3S-BRS; OVERVIEW APPLICATIONS & DATA GAPS

BRS WORKSHOP, SMM, SAN FRANCISCO

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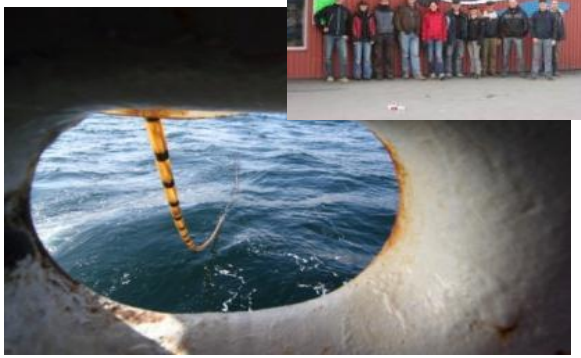
TNO innovation for life

SEA MAMMALS AND SONAR SAFETY PROJECT

International research project with the aim to investigate behavioral reactions of cetaceans to naval sonar signals, in order to establish safety limits for sonar operations.

- **Partners: FFI (NO), TNO (NL), SMRU (UK), WHOI (USA)**
- **Sponsors: RNoN/MOD, RNLN/MOD, US-ONR, DGA Fr-MOD**
- **30 scientists from 10 different countries.**
- **3S-board: Kvadsheim, Miller, Lam, Tyack**

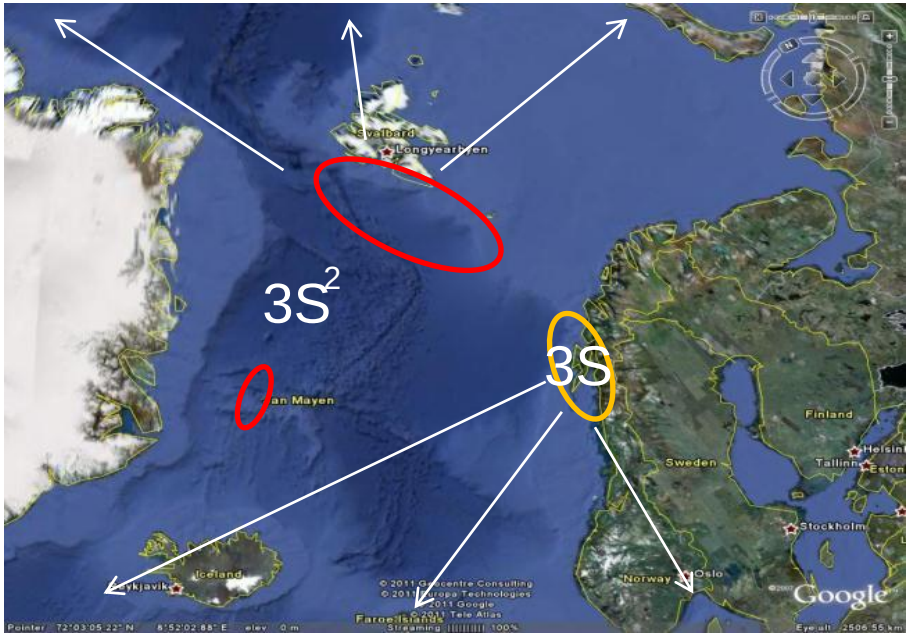


3S2

2011-2015

3S

2006-2010



SONAR SYSTEMS - CONFIGURATIONS

- Hull mounted

- Towed

UK NL

SONAR SYSTEMS & FREQUENCIES USED

USN:

- **LFA-Surtass, 0.2 – 0.5 kHz**
- **MF, mid-frequency 2 – 10 kHz**
  - **AN/SQS-53C 3 – 3.5 kHz**
  - **AN/SQS-56 6 – 9 kHz**

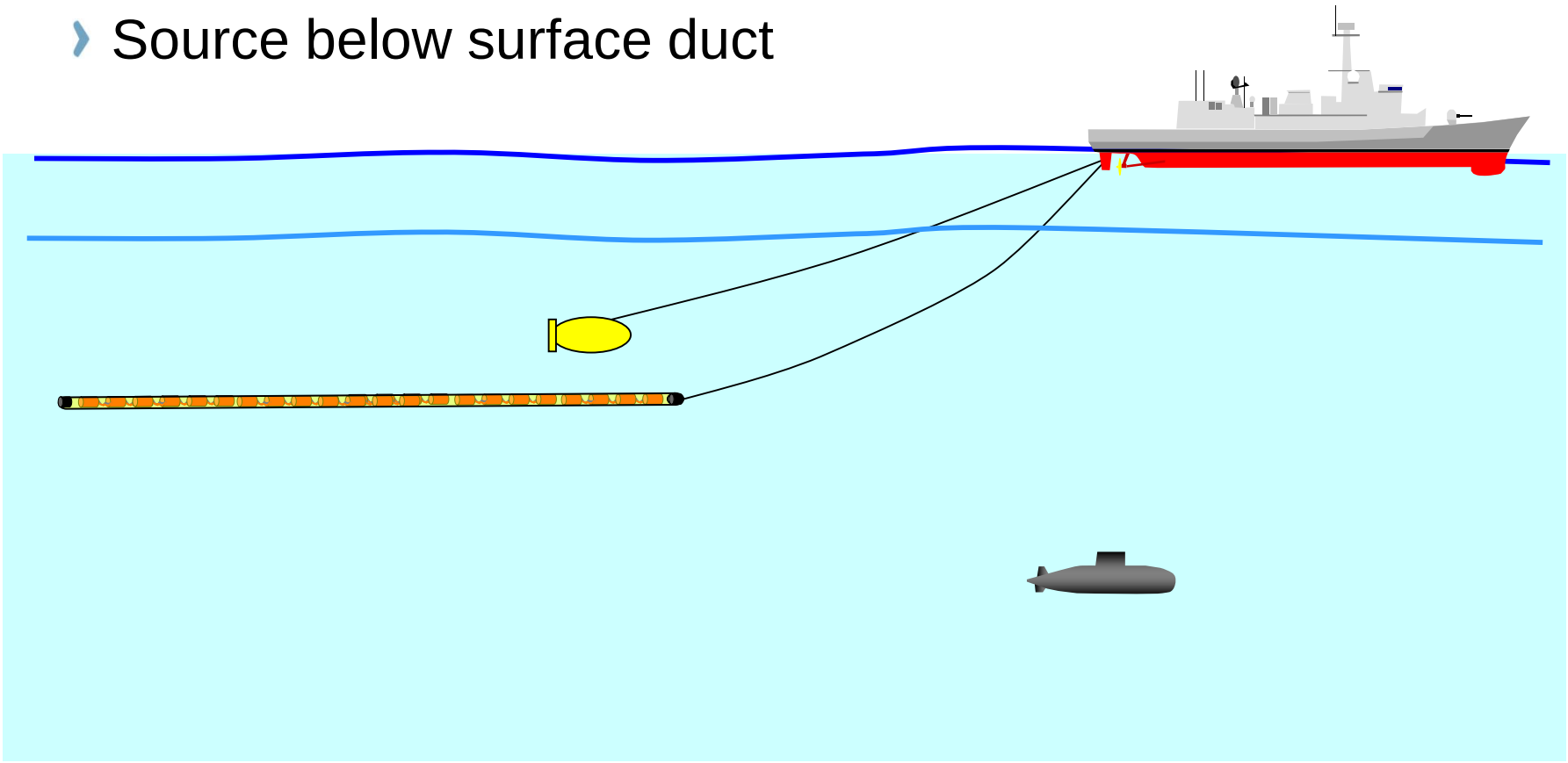
3S:

- **LFAS 1 – 2 kHz**
- **MFAS 6 – 7 kHz**

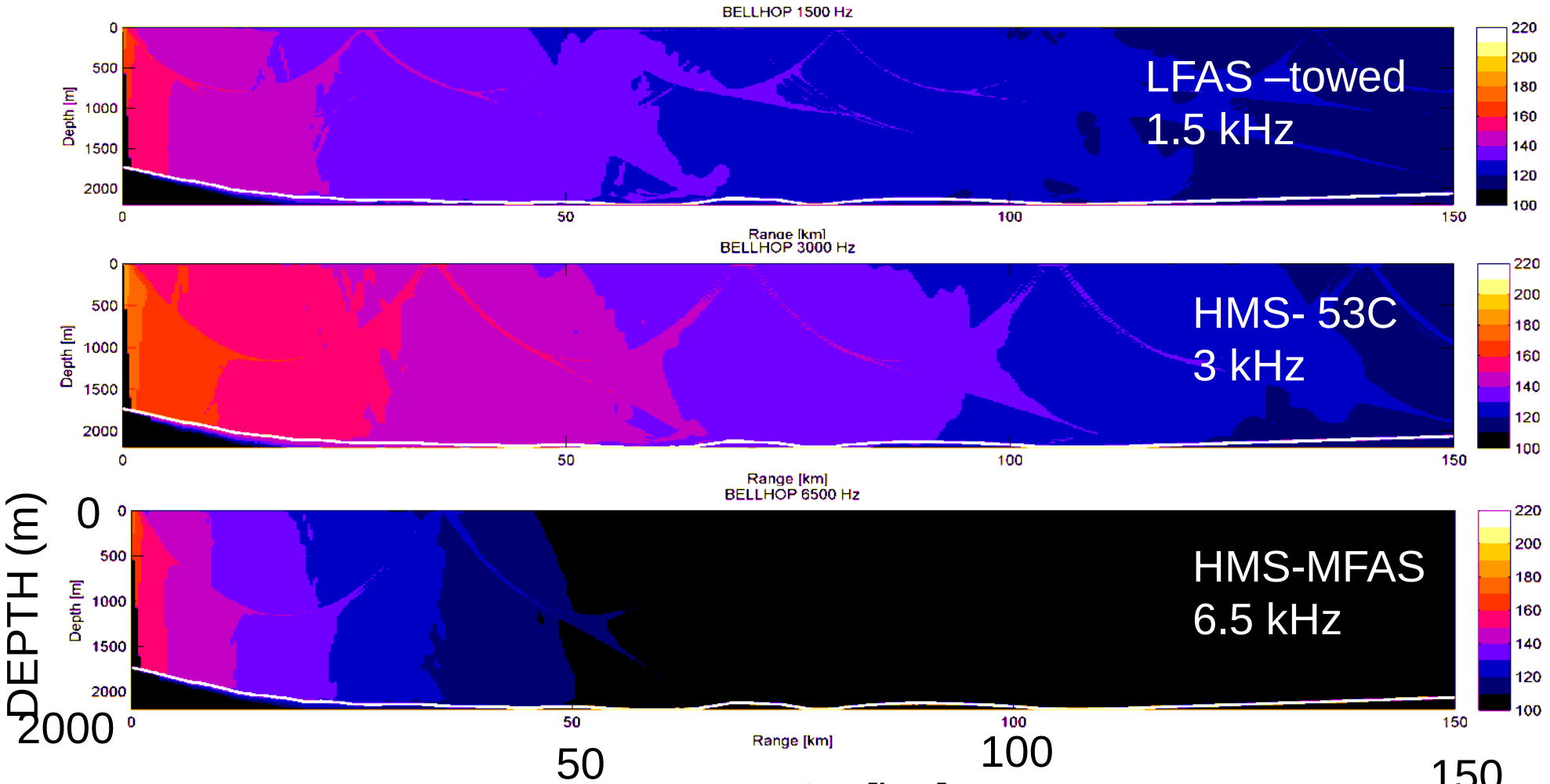
- Helicopter sonars not included here

TOWED LFAS SYSTEMS

- Frequency slightly lower than 53C
- Source below surface duct



SPL MAPS FOR DIFFERENT SONARS (UNCLASS. SL, JAN MAYEN EXAMPLE)



RECIPE:
HOW TO EXECUTE BRS/CEE AT SEA

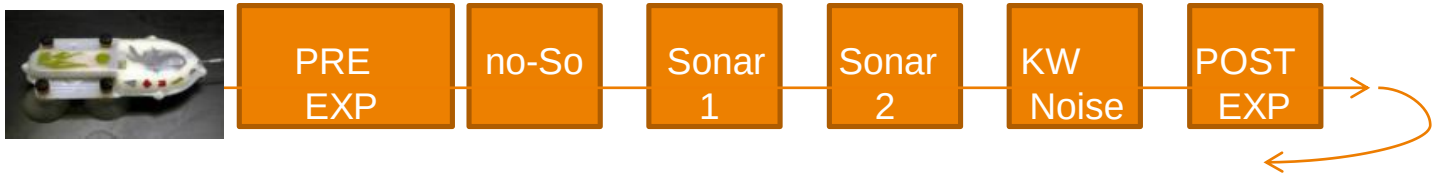
1. Find (detect) animals
2. Place (acoustic) tag
3. Expose to sound
4. Observe behaviour before/during/after)

Northern Bottlenose whales. Photo: Fleur Visser

3S DATA COLLECTION

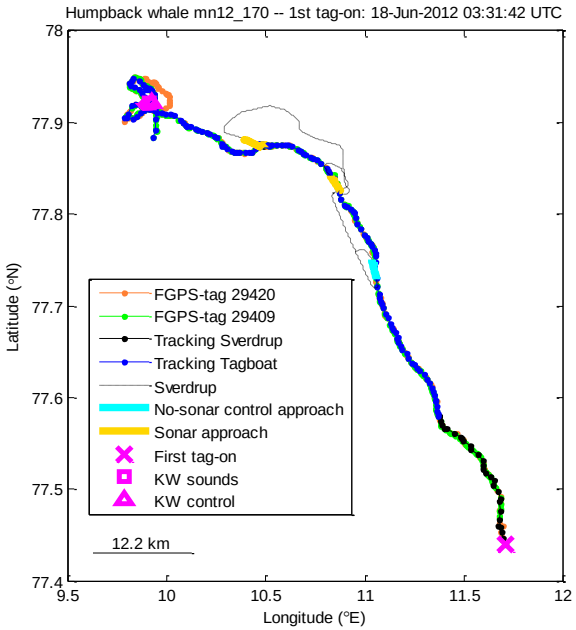
TNO innovation for life

6 BRS cruises (2006, 2008, 2009, 2011, 2012, 2013)
7 baseline cruises (2007, 2010, 2013, 2014, 2015)

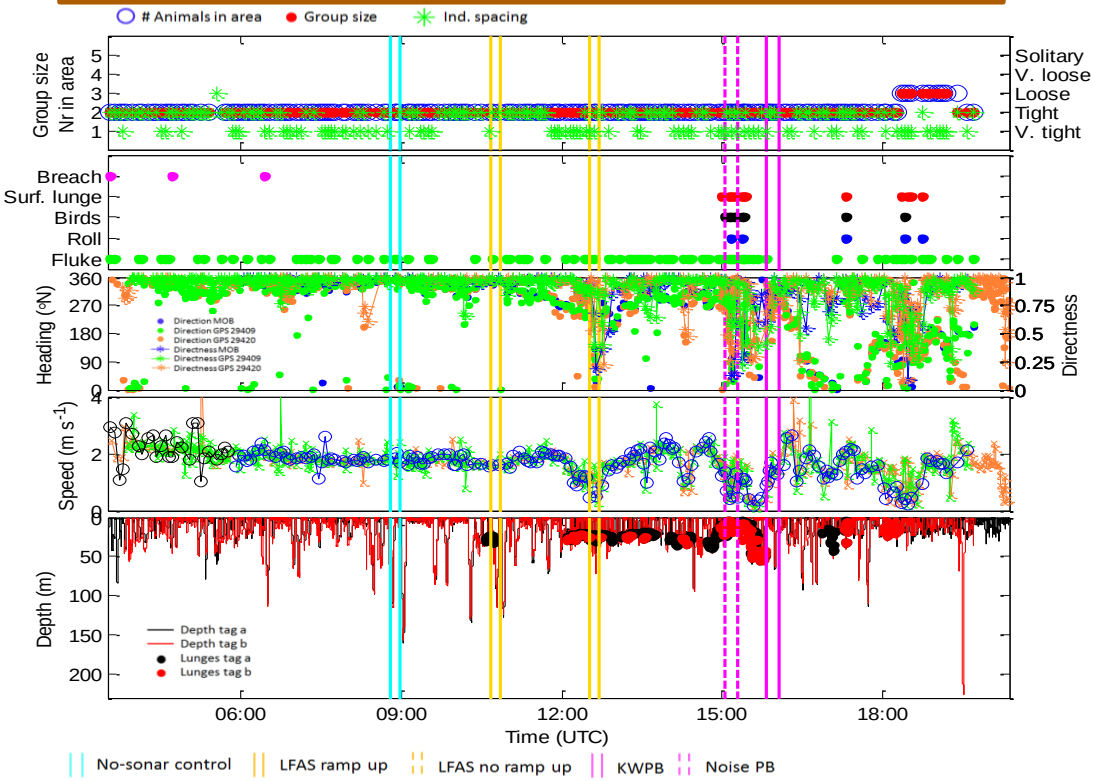


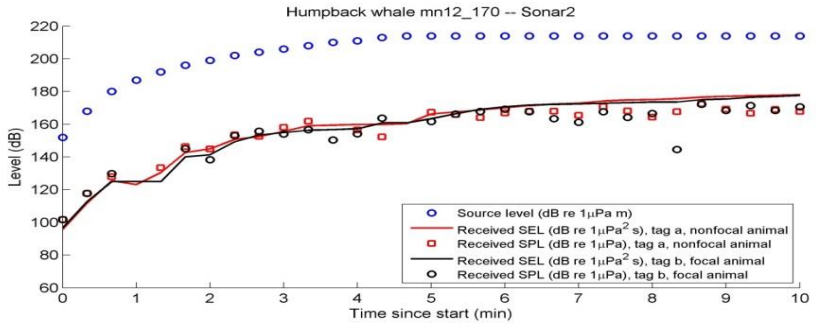
Species	# TAGs deployed	# Sonar exp.	# Control exp.	Trial - year	
Killer whales	22	8	3	3S-05, 3S-06, 3S-08, 3S-09, ICE-09	
Pilot whales	34	14	28	3S-08, 3S-09, 3S-10, 3S-13	
Sperm whales	10	10	9	3S-08, 3S-09, 3S-10	3S
Herring	0	38	25	3S-06, 3S-08	
Minke whales	2	1	2	3S-10, 3S-11	
Bottlenose whales	16	1	3	3S-13, JM-14, JM-15	3S2
Humpback whales	27	20	29	3S-11, 3S-12	
SUM	**111**	**92**	**99**		

DATA STREAMS

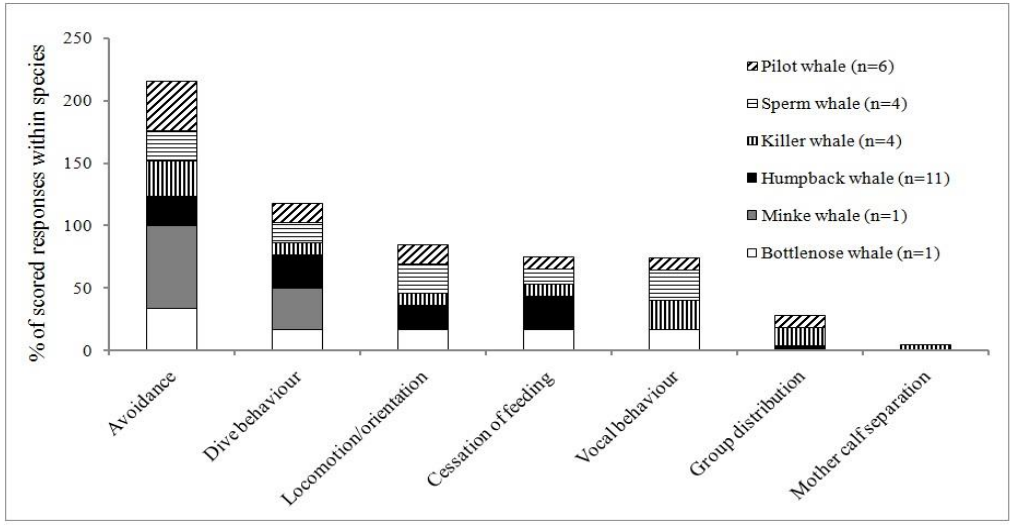


Vocalization





EXPERT SEVERITY SCORING



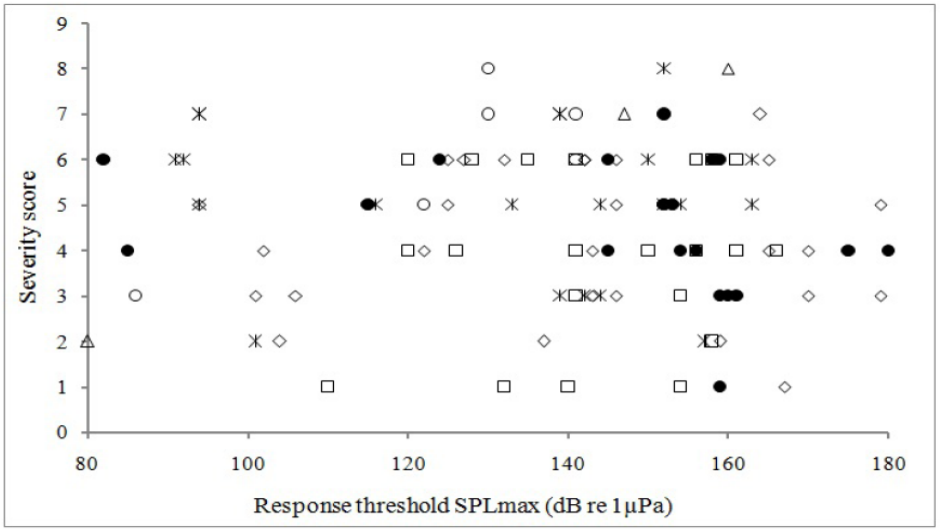


Figure 5. Scored severity vs threshold of all responses in the three species of this study and the three species of Miller et al. (2012): humpback whale (◇), minke whale (Δ), bottlenose whale (○), pilot whale (●), killer whale (*), and sperm whale (□).

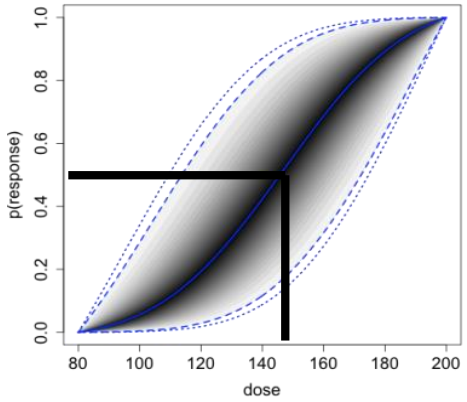
Miller et al. (2012)
Sivle et al. (2015)

Sivle et al. (*2015*). Severity of expert-identified behavioural responses of humpback whale, minke whale and northern bottlenose whale to naval sonar. *Aquatic Mammals 41(4), 469-502*

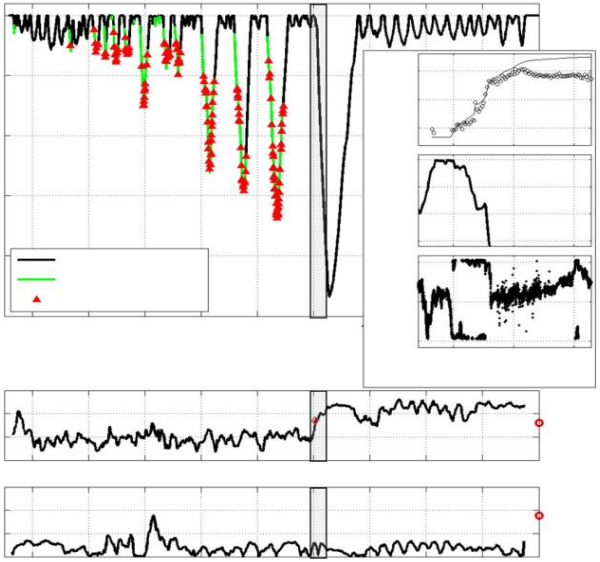
Miller, P.J.O., Kvadsheim, P.H., Lam, F.P.A.., Wensveen, P.J., Antunes, R., Alves, A.C., Visser, F., Kleivane, L., Tyack, P.L., Sivle, L.D. (2012). The severity of behavioral changes observed during experimental exposures of killer (Orcinus orca), long-finned pilot (Globicephala melas), and sperm whales (Physeter macrocephalus) to naval sonar. *Aquatic Mammals* 38: 362-401.

QUANTITATIVE ANALYSIS

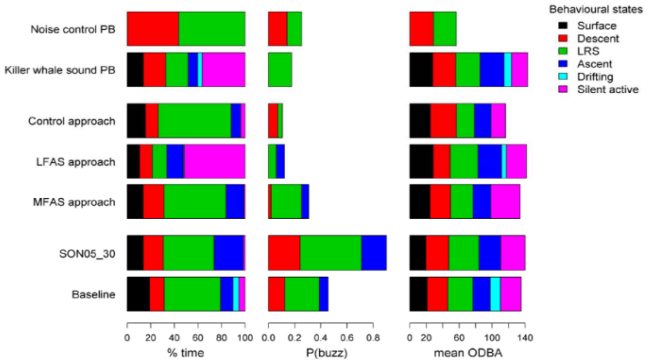
Dose response analysis



Breakpoint analysis

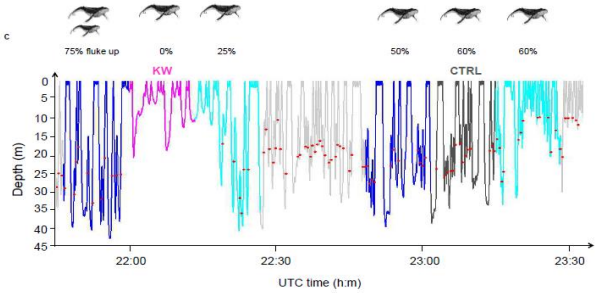


Changes in behavioral states

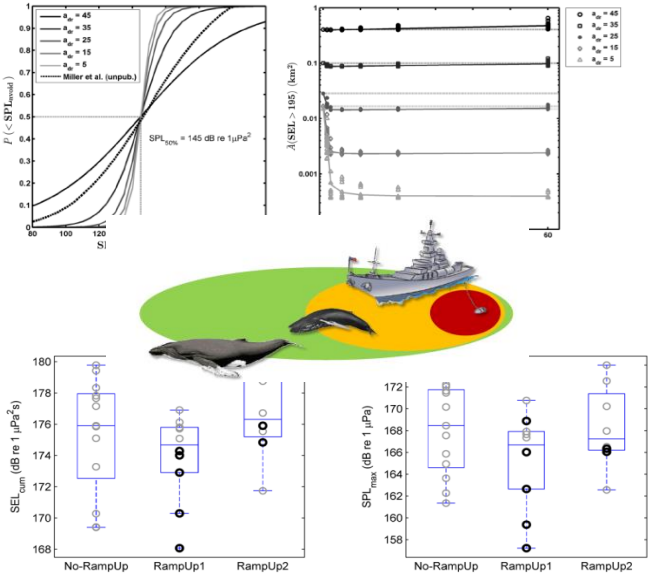


Social responses

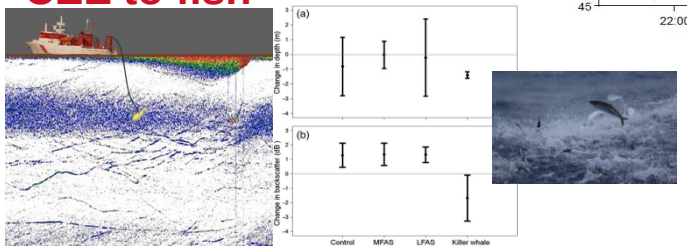
Predator playback



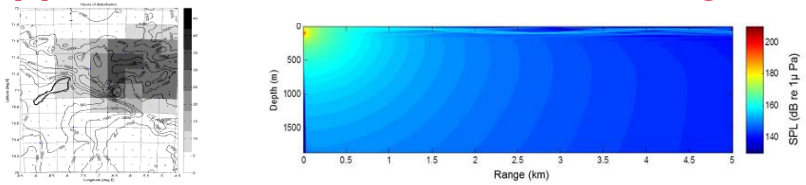
Effectiveness of Ramp Up



CEE to fish



Application of BRS results in management



3S ANALYSIS AND PUBLICATION PLAN

31 peer review papers published
4 in review

18 reports and proceeding papers

17 theses with 3S contribution

All 3S2 data and list of publications (so far):
Kvadsheim et al. (2015), FFI-report 2015/01001
www.ffi.no/no/Rapporter/15-01001.pdf

BRS-symposium St.Andrews, Oct.2015
All presentations: www.tno.nl/smss

2013 EXPERIMENT ON N.BOTTLENOSE WHALES

- Miller et al. (2015)

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Research

Cite this article: Miller PJO *et al.* 2015 First indications that northern bottlenose whales are sensitive to behavioural disturbance from anthropogenic noise. *R. Soc. open sci.* **2**: 140484.
http://dx.doi.org/10.1098/rsos.140484

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Subject Category:
Biology (whole organism)

Subject Areas:
environmental science, behaviour, biomechanics

Keywords:
bottlenose whale, anthropogenic noise, behavioural response, mitigation, naval sonar, *Hyperoodon ampullatus*

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First indications that northern bottlenose whales are sensitive to behavioural disturbance from anthropogenic noise

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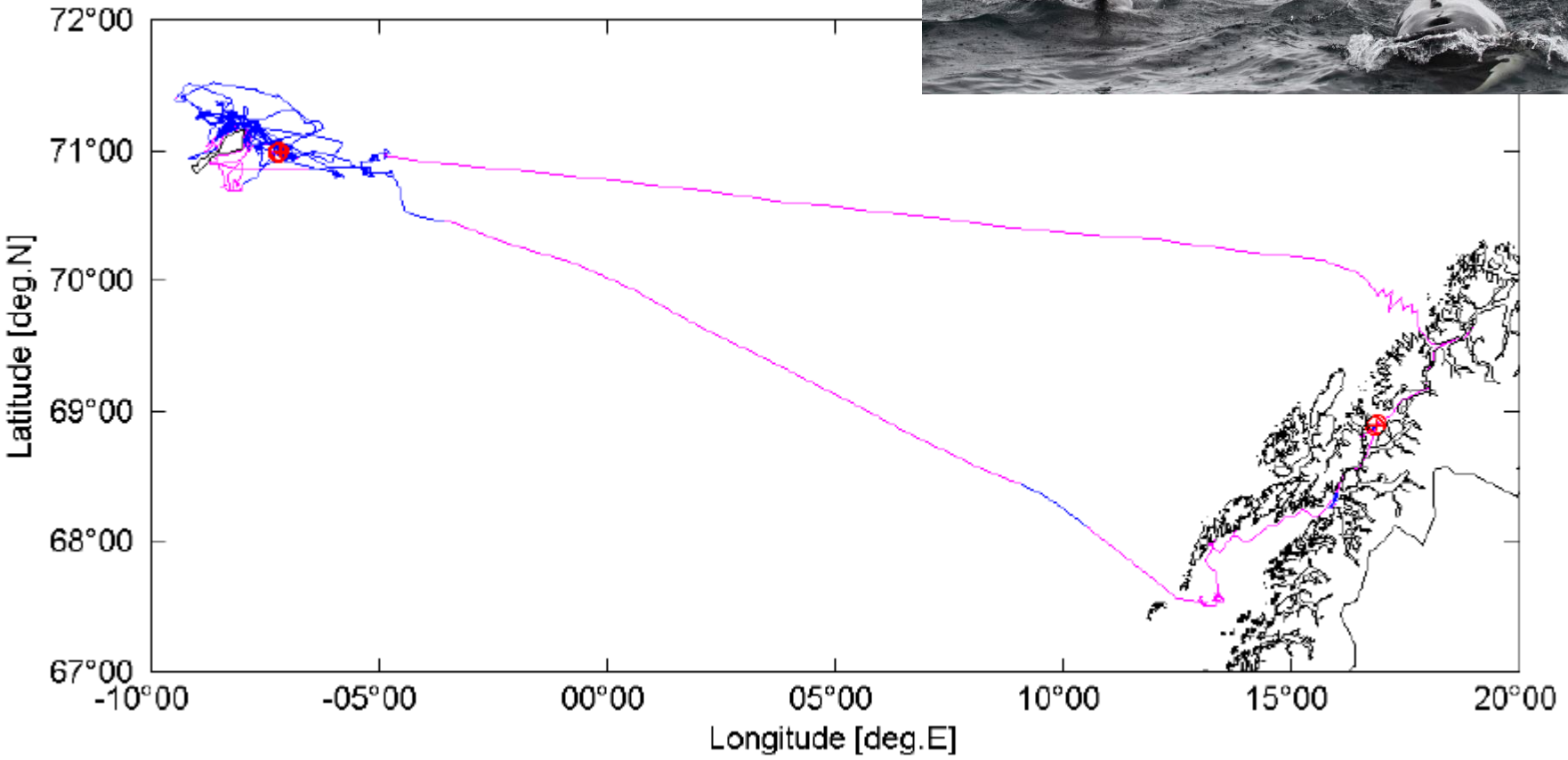
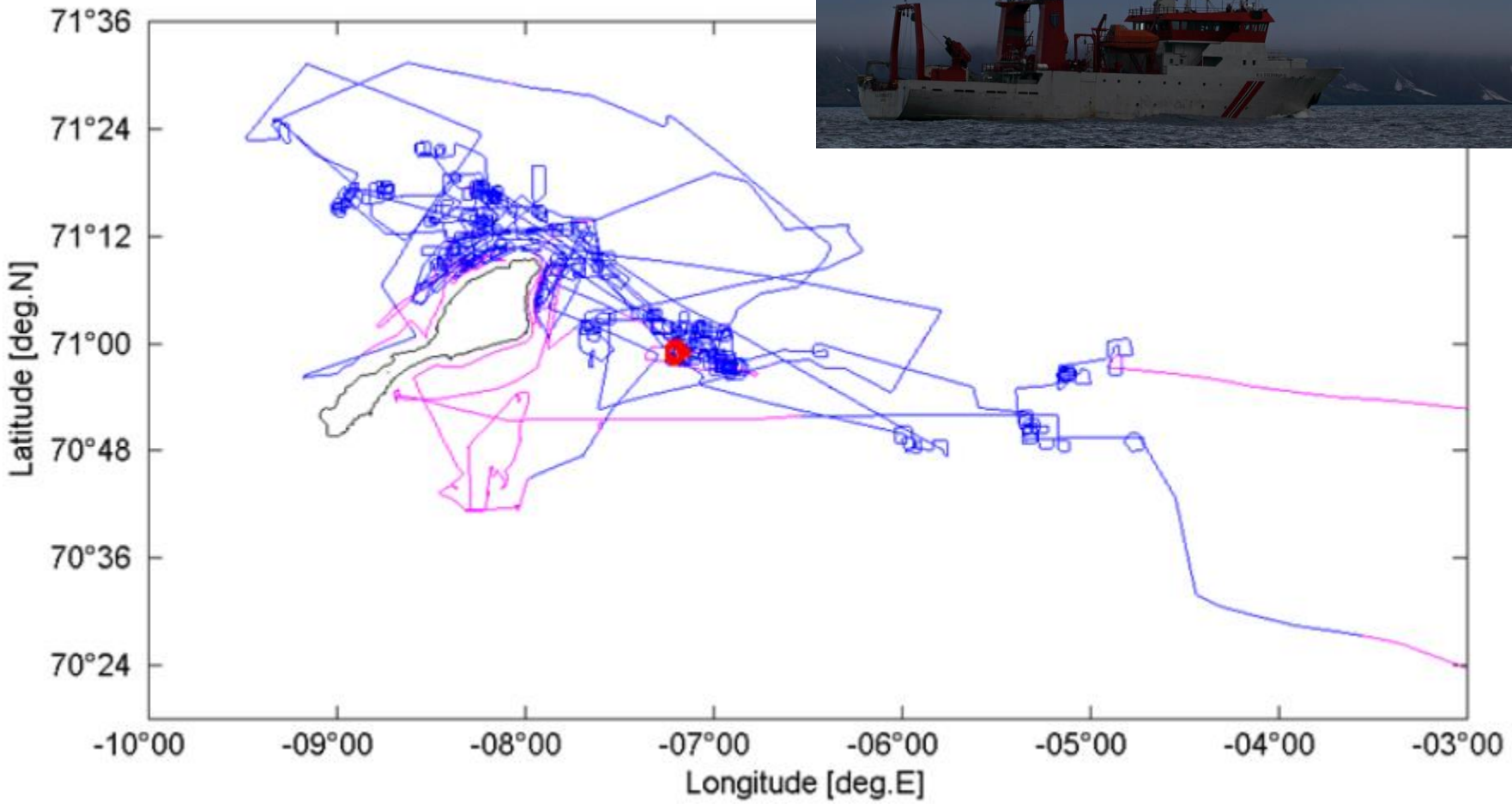
SAILED TRACK JUN/JUL 2013
R/V H.U. SVERDRUP II

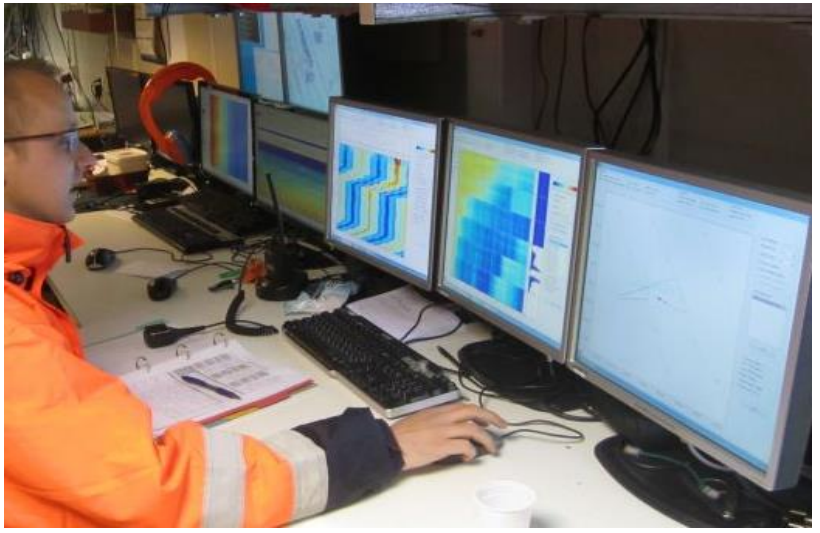


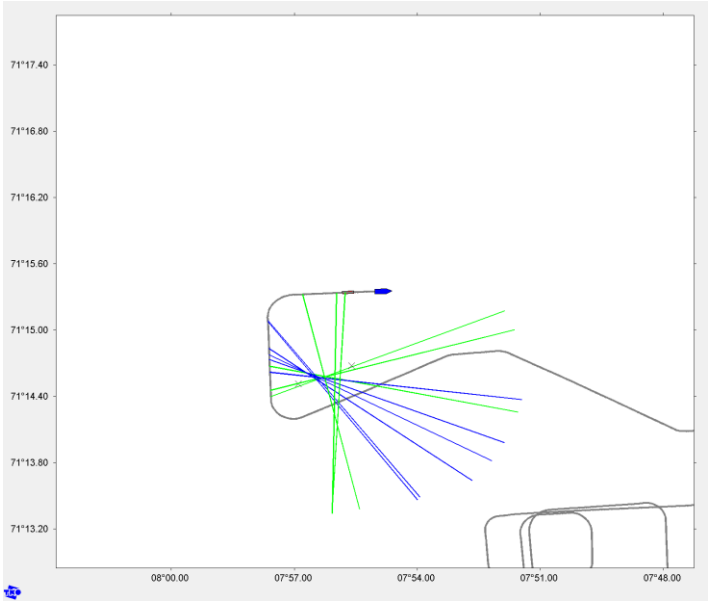
SAILED TRACK NEAR JAN MAYEN



1. FIND (DETECT) ANIMALS

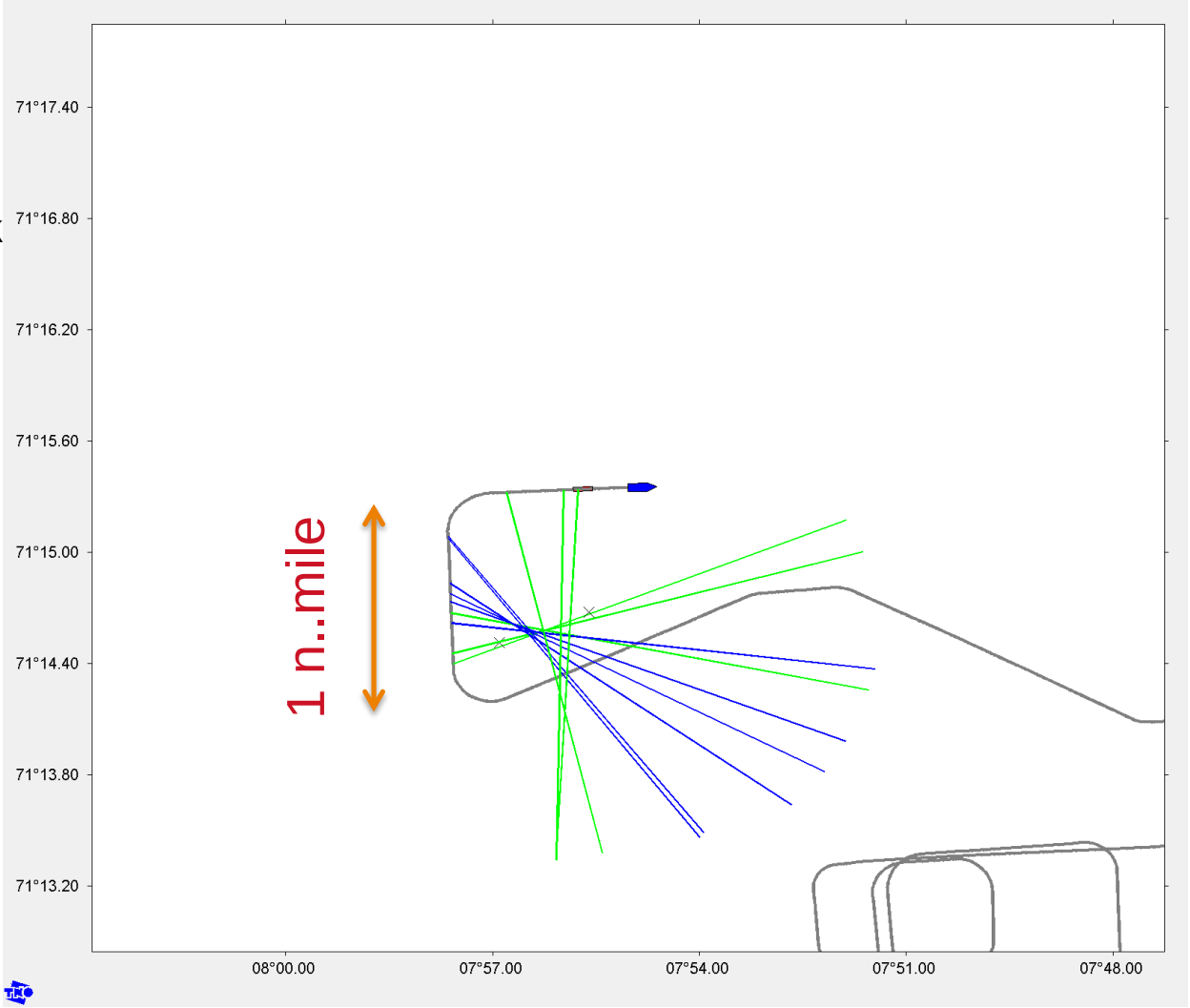
- Visual observers;
- PAM; TNO *Delphinus* system;



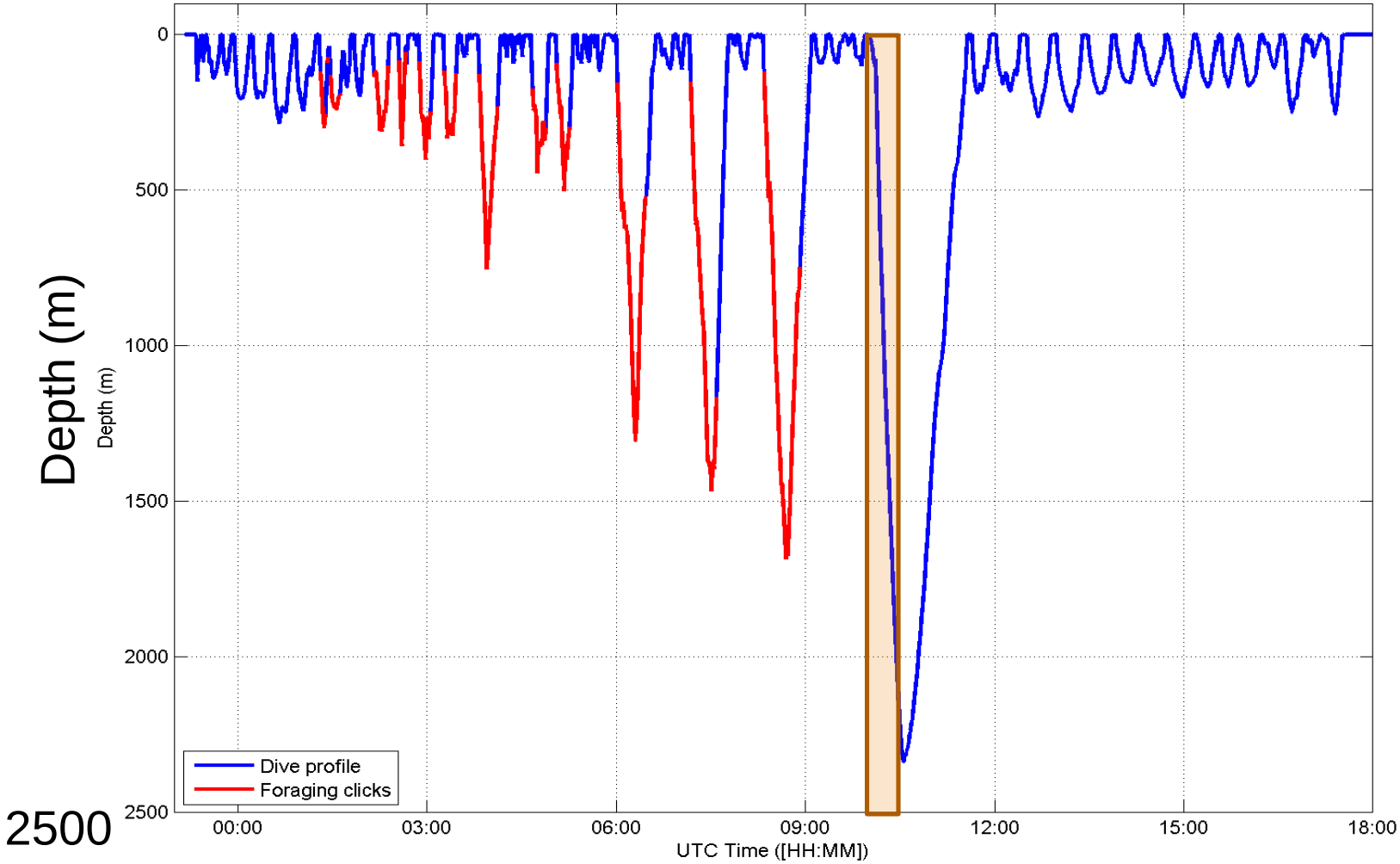


EXAMPLE TRACKING -- GEOGRAPHIC DISPLAY

- Near real time
- Link to visual observation deck (tablet & onboard wifi)



CEE ON N.BOTTLENOSE WHALE, 25 JUNE 2013



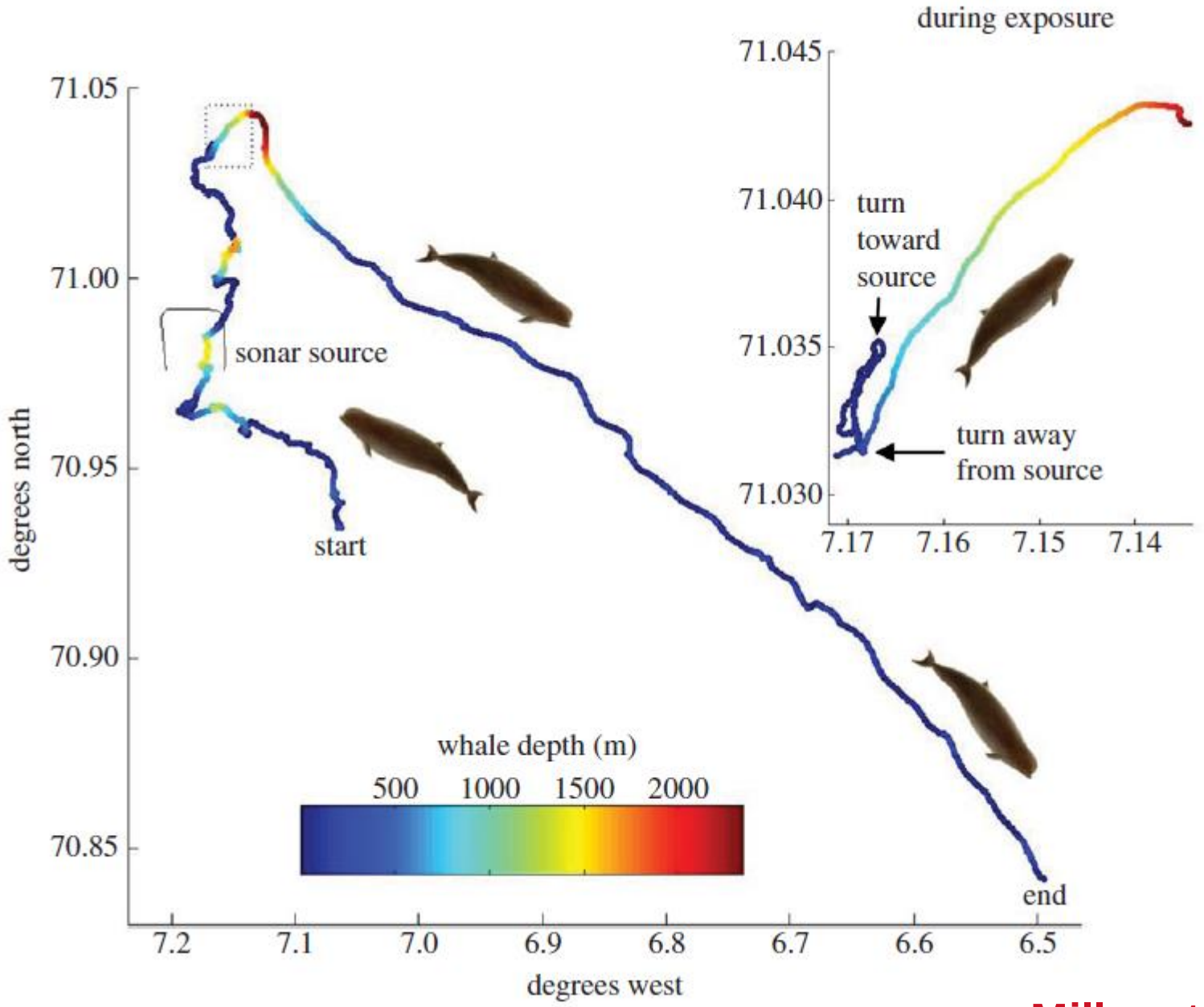
2500

00:00

UTC time (hh:mm)

18:00

HORIZONTAL AVOIDANCE



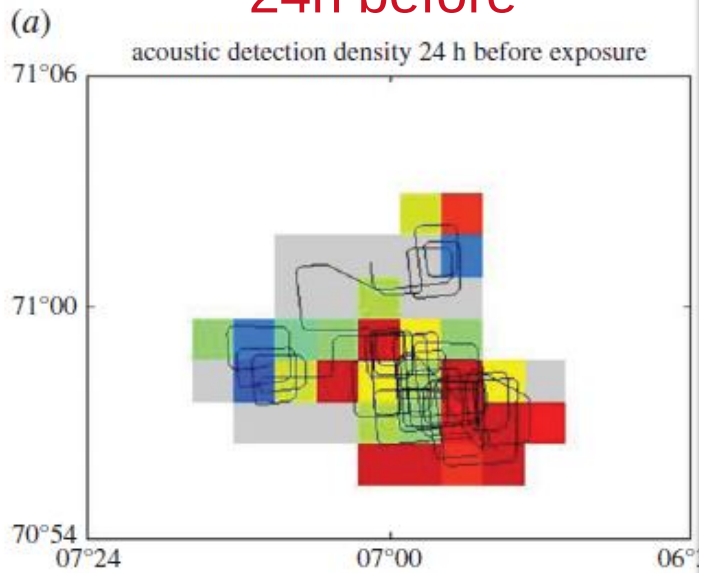
Miller et al. (2015)

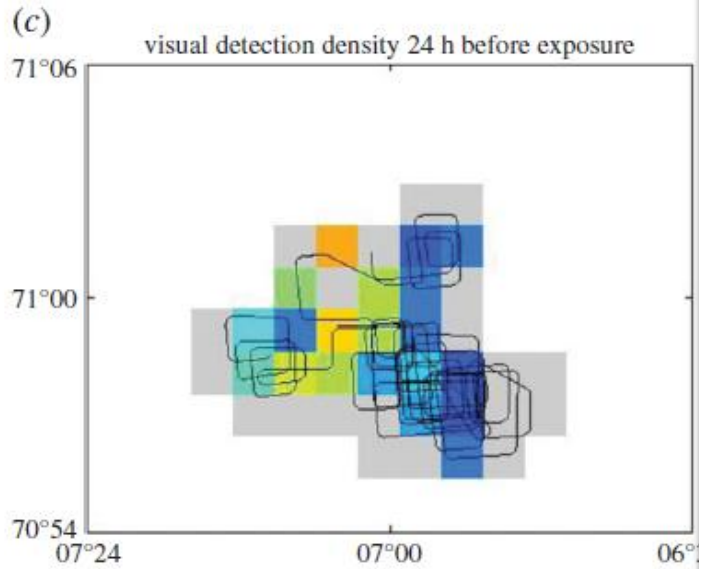
DISTRIBUTION OF ANIMALS BEFORE/AFTER

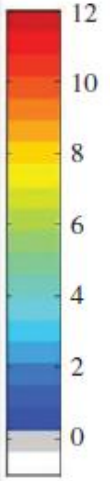
TNO innovation for life

24h before

- Acoustic detections
- visual detections







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Miller et al. (2015)

DISTRIBUTION OF ANIMALS BEFORE/AFTER

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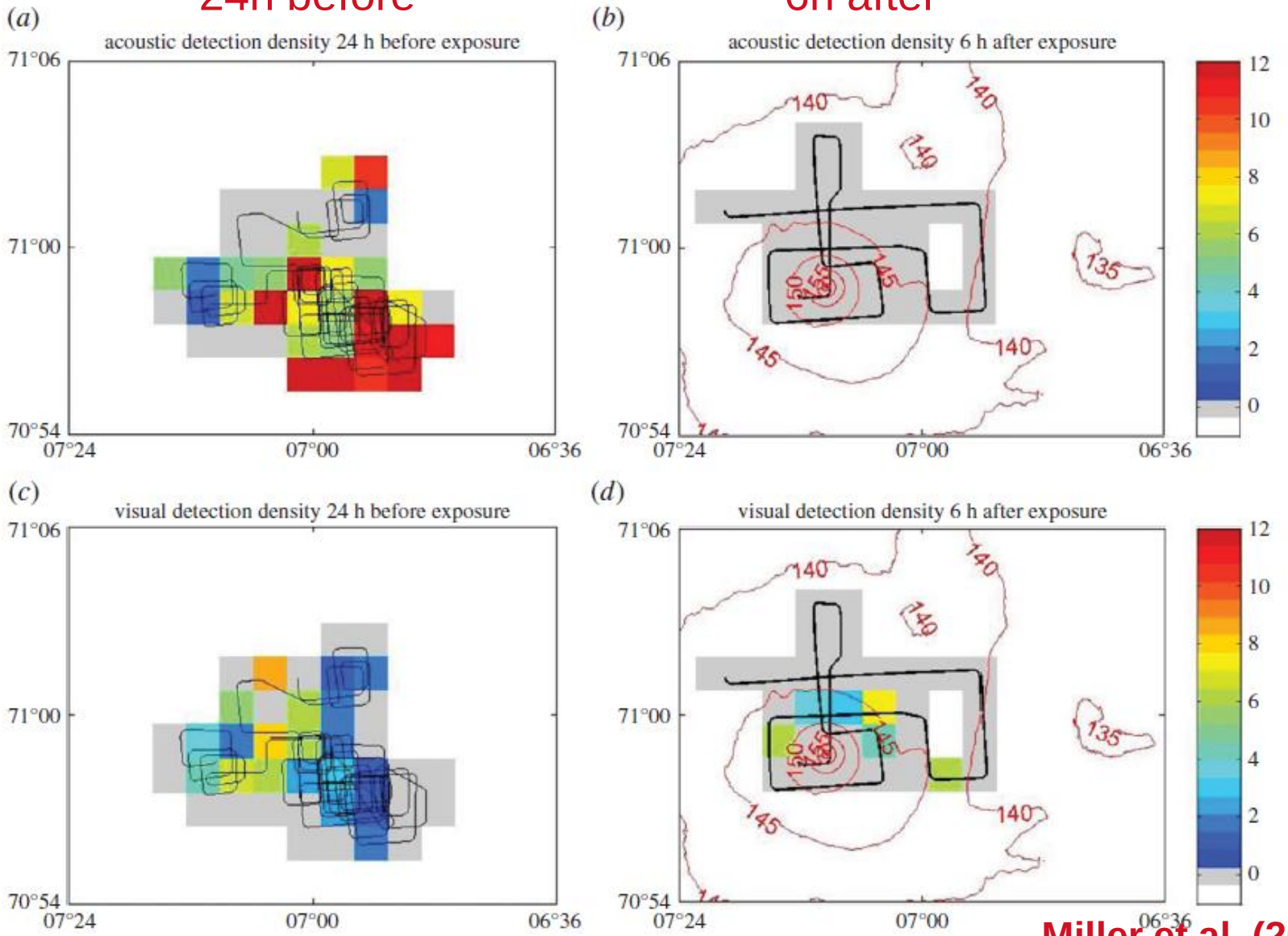
- Acoustic detections
- visual detections

24h before

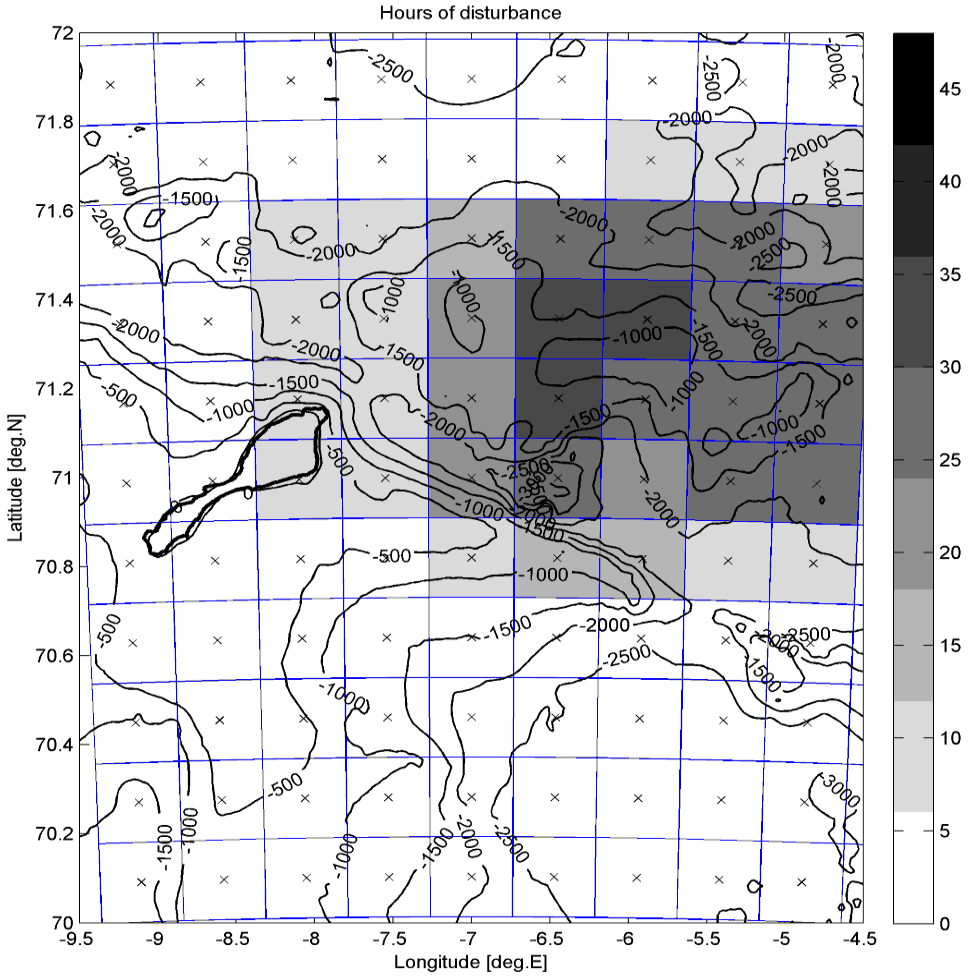
6h after



Miller et al. (2015)

DISTURBANCE MAP

FOR SIMULATED SONAR EXERCISE

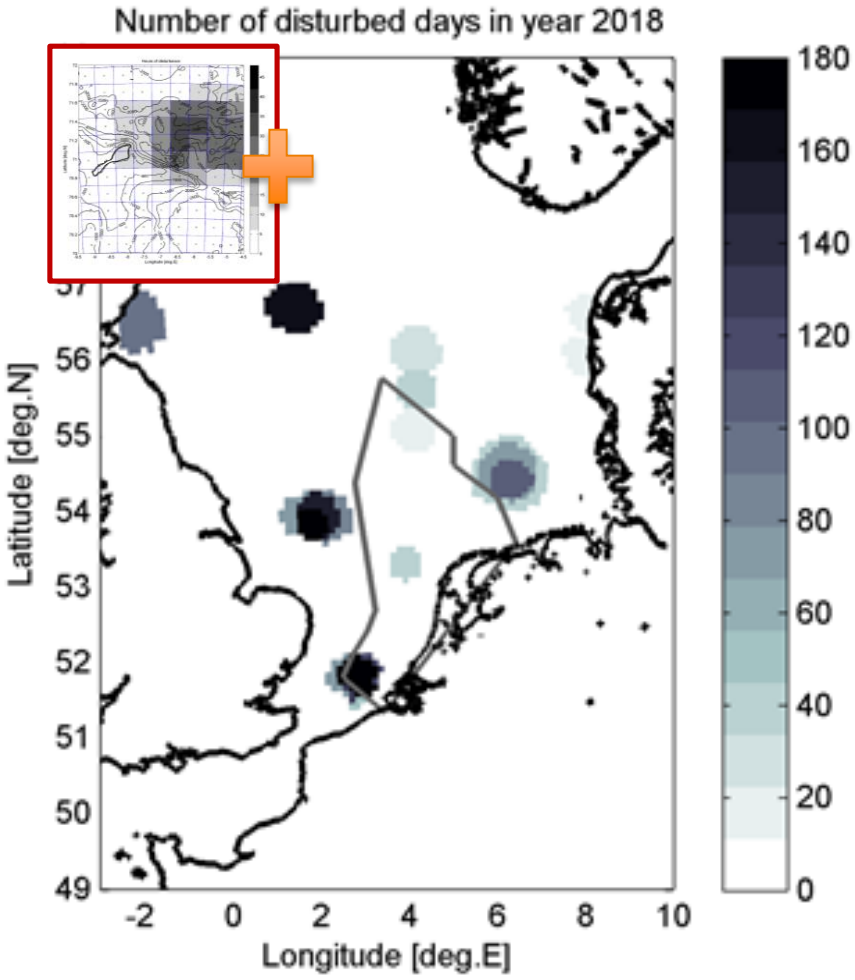


- Hours of disturbance (SPL > 140 dB re 1µPa^2)
- Per area -> not per animal!
- Indicator of ‘habitat loss’
  - Compare to important areas (e.g. feeding, breeding areas)

ACCUMULATION OF DISTURBANCE DUE TO MULTIPLE SOUND SOURCES

- Accumulation of disturbance due to pile driving and seismic surveys in North Sea
  - Study by NL working group underwater noise (Heinis & de Jong et al., 2015)
  - iPCOD modelling shows 24% decline of porpoise population in 6 years

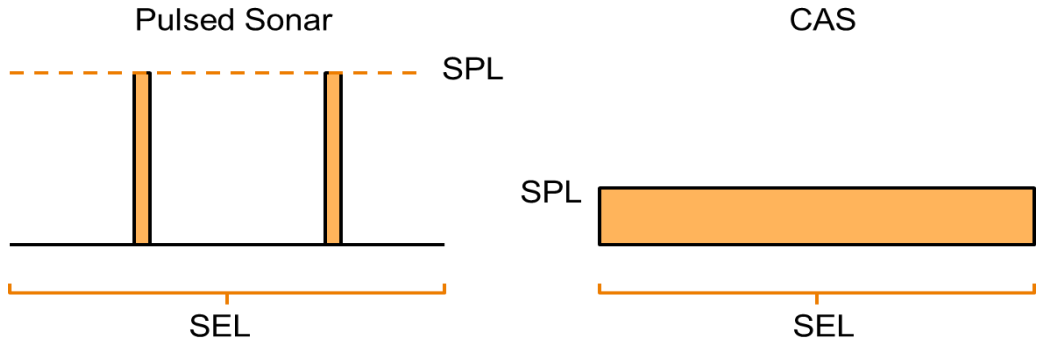
- Include footprint of sonar to assess Good Environmental Status (GES) under EU Marine Strategy (MSFD)?



DATA GAPS – 3S2

- **3S project has contributed to major improvement of our understanding of environmental effects of sonar.**
- We have identified four important data gaps, which will also greatly increase the value of the existing data.

Research gap 1: Confirmation of sensitivity in apparently sensitive species (n=1)
Research gap 2: Is received level or proximity the main response driver?
Research gap 3: What is the effect of exposure duration?
Research gap 4: What are the effects of future CAS versus pulsed sonars?



PULSED VS. CONTINUOUS ACTIVE SONAR -CAS

PULSED

Conventional Pulsed Sonar

Short pulsed signal followed by long listening time

Duty cycles up to 5-10 %

Full source level

CAS

Continuous Active Sonar

Continuous signal

Duty cycle up to 90-100 %

Reduced source level

THANK YOU!

Photo: Eirik Grønningsæter/WildNature.no/FFI/3S Project