Using acoustics to study impacts to marine mammal populations

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March 29, 2918
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Oil spill response, assessment, and restoration: marine mammals
Photo: Manny Garcia, LADCGEMM.org
LADC-GEMM (Littoral Acoustic Demonstration Center – Gulf Ecological Monitoring and Modeling)
Goals

• **Goal:** Gain a better understanding of how the Deepwater Horizon oil spill impacted marine mammal populations (sperm and beaked whale)

• **Methods:**
  - Apply passive acoustic data collection to obtain estimates of regional abundances before and after the spill
  - Develop mathematical methods to predict the possible long-term impacts of events such as oil spills on marine mammals
Experimental sites

- Northern & Southern site: ~1500 m deep
- Western site: ~1000 m deep

Ackleh et al. 2012
Data description

- **July 2007**: a two-week visual and acoustic survey of marine mammal activity for northern and southern site (baseline data at the oil spill site)
- **September 2010**: a two-week acoustic survey at all previous sites and add a western site to collect post-spill data
- **June-October 2015**: 4-month acoustic survey at previous sites (2010) to collect post-spill data
- **(September 2016- January 2017)**: 5-month acoustic survey
Environmental Acoustic Recording System (EARS) buoys

- 500 lbs (1102kg) flotation
- EARS BUOYS
- 250 lbs (550kg) weight in water
- 1/4” (6mm) Nylon Jacketed wire
- 20 lbs (44kg) weight in water
- 100 lbs (220kg) flotation
- Dual acoustic releases
- 150 lbs (331kg) weight in water
- 3/8” chain
- 49.4 lbs (109kg) weight in water
- 800 lbs (1764kg) anchor weight in water

Ackleh et al. 2012
Autonomous surface vehicles (ASVs) and Gliders
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Beaked whale detection results

Sidorovskaia et al., *under review*
Distribution of beaked whales  
Northern site (2015)

Sidorovskaia et al., *under review*
Distribution of beaked whales
Western site (2015)

Acoustic activity of beaked whales detected at the western site

Sidorovskaia et al., under review
Density estimation

Beaked whale

Population density (per 1000 km²)

07/07 07/15 09/10 09/15

Northern site

Southern site

Sidorovskaia et al., under review
Sperm whale density estimates

Ackleh et al. 2012
Preliminary sperm whale density estimation trend
Summary

• We observe three types of beaked whales: Cuvier, Gervais, and BWG.

• Overall, beaked whale abundance increased after the spill.

• Cuvier density increased at the N site. Gervais density may have decreased at S site.

• From 2007 to 2010, sperm whales decreased in the N site and increased in the S site.
Modeling as a complementary tool to acoustic data

• Key question: what are long-term population trends for marine mammals in the Gulf of Mexico?
• Depends on properties of the species: survival rates, fecundity, maturation time
• Depends on external environmental conditions: oil spills (frequency and severity), other disturbances, and human activities
Model for female sperm whales

• 1- calf, 2- immature, 3- mature, 4- mother, 5-post breeding (Chiquet et al. 2013)

• The population is growing at a slow rate of 0.96% per year [-3.6% to 3.0%]
How do we model disturbances?

**Input:**
- magnitude of effect
- length of effect
- time between events

**Output:**
- population size over time
- recovery time and sensitivities
- probability of extinction
Recovery time following a single disturbance
Probability of recovery

Reductions in survival

Reductions in fecundity

Length of impact = 10 years
Ackleh et al. 2017
Sensitivity of recovery time

- Sensitivity/Elasticity measures how additive/proportional changes in an input variable affect an output variable (recovery time).
- The recovery time is more sensitive to the adult reproductive class (initial density and survival) than the other stages.
- The recovery time is more sensitive to changes in the magnitude of impact than the duration of impact.
Population persistence under reoccurring disturbances
The growth rate is always more sensitive to proportional changes in the magnitude of impact than the average time between disturbances or the average length of effect of a disturbance (for any population).
Summary

• General mathematical methods have been developed that can be applied to better understand the relationship between disturbances and population recovery or persistence.
• Available data can be implemented into the model to improve model outputs.
• The magnitude of impact appears to be the most important feature of a disturbance for population recovery and persistence.
References


• Veprauskas, A., Ackleh, A.S., and Tang, T., Examining the effect of multiple disturbances on population persistence with application to marine mammals, under review.