

A spatial risk assessment tool that connects oceanographic and demographic information to predict distribution and abundance for protected species

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# Outline

- Knowledge of species distribution is important
- Predicting distributions of marine species: method for connecting organismal movement, ocean circulation, and demographic information
- Case Study: Deepwater Horizon oil spill impacts to juvenile sea turtles
- Other applications

# Where organisms are is important

Individuals:

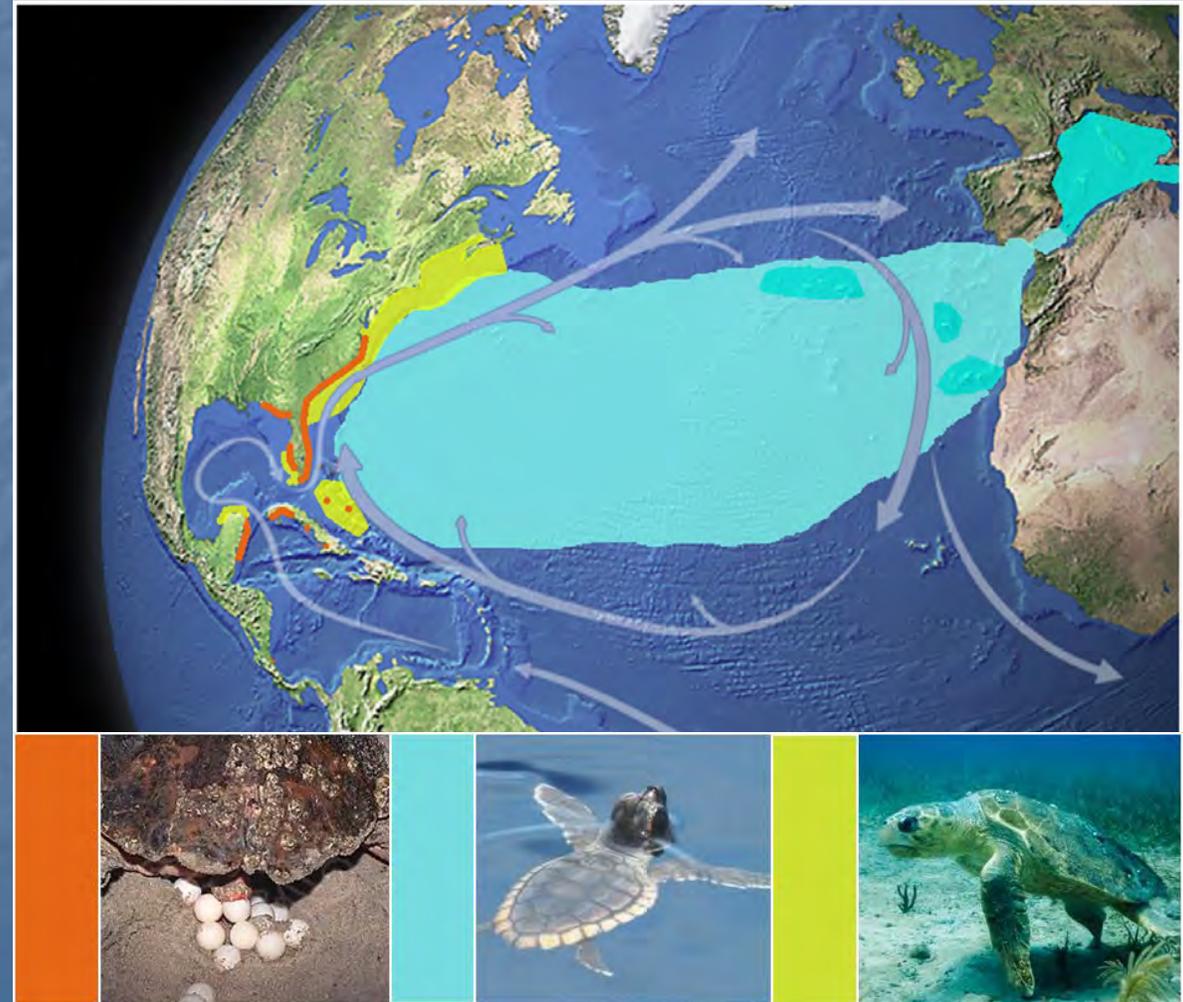
- Survival
- Metabolic costs / growth
- Reproductive output



## Range of North American Loggerhead Sea Turtles

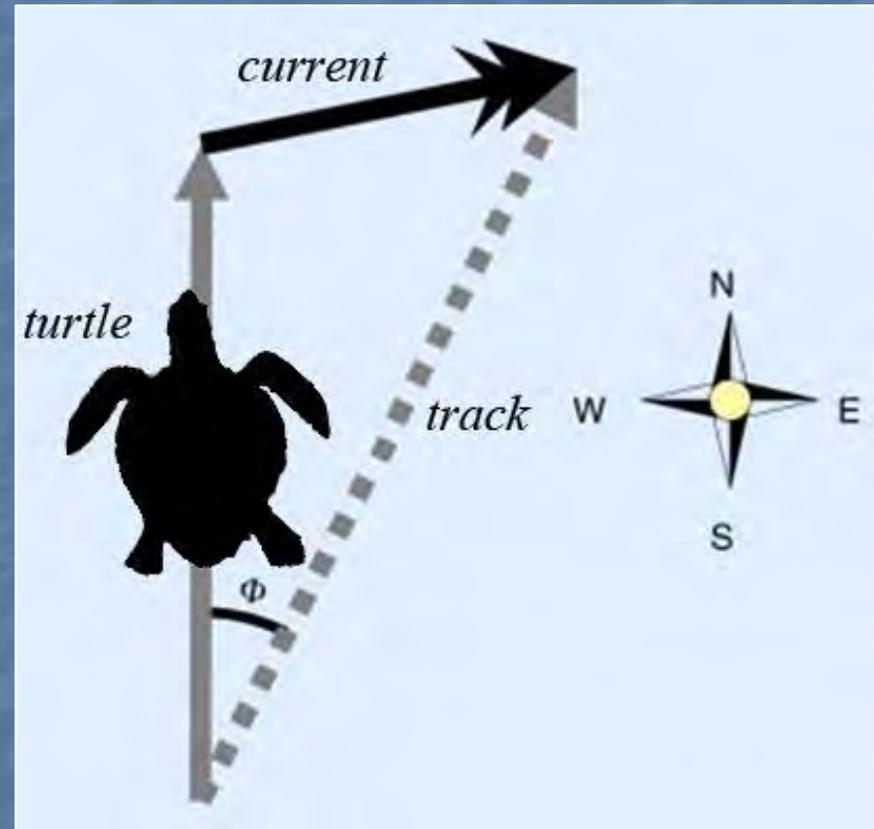
### Populations:

- Population dynamics
- Genetic connectivity / evolution
- Disease ecology
- Transport of nutrients among ecosystems
- Responses to climate change
- Anthropogenic interactions



# Movement of marine animals

The path of a marine animal is a combination of its swimming velocity and that of the surrounding fluid.

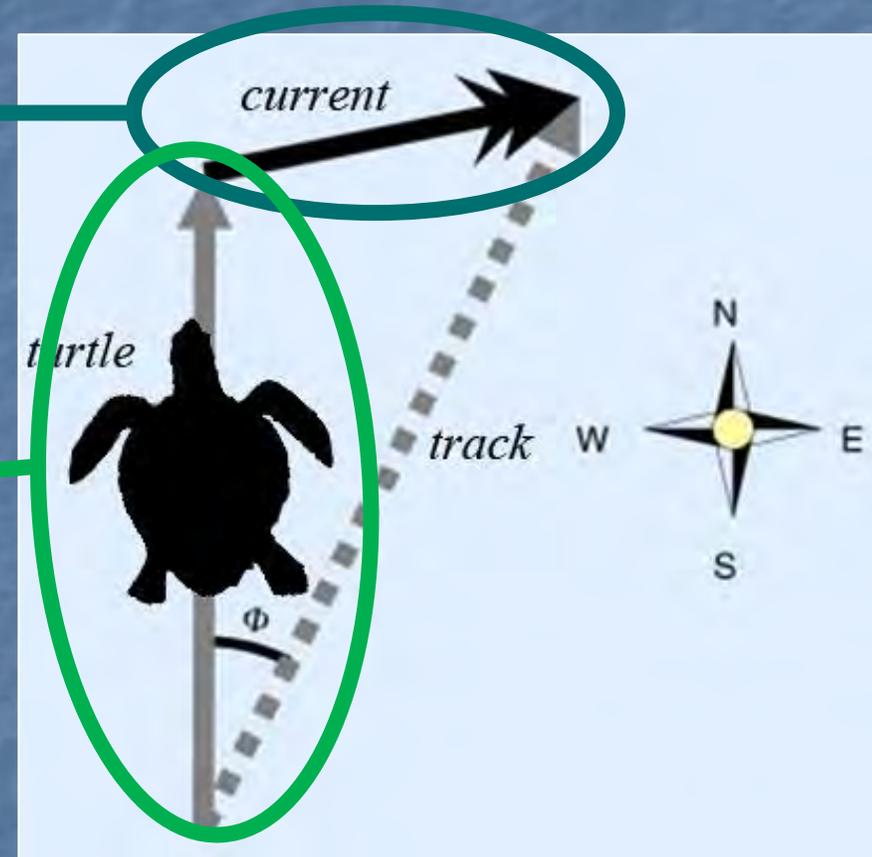


# Movement of marine animals

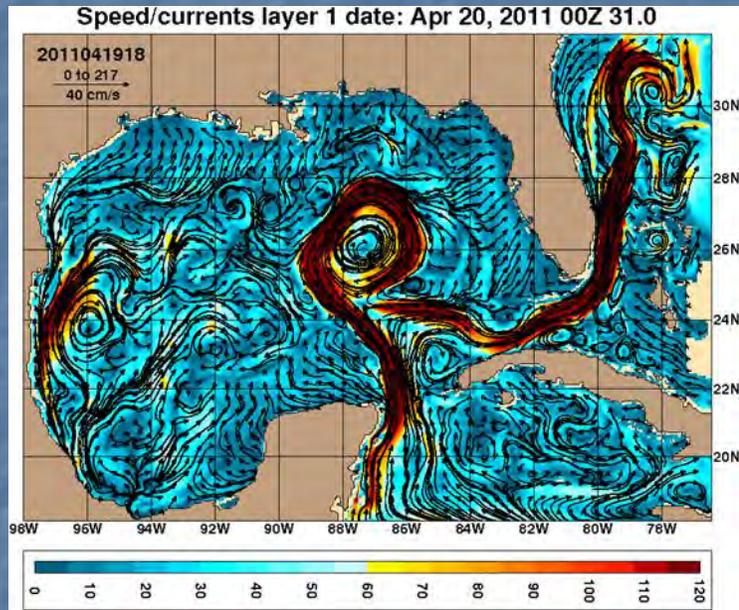
Ocean circulation models

Lab-based experiments

Satellite telemetry data



# Virtual particle tracking with ICHTHYOP and the Hybrid Coordinate Ocean Model to investigate influence of ocean circulation on young sea turtles



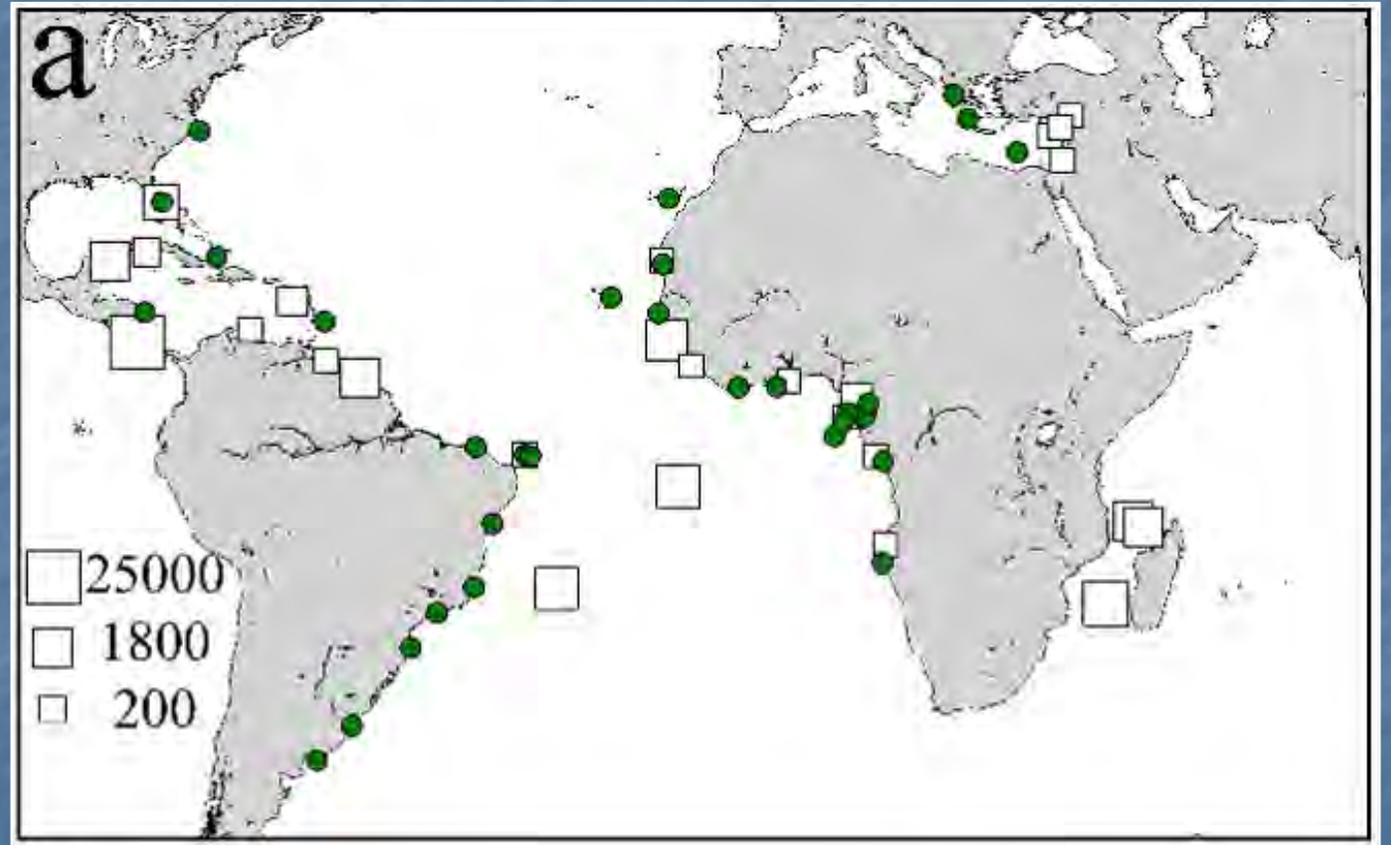
## Global HYCOM

- 0.08° grid resolution
- Daily snapshots at 0 m
- Data assimilation

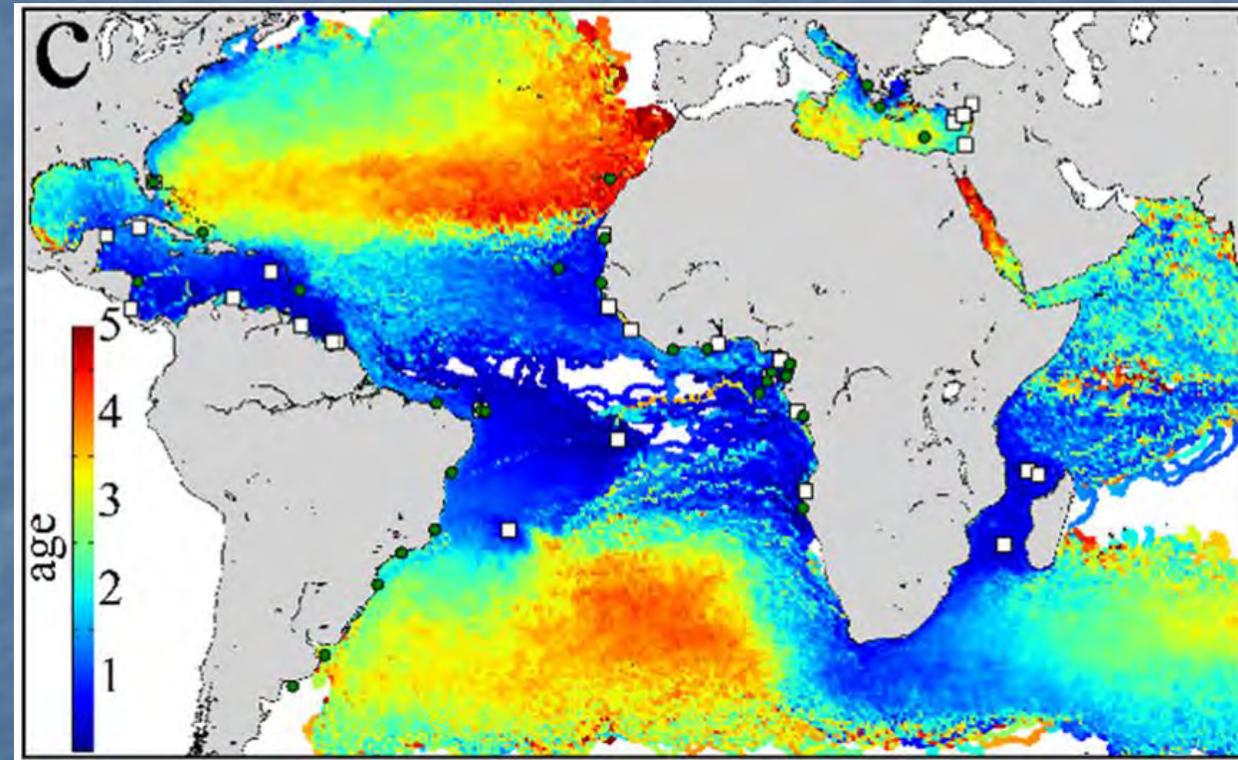
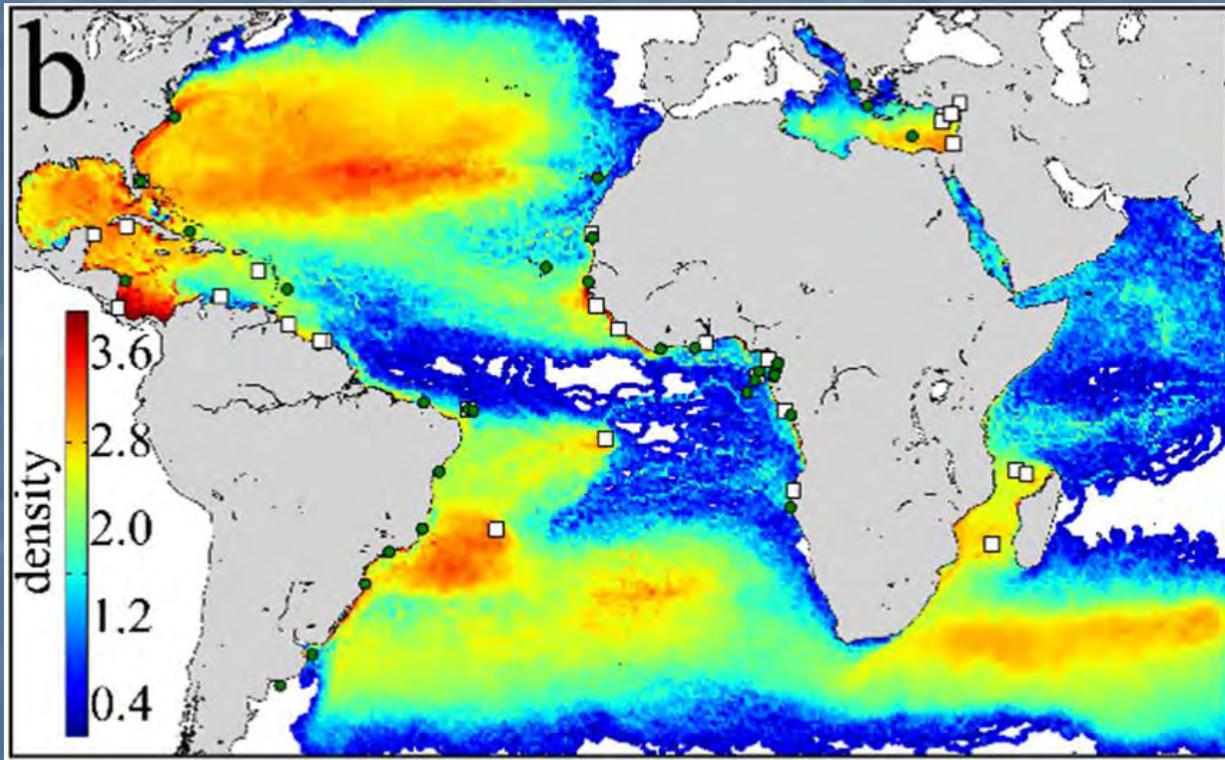
## ICHTHYOP

- Runge-Kutta 4<sup>th</sup>-Order Method for computing particle movement through velocity fields
- Swimming behavior, mortality, and recruitment can be simulated

# What is the oceanic distribution of juvenile green turtles in the Atlantic?



# “Null hypothesis” of distribution and age-structure of oceanic stage green turtles throughout the Atlantic basin



# Application of the modeling technique: Impacts of the 2010 Deepwater Horizon Oil Spill on Juvenile Sea Turtles



*New York Times*



*NOAA*

# Translating predictions of physical transport to estimates of abundance



=



x



x



x



x



*Turtles in  
an area of  
interest*

*Nests*

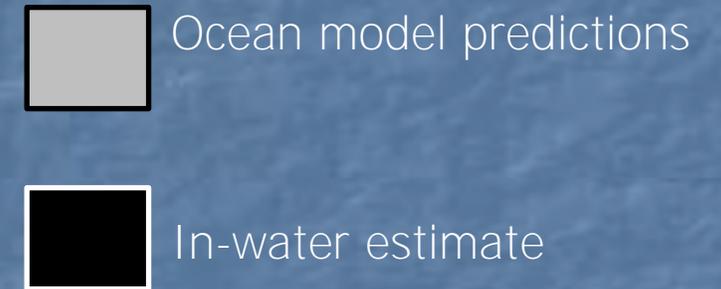
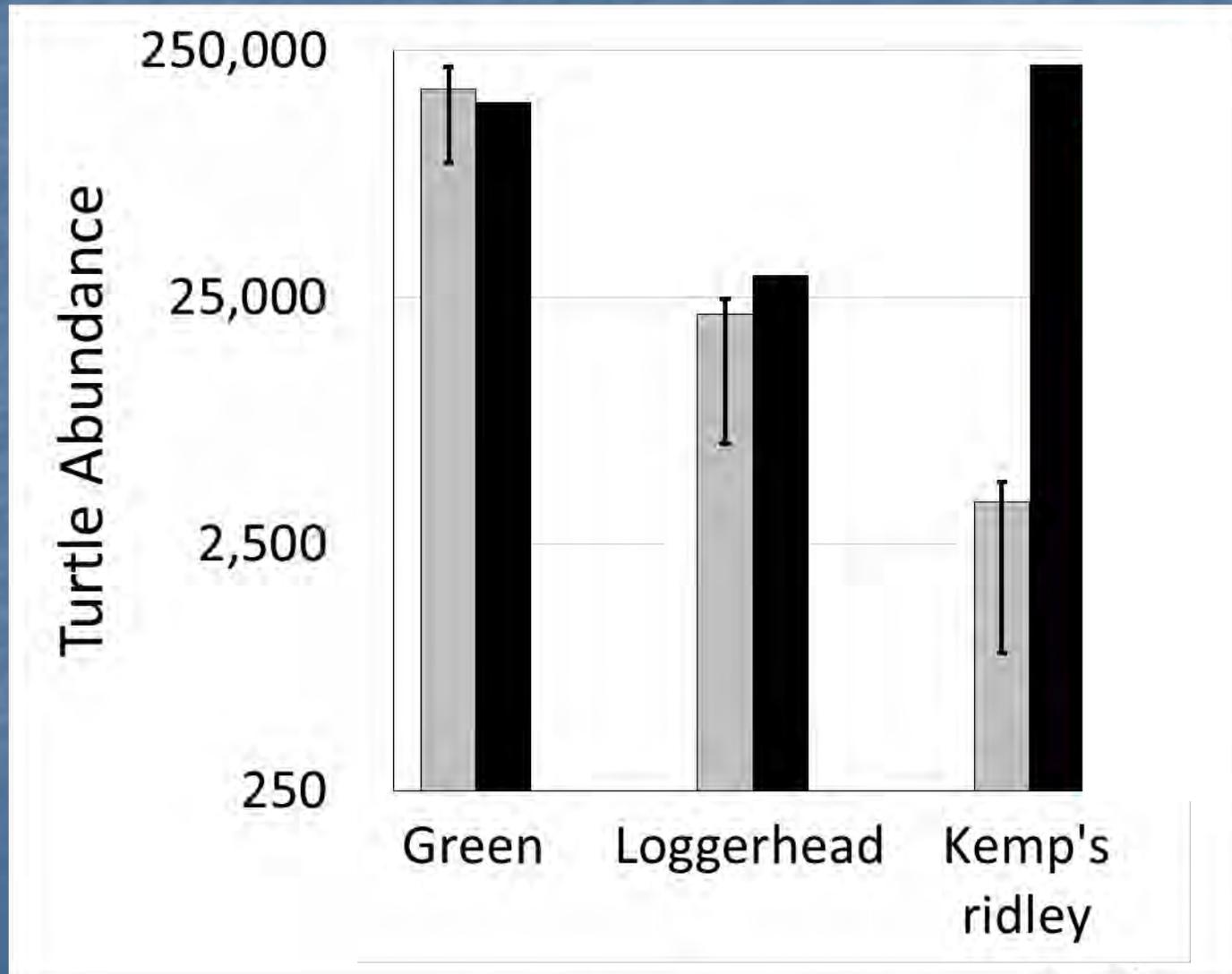
*Eggs per nest*

*Probability  
of  
hatching  
survival*

*Probability  
of transport  
from beach  
to area of  
interest*

*Probability of  
oceanic  
survival*

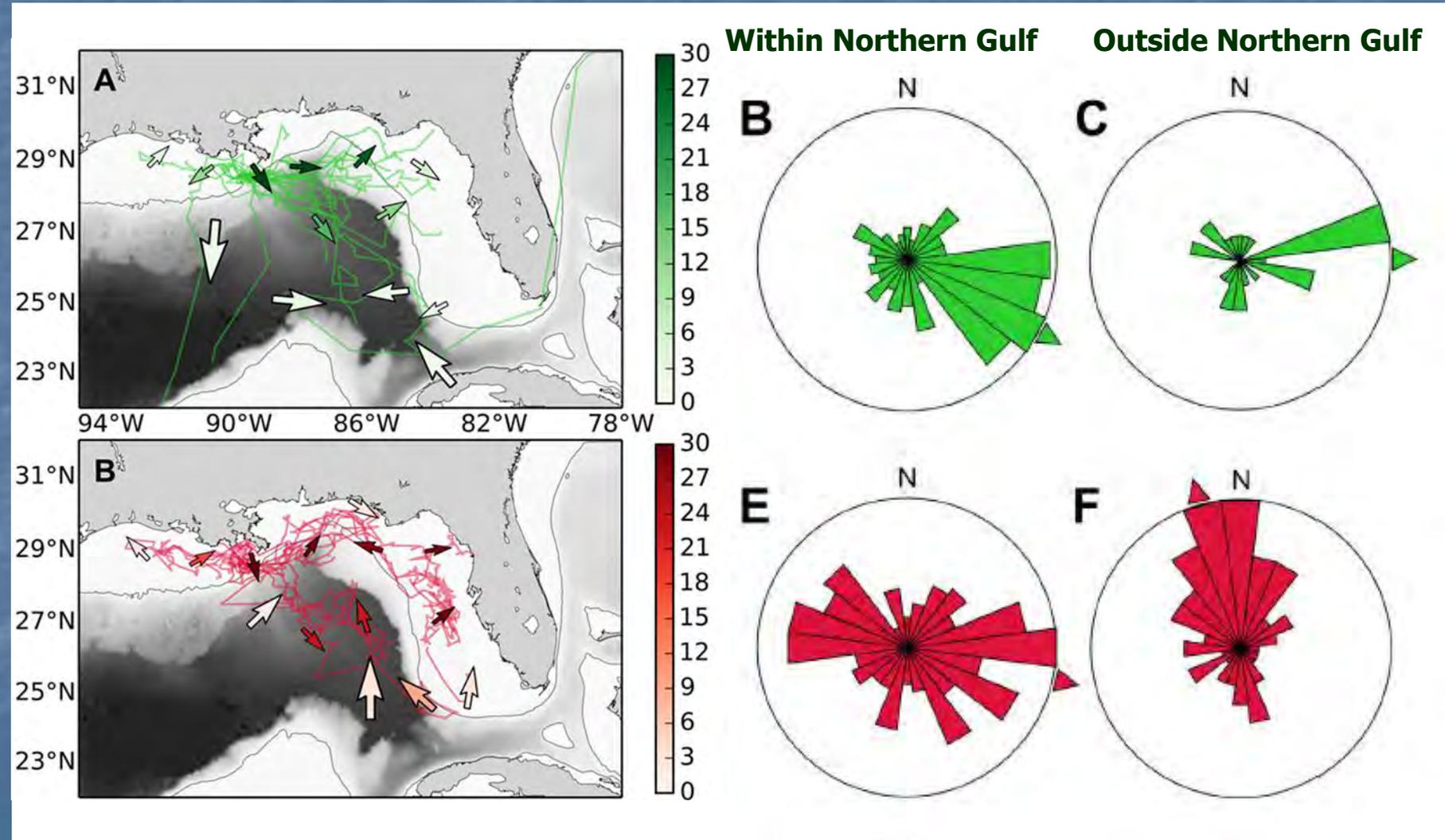
# Oceanic-stage juveniles at spill site



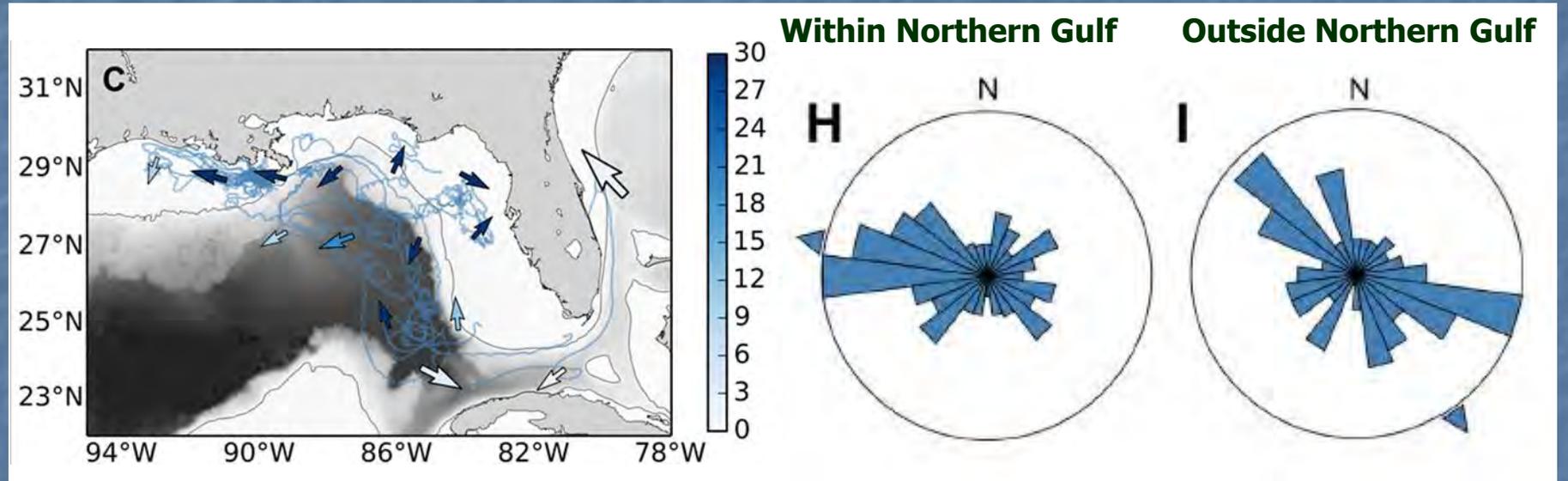
# Simultaneously tracking turtles and ocean currents



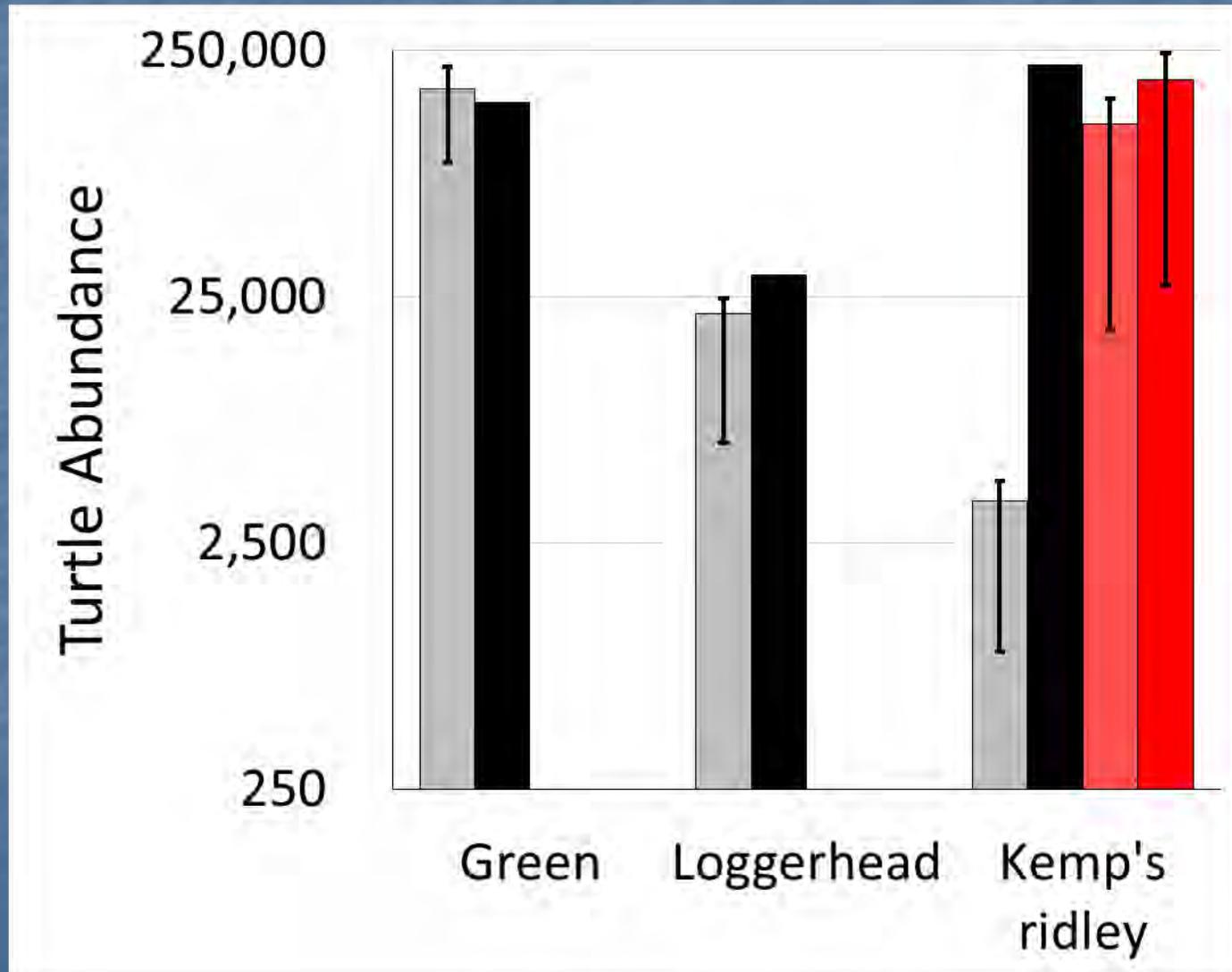
# Green (& loggerhead) turtles rapidly transit through northern Gulf of Mexico, but Kemp's ridley display "retentive" and "seeking" behavior



# Observed behavior in turtles unlikely to be an artefact from Gulf of Mexico HYCOM

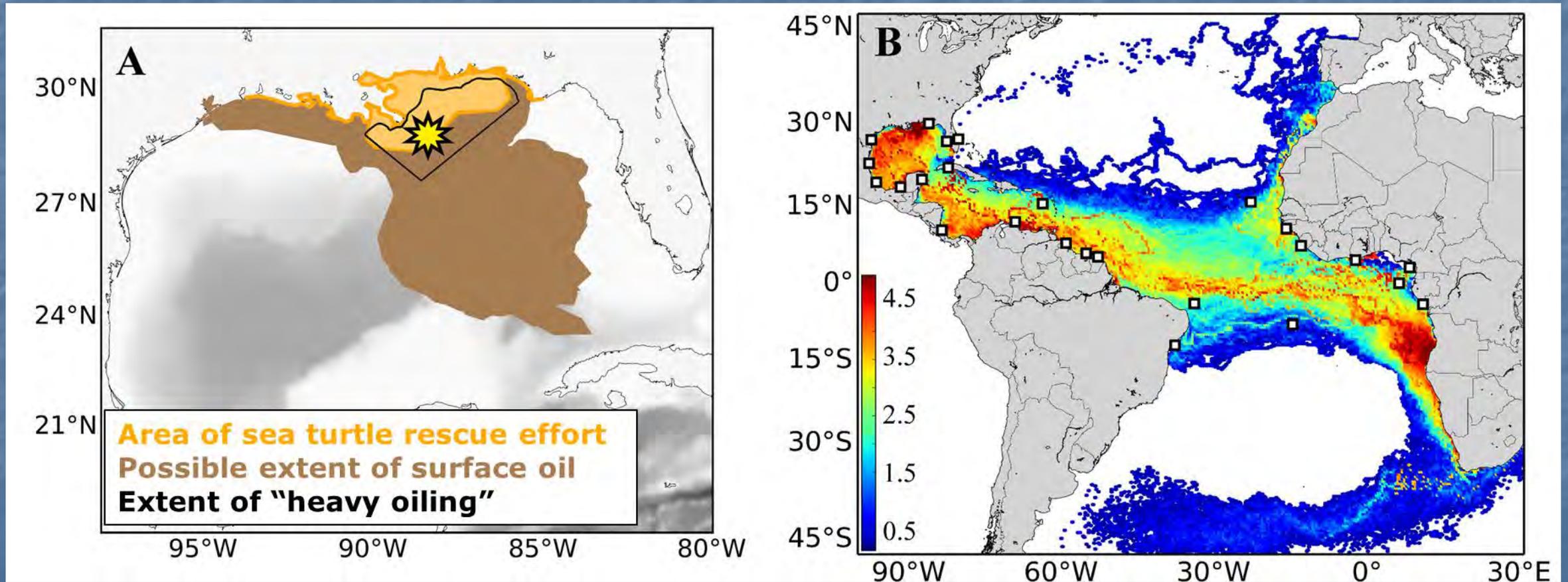


# Oceanic-stage juveniles at spill site

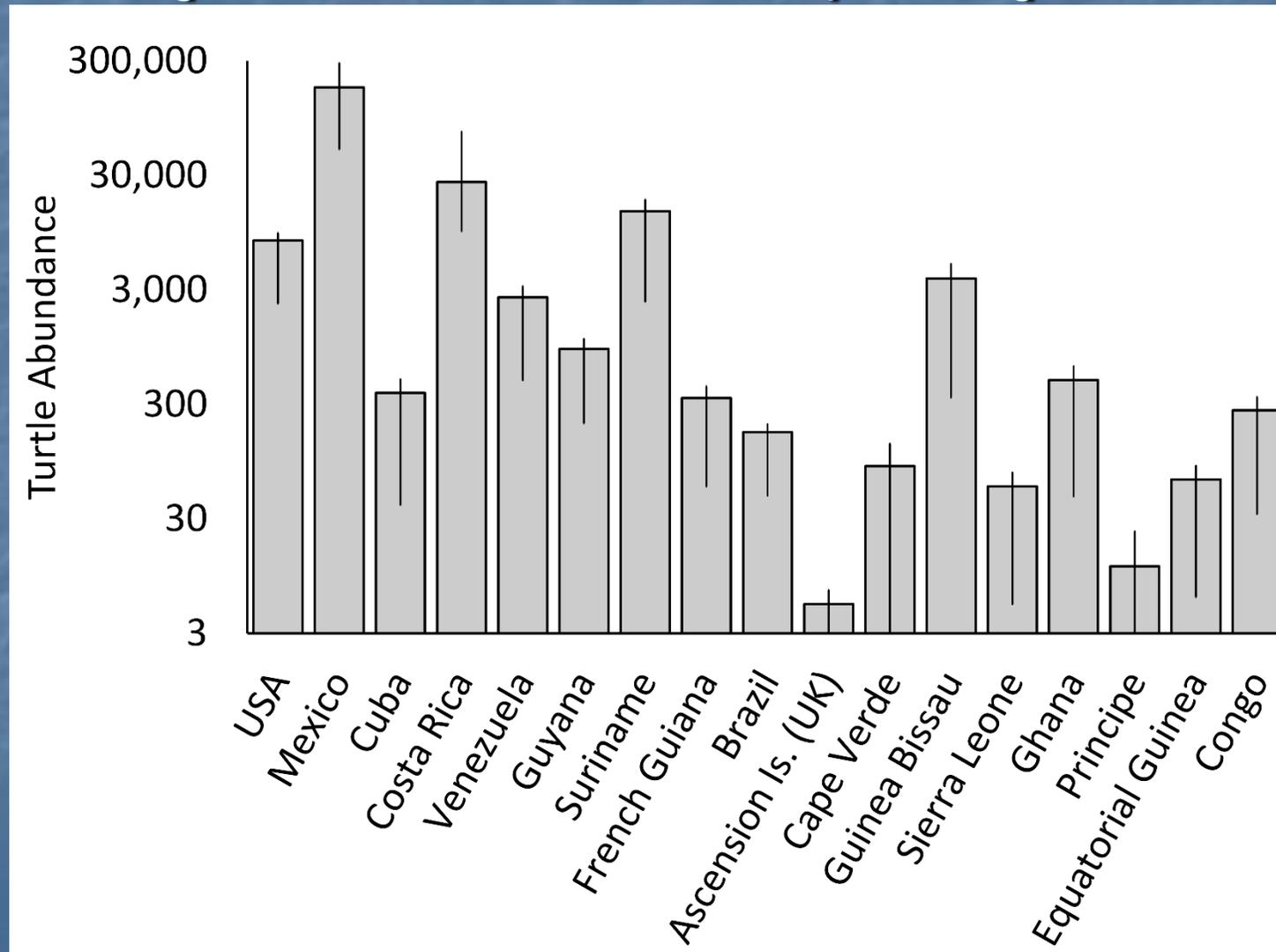


-  Ocean model predictions
-  In-water estimate
-  Ocean model + "retentive" behavior
-  Ocean model + "retentive" behavior + "seeking" behavior

# Predicted oceanic transport to spill site from major sea turtle nesting beaches



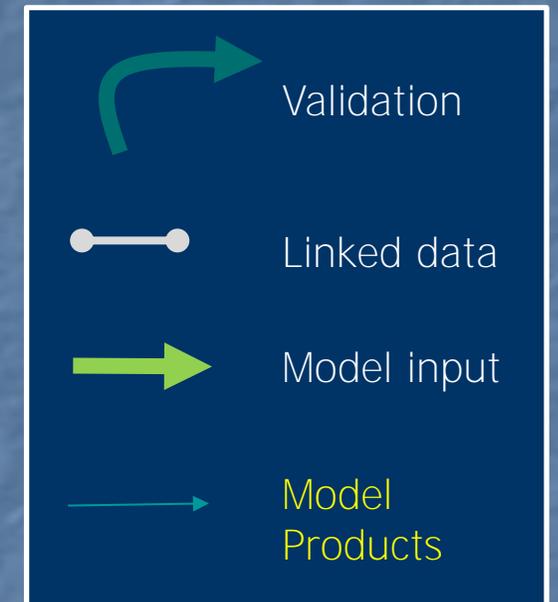
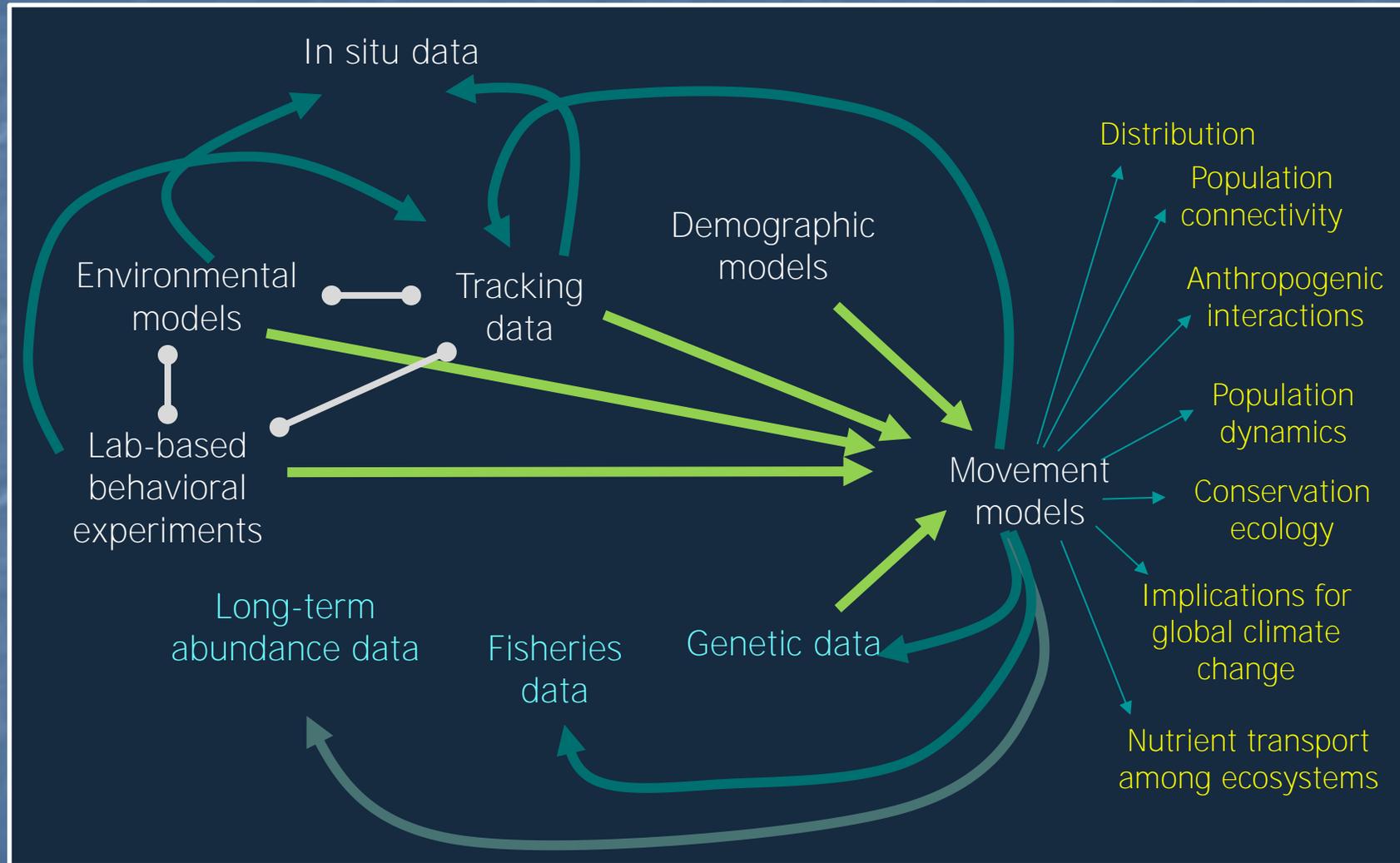
# Geographic-scope of anthropogenic impacts in marine systems can be explicitly estimated



Research approach is broadly applicable to diverse marine organisms and questions



# Framework for further application of the modeling technique



# Conclusions

- Consideration of the movements of marine organisms allows predictions of spatiotemporal variation in distribution.
- Modeling approach compares favorably to in-water estimates of distribution and abundance.
- Strong potential to answer important questions related to the management of diverse marine species with data to parameterize behavior.

# Acknowledgements

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