

Using acoustics to study impacts to marine mammal populations

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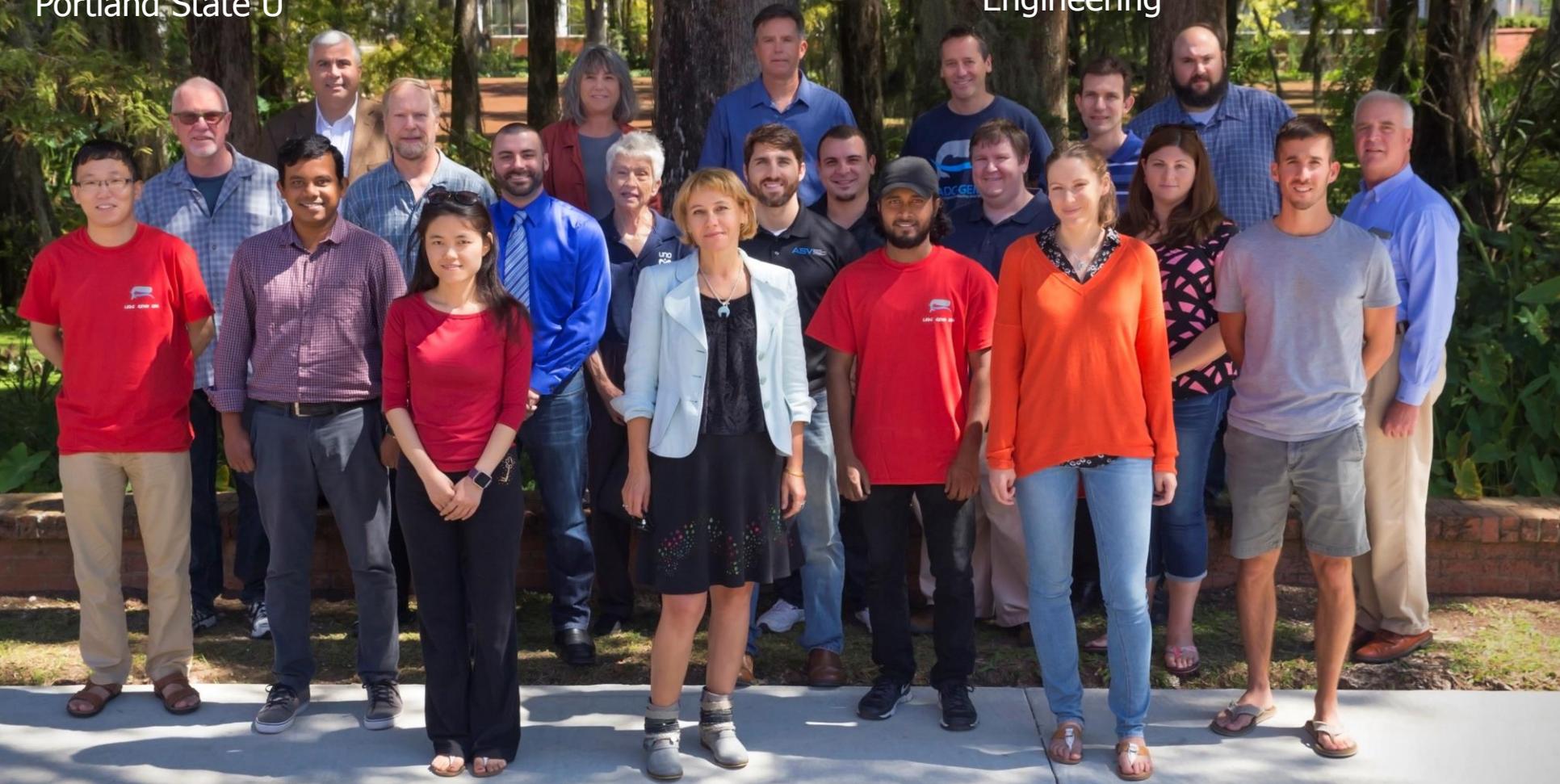
Oil spill response, assessment, and restoration: marine mammals

Photo: Manny Garcia, LADCGEMM.org

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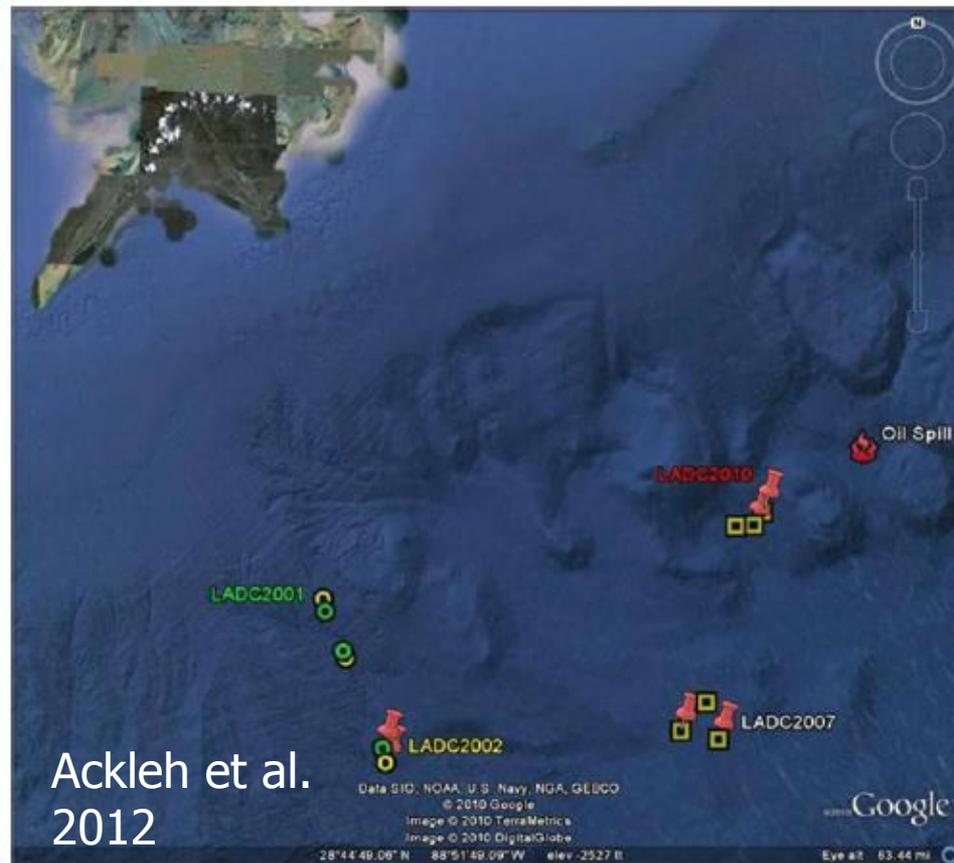


LADC-GEMM (Littoral Acoustic Demonstration Center – Gulf Ecological Monitoring and Modeling)

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

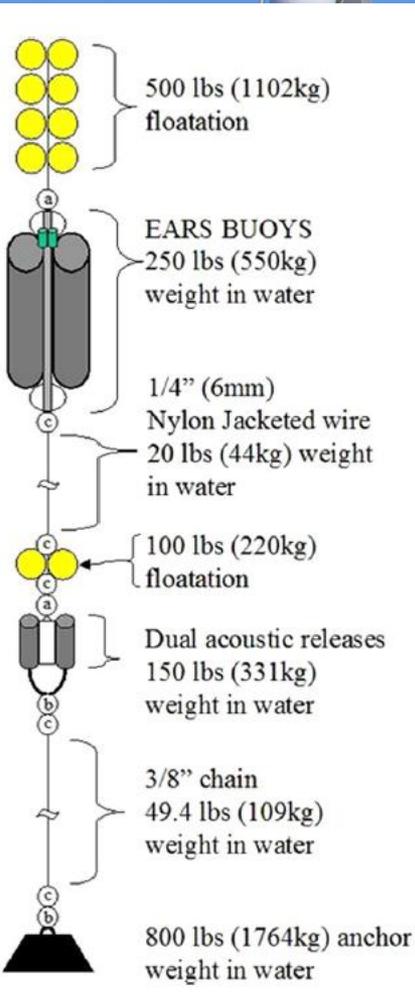


- Northern & Southern site: ~ 1500 m deep
- Western site: ~ 1000 m deep

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



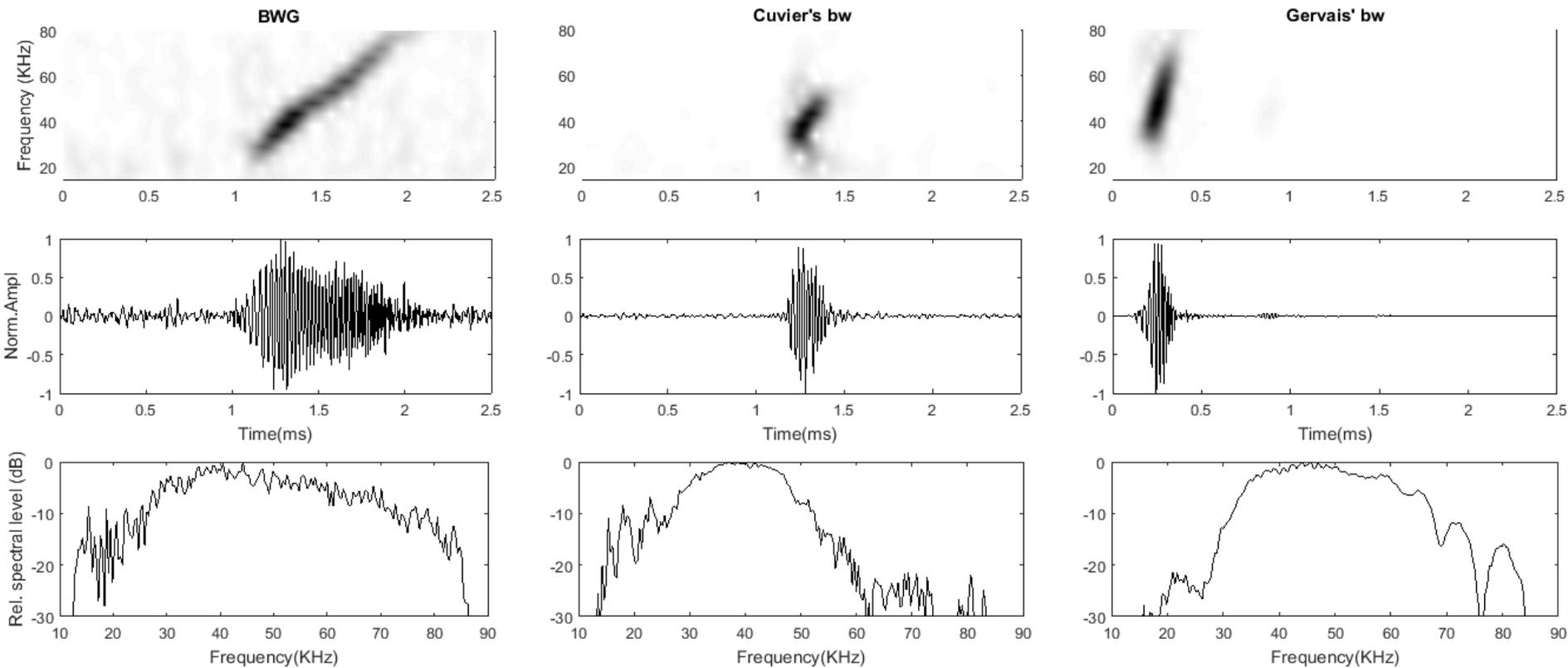
Autonomous surface vehicles (ASVs) and Gliders



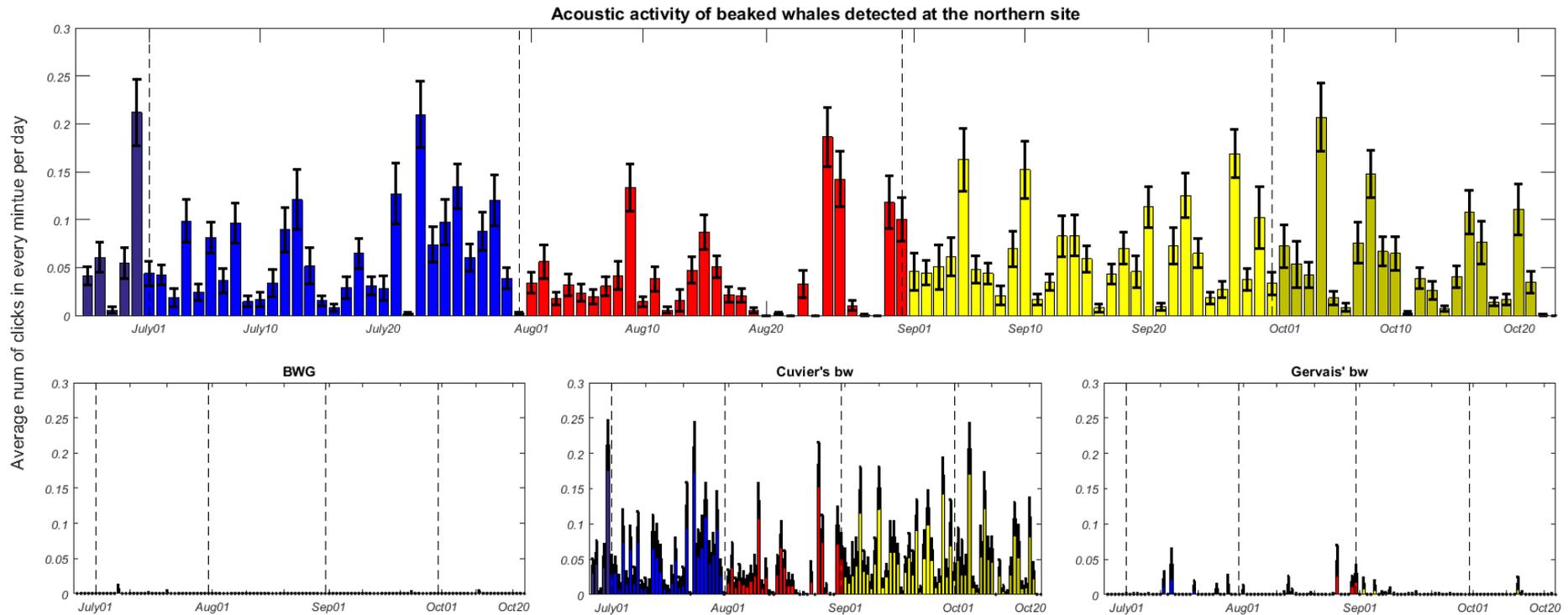
Autonomous surface vehicles (ASVs) and Gliders



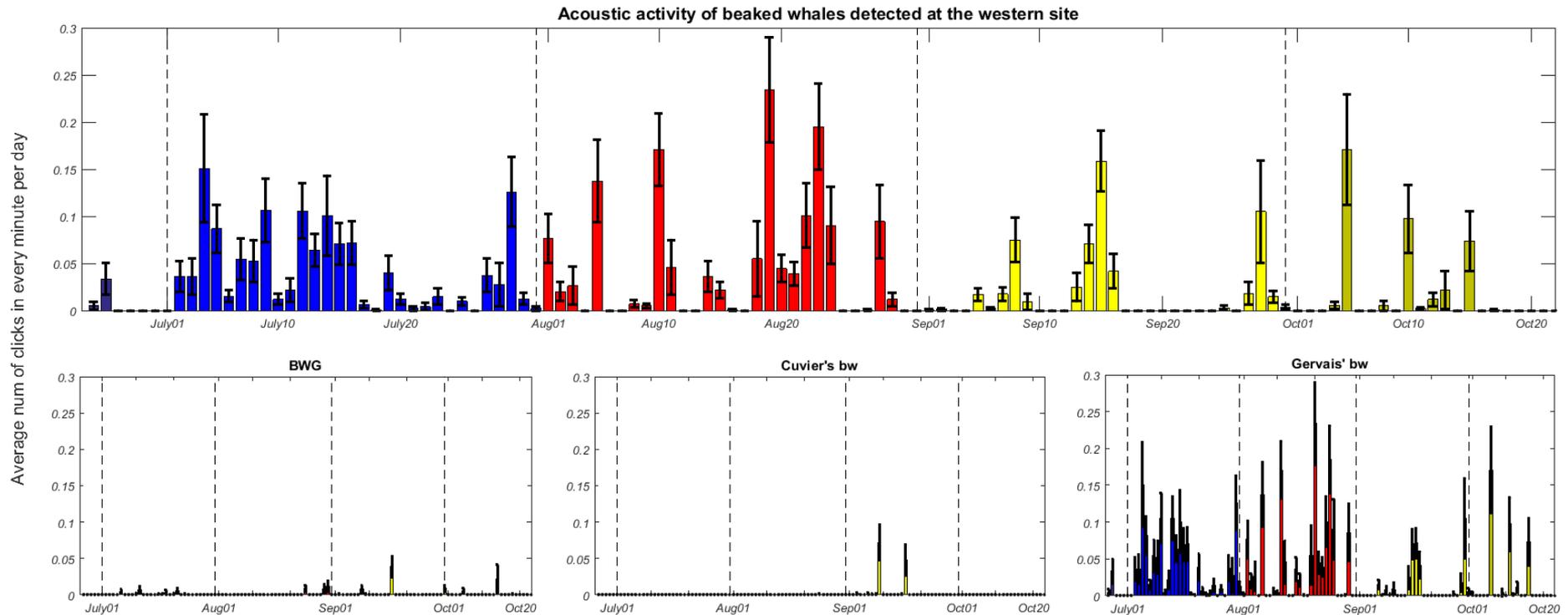
Beaked whale detection results



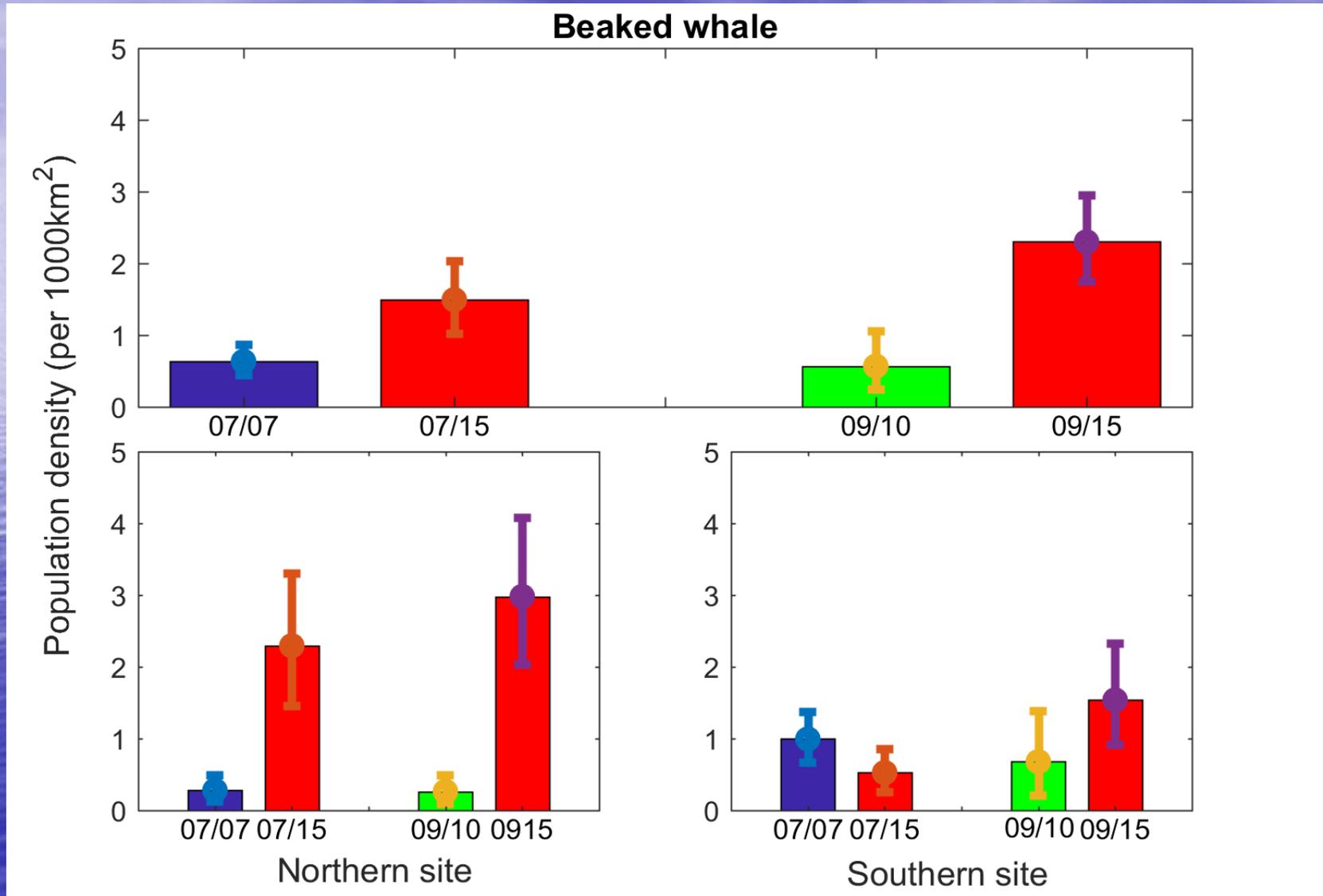
Distribution of beaked whales Northern site (2015)



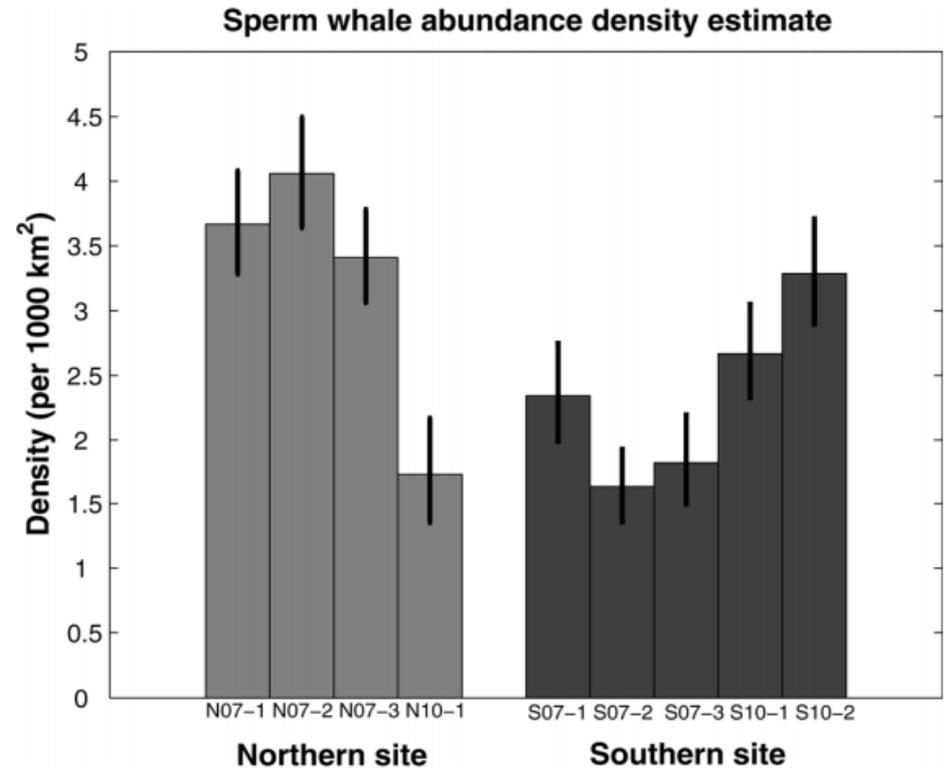
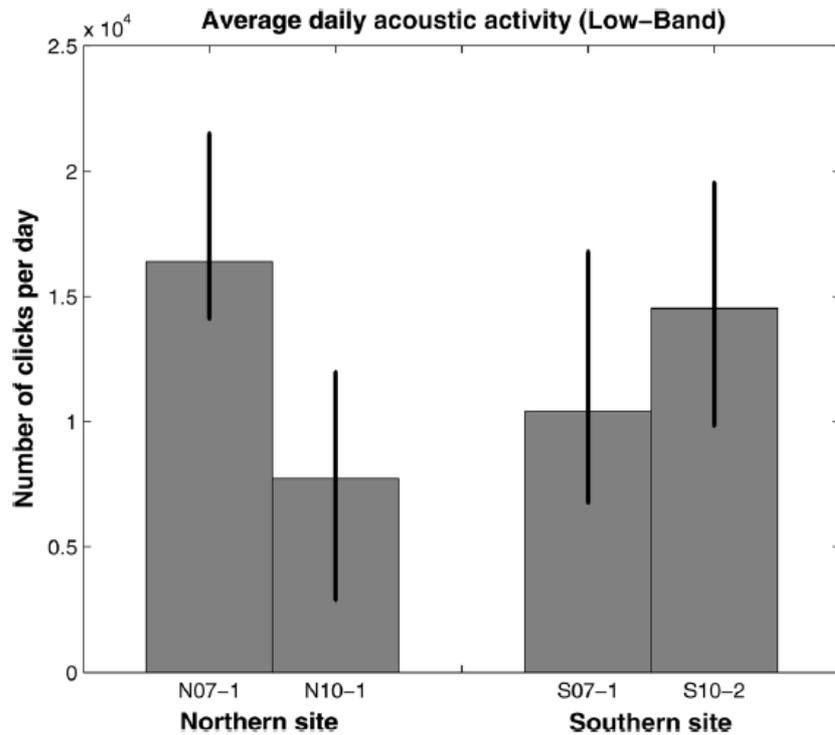
Distribution of beaked whales Western site (2015)



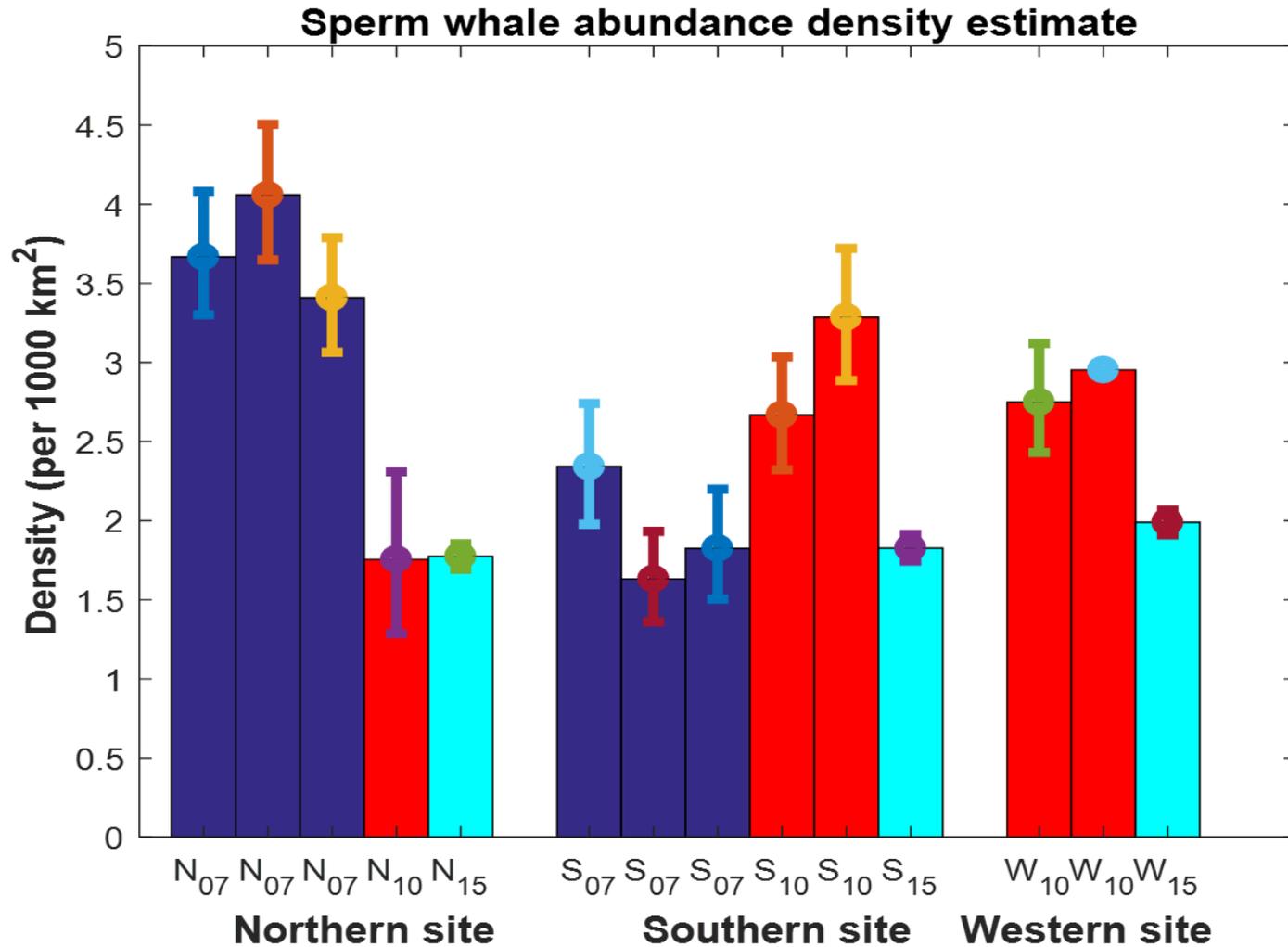
Density estimation



Sperm whale density estimates



Preliminary sperm whale density estimation trend



Summary

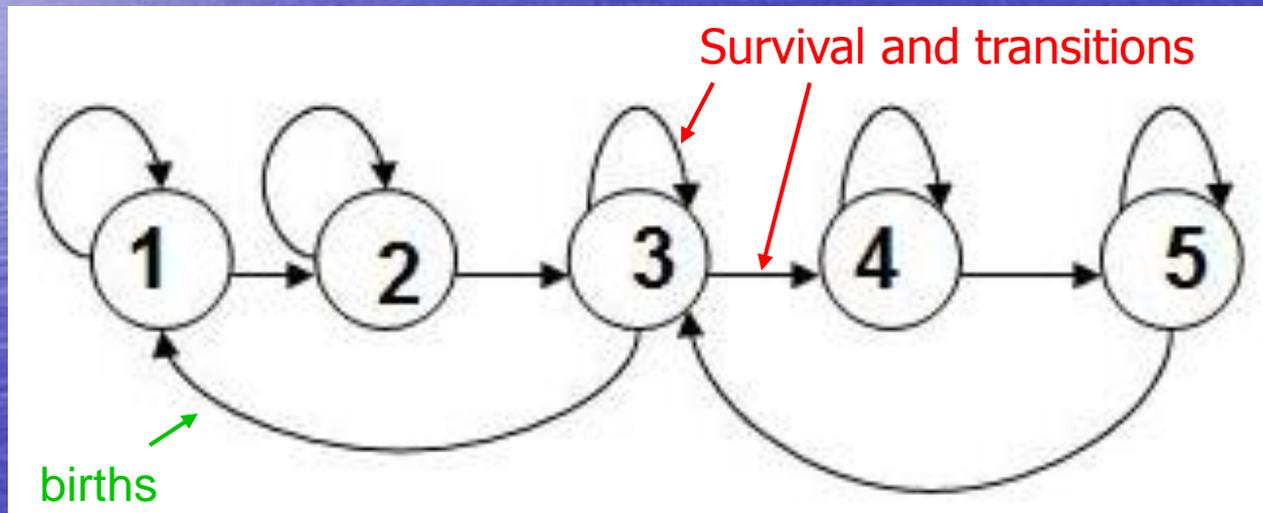
- We observe three types of beaked whales: Cuvier, Gervais, and BWG.
- Overall, beaked whale abundance increased after the spill.
- Cuvier density increased at the N site. Gervais density may have decreased at S site.
- From 2007 to 2010, sperm whales decreased in the N site and increased in the S site.

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

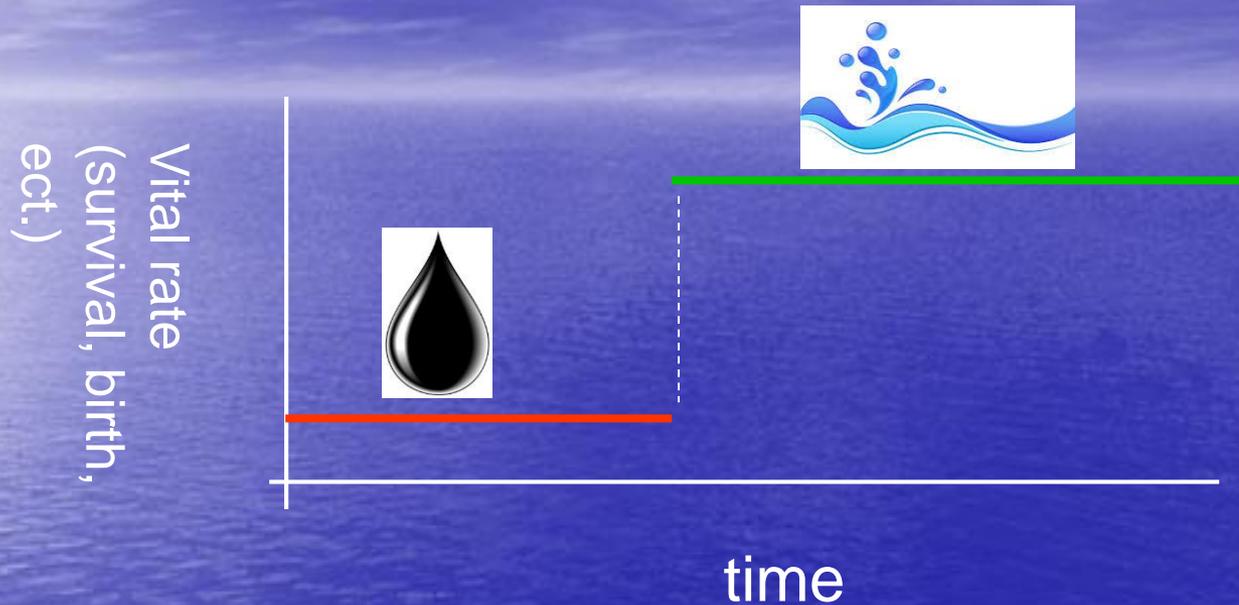
Model for female sperm whales

- 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?



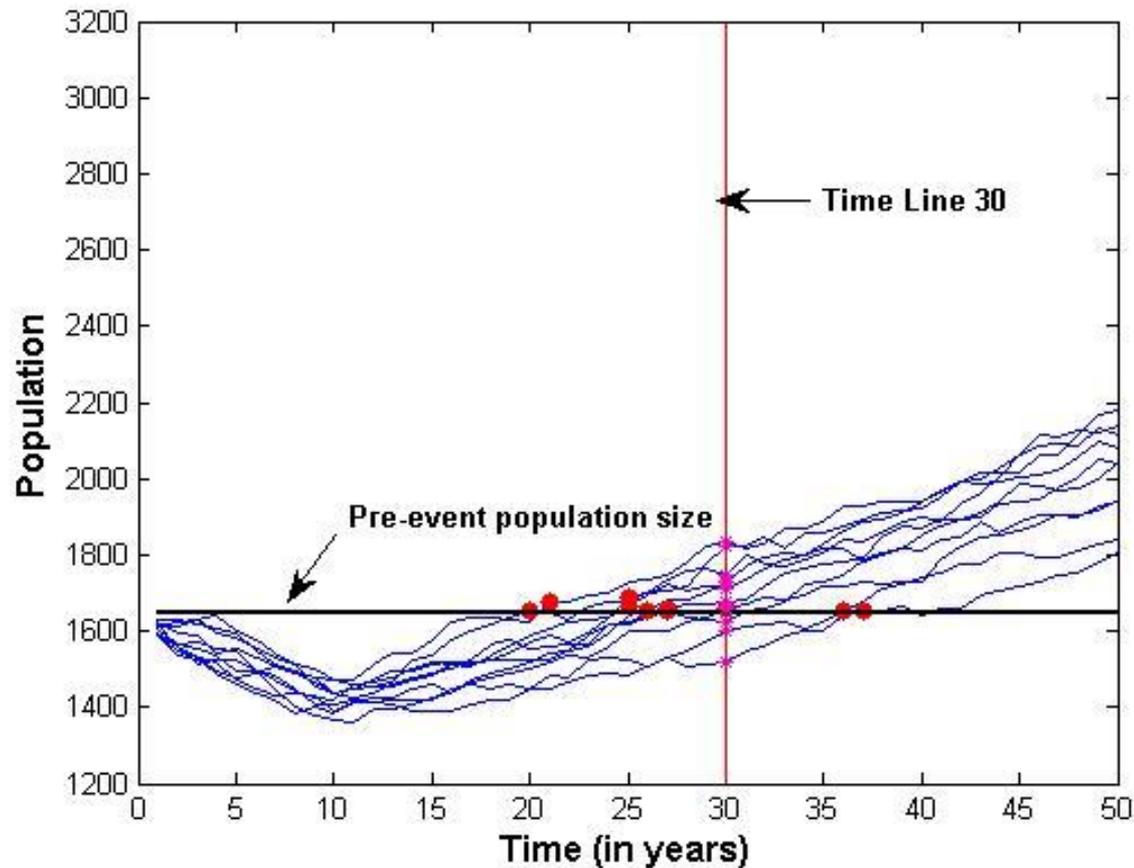
- Input:

- magnitude of effect
- length of effect
- time between events

- Output:

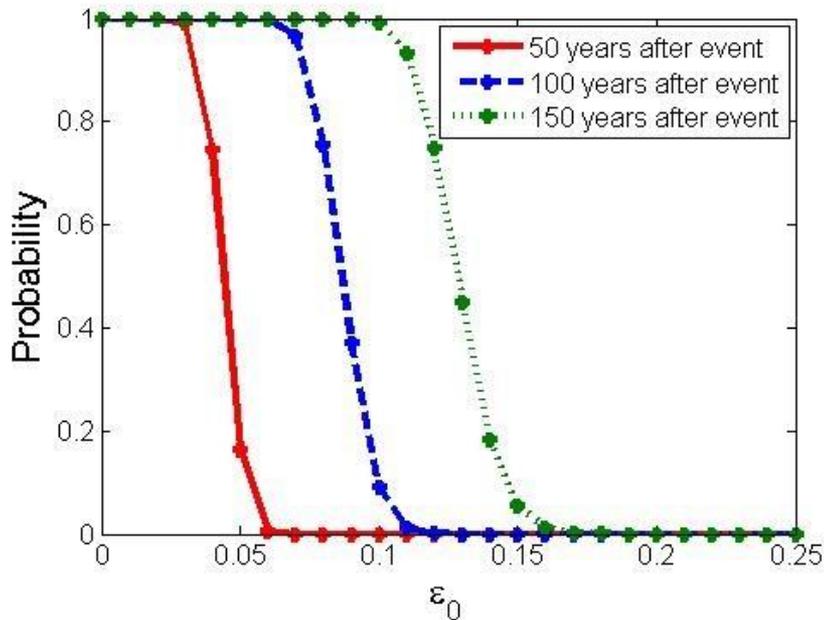
- population size over time
- recovery time and sensitivities
- probability of extinction

Recovery time following a single disturbance

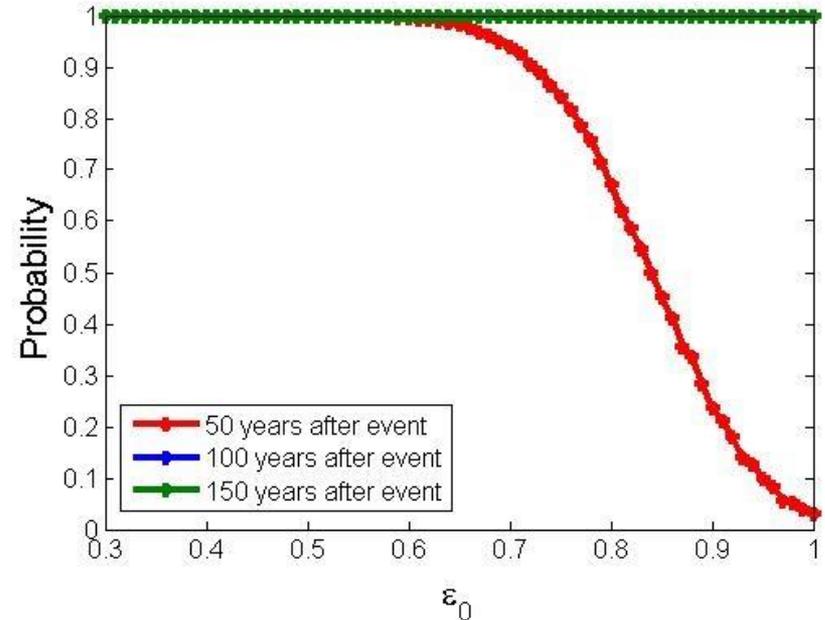


Probability of recovery

Reductions in survival



Reductions in fecundity



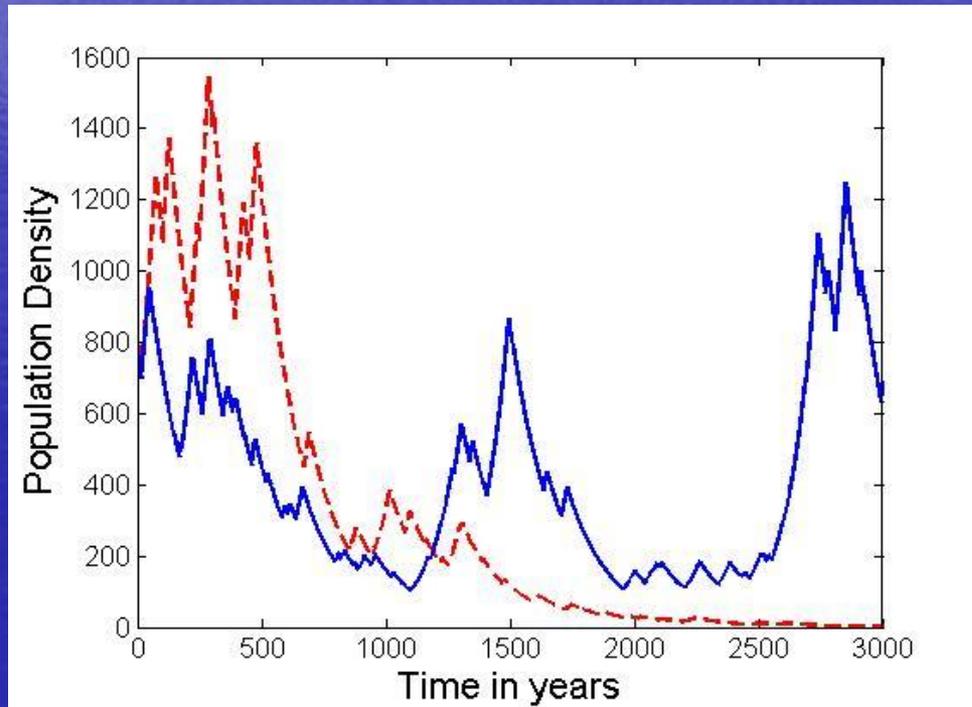
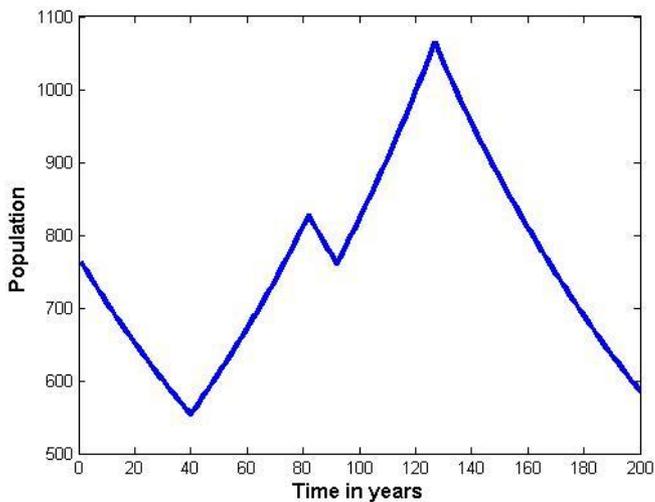
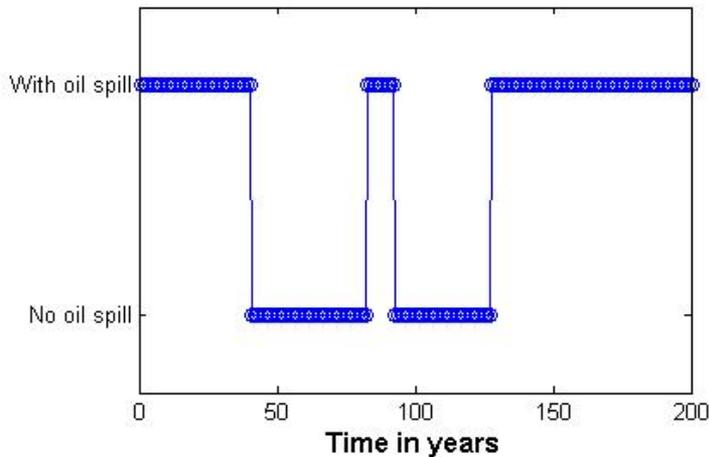
Length of impact = 10 years
Ackleh et al. 2017

Sensitivity of recovery time

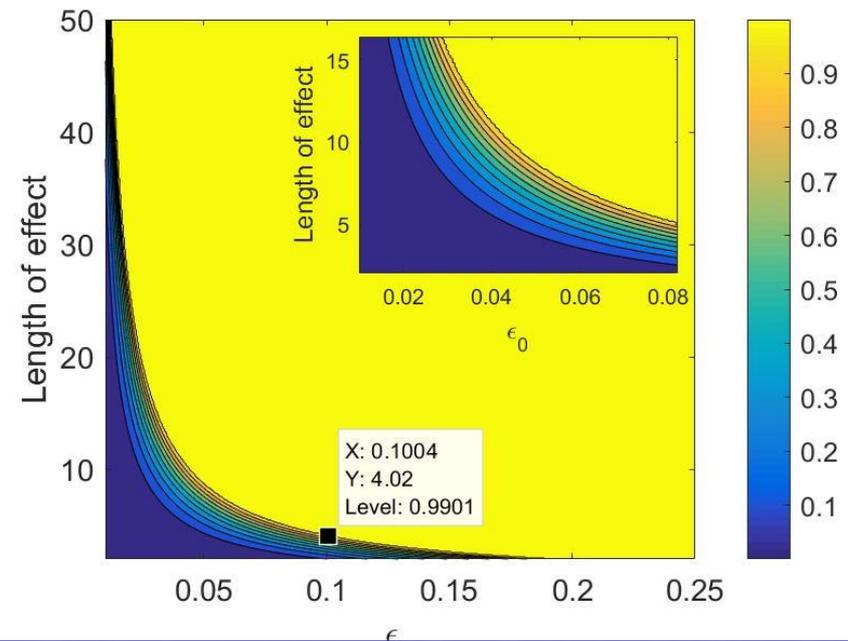
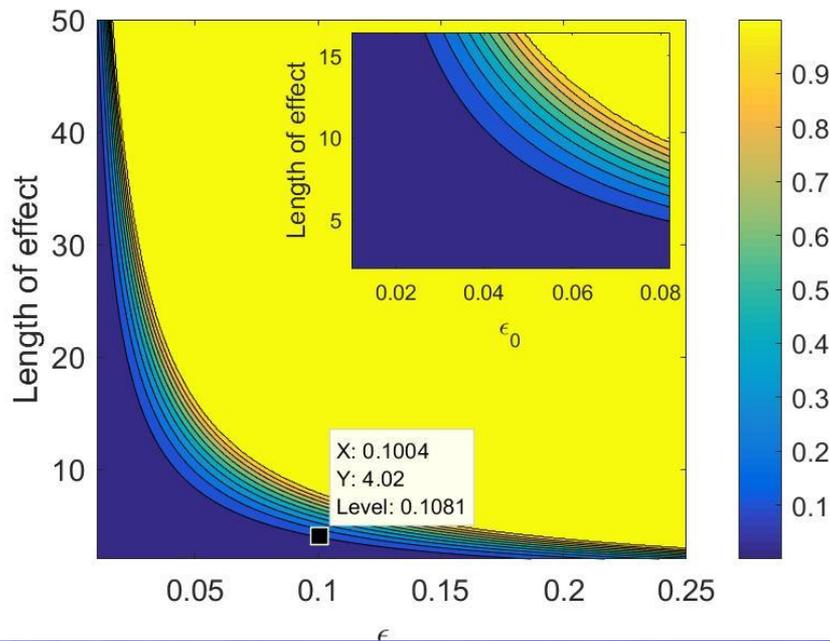
- Sensitivity/Elasticity measures how additive/proportional changes in an input variable affect an output variable (recovery time)
- The recovery time is more sensitive to the adult reproductive class (initial density and survival) than the other stages
- The recovery time is more sensitive to changes in the magnitude of impact than the duration of impact

Population persistence under reoccurring disturbances

The Environment



Probability of extinction given one (left) or two (right) events every 100 years



- 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

- Ackleh, A.S., Caswell, H., Chiquet, R. A., Tang, T., and Veprauskas, A. (2018) Sensitivity analysis of the recovery time for a population under the impact of an environment disturbance, to appear in Natural Resource Modeling. doi: 10.1111/nrm.12166.
- Ackleh, A. S., Chiquet, R. A., Ma, B., Tang, T., Caswell, H., Veprauskas, A., and Sidorovskaia, N. (2017). Analysis of lethal and sublethal impacts of environmental disasters on sperm whales using stochastic modeling. *Ecotoxicology*, 26, 820-830.
- Ackleh, A. S., Ioup, G. E., Ioup, J. W., Ma, B., Newcomb, J. J., Pal, N., Sidorovskaia, N. A., Tiemann, C. (2012). Assessing the Deepwater horizon oil spill impact on marine mammal population through acoustics: endangered sperm whales. *The Journal of the Acoustical Society of America* 131(3):23062314.
- R. A. Chiquet, B. Ma, A. S. Ackleh, N. Pal, and N. Sidorovskaia (2013), Demographic analysis of sperm whales using matrix population models, *Ecological Modeling*, 248, 71-79.
- Sidorovskaia, N.A., Ackleh, A.S., Kun, L., Tang, T., Tiemann, C.O., and Griffin, S., Assessing the Deepwater Horizon oil spill impact on beaked whale populations through acoustics, *under review*.
- Veprauskas, A., Ackleh, A.S., and Tang, T., Examining the effect of multiple disturbances on population persistence with application to marine mammals, *under review*.