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Probability of acoustic detection of beaked whales from deep and shallow hydrophones

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Several mass strandings of beaked whales (Ziphiidae) have been associated with naval exercises using high-intensity sonar or underwater explosions, suggesting that these whales are especially sensitive to some types of acoustic pollution, potentially including seismic activities (Cox *et al. 2006*) . Due to the low probability of visual detection of these deep-diving species (Barlow 1999), monitoring of beaked whales presence for mitigation efforts should be complemented with acoustic methods.

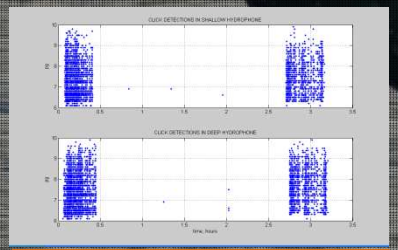
Passive acoustic detection is a valuable method to record beaked whale occurrence (Marques *et al.* 2009) given the characteristic clicks produced by studied beaked whales (Johnson *et al.* 2006). However, acoustic detection is limited by the fact that studied ziphiids are vocally active during some 20% of their time and when deeper than 200 meters depth (Aguilar Soto *et al.*, in press). The combination of whales vocalizing only at depth, increased ambient noise near the surface and downwards refraction of upwelling sound suggests that the probability of acoustic detection will increase in hydrophones located at depth with respect to shallow hydrophones. This would make acoustic detection methods of ziphiids cumbersome and expensive.

Here we test this hypothesis comparing acoustic detections recorded at 20 and 200m depth in waters off El Hierro, in the Canary Islands, where year-round coastal populations of ziphiids provide an excellent experimental site.

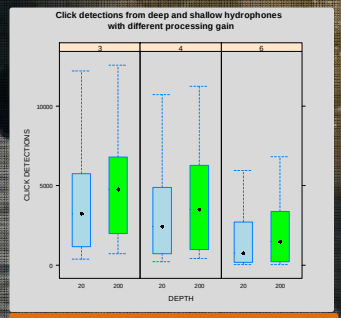
METHODS

Broad-band autonomous recorders (DMON, M. Johnson, WHOI) were suspended at 20 and 200m depth from GPS-linked drifting buoys. DMONs were programmed to record sound continuously (120 kHz sampling-rate, 55 kHz bandwidth, 16 bit) while running a matched-filter click detector. Buoys were deployed for 23 days in spring 2010 summing 276 recording hours. Two buoys were deployed each day, with two DMONs each, and a double platform approach was used to estimate the probability of detecting individual clicks at the shallow and deep hydrophones. The deployment area was within the visual field of a shore station with four rotating observers equipped with high power binoculars with reticUle and compass to geolocate cetacean sightings. One or more group of Blainville´s or Cuvier´s beaked whales (*Mesoplodon densirostris* and *Ziphius cavirostris*) were observed every recording day.

RESULTS



Example from 3.5 hours of recording showing the temporal distribution of click detections in both DMONs (pg: processing gain).



Comparison between click detections from 16 DMONs. Processing gain is a threshold and refers to how similar is the received click to a typical on-axis *Mesoplodon* click. The higher the threshold, the more similar the click has to be to a "standard" beaked whale click before it is counted as a detection

Beaked whales acoustic probability of detection is similar for hydrophones at 20 and 200m depth, with a mean performance loss of only 31% On average 528 more clicks detected at 200. The mean ratio is 1.46 so it is detected 1.46 times more clicks at 200 meters than at 20 meters.

CONCLUSION

These results consolidate acoustic methods as a useful tool for detecting presence of beaked whales in an area. Further work is required to assess the acoustic monitoring time required to evaluate presence/absence of beaked whales accurately in order to provide effective mitigation protocols to prevent impact from acoustic human activities on ziphiids.

Autonomous acoustic detector and recorder

DMON were deployed from GPS-linked drifting buoys. Two buoys with two DMONs each were deployed every day in the study area off El Hierro, Canary Islands.

AKNOWLEDGMENTS:

Many thanks to all the enthusiastic and hard-working volunteers who made the survey possible. Funding for developing and field-testing of DMONs was provided by the Office of Naval Research (US Government). Research was performed under a permit from the Canary Islands Government to ULL. N. Aguilar is currently funded by a Marie Curie Outgoing Fellowship within the 7th EU FP7 Program.

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