Spatial and temporal dynamics of seal bomb use in Channel Islands and Monterey Bay National Marine Sanctuaries: Acoustic impacts on cetaceans and recommendations for fisheries

Student Author: Anastasia Kunz | MESM Masters Candidate 2022 | anastasiakunz@bren.ucsb.edu

Faculty Sponsor: Steve Gaines, PhD | Bren School Dean & Distinguished Professor | gaines@ucsb.edu

Client: Lindsey Peavey Reeves, PhD | West Coast Region Sanctuary Sound Monitoring Project Coordinator | NOAA Office of National Marine Sanctuaries | lindsey.peavey@noaa.gov

Additional Collaborators:

Simone Baumann-Pickering, PhD | Associate Professor | Scripps Institution of Oceanography | Acoustic Ecology Laboratory | sbaumann@ucsd.edu

John Ryan | Senior Research Specialist | Monterey Bay Aquarium Research Institute | ryjo@mbari.org

---

Objectives:
The goal of this project is to evaluate the acoustic impact of a specific non-lethal acoustic deterrent on cetaceans in Monterey Bay and Channel Islands National Marine Sanctuaries. This project will:

1. Assess the dynamics of past and current seal bomb use by overlaying spatial and temporal distribution of fishing activity (e.g., squid fishery) with confirmed seal bomb detonations recorded on historic and current passive acoustic monitoring data sets.
    a. Contextualize these dynamics by describing how climate (i.e., temperature) has influenced spatial fishing behavior, and in turn seal bomb use.
2. Spatially overlay recorded seal bomb explosions with existing cetacean habitat distribution models, including seasonal migratory patterns, highlighting where detonations exceed species-specific acoustic exposure thresholds reported by National Marine Fisheries Service to assess impact.
3. Provide recommendations to the National Marine Fisheries Service and State of California for management options for fisheries to lessen impact on acoustically sensitive marine mammals.

Significance:
Oceans are facing increasing anthropogenic pressures, and noise pollution is a growing concern. Exposure to acute sound sources that exceed species-specific thresholds poses significant risk to acoustically sensitive species protected under the Marine Mammal Protection Act and/or Endangered Species Act. This project will provide targeted analysis of the acoustic impacts of a legal marine mammal acoustic deterrent known as seal bombs on cetaceans. These analytical products will provide integrative information needed to advance National Marine Fisheries Service's proposed rule guiding legal acoustic deterrent use. By providing insight into the effects of seal bomb detonations on non-target cetacean species of concern in sanctuary waters, fisheries and regulatory agencies may be able to collaborate to avoid high impact times or locations while still maintaining efficient fishing practices.

Background:
Channel Islands National Marine Sanctuary (CINMS, Figure 1) and Monterey Bay National Marine Sanctuary (MBNMS, Figure 2) support a number of essential ecosystem services, such as biodiversity and food supply. Ocean noise is a growing concern for protected marine resources, as current and projected levels of anthropogenic noise are unprecedented (Swaddle et al. 2015; Buxton et al. 2017). Concern is particularly high for marine mammals because they rely on vocalization to communicate and navigate. Efforts are underway to better understand sanctuary soundscapes, the combined contributions of physical processes (wind, waves), biological sources (fish, marine mammals, invertebrates), and anthropogenic sources (ship noise, navy sonar, fishing). NOAA's Office of National Marine Sanctuaries and National Marine Fisheries Service (NMFS) are tasked with facilitating multiple-uses of sanctuary waters including commercial fishing, while minimizing negative impacts to living resources and habitat.

Underwater noise presents a unique challenge in balancing these objectives, because it is widespread, variable, and baseline soundscapes have only recently begun to be sufficiently characterized across sanctuaries (NOAA National Marine Sanctuaries, 2020). Elucidating the spatial and temporal dynamics of how soundscape components overlap can inform marine spatial planning, as well as when, where, and how anthropogenic sound production can/should be managed.

Acoustic deterrents used to prevent economic loss to fisheries are man-made noise sources of concern in sanctuaries. The use of such deterrents has increased in recent decades, because "nuisance" animals have become more common. Environmental laws like the Marine Mammal Protection Act (MMPA) of 1972 have facilitated the recoveries of pinniped populations including California sea lions (Lake et al. 2018). The majority of California sea lions use rookeries on the northern Channel Islands within CINMS, and the population has now reached an 'optimum sustainable population' level, leading to increased interactions with fishing operations (Alaska Fisheries Science Center 2018). At first, fishers used lethal force to deter nuisance animals like sea lions, often injuring or killing individuals. However, this was in violation of the MMPA, and in some cases the Endangered Species Act. To avoid these illegal offenses, NMFS instead encourages the use of legal, non-lethal deterrence methods. There are a number of such methods that include auditory, physical, and chemical sensory assaults meant to signal an animal to vacate. One of the legal but unregulated auditory methods has raised concern in CINMS and MBNMS: the use of "seal bombs." Seal bombs are powerful firecrackers which can be thrown into the water to detonate a few meters below the surface. The intention is that these explosions will reduce damage to fishing gear and/or stealing the target catch caused by nuisance animals.

The Marine Bioacoustics Research Collective at Scripps Institution of Oceanography (SIO) conducted initial investigations into seal bombs as a source of underwater sound. Results indicate that they reach source levels of 234 dBp re 1 μPa at 1m that can travel underwater for tens of miles depending on topography. As a result, the acoustic impacts of seal bombs often reach beyond the target pinnipeds, impacting sensitive non-target species in the region (Simonis et al. 2020). SIO has also reported correlations between seal bomb explosions and fishing activity in CINMS revealing that through 2014, it was largely market squid fishing activity tied to recorded seal bomb explosions in space and time (Meyer-Loebbecke et al. 2016). The highest daily seal bomb use recorded at a listening station south of CINMS was >3,500 in 2006 (Meyer-Loebbecke et al. 2015). In MBNMS, the Monterey Bay Aquarium Research Institute (MBARI) recorded similarly concerning use of thousands of seal bombs annually. The current understanding is that peak seal bomb use in MBNMS occurs in the summer, with counts as high as 88 explosions in one hour and 335 in one day, recorded in 2018 (Simonis et al. 2020). While there is evidence that suggests a steady decrease in seal bomb activity in CINMS since 2010, there has not been an integrative analysis of this management issue since 2014, or expanded to include other regions of interest like MBNMS across any time scale. The data and management concern exists to complete a comprehensive analysis of the temporal and spatial dynamics of this issue at the scale of California sanctuaries, and to consider how environmental conditions affect fisheries, subsequently driving seal bomb use.

NMFS is currently addressing the concern surrounding unregulated seal bomb use. In August 2020 the agency proposed a rule that would provide guidance for the use of legal, non-lethal methods to safely deter "marine mammals from damaging fishing gear or catch, damaging personal or public property, or endangering personal safety" (NOAA Fisheries, 2020). NMFS is currently considering the submitted public comments in response to the proposal and will finalize the rule at a later date. At the same time, since 2018 a team of government and academic researchers have been passively and near-continuously recording the underwater soundscape at new listening stations: three stationary monitoring locations in MBNMS, and five stationary monitoring locations in CINMS (NOAA National Marine Sanctuaries, n.d.). These stations combined with the SIO and MBARI long-term listening stations provide good spatial and temporal coverage of CINMS and MBNMS to examine this issue.

Data:

Objective 1:

Fishing activity data - *available through Office of National Marine Sanctuaries & partners*

- Global Fishing Watch and Visible Infrared Imaging Radiometer Suite (VIIRS) day/night band to track squid fishing
- Automatic Identification System (AIS) fishing activity data from SanctSound program
- Vessel Monitoring System (VMS) fishing activity data from CINMS
- California Department of Fish and Wildlife fish ticket/landing data

Acoustic monitoring data - *available through Office of National Marine Sanctuaries & partners*

- NOAA's SanctSound monitoring data for CINMS and MBNMS, preprocessed for seal bomb detections 2018 through present day.
- SIO Acoustic Ecology Laboratory and MBARI (from 28 July 2015 - 2019) historic acoustic data
- Sea surface temperature. Open source available satellite imagery; NOAA, NASA

Objective 2:

Species-specific data - *open access*

- Cetacean migration/distribution from Point Blue Conservation, NOAA Southwest Fisheries Science Center
- Marine mammal acoustic thresholds using NMFS open source impact assessment ShinyApp tools

Possible Approaches:

1. Utilize the historic (SIO and MBARI) and current passive acoustic data from NOAA's National Marine Sanctuary Sound Monitoring program (SanctSound) to track the temporal and spatial changes in the distribution of fishing activity using non-lethal acoustic deterrents in fishing practices.
   a. In ArcGIS, overlay locations of seal bomb detonations in CINMS and MBNMS each year to create time series tracking locational changes.
   b. Overlay fishing activity data (AIS, VMS, CDFW landings, satellite imagery, or Global Fishing Watch and VIIRS) to track fishing activity changes in relation to seal bomb distribution in ArcGIS.
   c. Create a time series of sea surface temperature changes as a potential driver of shifts.
2. Overlay seal bomb detections from passive acoustic data (2014 - present) with known cetacean migration and distributions in ArcGIS within both marine sanctuaries as geographic study units.
   a. Identify species-specific acoustic exposure thresholds, highlighting locations and times of the year where seal bomb detonations exceed these thresholds within the seasonal and spatial migration path using NOAA's open access technical tools.
3. Create an outward facing interactive map (RStudio, Google Earth Engine, or ArcPy) that allows users to navigate through both marine sanctuaries' bounds to see where there is a high likelihood of seal bomb use exceeding acoustic exposure for cetacean species.

Deliverables

In addition to the project final report, poster, and presentation, final deliverables for this project include:

- **Time series map** of distribution changes in fishing activity using seal bombs across Channel Islands and Monterey Bay National Marine Sanctuaries.
- **Map** highlighting regions where seal bomb detonations exceed acoustic threshold for cetaceans within migratory or distribution ranges.
- **Recommendations** to NMFS for best management practices to mitigate impact on cetaceans within MBNMS and CINMS (e.g., seasonal and spatial restrictions on use).
- **Public facing interactive web resource** to highlight recommended times and locations to limit seal bomb use to avoid impacting acoustically sensitive marine mammals.

Internships

NOAA Office of National Marine Sanctuaries is able to sponsor one or two paid internships up to $5,000. Intern(s) will be supervised by Dr. Peavey Reeves and can work remotely, or sit in any NOAA office. The internship will be focused on sanctuary communications of this work.

Budget and Budget Justification

The budget for this project is not projected to exceed the $1,300 provided by the Bren School of Environmental Science & Management.

Supporting Materials

Gedamke, Jason; Hatch, Leila; Harrison, Jolie. NOAA's Ocean Noise Strategy: 2019 Progress Report. December 2019.

Wiggins, S. M, Krumpel, A., Dorman L. M., Hildebrand, J. A., Baumann-Pickering, S. "Seal Bomb Sound Source Characterization," Marine Physical Laboratory, Scripps Institution of Oceanography, University of California San Diego, La Jolla, CA, MPL Technical Memorandum 633 February 2019. Report submitted to and funded by National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service (NMFS) under Cooperative Agreement Grant No. NA15OAR4320071 Amendment 101. Experiment funding provided by Okeanos Foundation for the Sea. Experiment conducted under US Department of Justice (DOJ) Bureau of Alcohol, Tobacco, Firearms and Explosives (ATF) Federal Explosives license/permit No. 9-CA-073-33-0M-02140.

Data References

Global Fishing Watch and VIIRS fishing activity data on squid fishing. Reference
NOAA's Sound Monitoring passive acoustic monitoring. Reference
SIO Acoustic Ecology Laboratory and MBARI historic acoustic data Reference
Acoustic thresholds for marine mammals. Reference
NOAA's open access tools for acoustic thresholds. Reference

Citations

Alaska Fisheries Science Center. *California Sea Lion Population Rebounded to New Highs*, NOAA Fisheries, 2018, www.fisheries.noaa.gov/feature-story/california-sea-lion-population-rebounded-new-highs.

Buxton, Rachel; McKenna, Megan; Mennitt, Daniel; Fristrup, Kurt; Crooks, Kevin; Angeloni, Lisa Wittemyer, George. (2017). Noise pollution is pervasive in U.S. protected areas. *Science.* Vol. 356, Issue 6337, pp. 531-53. DOI: 10.1126/science.aah4783

Laake, Jeffrey; Lowry, Mark; Delong, Robert; Melin, Sharon; Carretta, James. (2018). Population growth and status of California sea lions: Status of California Sea Lions. *The Journal of Wildlife Management.* 82. 10.1002/jwmg.21405.

Meyer-Loebbecke, Anna; Debich, Amanda; Širović, Ana; Trickey, Jennifer; Roch, Marie; Carretta, James; Fraiser, Kait; Wiggins, Sean; Hildebrand, John; Denzinger, Annette; Schnitzler, Hans-Ulrich; Baumann-Pickering, Simone. (2016). Noise from explosive deterrents used by California fisheries and possible effects on marine life. Scripps Institute of Oceanography. http://baumann.ucsd.edu/docs/posters/MeyerLoebbecke_AN2016.pdf

Meyer-Loebbecke, Anna; Debich, Amanda; Širović, Ana; Trickey, Jennifer; Roch, Marie; Carretta, James;Wiggins, Sean; Hildebrand, John; Denzinger, Annette; Schnitzler, Hans-Ulrich; Baumann-Pickering, Simone.(2015). The use of "seal bombs" in fisheries and possible influences on cetacean acoustic behavior in Southern California. Scripps Institute of Oceanography.

NOAA. "Noise Sanctuary Sentinel Site Issue." *Noise*, NOAA & US Department of Commerce (2013) https://sanctuaries.noaa.gov/science/sentinel-site-program/noise.html

NOAA Fisheries. *Deterring 'Nuisance' Pinnipeds.* NOAA Fisheries. Sept. 2020, www.fisheries.noaa.gov/west-coast/marine-mammal-protection/deterring-nuisance-pinnipeds#deterrence-methods.

NOAA National Marine Sanctuaries. "Sound Monitoring." (n.d.) *Sound Monitoring | Office of National Marine Sanctuaries*, NOAA, https://sanctuaries.noaa.gov/science/monitoring/sound/

NOAA National Marine Sanctuaries. NOAA-Navy Sanctuary Soundscape Monitoring Project (SanctSound) 2020 Progress Report. (2020).

Simonis, A. E., K. A. Forney, S. Rankin, J. Ryan, Y. Zhang, A. DeVogelaere, J. Joseph, T. Margolina, A. Krumpel, and S. Baumann-Pickering (2020), Seal Bomb Noise as a Potential Threat to Monterey Bay Harbor Porpoise, Frontiers in Marine Science, March 13, 2020, https://doi.org/10.3389/fmars.2020.00142

Swaddle, John & Francis, Clinton & Barber, Jesse & Cooper, Caren & Kyba, Christopher & Dominoni, Davide & Shannon, Graeme & Aschehoug, Erik & Goodwin, Sarah & Kawahara, Akito & Luther, David & Spoelstra, Kamiel & Voss, Margaret & Longcore, Travis. (2015). A framework to assess evolutionary responses to anthropogenic light and sound. Trends in Ecology & Evolution. 10.1016/j.tree.2015.06.009.

Maps and Figures

Figure 1. Map of Channel Islands National Marine Sanctuary

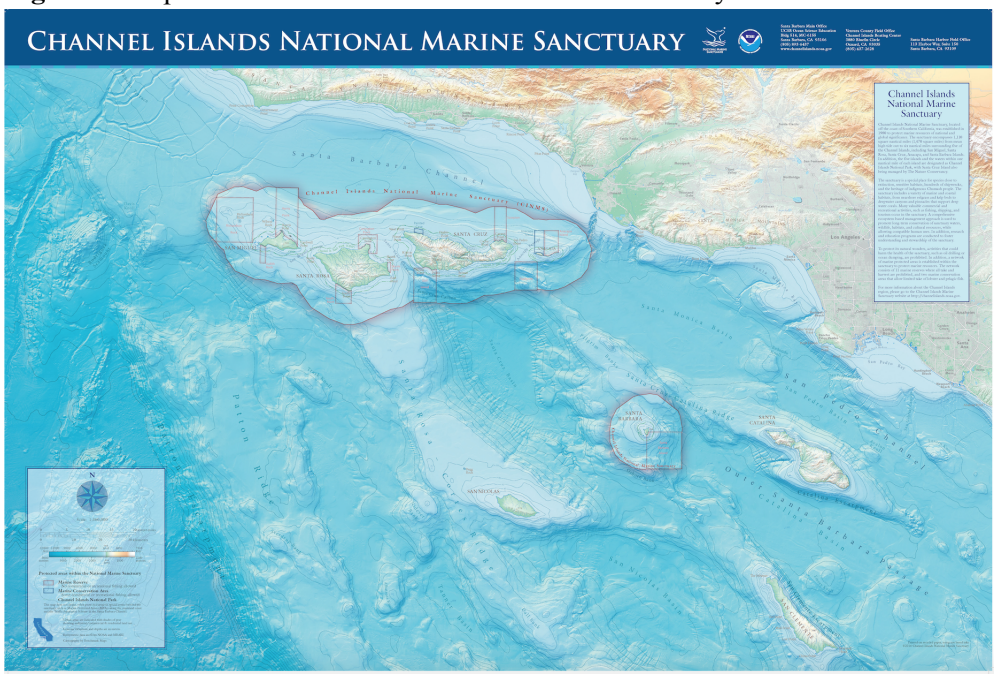
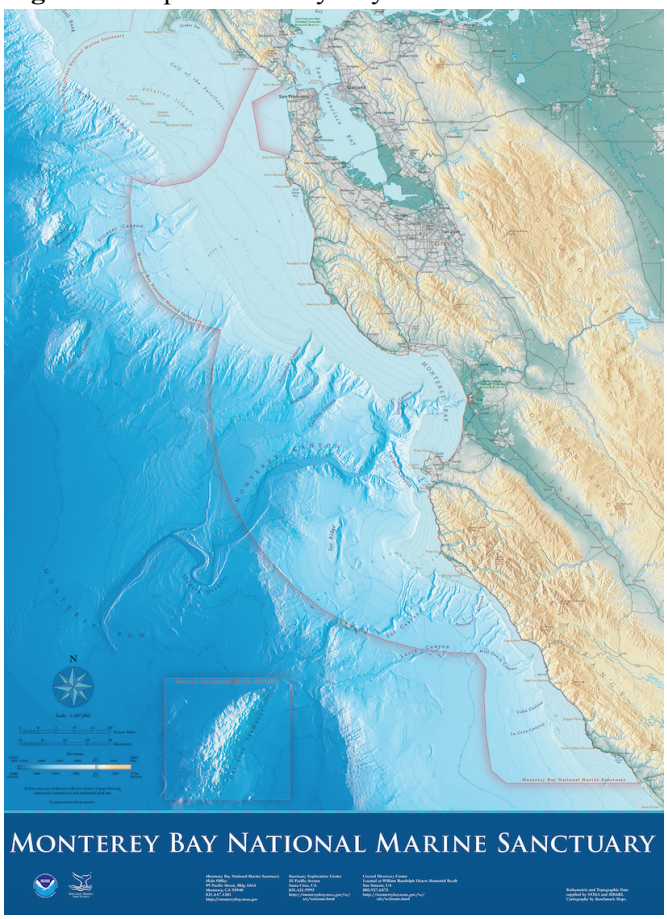


Figure 2. Map of Monterey Bay National Marine Sanctuary



UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL OCEAN SERVICE
Office of National Marine Sanctuaries
Conservation Science Division
1305 East-West Highway, 11th Floor
Silver Spring, MD 20910

January 18, 2021

Group Project Committee
Bren School of Environmental Science & Management
2400 Bren Hall
University of California
Santa Barbara, CA 93106

Re: Group Project Proposal – *Spatial and temporal dynamics of seal bomb use in Channel Islands and Monterey Bay National Marine Sanctuaries: Acoustic impacts on cetaceans and recommendations for fisheries*

Dear Group Project Committee,

I am writing to express NOAA Office of National Marine Sanctuaries (ONMS) Conservation Science Division's support for and commitment to the Group Project Proposal: *Spatial and temporal dynamics of seal bomb use in Channel Islands and Monterey Bay National Marine Sanctuaries: Acoustic impacts on cetaceans and recommendations for fisheries*. The project aims to evaluate the impacts of a specific non-lethal acoustic deterrent, seal bombs, on cetaceans in Monterey Bay and Channel Islands National Marine Sanctuaries. The analytical approach will integrate data from passive acoustic monitoring, environmental conditions, fisheries, and cetacean habitat use to define areas and time periods where cetaceans have been exposed to seal bomb explosions in CINMS and MBNMS. The approach will also describe the dynamics driving seal bomb use variation across space and time, and in turn a better understanding of how this sound source has posed risk to cetaceans. Both sanctuaries will be end-users of this information to better track sound stressors introduced from fishing activity within sanctuary boundaries. Additionally, the information will be presented to the State of California and the National Marine Fisheries Service to support their management of acoustic stressors to cetaceans in marine protected areas. NOAA ONMS Conservation Science Division's west coast regional coordinator of sanctuary soundscape monitoring will help formulate the project including developing the work plan, schedule and outcomes/deliverables, and provide support through regular communication and facilitation.

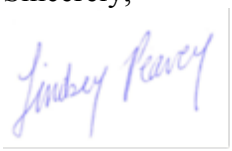
Internships: NOAA ONMS has a strong track record of managing and mentoring students and interns. We would like to offer one or two paid (up to $5,000) summer internships to students working on this project. The focus of the internship will be developing ONMS communication of the group project's results. I will be the internship mentor and am based in Santa Barbara, CA. The intern(s) would be able to work from the Bren School, home, sit at the NOAA CINMS office located on the UCSB campus, or sit in any other NOAA office around the country if needed. I am prepared to manage the intern(s) remotely, however if the intern(s) remains in Santa Barbara for the summer we will plan to meet in-person regularly. I will work with the intern to set concrete deadlines, work through sticking points and help them appropriately engage with the correct collaborators to meet objectives. The intern will also be working with Dr. Leila Hatch, the national lead for the SanctSound program, as well as ONMS communications staff members located at our headquarters office in Washington, DC.

Funding: As the project is focused on processing existing datasets, we do not anticipate the need for funding needs beyond the costs for ONMS staff time to engage with the project team and mentor the intern(s), which we will contribute as in-kind funding.

Data: The project plans to use publically available data, as outlined in the proposal. Although the datasets and data products are public, in several cases they are not readily discoverable and instead held by agencies, such as California Fish and Wildlife. We do not anticipate any hurdles to use, but I can help Bren students navigate data acquisition.

The proposed project will result in interactive acoustic risk maps and estimates of impacts to cetaceans that will inform sanctuary condition reporting and management planning. The products will be immediately relevant to current regulatory processes underway to issue legal guidance to fisheries and others using seal bombs as non-lethal acoustic deterrents. We are excited to work with Bren School students and offer them valuable science-based management experience during this stage of their career path. As the next leaders in the environmental management field, soon they will be working for the organizations eager to receive these project results. We urge the Bren School to support this timey and important project.

Sincerely,



Lindsey Peavey Reeves, Ph.D.
West Coast Region Sanctuary Soundscape Monitoring Project Coordinator
NOAA Office of National Marine Sanctuaries
Conservation Science Division