Estimating minke whale boing density at PMRF, Hawaii

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PMRF phones utilized*

- 17 phones 100Hz- ~19KHz
- Spacing nom 7Km N-S ~12Km+ E-W
- Water depths 2.4Km- 4.6Km
- *other phones available, closer to shore, shallower water, all but 6 high pass filtered @~10KHz
- Study area ~ 2,400Km² ( 30Km x 80Km )
Minke whale boing

- Boing sound widely known in Pacific (Wenz 1964), Thompson and Friedl (1982) suspected whale origin, recently attributed to minke whale (Rankin and Barlow 2005).
- Boing itself described as an onset pulse followed by a long call with initial FM upsweep and CW component (similar to Gedamke 2001 SW).
- Descriptions of San Diego/Hawaii boing differences from reported PRR (also reported as a fundamental frequency of between 90 and 110 Hz with usually the 12th and 18th harmonic components prominent (Turl 1980 unpublished).
Boing characteristics

- 7 sec of Hawaii/Central boing showing over 40 ‘components’ to over 11KHz
- Described as an onset pulse followed by an initial FM upsweep and long AM - CW component. (ABC)
- Existing literature describes some characteristics of boings (durations, pulse repetition rates, inter boing intervals, geographic variations of PRR, …)
- Investigation of PMRF data shows the ~1.4KHz component, termed the dominant signal component (DSC), is the strongest component and last component typically observed for long ranges.
Associating boings across phones

- Boing density can be high, sometimes overlapping calls
- Association aides:
  - DSC’s tail frequency for a specific boing
  - Spatial/temporal patterns observed on multiple phones – BB energy or detections (auto detector TDOA localization concerns)
  - Multipath (bottom-surface) has been observed - providing additional info (distance from phone).
DSC’s tail frequency
High Res FFT (sub-Hz res)

27 April 2009, B8 phone @ 13:21:58 (file 34 first B8 boing)
Tail only (no onset, sweep at start)

DSC ‘dominant signal component’ ~ 1400Hz
  Dominant signal tail constant frequency (DSTCF) ~ 1383Hz
  Lsb @ 1267 Hz and Usb ~ 1497 Hz
  AM rate (PRR) 114 – 116 Hz
Dominant signal components and bottom MP
Two boings in 20 seconds of data 27 Apr 2009, B5 @ 13:44 HST
White lines mark 1350Hz to 1450Hz
first boing has DSTCF of ~1410Hz with ~1.8sec MP (~22Km)
Second boing has DSTCF of 1386Hz with 2.3 sec MP (~20.5Km)
DSC Consistency Observed for an individual*

• Apr 2009 PMRF field work w/ Tom Norris (Bio-Waves)
• Spatial BB patterns on phones observed in near real time from shore aided the sighting
• Post analysis has found the DSTCF for what is believed* to be the sighted individual remained constant over 5.5 hours (56 boings, mean IBI=373 sec SD=117sec)
• DS TCF - consistency?
Spatial patterns show various chevrons/delays for different geometries (<< TDOA localization).
Rules to require detection on both vertical 'strings' (non-colinear detections)
e.g. clusters 1 & 3 > no posits
DSC potential aide in separating individuals
Multipath detection allows range est. in some cases
Detection per phone index vs time (~100 sec)

1389-1399Hz medFreq
Detections phones vs time

Detection medFred vs time
27Apr09 7:47 to 13:45 (10:28-12:09 shown below)
Top: All detections & freqs – phone index vs. time
Bottom: 1388-1400Hz medFreq filtered detections phones vs. time
Abrupt reduction in call activity

27 April 2009 10+ hours of auto boing detector calls vs phone index
TOP: All calls (8,307)
BOTTOM: DSTCF filtered (1388Hz<median freq peaks<1400Hz)
Note at around 22000 seconds (~ 13:50 HST) activity reduced, which supports previous manual analysis (response to surface craft, feeding, ?)
Density estimation

- Consider data of boings detected across different hydrophones to the same source boing
- This leads to capture histories for each boing
- Intuitive idea is to estimate number of unobserved capture histories (and area they come from)

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Some simulation results

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Table 1: Summary of 100 simulations where $N = 440$ ($D = 0.063$), detection function scale parameter was 6. Each entry represents the mean of the corresponding statistic.

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Table 2: Summary of 100 simulations where $N = 300$, detection function scale parameter was 6. Each entry represents the mean of the corresponding statistic.
Minke boing acoustic density considerations

- Key issue is correct association of boings (e.g. a couple of boings in two hydrophones, same original boing or 2 different boings?)
- Assumptions:
  1) we will be able to get an average boing production rate with reasonable SD … eventually….
  2) Boinger spacing?
  3) Determining if boinger is in study area