

U.S. Navy Marine Species Monitoring Program

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Please visit the US Navy Marine Species Monitoring Program web portal for additional information on this project –
www.navymarinespeciesmonitoring.us



PMRF PASSIVE ACOUSTIC MONITORING DURING ASW EXERCISES

presented at the 2015 US Navy Marine
Species Monitoring Technical Review
Meeting, San Diego, CA

presented by Stephen Martin, NMMF
March 16, 2016

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Presentation overview

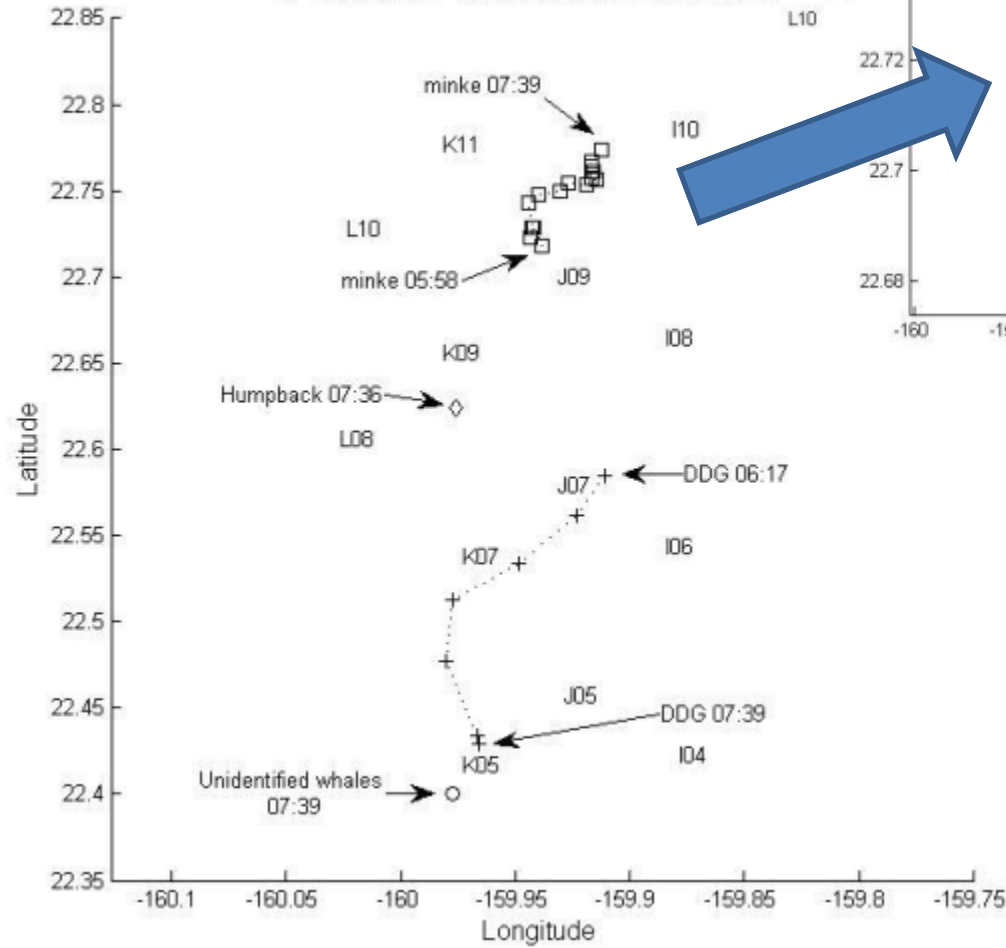
- History of MFAS analysis **during** US Navy training @PMRF
- **Before-During-After** experimental paradigm
- Current methods of estimating RL
- Est. RL exposures 2 fin, 1 minke Feb 15-16, 2015
- Est. RL exposures 1 minke 17 Feb 2015 onset of SCC phase B MFAS
- Feb 2016 onset of SCC MFAS **preliminary** analysis
- Summary & Conclusions
- Future efforts

History

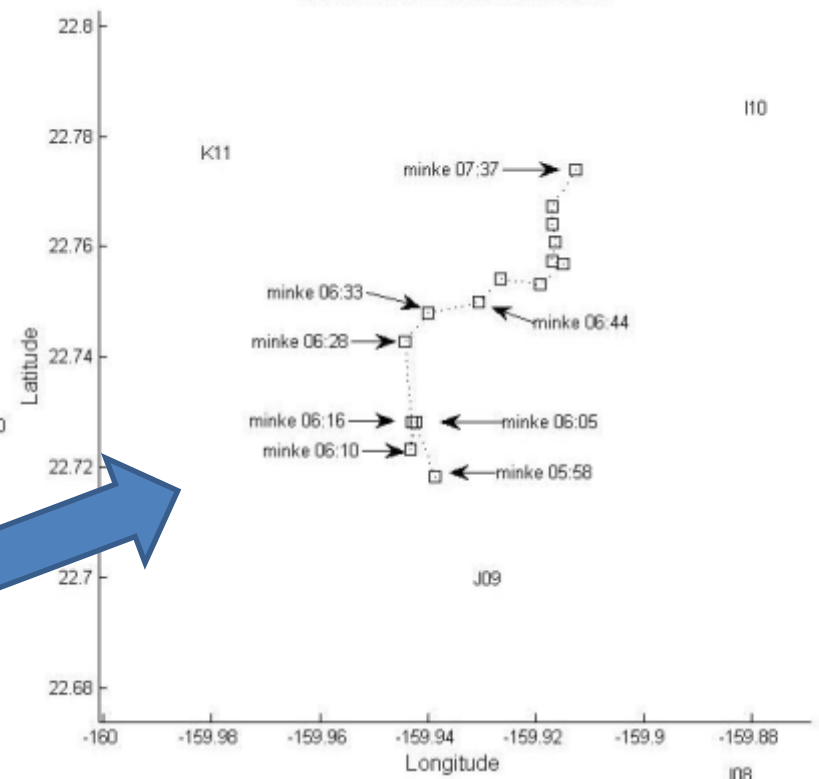
- On-line reports estimating Receive Levels on marine mammals at PMRF from 2011-2014 are available at: <http://www.navy Marinespeciesmonitoring.us/>
- 2011 Hawaii Regional Complex reports
 - Martin and Kok, 'Analysis for Marine Mammals Before, During and After the Feb 2011 Submarine Commanders Course Training Exercise', Appendix N to 2011 yearly report.
 - **Methods for estimating exposures** which may be applied to **any localized animal** (e.g. PAM, MMO, aerial sighting).
 - Focus period of 90 min of data 17 Feb 2011.
 - Identified **importance** of: **surface ducted propagation** at PMRF and **relative bearing of animal w.r.t. MFAS ship heading**
 - Provided **est. RL for minke whale, humpback whale, unident whale** for **two propagation models** (ray trace and sonar equation) with levels between 141 to 162 dB re 1 microPascal (rms)
 - Identified importance of model validation using in-situ acoustic data collection (estimated a 7dB bottom loss @ PMRF for ~ 3 kHz)

From Martin and Kok 2011
 90 min focus period for exposures
 PAM minke whale-16 boings
 PAM humpback – one loc
 MMO unidentified whales

17 Feb 2011 DDG and animal locatio



17 Feb 2011 DDG and animal locations



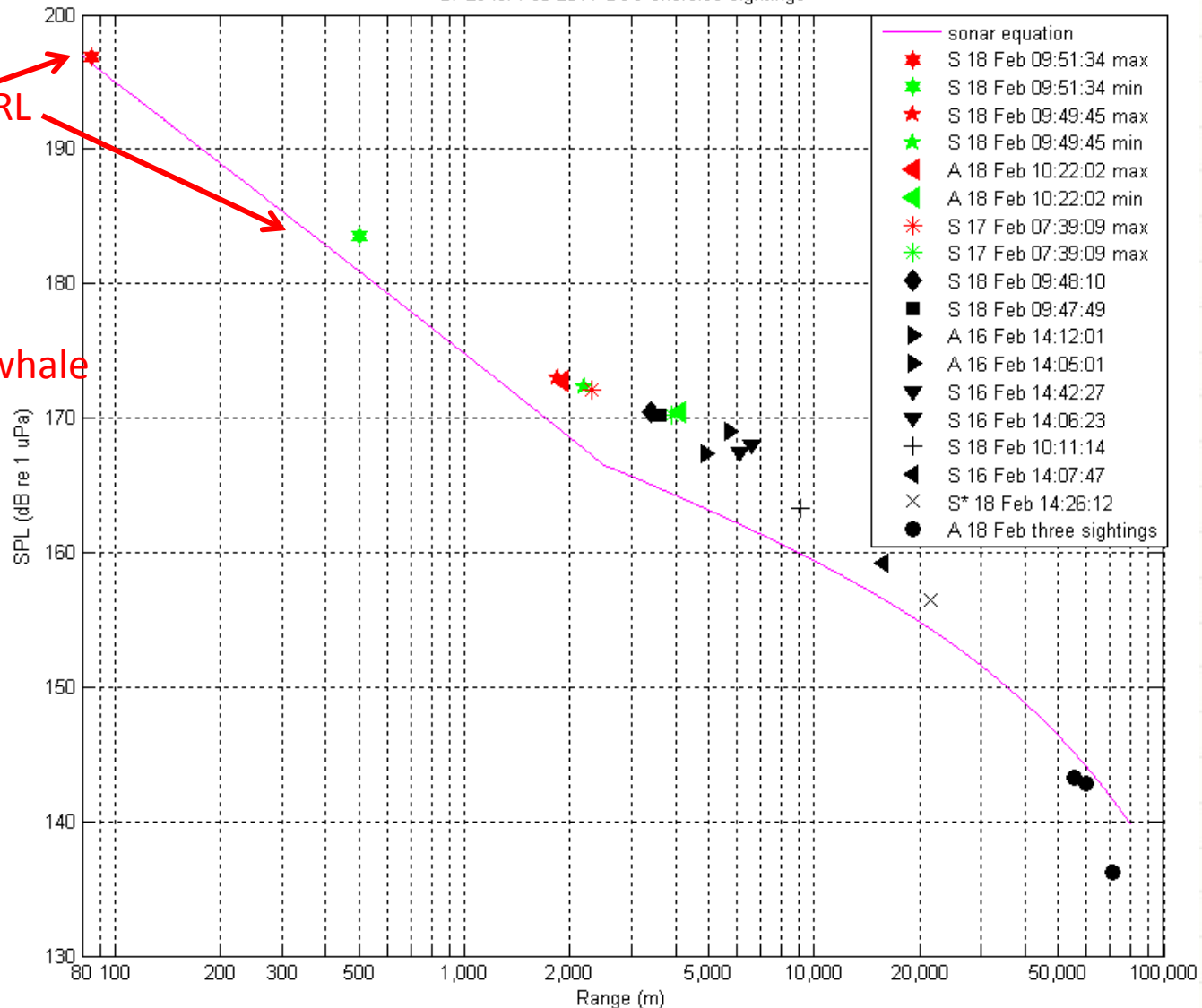
History (cont.)

- **2012** On-line reports re monitoring during US Navy training
 - Martin and Manzano-Roth. 2012. Estimated acoustic exposures on marine mammals sighted during a US Naval training event in **Feb 2011**
 - **Refined methods** applicable to MMO & aerial sightings (sighting accuracy, delta time MFAS to animal location, animal movement)
 - Compared **PCIMAT estimates with sonar equation w/ducting** and spherical to cylindrical spreading
 - Martin et al. 2012. Estimating Sound Pressure Levels that Acoustically Detected Beaked Whales Were Exposed to During a US Naval Training Event in Hawaiian Waters, **Feb 2011**
 - 10 bw group dives from Feb 2011 est. RL's using **PCIMAT** showing **strong surface ducting**
 - **“localize”** to hydrophone location +/-6 km

From Martin and Manzano-Roth 2012, estimated RLs on aerial and Ship board marine mammal sightings from Feb 2011 SCC using sonar equation and ray trace model

SPLs for Feb 2011 SCC exercise sightings

Highest est RL
observed
to date for
shipboard
MMOs and
Humpback whale
group
off bow



History (cont.)

- **2013** On-line reports re monitoring during US Navy training
 - Manzano-Roth et al. 'Impacts of a U.S. Navy training event on beaked whales in Hawaiian waters', **Feb 2012 SCC, 258 Md group dives & 31 Cross Seamount type dives**, PCIMAT, 10 dives during MFAS 13 to 52 km distant w/ large variation in est. RLs again showing strong surface ducting, historical and in-situ SVP issues
- **2014** On-line reports re monitoring during US Navy training
 - Martin et al. 'Minke whales respond to navy training', **large study area >3800 km², 2011-2013, reduced min. density of minke whales during MFAS training** (phase B of SCC). Navy annual report -> **JASA 135(5)**
 - Baird et al., 2014. Assessment of Modeled Received Sound Pressure Levels and Movements of Satellite-Tagged Odontocetes Exposed to MFAS at the Pacific Missile Range Facility: February 2011 Through February 2013.
 - Henderson et al. 'Impacts of U.S. Navy Training Events on Beaked Whale Foraging Dives in Hawaiian Waters: Update'

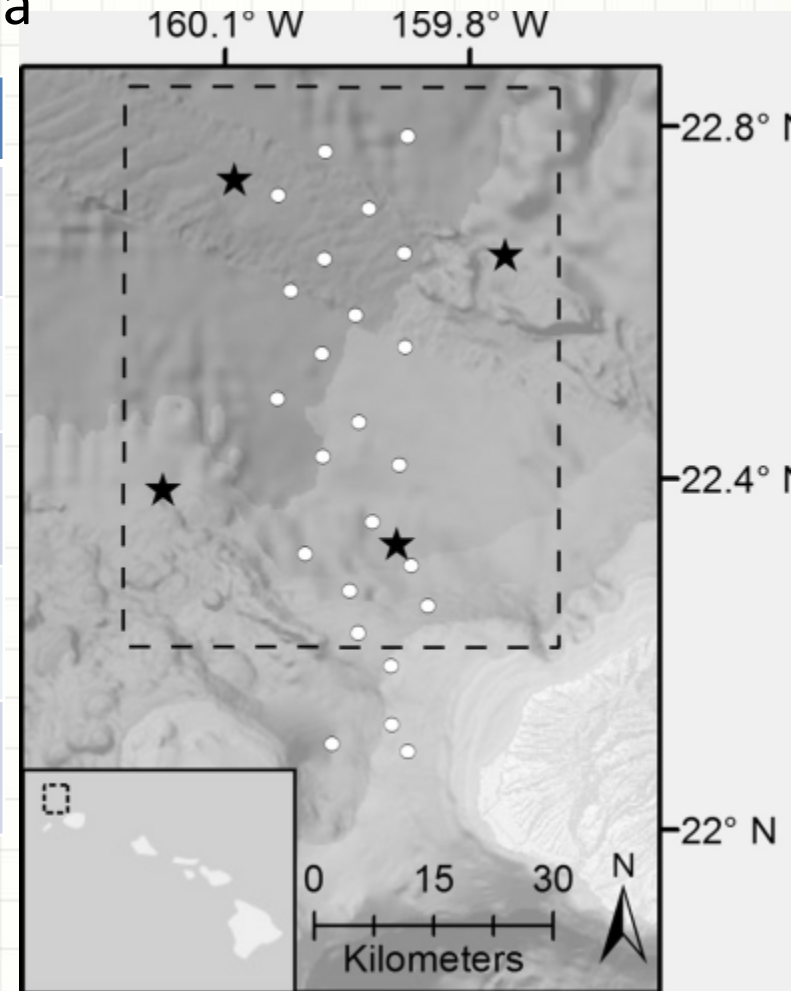
minke whales respond to navy training

766 hr data from multiple hydrophones Feb 3 years

$\hat{D}_{\min}$ (95% CI) in 3,780 sq.km study area

	Feb 2011	Feb 2012	Feb 2013
Before	3.64 (3.31-4.01)	2.77 (2.41-3.18)	- -
During ΦA	2.81 (2.31-3.42)	2.04 (1.65-2.52)	1.21 (0.84-1.75)
Between n	NA	NA	1.58 (1.14-2.19)
During ΦB	0.69 (0.27-1.8)	0.7 (0.28-1.76)	0.06 (0.001-4.6)
After	4.44 (4.04-4.88)	2.08 (1.73-2.5)	1.41 (0.93-2.12)

count localized individuals



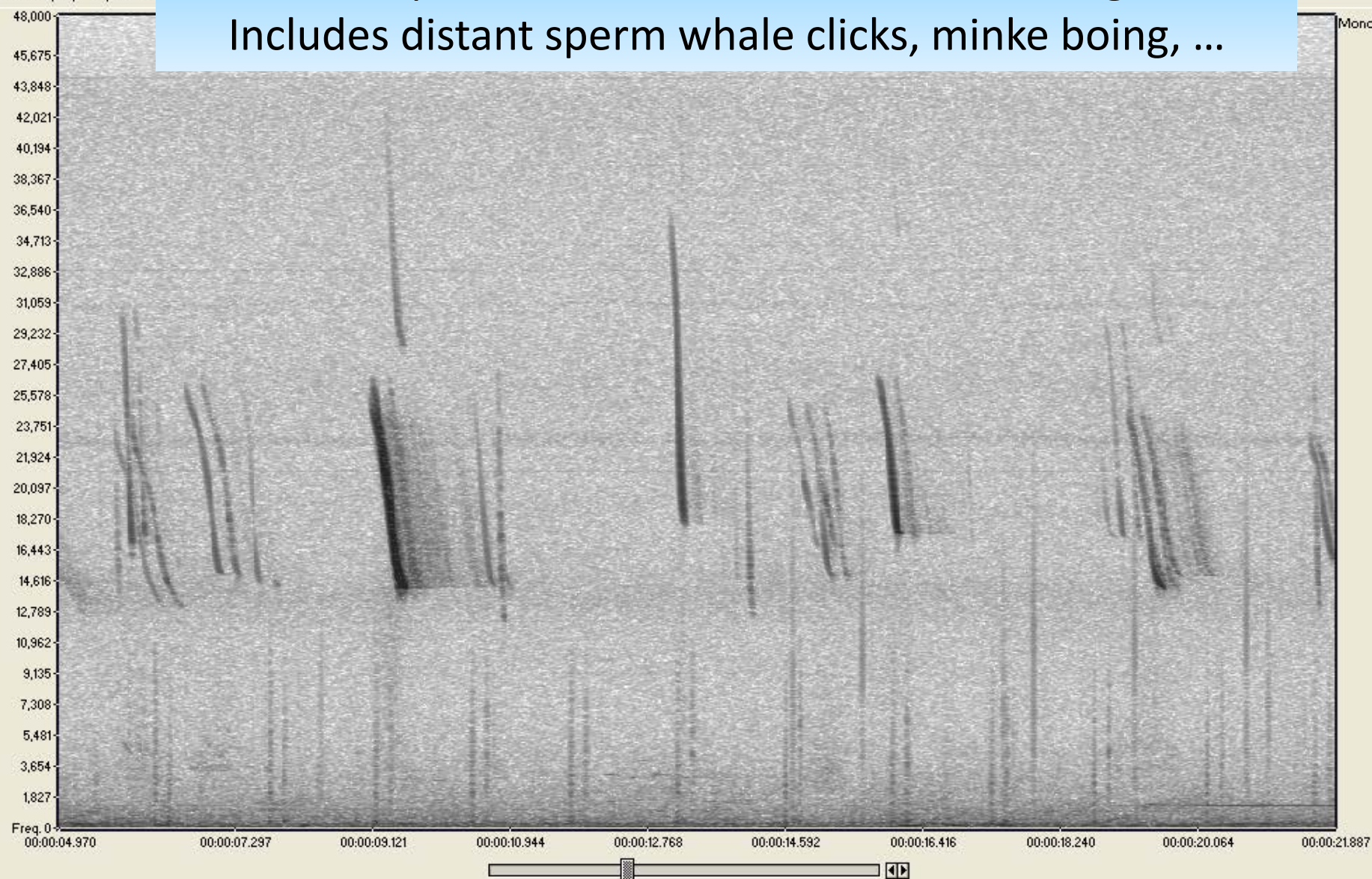
Before – During – After paradigm (issues re other training events)

- Feb 2015 (SCC Φ A 11th-13th, Φ B 17th-20th)
AND SUBEX 5th, AirASWEX 9th-10th, NSFS
Gunnery & MFAS ASW CERTEX 15th
- Feb 2016 (SCC Φ A 10th–12th, Φ B 15th – 18th)
AND 9th SUBEX 0730-1700, AIRASWEX 0900-1400 P3,
LMR OASIS REMUS ACOMS 14 Feb a few hours. Gunex
planned for 19th Feb.
- and uncontrollable factors such as prey
abundance and

Killer Whales on mid BSURE Feb 2016 before SCC training event

- Phones K5/J4/K4 10 Feb ~1400 local time

17 sec data phone K04 on 10 Feb 2016 @ midnight GMT
Includes distant sperm whale clicks, minke boing, ...



Frequency (Hz): 46,505
Sample: 1,029,258
Slice: 339

FFT Size: 16,384 Slices: 1000 Overlap: 50%
Blackman-Harris, Linear, Mono Samples: 477,184 to 2,101,247
-48 dB -140 dB

Killer Whales on mid BSURE Feb 2016 before SCC training event

- Phones K5/J4/K4 10 Feb ~midnight local time
- Robin Baird: report of killer whales in the area post SCC.
- Similar to signals in Simonis et al. JASA 131(4) 'High frequency modulated signals of killer whales in the north Pacific'
- Similar to signals in Filatova et al. JASA 132(6) 'Ultrasonic whistles of killer whales in the North Pacific'. Results mentioned 'pieces of tissue (from possible unidentified prey) observed floating on the waters surface' midway through 2 h encounter near Bering Island (western North Pacific).

Updated Methods (late 2015-2016):

- **Need ship positions & time of MFAS & whale localizations**
- Auto-localize fin, sei, Bryde's, humpback & sperm whales, **manual and semi-auto tracking of locs**
- **Delta time** between sonar pulse and animal location
- **Propagation models (Peregrine & sonar equation)** to estimate RL at animals batch mode (previously PCIMAT)
 - **Required as no Acoustic tag on animal**
 - **Peregrine** provides a vector of estimates over distance allowing **statistical description of sound field**
- **Future** – need more samples, possible to account for **each** ping from **multiple ships** and **est. cumulative SEL** on multiple animals present at different distances from MFAS training.

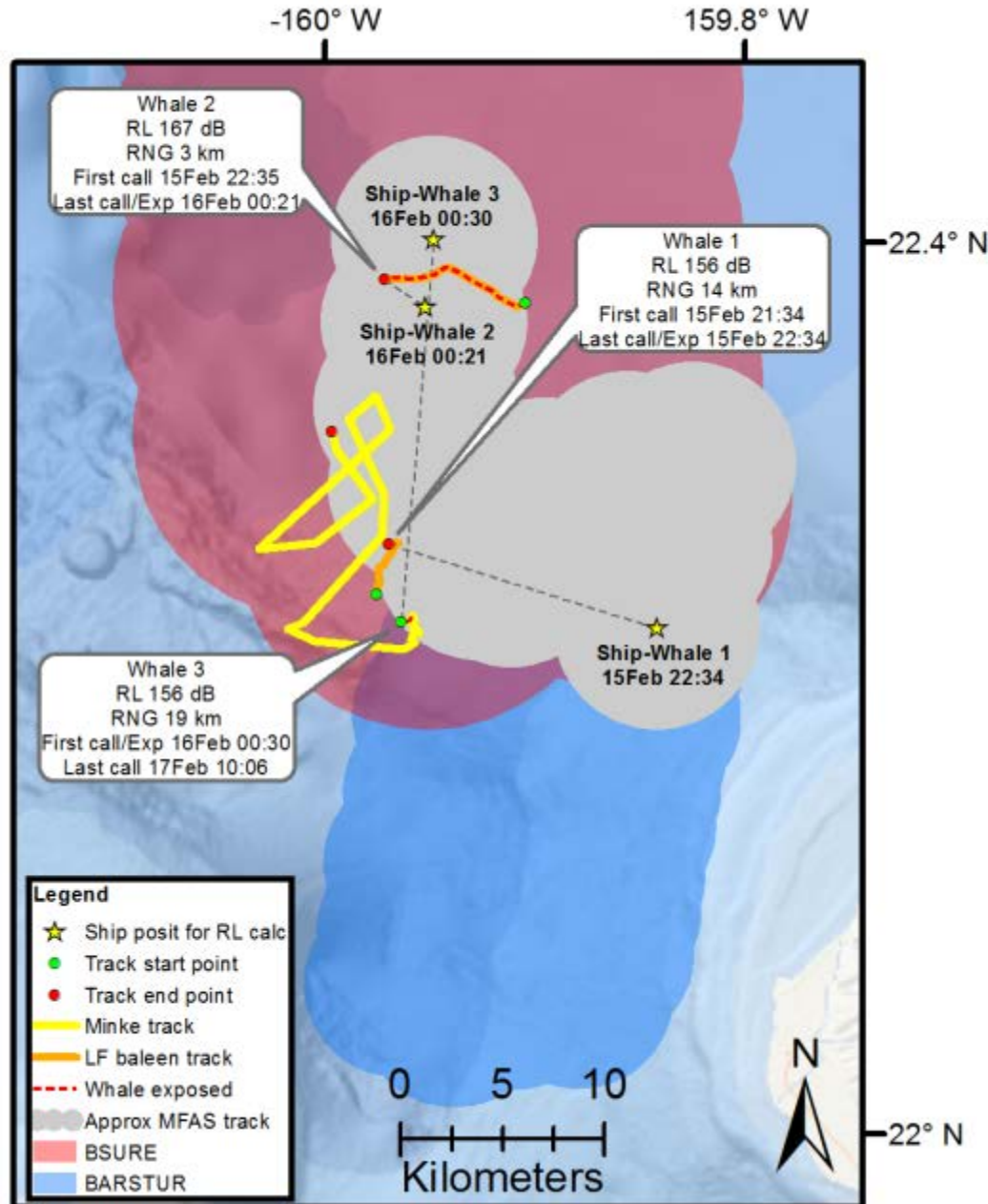
Relatively new restrictions

- New direction Dec 2015 re unclassified information
 - Unable to say how many MFAS ships involved when > 1
 - Unable to say which sonar types (e.g. 53C, 56) used.
- Current approach was reviewed and got confirmation re suitability for unclassified reporting

Recent samples of exposures

- Feb 2015 SCC related (in 2015 year end report)
- Feb 2016 SCC related VERY preliminary analysis

Two fin whales & one minke whale exposures Feb 2015



Plan view display

Single ship MFAS training vs. Mk30 target ~ 2 h MFAS (15 Feb 22:34 Z- 16 Feb 00:30 Z)

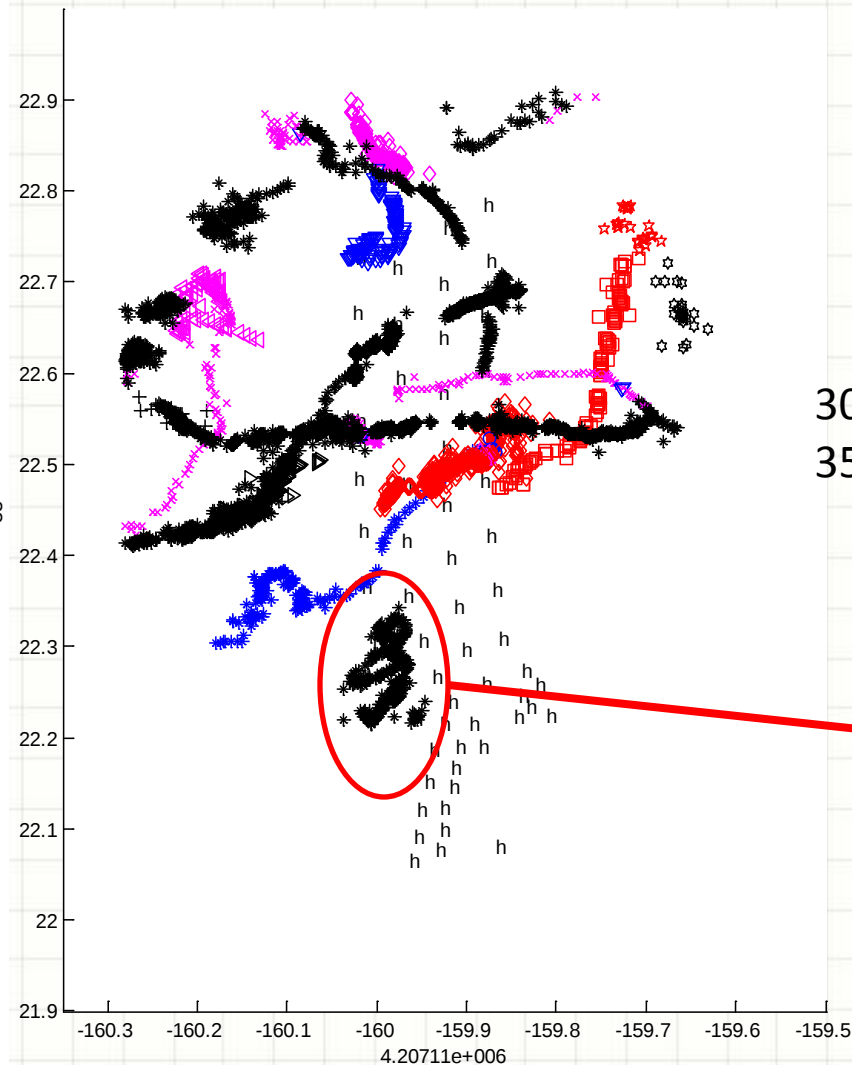
Whale 1 fin: 14km distant
 Calling ~ 1h before MFAS and stops at onset of MFAS
Est. RL 156dB

Whale 2 fin: begins calling after onset of MFAS, continues throughout MFAS to 00:21 (1 h 46 min), **stopped w/ship 3km away, est. RL 167 dB** re uPa

Whale 3 minke: starts calling at end of MFAS activity 19 km to south **est. RL of 156 dB** (but astern MFAS ship)
This animal continues calling for 33 h 36 min to start of SCC ph B.

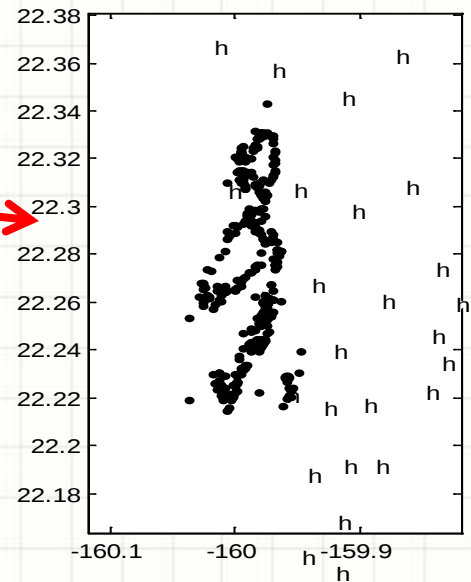
Minke whales tracks after ASWEX to before start of SCC ΦB (surface ship MFAS)

Number of valid tracks: 33

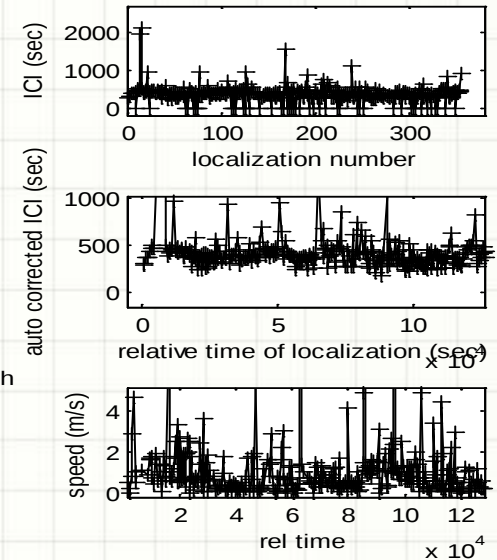
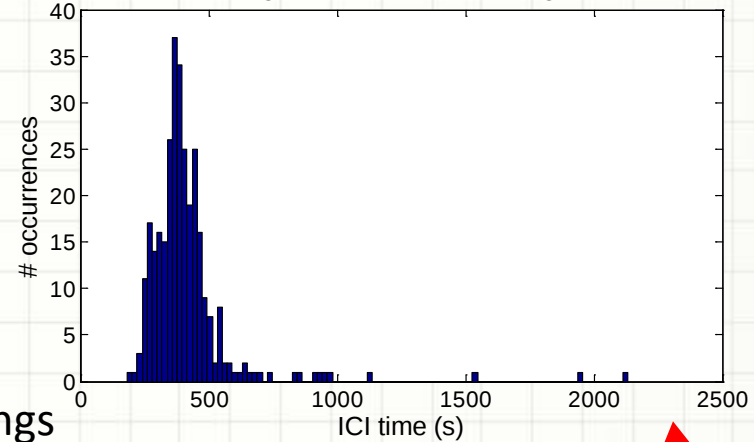


308 separate boings
35.7 h, ICI = 416.1s (189.2s)

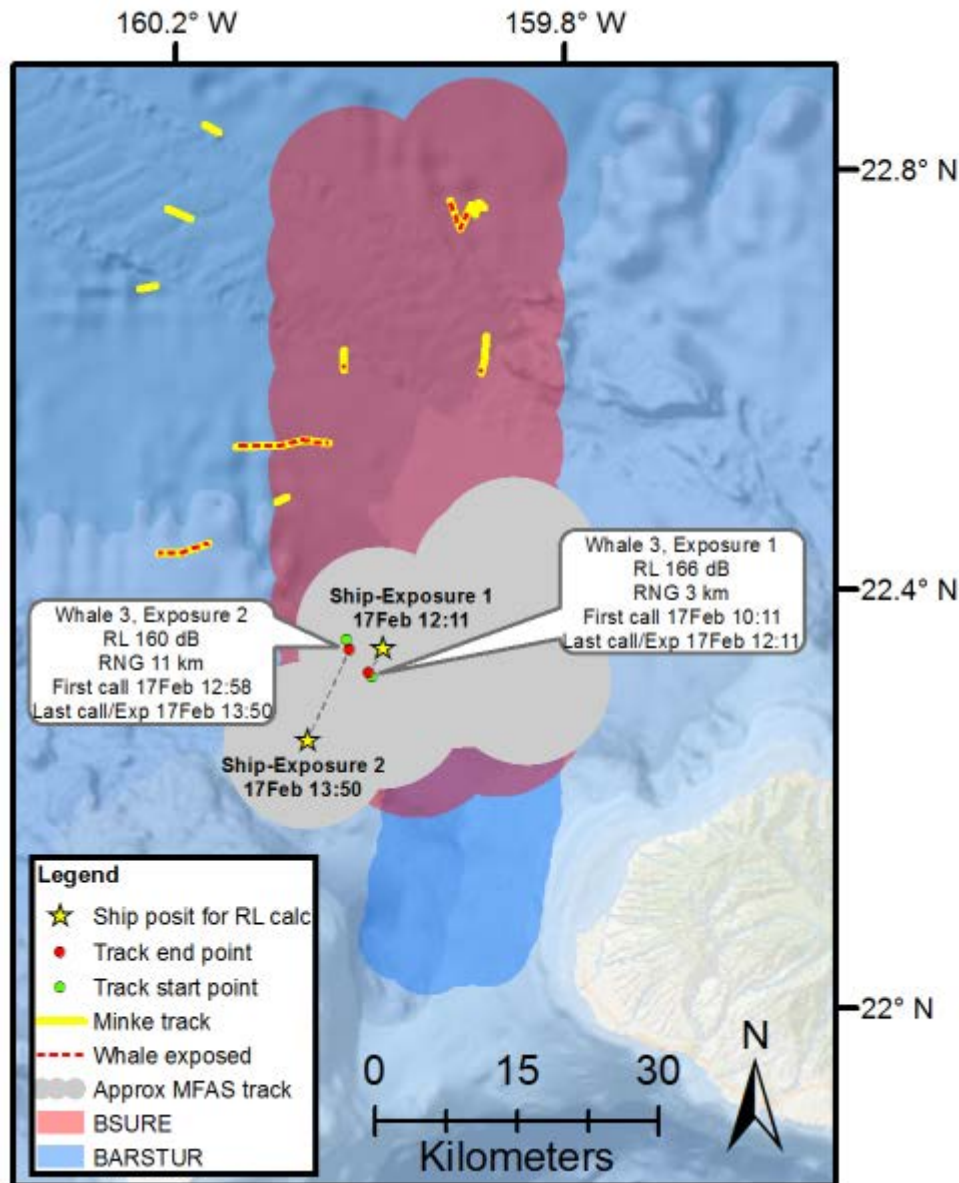
Track number: 1



Histogram minke whale 3 boing ICI



Onset of SCC phase B 17 Feb 2015 ~12:00 GMT



Situational Display

Multiple ship MFAS training SCC ph B

Multiple minke whales (10) localized in the area 10:10 to 12:00

Whale 3 believed to be same minke from end of ASWEX 16 Feb 00:30

Began calling at end of ASWEX 16 Feb 00:30, 19km away from ship which was moving directly away from the whale.

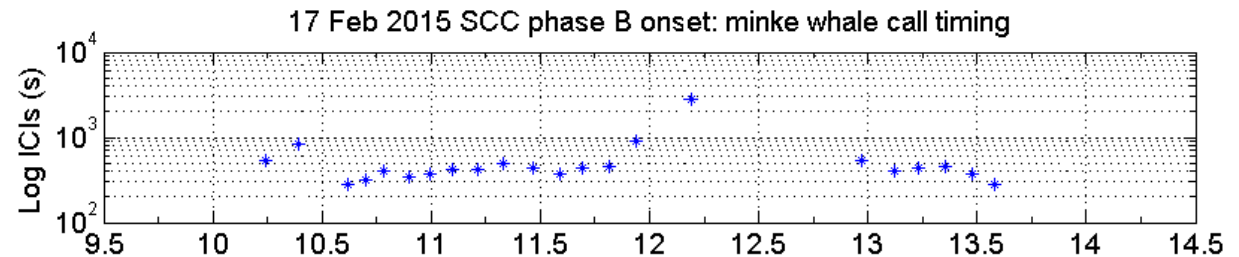
17 Feb 10:06 z recording disk change continues calling, ceasing right after the first MFAS pulse in SCC ph B. Est. RL 166 dB re uPa from 3km.

47 min later, a minke whale (presumed same whale DSC similar, limited movement from prior minke whale location). Calls for 52 min, exposed to est. RL of 160 dB from 11km.

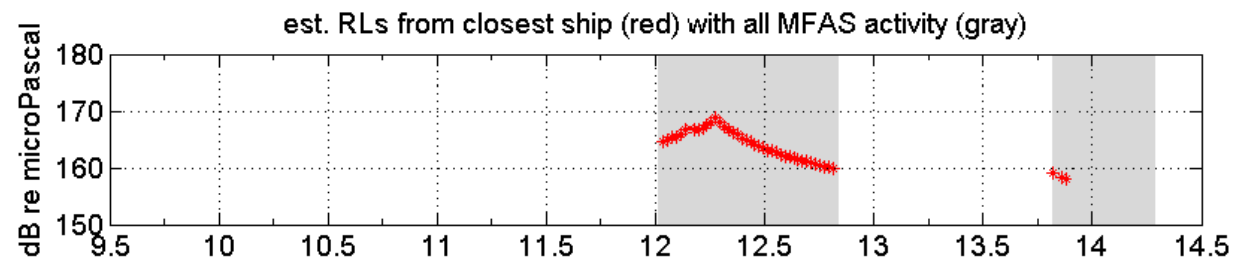
Onset of PMRF SCC phase B data 17 Feb 2015 at 12:00

(data 10:10 to 14:17, closest minke whale encounter details)

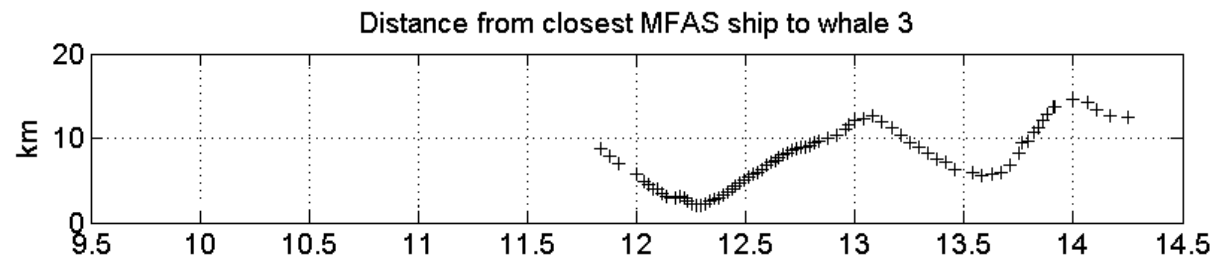
Boing call ICI
(log scale) vs.
time



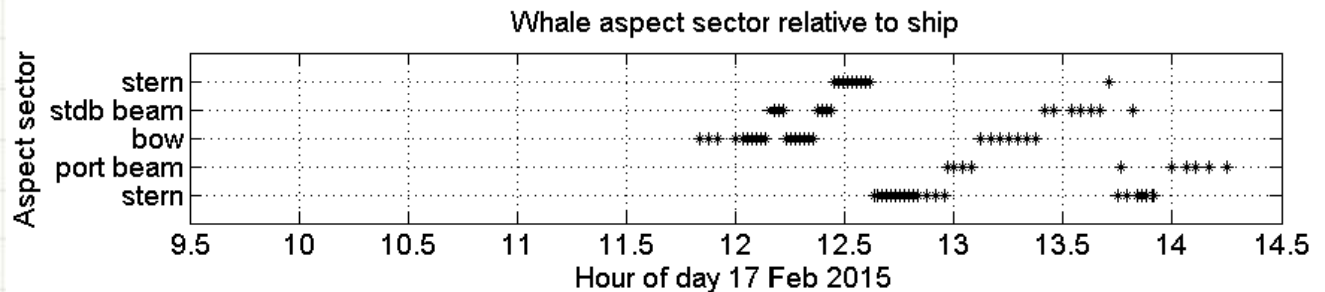
Est. RL in dB
re uPa (simple
model of whale
movement)



Horizontal
distance from
closest ship to
whale



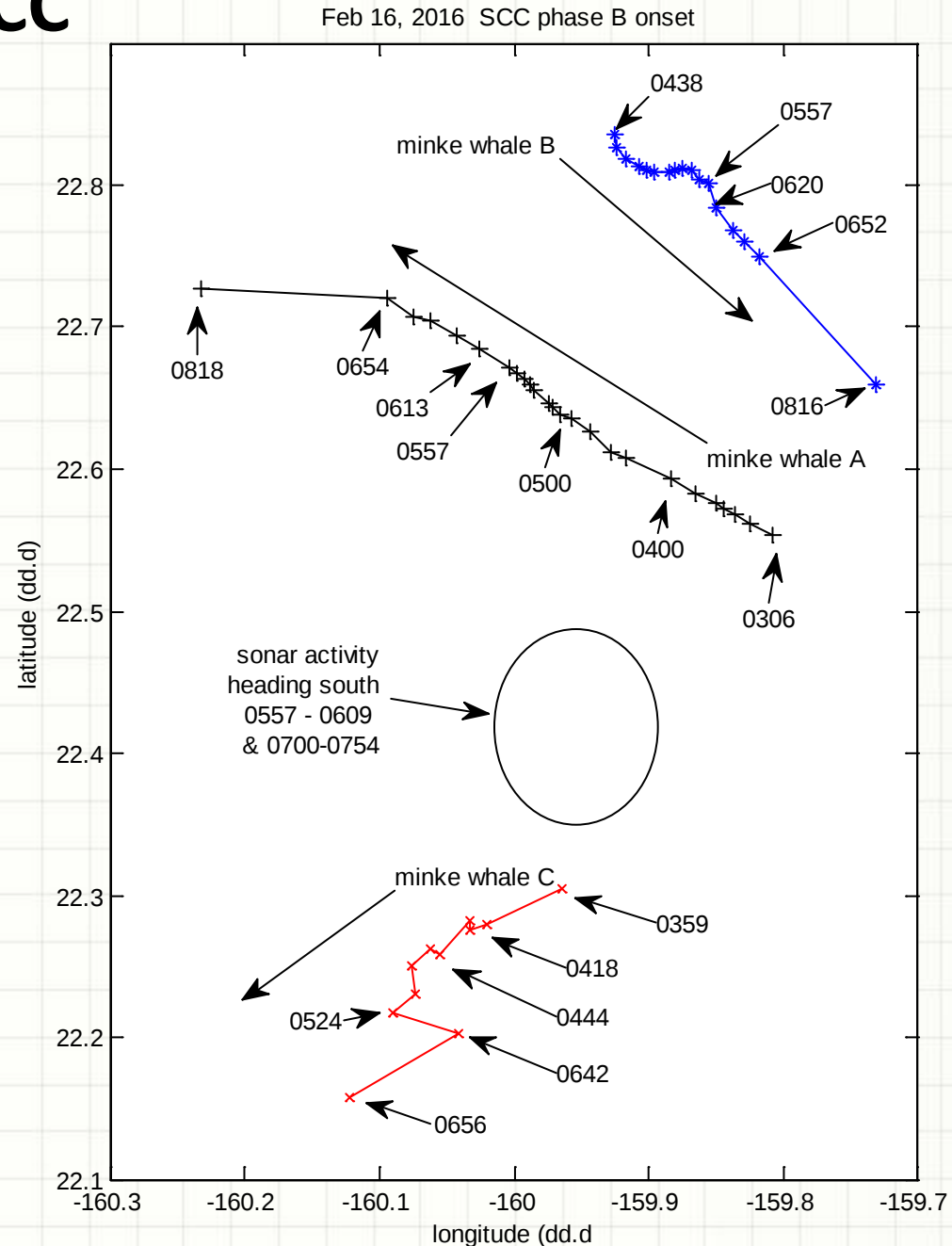
Rel. angle
of whale off
bow of ship



Feb 2016 onset of SCC

Φ B prelim analysis

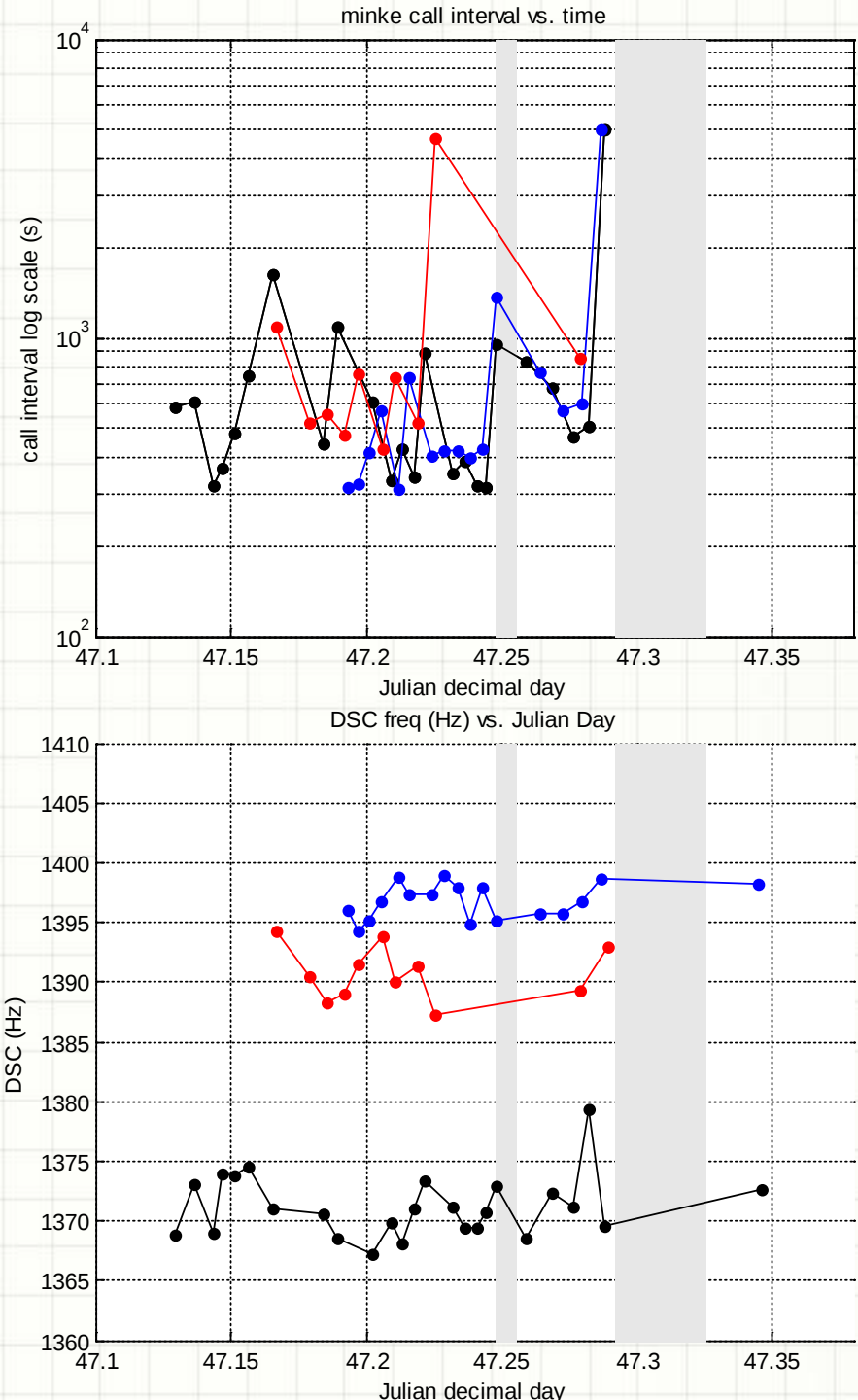
- From information obtained on-site
- 3 minke whales calling before & after MFAS activities
- Recorded data arrived, needs copied and detailed analysis (missed calls, confirming locs, in-band noise levels, etc.)



Feb 2016 onset of SCC

ph B prelim analysis

- Both figures- JDD 47.1 to 47.35 (Feb 16, 2016 0224 to 0824 GMT)
- Gray areas show first two MFAS sonar 'blocks'
black=minkeA,
blue=minkeB,
red=minkeC
- Upper fig – ICI (log scale in sec) vs. time
- Lower fig – DSC vs. time

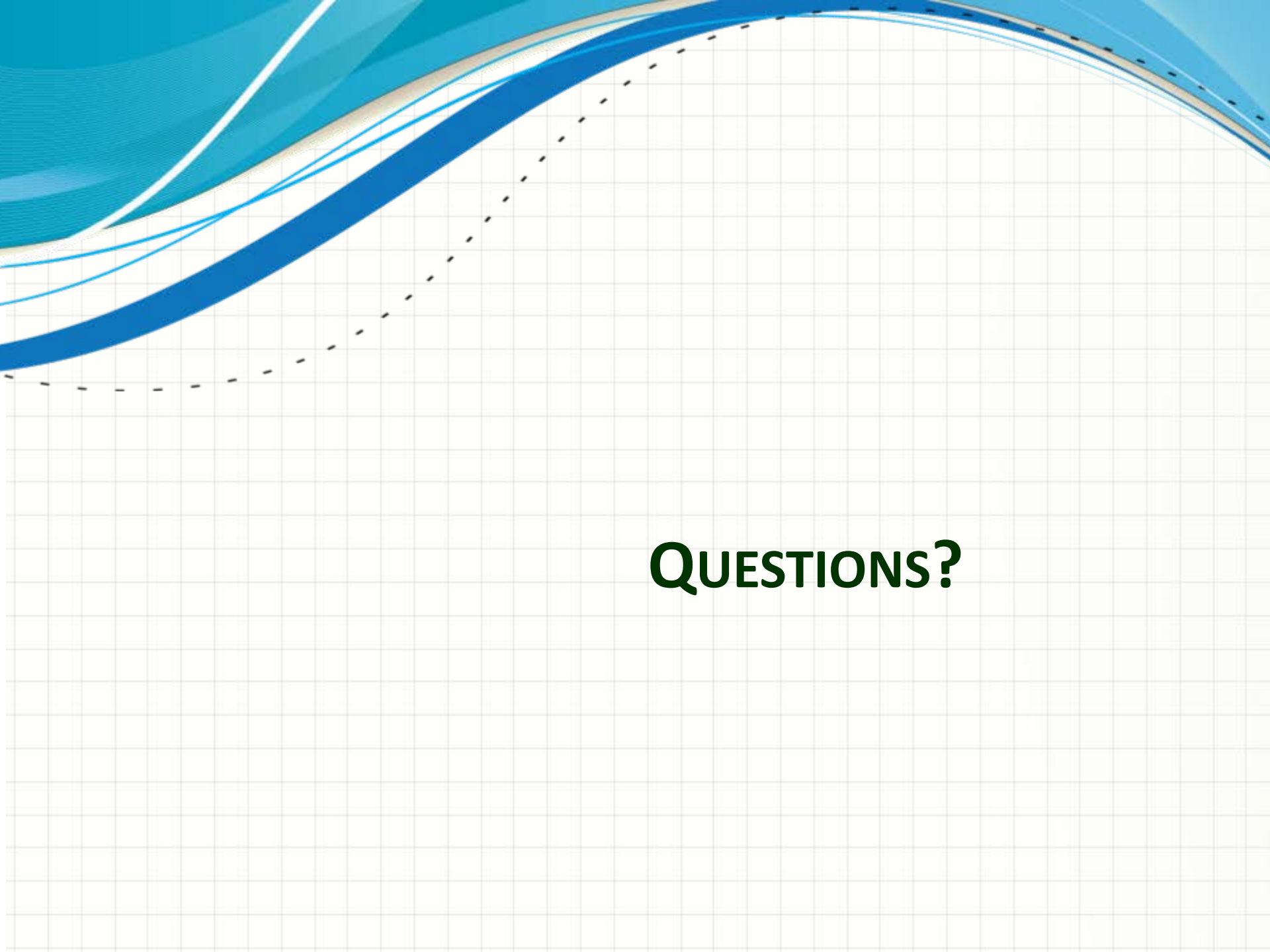


Summary & Conclusions

- Opportunistic Behavioral Response Study using PAM
 - Evolving since Feb 2011 when first obtained During data
 - Behavioral response: Ceasassion of calling, call intervals?, swim kinematics?
 - Information when animal not calling limited (assume linear path between updates attributed to the individual).
 - Onset of MFAS activities high interest
- Large area reductions of number of calling whales
- Methods and metrics continue to improve
 - Histograms of estimated RLs insightful (tag brief)
- Need to systematically go through data and document large N using robust baselines

Future work

- Continued analysis of recorded training events Feb 2011 and after
- Correlations with oceanographic data (e.g. satellite remote sensing) and prey densities
- Analysis of historical data back to 2003
- ONR proposed effort 'Behavioral Response Evaluation Employing robust baselines' collaboration with CREEM, SSC PAC and NMMF.



QUESTIONS?