LADC-GEMM 2015-17

Towed hydrophones Surveys of the Gulf of Mexico using Unmanned Surface Vehicles

Chris Pierpoint (Seiche Ltd.), David Comeaux (ASV Global), Lorenzo Scala (Seiche Ltd.)

& Natalia Sidorovskaia (University of Louisiana)

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Unmanned Surface Vehicles 2015

C-Worker 6

C-Enduro

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C-Worker 5 Improvements 2017

C-Worker 5

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C-Worker 5 Improvements 2017

- Remote-controlled Winch

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C-Worker 5 Improvements 2017

- Remote-controlled Winch
- Real-time PAM via Cobham Radio Telemetry Link

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C-Worker 5 Improvements 2017

- Remote-controlled Winch
- Real-time PAM via Cobham Radio Telemetry Link
- Instrument Payload Bay

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C-Worker 5 Improvements 2017

- Remote-controlled Winch
- Real-time PAM via Cobham Radio Telemetry Link
- Instrument Payload Bay
- Survey Speed

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C-Worker 5 Improvements 2017

- Remote-controlled Winch
- Real-time PAM via Cobham Radio Telemetry Link
- Instrument Payload Bay
- Survey Speed
- True Heading not GPS COG

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C-Worker 5 Improvements 2017

- Remote-controlled Winch
- Real-time PAM via Cobham Radio Telemetry Link
- Instrument Payload Bay
- Survey Speed
- True Heading not GPS COG
- …Defence against the Sargassum Weed

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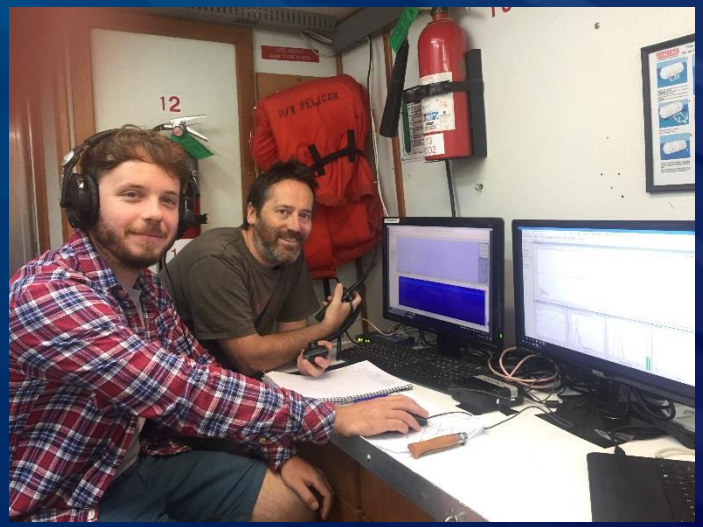
Towed PAM System

Real-time PAM

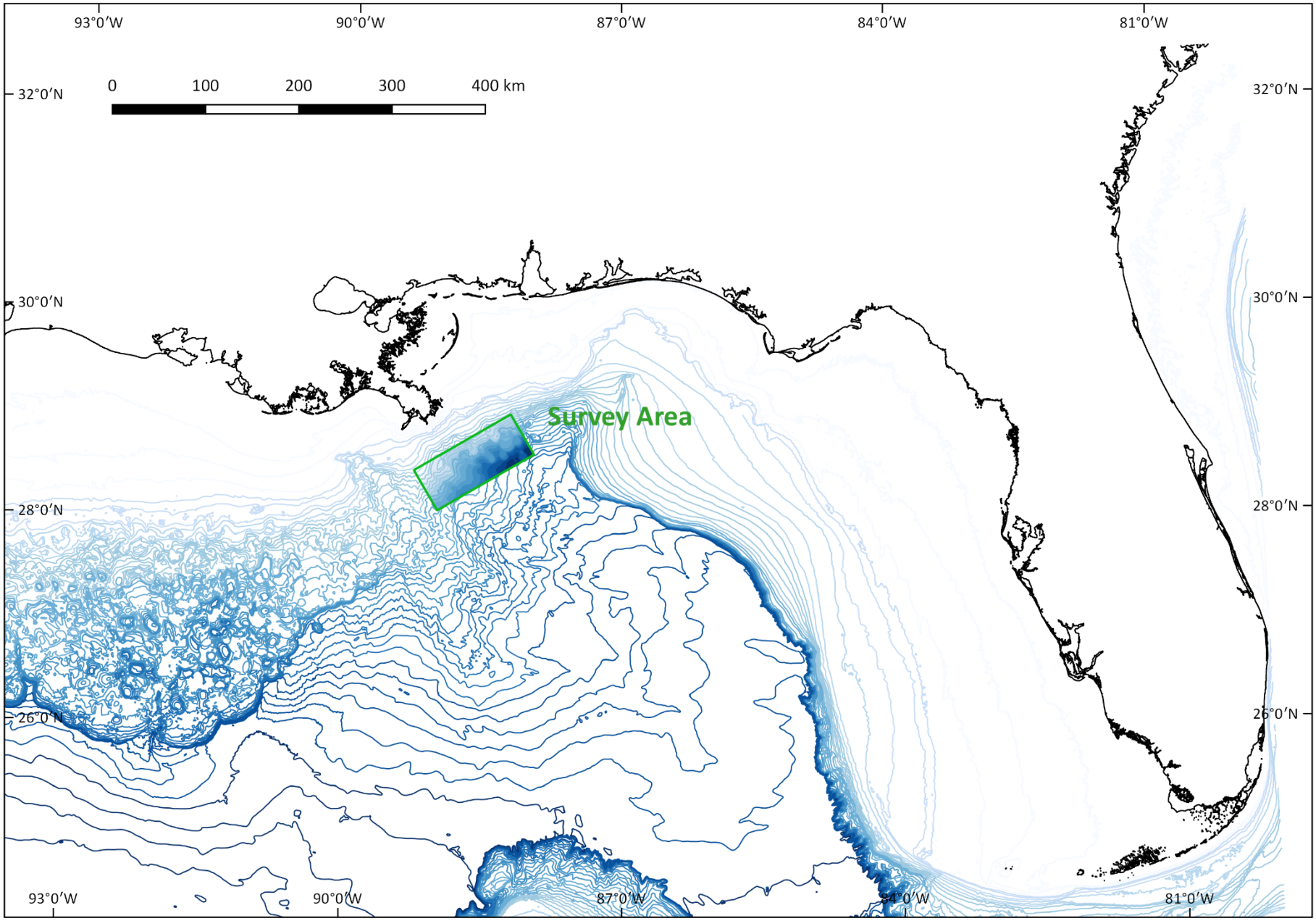
ASV unmanned marine systems

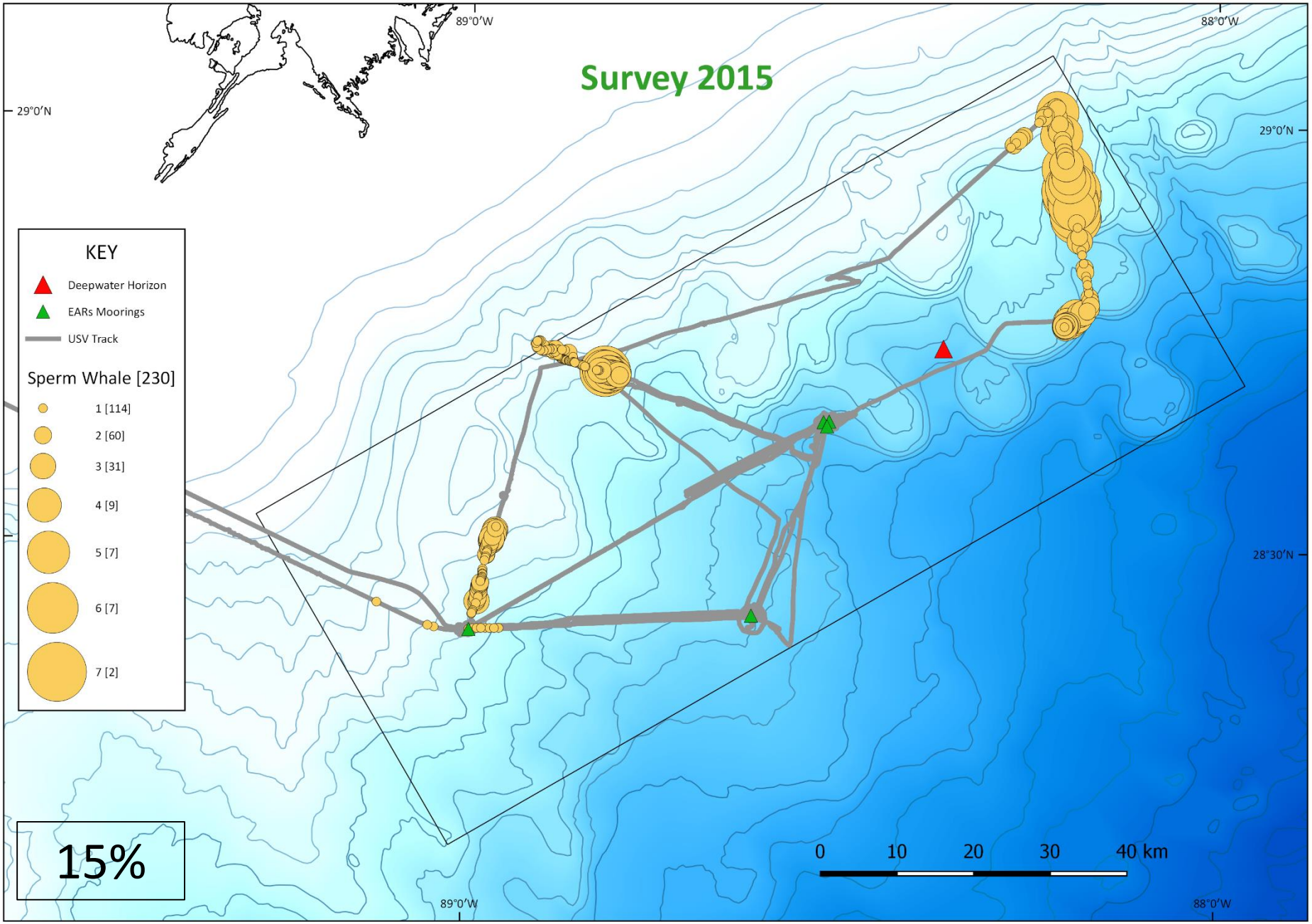


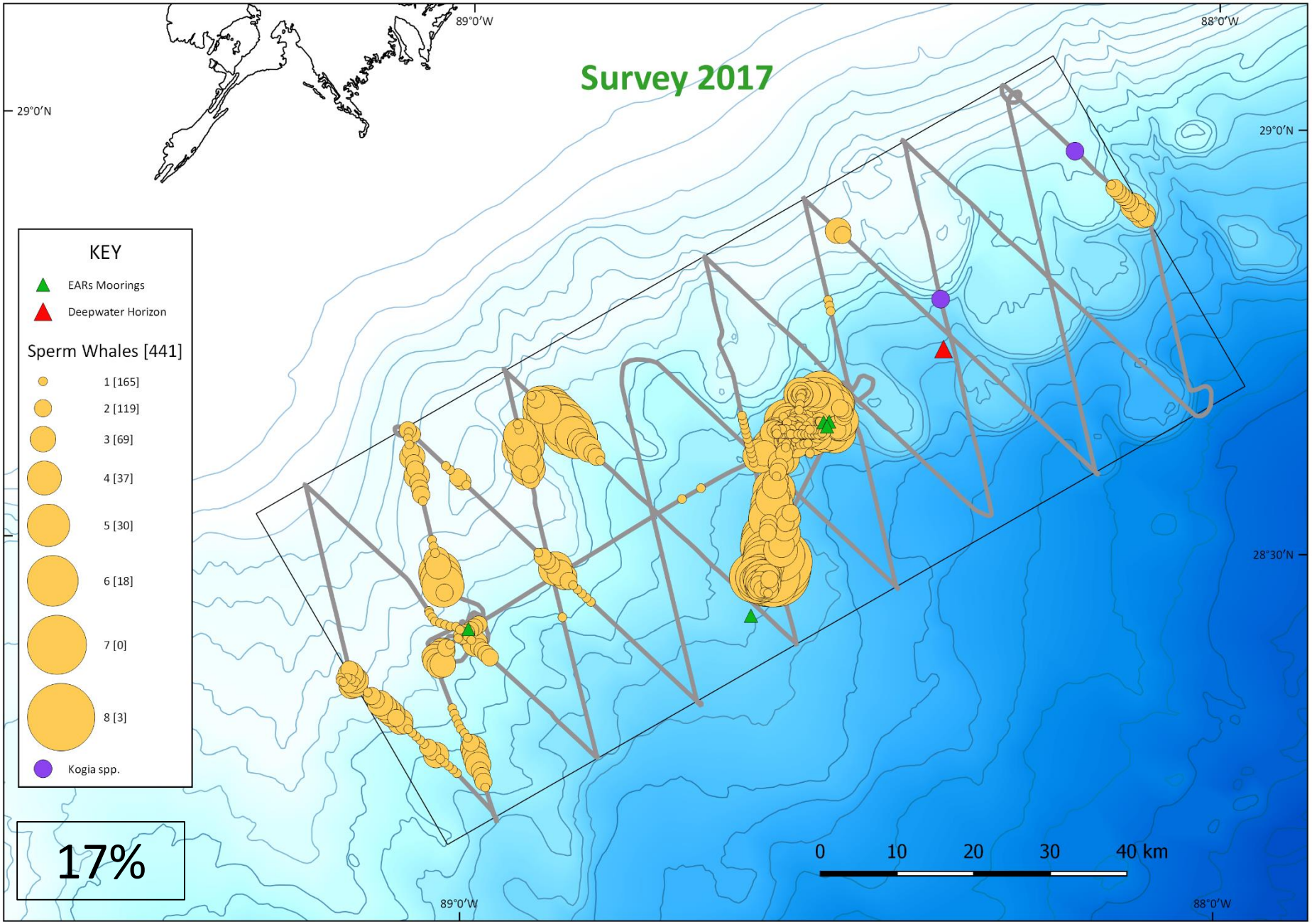
Onboard USV

- 2 ch each sampled at 500 kHz (16-bit)
- Continuous recording in wav-format
- Pamguard + PamDog utility
- GPS & true heading

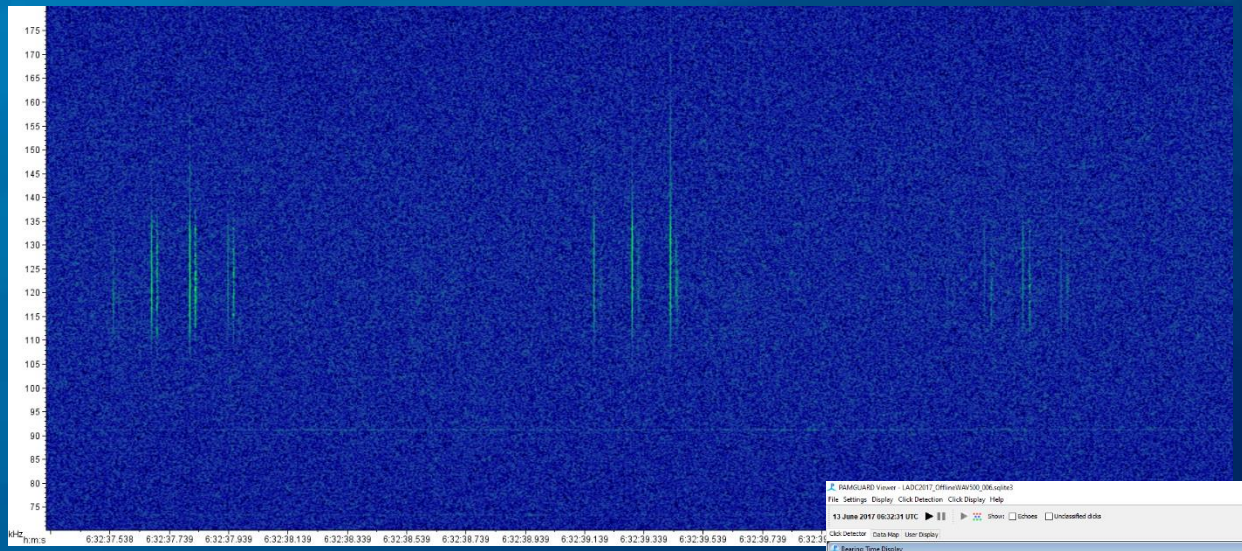
2 x hydrophones (20-180,000 Hz)
30-bar depth sensor

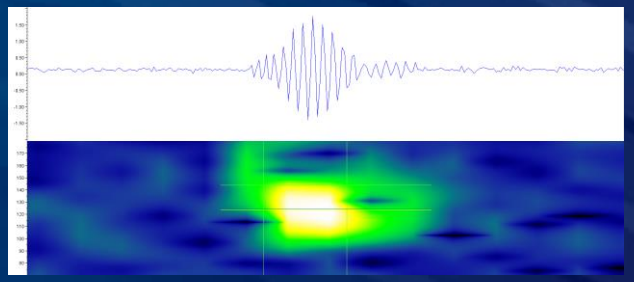

93°0′W
90°0′W
87°0′W
84°0′W
81°0′W
32°0′N
30°0′N
28°0′N
26°0′N
0
100
200
300
400 km
Survey Area


Survey 2015
89°0′W
88°0′W
29°0′N
28°30′N
KEY
Deepwater Horizon
EARs Moorings
USV Track
Sperm Whale [230]
1 [114]
2 [60]
3 [31]
4 [9]
5 [7]
6 [7]
7 [2]
15%
0
10
20
30
40 km


Survey 2017
89°0′W
88°0′W
29°0′N
28°30′N
KEY
EARs Moorings
Deepwater Horizon
Sperm Whales [441]
1 [165]
2 [119]
3 [69]
4 [37]
5 [30]
6 [18]
7 [0]
8 [3]
Kogia spp.
17%
0
10
20
30
40 km

Kogia spp.

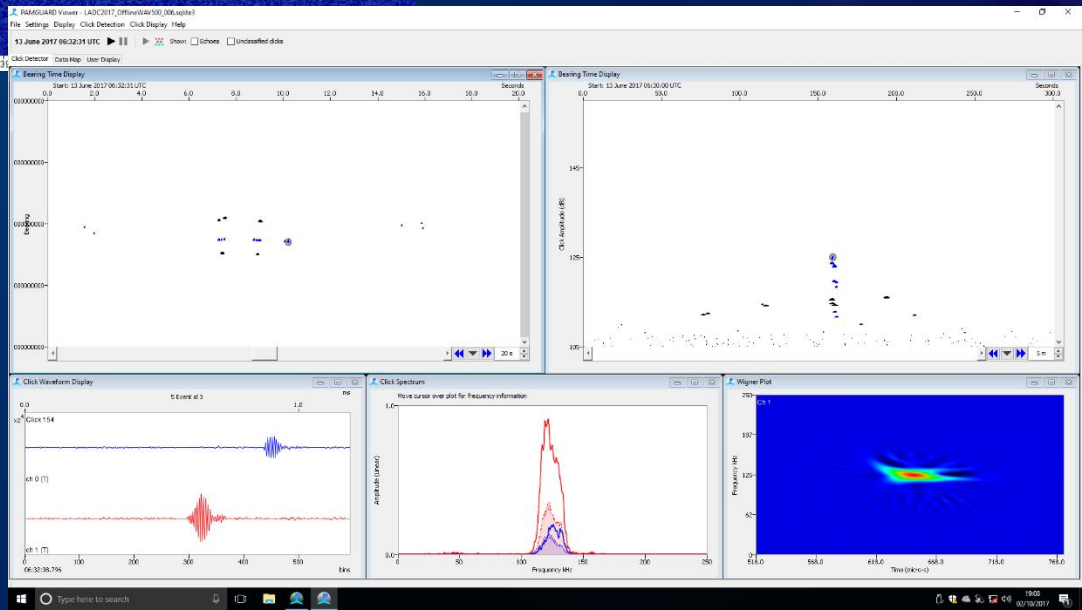


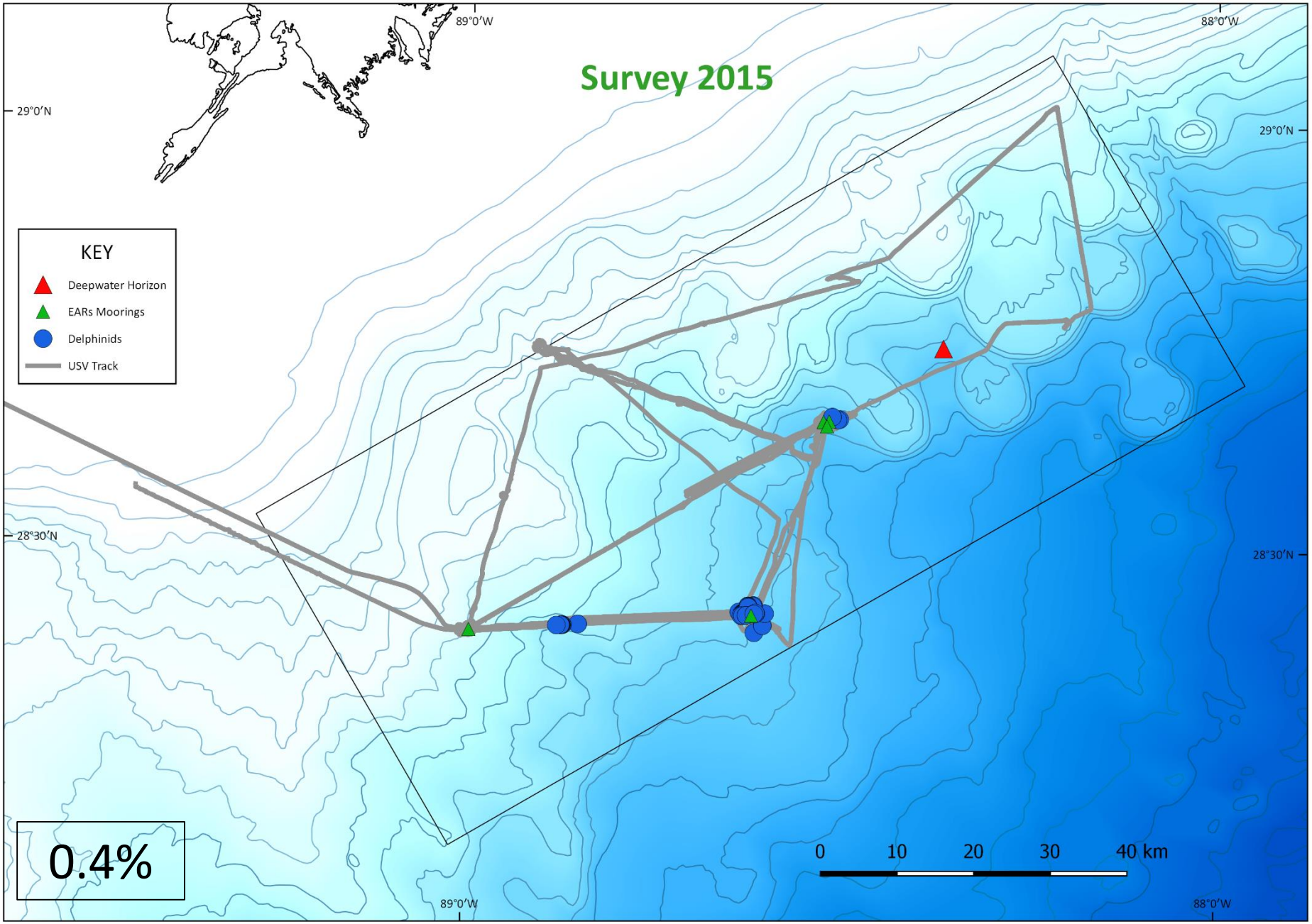


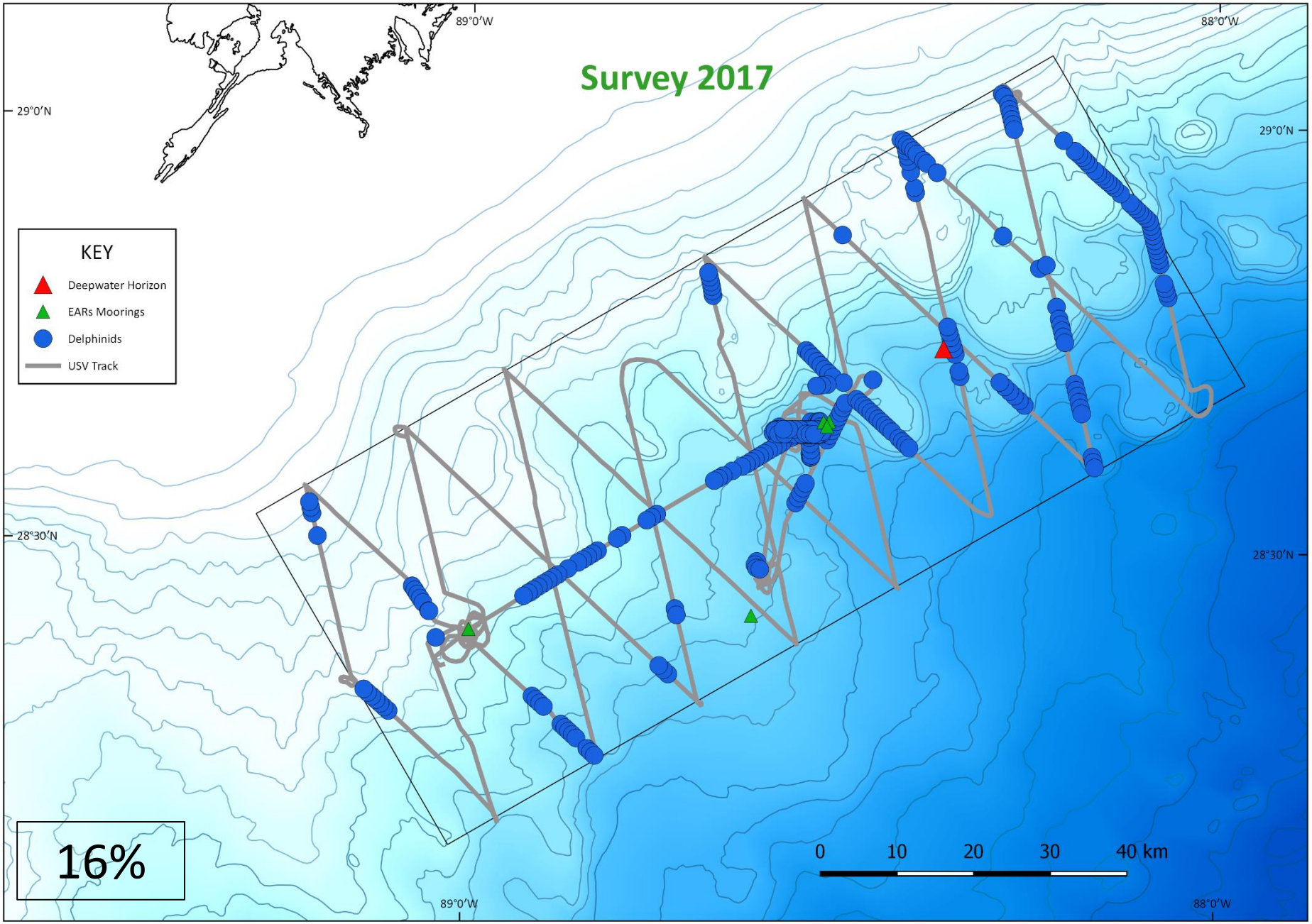
Peak Frequency: 123 kHz

IQ Frequencies: 117-131 kHz

90% Duration: 70 micro-S




Survey 2015
89°0′W
88°0′W
29°0′N
28°30′N
KEY
Deepwater Horizon
EARs Moorings
Delphinids
USV Track
0.4%
0
10
20
30
40 km


Survey 2017
KEY
Deepwater Horizon
EARs Moorings
Delphinids
USV Track
89°0′W
88°0′W
29°0′N
28°30′N
0
10
20
30
40 km
16%

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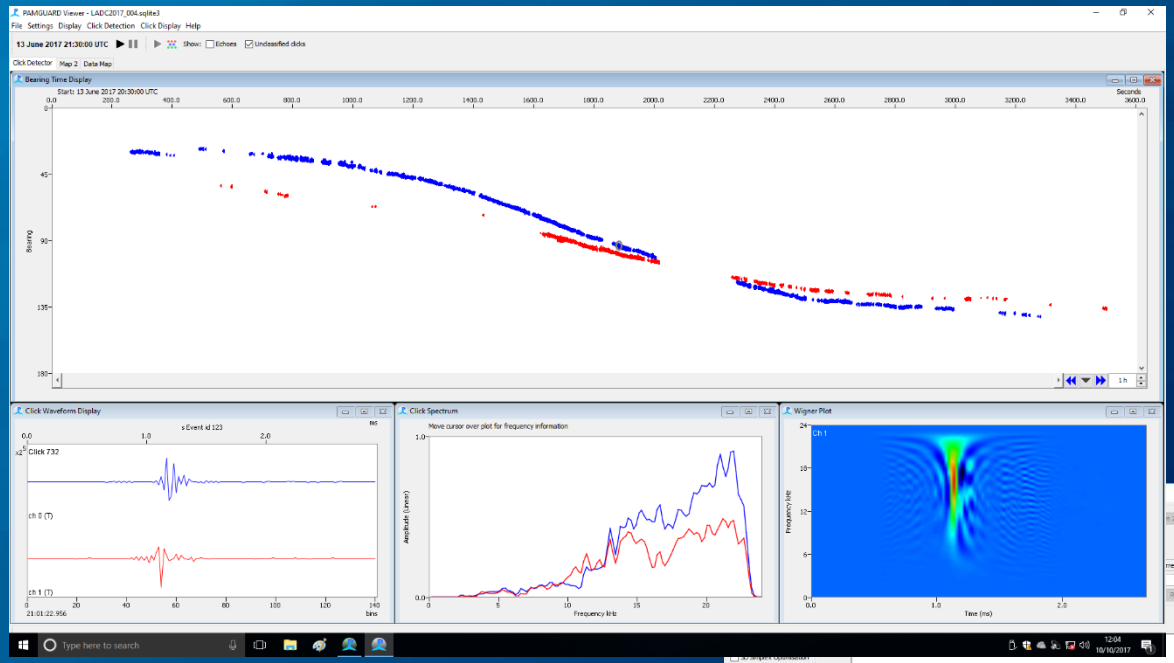
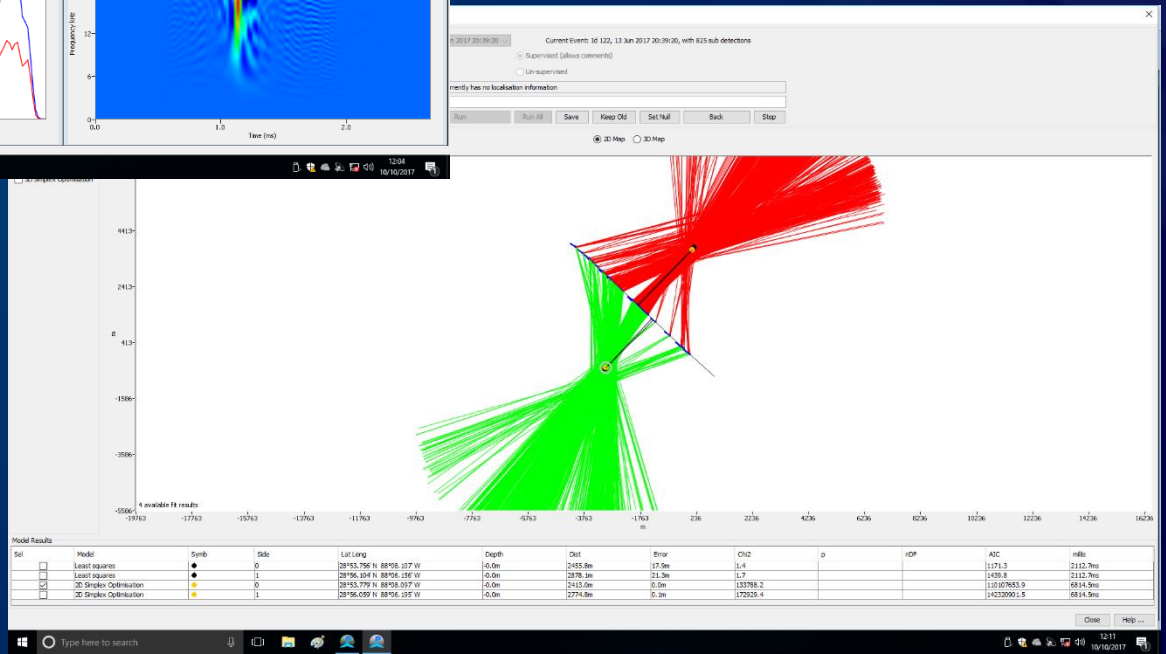
Target Motion Analysis

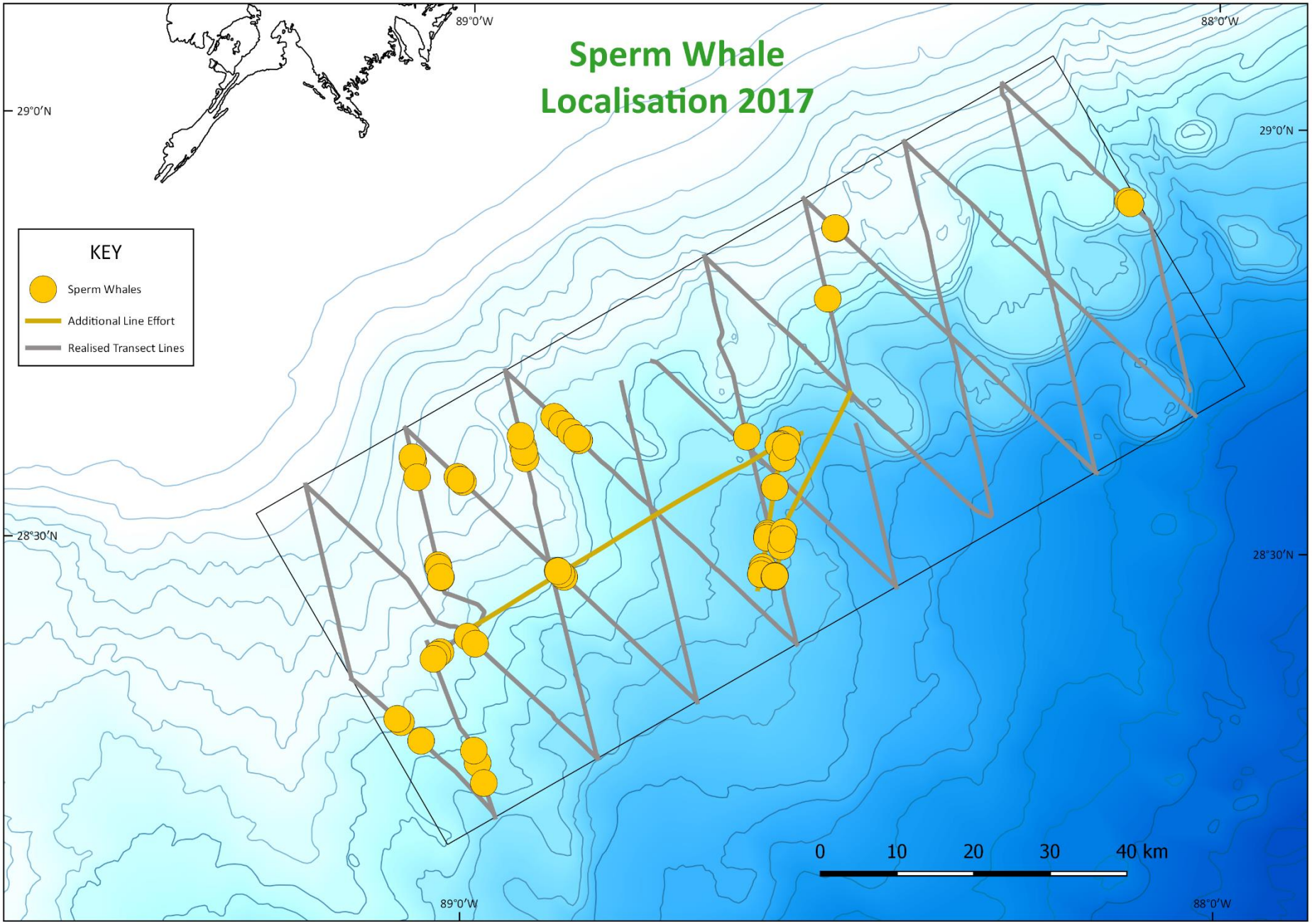


Pamguard Viewer – extract tracks of individual whales

Upper window: y-axis = click bearing angle, x-axis = time (1-h window in this case)

TMA used to estimate the whales' most likely positions and perpendicular range




Sperm Whale
Localisation 2017
KEY
Sperm Whales
Additional Line Effort
Realised Transect Lines
89°0′W
88°0′W
29°0′N
28°30′N
0
10
20
30
40 km

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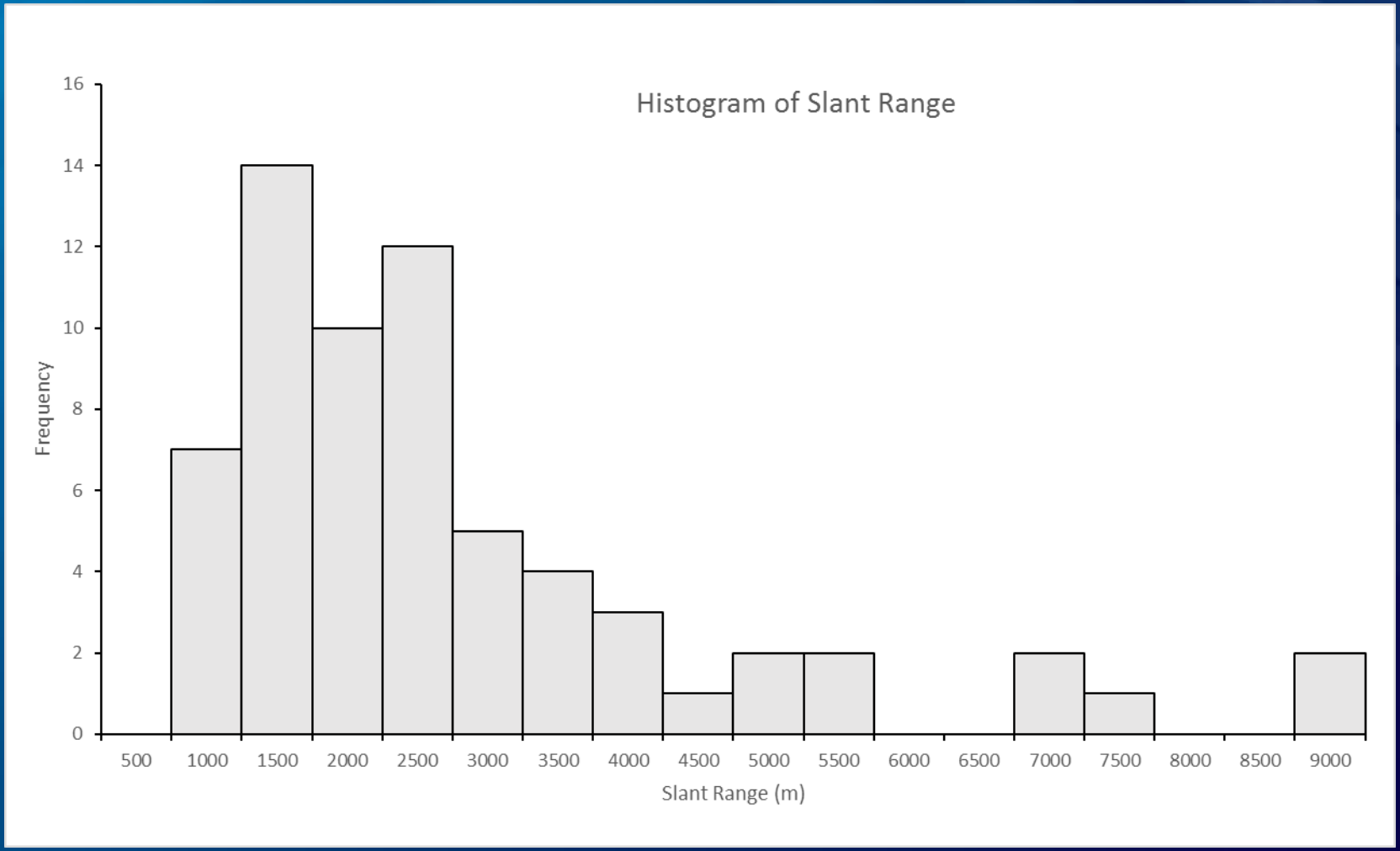

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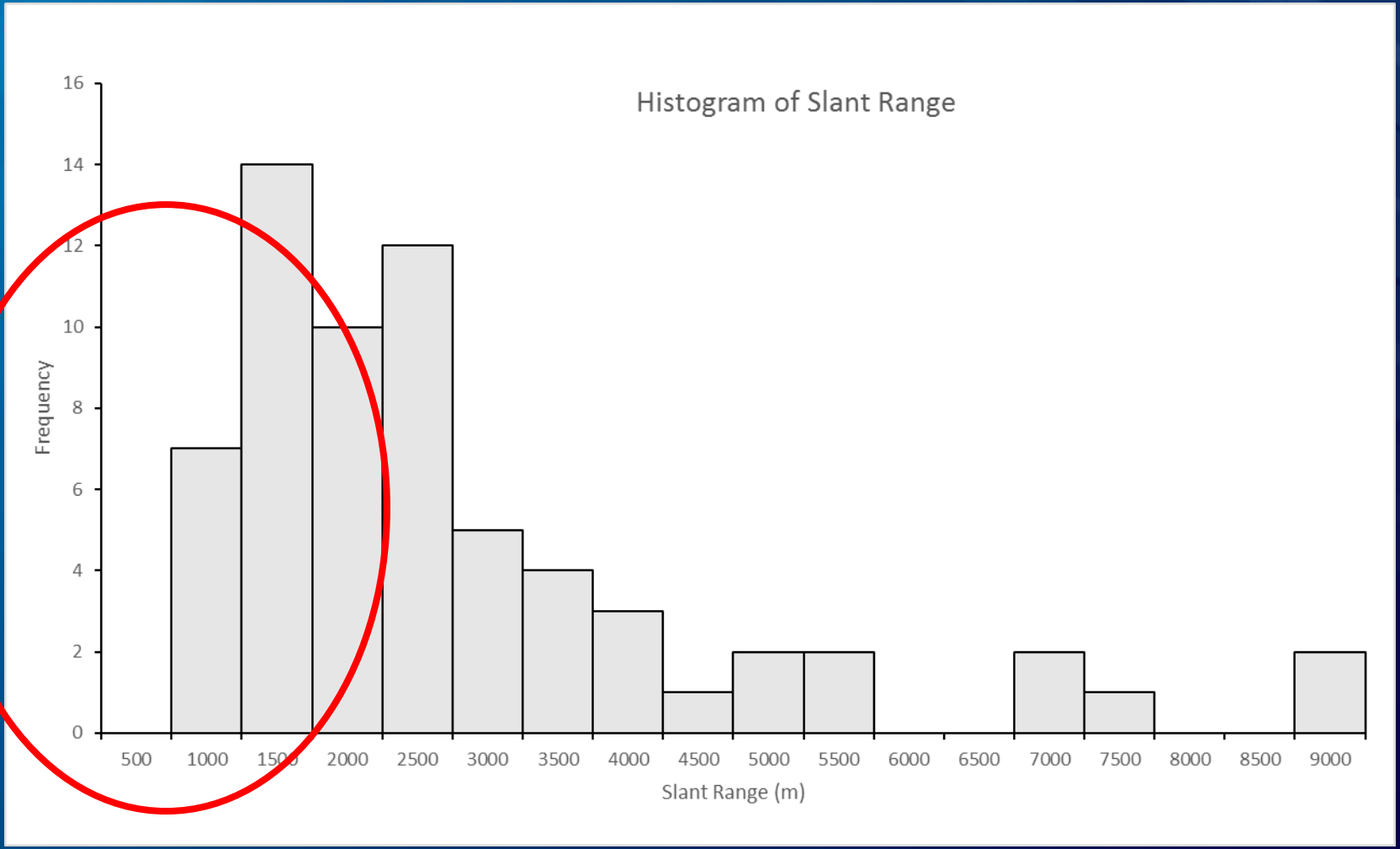

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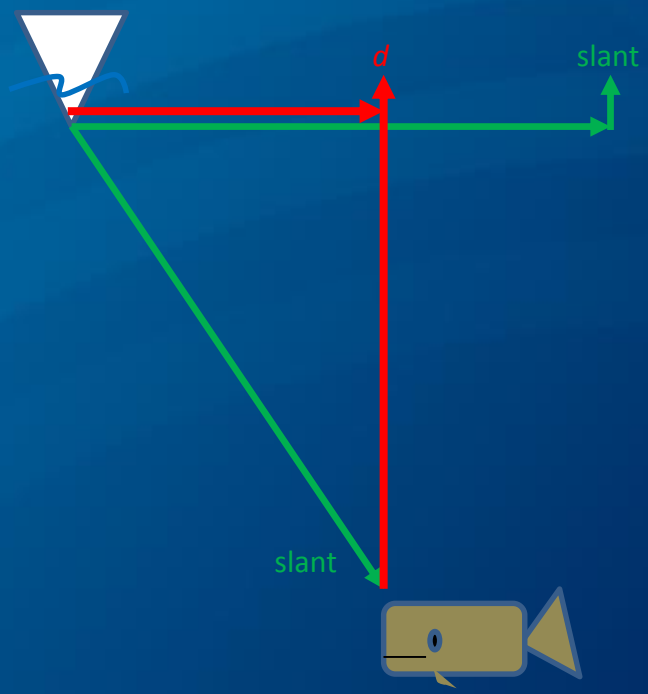

Measured slant ranges overestimate the **perpendicular ranges** to whales from the transect analysed by Distance Sampling

This leads to an overestimation of perpendicular range and the effective survey strip width

And to an underestimation of whale density

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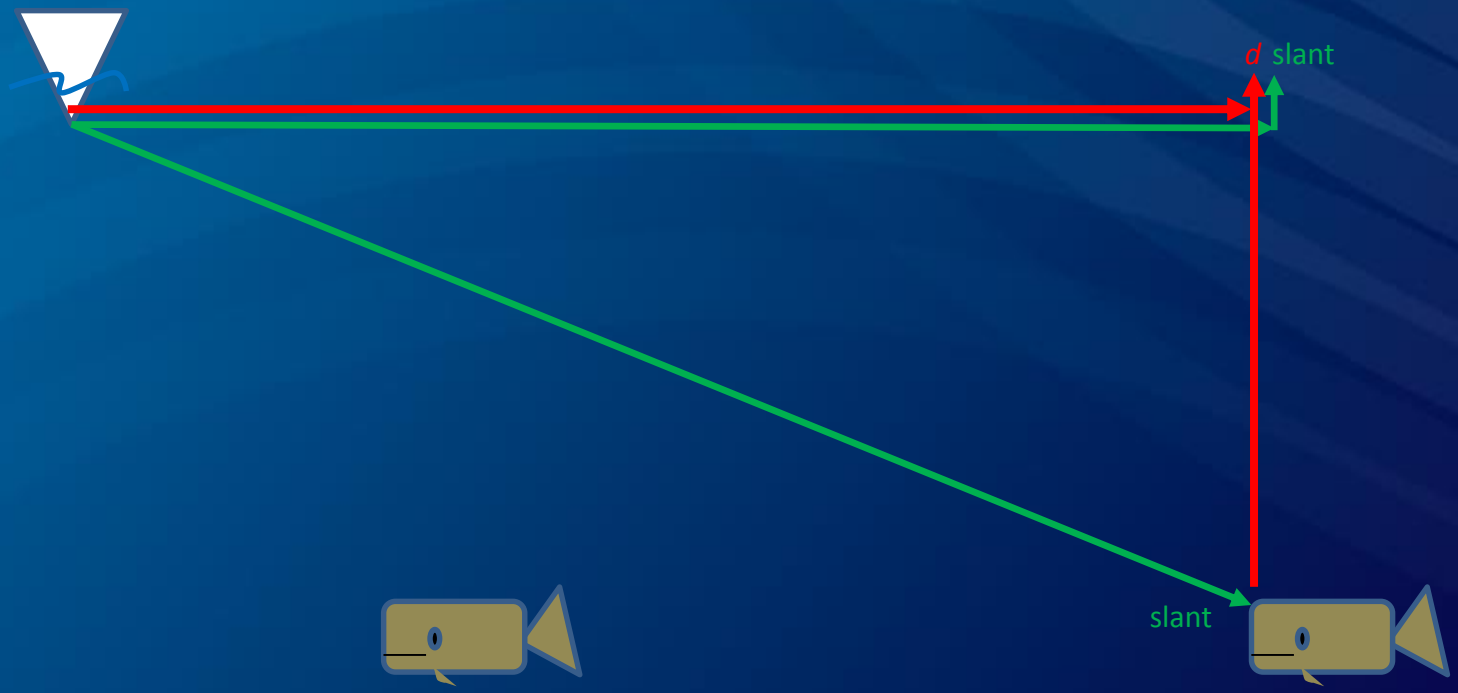

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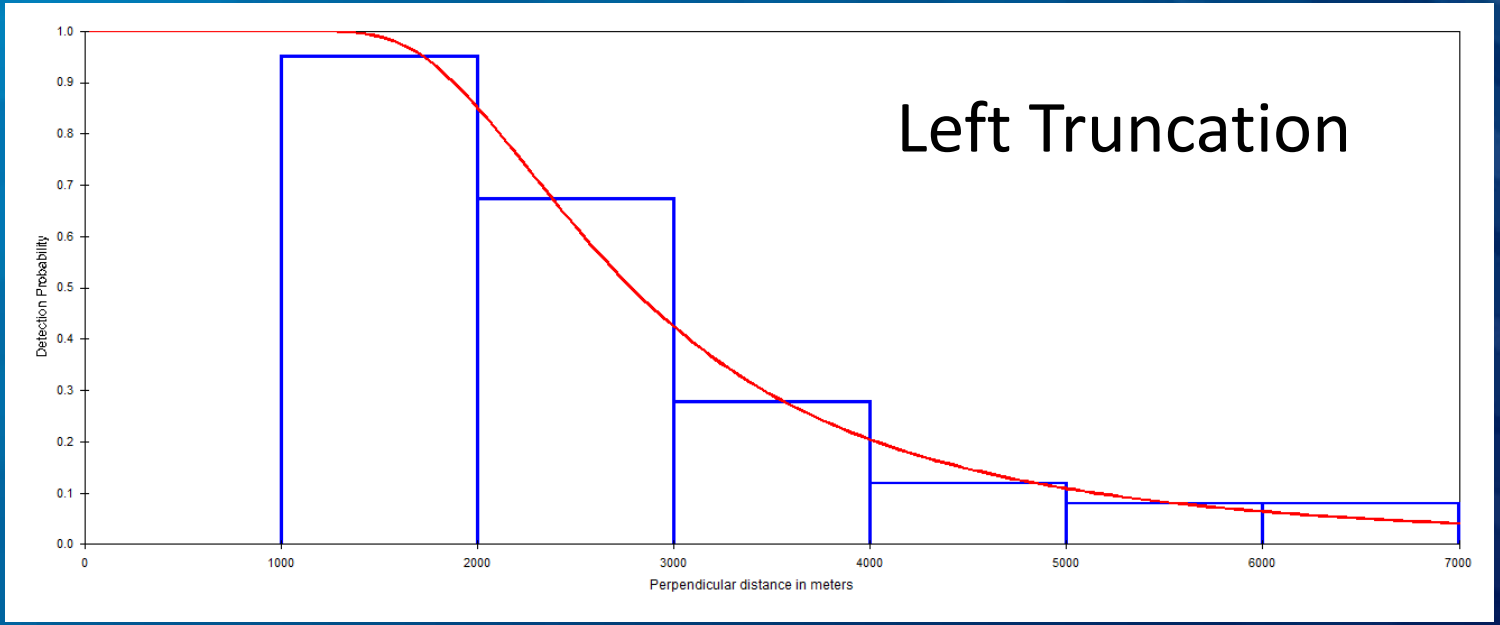
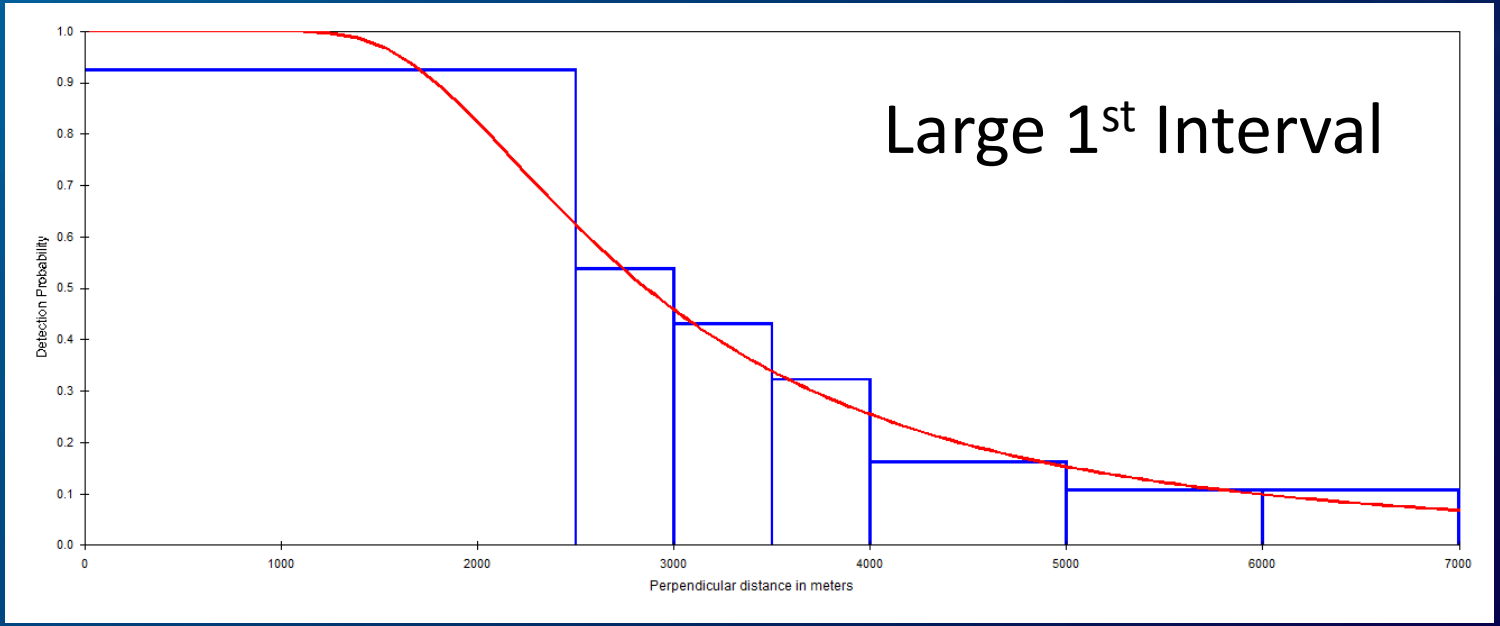
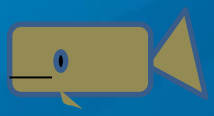
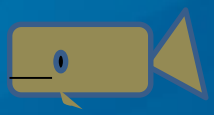




Availability Bias: g(0) = 0.95



Sperm whales click continuously, probability of detection at the transect g(0) = 1



If the extent of silent periods (no 'usual' click trains) means that the USV passes by without an opportunity to detect the whale acoustically g(0) < 1

Assuming g(0) = 1 in the latter case => underestimation of abundance

D-Tags => [including: Jochens *et al.* 2006; Watwood *et al*. 2006; Irvine *et al.* 2017; Azores data cited by Fais *et al.* 2016]

Following Fais *et al.* (2016) – Monte Carlo simulations – g(0) = 0.948 (se = 0.03)

Slant Range v Perpendicular Distance

		D/1000 km^2	N	CV	95% CI
0 m Depth	Wide 1st Interval	7.9	48	38%	23-100
	Left Truncate	10.0	63	41%	28-138
500 m depth	Wide 1st Interval	7.3	44	35%	22-88
	Left Truncate	9.8	59	43%	26-135

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Slant Range v Perpendicular Distance

		D/1000 km^2	N	CV	95% CI
0 m Depth	Wide 1st Interval	7.9	48	38%	23-100
	Left Truncate	10.0	63	41%	28-138
500 m depth	**Wide 1st Interval**	**7.3**	**44**	**35%**	**22-88**
	Left Truncate	9.8	59	43%	26-135

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Next Steps

- C-Worker Towed PAM Development
  - Non-acoustic array sensors
  - Further reduction in self-noise
  - Survey and real-time PAM via satellite control link
- Sperm Whale Density Estimation
  - Incorporate dive depth model
  - g(0) estimation for northern Gulf of Mexico
- Delphinids
  - Species discrimination

Thank You!

Captain & Crew of R/V Pelican

Tina Yack, Danielle Harris, Liz Ferguson, Tim Lewis, Tom Norris,

Doug Gillespie & Eric Rexstad.