U.S. Navy Marine Species Monitoring Program

This is a work product for the purpose of technical review. All data and information in this presentation is preliminary and should not be cited or reproduced without first contacting the presenter. All field work is conducted under appropriate permits under ESA/MMPA.

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

US Navy Marine Species Monitoring Program – Annual Technical Review Meeting
San Diego, CA *14-17 March 2016*

Blainville's Beaked Whales (*Mespolodon densirostris*) at PMRF: Occurrence, Habitat Use, and Impacts of Navy Training

E. ELIZABETH HENDERSON, ROANNE MANZANO-ROTH, STEVE MARTIN,

CAMERON MARTIN, BRIAN MATSUYAMA

2015 US NAVY MARINE SPECIES MONITORING TECHNICAL REVIEW MEETING

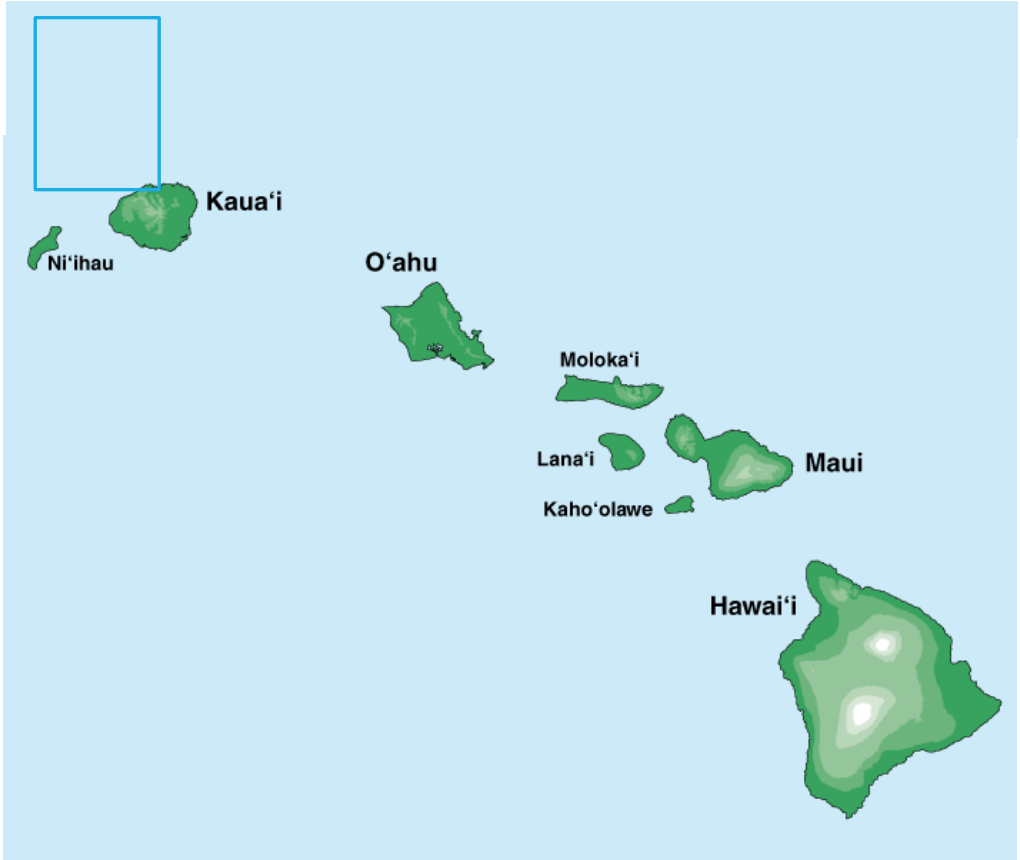
MARCH 16, 2016

HRC Monitoring Goals

- *What are the long term trends in occurrence of Blainville's beaked whales on the PMRF range?*
  - Evaluate trends in distribution and abundance for populations of protected species regularly exposed to sonar and underwater explosives
- *What is the occurrence and estimated received levels of MFAS on Blainville's beaked whales within the PMRF instrumented range?*
  - Establish the regional baseline vocalization behavior, including seasonality and acoustic characteristics, of marine mammals where U.S. Navy training and testing activities occur
- *What, if any, are the short term behavioral responses of Blainville's beaked whales when exposed to MFAS/explosions at different levels/conditions at PMRF?*
  - Determine what behaviors can most effectively be assessed for potential response to U.S. Navy training and testing activities
  - Evaluate behavioral responses by marine mammals exposed to U.S. Navy training and testing activities

PMRF

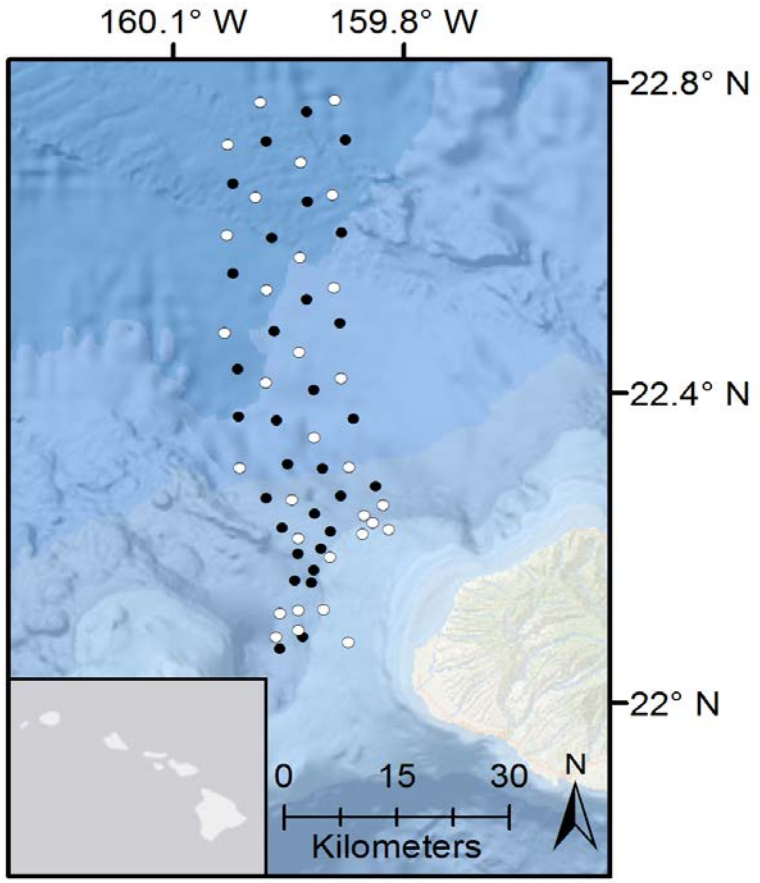
- Pacific Missile Range Facility
  - Kauai, HI
- 200+ bottom mounted hydrophones
  - Limited number of broadband phones
- Depth range 1 – 4+ km
- Hydrophone spacing 1.6 – 10+ km



http://satftp.soest.hawaii.edu/space/hawaii/maps/maps.html

PMRF

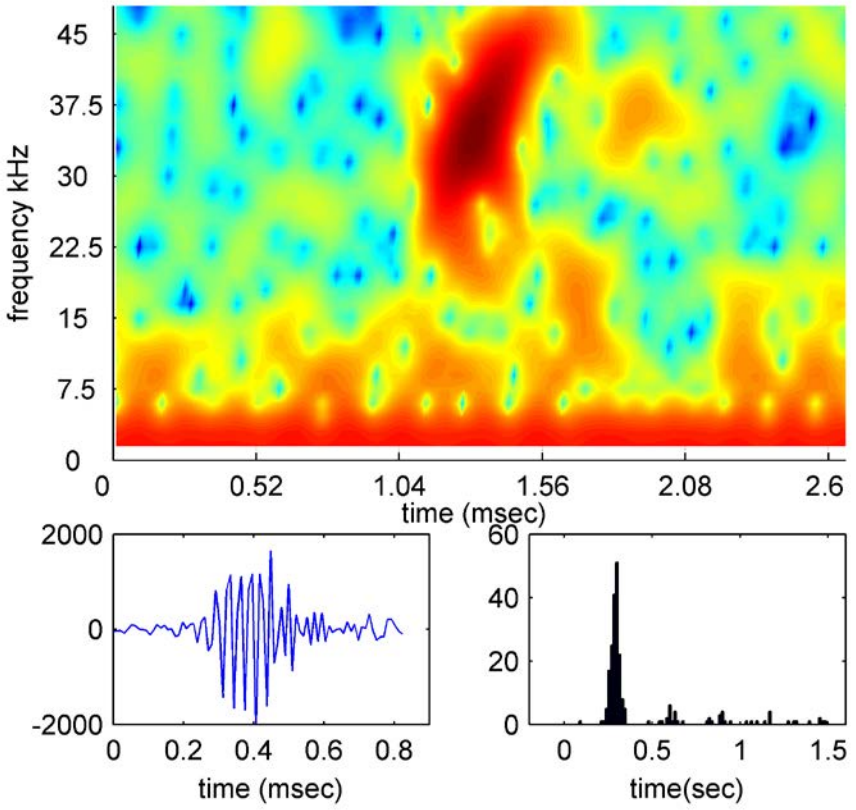
- Record raw data at least 2 days/month
  - Jan 2006 – Dec 2010
    - 13 broadband hydrophones
  - Jan 2011 – Aug 2012
    - 31 broadband hydrophones
  - Aug 2012 – present
    - 62 broadband hydrophones
- Record 3-5+ days of data before/after training events
- Record classified data during training events
  - Also get ship track data, sonar data
- Analyses conducted with 31 phones only



Blainville's beaked whale clicks

www.elhogarnatural.com

- 0.3 ms duration
- 27 – 45 kHz upsweep
- 0.3 s ICI
- High SNR threshold, > 25 dB
  - Probability of detecting individual clicks ≈ 0.39
  - Dive Detections (event)
  - Dives automatically grouped
- Detections manually validated
  - Remove all false positives
  - Sort groups



Manzano-Roth et al. submitted

2011 – 2013 Baseline Data

	2011	2012	2013	Total
Recording Effort (hours)	734	850	745	2329
Dive Count	1088	1089	781	2958
Dives per Hour	1.5	1.3	1	1.3

Temporal Patterns – Inter-annual

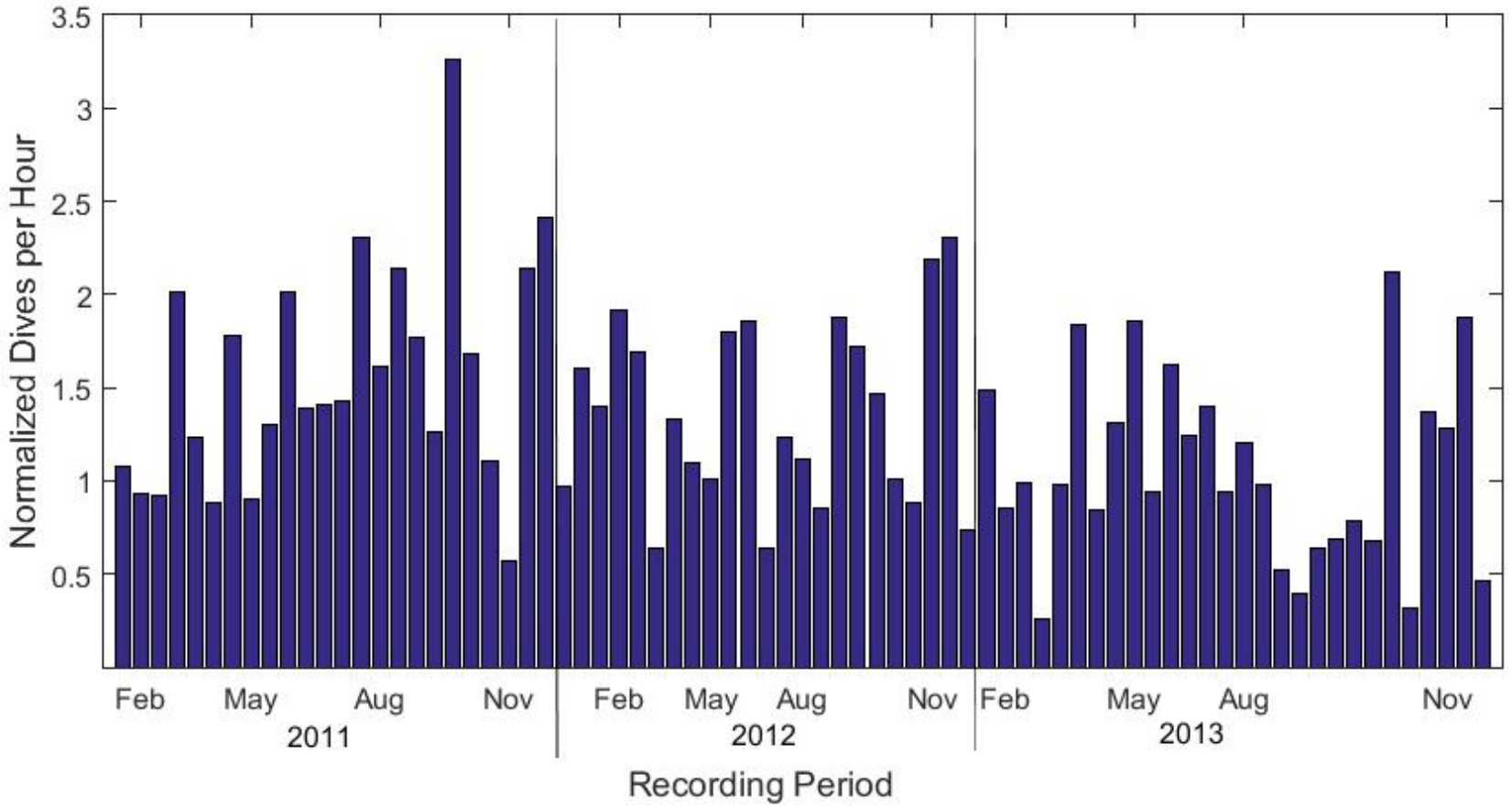
Chi-square

χ=57.64, p<0.0001

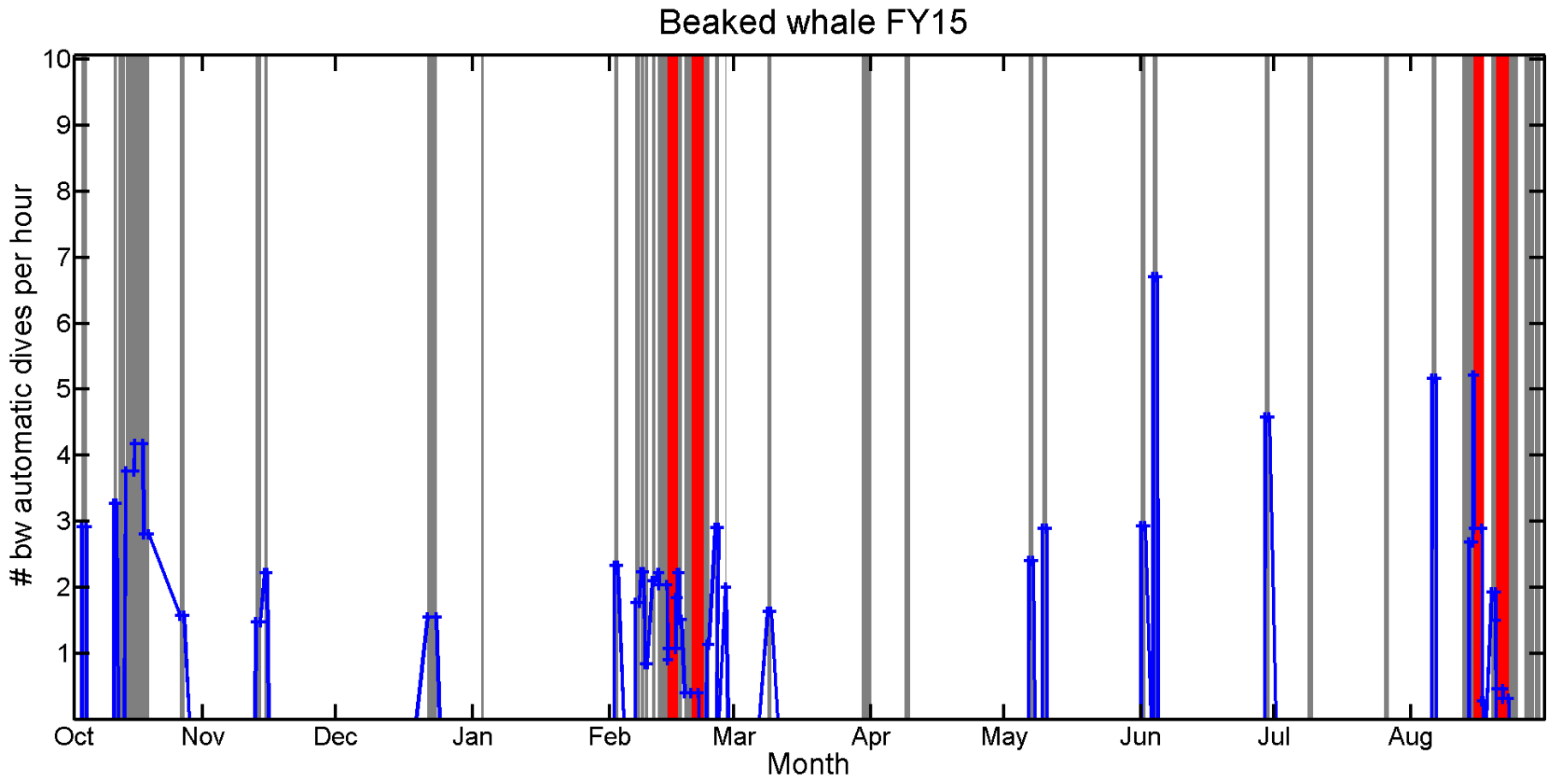
No observable pattern

Linear Regression

R^2 = 0.09



FY 2015 data (not validated)

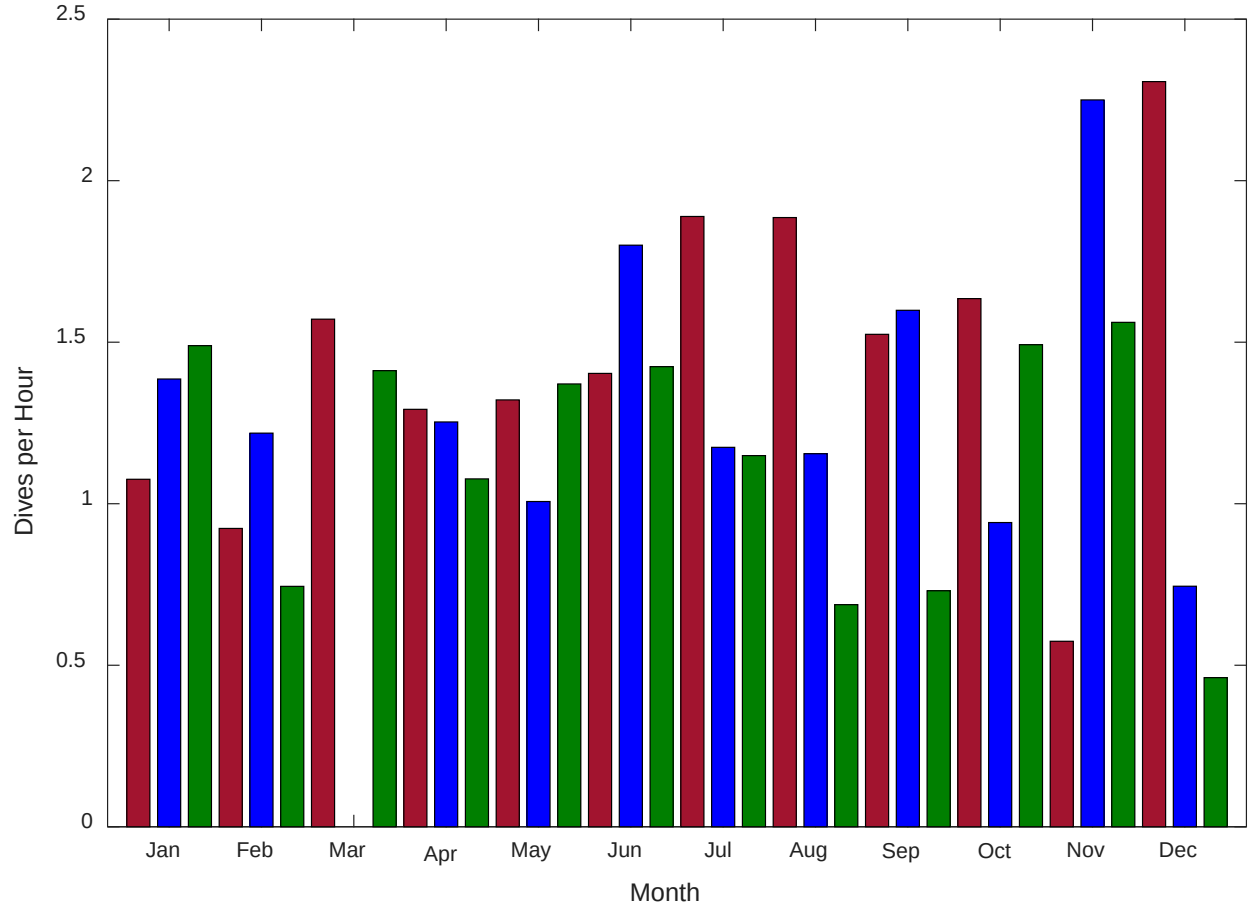


Temporal Patterns - Monthly

Chi-Square

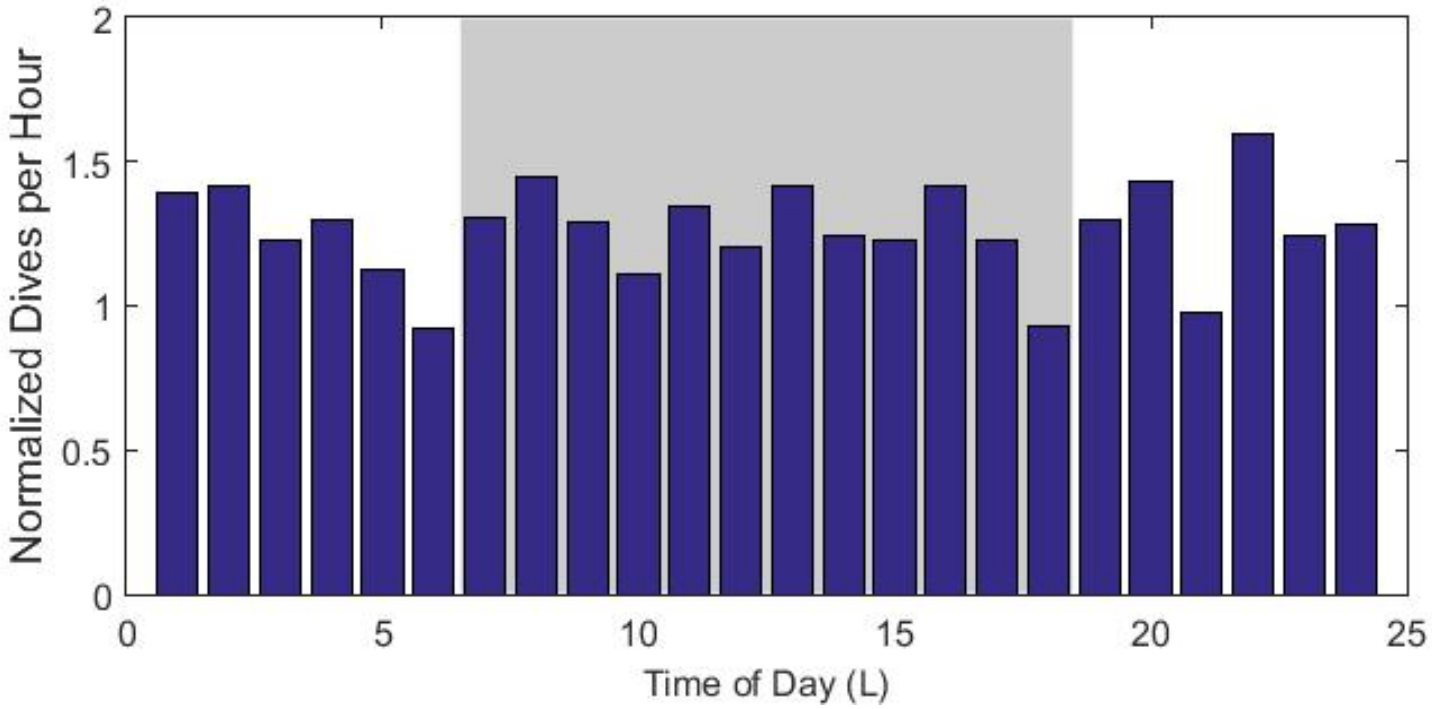
$\chi=54.97, p<0.0001$

No observable pattern



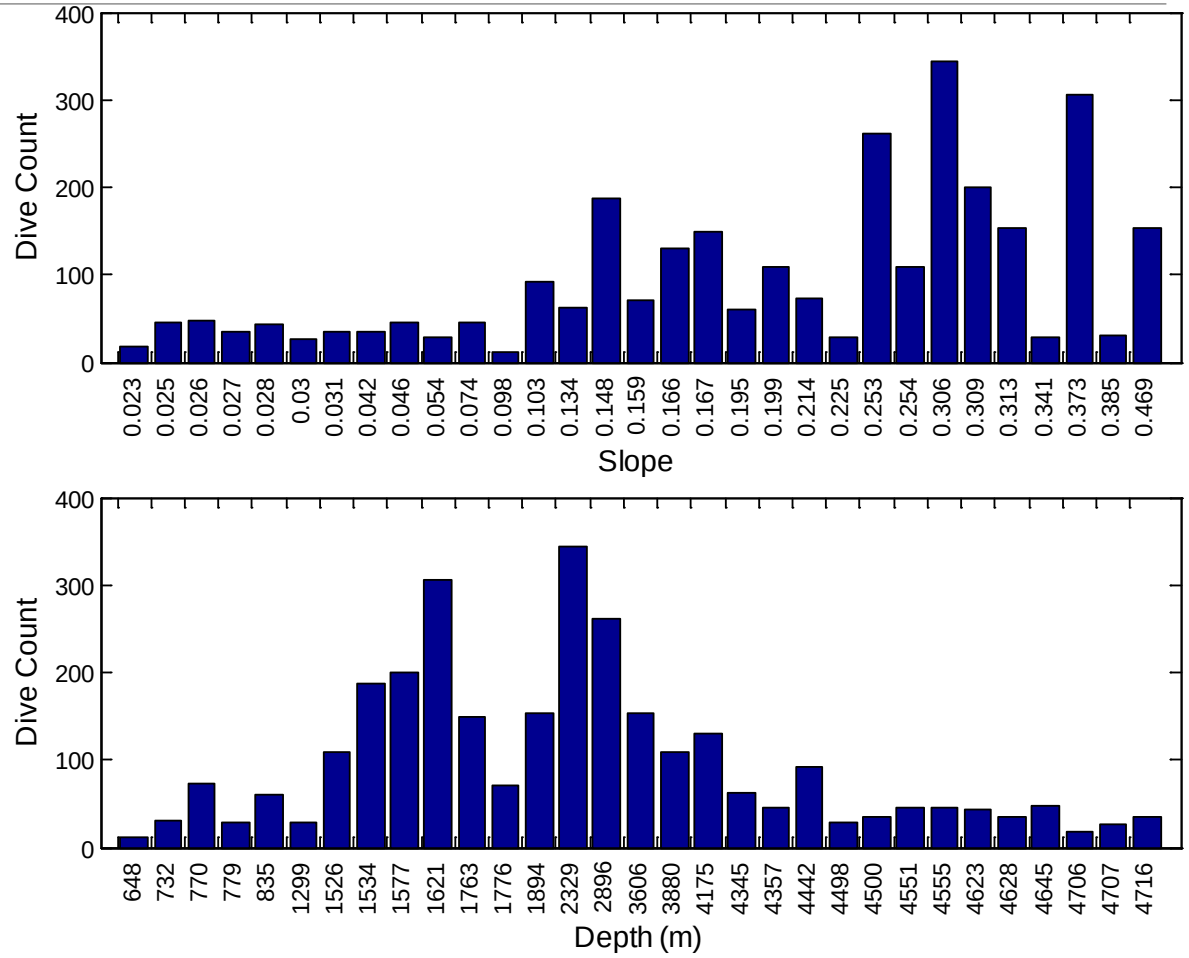
Temporal Patterns – Diel*

- All data combined
- Normalized by effort
- Slight diel pattern
  - Crepuscular dip
- χ=47.13, p = 0.002

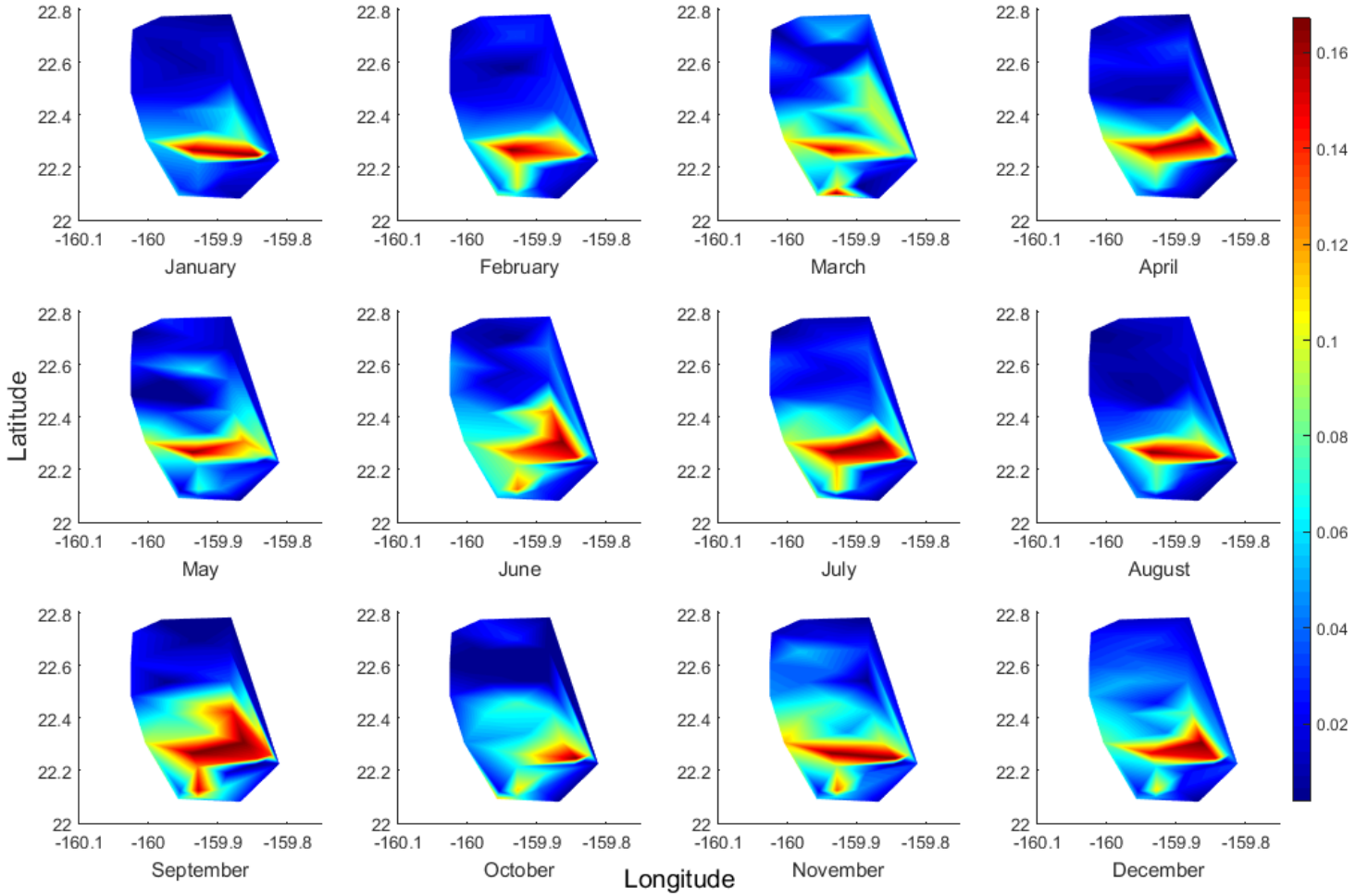


Spatial Patterns – Depth and Slope

- Dives do not occur equally across range
  - χ=2375.43, p<0.0001
- Mean Depth – 2612 m
- Mean Slope – 23%
- Phones between 9.8 – 32 km from shore



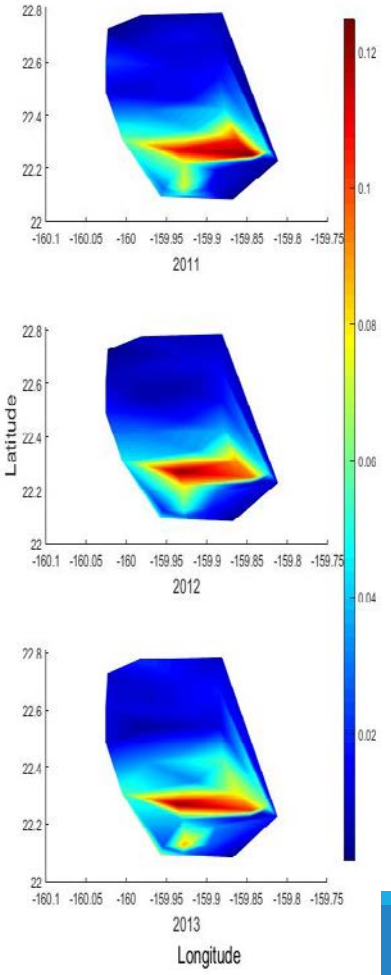
Spatial Patterns



2011

2012

2013



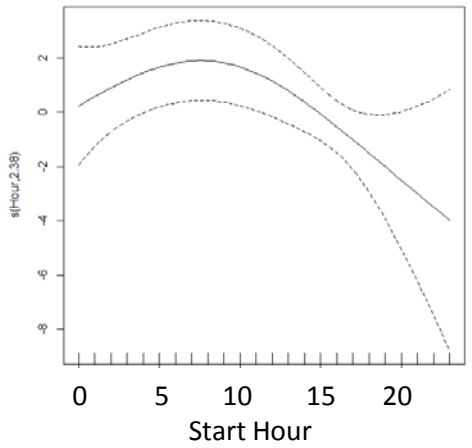
Spatio-Temporal Habitat Models

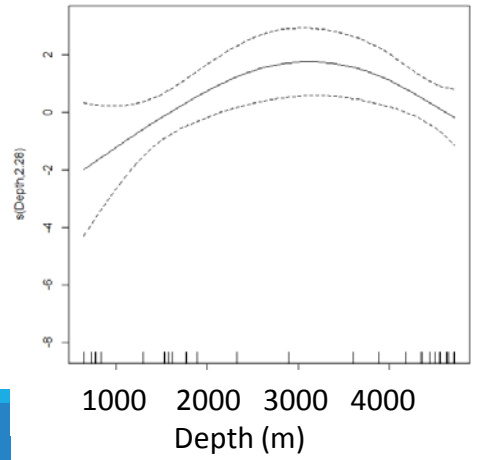
- Generalized Additive Model (GAM)
  - mgcv package in R
  - Possion family with log link
- Data in 1 hour time bins
  - Presence of dive on each phone (1/0)
  - Year, Month, Start Hour, Depth, Slope
  - Lunar Cycle
- Used Restricted Maximum Likelihood (REML) criterion
  - Remove least significant variables in stepwise iteration
  - Maximize both REML and explained deviance

Predictor Variables	P-value	REML score	Explained Deviance
Start Hour	0.07		
Depth	0.02	119.3	12.3%
Start Hour	0.07		
Depth/Slope	0.03	118.9	14.1%
Depth/Slope	0.03		
Start Hour/Lunar Phase	0.08	104.8	30.0%
Start Hour/Lunar Phase	0.04	108.0	22.6%

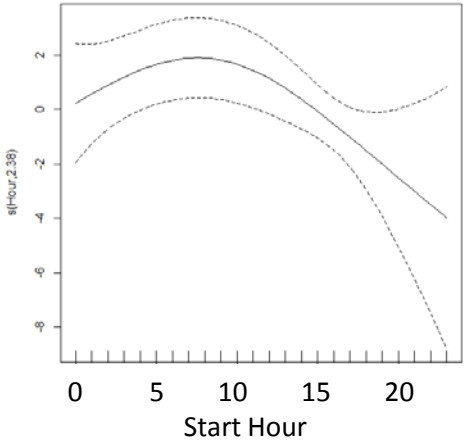
Spatio-Temporal Habitat Models

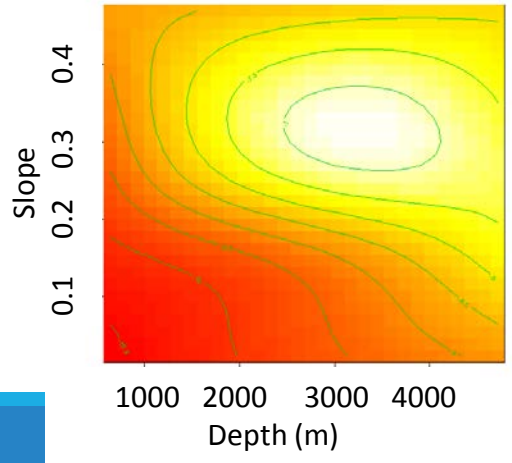
Start Hour + Depth



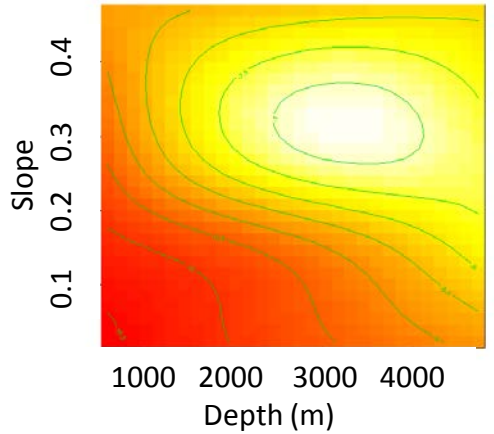


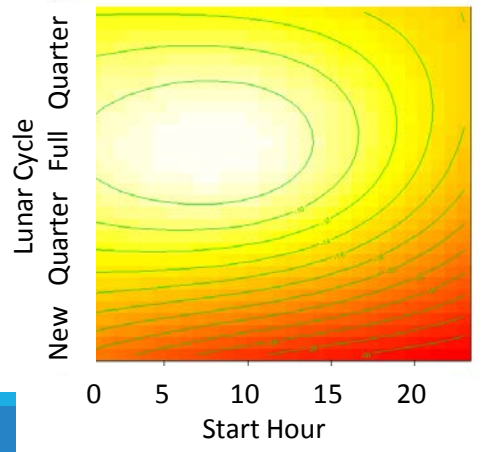
Start Hour + Depth/Slope



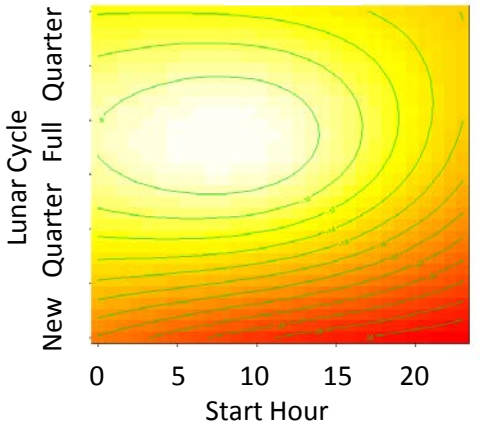


Depth/Slope + Start Hour/Lunar Phase





Start Hour/Lunar Phase

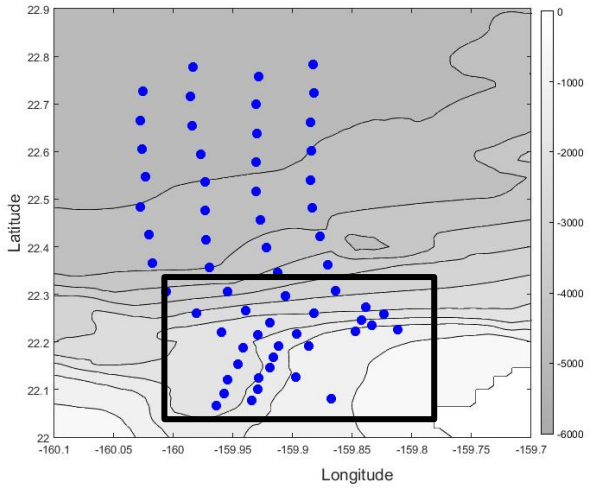


Habitat Models

- Need prey data, oceanographic data
  - Backscatter, net tows, CTDs
- Other habitat models
  - Great Abaco (northern Bahamas) (MacLeod & Zuur, 2005)
    - Gradient, depth, aspect (slope direction) – no deviance given
  - Tongue of the Ocean (Bahamas) (Hazen et al. 2011)
    - Depth, salinity, temp, backscatter, number of single targets – 54% deviance explained
  - Hawaii Island (Abecassis et al. 2015)
    - Included bathymetry, temp at 300m, backscatter (70 kHz, daytime, shallow) – 28.5% deviance explained

Preliminary Density Estimate (62 phones)

$$\widehat{D} = \frac{n_d s}{r_d T A}$$



- n_d = total number of group dives - 817 dives
- r_d = dive rate - 0.43/hour ± 0.11*
- s = average group size - 3.6 ± 3*
- T = time period measured - 585.2 hours
- A = total area sampled - 440 km² (southern phones only)

- c = proportion of false positives == 0
- p_d = probability of detecting dives ~= 1

- D = Density - **11.7 whales/440 km² → 26.5 whales/1000 km²**
  var(D) = 0.26

* Baird et al. 2006

Impacts of Navy Training Events

	Before	Phase A	Phase B	After	Total
Hours of data	**396**	**335**	**368**	**406**	**1505**
Verified dives detected	**562**	**404**	**158**	**332**	**1456**
Dives per hour	**1.4**	**1.2**	**0.4**	**0.8**	**0.9**

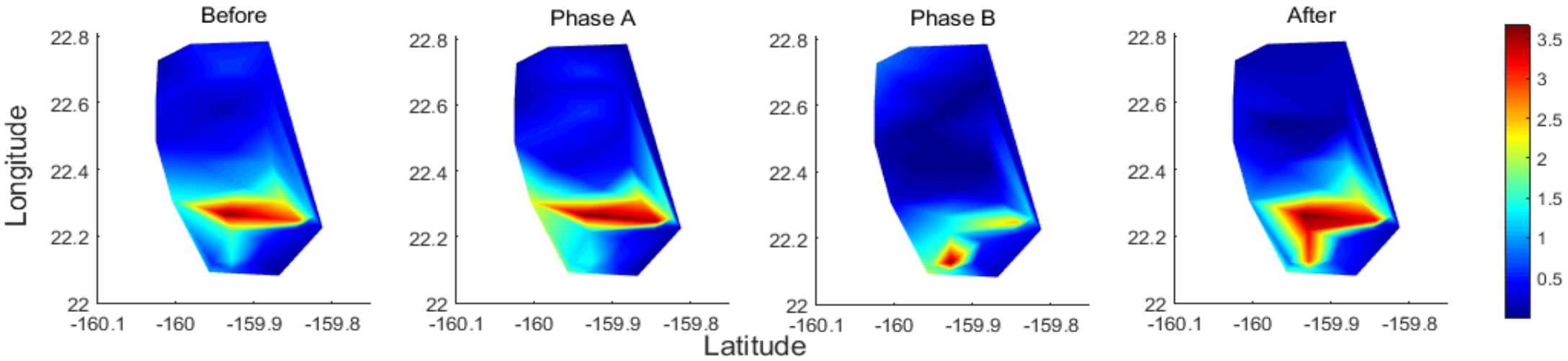
- Phase A – no MFA sonar, multiple ships
- Phase B – MFA sonar (1-10 kHz range), multiple ships

Dives During Sonar Periods

- Periods of sonar ~35% of Phase B
  - 20 – 53%
  - Ship sonar only
- 35% dives co-occurred with sonar
  - 10 – 86%
- More dives on edge phones/ southern portion of range

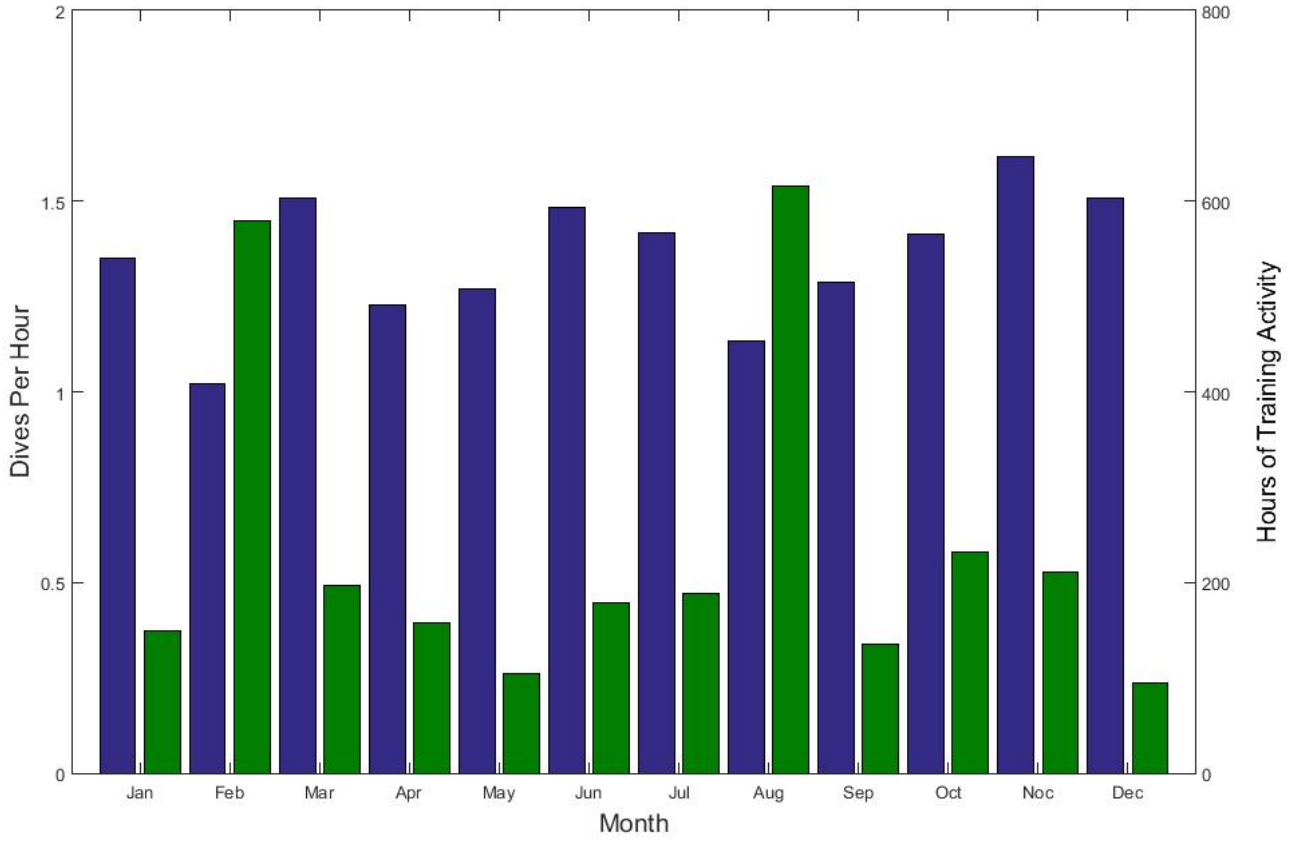
Training Event	Period	Duration (hours)	Dive Count	Dives per Hour	Sonar Duration (hours)	# dives with sonar
Feb 2011	Phase B	70	36	0.52	21	12
Aug 2011	Phase B	64	42	0.66	23	15
Feb 2012	Phase B	63	30	0.48	17	8
Aug 2012	Phase B	64	21	0.33	13	2
Feb 2013	Phase B	63	14	0.36	25	12
Aug 2013	Phase B	45	15	0.42	24	6

Spatial Patterns



All Training Events

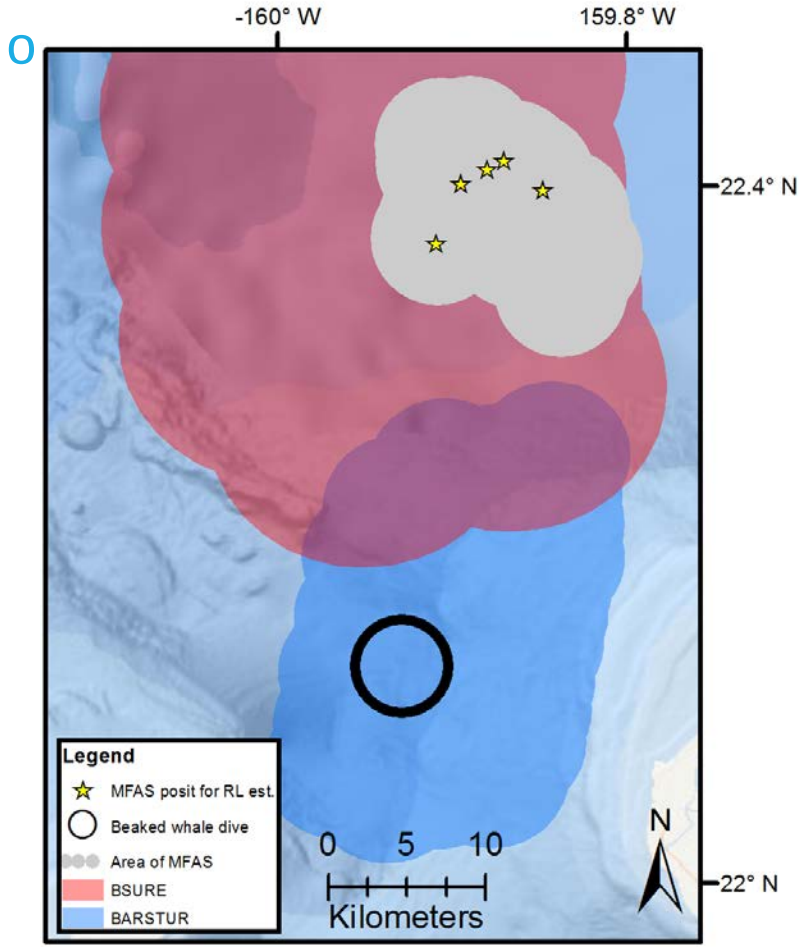
- Grouped hours of training and dives by month
  - No significant impact on dives
- Hours of training in week prior to recording
  - With and without time lag
  - Time lag weights more recent training
- In 2013 and when all data combined, significant impact of training on dive rates
- BUT, when Feb and Aug data removed, NO significance

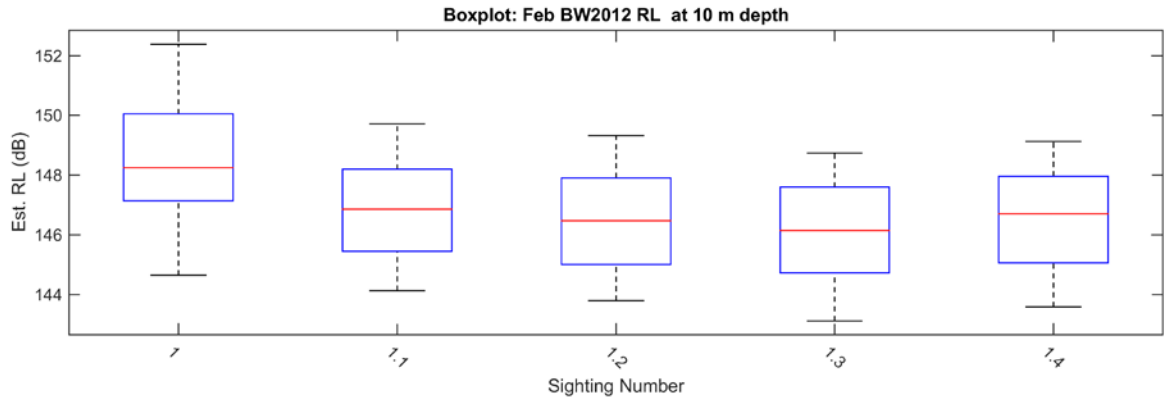


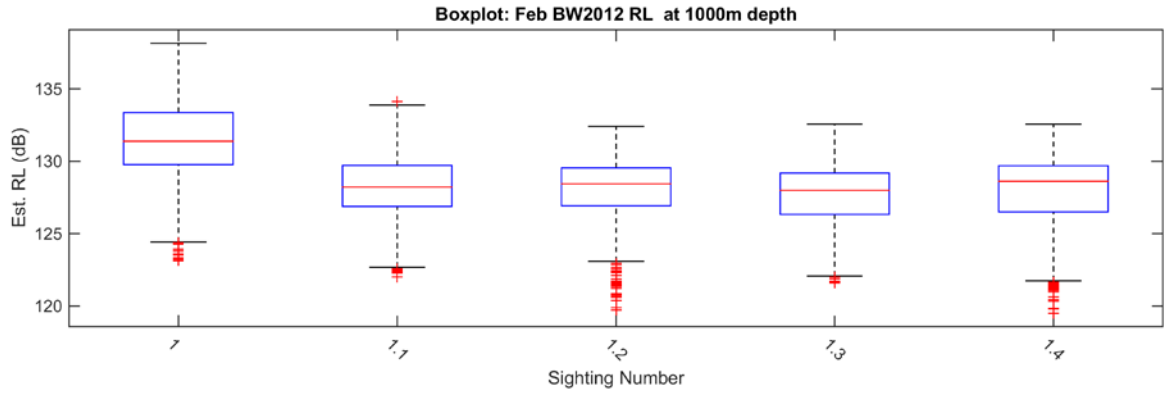
Behavioral Responses

- Individual group dives during sonar or within 30 min
  - 151 groups total
  - 81 groups with RL estimates
    - Estimated received levels at surface (10 m) – mean 147 dB re 1µPa (116 – 161 dB re 1µPa)
    - Estimated received levels during dive (1 km) – mean 142 dB re 1µPa (102 – 161 dB re 1µPa)
- 66 groups showed possible response
  - Cessation of foraging dive when sonar starts/start foraging dive when sonar ends
  - Mean ship distance 28.2 km (2.5 – 50.3 km)
- 85 groups did not appear to respond
  - Mean ship distance 33.0 km (13.1 – 51.3 km)
- Looking into ship movement/direction, other contextual factors

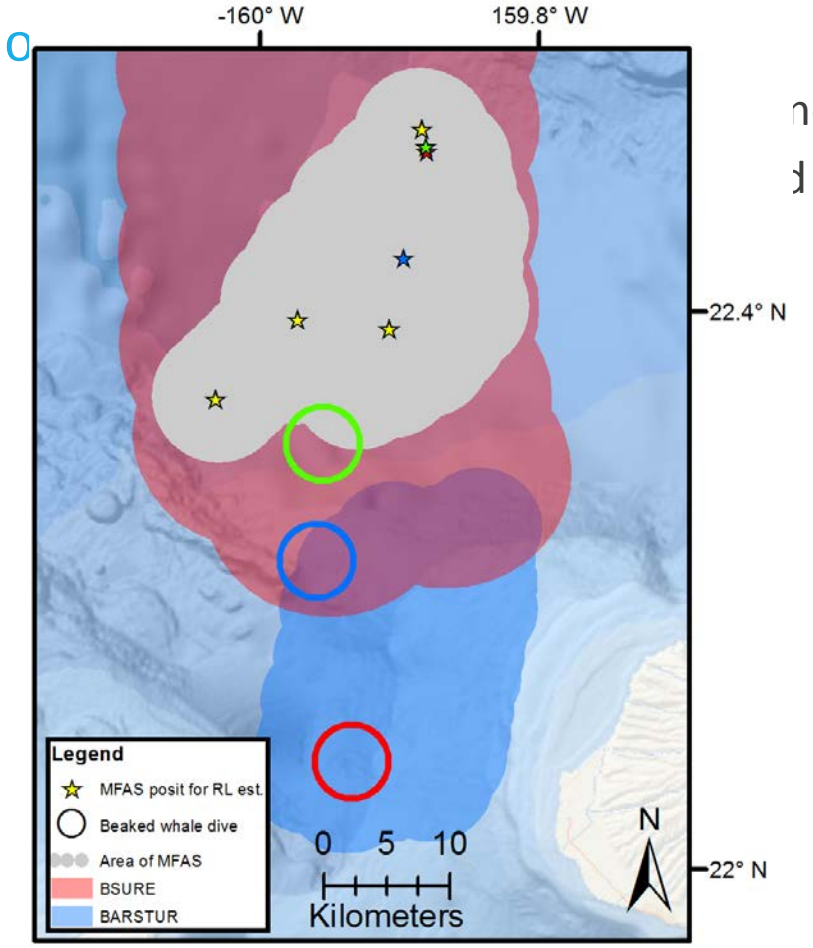
Response - Cessation of Foraging





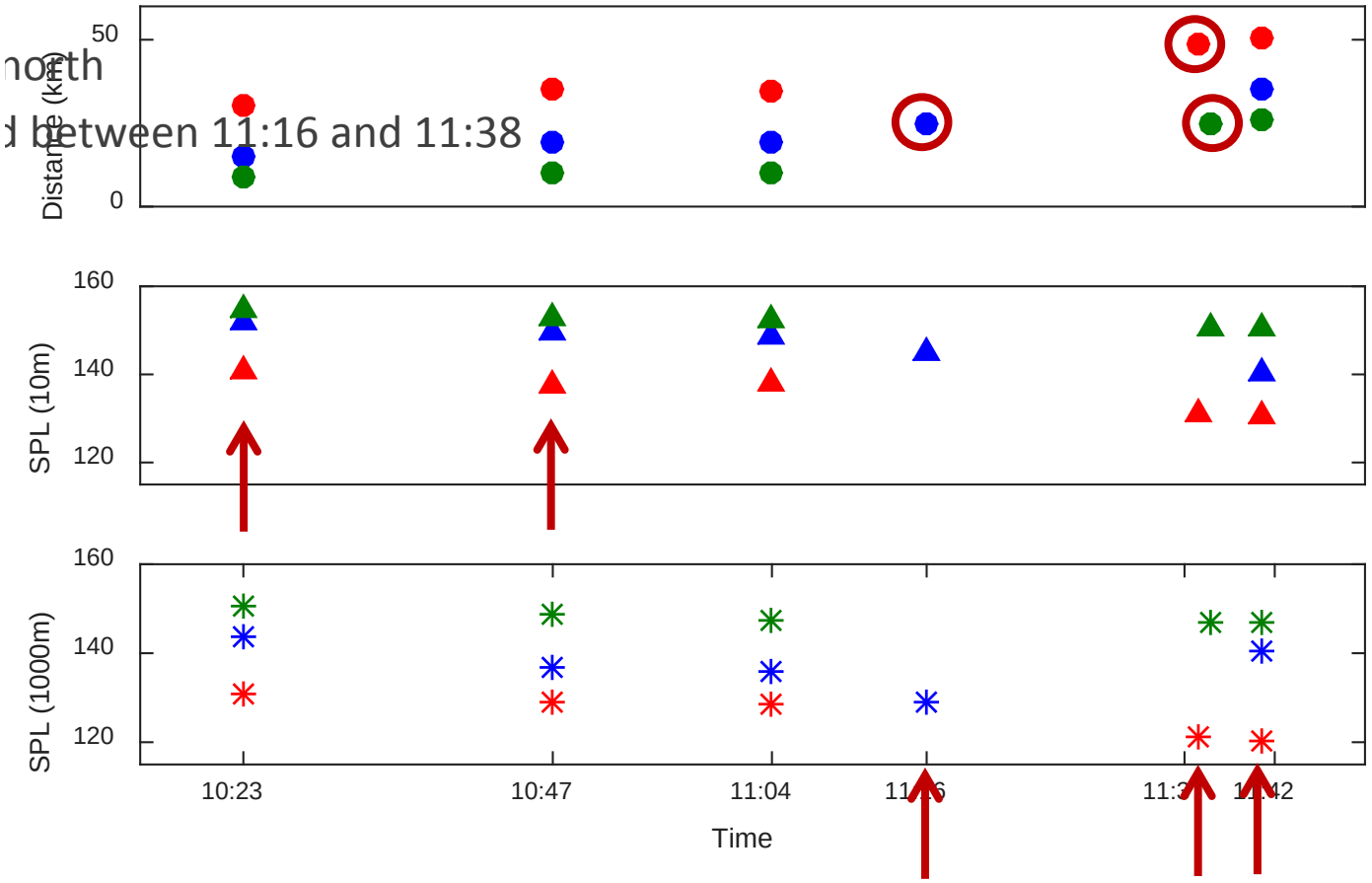


Response – Proximity/Directionality

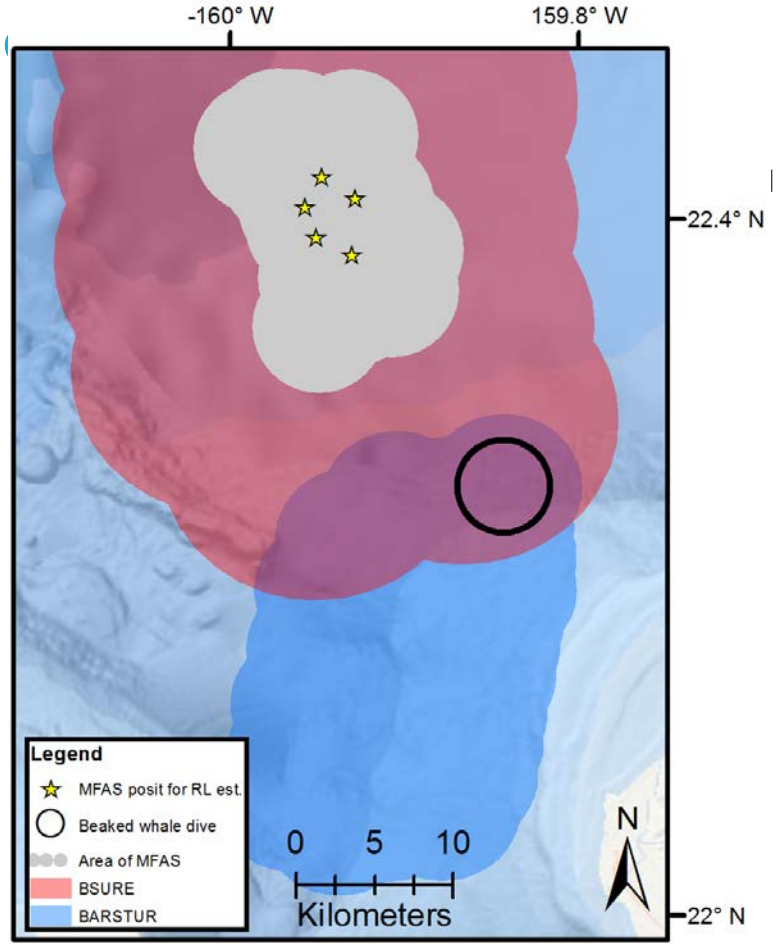


north

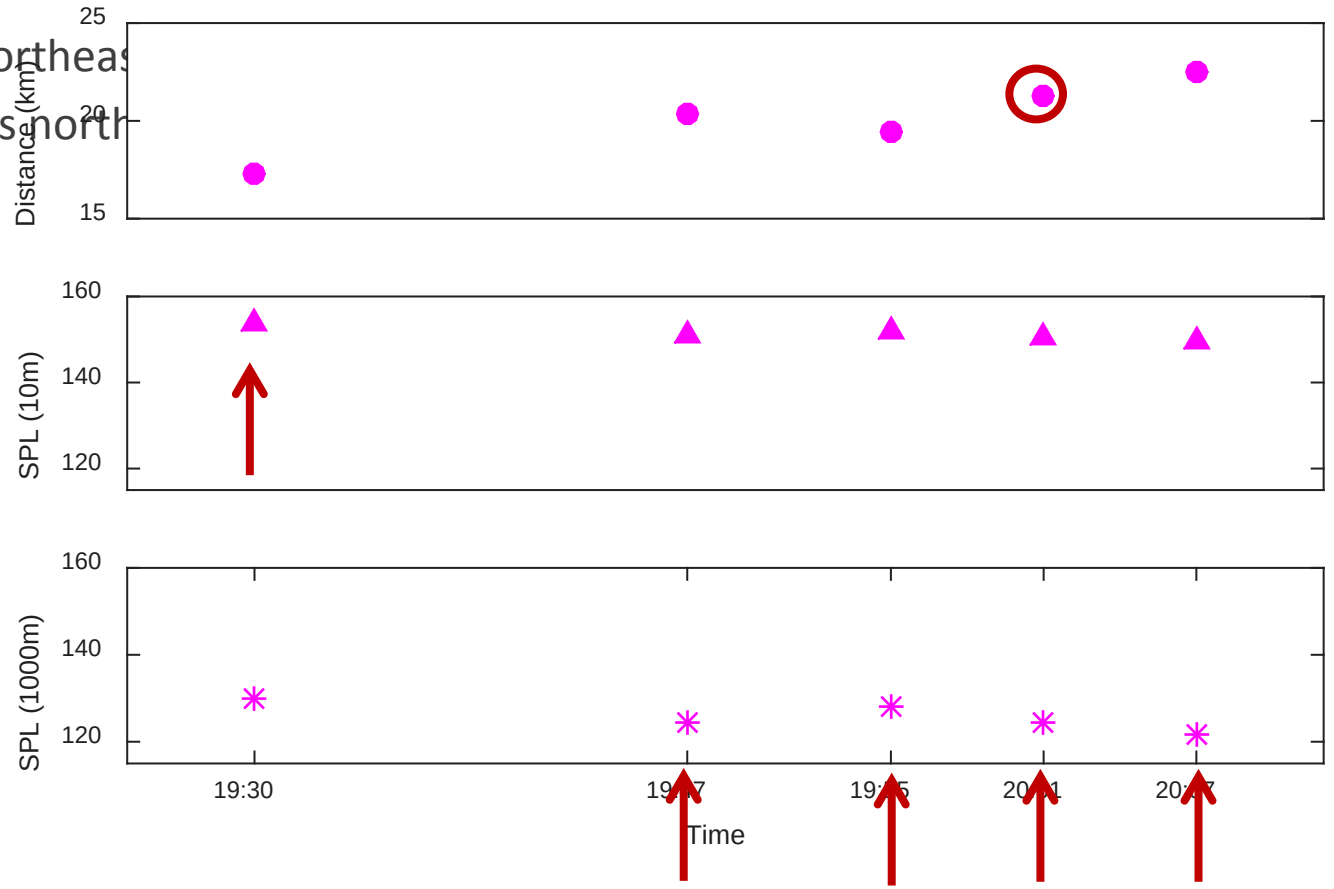
d between 11:16 and 11:38



Response – Directionality



northeas
rns north



Future Work

- Process and validate FY14-16 data
  - Long-term trends
- Better resolution of sonar use, improve estimation of short-term impacts
- Oceanographic sampling, prey mapping, improved habitat modeling
  - SVP data from range
- Collaboration with NUWC
  - Compare/Evaluate/Improve detection functions
  - Density Estimation
  - Behavioral Risk Function at PMRF (LMR)

Thank you!

Funding from Julie Rivers, ComPacFleet

PMRF personnel: Jim Hager, Eliseo Boloson, Robin Higuchi, Bryson Kurokawa

R. A. Manzano-Roth, E. E. Henderson, S. W. Martin, and B. Matsuyama. Submitted. Impacts of a U.S. Navy Training Event on Beaked Whale Foraging Dives in Hawaiian Waters. Aquatic Mammals.

E. E. Henderson, S. W. Martin, R. Manzano-Roth, B. Matsuyama. In Prep. Occurrence and Habitat Use of Foraging Blainville's Beaked Whales (*Mesoplodon densirostris*) on a US Navy Range in Hawaii.

E. E. Henderson, R. A. Manzano-Roth, S. W. Martin, B.Matsuyama. Submitted. Behavioral Responses of Individual Blainville's Beaked Whale Groups to US Navy Sonar. Effects of Noise on Aquatic Life Conference. Dublin, Ireland, July 2016.

E. E. Henderson, R. Manzano-roth, S. W. Martin, B. Matsuyama. 2015. Using Detections of Foraging Dives to Estimate the Density of Blainville's Beaked Whales at PMRF. Detection, Classification, Localization, and Density Estimation Workshop. San Diego, CA, July 2015.