Where Should They Spawn?

An assessment of the oceanic habitat of brown shrimp using dynamic linkages between offshore waters and estuarine nursery grounds

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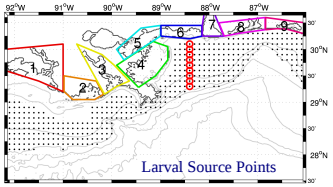
(1) Introduction:

Many ecologically and commercially important species in the northern Gulf of Mexico migrate as larvae from offshore spawning grounds to coastal estuarine nurseries. The migration path is complex and difficult to define. Routine direct sampling of larvae at the correct spatio-temporal scales is cost prohibitive. Here we use Lagrangian particle tracking [1] combined with hypothesis of larval behavior to generate millions of simulated paths to demonstrate the linkages between shelf regions and estuaries as source-sink maps and to generate a year to year time series of potential recruitment.

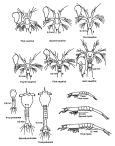


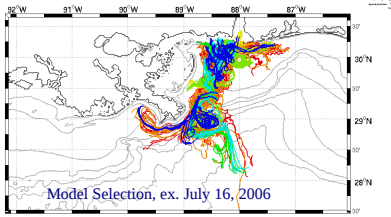
Model domain with exploratory test grid (red circles), shelf-wide larval source points (black), and estuarine targets (colored polygons 1-9).

(2) Method:

Ocean modeling is from the Northern Gulf of Mexico Nowcast/Forecast System (NGOMNFS), a 3D field of currents, salinity and temperature at an hourly, ~1.9 km resolution over a 191 x 318 cell (30 depths), domain including tidal and wind forcing based on satellite altimetry and additional Navy models (NOGAPS and COAMPS), [2].

Penaeid larval stages were given schedules of active behavior that included: light and tidal sensitive vertical swimming, bottom holding, aversion to cool temps and responses to changes in temperature, salinity, and sea height, all designed to detect incoming tidal motion.





Model exploratory development was intensive, covering 2 years of data and included quantitative scoring of models with: random walks (Red-yellow); increasing tidal perception (green-light blue); and the final model; tidal-diel behavior and environmental perception (dark blue).

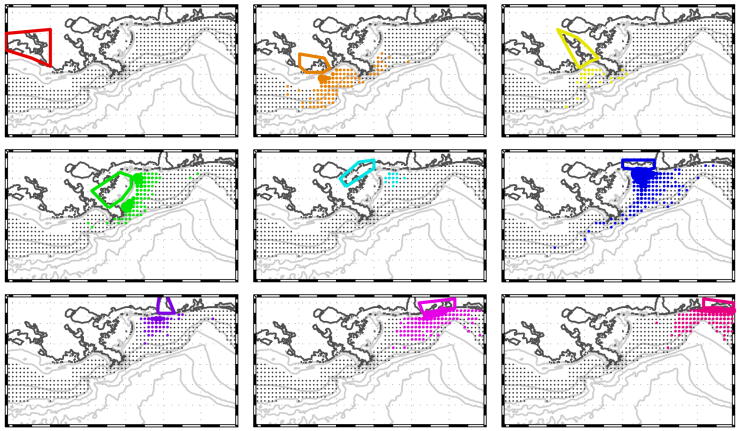
Subsequent modeling excluded all external biotic factors to give a uniform spawning grid constant over all seasons.

(3) Results:

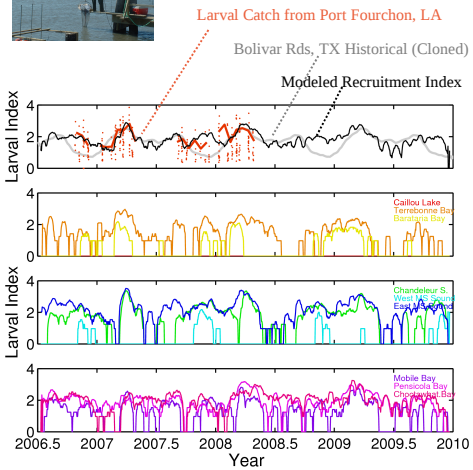
Probable Spawning Maps

Brown shrimp larval source-sink maps for test estuaries. Locations on the shelf are colored with circle size representative of the importance of that location to each estuarine system.

Time series plots of brown shrimp larval Recruitment Index for 9 test estuaries (lower panels, colored lines) modeled over 3 years and a sum of all estuaries compared to 'cloned' historical data from Bolivar Roads tidal pass and sampling from Port Fourchon during 06/07 and 07/08.



Model VS Sampled Time Series



(4) Discussion and Conclusions

Modeling suggests spawning and recruitment to estuaries should occur from distances of less than 30-60 nautical miles, in addition the model gives greater importance to the shallow end of the historical 20-80 m isobath range of suspected spawning.

Year to year ranges in the ocean driven larval flux are small (26 %) suggesting that the coupled behavior and ocean physics components of recruitment variability are surprisingly small.

Reasonable agreement between this behavior-physics based model and sampling is good, suggesting that secondary biological effects on larvae such as food and predation are less important than ocean currents.

(5) Future Plans

Software and oceanographic databases are in place for analysis of other species such as Gulf menhaden.

Modeling will soon be expanded to the entire Gulf of Mexico.

Phase II modeling will include greater biological complexity by adding: proxies of 1) food, 2) predation, and 3) historical spawning geography from trawl surveys.

ACKNOWLEDGEMENT

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COLLABORATION

All computations were in MATLAB® running in open source Ubuntu Linux. Collaborative efforts are underway for translation into C++ at Tulane Univ. and model applications at U. of Southern Mississippi. Other potential collaborators with interest in use and/or development of the code in open source are welcome and should contact the senior author: woody.nero@noaa.gov

REFERENCES

[1] Marinone, S. G., M. J. Ulloa, A. Pares-Sierra, M. F. Lavin, and R. Cudney-Bureno. 2008. Connectivity in the northern Gulf of California from particle tracking in a three-dimensional numerical model. J. Mar. Systems 71: 149-158.
[2] Ko, D. S., P. J. Martin, C. D. Rowley, and R. H. Preller. 2008. A real-time coastal ocean prediction experiment for MREA04. J. of Mar. Systems 69: 17-28.