Cetacean occurrence from passive acoustic monitoring in Guam and the Northern Mariana Islands, 2011-2012

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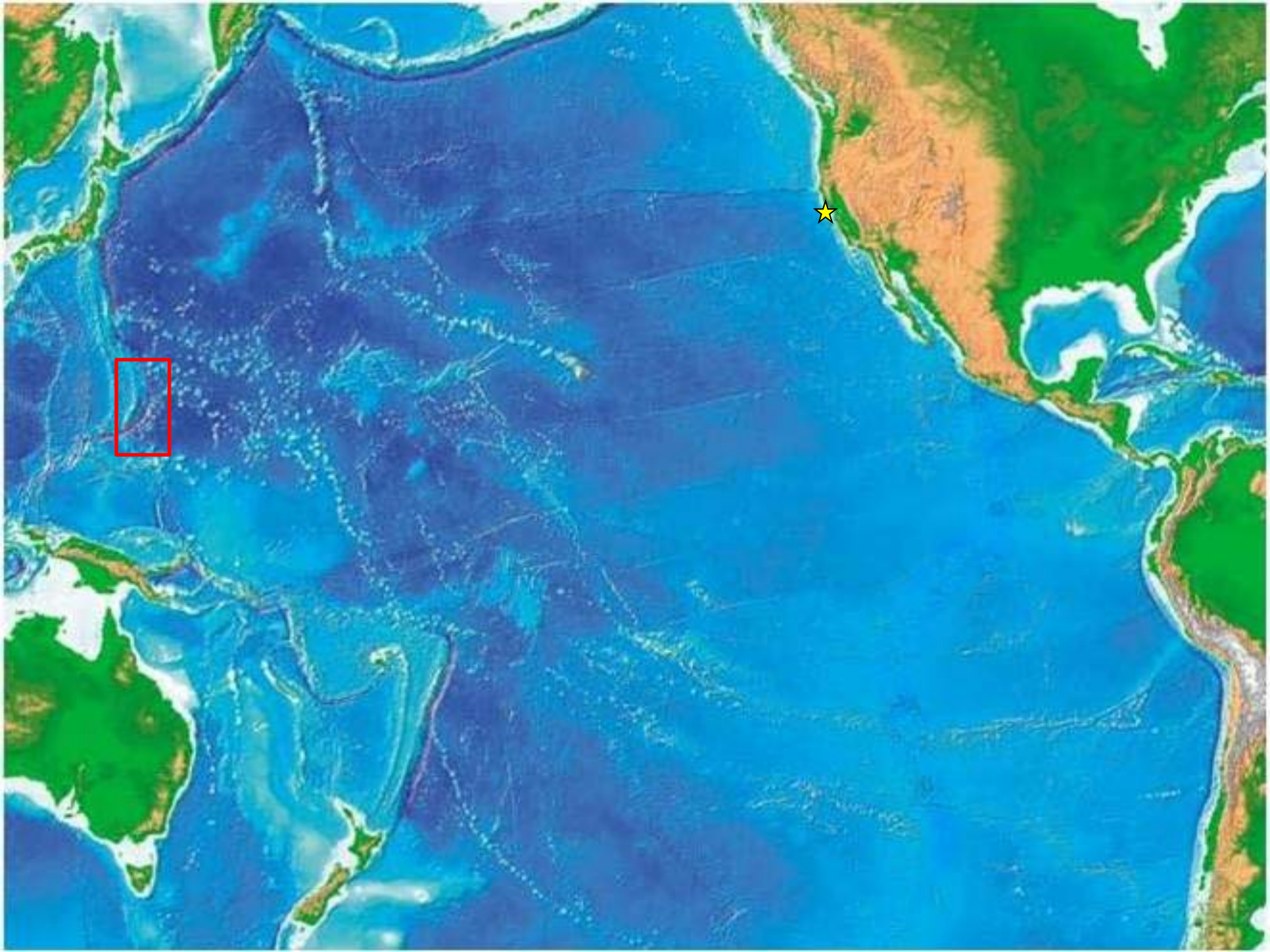
With thanks to: Michael Richlen[5], Mark Deakos[5], Susan Jarvis[6], Eden Zang[1]

1 OCEANWIDE SCIENCE INSTITUTE 2 3 Bio·Waves Incorporated 4 NAVFAC Naval Facilities Engineering Command 5 HDR 6 NAVSEA NAVAL SEA SYSTEMS COMMAND



Background

- Until recently, little/no systematic survey effort in Guam or Commonwealth of the Northern Mariana Islands (CNMI)
- Line-transect surveys in 2007, 2010 (Guam transit only), and 2015
- Small boat surveys annually since 2010
- Long-term PAM since 2010 (HARPs, EARs)

For more information:
http://www.navymarinespeciesmonitoring.us/regions/pacific/current-projects/
http://www.pifsc.noaa.gov/cetacean/staff_publications.php

Research questions

- What species are present?
  - Beaked whales?
  - Delphinids?
- What is their seasonal occurrence?
  - Baleen whales?
  - Sperm whales?
- Detection of mid-frequency active sonar (MFAS)?

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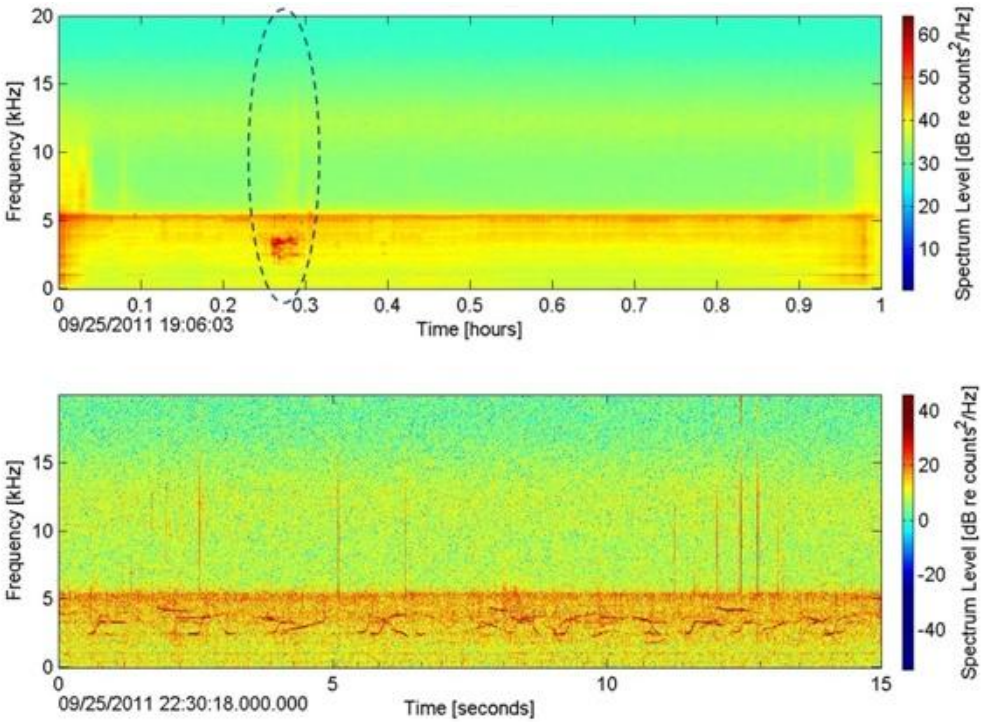
Ecological Acoustic Recorders (EARs)

Sampling Rate	80 kHz
Recording Duration	30 seconds (each recording ="file")
Recording Interval	Dep1: 360 seconds (6 minutes) Dep 2: 600 seconds (10 minutes)

Site	Depth (m)	Dates	# Effort-Days
Deployment 1			
Guam N	820	9/10/2011-1/06/2012	119
Guam S	952	9/16/2011-11/17/2011	63
Tinian W	869	9/12/2011-11/28/2011	78
Saipan N	850	9/12/2011-12/29/2011	109
Deployment 2			
Guam N	778	4/06/2012-9/05/2012	153
Guam S	944	NR	NR
Tinian W	860	4/08/2012-4/23/2012	16
Saipan N	840	4/8/2012-9/22/2012	168

Data analyses

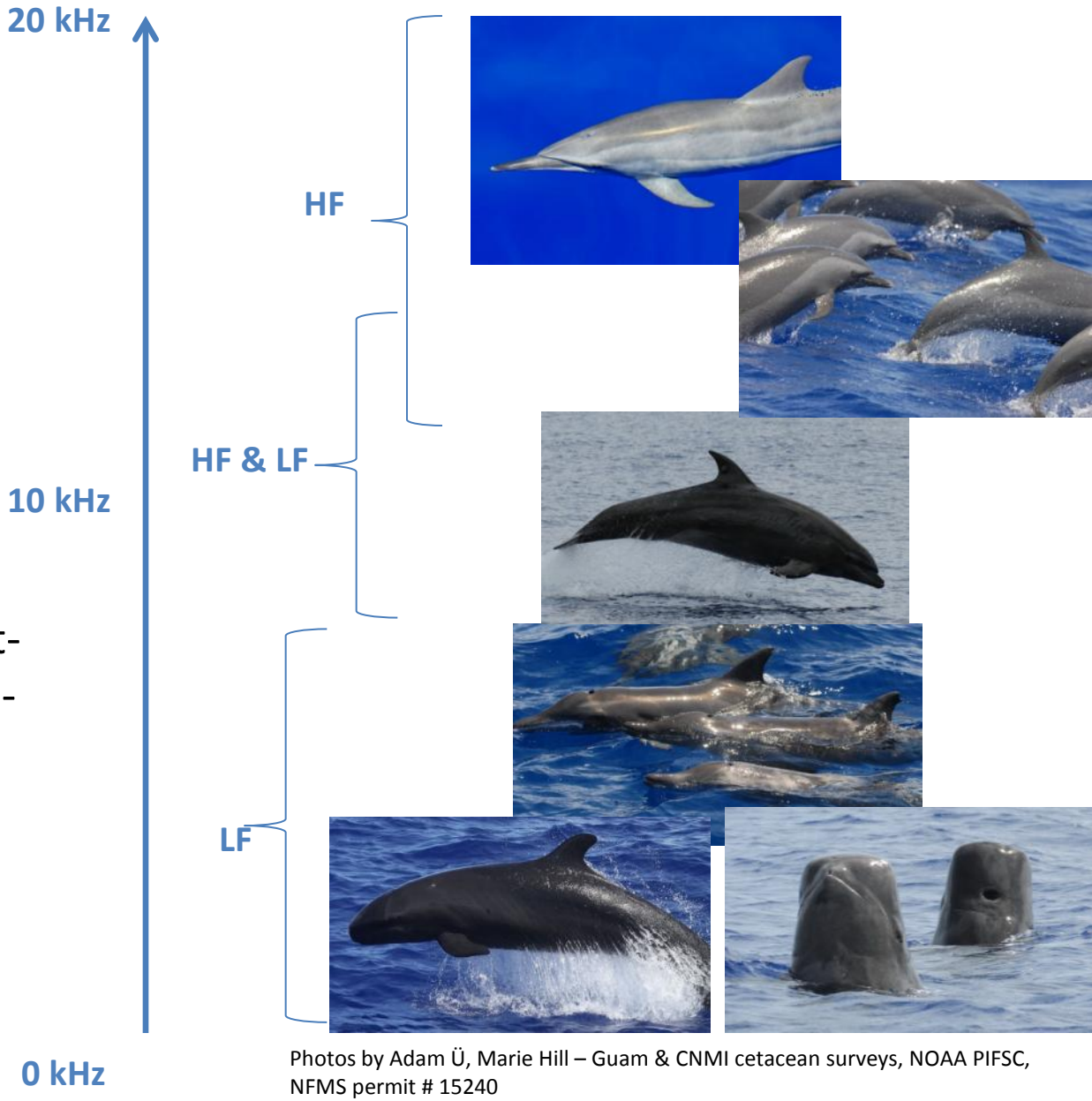
- Automated D & C: sperm whales, beaked whales, baleen whales
  - U.S. Navy M3R CS-SVM[1,2]
  - Baleen5[3]
  - Manual validation of some (sperm and beaked whale) or all (baleen whale) detections
- Manual D & C: dolphins, sperm whales, MFAS, baleen whales
  - Dolphins & sperm whales: acoustic "encounters" contain signals up to 30 min apart
  - Baleen whale search effort in Sep-Apr



1. Jarvis, S., et al. 2008. A novel multi-class support vector machine classifier for automated classification of beaked whales and other small odontocetes. Canadian Acoustics 36: 34-40.
2. Jarvis, S., et al. 2014. Marine Mammal Monitoring on Navy Ranges (M3R): A Toolset for Automated Detection, Localization, and Monitoring of Marine Mammals in Open Ocean Environments. Marine Technology Society Journal, 48(1): 5-20.
3. Ou, H., et al. 2015. Discrimination of frequency-modulated Baleen whale downsweep calls with overlapping frequencies. J. Acoust. Soc. Am. 137: 3024-3032.

Dolphin encounters further classified into 4 “signal groups”: Clicks Only and 3 based on whistle frequency:

- HF = spinner & spotted dolphins
- HF & LF = bottlenose & spotted dolphins
- LF = false killer whale, short-finned pilot whale, & rough-toothed dolphins



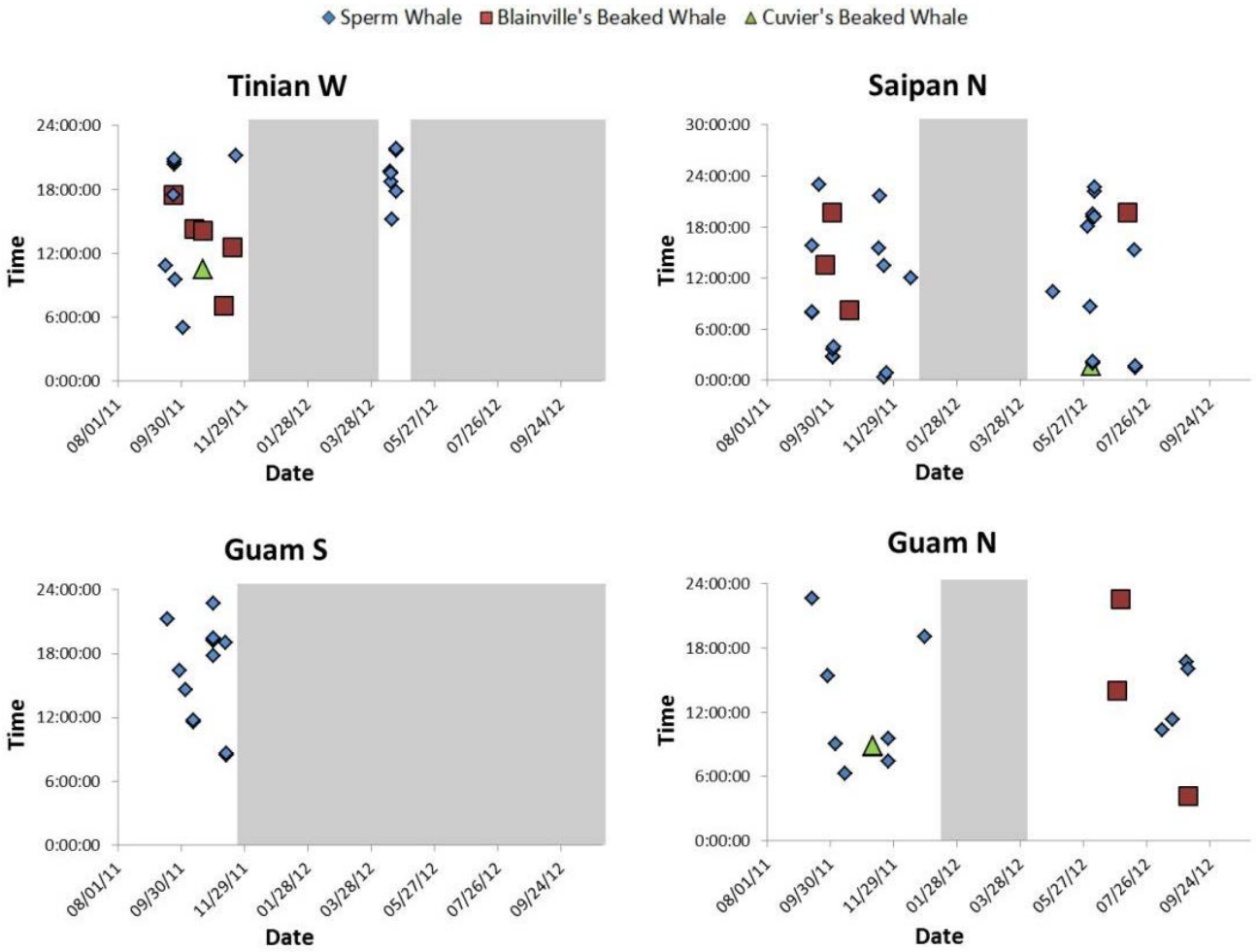
*Most commonly encountered sm. odontocete spp in Guam/MIRC (Hill et al. 2014 & others)
Whistle characteristics based on Oswald et al. (2003, 2007)

Photos by Adam Ü, Marie Hill – Guam & CNMI cetacean surveys, NOAA PIFSC, NFMS permit # 15240

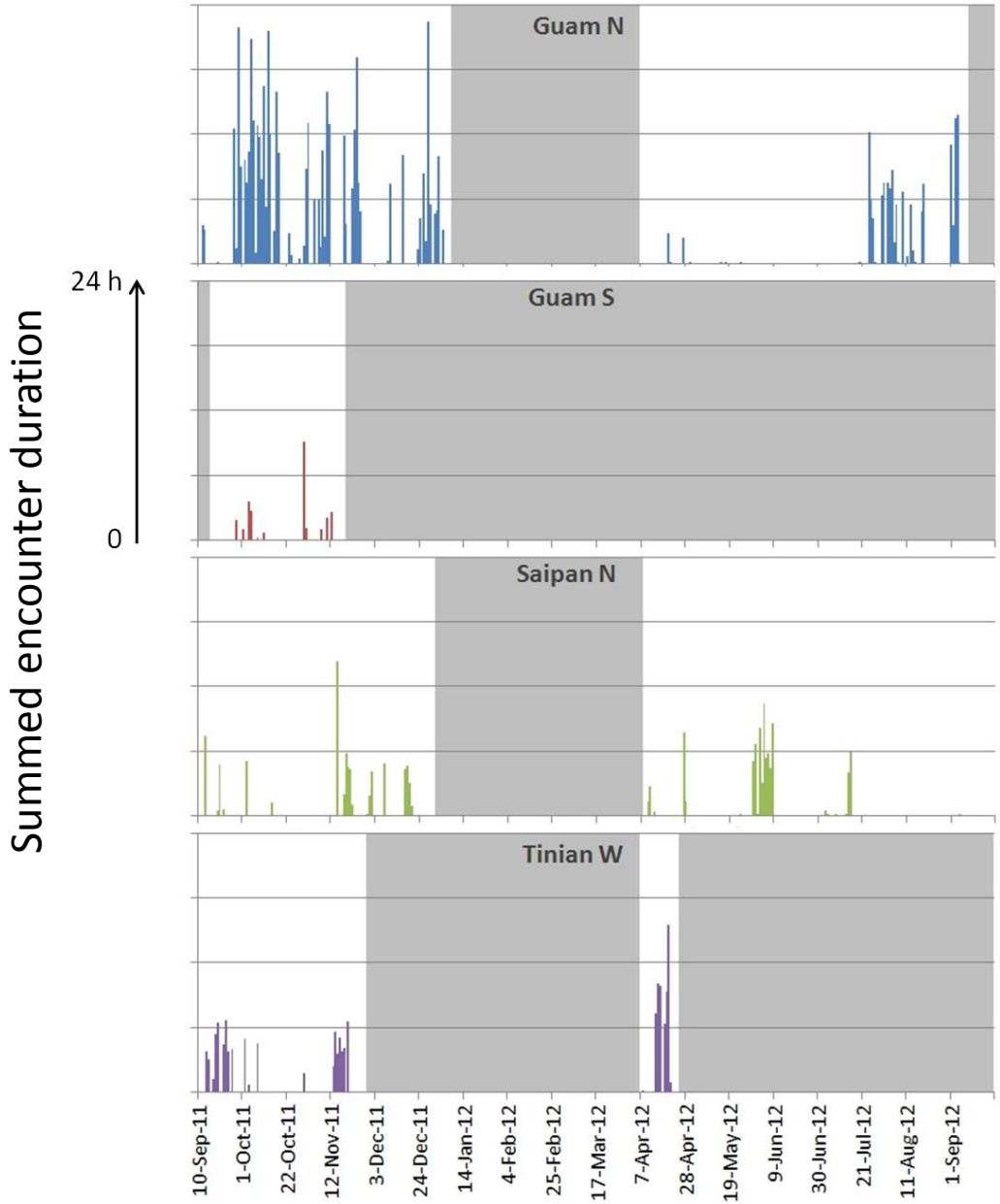
Beaked Whales & Sperm Whales

- 134,856 files in data set
- 11,237 files with auto click detections
- 1,543 files met threshold criteria* for click trains
- 131 files reviewed manually

* ≥ 70% of clicks within file classified to target spp., 1+ clicks for BW and 10+ clicks for SW



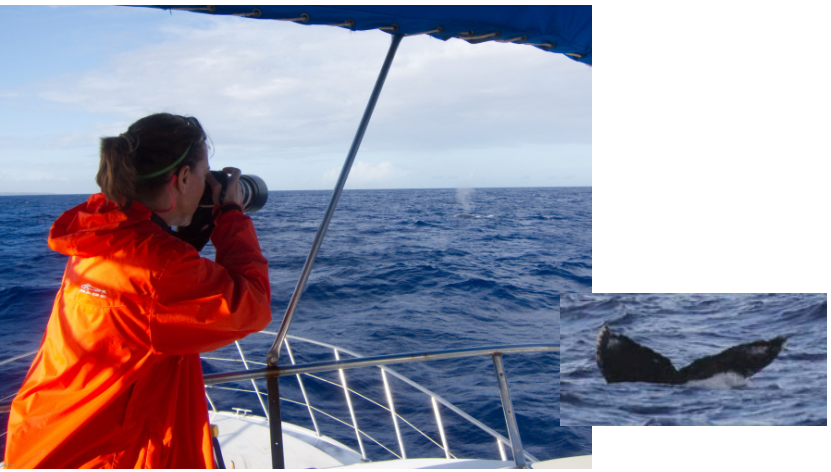
Sperm whale results – manual



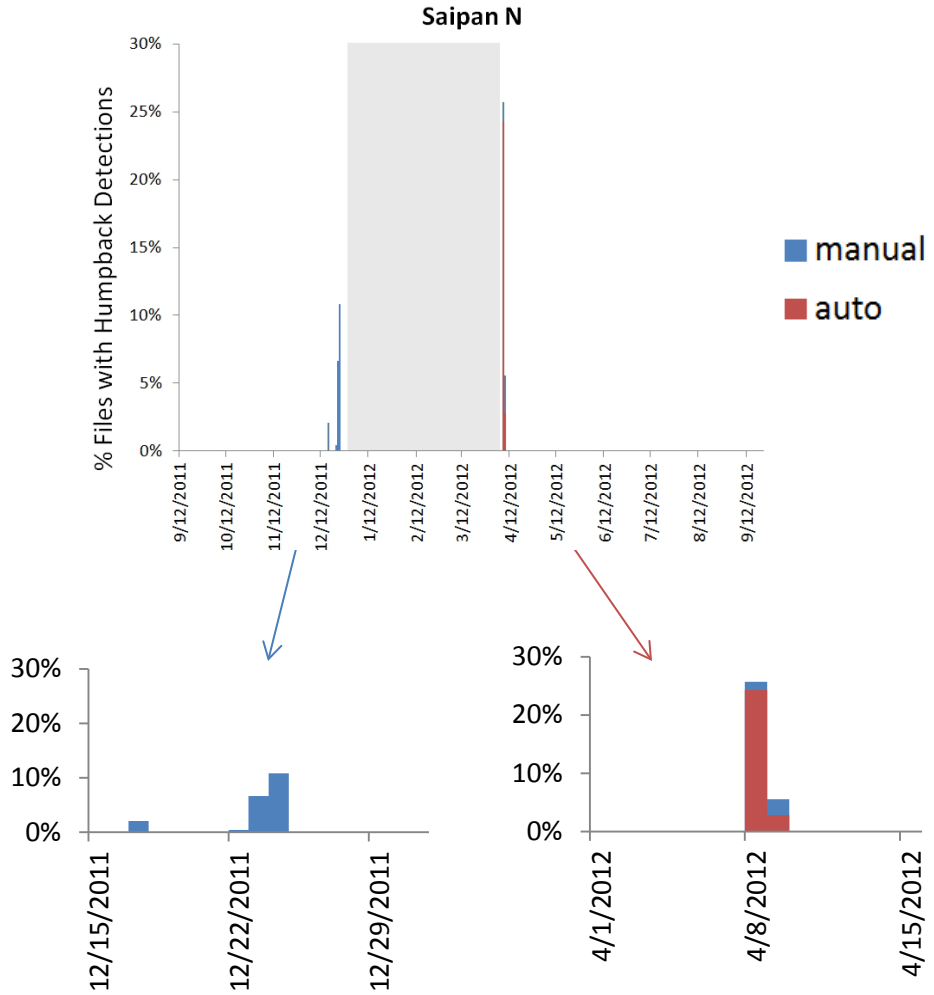
- Most prevalent at Guam N
- More & longer encounters in autumn
- Days to weeks between encounters

Baleen whales

- Automated detection results:
  - Minke whale: 3 files (false positives)
  - Humpback whale: 41 files
    - 39 true positive
      - Saipan N, 08-09 April 2012
    - 2 false positive
    - 53 false negative (missed)
      - Saipan N, 17-24 Dec 2011



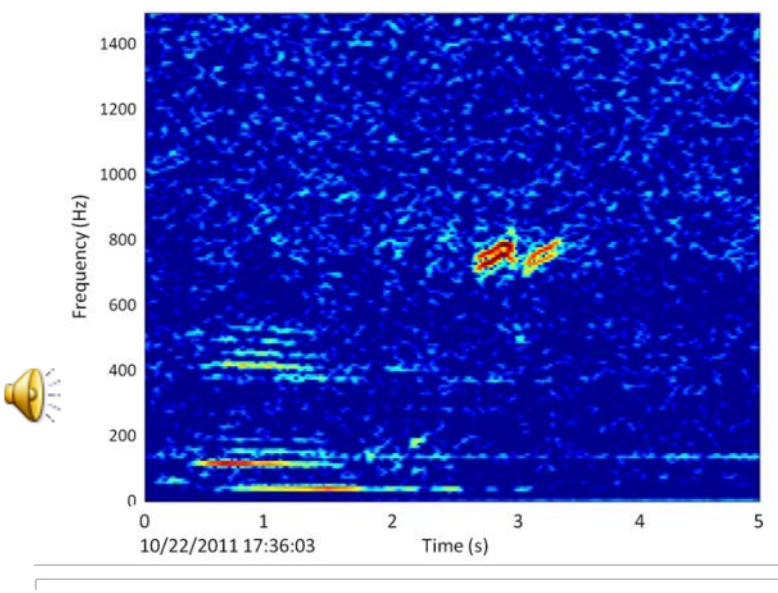
NOAA PIFSC surveys off Saipan earlier this year. Photos: Amanda Bradford & Adam Ü.
https://pifscblog.wordpress.com/2015/03/23/humpback-whales-in-the-marianas/

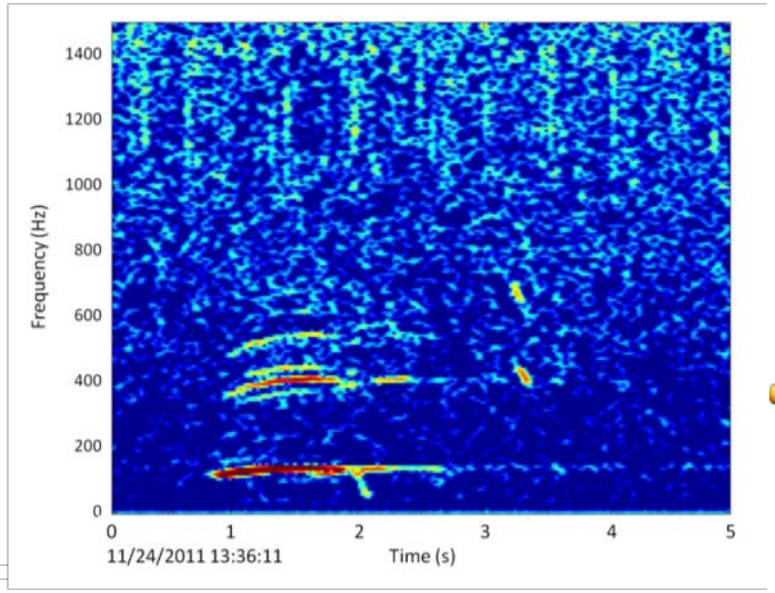


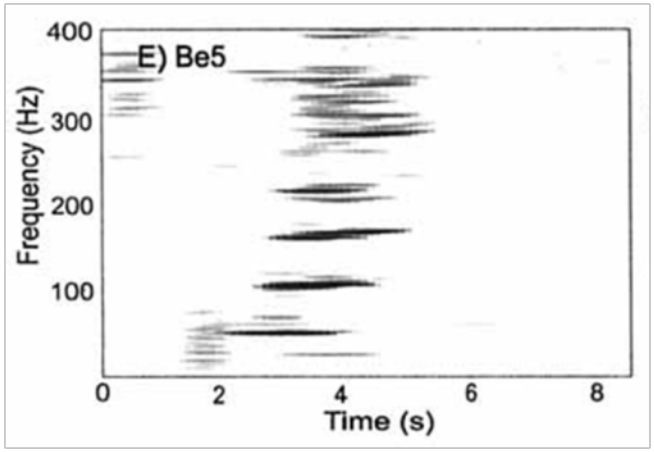
Poster in s1 by Oleson et al.

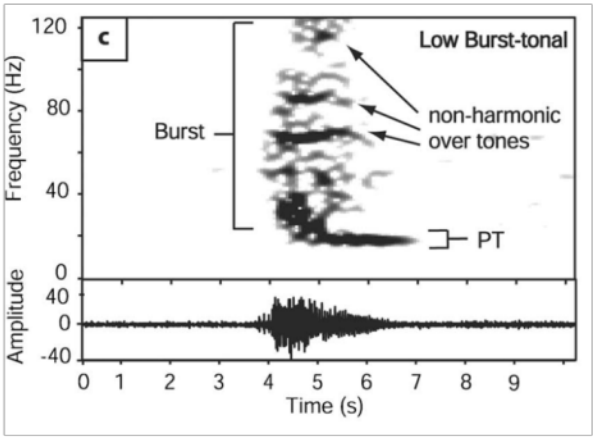
Unknown [baleen whale] calls at Guam N

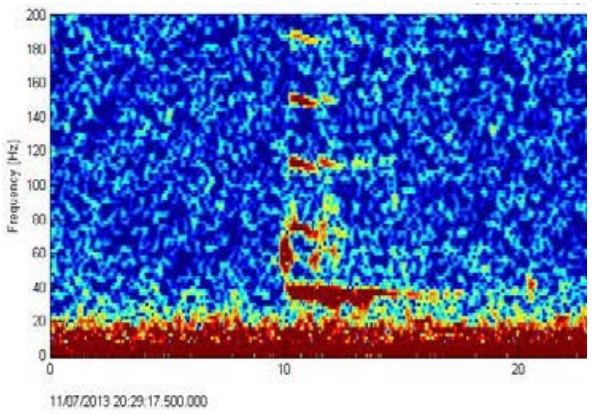
...Bryde's whale?









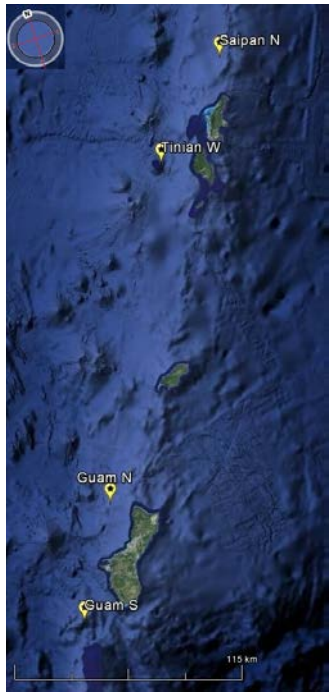


Unid call from HARP recording off Tinian, Nov 2013.

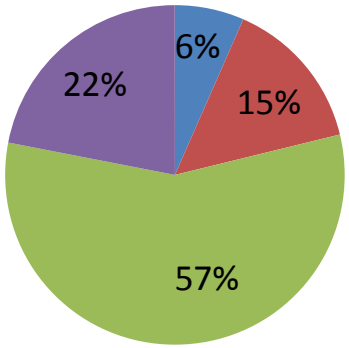
Bryde's whale call spectrograms from Oleson et al. 2003 (left), Heimlich et al. 2005 (center).

Dolphins

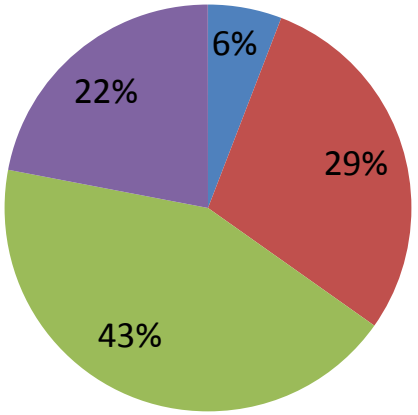
% of time present



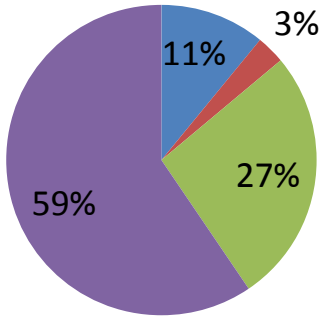
Tinian W **Dep 1: 4.5%** **Dep 2: 5.2%**



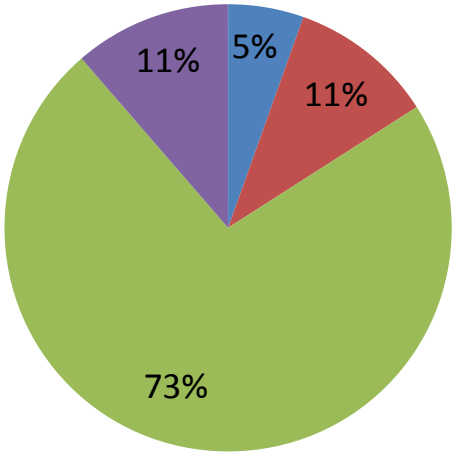
Saipan N **Dep 1: 8.8%** **Dep 2: 13.4%**



Guam S **Dep 1: 2.1%** **Dep 2: NR**



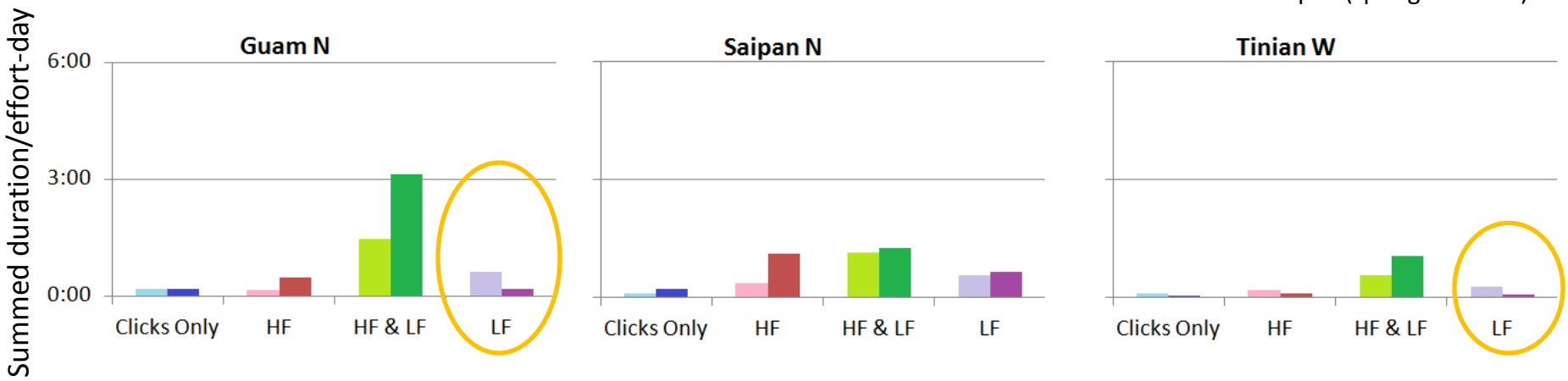
Guam N **Dep 1: 10.1%** **Dep 2: 16.6%**



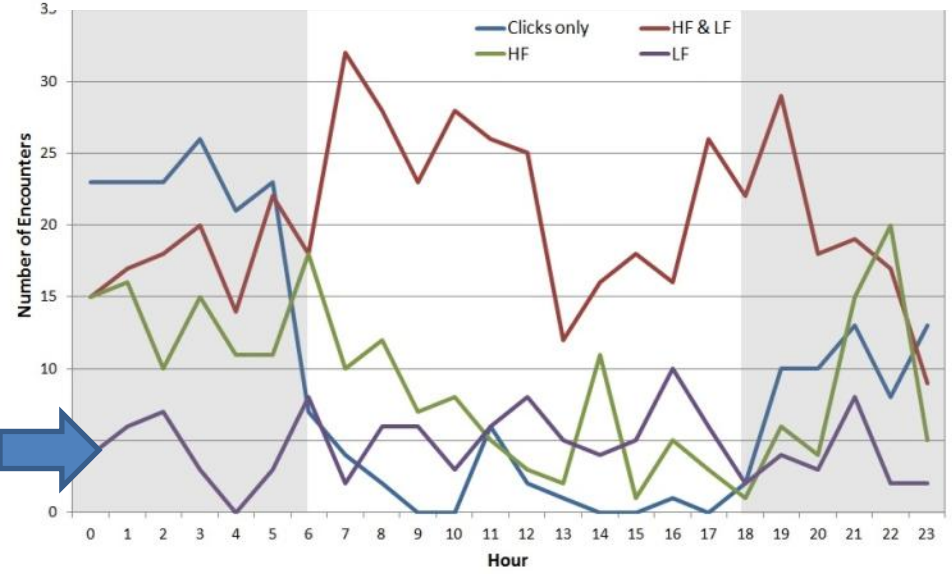
Poster in s1 by Hill et al.

Seasonal and Diel Pattern

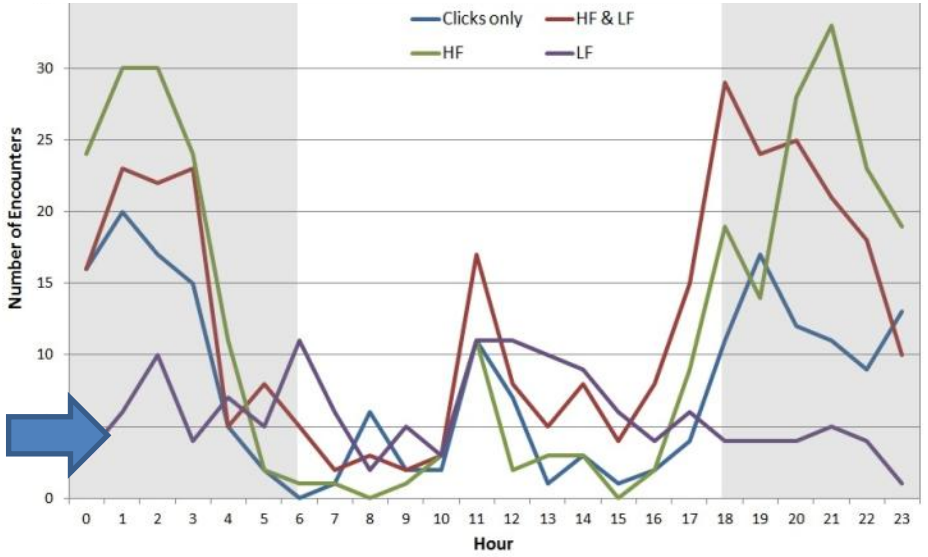
L= Dep. 1 (autumn-winter)
R = Dep. 2 (spring-summer)



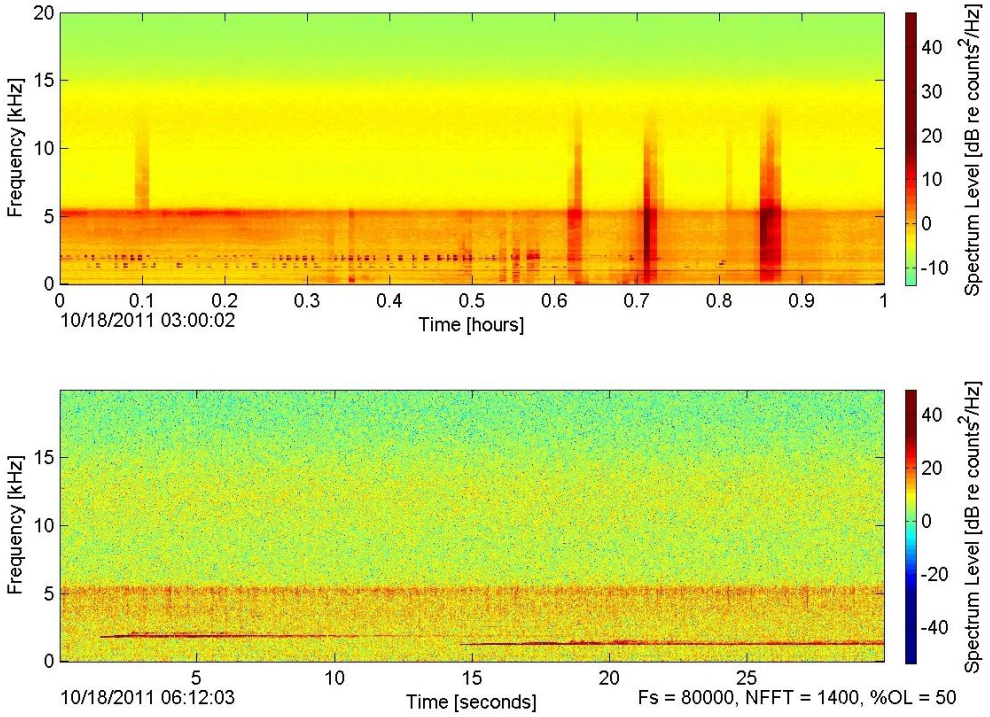
Guam N



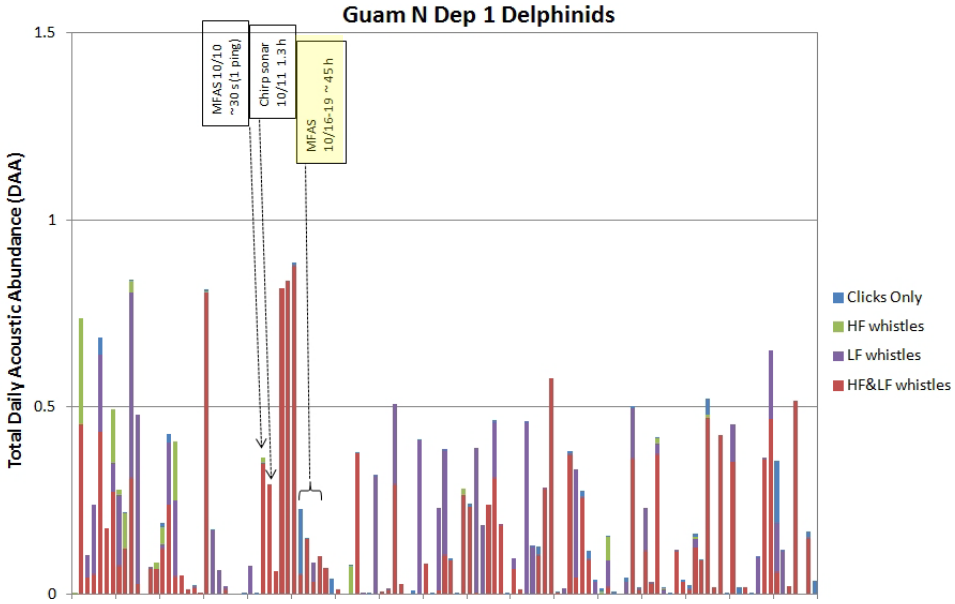
Saipan N

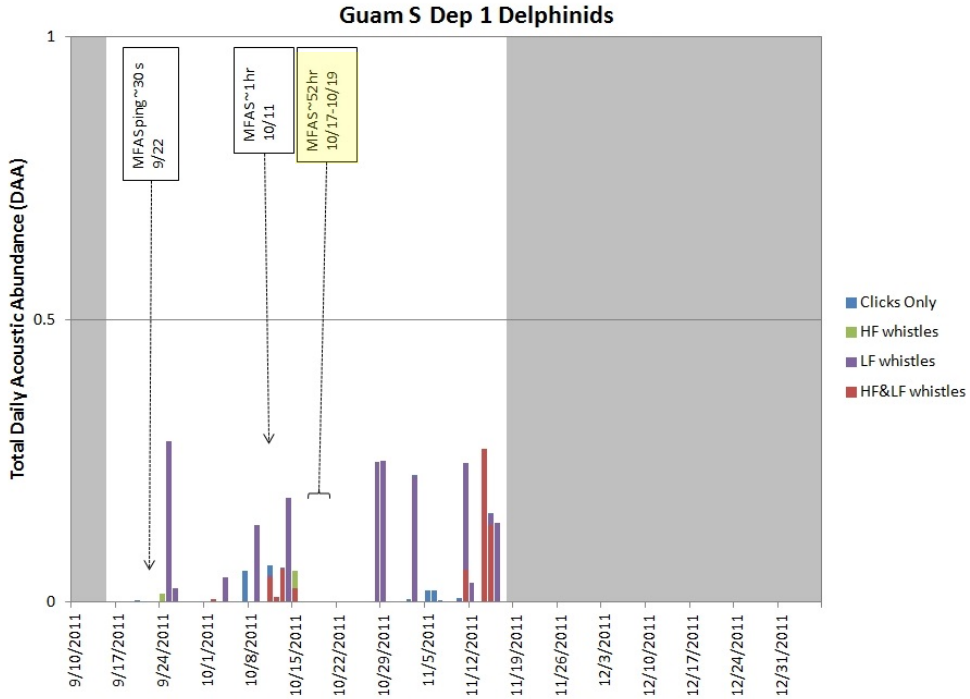


MFAS



Date	Guam N	Guam S	Saipan N
09/22/2011		0:00:30	
10/10/2011	0:00:30		
10/11/2011	1:18:30 (chirp)	1:06:30	
10/16/2011	0:01:00		
10/17/2011	4:42:00	4:42:00	
10/18/2011	17:06:30	24:00:00	
10/19/2011	23:36:30	23:48:30	
12/22/2011			9:54:30
07/02/2012	0:40:30		
08/28/2012			3:51:00
08/29/2012			6:11:30
08/30/2012			16:22:00
08/31/2012			24:00:00
09/01/2012			18:00:30
09/02/2012	0:00:30		21:00:00
09/03/2012			24:00:00
09/04/2012			24:00:00
09/05/2012			20:10:30
09/07/2012			0:00:30
09/08/2012			2:21:00
09/21/2012			0:00:30





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10/17/2011	4:42:00	4:42:00	
10/18/2011	17:06:30	24:00:00	
10/19/2011	23:36:30	23:48:30	
12/22/2011			9:54:30
07/02/2012	0:40:30		
08/28/2012			3:51:00
08/29/2012			6:11:30
08/30/2012			16:22:00
08/31/2012			24:00:00
09/01/2012			18:00:30
09/02/2012	0:00:30		21:00:00
09/03/2012			24:00:00
09/04/2012			24:00:00
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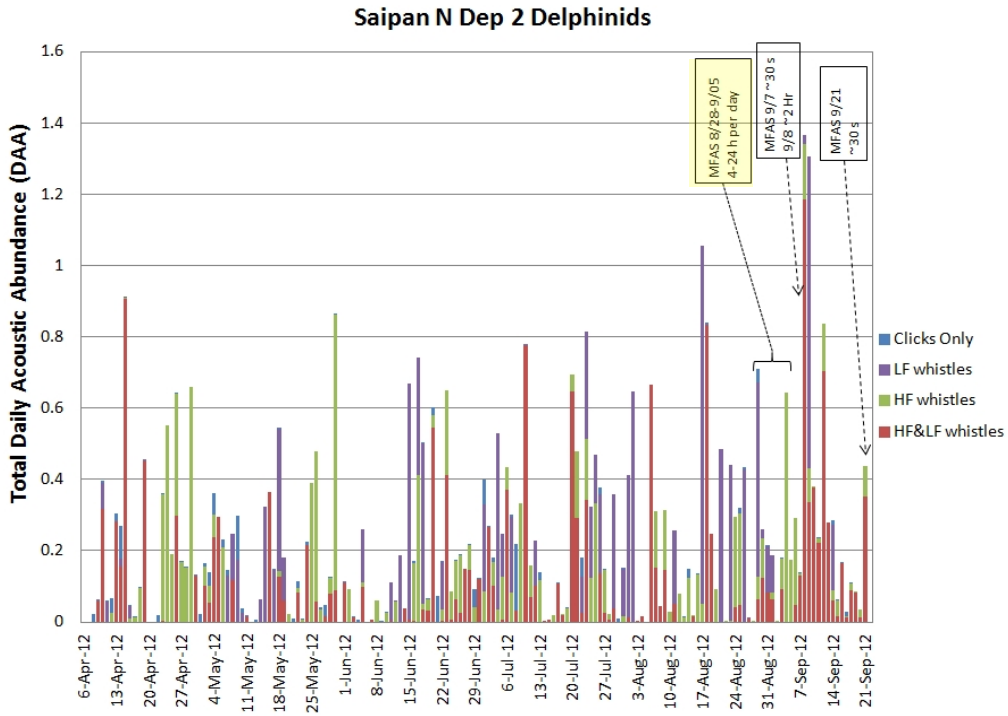
09/07/2012			0:00:30
09/08/2012			2:21:00
09/21/2012			0:00:30



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10/16/2011	0:01:00		
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10/19/2011	23:36:30	23:48:30	
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08/29/2012			6:11:30
08/30/2012			16:22:00
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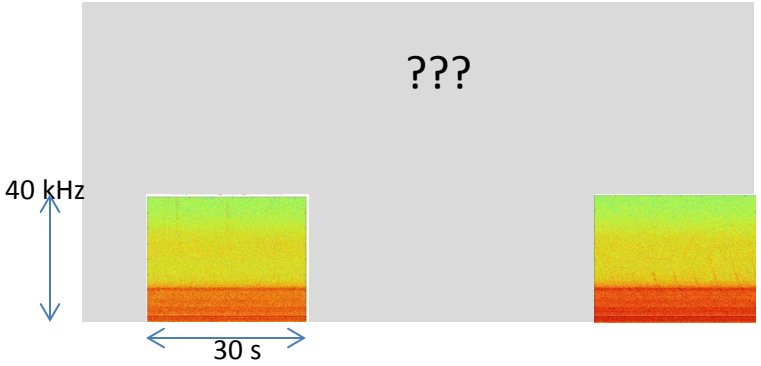
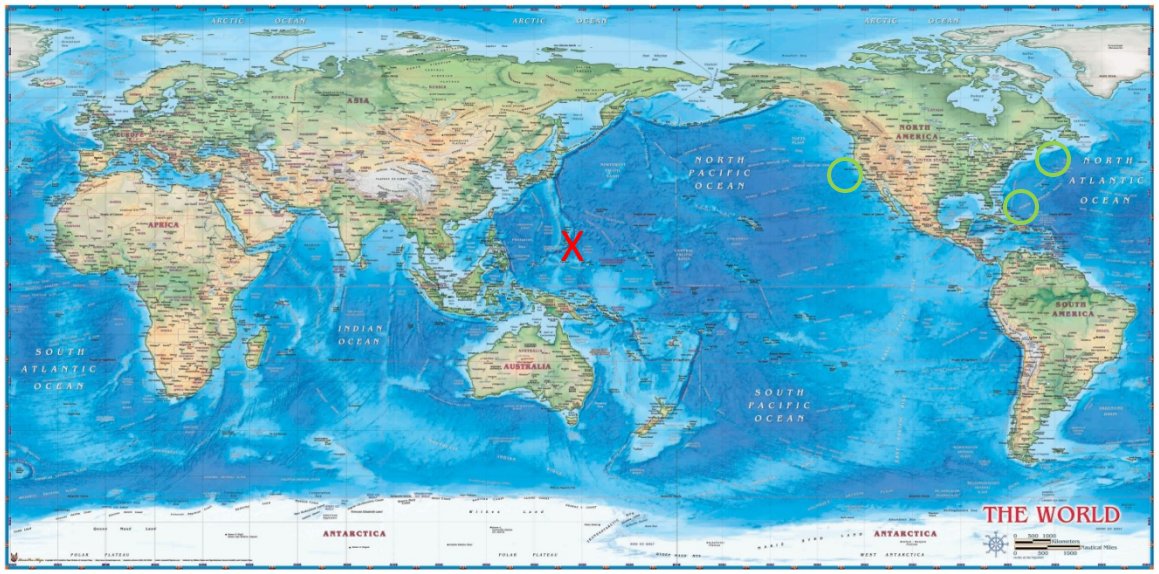
09/01/2012			18:00:30
09/02/2012	0:00:30		21:00:00
09/03/2012			24:00:00
09/04/2012			24:00:00
09/05/2012			20:10:30
09/07/2012			0:00:30
09/08/2012			2:21:00
09/21/2012			0:00:30

Caveats/Limitations:

- Recording bandwidth & duty cycle
- Gaps in seasonal coverage
- Automated detectors trained using recordings from other regions





Summary & Conclusions

- Long-term PAM useful for documenting spatial and temporal patterns in cetacean occurrence
- Continuing to build knowledge in the Guam/CNMI region
- More species-ID'ed recordings needed to train detectors and interpret archival acoustic data

Check Navy marine species monitoring website for full report

Thank you!