Noise from explosive deterrents used by California fisheries and possible effects on marine life

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Abstract

In Southern California, a variety of fisheries (e.g. purse seiners) use commercially produced explosive deterrents, commonly known as "seal bombs", to protect the fishing gear and catch from pinniped predation. Passive acoustic monitoring data collected between 2005 and 2016 at multiple sites within Southern California have revealed first insights into large numbers of small-charge underwater detonations. Maximum explosion counts per site exceeded 37,000 per month, the majority occurring at night. By comparing spatial and temporal patterns of explosions with daily operating hours and monthly commercial fisheries landings data, a clear relationship especially with the California market squid (*Doryteuthis opalescens*) purse-seine fishery was found. The persistence of this noise source combined with a possible habitat overlap for these fisheries and marine top-predators, indicate the potential to affect the behavior of marine animals, especially cetaceans.

Fig. 1 a-d: Seal bomb, purse seine fishing boat, market squids and Pacific sardines.

Methods

- **18 High-Frequency Acoustic Recording Packages (HARPs)**
- **Data from 2005 – 2016 with varying deployment periods per site (<4 months – >7 years)**
- **> 40 cumulative years of data analyzed for explosions**
- **Spatial and temporal explosion occurrence compared to commercial landings* data for two major purse-seine fishery fleets in California:**

Market squid

Anchovy/Sardine/Mackerel

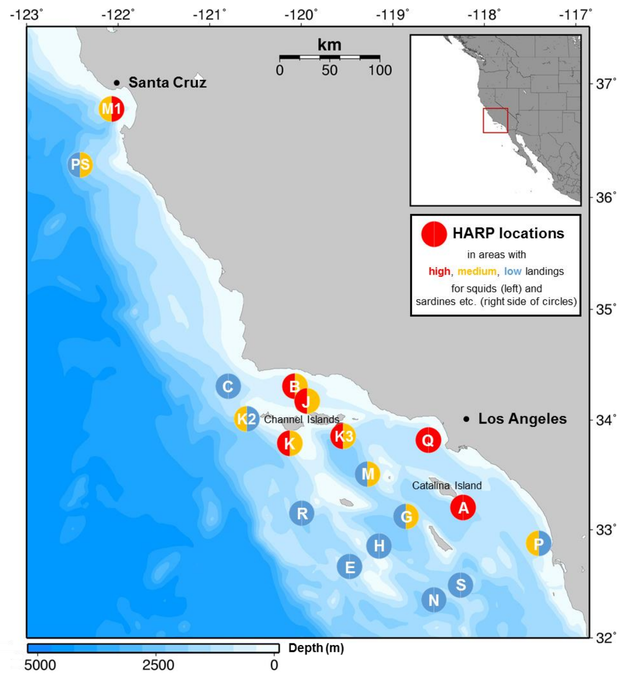
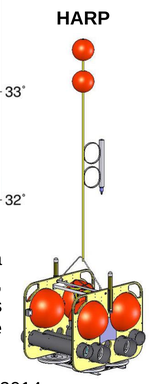


Fig. 2: Map of 18 HARP sites (circles) in the Southern California Bight and Monterey deployed in areas with average low (blue), medium (orange) and high (red) landings (sum for fishing blocks within 50 km radius) for squid (left) and sardine/anchovy (right side of circles); map generated using SEATURTLE.ORG's Maptool.



*Landings data from California Department of Fish and Wildlife 2005-2014.

Results & Discussion

Night vs. Day → Weekdays vs. -end → Monthly Pattern → Annual Trend

Temporal patterns

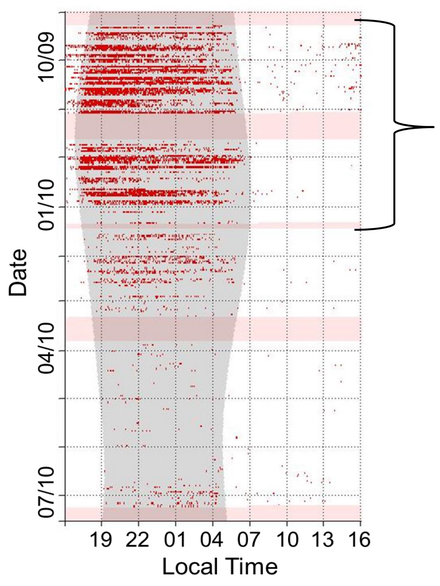


Fig. 3: Example of explosion occurrence/minute (red dots) during daytime (white area) and night-time (grey area) at site Q in the Santa Monica Basin (pink horizontal bands indicate no acoustic effort).

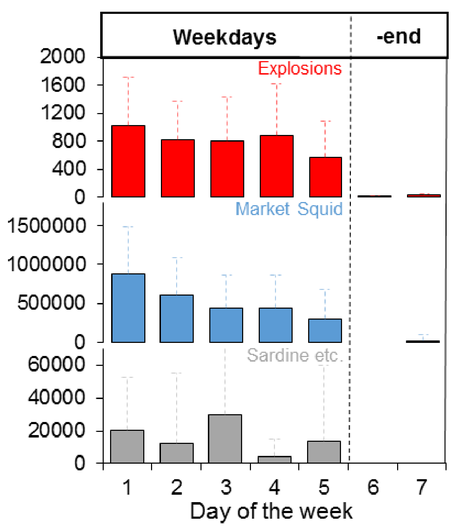


Fig. 4: Example for daily pattern of explosion counts (red bars), market squid (blue bars) and anchovy/sardine/mackerel landings (grey bars) on weekdays (1-5) and weekends (6-7) at site Q.

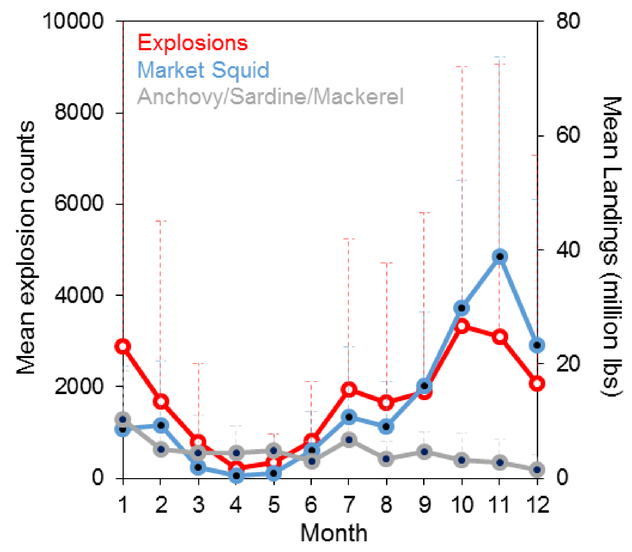


Fig. 5: Mean explosion counts (red) for all sites and mean landings of market squids (blue) and sardine/anchovy/mackerel in million lbs (grey) per month in 2005-2014 (with standard deviation).

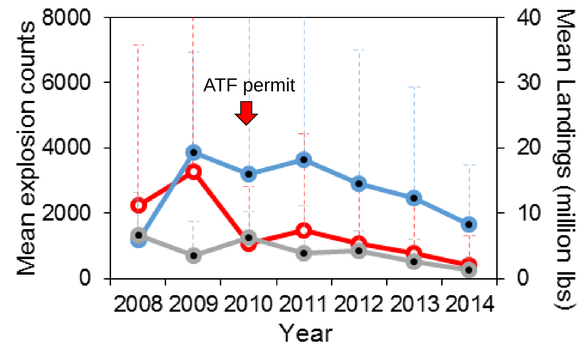
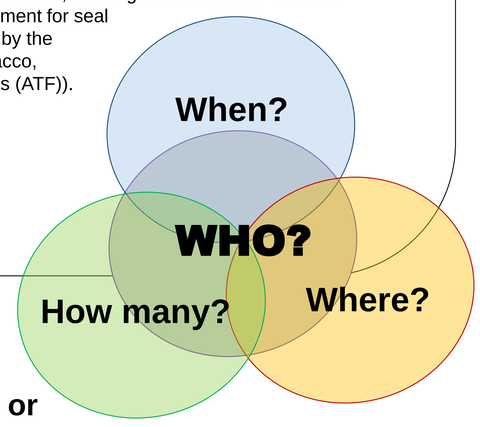
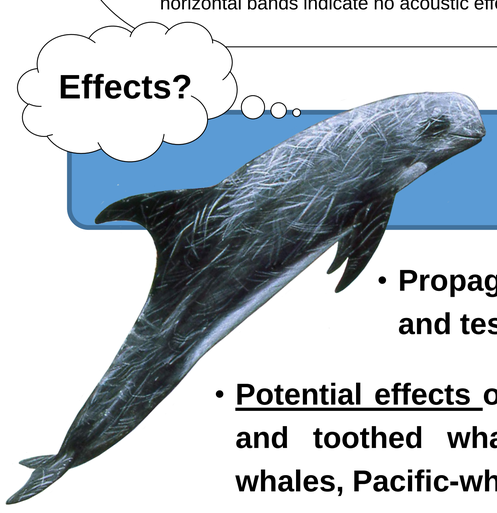


Fig. 6: Mean explosion counts (red) for sites B, C, H, M and N and mean landings of market squids (blue) and sardine/anchovy/mackerel in million lbs (grey) per year in 2008-2014 (with standard deviation; landings corrected for acoustic effort; 2010 law enforcement for seal bomb permit regulation by the Bureau of Alcohol, Tobacco, Firearms and Explosives (ATF)).





Outlook…

- **Propagation modeling with PAM data and test explosions at sea**
- **Potential effects on baleen (blue and fin whales) and toothed whale species (Cuvier's beaked whales, Pacific-white sided and Risso's dolphins)**
- **Potential species-specific effect thresholds?**
- **Might Risso's dolphins be especially vulnerable to this noise source, as they exclusively feed on squid?**
- **Collaboration with the local fishing community: Questionnaire online survey on the importance of seal bombs for fishing efficiency**

- **Maximum monthly explosion counts ranged from ~12,000 – 37,500 at site B, A, Q, K3, H, J and M (Fig. 2; all within or at least close to major fishing grounds; except site H) and from ~0 – 6,500 at the other 11 sites**
- **The vast majority of explosions happen at night (Fig. 3; a pattern persistent for all sites) and explosion counts are much lower during weekends (Fig. 4)**

→ **Night-time fishing and ban for weekends; both applies to greater extent for squid fishery**

- **Maximum of explosions during fall and early winter, minimum in spring (Fig. 5)**

→ **Monthly pattern shows strong correlation with the market squid fishery only**

- **Explosion peak in 2009, initially abrupt, then steady decrease since 2010 (Fig. 6)**

→ **Simultaneous 2009 peak with squid landings, steady decrease of both fisheries since 2011**

→ **Abrupt explosion decline in 2010 coincides with new law enforcement (ATF permits)**

CONCLUSIONS: Temporal and spatial explosion patterns highlight a correlation with both major California fisheries, but especially with the market squid fishery. Impact studies are needed to assess potential effects on marine life due to high intensity and persistence of seal bomb noise.

THANK YOU!

Collaborators & Sponsors

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