The response by coastal dolphins to naval mine exercise (MINEX) training activities off Virginia Beach, USA

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INTRODUCTION

The naval forces of many nations conduct mine detonation exercises in coastal waters as part of their regular training. These exercises have the potential to disturb, injure or even kill marine mammals occurring in the same area. To address concerns about this possibility at the U.S. Navy's Virginia Capes (VACAPES) Range Complex, an effort was conducted beginning in 2012 to monitor odontocete activity at the W-50 mine exercise (MINEX) training range using passive acoustic methods. The objectives of the project were to document the daily and seasonal patterns of occurrence of dolphins in the VACAPES MINEX training area, to detect explosions related to MINEX activities, and to investigate potential behavioral and acoustic responses of dolphins to MINEX events.

METHODS

Four Ecological Acoustic Recorders (EARs) programmed to achieve continuous monitoring were deployed at distances of 1 km, 3 km, 6 km and 12 km from the known 'epicenter' of training events and were refurbished approximately every two months. They were programmed to sample at a rate of 50 kHz for 3 minutes every 6 minutes on offset duty cycles so that at least one unit was always recording. EARs were deployed to the south, east and north of the epicenter during alternating deployments (Fig 1).

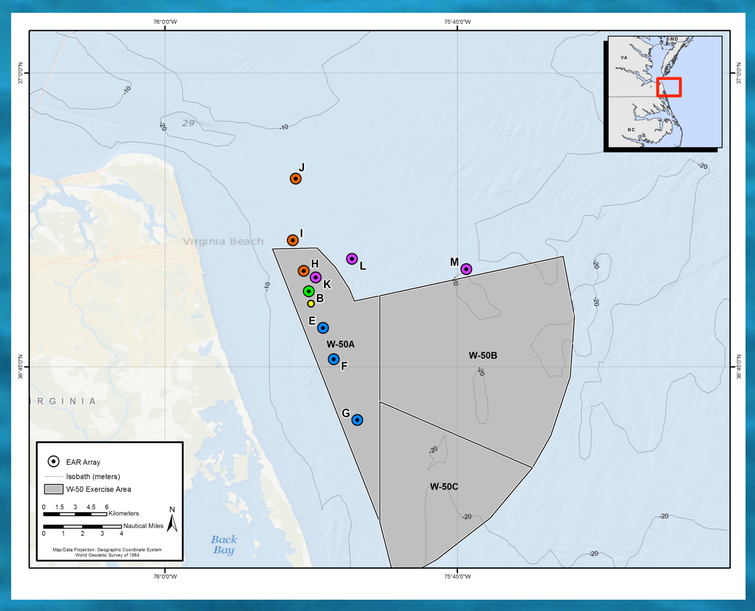


Figure 1 – EAR deployment locations in W-50 training area color-coded by north, east and south deployment orientation. The yellow dot represents the 'epicenter'.

Recordings were visually inspected for the presence/absence of dolphin signals & underwater detonations (UNDETs) using the Matlab™ program Triton (Wiggins 2007). An acoustic activity index, representing the abundance of various dolphin sounds detected was assigned for each 3-minute recording to quantify acoustic activity. Activity indices were then used to quantitatively compare the acoustic activity of dolphins on three different time scales: minutes after an UNDET, hours after an UNDET, and days surrounding an UNDET (i.e. the day before, the day during and the two days following and exercise).

In addition to quantifying dolphin acoustic activity during periods associated with MINEX events, dolphin presence/absence was noted on a recording-by-recording basis at the 1 km site for the entire deployment period.

RESULTS

63 UNDETs were detected in the data analyzed between 15 August 2012 and 30 August 2015, representing 31 MINEX training events. Dolphins were present year-round and on 97% of recording days. However, the highest detection rates occurred between late spring and early fall.

A short-term increase in production of whistles occurs during the 30 seconds immediately after an UNDET. Dolphin acoustic activity then decreases during the hours after an UNDET.

Averaged over the 31 training events, dolphins were most active during mid-day (11:00–12:00 EST) and nighttime hours (19:00–04:00 EST) during the day before a MINEX event (Fig. 2). On the day of a training exercise and the following day, the daytime peak in activity was reduced or absent. A paired t-test comparing the hourly bins of the day before and the day of the exercise revealed a significant difference ($t = 2.798$, $DF = 23$, $p = 0.010$). Conversely, a paired t-test comparing the 24 hourly bins of the day of the exercise and the first day after the exercise was not significant ($t = 0.328$, $DF = 23$, $p = 0.746$).

In contrast to the reduced or absent daytime peak, the nighttime peak in activity persisted following MINEX training events, suggesting that the animals in the area resumed normal activity during these hours. This trend also suggests that the decreased activity observed during daylight hours of the following day might represent avoidance of the area.

During the second day following a training event the acoustic activity levels were significantly higher (Paired t-test, $t = 6.904$, $DF = 23$, $p < 0.001$) than the levels observed during the day before the event suggesting that animals were more active and/or abundant in the area during this time than during the baseline period (the day before an exercise).

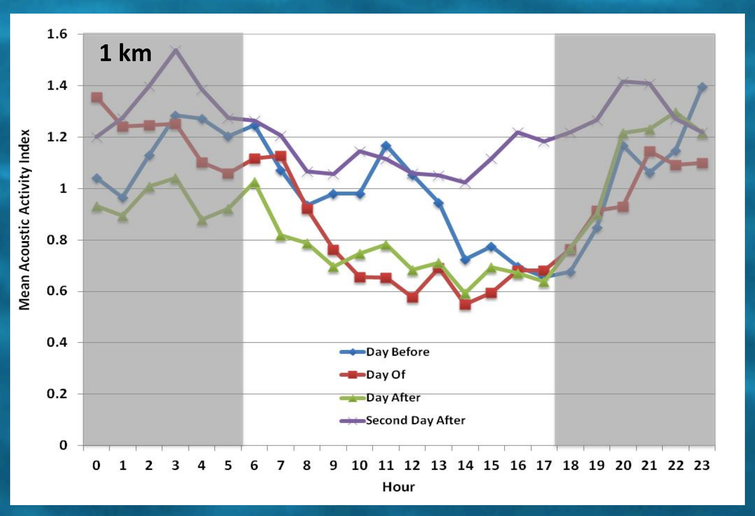
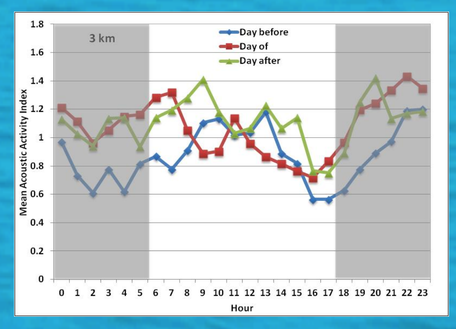
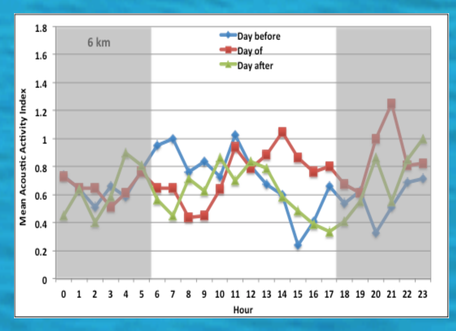


Figure 2 – The hourly dolphin acoustic activity observed over the 24-hour period of the days before (N = 25), the days of (N = 31), and the first (N = 27) and second (N = 23) days after a MINEX training event at the 1 km site. Shaded periods represent twilight/nighttime hours.





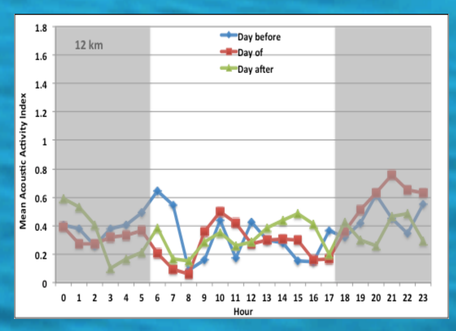


Figure 3 – The hourly dolphin acoustic activity observed over the 24-hour period of the days before, the days of, and the days after a MINEX training event pooled across sites 3 km (N = 13), 6 km (N = 4) and 12 km (N = 10) from the epicenter of training activities, regardless of array orientation.

Significantly greater acoustic activity was observed at the 3 km site the day before and both the day of and the day after a MINEX training event (paired t-test of mean hourly bins, $p=0.009$ and $p<0.001$, respectively), suggesting that a re-distribution of animals may occur (Fig. 3). No inference was attempted on the pooled data from the 6-km sites because of the small sample size (N = 4) due to instrument problems at this site during two deployments. For the pooled data from 12 km away (N = 10), no statistically significant differences were found between the day before, the day of, and the day after an exercise.

CONCLUSIONS

These findings reveal that dolphins in the W-50 training area are periodically exposed to noise from UNDETs, although it is not clear at what distances or received levels. Based on 3 years of monitoring data, there is evidence that dolphins respond behaviorally to MINEX training events. Following an UNDET, dolphin acoustic activity decreases during the subsequent hours and this response apparently persists into the following day. It is still not clear whether this represents a suppression of acoustic activity by the animals, individuals moving away from the area, or both. There is evidence to suggest that dolphins are more acoustically active or abundant 3 km from the epicenter on the day of and after an exercise, suggesting that a re-distribution of animals may take place, but additional data are needed to verify this trend. These results underscore the value of long-term monitoring to inform the military on the potential impacts on marine mammal populations from training activities involving UNDETs.

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