

Surveys of endangered toothed whales using acoustic gliders

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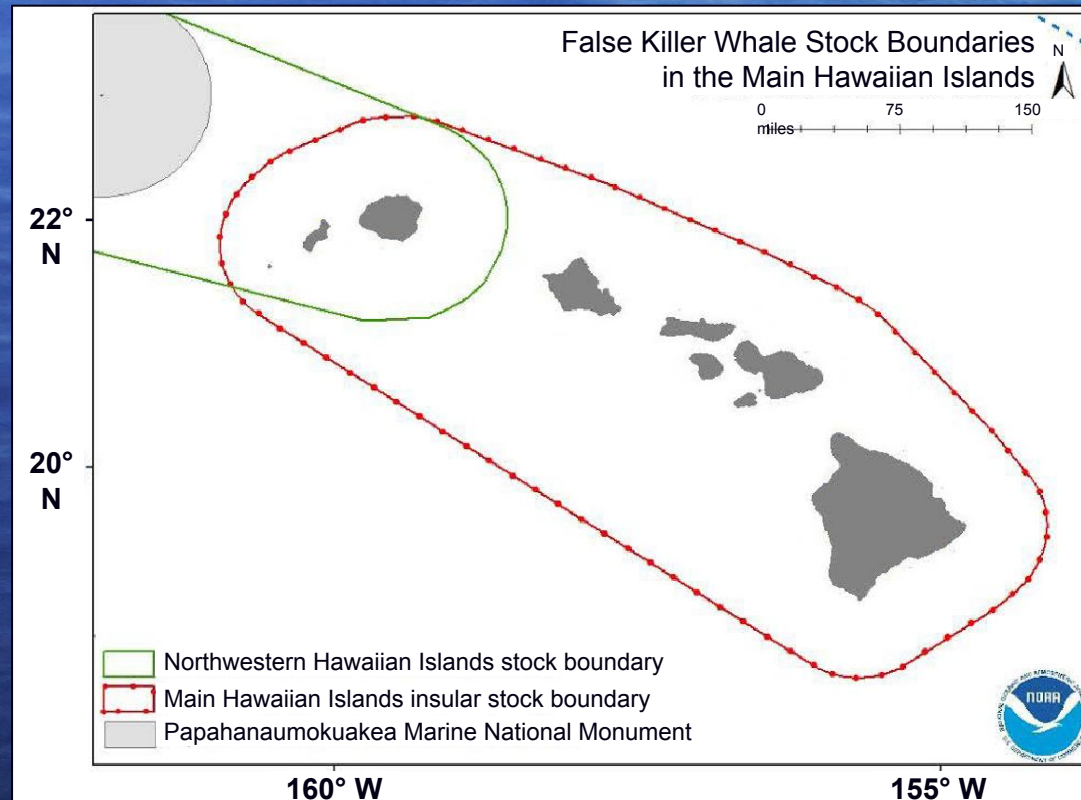


False Killer Whales in Hawai'i

Medium-sized odontocete (toothed small whale/large dolphin)

Main Hawaiian Islands population:

- island-associated habitat - live relatively near the coast
 - > distinct from pelagic population



Jim Cotton

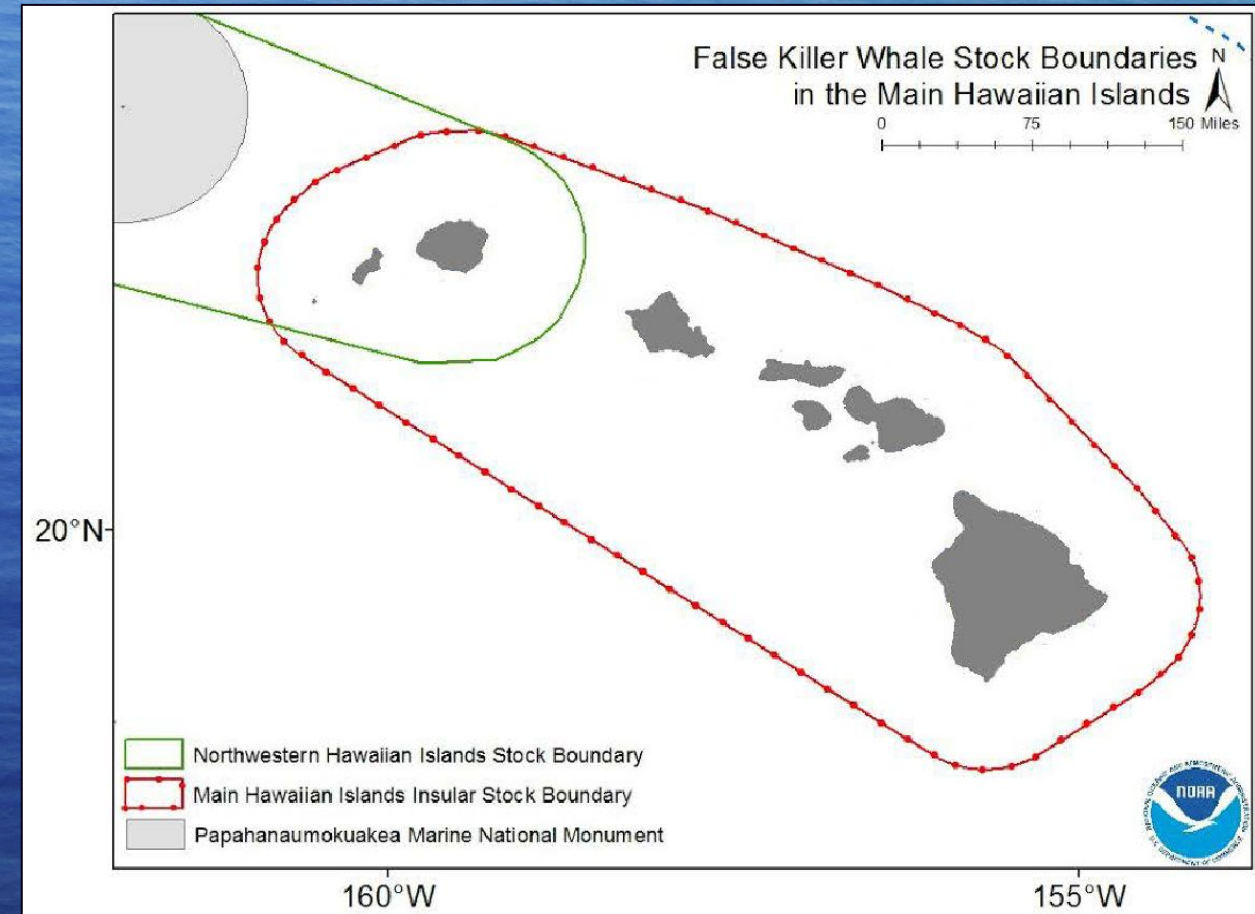
False Killer Whales in Main Hawai'ian Islands

MHI population:

- very small: <200 individuals
- declining 1%-3% per year (NOAA 2023)
- “depleted” (Marine Mammal Protection Act)
- “endangered” (Endangered Species Act)

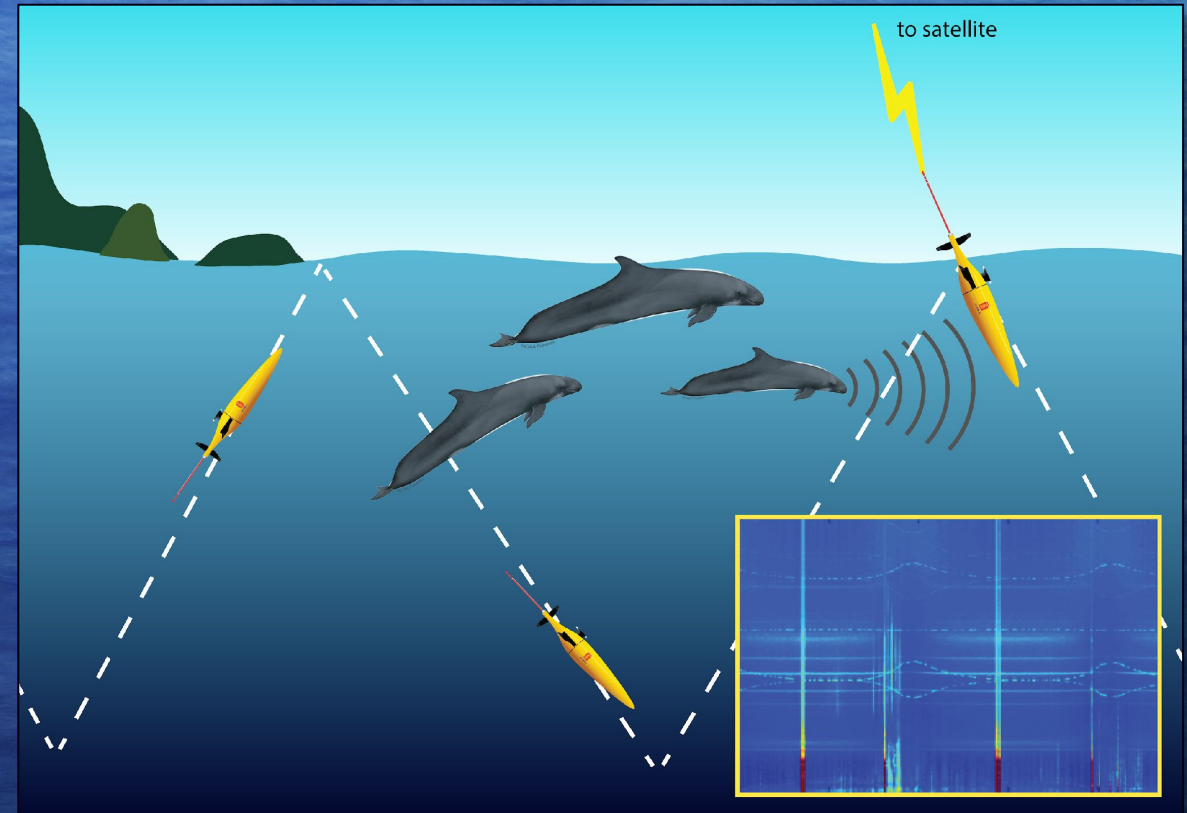
Threats to MHI population:

- Longline fishery bycatch
 - > whales take bait or fish off lines and get hooked
- Fisheries competition for prey
- Small population size leading to inbreeding



Passive acoustics for surveying false killer whales

- Odontocetes are highly vocal
- Communication whistles and echolocation clicks travel many kilometers
- Passive acoustic monitoring (PAM) allows...
 - > detection at night and in poor weather
 - > long-duration monitoring
 - > reduced vessel cost and fuel use
 - > broad spatial coverage



Glider acoustics

Seaglider

- dives to 1000 m
- runs on batteries for 3 months
- travels up to 1800 km
- piloted from shore via satellite
- moves slowly □ very quiet □ good for acoustics

Acoustics:

- hydrophone mounted on glider
 - > HiTech HTI-92-WB model
- acoustic recorder captures sound up to 100 kHz
 - > PMAR (APL-UW) and WISPR (EOS, Inc.) models
- data (~4 TB) obtained after glider recovery



Acoustic analysis

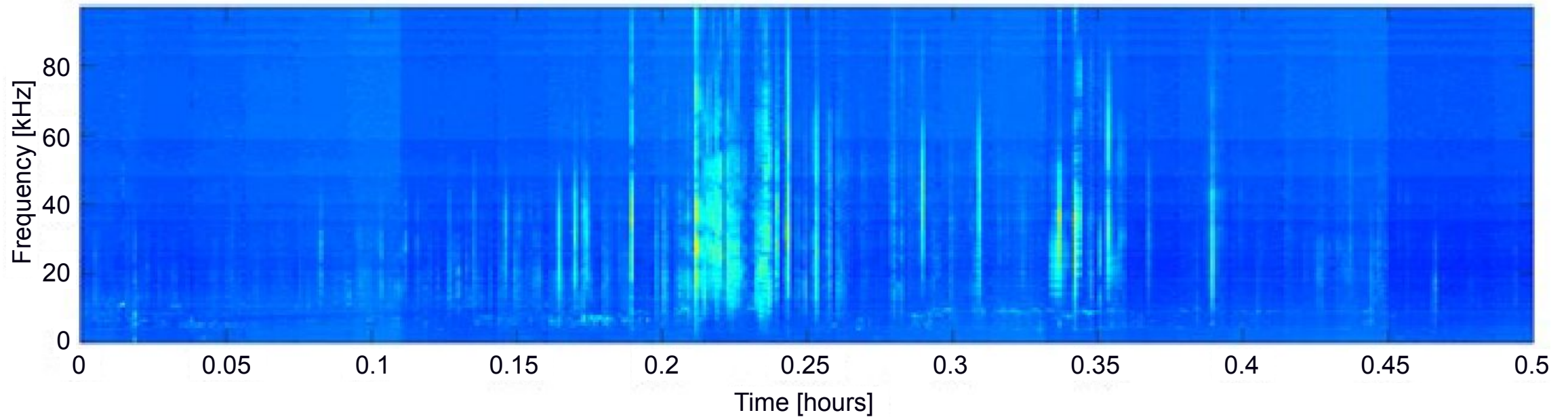
Combined automated and manual analysis approach to identify target species from species-specific vocalizations

- Used several software packages for detection and classification
 - > high diversity of click, whistle, and complex sounds
- Existing detectors and classifiers developed using other passive acoustic datasets were modified as required for use on Seaglider datasets
 - > Template detectors for stereotyped frequency contours in Ishmael (Mellinger et al. 2018)
 - > Energy or template-based detection in PAMGuard (Gillespie et al. 2009)
 - > Ensemble random forest classification using BANTER (Rankin et al. 2017, McCullough et al. 2021)
 - > Custom routines designed for beaked whales (Soldevilla et al. 2008, Baumann-Pickering et al. 2013)

Analysis for false killer whale events

Preliminary analysis: coarse time scale to find whole FKW encounters

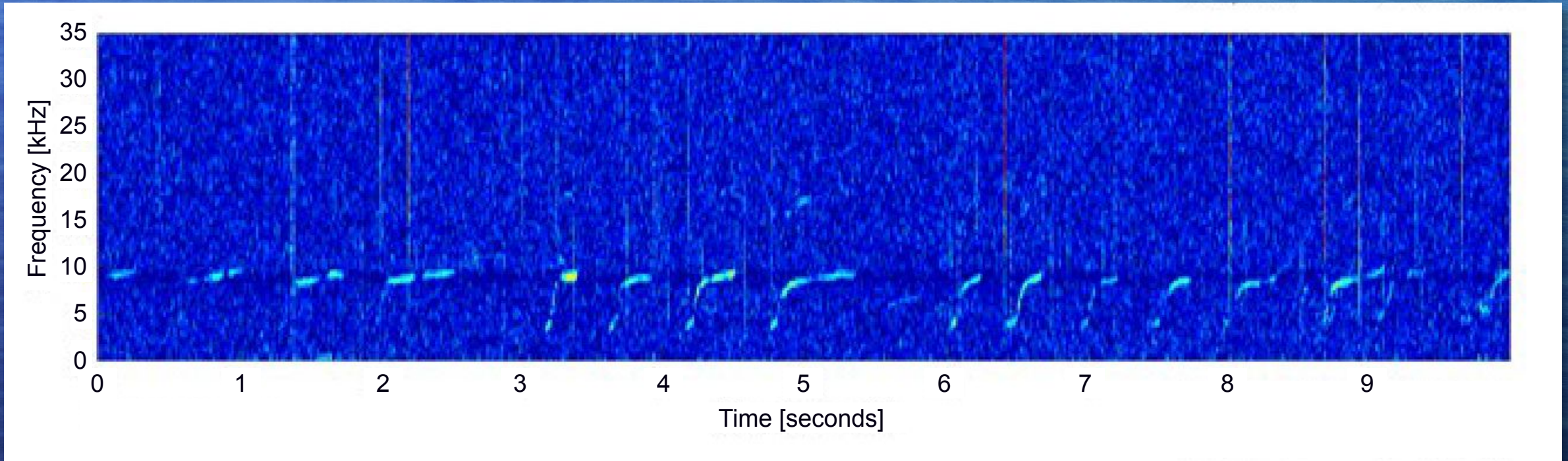
False killer whale encounter



Analysis for false killer whale events

Secondary analysis: fine time scale showing individual whistles and clicks

False killer whale whistles



Surveys

Three surveys:

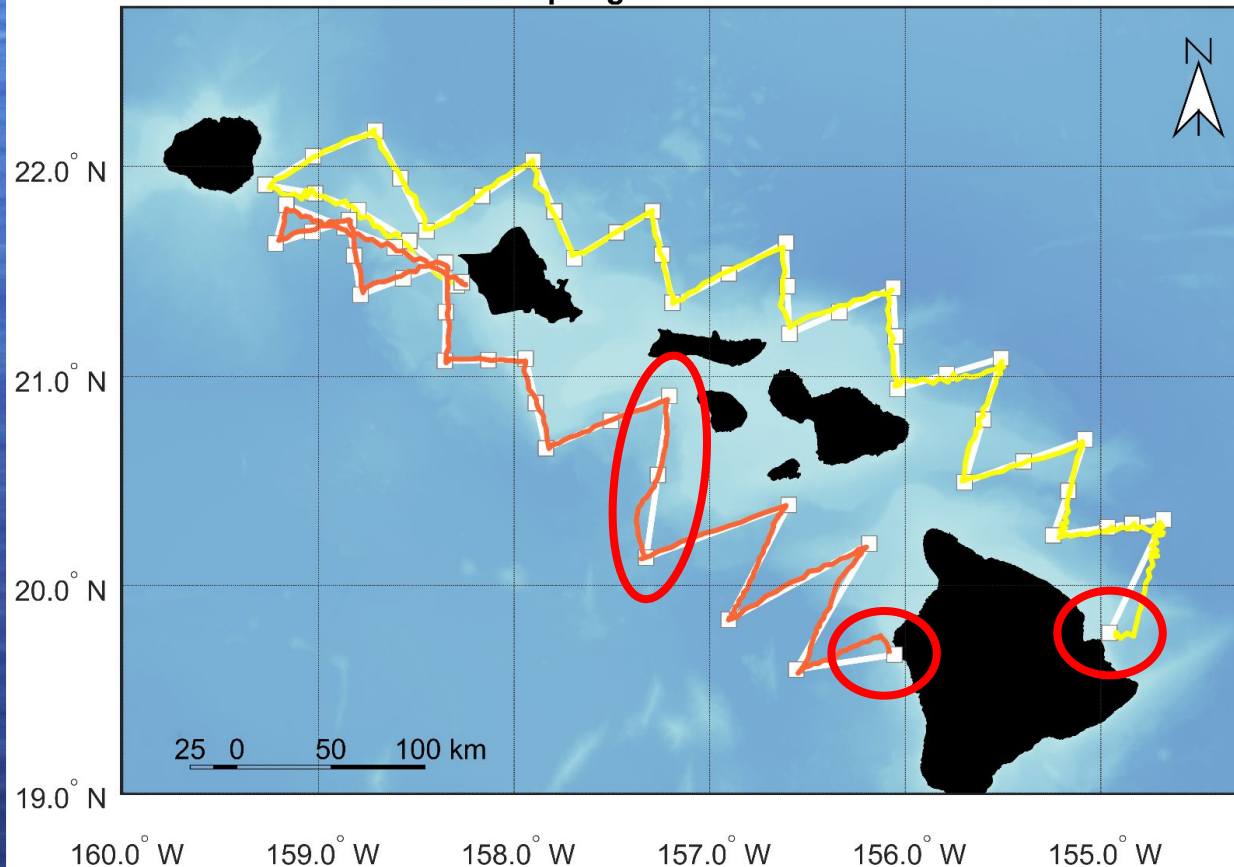
- April-June 2022, two gliders
- April-June 2023, two gliders
- January-April 2026, five gliders

Target species (these vary by year):

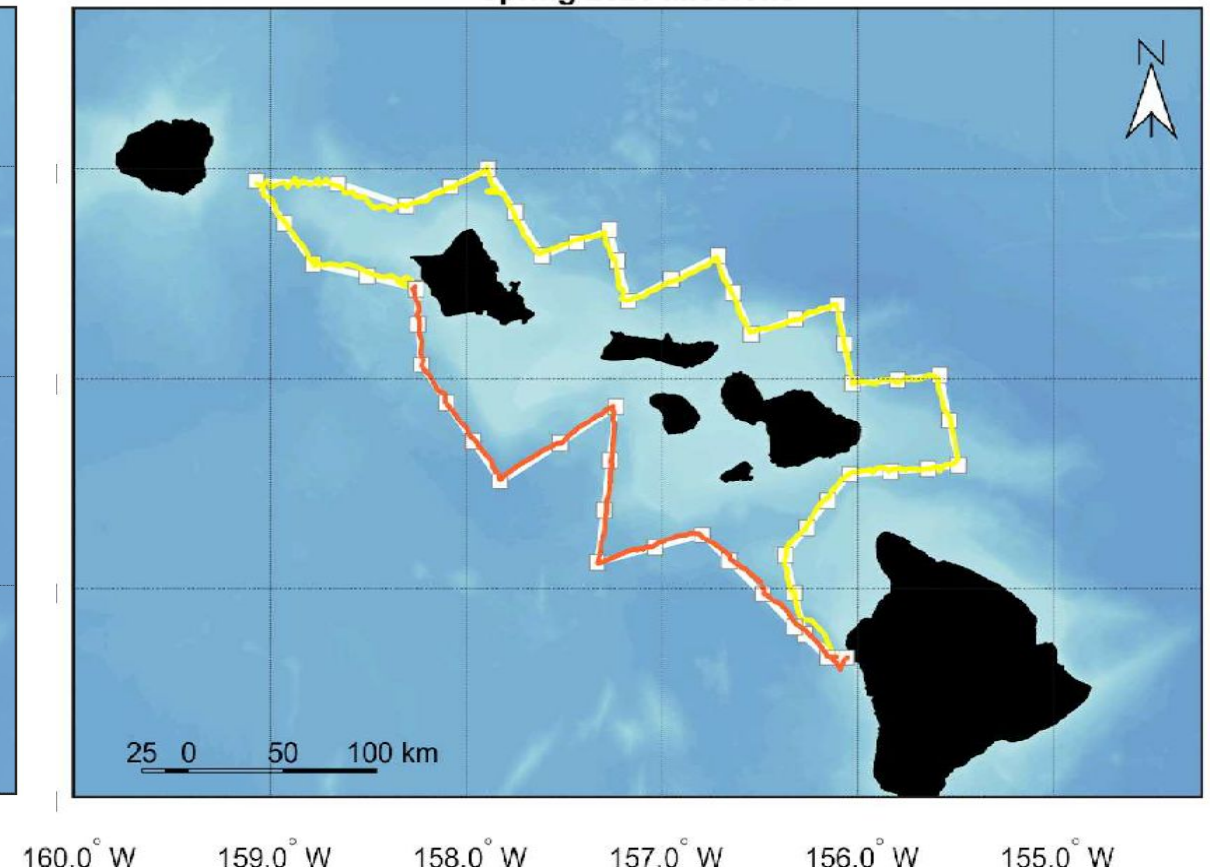
- false killer whales (*Pseudorca crassidens*)
- beaked whales
 - > Blainville's beaked whales (*Mesoplodon densirostris*, “Md”)
 - > Cross Seamount beaked whale (“BWC”)
- sperm whales (*Physeter macrocephalus*)

2022 and 2023 surveys: ability to follow tracks

Spring 2022 Missions

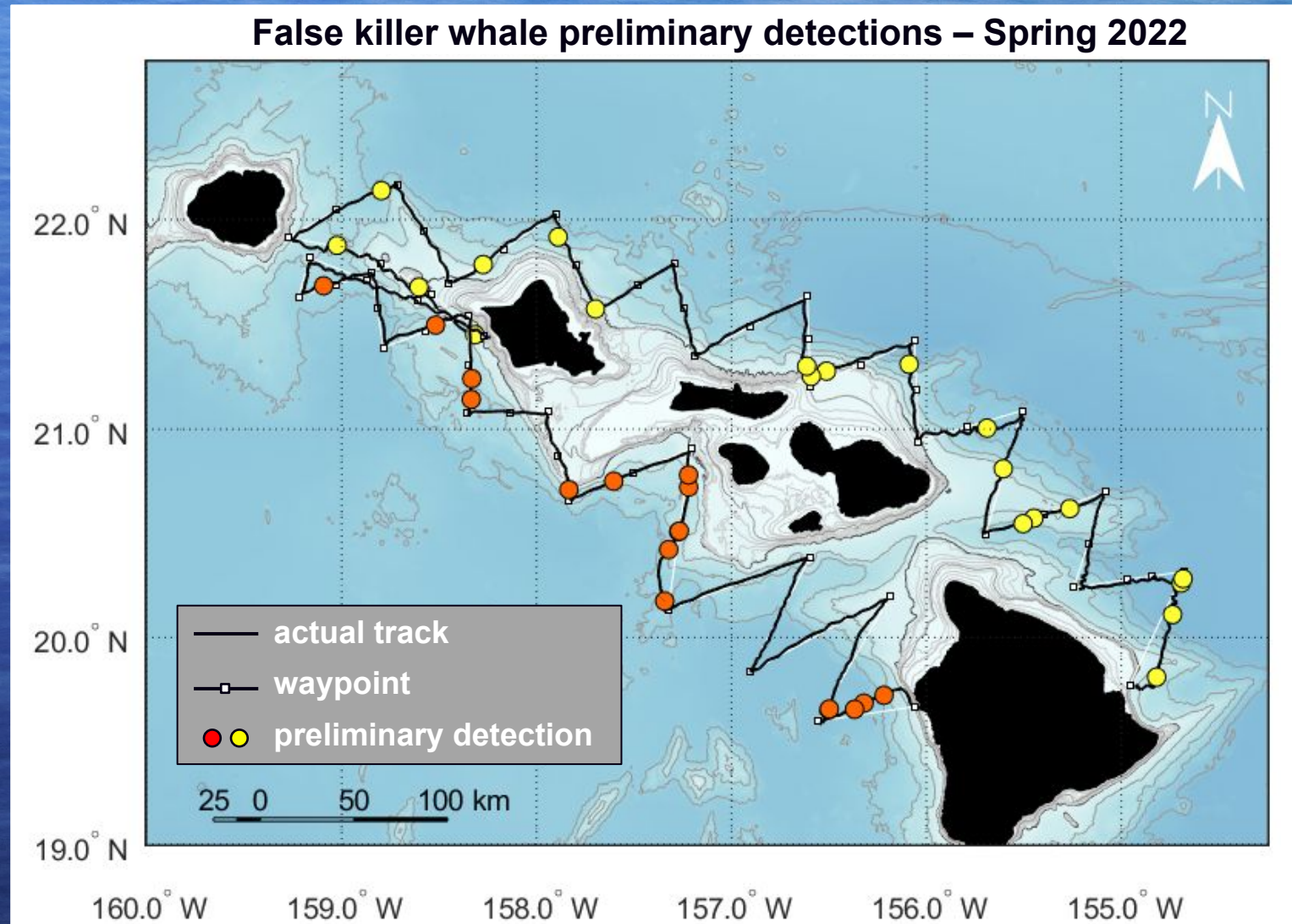


Spring 2023 Missions

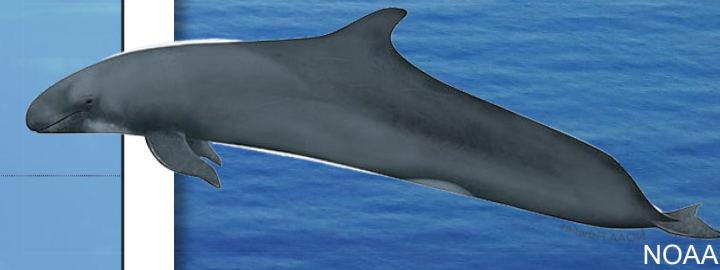
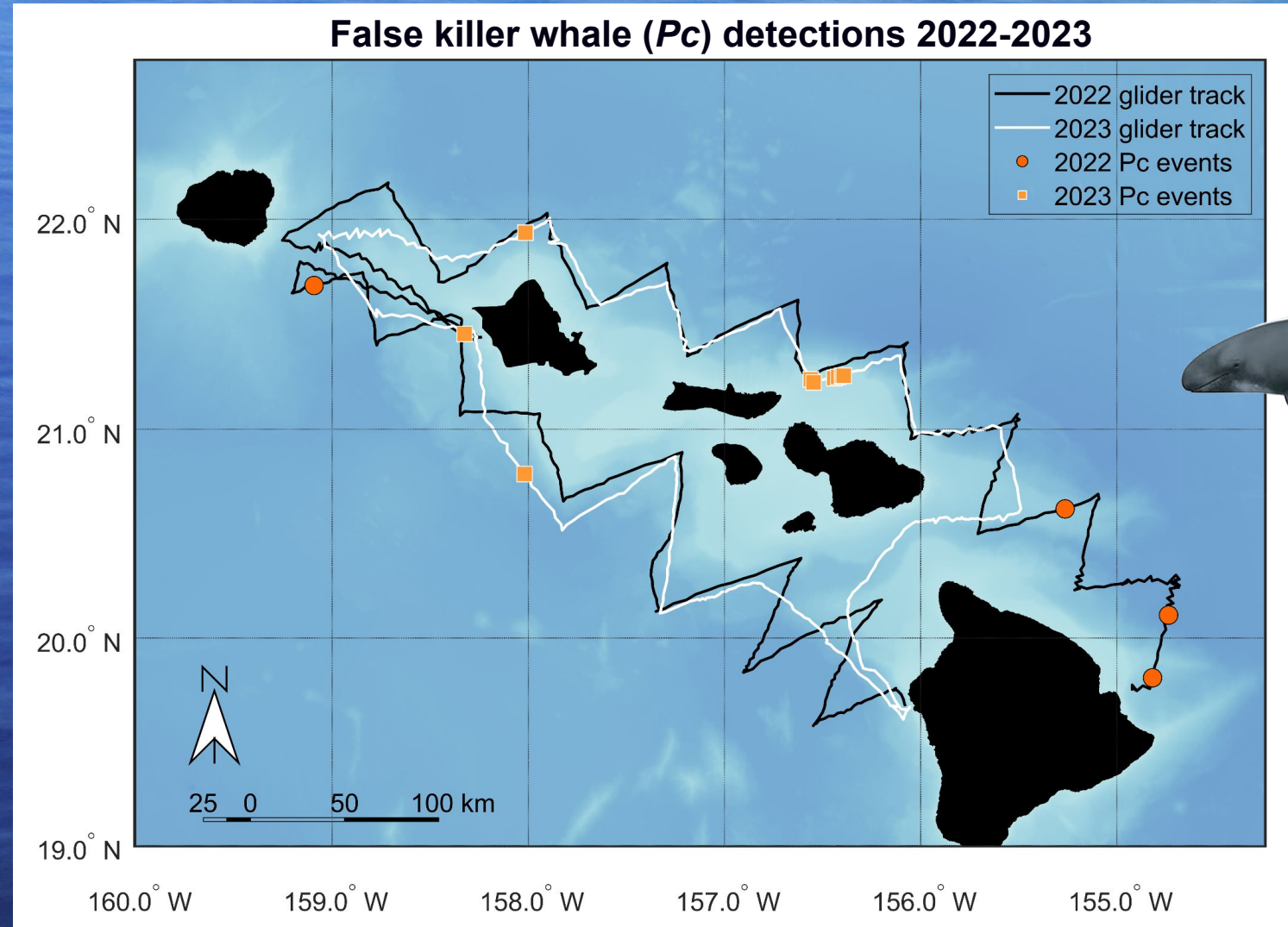


- planned track
- waypoint
- actual tracks

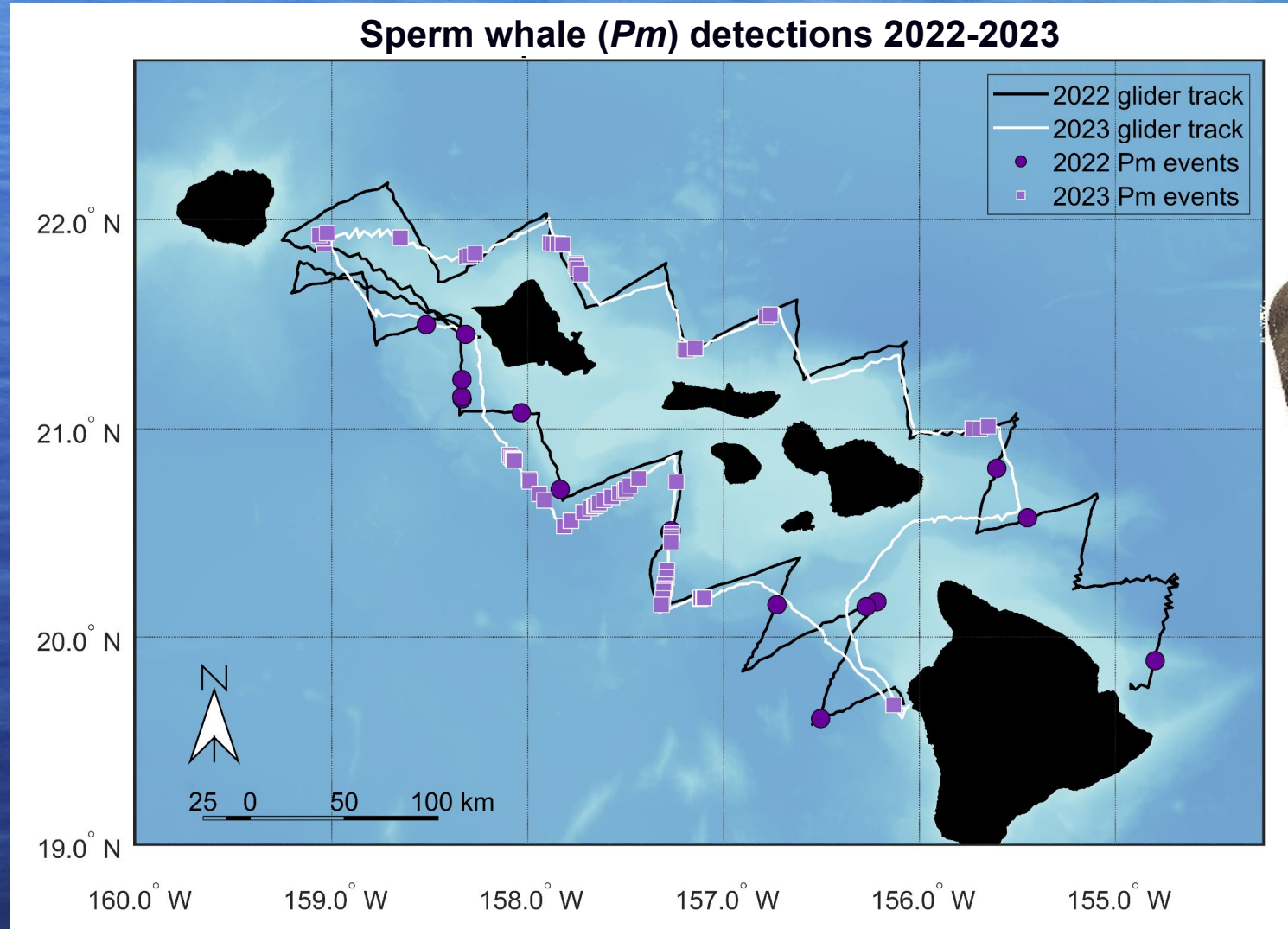
2022 survey: false killer whale preliminary detections



2022, 2023 surveys: false killer whale (*Pc*) verified detections

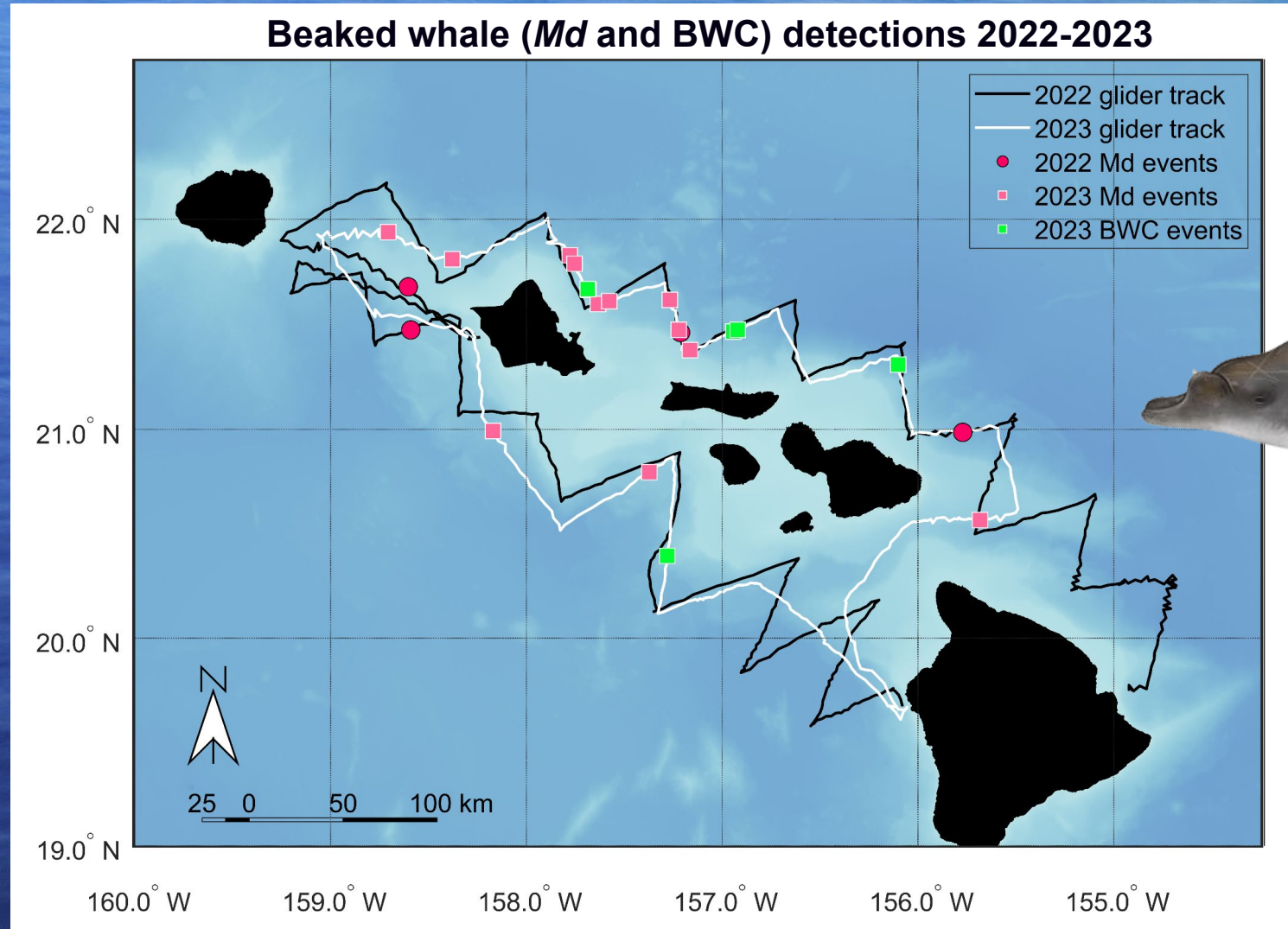


Spring 2023 survey: sperm whale (*Pm*) verified detections



P. Folkens

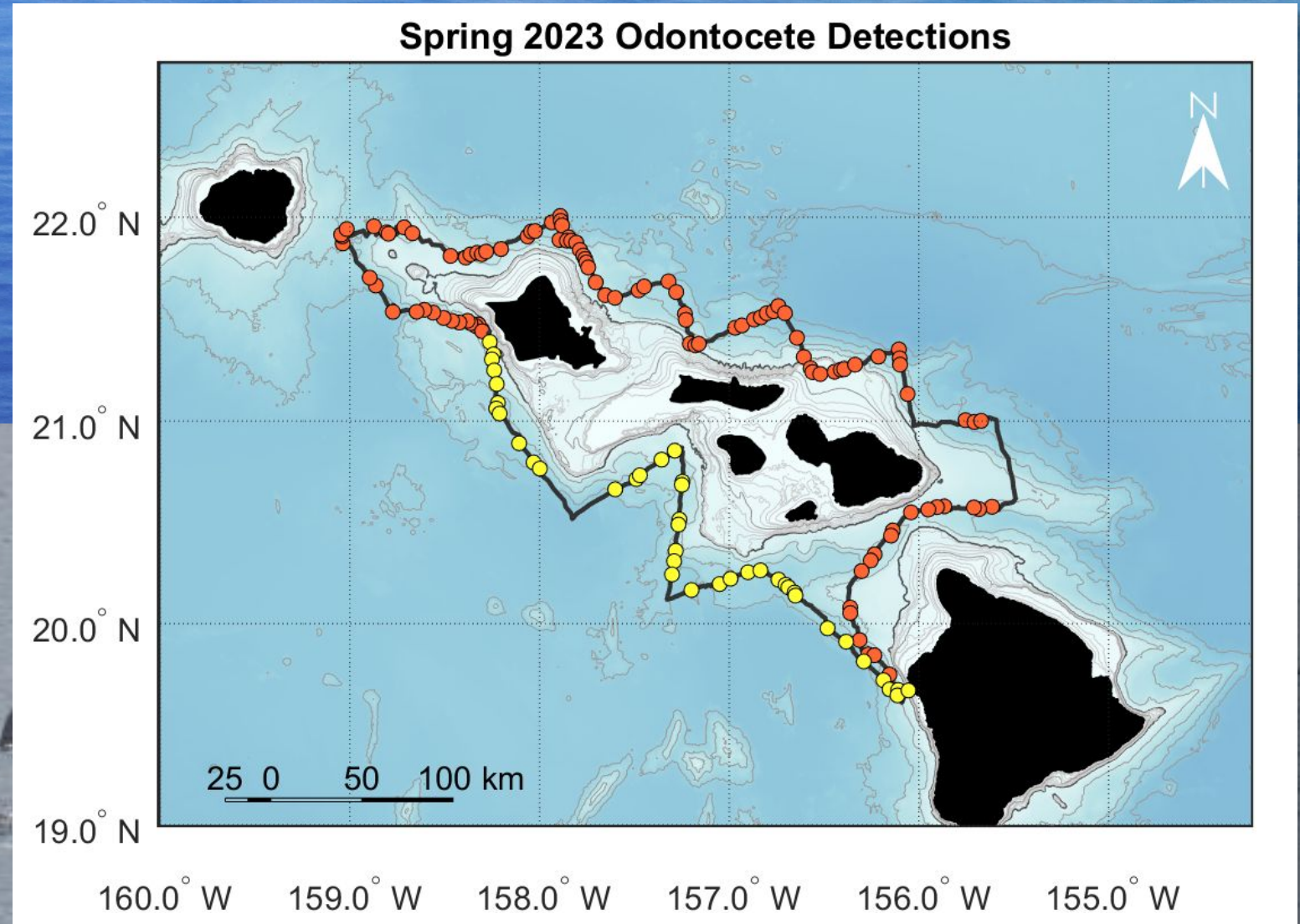
Spring 2023 survey: beaked whale verified detections



Spring 2023 survey: all odontocete detections

Includes

- false killer whales
- sperm whales
- beaked whales
- several dolphin species

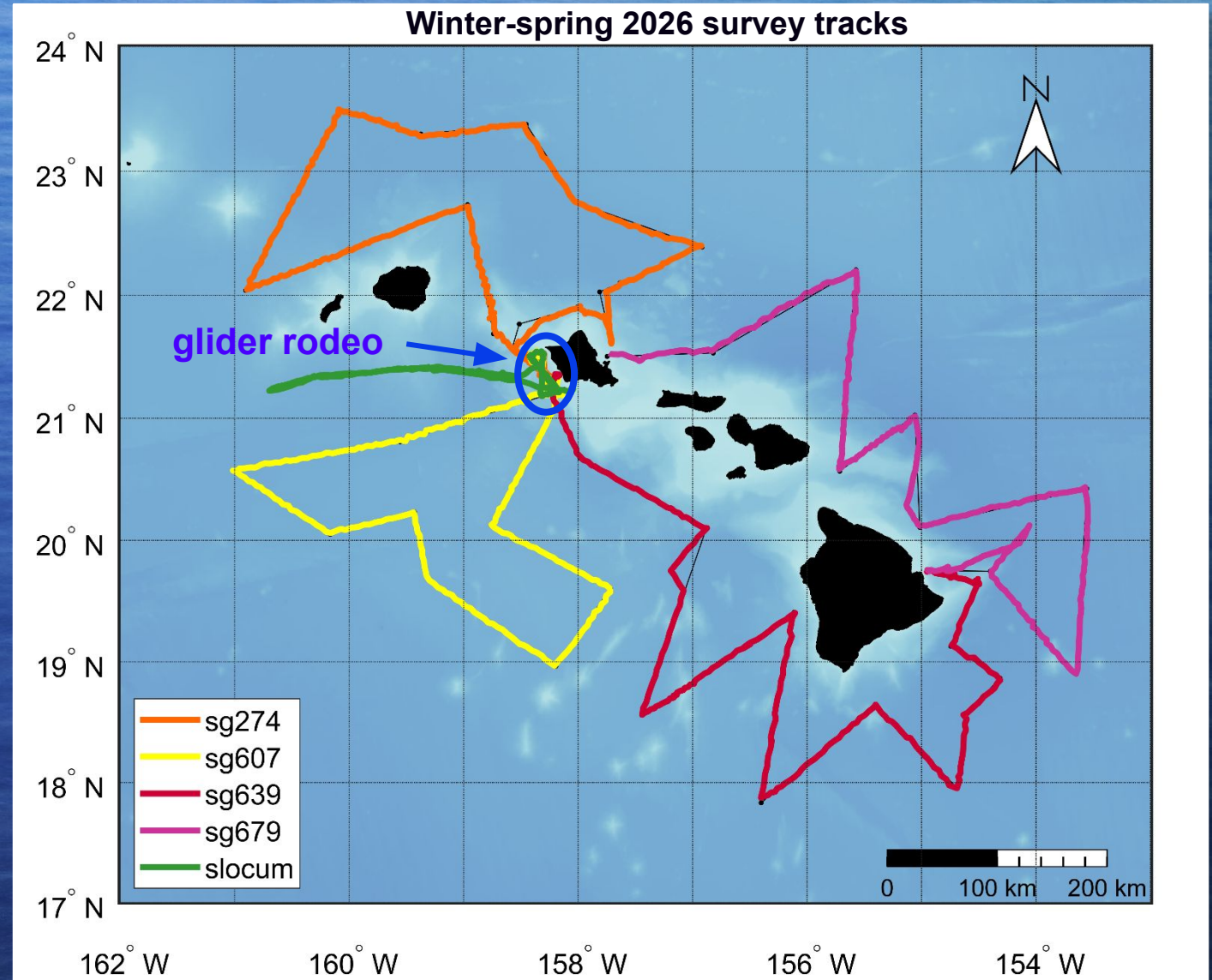


Summary of detections

Species	2022 Events	2023 Events	Total Events	Duration (hours)
Sperm whales	17	66	83	95
False killer whales	4	9	13	17.7
Blainville's beaked whales	4	13	17	4
Cross Seamount beaked whale	0	5	5	1.6
Unidentified odontocete	108	161	269	242

Winter-spring 2026 survey

- This finished earlier this year
 - > late January to late April
 - > data analysis is ongoing
- Five gliders (four Seaglidors, one Slocum)
- Much larger area coverage
- At the beginning, had a “glider rodeo” with 11 gliders in the same area for two weeks
 - > want to compare performance



Real-time detection

Idea: detect desired species on glider, alert people on shore in near-real time

- can send out a vessel for biopsy, group size & social association study, behavior, etc.

Difficulties

limited power on glider (~1 watt)

limited data transmission (10 kb)

limited space on glider

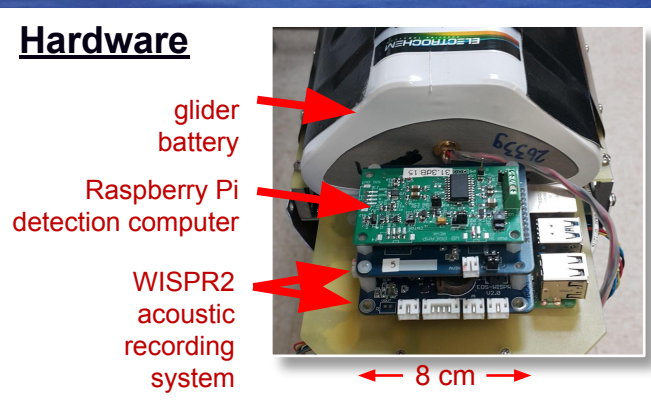
Solutions

use low-power “ERMA” detector (Klinck & Mellinger 2012)

send small “detection report” for human verification

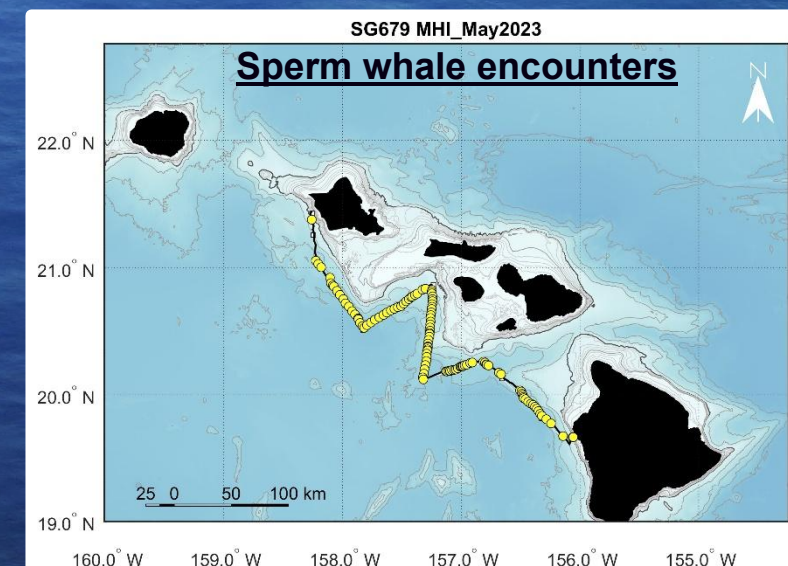
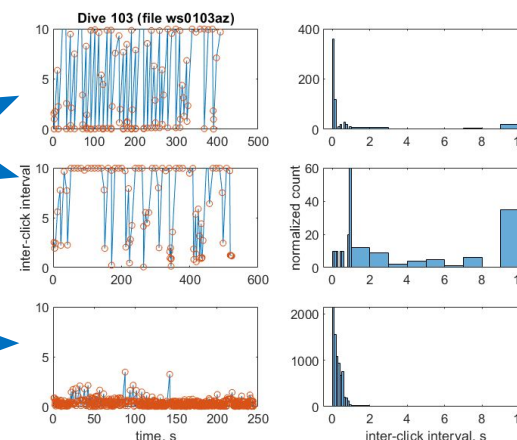
use small 2”x2”x3” system: WISPR & Raspberry Pi

Hardware



Detection reports

wrong:
false
detection
ns
correct:
sperm
whales



Conclusions

Gliders as survey platforms

- Effective – they cover the desired tracklines
- Inexpensive, relative to ship-based surveys
 - > they give you different types of data

Species detections

- found false killer whales, beaked whales (2 species), sperm whales, other odontocetes
- working on statistical methods for density estimation for slow-moving platforms

Real-time odontocete detection system

- basic operation worked – low power, found desired species
- needs refinement

Technology transition to NOAA

- going well – NOAA has own gliders, techs trained in using them, analyzing data

Acknowledgements

Thanks to...

- The many captains and crews of vessels that went on deployment and recovery cruises
- The many engineers, technicians, etc. who helped prepare and pilot gliders and analyze data
- Funding agencies



Inflation Reduction Act

