A Stage-structured Population Model for Deepwater Horizon Oil Spill: Potential Impacts of Deepwater Horizon Oil Spill Event

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Abstract / Introduction

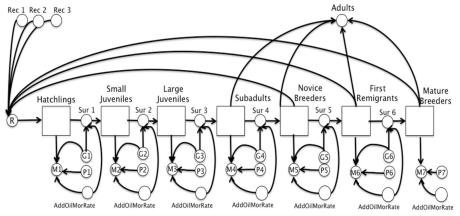
Deepwater Horizon (DWH) oil spill significantly affected the Gulf of Mexico and surrounding beaches, including threatened and endangered marine life such as the loggerhead sea turtle. Short and long-term effects to juvenile and adult loggerheads result from catastrophic oil spills, such include oil adhesion, over-heating, and oil ingestion which can lead to egg mortality, developmental defects, and impacts to the skin, blood, salt glands, and digestive and immune systems. The objective of our research was to determine how the event of oil spills affected the population dynamics of loggerhead sea turtles. Methods: we conducted a thorough literature review to obtain the demographic data and developed a stage-structured stochastic population dynamics model using STELLA® 7.0.1 for loggerhead sea turtles. Three conservation scenarios were modeled along with a baseline scenario. Conservation scenarios were then subjected to added oil mortality. Results: Although the baseline scenario showed a decrease in population numbers over time, all 3 conservation scenarios without added oil mortality showed an increase over time. Conservation scenarios after added oil mortality all decreased approximately 79% and then gradually increased after a period of time.

Model

The figure below shows a conceptual model of Loggerhead sea turtle population dynamics. Arrows (material transfers) portray individuals entering each stage in the form of recruitment (R) and survival (Sur1, Sur2, etc.), as well those exiting through mortality (Mor1, Mor2, etc.). G1, G2, etc. represent the probability of surviving and growing to the next stage, while P1, P2, etc. represent the probability of surviving and remaining in the same stage class. "Adults" are the individuals in the last three stages combined. Depending on the level of oil exposure, additional mortality rates were added to each stage.

Stage-Class	Starting population	G	P	Rec
Hatchlings	9,855	0.6747	0	--
Small Juveniles	31,962	0.0486	0.7370	--
Large Juveniles	5,469	0.0147	0.6610	--
Subadults	315	0.0518	0.6907	--
Novice Breeders	19	0.8091	0	127
First Remigrants	14	0.8091	0	4
Mature Breeders	86	--	0.8089	80

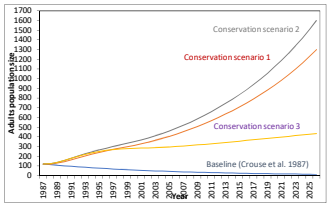
Table of baseline model values



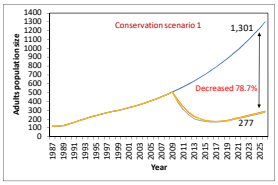
Methods

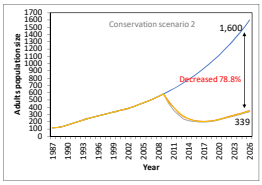
- For this study, a stage-structured stochastic population dynamics model was developed for Loggerhead sea turtle. We used parameters from Crouse et al. 1987 and develop the model using STELLA® 7.0.1.
- The loggerhead population was separated into seven stages with different survival rates: Hatchlings, Small Juveniles, Large Juveniles, Subadults, Novice Breeders, First Remigrants, and Mature Breeders.
- Three different scenarios were modeled: the conservation scenarios 1, 2, and 3 with the effects of Deepwater Horizon oil spill. The values of effects were obtained from Milton et al. (2010). We assigned the proportion of lightly-, moderately-, and heavily-oiled mortality rates stochastically to calculate the weighted oiled mortality rate for 2010, and let the weighted oiled mortality rates decreased linearly in 10 years.
- The model ran for 40 years from 1987 to 2026.

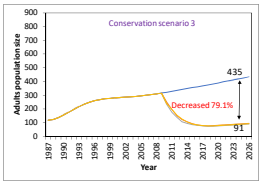
Results



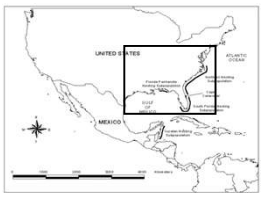
The results of the baseline model without oil effects show a decrease in the population, implying the possibility of the population's extinction despite current conservation efforts. All three conservation scenarios without oil effects show an increase, with conservation scenario 2 showing the greatest population growth over time. Each conservation scenario with the effects of Deepwater Horizon oil spill , showed a population decrease of 78.7%, 78.8% and 79.1% respectively. Over a period of time the population started to recover in every scenario.







Study Area



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Acknowledgements

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