

Beaked whale foraging behavior before, during, and after sonar exposure on a Navy test range

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Cuvier's beaked whale response to sonar

DeRuiter et al.
2013

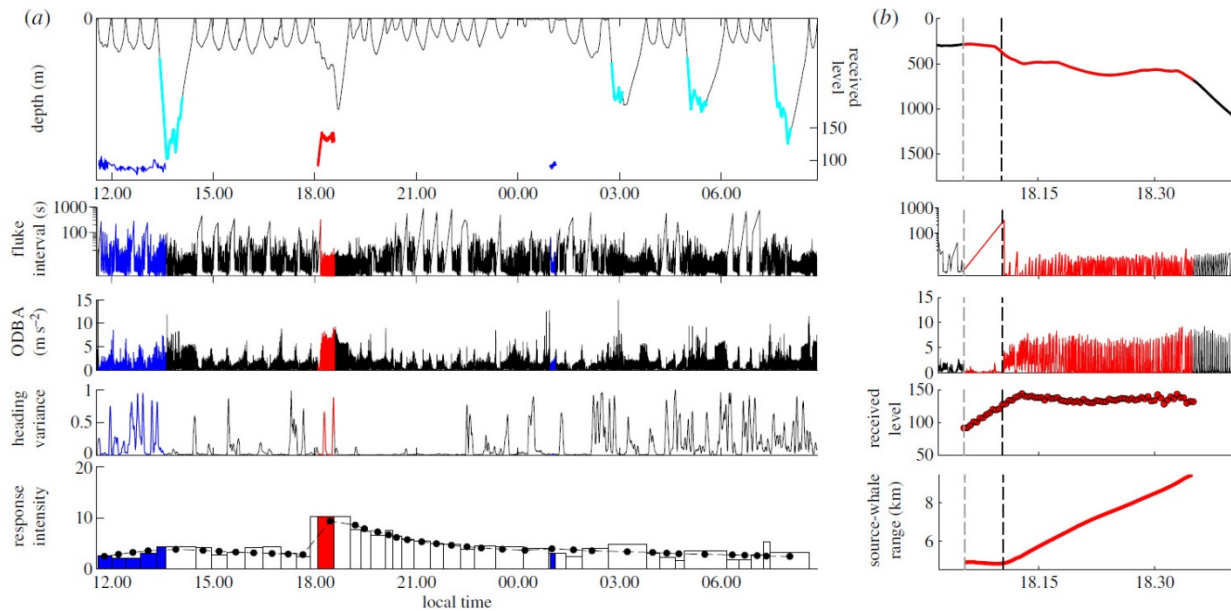


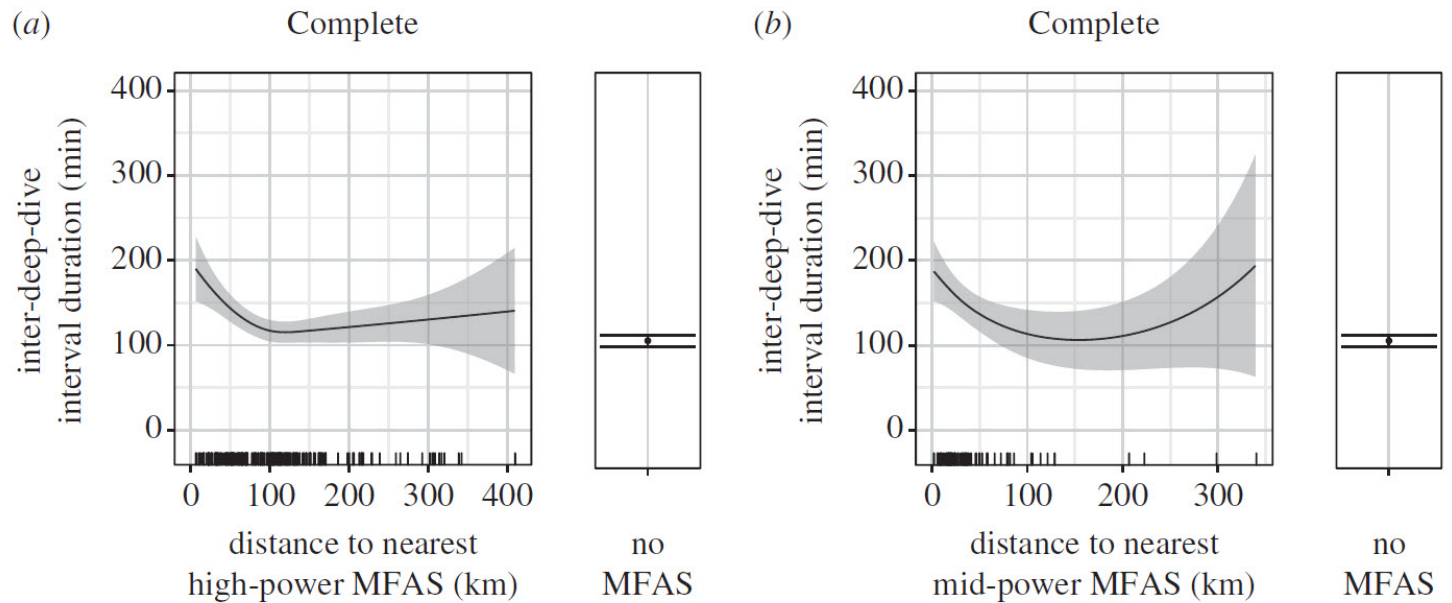
Figure 2. DTAG data from the *Ziphius* tagged in 2011, which underwent controlled exposure to simulated MFA sonar sounds and incidental exposure to naval MFA sonar. Figure layout and colour- and symbol-coding are the same as figure 1, but with blue traces for incidental exposure periods.

CRC-Zc-007: 2011



Cuvier's beaked whale response to sonar

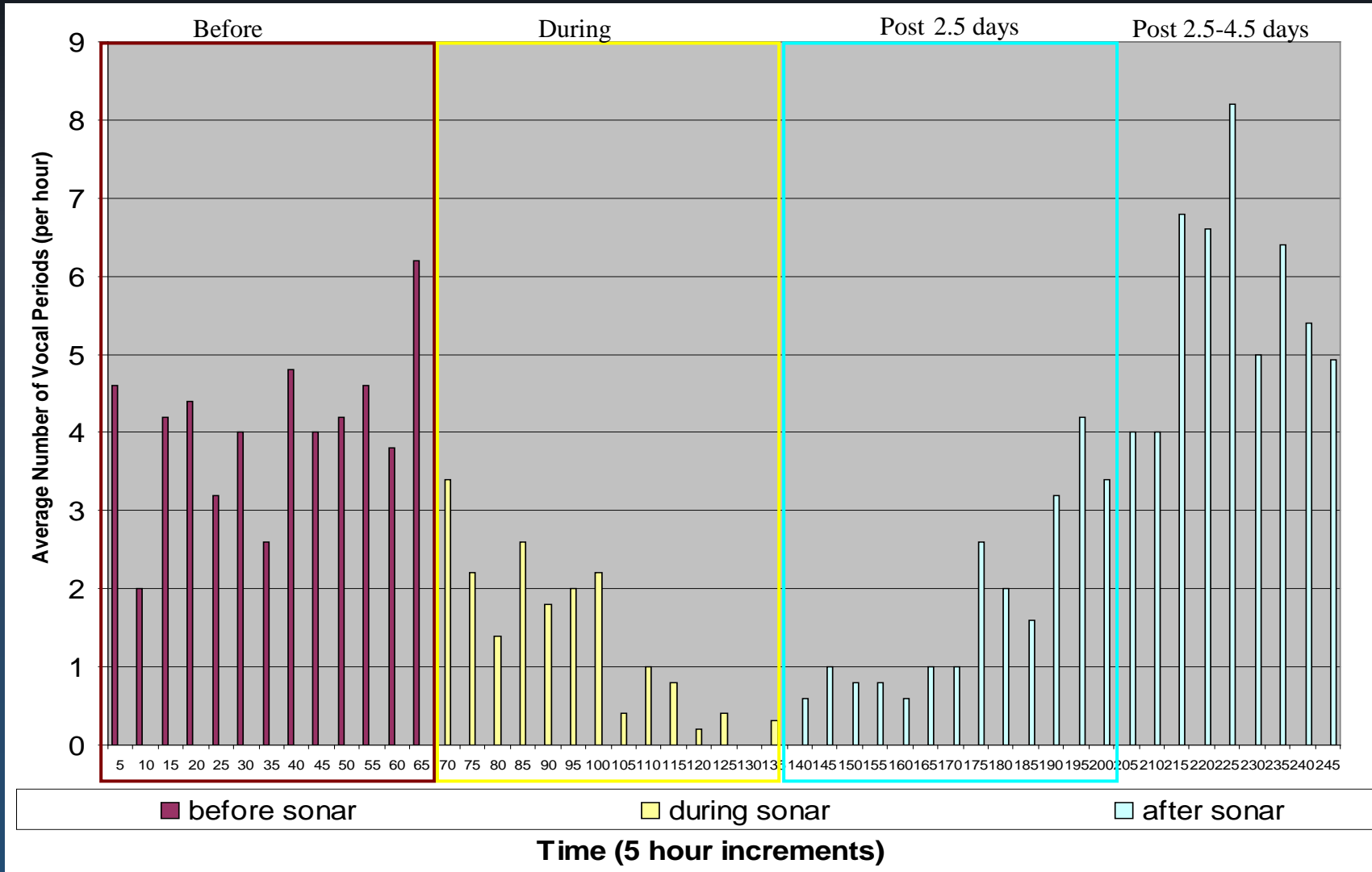
Falcone et al.
2017



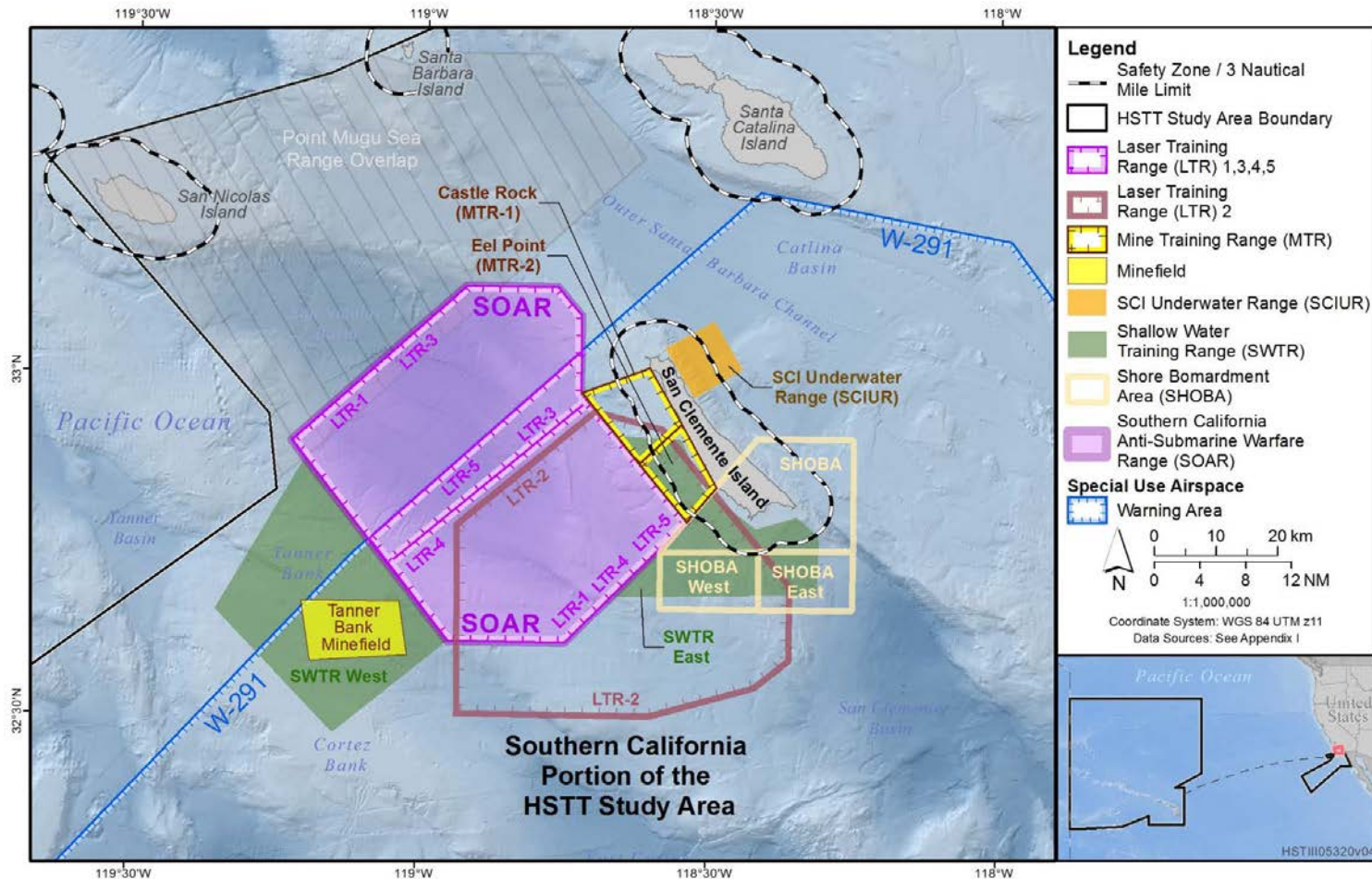
CRC-Zc-007: 2011



Blainville's beaked whale response to sonar: AUTEC range



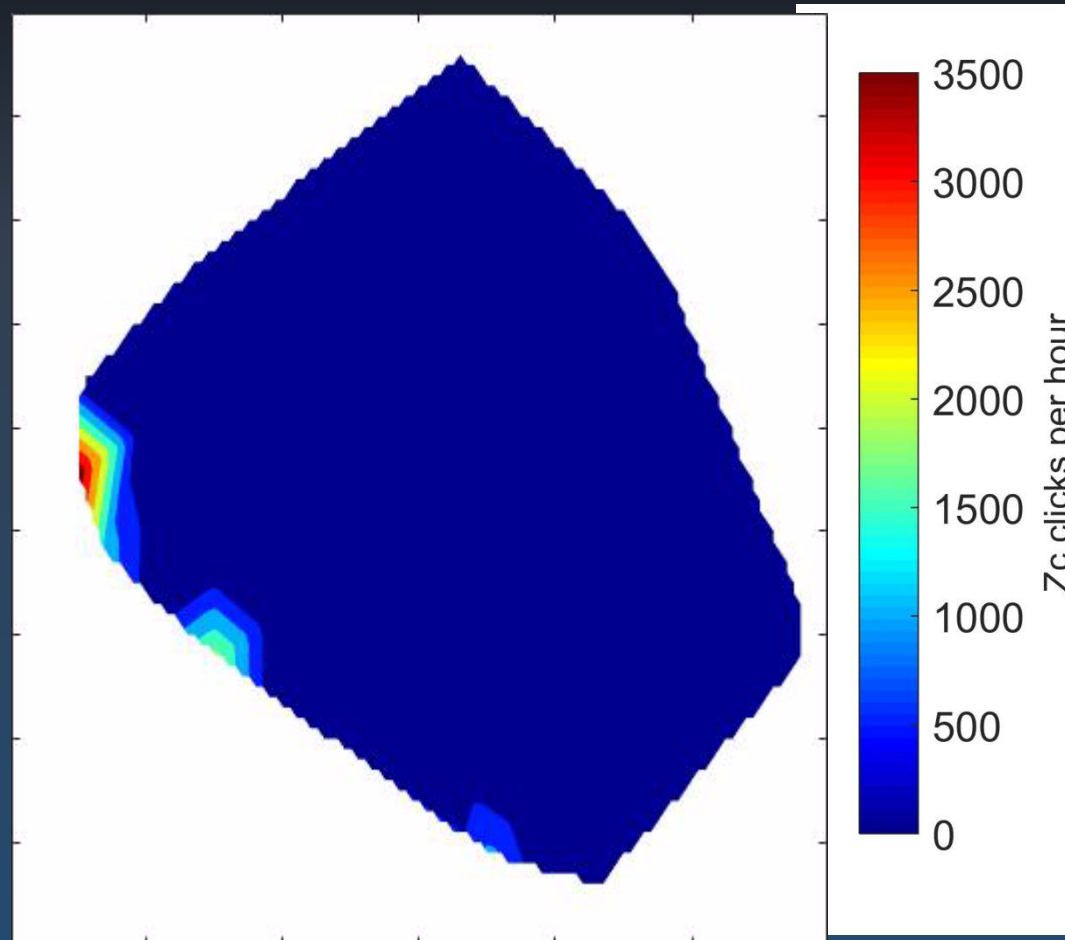
Southern California Anti-Submarine Warfare Range (SOAR)



Notes: HSTT = Hawaii-Southern California Training and Testing, SCI = San Clemente Island

Figure 2.1-7: San Clemente Island Offshore Training and Testing Areas

Echolocating Cuvier's beaked whales on the SOAR range

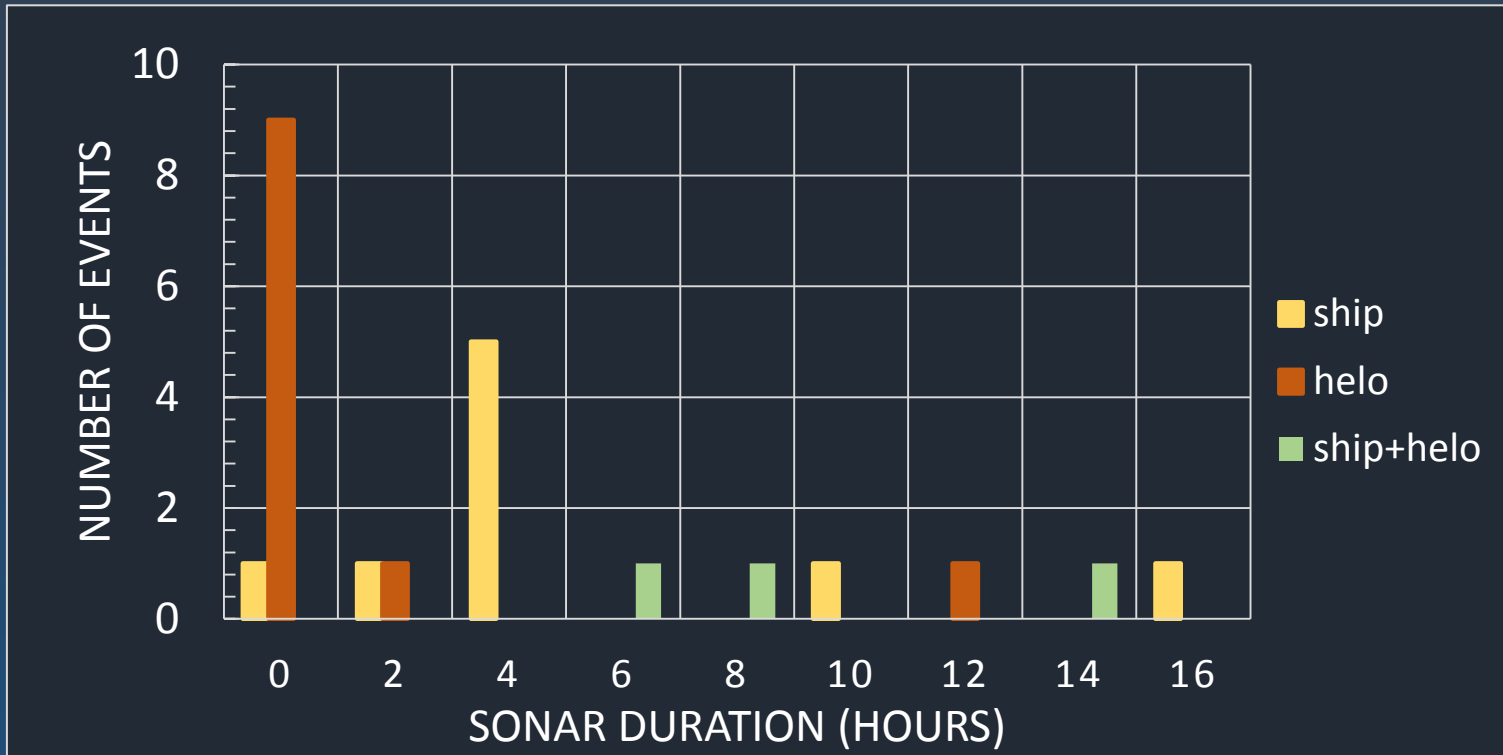


Analysis Methods

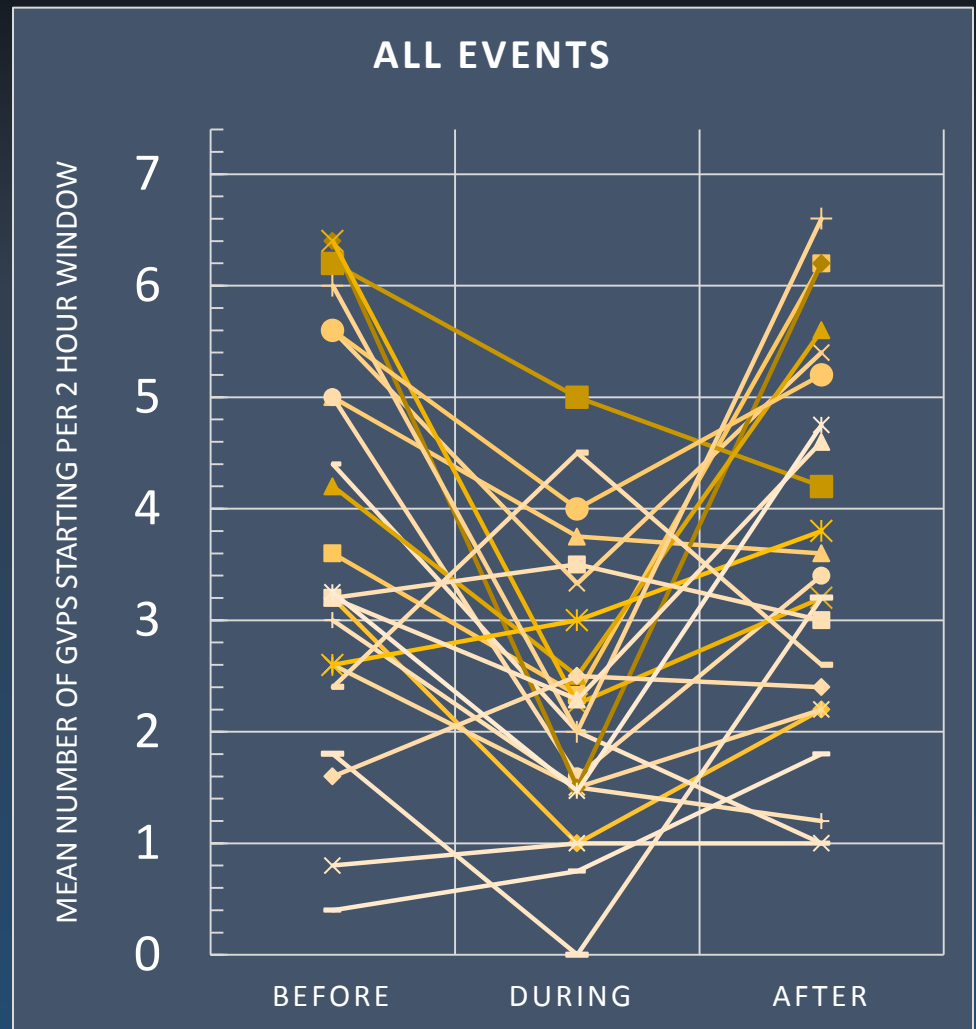
- Custom Java sonar detector algorithm to detect periods of potential sonar
 - Compared sonar detector output and range event schedule to determine type of operation
- 2 hour windows
 - 5 time windows **before** and **after** each event
 - time windows in **during** period dependent on event length
- Custom Matlab algorithm to isolate group vocal periods (GVPs)
- Counted GVPs starting in each 2 hour window
- Determined maximum peak magnitude level on each hydrophone in each 2 hour window
 - Converted to estimated RL in dB rms at hydrophone
- Generalized Linear Model to examine effect of sonar presence and event type on number of GVPs

| # of Events | Event Type | Sonar Types |
|-------------|-------------|---|
| 9 | ship | High-powered sonar: Hull-mounted ship sonar, e.g., AN/SQS-53C |
| 11 | helo | Mid-powered sonar: Helicopter-deployed dipping sonar, e.g., AN/AQS-22 |
| 3 | ship + helo | both |

Event dates: April 2014 – October 2015



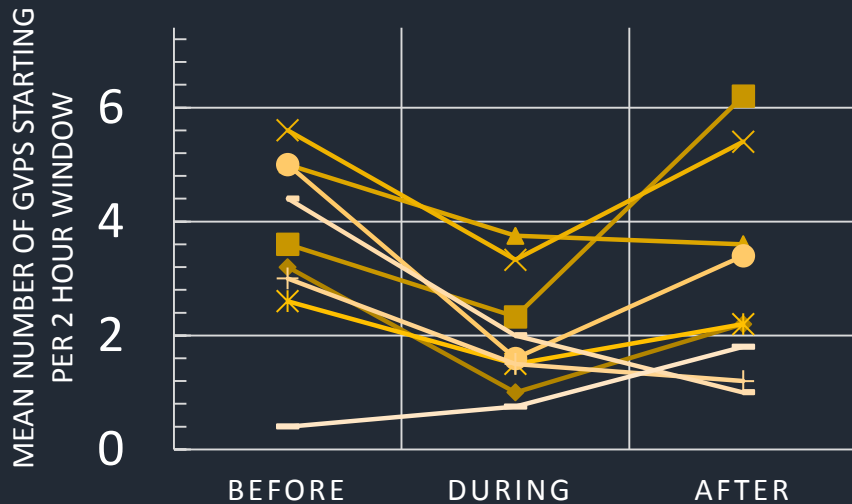
Mean number of GVPs starting per 2 hour window



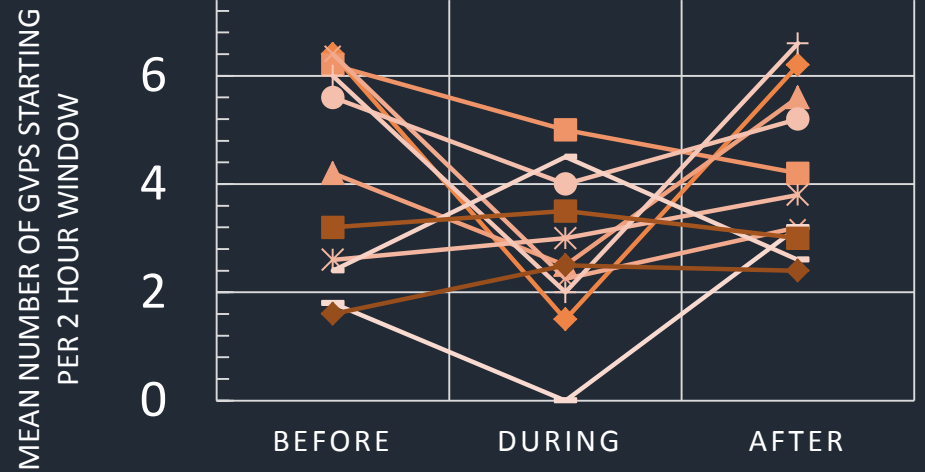
MEAN GVPs: 3.8 2.3 3.6

Mean number of GVPs starting per 2 hour window

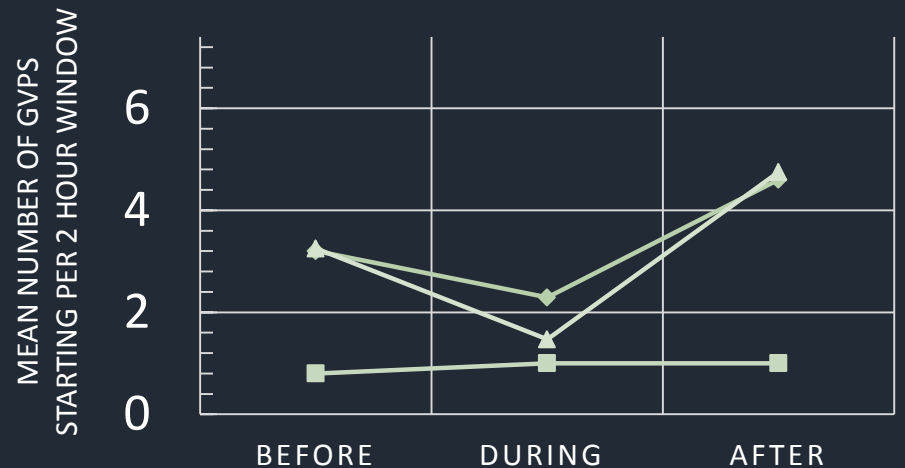
SHIP EVENTS



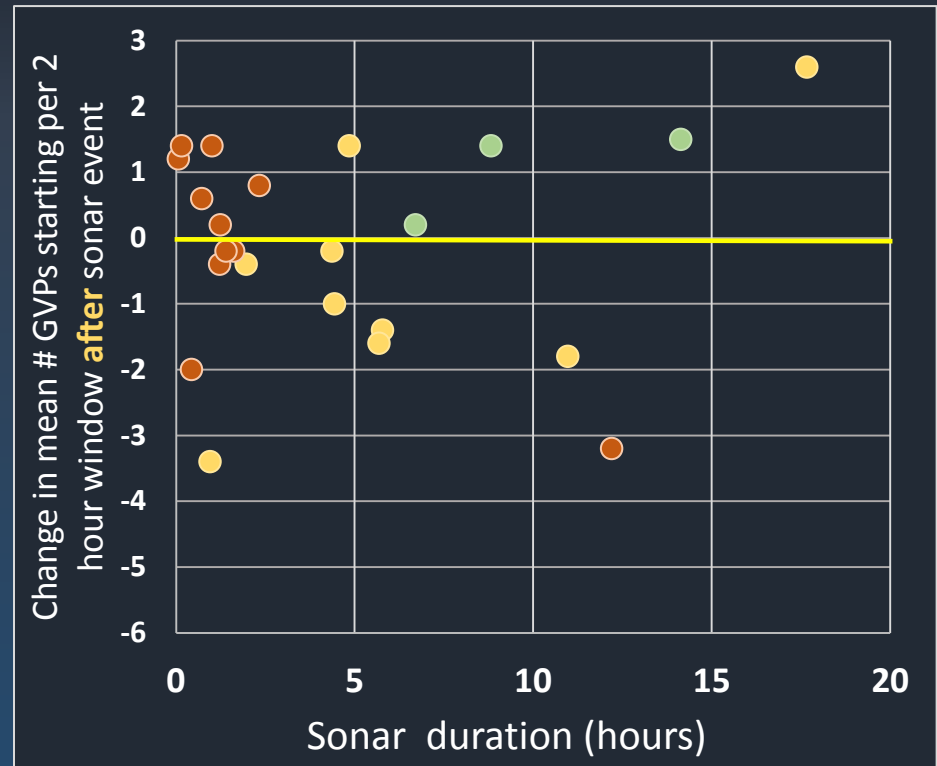
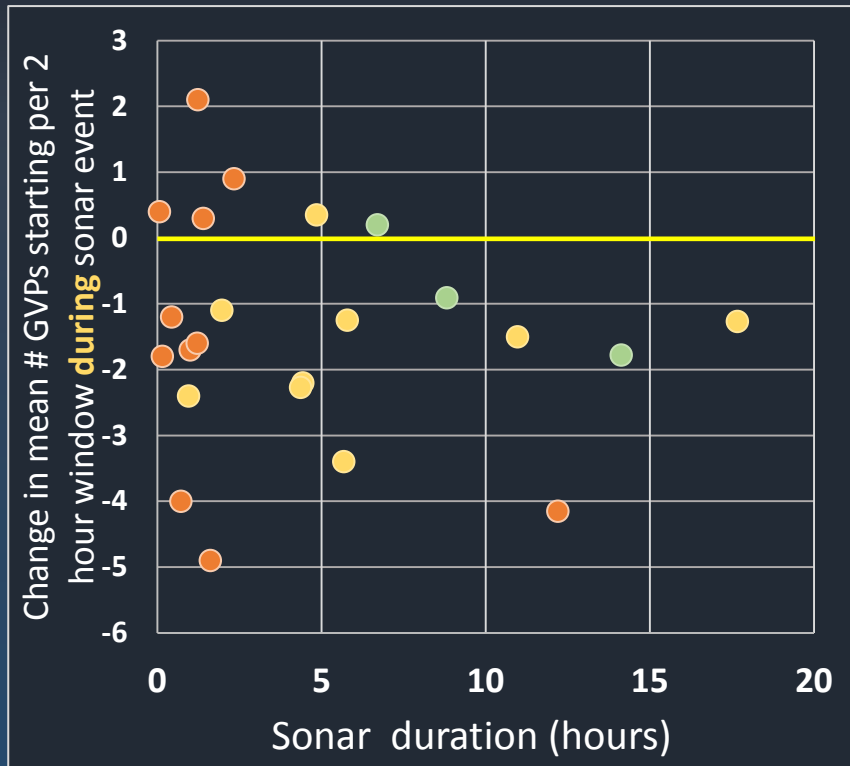
HELO EVENTS



SHIP + HELO EVENTS



Change in mean number of GVPs in **During** and **After** time periods compared to **Before** time period



● helo

Before → During

● ship

● ship + helo

Before → After

GLM results

- Significant decline in GVPs **during** events compared to **before** for all event types
- No difference in GVPs **before** and **after** for all event types
- Significantly less of a decline in GVPs during helo events compared to ship events
- GVP decline not different between ship events and ship+helo events

```
Call:
glm(formula = GVP ~ Period_BDA + Sonar.Type, family = poisson,
    data = subdat)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-2.9181  -0.9129  -0.1432   0.5042   4.3953

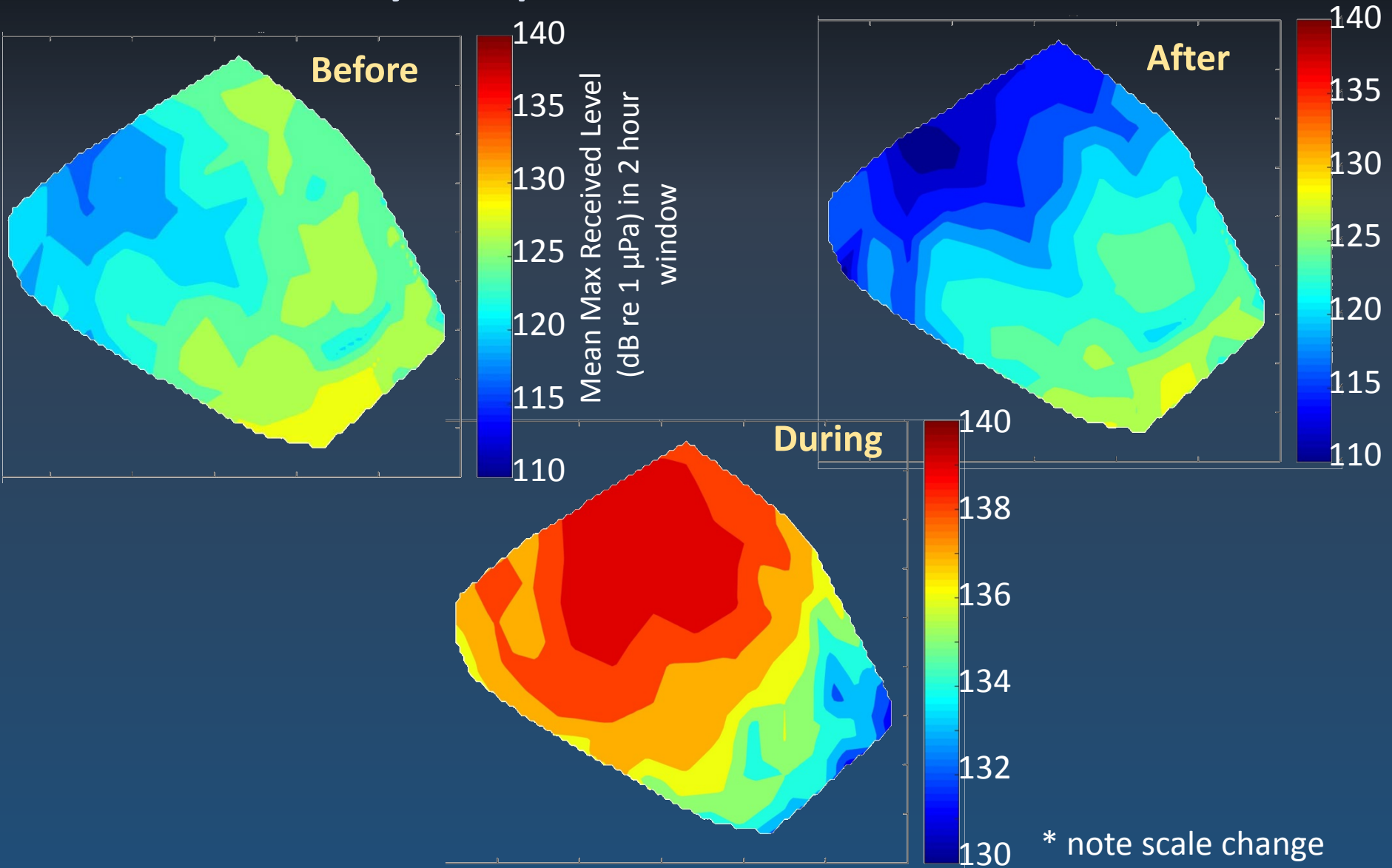
Coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)  1.19451    0.06346  18.822 < 2e-16 ***
Period_BDA2 -0.36947    0.07884  -4.687 2.78e-06 ***
Period_BDA3 -0.01248    0.06761  -0.185  0.85361
Sonar.Type2  0.25421    0.06676   3.808 0.00014 ***
Sonar.Type3 -0.03233    0.08456  -0.382  0.70220
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for poisson family taken to be 1)

    Null deviance: 659.19  on 356  degrees of freedom
Residual deviance: 594.99  on 352  degrees of freedom
AIC: 1568.6

Number of Fisher Scoring iterations: 5
```

Ship Events: Estimated Mean Max Received Levels on Hydrophones

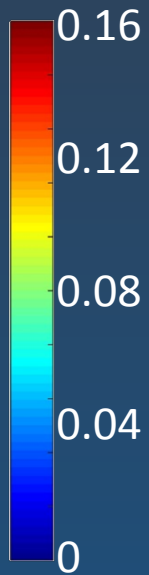
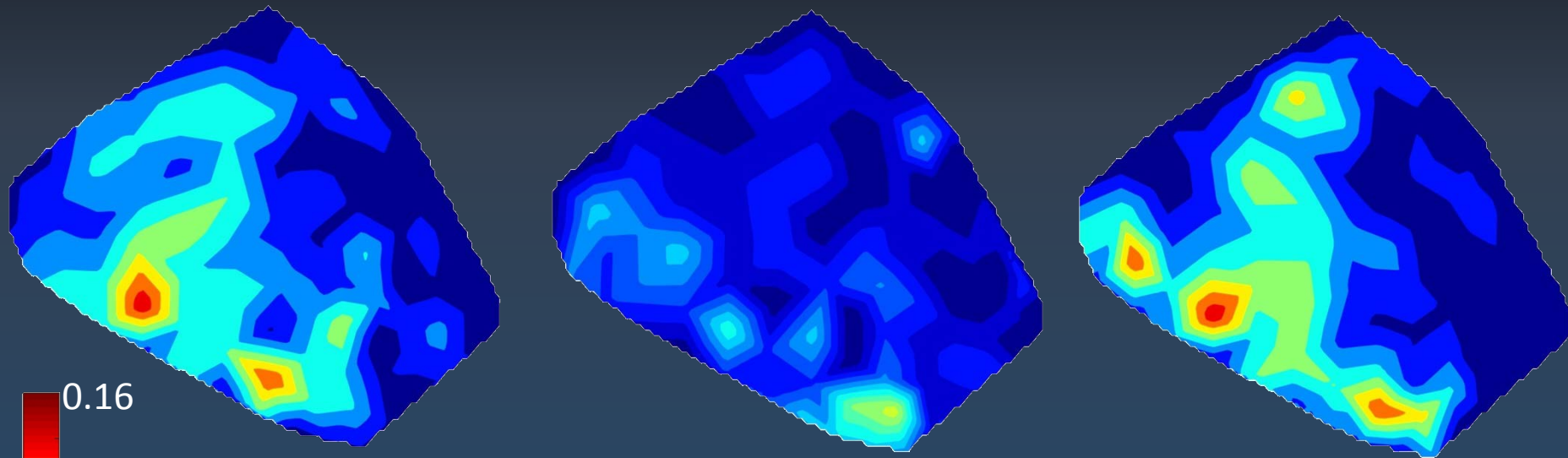


Ship Events: Mean GVPs

Before

During

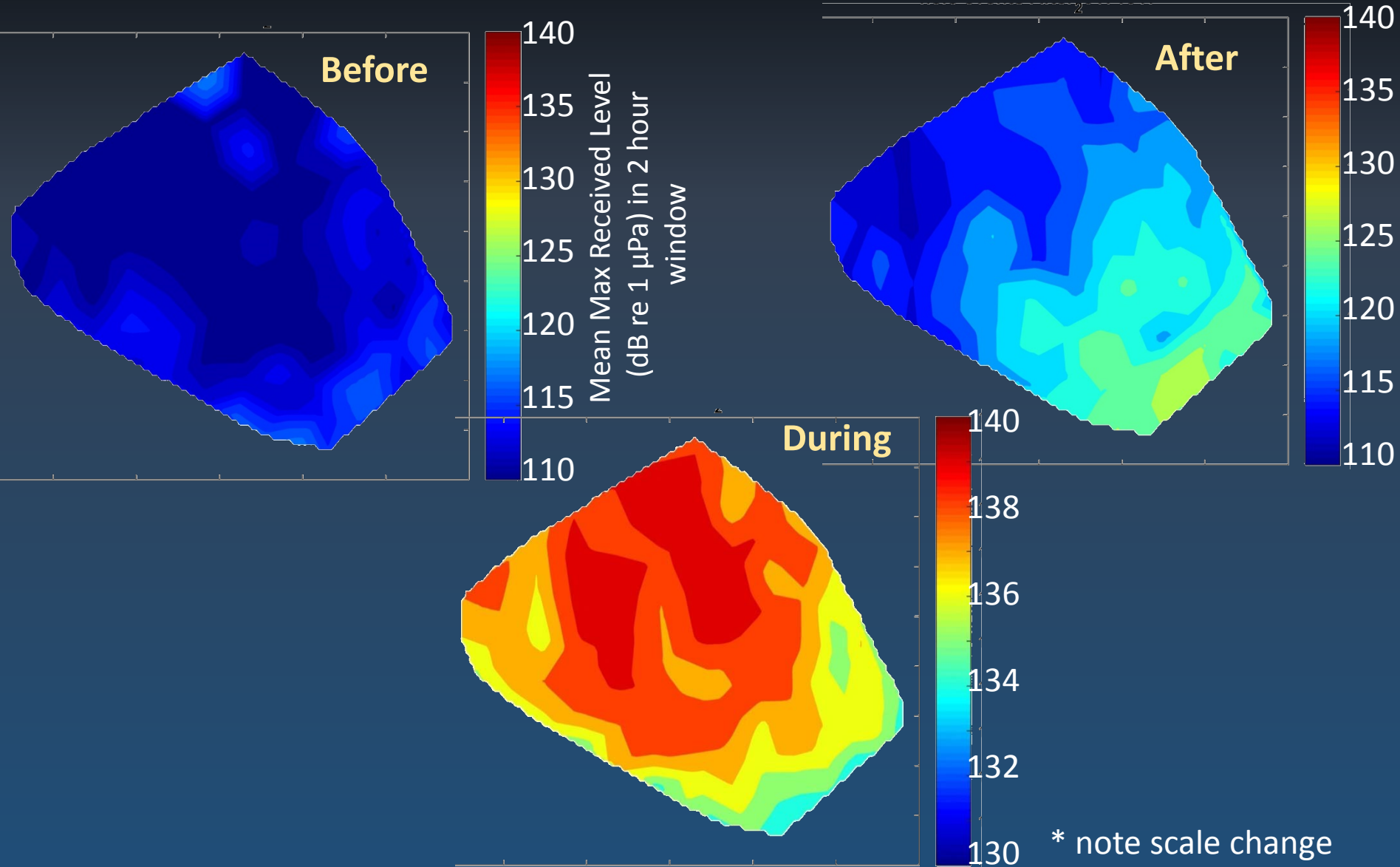
After



Mean # GVPs starting
per 2 hour window

Starts on GVP center phone only for on-
range groups

Helo Events: Estimated Mean Max Received Levels on Hydrophones

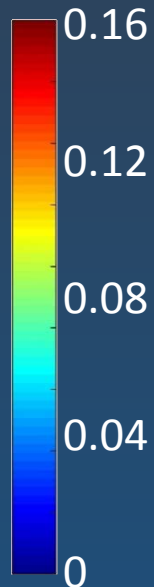
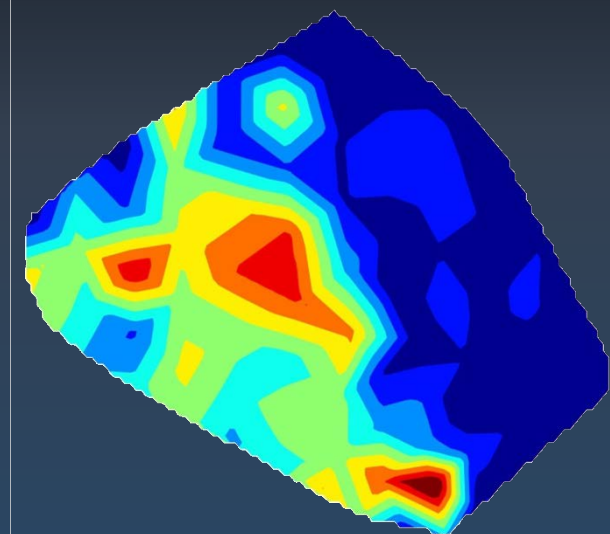
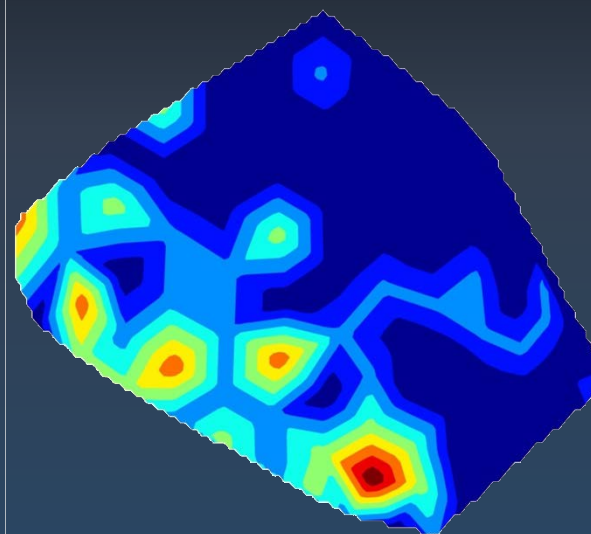
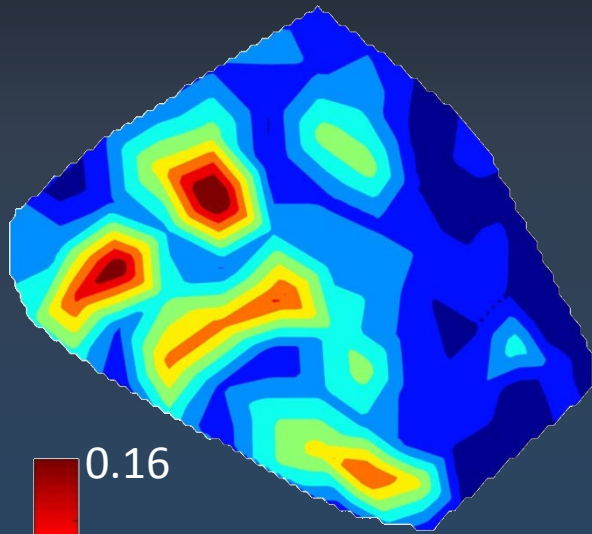


Helo Events: Mean GVPs

Before

During

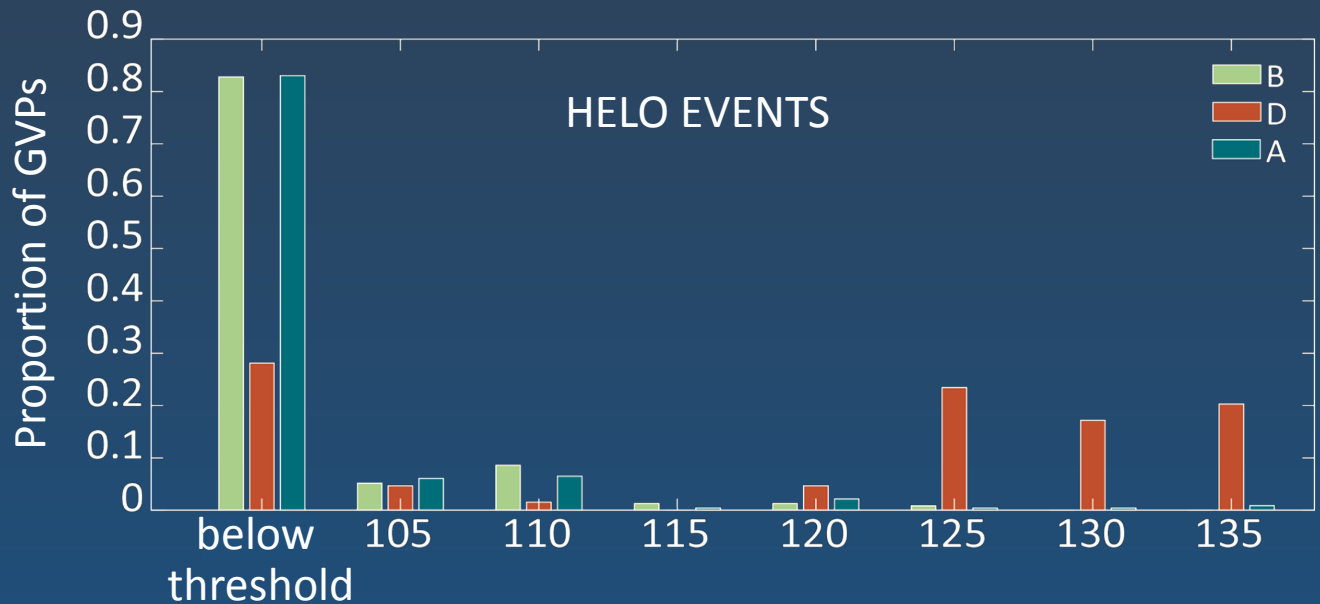
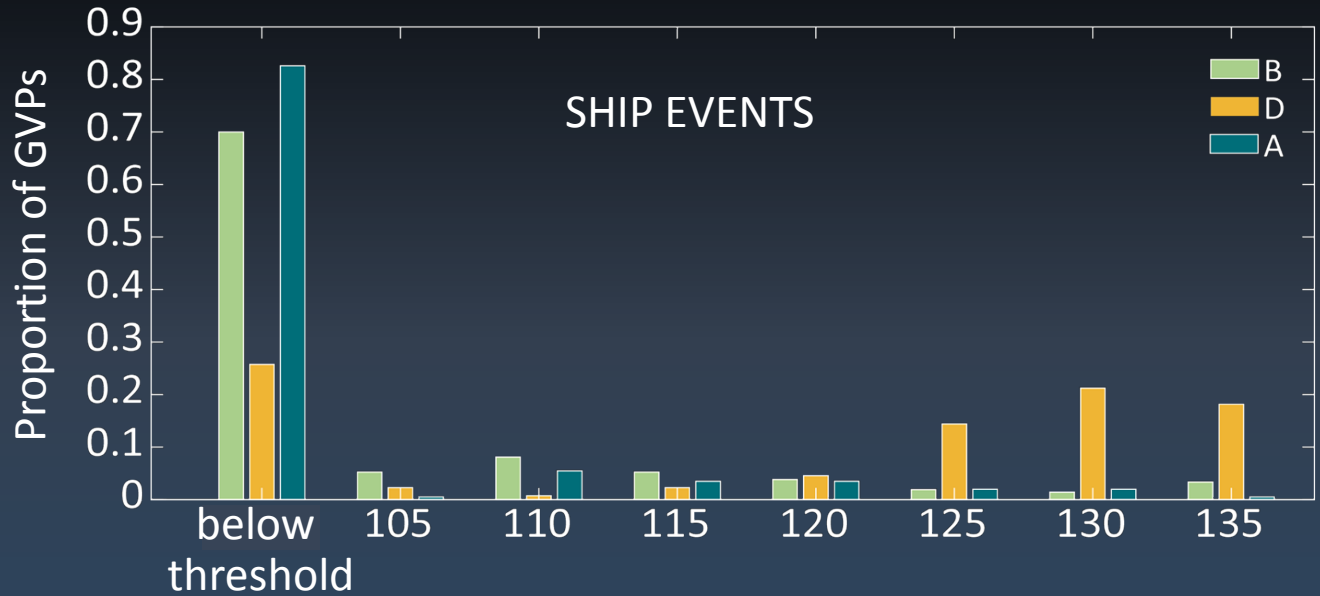
After



Mean # GVPs starting
per 2 hour window

Starts on GVP center phone only for on-range groups

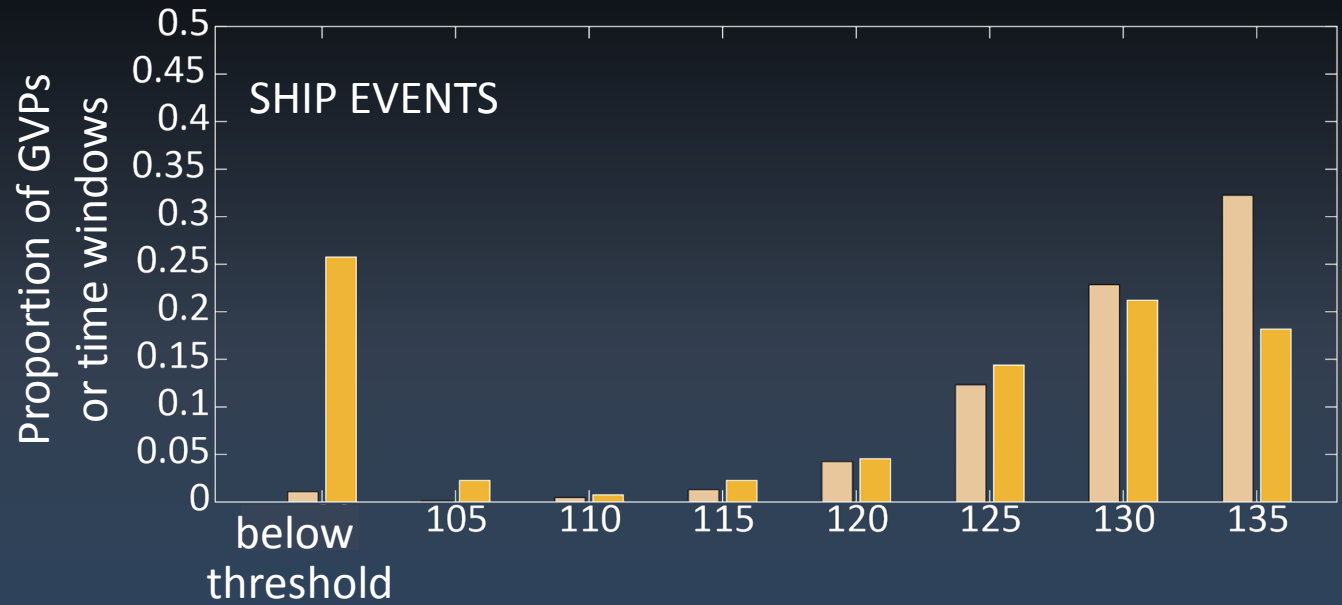
Max Estimated Received Levels



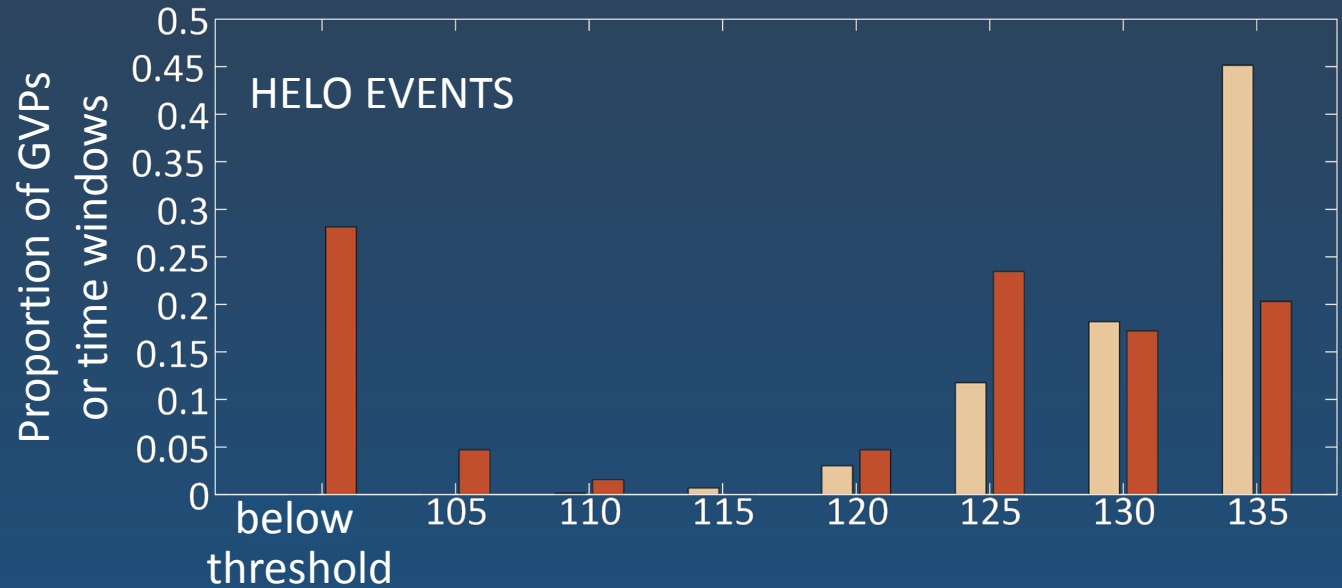
Max estimated RL during GVP duration on GVP center phones for GVPs starting **Before**, **During**, and **After** events

Max Estimated Received Levels

Max RL during 2 hour window on all hydrophones on range **During** events



Max RL during GVP duration on GVP center phones for GVPs starting **During** events



Conclusions

- Significant declines in foraging beaked whales during events on SOAR when hull-mounted ship sonar and helicopter-deployed dipping sonar are active
- Greater declines in foraging beaked whales seen when hull-mounted ship sonar is active compared to when only helicopter-deployed dipping sonar is active
- Recovery in foraging Cuvier's beaked whales much faster than seen during AUTECH training events for Blainville's beaked whales

Acknowledgements

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