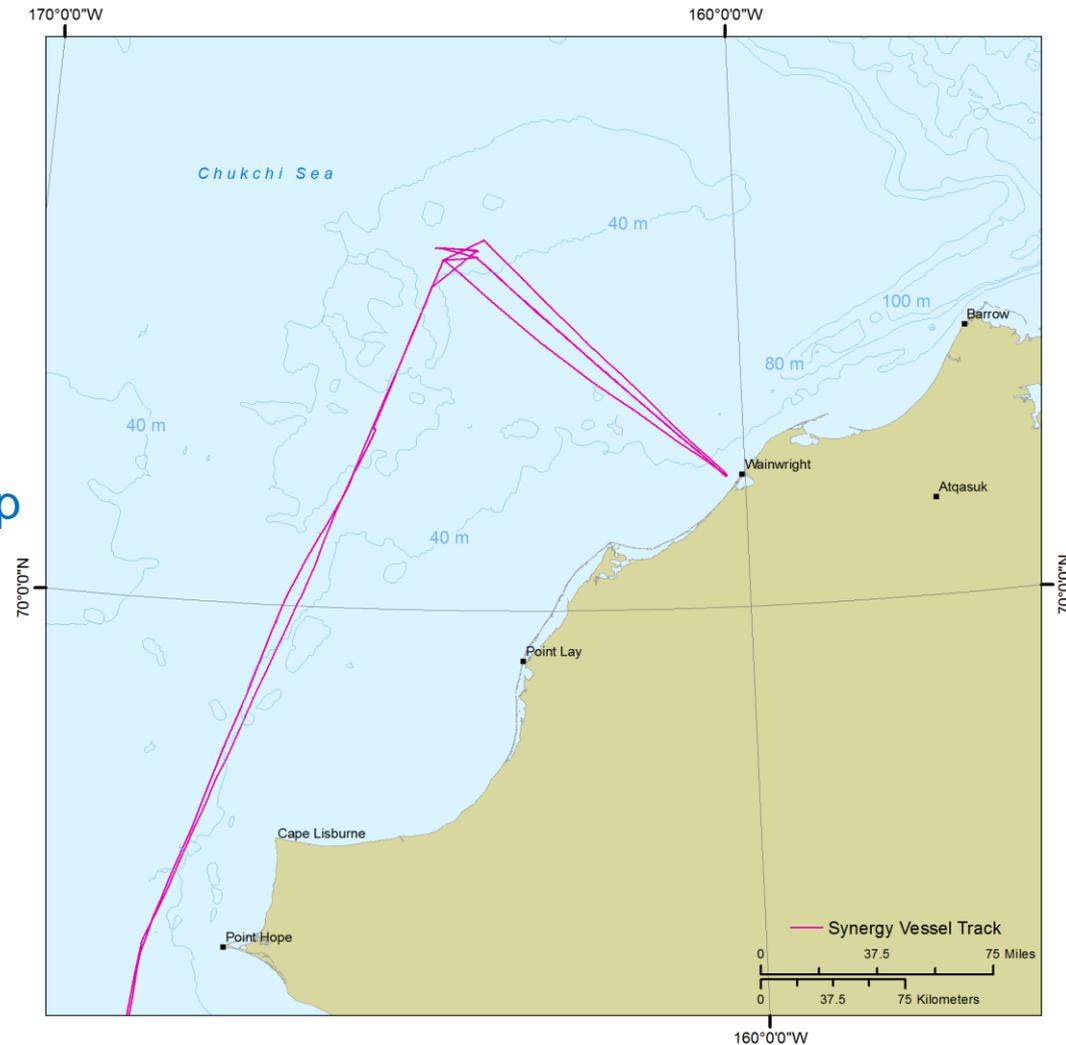
Duke (Site Clearance Survey Vessel)

- Left Dutch Harbor 1 Aug
- Entered Chukchi Sea 5 Aug
- Began Site Survey 7 Aug
 - One trip to Wainwright on 28 Aug
- Finished Site Survey (44 days) 20 Sep
- Departed Chukchi Sea 21 Sep
 - Drop off at Nome on 22 Sep
- Returned to Dutch Harbor 25 Sep



Synergy (Geotechnical Coring Vessel)

- Left Dutch Harbor 31 Aug
- Entered Chukchi Sea 3 Sep
- Began Site Survey 5 Sep
 - Two trips to Wainwright
 - 16 Sep and 22 Sep
- Finished Site Survey (21 days) 26 Sep
- Departed Chukchi Sea 26 Sep
- Returned to Dutch Harbor 30 Sep



Marine Mammal Monitoring and Acoustic Measurements During Statoil's 2011 Chukchi Sea Site Survey and Geotechnical Coring Operations



2011 Marine Mammal Monitoring and Mitigation Program

- Measure sounds produced by survey equipment
- 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 the 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.

2011 Peer Review Panel Recommendations

Implemented as previously planned in 2011

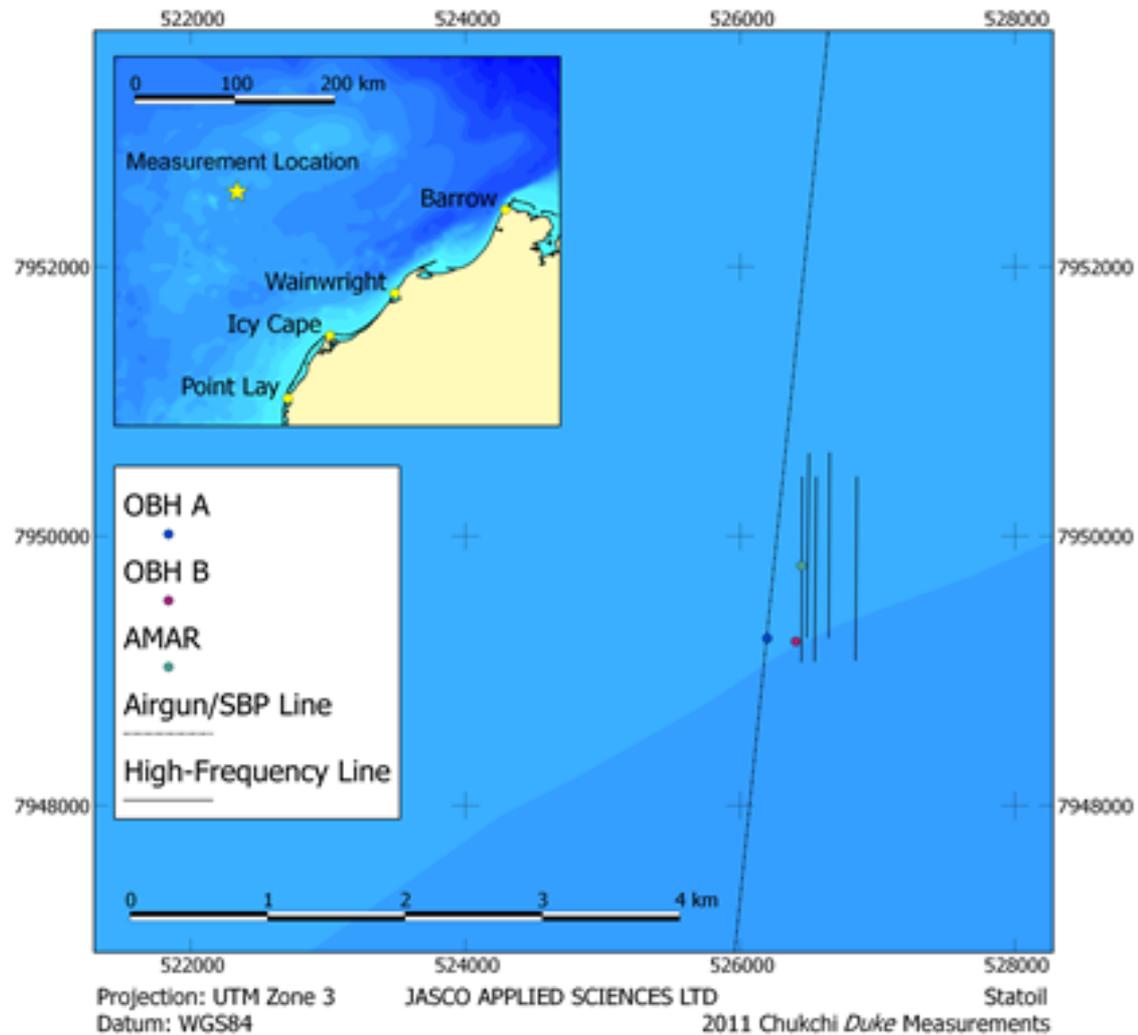
- Train all observers together at the same time
- Use visual aids (e.g. photos) in similar conditions as they are likely to be seen
- Pair experienced and new observers together during training and in the field
- Document visibility conditions during observation periods
- Maximize time spent monitoring areas within the safety radii
- Conduct observations from the best possible vantage point
- Alternate visual scans using unaided eyes, high-power binoculars, and low-power binoculars
- Record survey activity status and environmental conditions every 30 minutes or whenever a parameter changed

2011 Peer Review Panel Recommendations

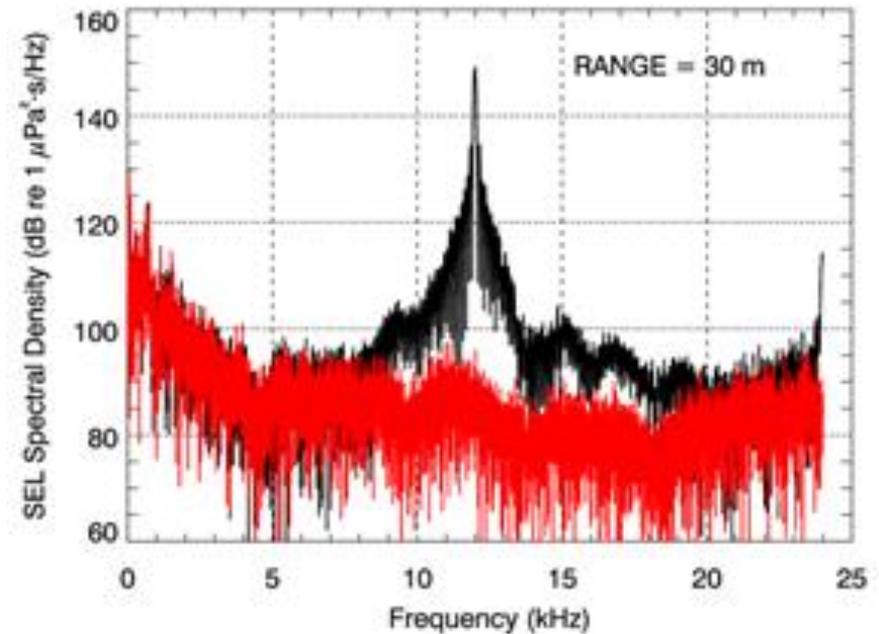
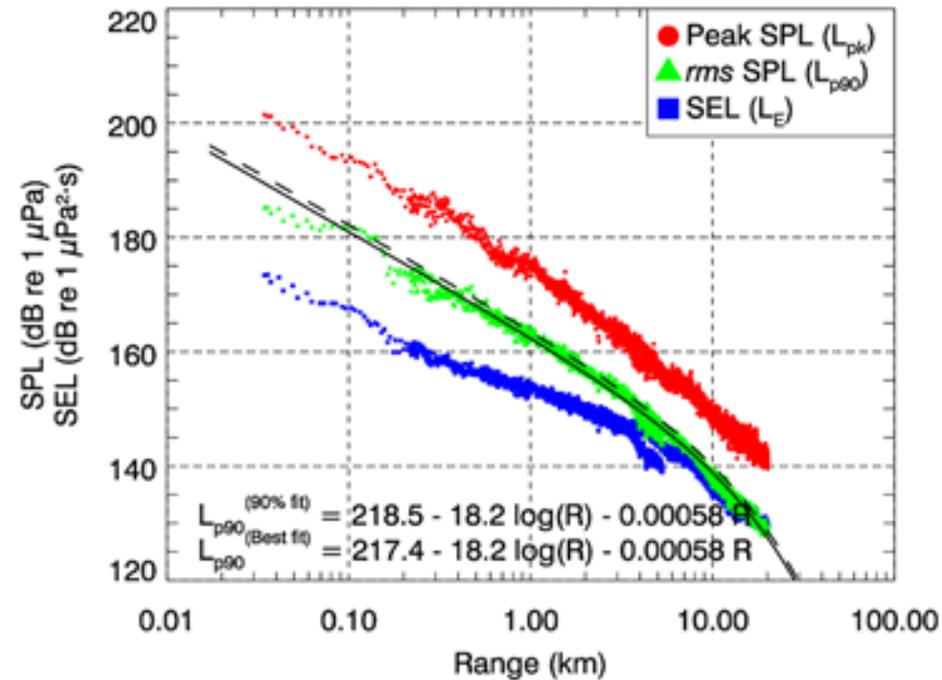
Changes Made to 2011 Monitoring Program

- Additional emphasis during training on recording sightings as “unidentified” if the observer was not certain of the species
- Recorded pertinent biological information for “unidentified” sightings
- Used an electronic database to record survey activity, environmental, and sighting data in real time. This allowed real-time geographic display of the data
- Observers specifically conducted more nighttime watch effort using night-vision devices and summarized the findings in the 90-day report.

Sound Source Measurements - *Duke*



Sound Source Measurements - *Duke*



Airgun Sound Level Distances (meters)

Full Airgun Array

Received Level dB (rms)	Pre-Season Modeled Radii	Field Season Measured Radii	Final Measured Radii
≥190	50	37	37
≥180	190	130	130
≥160	2,250	1,500	1,500
≥120	39,000	30,000	30,000

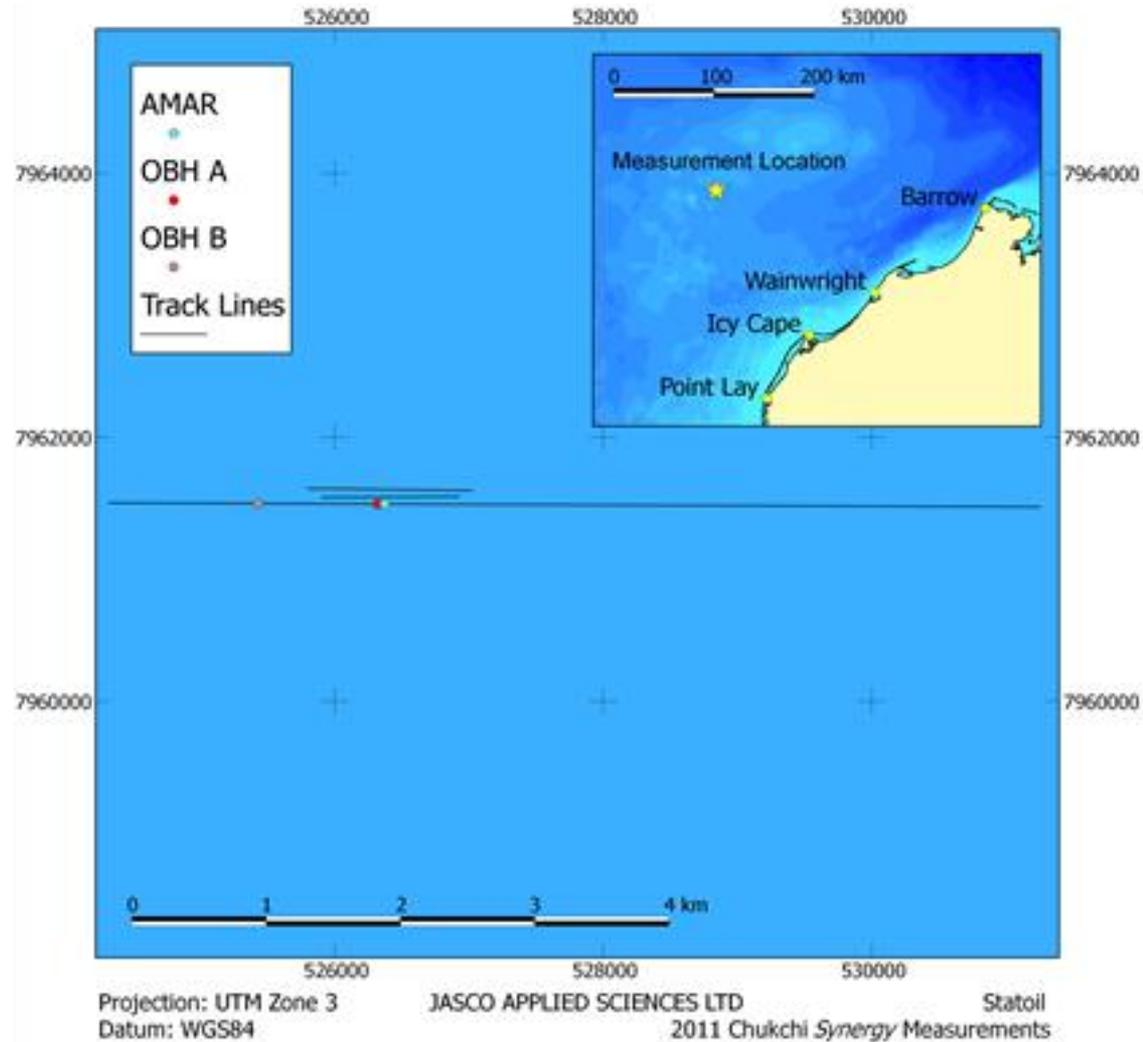
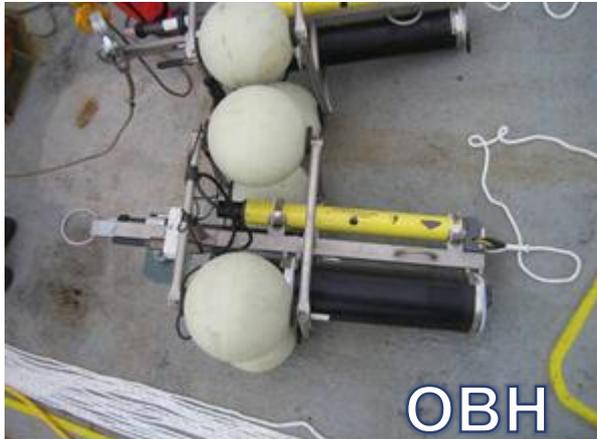
Mitigation Airgun

Received Level dB (rms)	Pre-Season Modeled Radii	Field Season Measured Radii	Final Measured Radii
≥190	10	15	15
≥180	45	59	59
≥160	715	840	840
≥120	24,000	29,000	29,000

Sound Source Measurements - *Duke*

Sound Source	Peak Frequency (kHz)	Dominant Frequency Range (kHz)
40 in ³ airgun array	0.01 - 0.1	<1
10 in ³ airgun	0.01 - 0.1	<1
Single beam echosounder (12 kHz)	12	10 - 14
Sub-bottom profiler (2-7 kHz)	2 - 7	2 - 7
Side-scan sonar (114 kHz)	110	100 - 115
Multibeam sonar (200-400 kHz)	220	210 - 240
SonarDyne positioning system	27	25 - 30
SonarDyne beacon	33	25 - 35
Duke transiting at 4.5 kts	0.01	<1

Sound Source Measurements - Synergy



Coring Sound Level Distances (meters)

Dynamic Positioning Only

Received Level dB (rms)	Pre-Season Modeled Radii	Field Season Measured Radii	Final Measured Radii
≥190	0	0	0
≥180	0	0	0
≥160	0	6	6
≥120	7,500	2,300	2,300

Dynamic Positioning and Coring

Received Level dB (rms)	Pre-Season Modeled Radii	Field Season Measured Radii	Final Measured Radii
≥190	0	0	0
≥180	0	0	0
≥160	0	2	2
≥120	7,500	1,800	1,800

Sound Source Measurements - *Synergy*

Sound Source	Peak Frequency (kHz)	Dominant Frequency Range (kHz)
Single beam echosounder (18 kHz)	18	12 - 25
Single beam echosounder (200 kHz)	200	190 - 205
HiPAP positioning system (22/23 kHz)	22, 23	20 - 25
HiPAP positioning system (21/21.5 kHz)	21, 21.5	20 - 23
Synergy in DP w/o Coring	0.15	0.110 - 0.140
Synergy in DP with Coring	0.12	0.110 - 0.140
Synergy transiting at 4.5 kts	0.03, 0.09 - 0.4	<1

Marine Mammal Visual Monitoring

5 MMOs aboard Duke

4 MMOs aboard Synergy

Permit Watch Requirements:

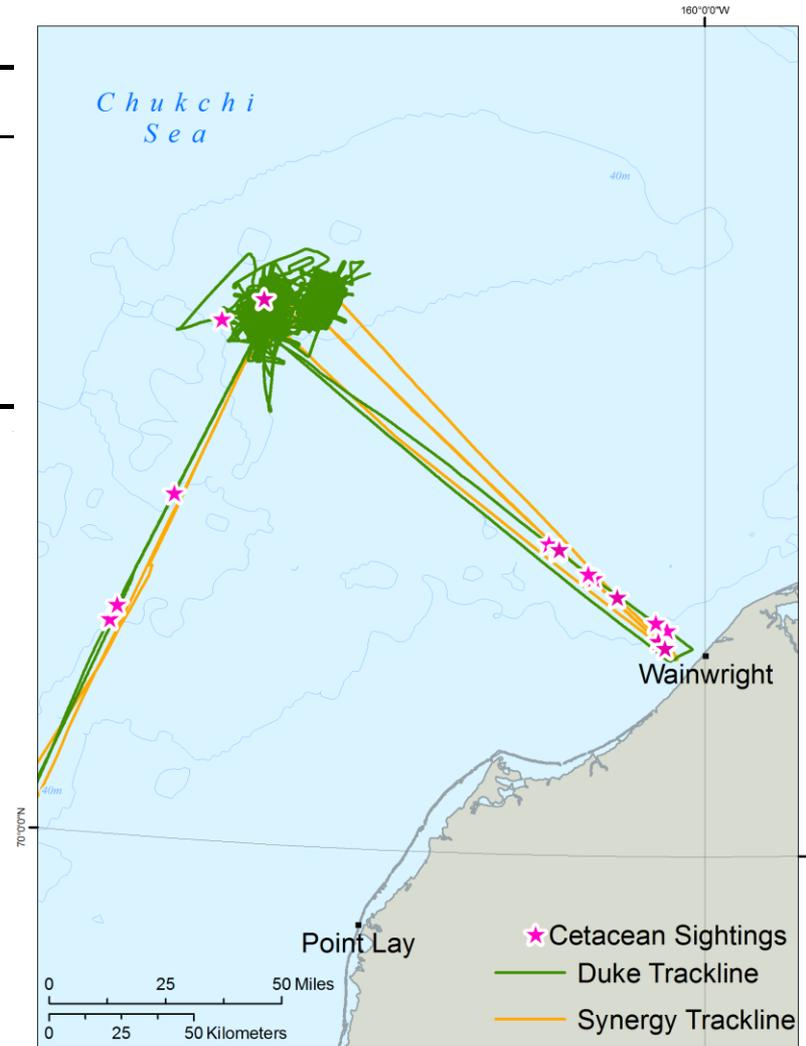
- At least 1 MMO on duty on the Source vessel during all daylight seismic operations
- 2 MMOs on duty 30 min before & during all full ramp ups, and as much as possible during other survey operations

2011 Actual Watch Statistics:

- At least 1 MMO on watch
 - 100% of daylight seismic
 - 100% of nighttime seismic
 - 94% of all operations
 - 20% of operations in darkness
- 2 MMOs on Watch
 - 100% of ramps ups
 - 88% of daylight seismic
 - 55% of nighttime seismic

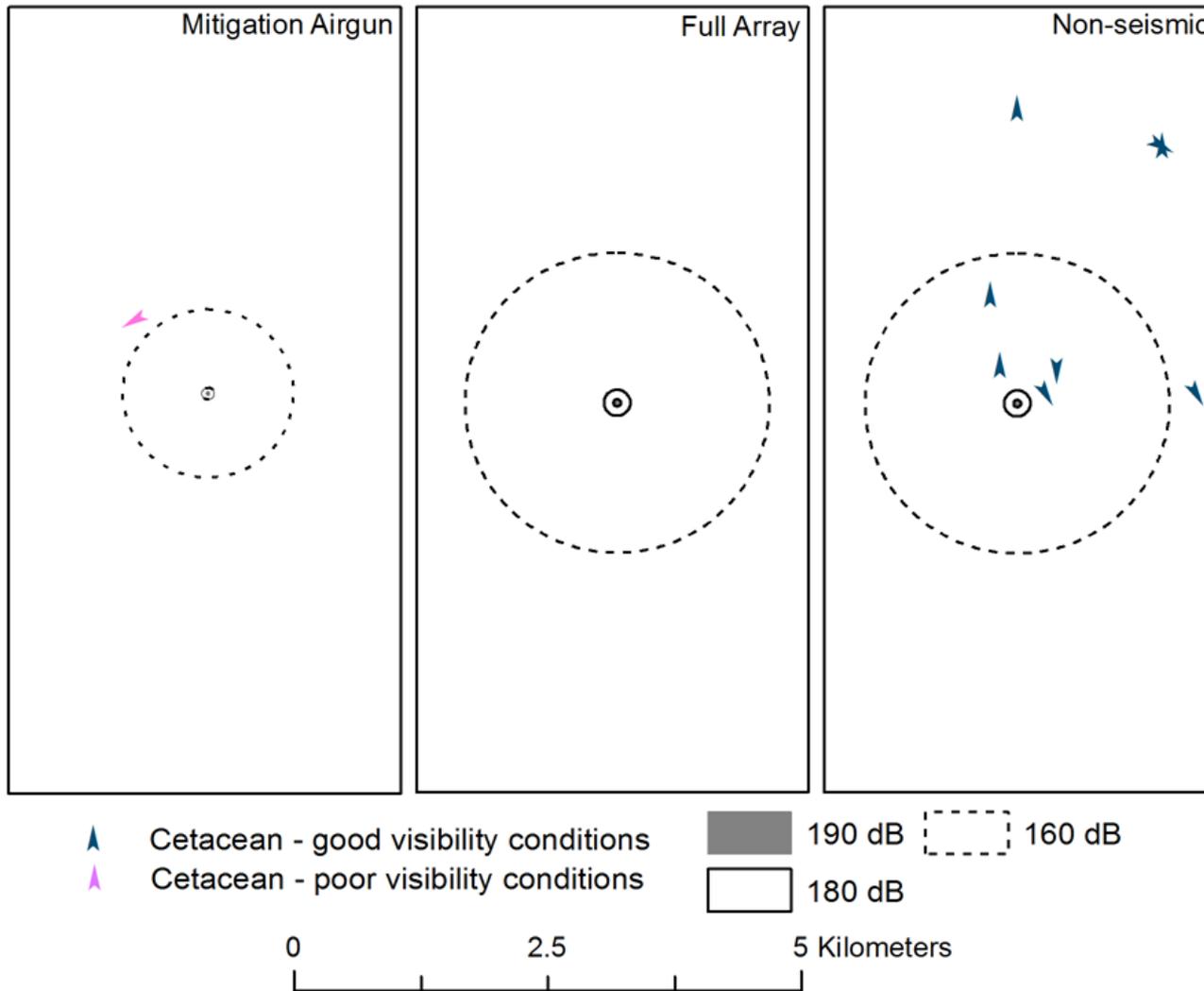
Cetacean Sightings (number of individuals)

Species	Duke	Synergy	Total
Cetaceans			
Gray Whale	6 (29)	2 (4)	8 (33)
Unidentified Mysticete Whale	5 (6)	3 (4)	8 (10)
Total Cetaceans	11 (35)	5 (8)	16 (43)



Cetacean Sightings Relative to Airguns

All Survey
Periods



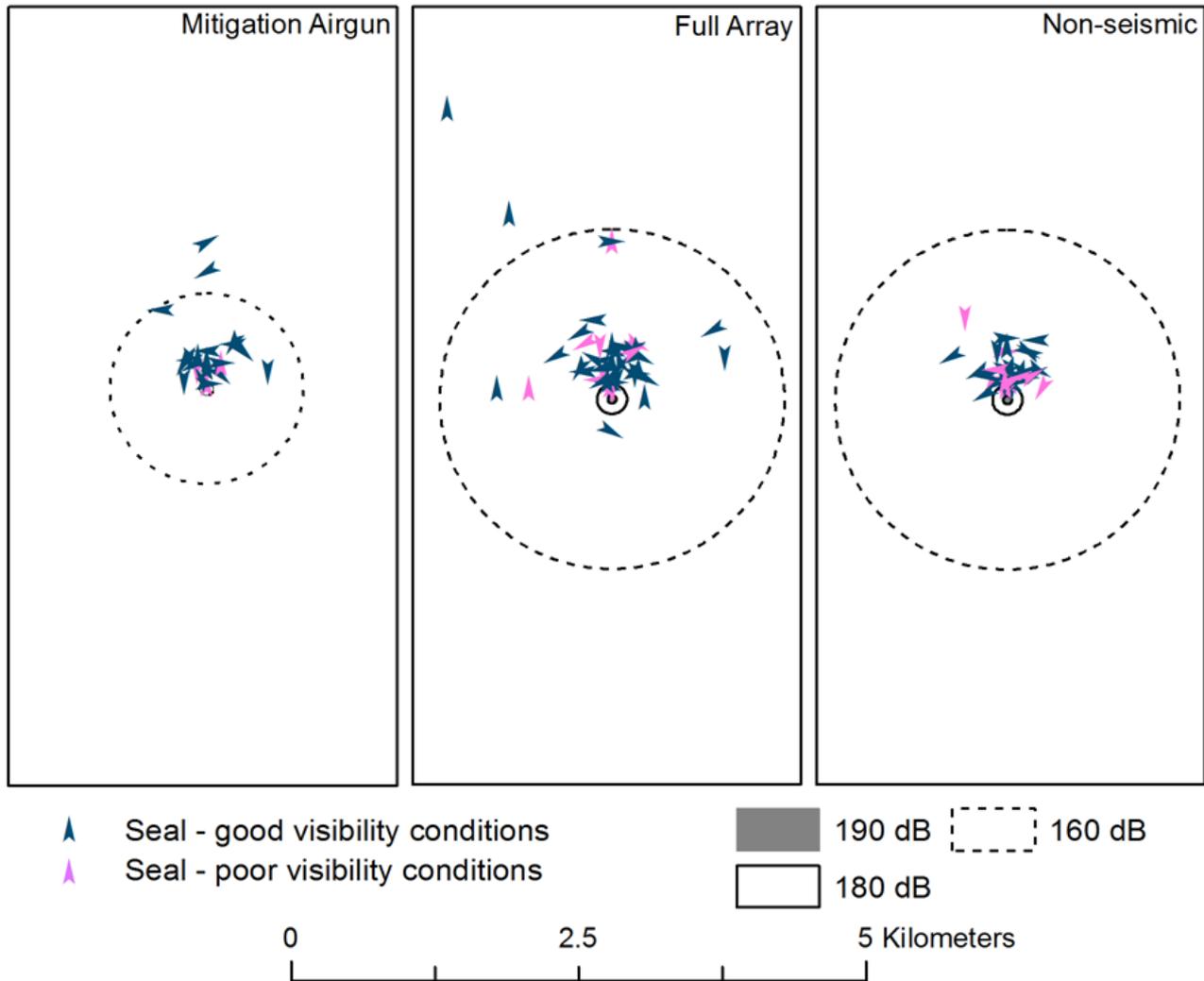
Pinniped Sightings (number of individuals)

Species	Duke	Synergy	Total
Pinnipeds			
Bearded Seal	59 (61)	0	59 (61)
Ringed Seal	18 (18)	2 (2)	20 (20)
Spotted Seal	1 (1)	0	1 (1)
Unidentified Pinniped	12 (12)	5 (5)	17 (17)
Unidentified Seal	19 (19)	5 (5)	24 (24)
Pacific Walrus	61 (98)	20 (49)	81 (147)
Total Pinnipeds	170 (209)	32 (61)	202 (270)



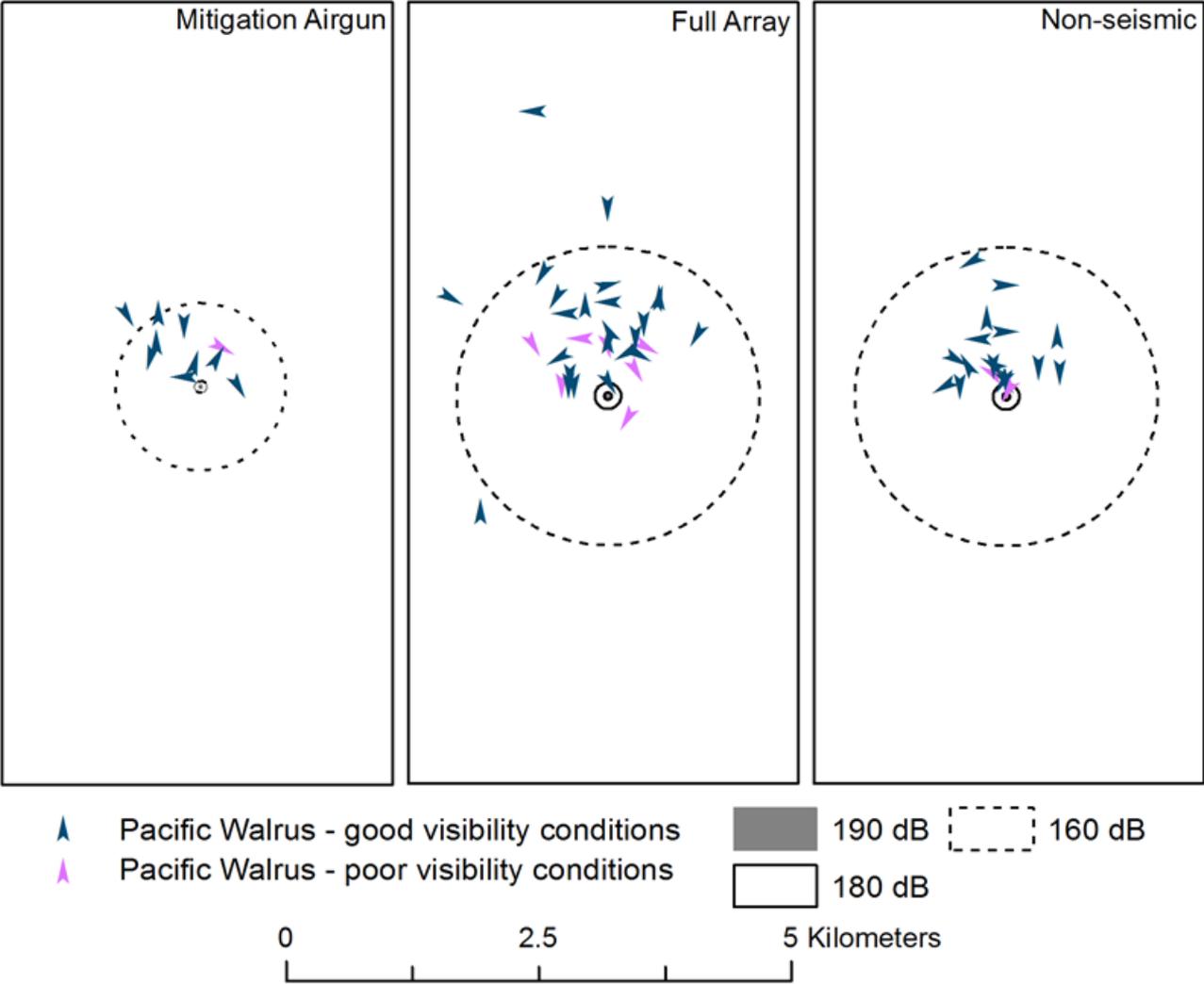
Seal Sightings Relative to Airguns

All Survey
Periods



Walrus Sightings Relative to Airguns

All Survey
Periods



Numbers of marine mammals observed within Safety Radii:

Cetaceans	Seals	Pacific Walrus
≥180	≥190	≥180
0	0	2

- Full Airgun Array
 - ≥ 180 dB distance = 130 m
 - ≥ 190 dB distance = 37 m
- Mitigation Airgun
 - ≥ 180 dB distance = 59 m
 - ≥ 190 dB distance = 15 m

Mitigation Measures Implemented:

Duke

Date	Mitigation	Species
15-Aug	Shut Down	Unidentified Pinniped Carcass
17-Aug	Power Down	Pacific Walrus
17-Aug	Power Down	Pacific Walrus
19-Aug	Power Down	Pacific Walrus

Synergy

Date	Mitigation	Species
10-Sep	Moon Pool Monitoring	Pacific Walrus
11-Sep	Moon Pool Monitoring	Pacific Walrus
16-Sep	Speed Reduction	Gray Whale
22-Sep	Speed Reduction	Pacific Walrus

Numbers of marine mammals observed within Disturbance Radii:

Cetaceans	Seals	Pacific Walrus
≥160	≥160	≥160
0	71	60

- Full Airgun Array
 - ≥ 160 dB distance = 1,500 m
- Mitigation Airgun
 - ≥ 160 dB distance = 840 m
- Coring Operations
 - ≥ 120 dB distance = 1,800 – 2,300 m

Estimated numbers of marine mammals *potentially* exposed to

- seismic sounds ≥ 160 dB re $1\mu\text{Pa}$ (rms), or
- coring sounds ≥ 120 dB re $1\mu\text{Pa}$ (rms),

Based on densities calculated during Seismic and Non-seismic periods

Species	Estimated No. Individuals			
	Seismic Densities	Non-seismic Densities	Requested Take	
	Mean	Mean	Mean	Max
Cetaceans				
Gray whale	0	18	44	88
Unid. mysticete whale	0	4	--	--
Total Cetaceans	0	21	77	184
Seals				
Ringed Seal	48	38	804	1331
Spotted Seal	3	0	16	26
Bearded Seal	91	48	27	52
Unid. Seal	28	37	--	--
Unid. Pinniped	16	9	--	--
Total Seals	185	131	848	1418
Pacific walrus	87	138	--	--

Evaluation of Monitoring Equipment

Night Vision Devices

- Typical observation sessions lasted 5-10 minutes, after which eye fatigue diminished quality of observations
- Most useful when there was still a small amount of natural light (twilight periods)
- Nights with fog, no ambient light, or heavy seas made observations nearly impossible
- Vessel Deck Lights and/or internal bridge lights limited usefulness from inside of the Bridge.
- Effective range was estimated to be 10-500 meters, depending on ambient light and vessel lighting conditions



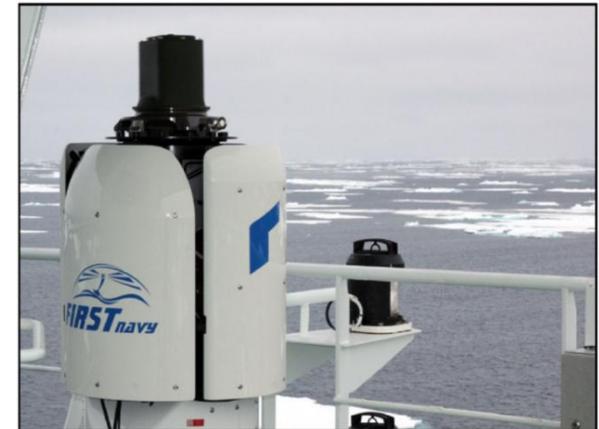
Evaluation of Monitoring Equipment

Observations

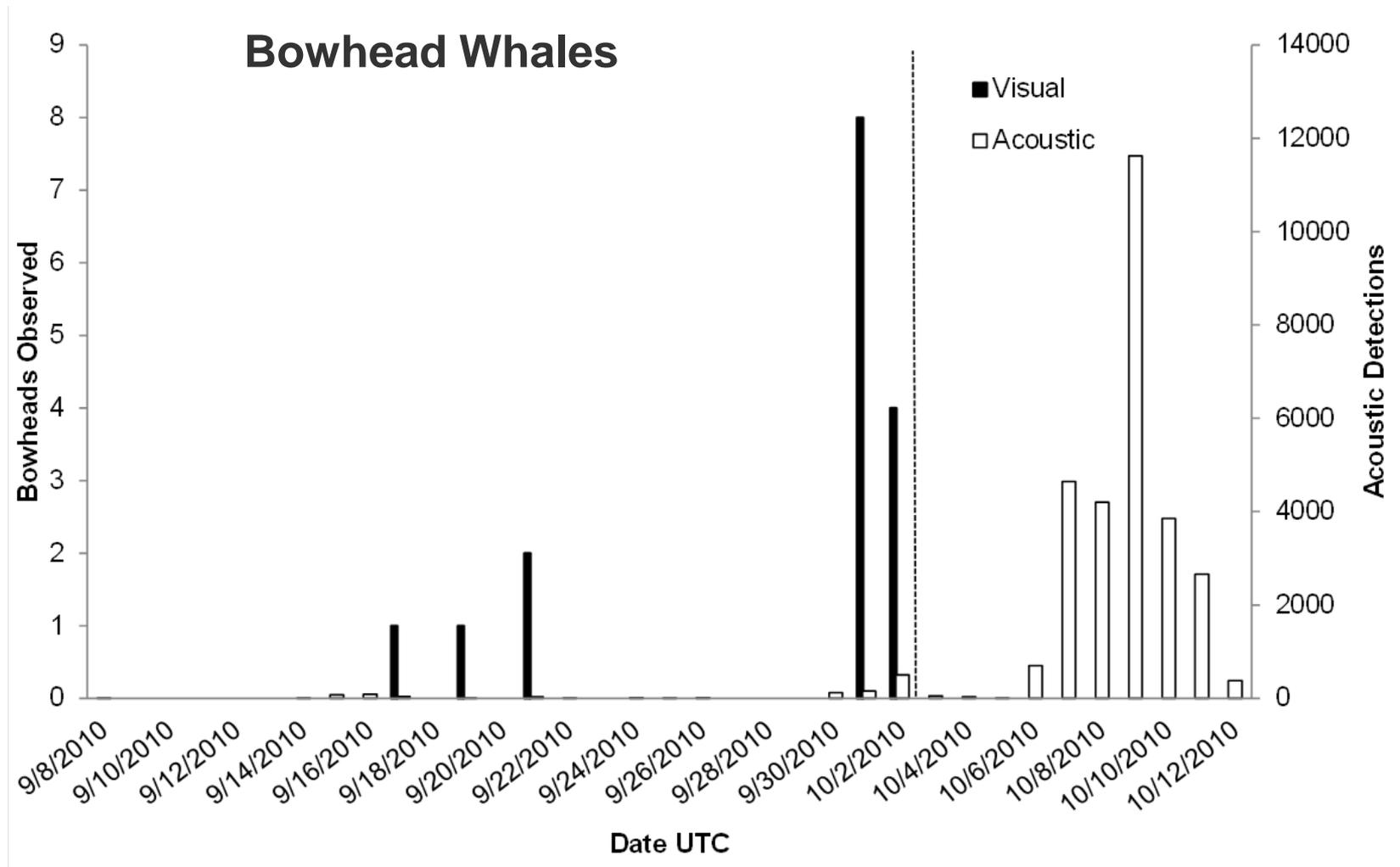
- Jellyfish and seabirds sighted when conditions were good
- Two Pacific Walrus sighted with NVDs
 - From the Synergy while it was stationary
 - Both were initially detected with the unaided eye
- Aurora Borealis

2010 Infrared Camera System

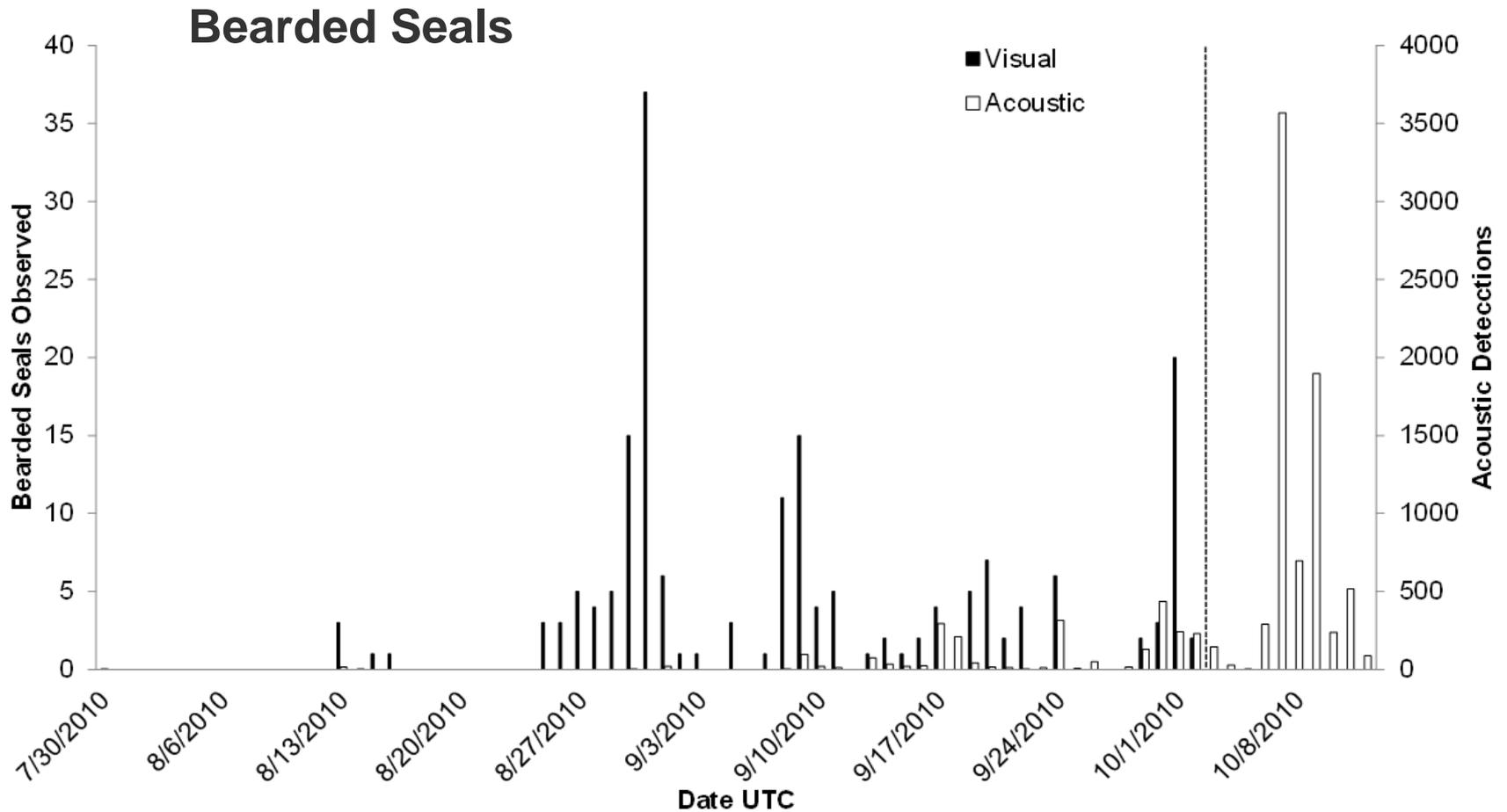
- Similar environmental limitations (fog, high seas)
- IR system generated less observer fatigue and has potential for auto-detection
- Much wider field of View
- Still in testing and development phase; not commercially available



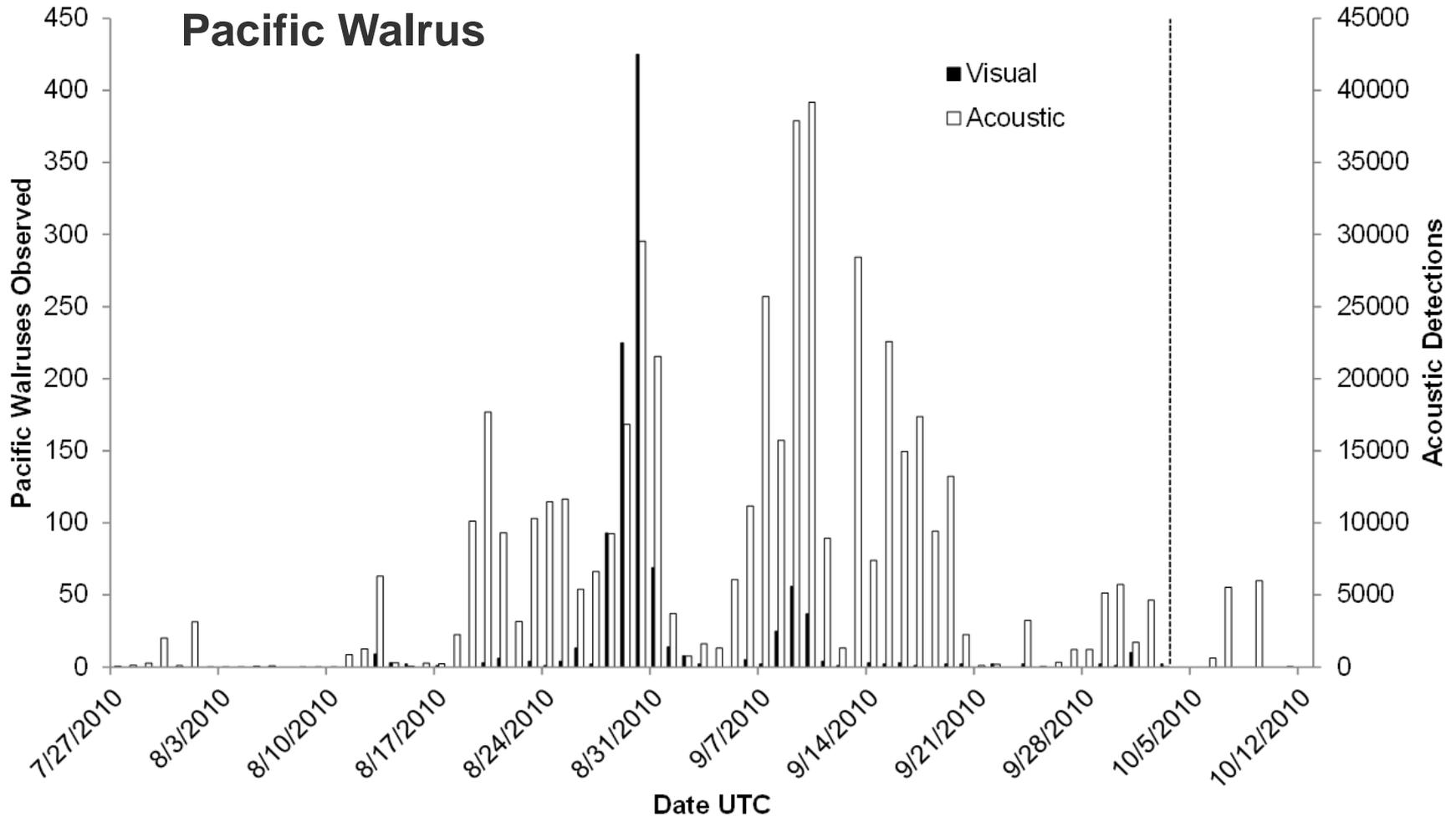
2010 Acoustic and Visual Detections



2010 Acoustic and Visual Detections



2010 Acoustic and Visual Detections





Thank you

Statoil 2010 Chukchi Sea Seismic Survey: Marine Mammal Monitoring

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