

# Considerations when applying classification models across recording platforms: A case study with Hawaiian false killer whales

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**SELENE FREGOSI**

JENNY TRICKEY, MEGAN WOOD, YVONNE BARKLEY\*, JENNIFER  
MCCULLOUGH, ANNE SIMONIS, ERIN OLESON

\*Stay tuned for more FKW classification from  
Yvonne at the end of this session!!

# Hawaiian false killer whales (*Pseudorca crassidens*)

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- High-priority species in the Pacific Islands Region (PIR)
- Conservation concern due to fishery interactions
- Behaviorally complex, difficult to study visually
- PAM is a valuable tool for studying their distribution and behavior
- Acoustic repertoire and acoustic behavior are not well known



Photo: Marie Hill, Permit #25754

# BANTER classification approach effective for FKW

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Bio-Acoustic event classifier (Rankin et al. 2017)

Uses all signal types (whistles, clicks, and burst pulses)

Established open-source pipeline:



Very effective for Hawaiian false killer whales (McCullough et al. 2021)

# Varied passive acoustic data collection platforms

## Towed array



Visually verified detections  
Reliable BANTER FKW classifier  
built with the *DCLDE 2022 dataset*

## Longline fishing gear



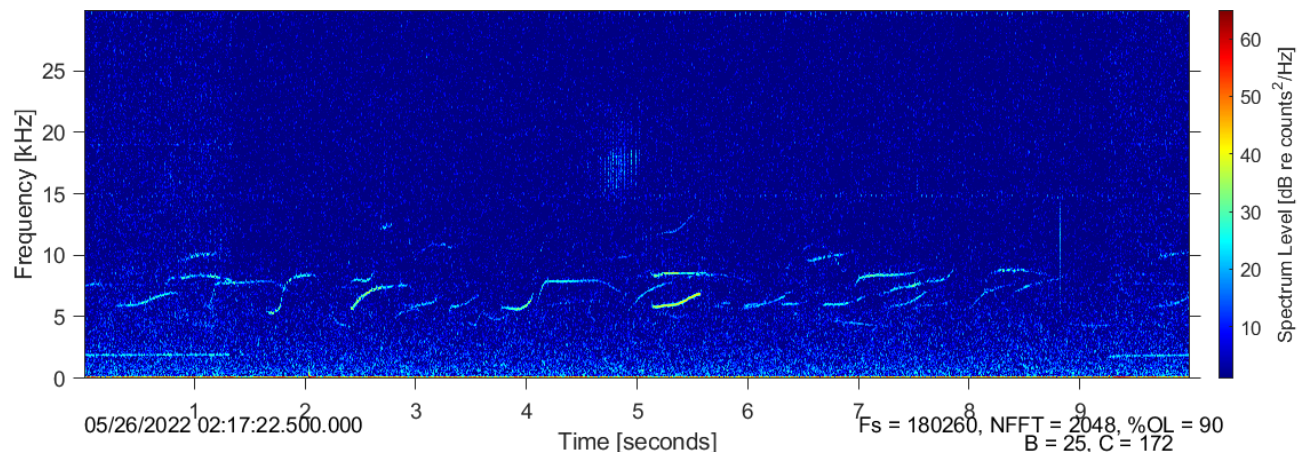
Collaboration with pelagic  
longline fishery  
Modified HARP - LLHARP  
Rare visual confirmation

## Glider



Fully autonomous - no  
visuals  
PMARXL recording  
system

Can we use our visually verified towed array model to find false killer whales in acoustic data collected by other platforms?



*Recording platform, location, season all known to have an effect on performance of detection and classification methods*

# Ground-truth data



## Towed array

HICEAS 2017/DCLDE 2022

Single-species events with  
visual verification



## Longline

38 fishing trips over 10 years

‘True’ Pc events identified by  
multiple trained analysts



## Glider

Two 8-week missions in 2022  
and 2023

‘True’ Pc events identified by  
multiple analysts

	UO Events	Pc Events	Total Events
Towed array	208	20	228
Longline	395	48	443
Glider	129	11	140
Total	732	79	811

# Methods

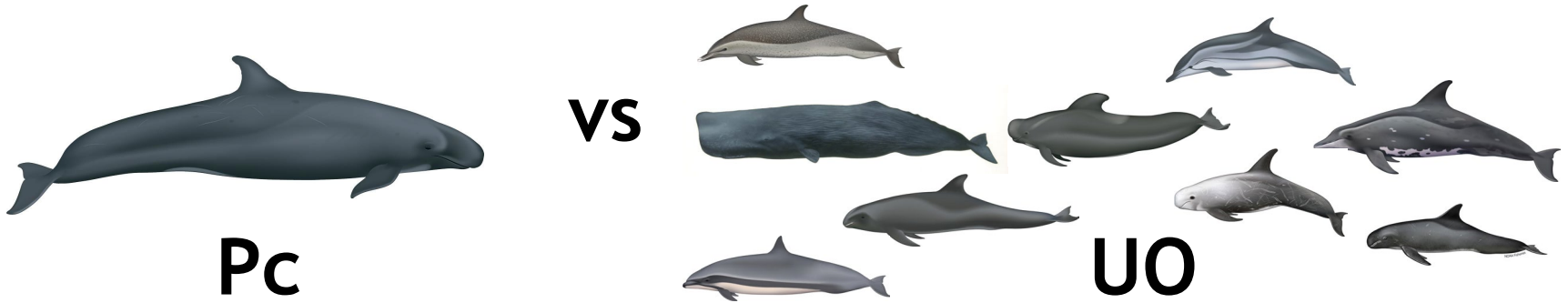
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# Methods

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- Trained individual BANTER models for each platform





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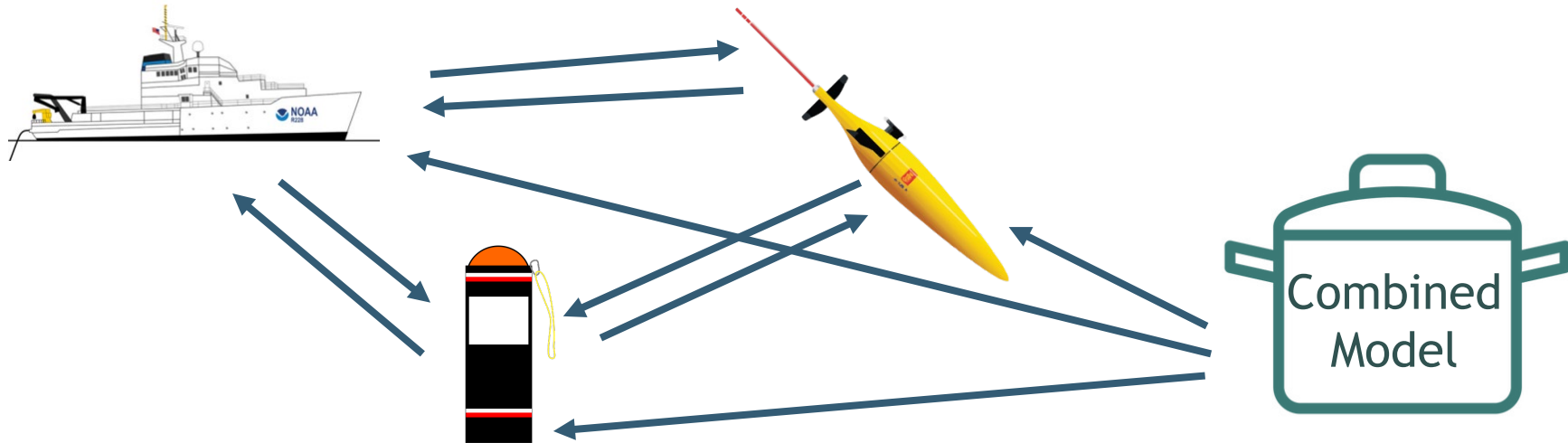
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- Ran suite of Pamguard detectors across all platforms
- Trained individual BANTER models for each platform
- Trained a combined BANTER model using data from ALL platforms







# Methods

- Ran suite of Panguard detectors across all platforms
- Trained individual BANTER models for each platform
- Trained a combined BANTER model using data from ALL platforms
- Used models trained on other platforms and the combined model to predict species and compared rates of misclassification



# Model performance results

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Percent correct				
Pc	100% (90-100)	98% (89-100)	90% (59-100)	96% (89-99)
UO	98% (96-99)	99% (97-99)	93% (87-97)	92% (90-94)
Overall	98% (97-99)	98% (97-99)	93% (87-97)	93% (91-94)

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# Cross-platform predictions

		<i>Predicted</i>							
		Towed array model		Longline model		Glider model		Combined model	
		<i>Pc</i>	<i>UO</i>	<i>Pc</i>	<i>UO</i>	<i>Pc</i>	<i>UO</i>	<i>Pc</i>	<i>UO</i>
<i>Original</i>	Towed array data	<i>Pc</i>	20	0					
		<i>UO</i>	4	204					
	Longline data	<i>Pc</i>		48	0				
		<i>UO</i>		6	389				
	Glider data	<i>Pc</i>				10	1		
		<i>UO</i>				9	120		

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<i>Original</i>	Towed array data <i>Pc</i>	20	0	19	1	19	1		
	Towed array data <i>UO</i>	4	204	32	176	50	158		
	Longline data <i>Pc</i>	23	25	48	0	48	0		
	Longline data <i>UO</i>	0	395	6	389	23	372		
	Glider data <i>Pc</i>	10	1	10	1	10	1		
	Glider data <i>UO</i>	0	129	6	123	9	120		



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<i>Original</i>	Towed array data <i>Pc</i>	20	0	19	1	19	1	20	0
	Towed array data <i>UO</i>	4	204	32	176	50	158	44	164
	Longline data <i>Pc</i>	23	25	48	0	48	0	47	1
	Longline data <i>UO</i>	0	395	6	389	23	372	6	389
	Glider data <i>Pc</i>	10	1	10	1	10	1	10	1
	Glider data <i>UO</i>	0	129	6	123	9	120	5	124

# Conclusions

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- BANTER works well for FKW on all platforms
- Glider had smallest sample size and worst performance
- Towed array model had the lowest false positive rate for all platforms but increased misses on longline data
- Whistles are very important
  - Top predictor in all 3 models
  - Removing whistles decreases accuracy 45-72%

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- Whistles are very important
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# Future directions

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- Pre-processing to remove glider self-noise that gets detected as whistles
- Define criteria required to allow for prediction (Minimum number of detections? Event duration? No noise?)
- What prediction threshold is most appropriate for our questions?

The background image shows a large white NOAA research vessel with yellow cranes and various antennas on its deck, sailing on a blue sea under a cloudy sky. In the foreground, a dark whale is breaching the water, creating a splash. The text 'Acknowledgements' is overlaid on the left side of the image.

# Acknowledgements

NOAA Fisheries PIFSC

NOAA UxSOC

Longline vessel captains, crew,  
and fisheries observers

*Photo: Corey Sheredy/NOAA Fisheries*

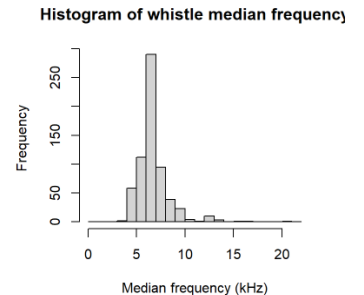
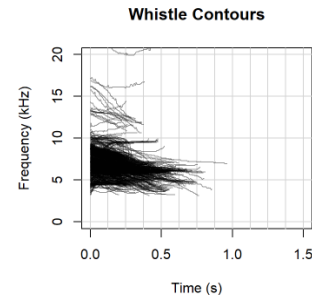
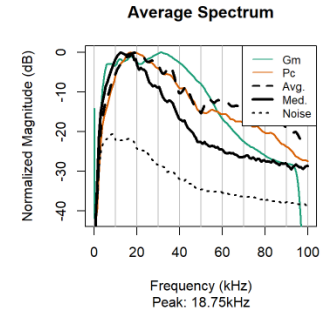
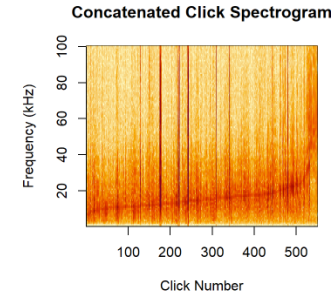
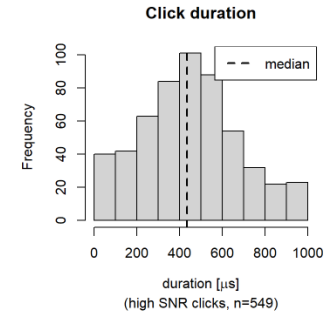
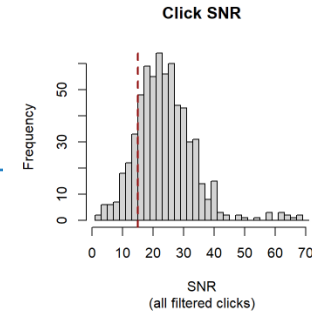
[selene.fregosi@noaa.gov](mailto:selene.fregosi@noaa.gov)

# Standardized event reporting

- Tool for bulk manual analysis
- Use R packages *PAMPal* and *PamBinaries* and PamguardMatlab tools
- Open-source R code available at [github.com/sfregosi/cross-platform-comparison](https://github.com/sfregosi/cross-platform-comparison)

parameter	value
Median begin frequency [kHz]	7.32
Median end frequency [kHz]	6.05
Median mean frequency [kHz] (SD)	6.57 (0.50)
Median duration [s]	0.333
Median frequency range [kHz] (min-max)	1.66 (5.96)

parameter	value
Median Peak Frequency [kHz]	14.8
Median 3dB Center Frequency [kHz]	14.5
Median 10dB Center Frequency [kHz]	13.9
Median 3dB Bandwidth [kHz] (lower-upper)	1.15 (13.8 - 15.1)
Median 10dB Bandwidth [kHz] (lower-upper)	6.3 (10.5 - 17.4)
Median duration [μs] (25-75 percentile)	436 (286 - 1000)



# Platform recording specs

	Towed array	Longline	Glider
Sampling rate	250 kHz	200 kHz	180 kHz
High-pass filter	4 kHz	2 kHz	2 kHz
Hydrophone sensitivity	-158 dB re 1V/ $\mu$ Pa	-170 dB re 1V/ $\mu$ Pa	-164.5 dB re 1V/ $\mu$ Pa
Frequency resolution	73.24 Hz	97.66 Hz	88.02 Hz
time resolution	13.65 ms	10.24 ms	11.36 ms
WM Threshold	7 dB	7 dB	7 dB
Click Threshold	14 dB	16 dB	16 dB



# Model performance notes

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## Towed array

- Most important predictors: WMD.Pc, WMD.UO, Cep.Pc, prop.WMD
- Excluding WMD.Pc decrease accuracy by up to 63%
- 4 UOs misclassified as Pc with scores 0.52, 0.53, 0.58, 0.64

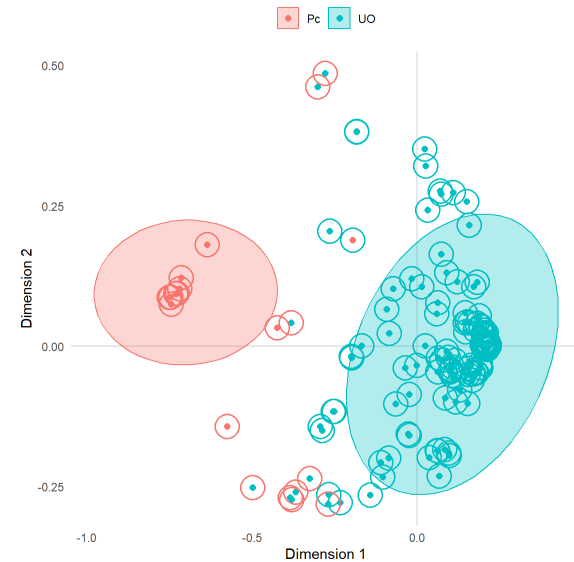
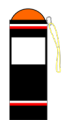
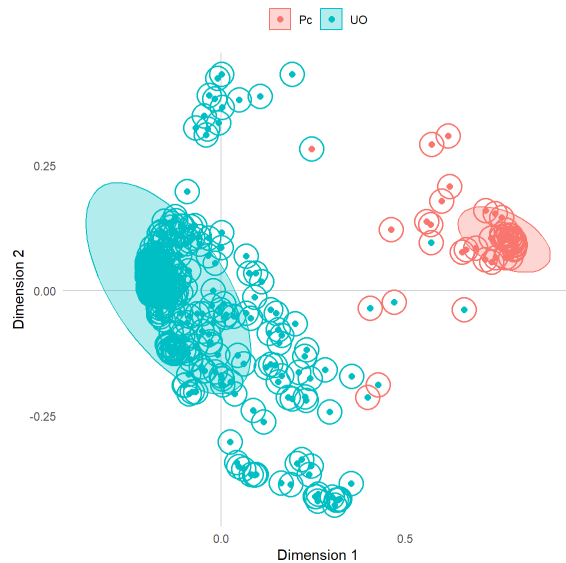
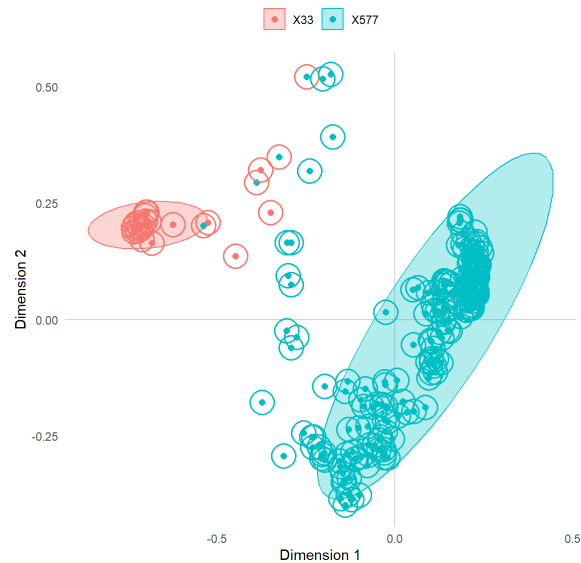
## Longline

- Most important detectors: WMD, Click\_Detector 3, Click Detector 2
- Excluding WMD decrease accuracy by up to 72%
- 6 UOs misclassified as Pc with scores 0.54, 0.56, 0.50, 0.74, 0.58, 0.75 (only 2 with 60% threshold)
- 1 Pc misclassified as UO with score 0.46

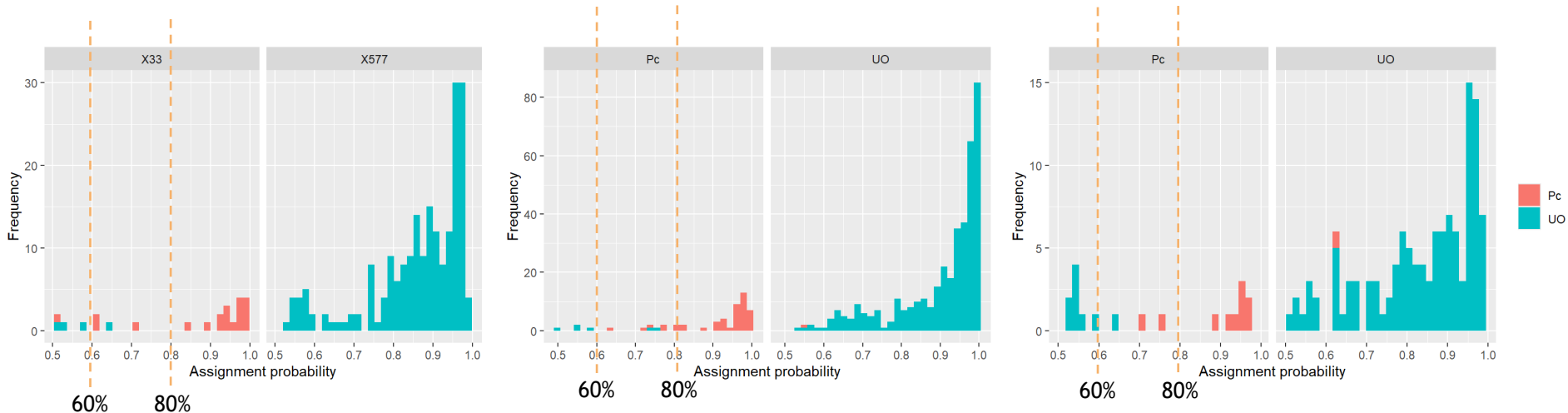
## Glider

- Most important predictors: WMD, CD2, CD1
- Excluding WMD decreases accuracy by 44%
- 9 UOs misclassified as Pc with scores 0.52 to 0.65 (only 1 misclass if used 60% threshold)
- 1Pc misclassified as UO, score 0.37

# Proximity plots



# Prediction probability plots



# Cross-platform predictions

		<i>Predicted</i>							
		Towed array model		Longline model		Glider model		Combined model	
		<i>Pc</i>	<i>UO</i>	<i>Pc</i>	<i>UO</i>	<i>Pc</i>	<i>UO</i>	<i>Pc</i>	<i>UO</i>
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