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

Nathan F. Putman[1] & Paul M. Richards[2]

1. University of Miami, Cooperative Institute of Marine & Atmospheric Studies
2.Southeast Fisheries Science Center Protected Resources & Biodiversity Division

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

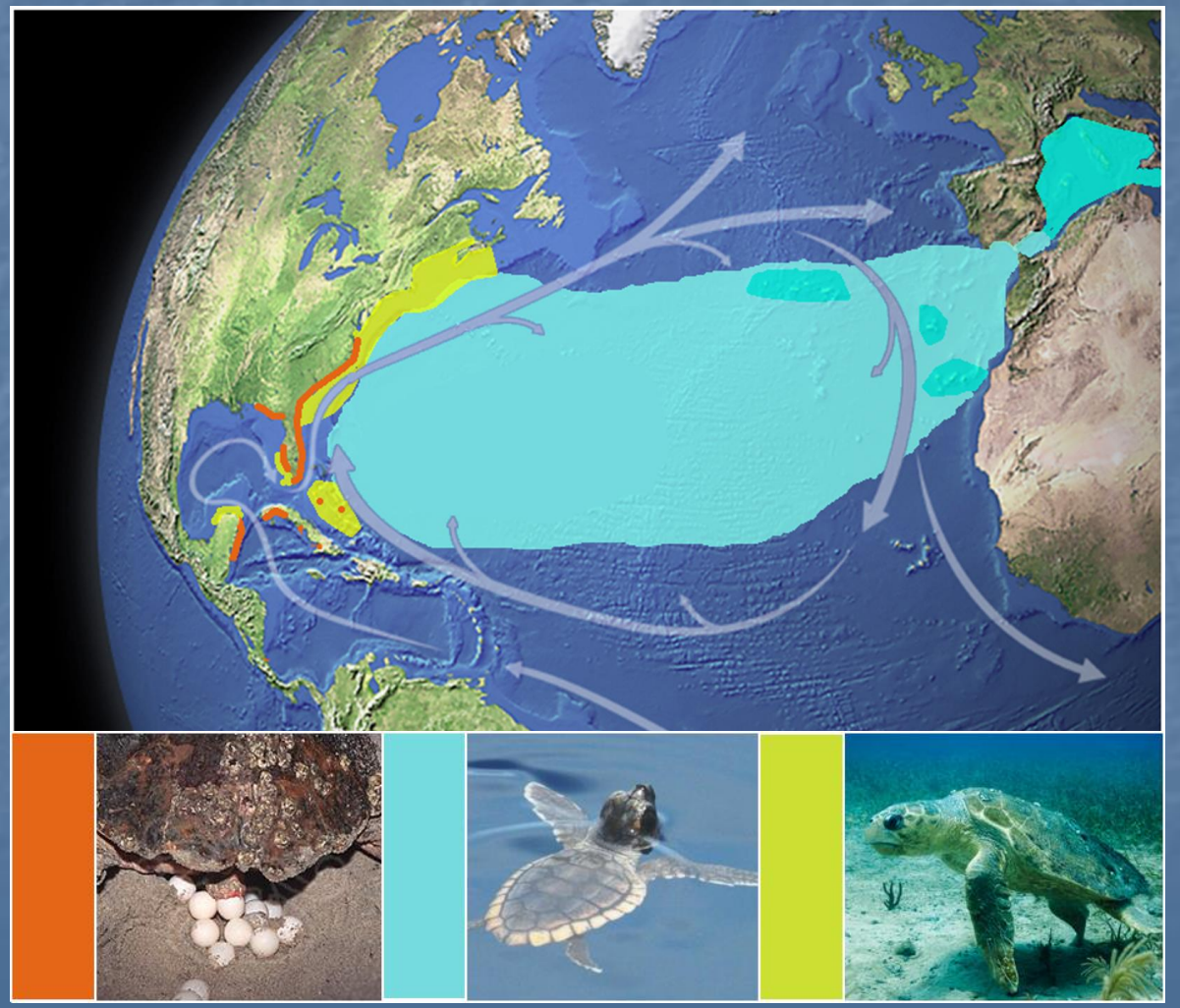
Individuals:

- Survival
- Metabolic costs / growth
- Reproductive output

Populations:

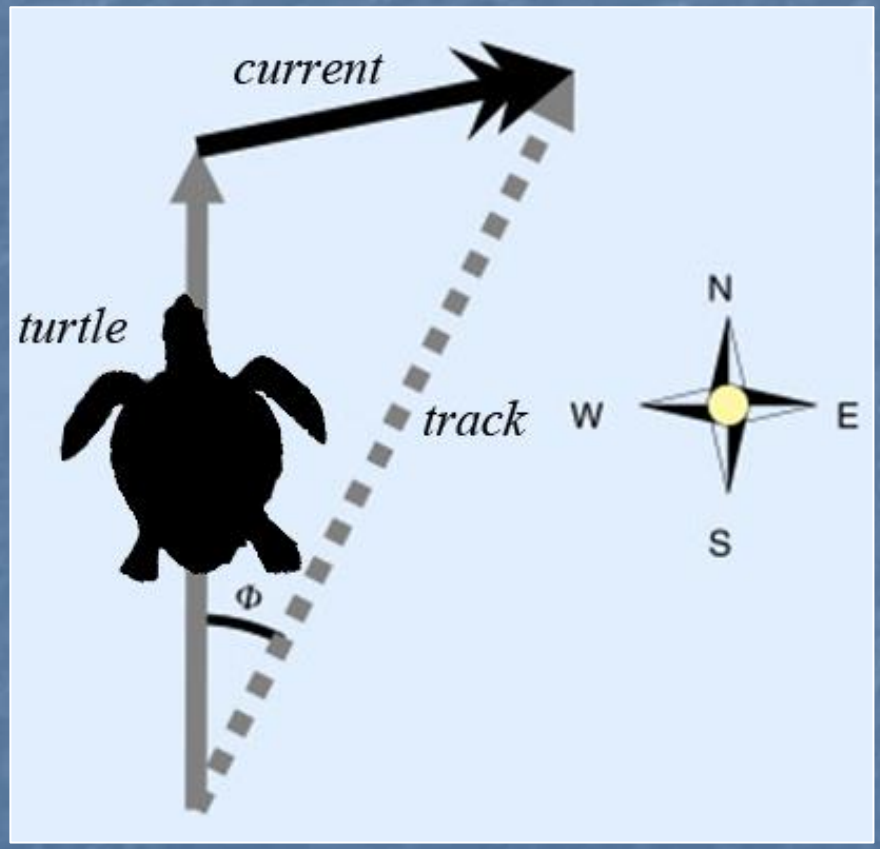
- Population dynamics
- Genetic connectivity / evolution
- Disease ecology
- Transport of nutrients among ecosystems
- Responses to climate change
- Anthropogenic interactions

Range of North American Loggerhead Sea Turtles



Movement of marine animals

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



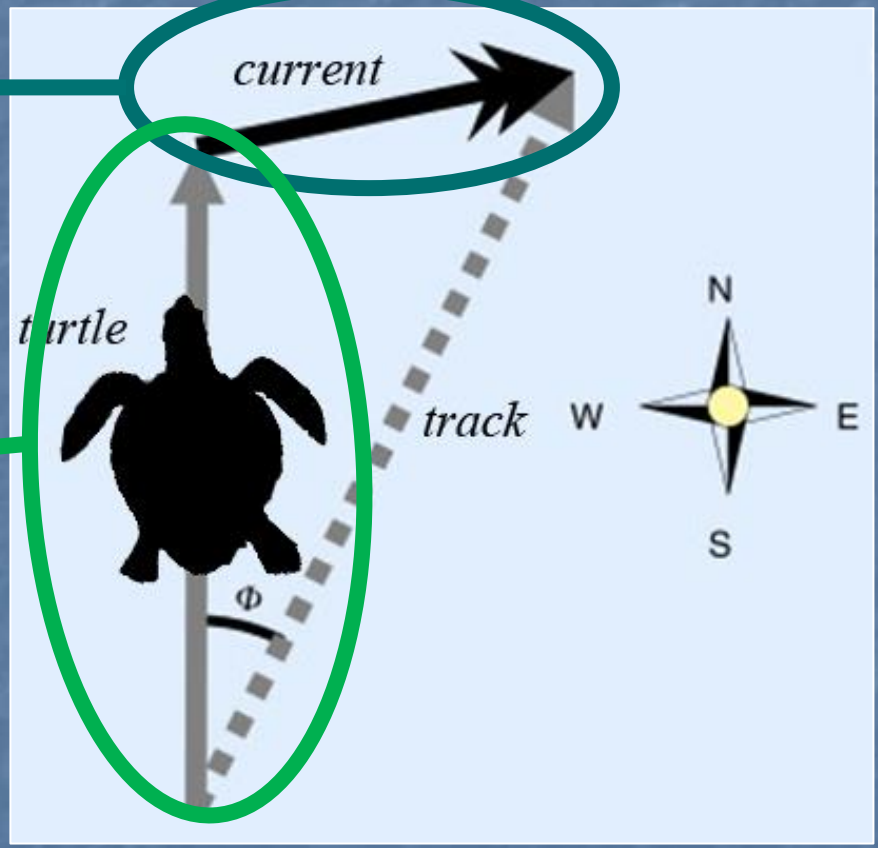
Modified from Chapman et al. 2011

Movement of marine animals

Ocean circulation models

Lab-based experiments

Satellite telemetry data

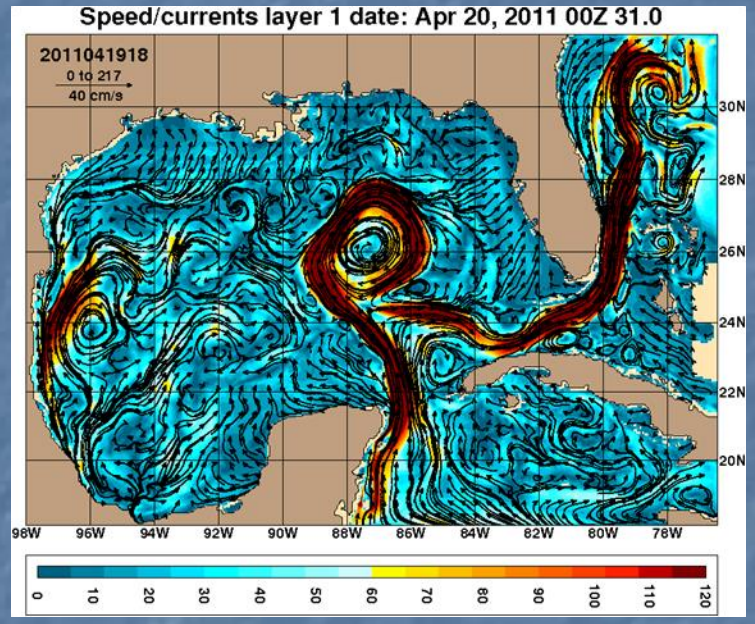


Modified from Chapman et al. 2011

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

ICHTHYOP

HYCOM



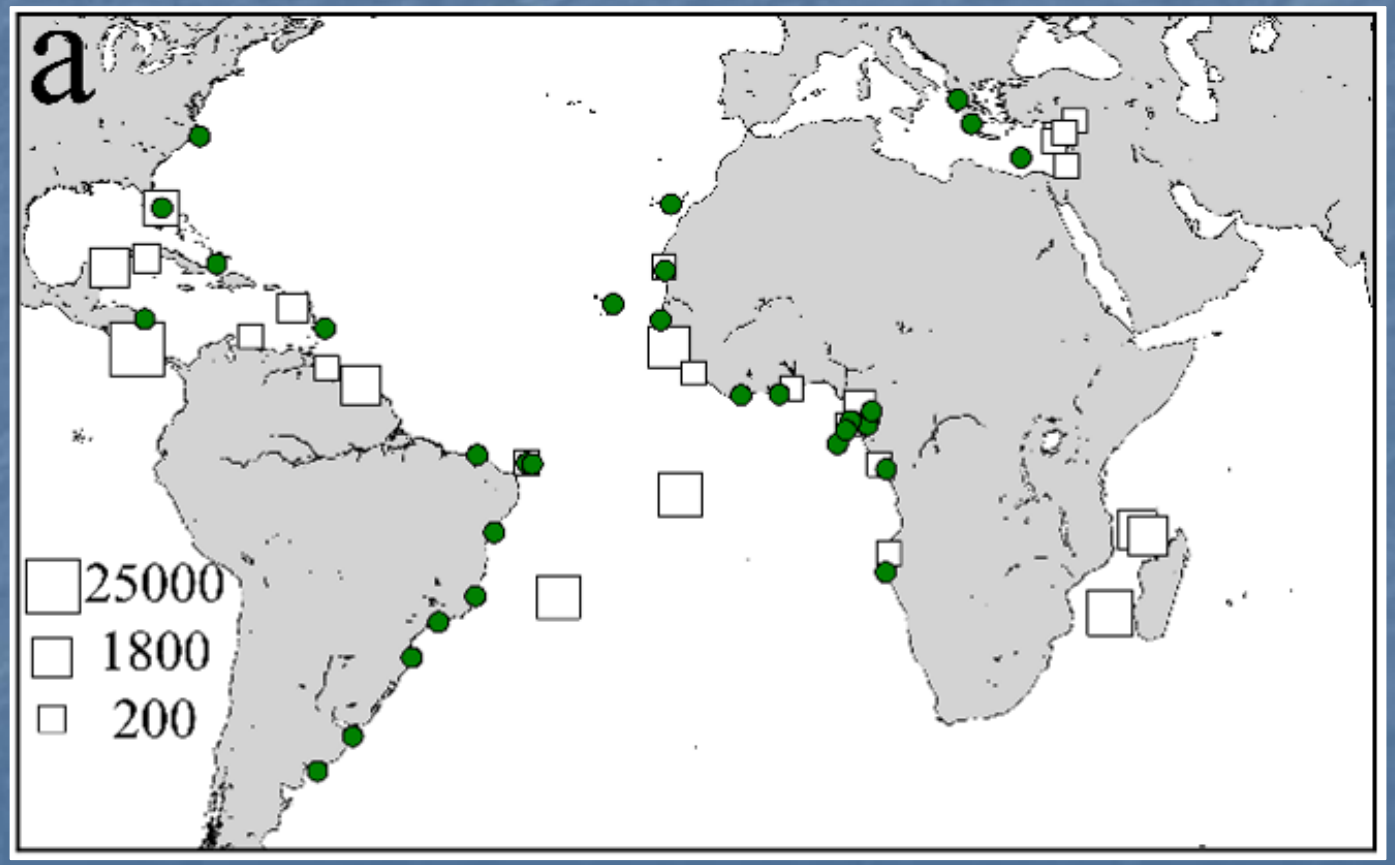
Global HYCOM

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

ICHTHYOP

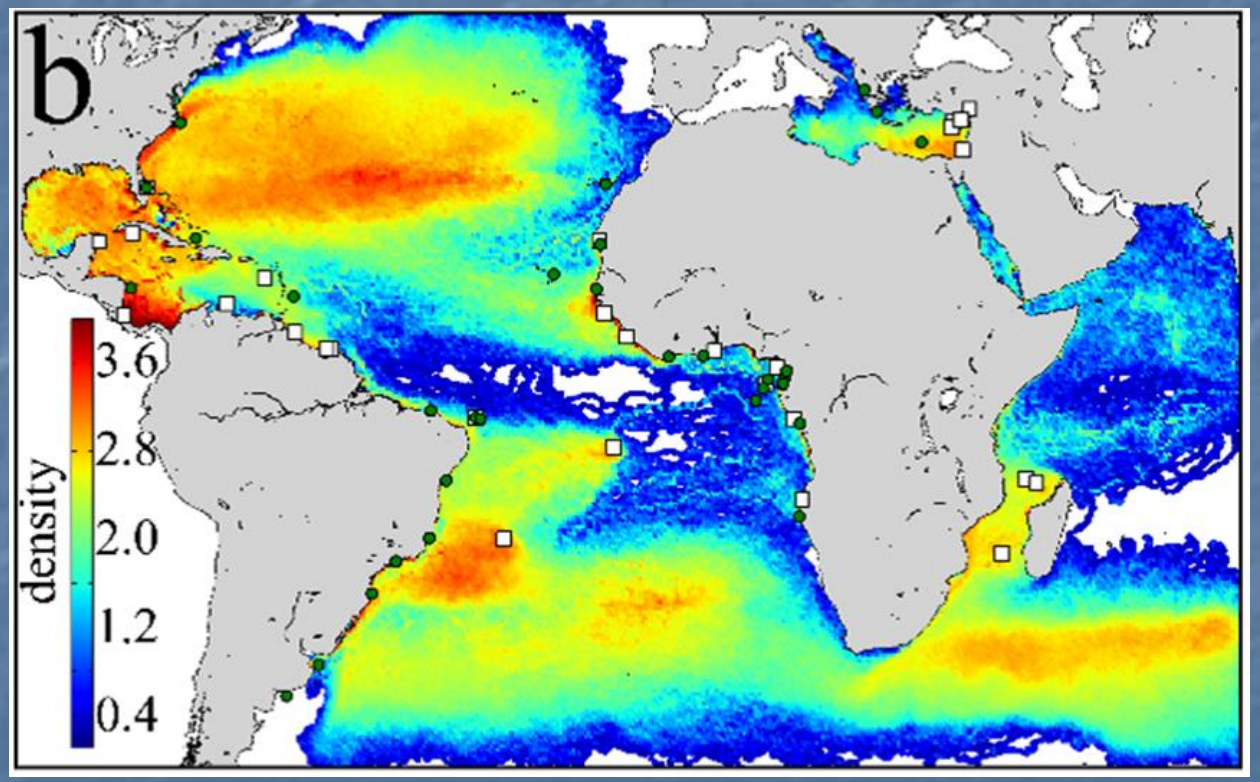
- Runge-Kutta 4th-Order Method for computing particle movement through velocity fields
- Swimming behavior, mortality, and recruitment can be simulated

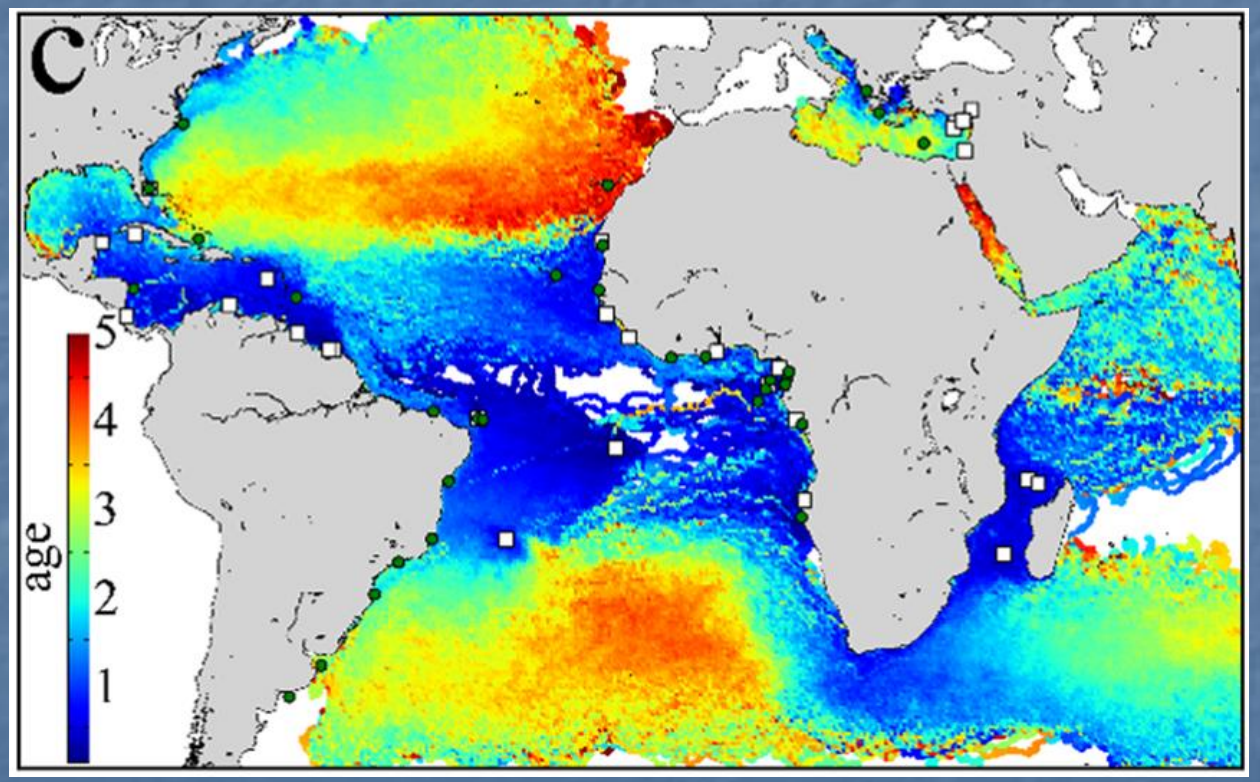
What is the oceanic distribution of juvenile green turtles in the Atlantic?



Putman & Naro Maciel 2013
Proceedings of the Royal Society

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





Putman & Naro Maciel 2013
Proceedings of the Royal Society

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

Turtles in an area of interest

=

Nests

x

Eggs per nest

x

Probability of hatching survival

x

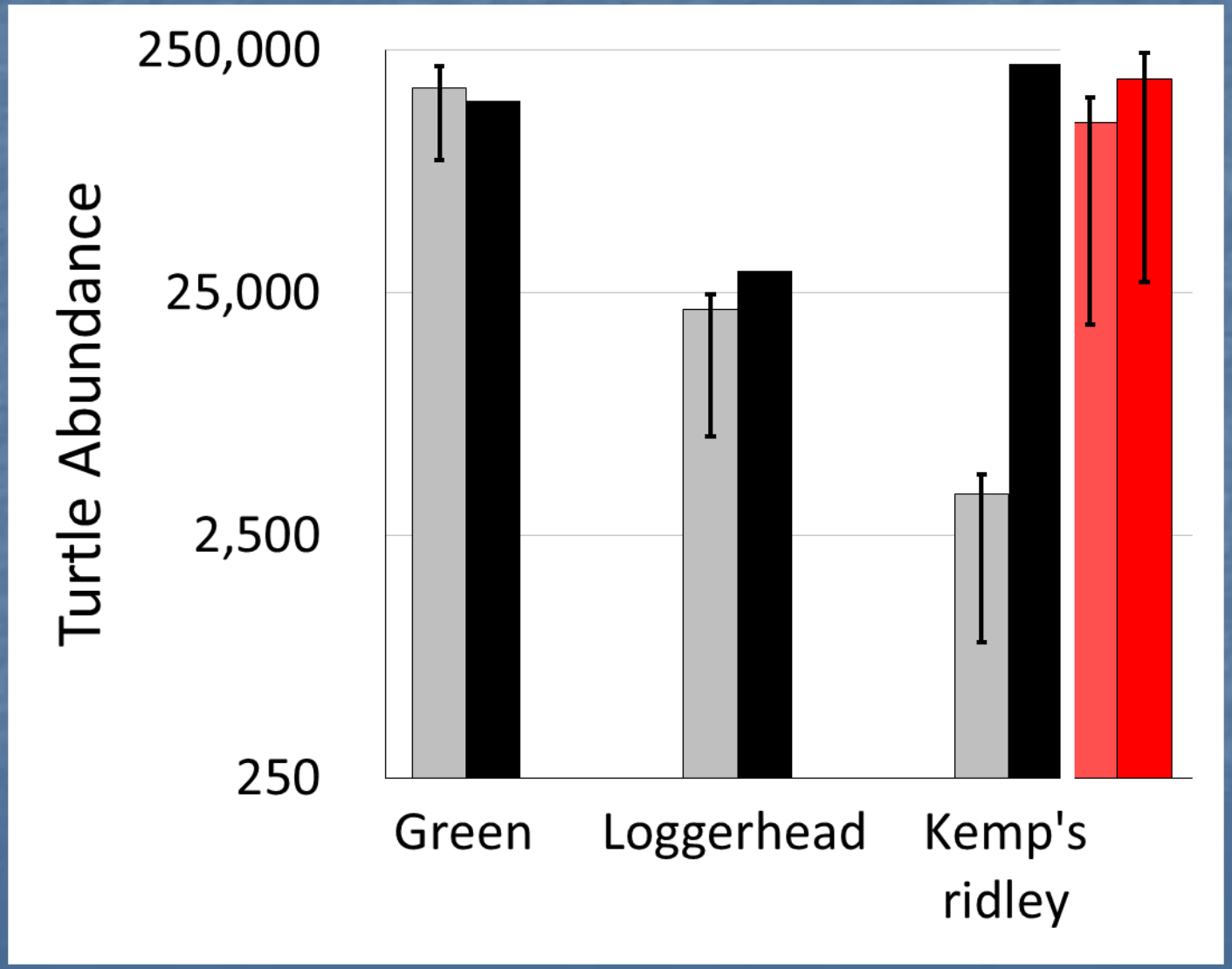
Probability of transport from beach to area of interest

x

Probability of oceanic survival

Putman et al. *in revision*

Oceanic-stage juveniles at spill site

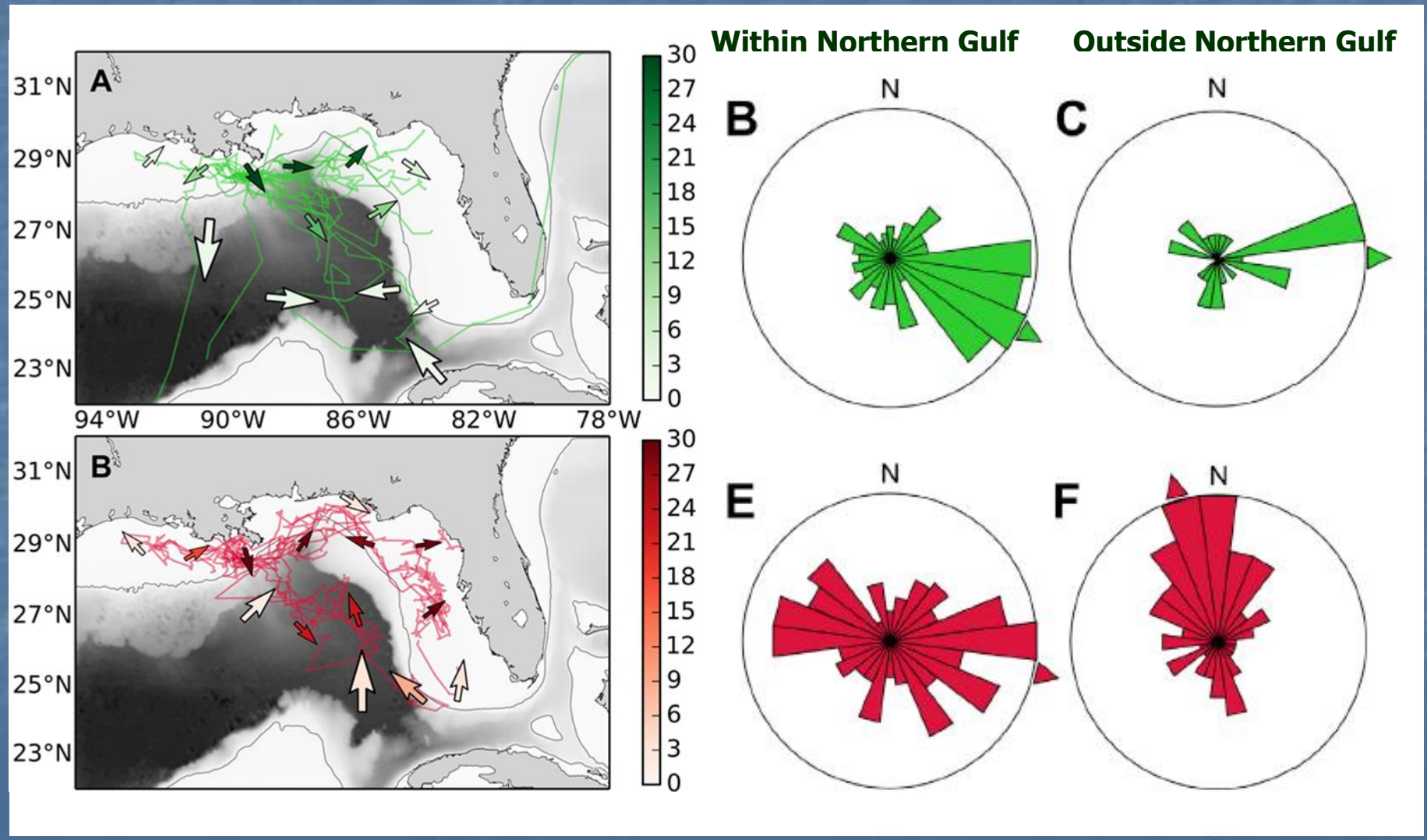


Putman et al. *in revision*

Simultaneously tracking turtles and ocean currents

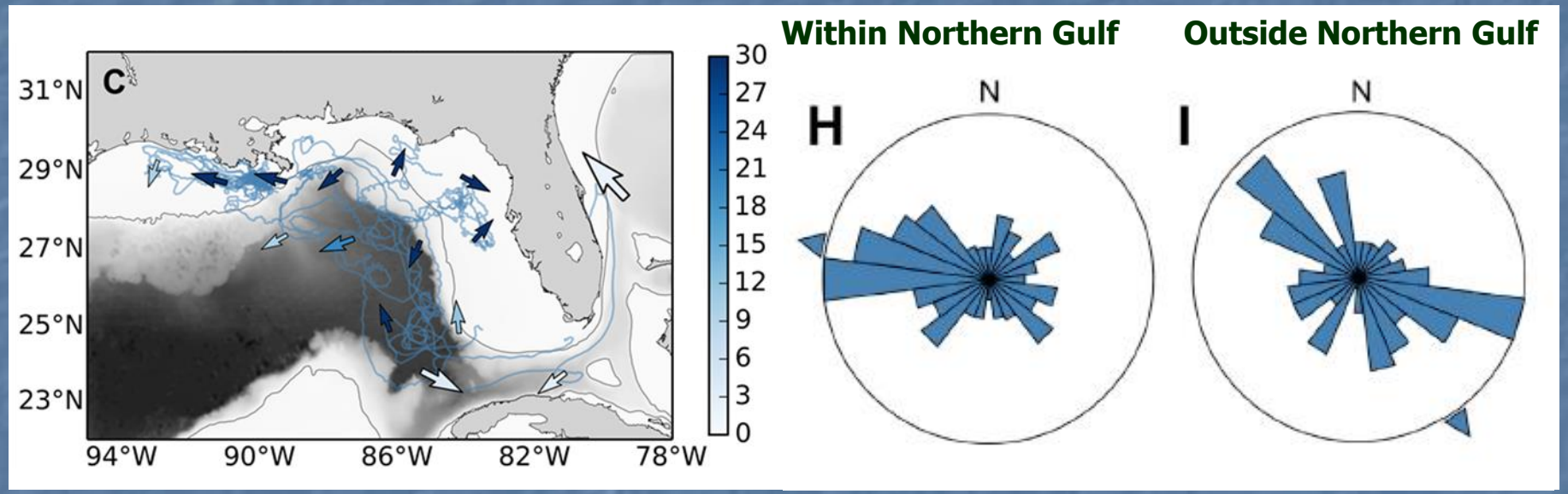
Putman & Mansfield 2015
Current Biology

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



Putman & Mansfield 2015
Current Biology

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



Putman & Mansfield 2015
Current Biology

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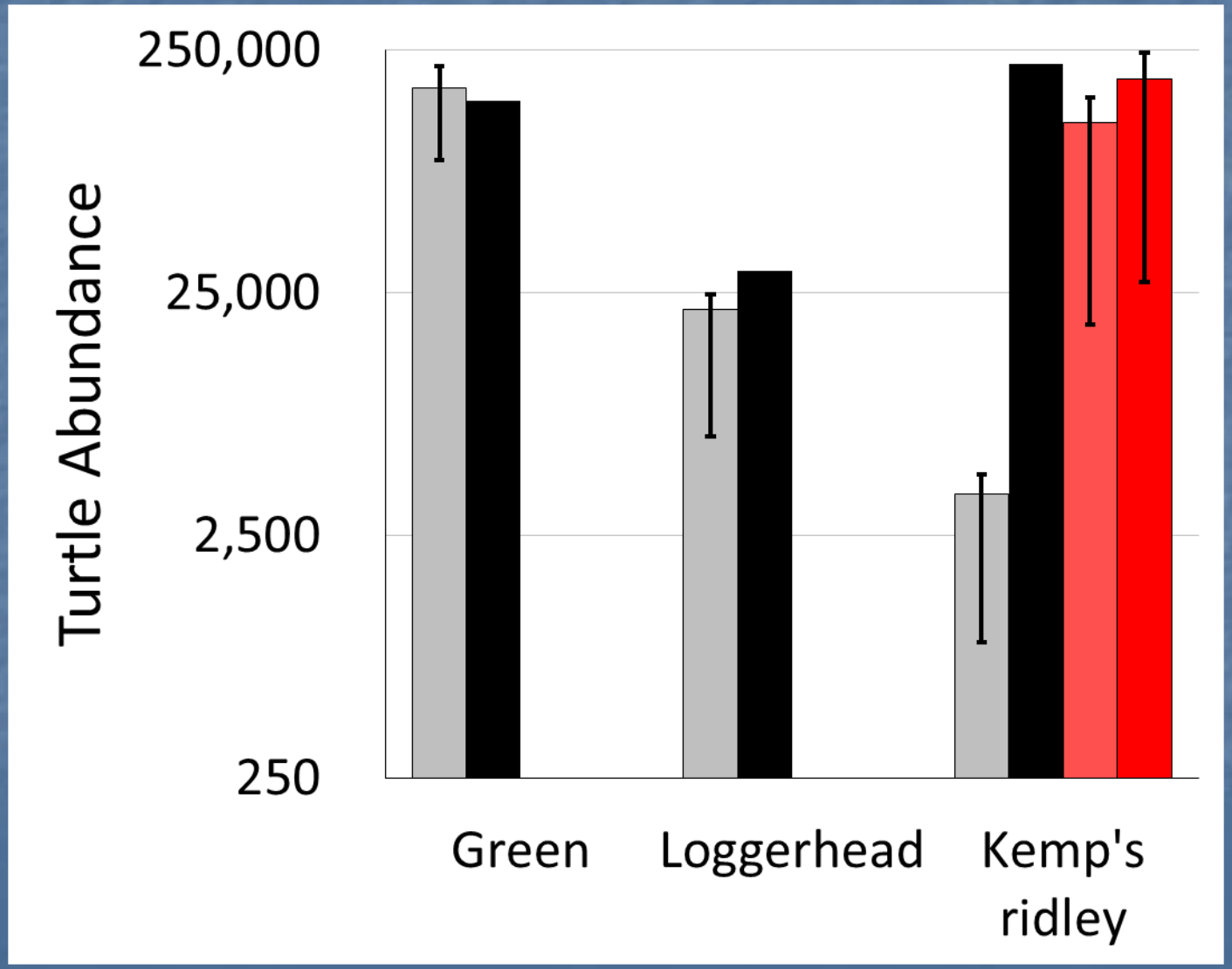


Ocean model predictions

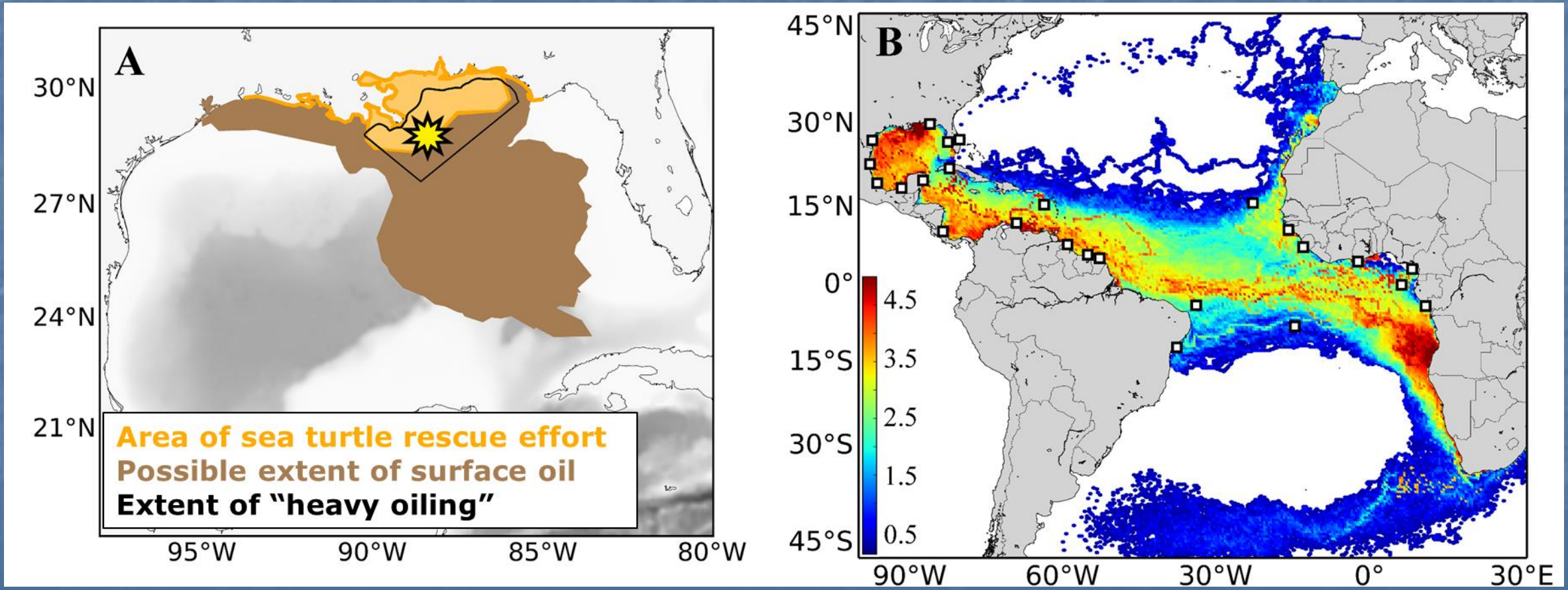
In-water estimate

Ocean model + "retentive" behavior

Ocean model + "retentive" behavior + "seeking" behavior

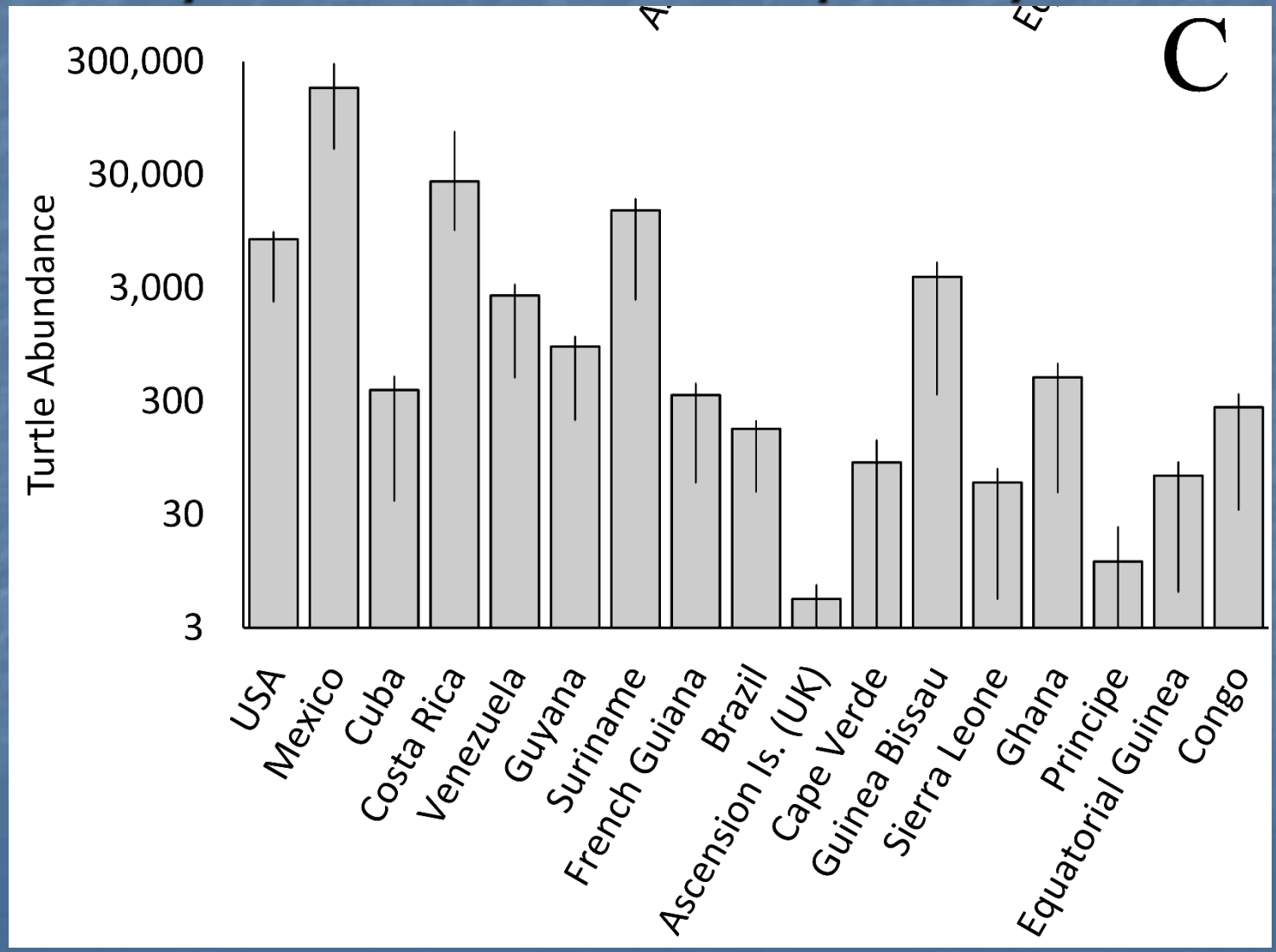
Putman et al. *in revision*

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



Putman et al. *in revision*

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



Putman et al. *in revision*

Research approach is broadly applicable to diverse marine organisms and questions

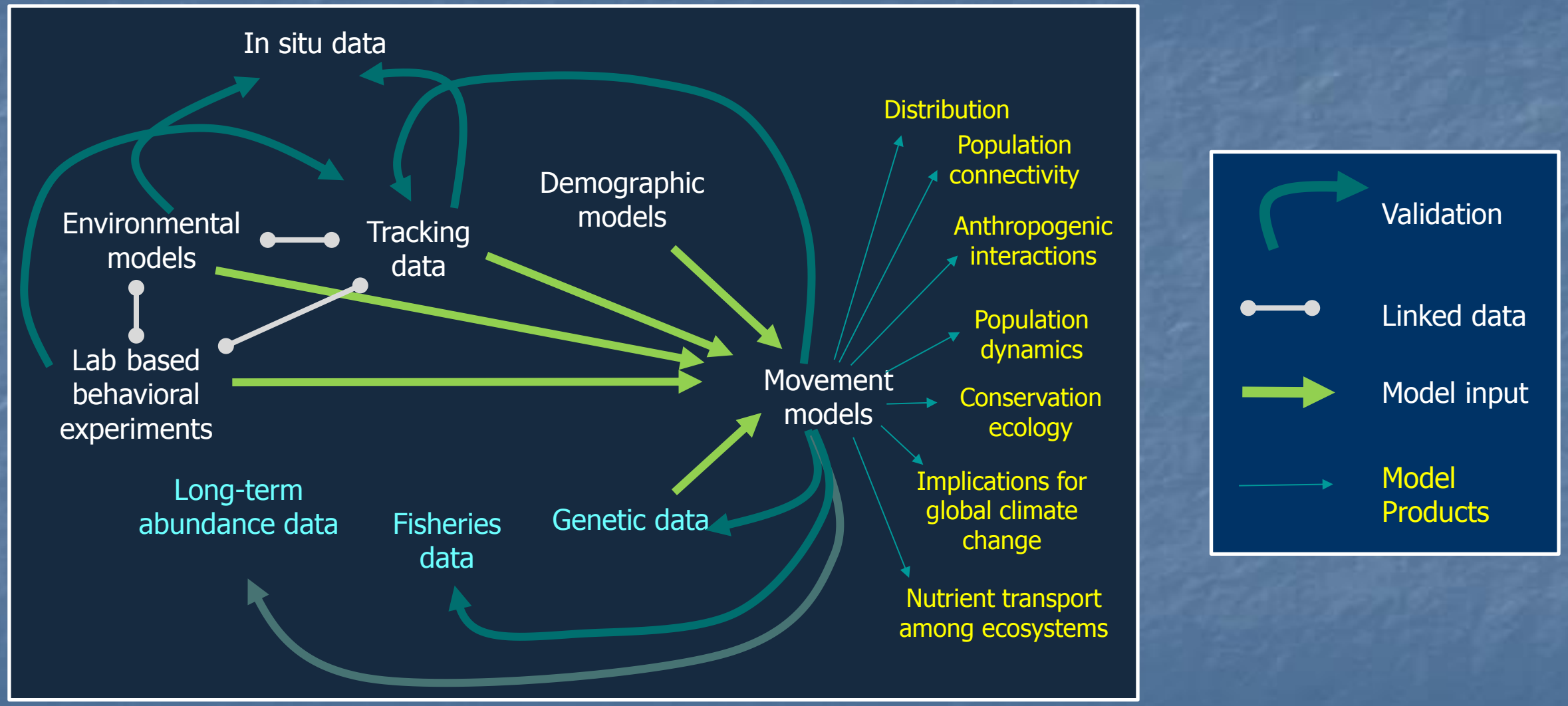









Framework for further application of the modeling technique



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.

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This PDF was later amended to make the document 508 compliant.

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