

GODAE boundary condition effects on the modeling of biophysical coastal processes around the Florida Keys Reef Tract



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SUMMARY

The coastal seas around the Florida Keys Reef Tract exhibit complex dynamics resulting from the interaction with offshore flows, namely the Loop Current/Florida Current system and the frontal eddies that interact with the complex reef topography. A nested modeling approach has been employed to ensure the proper representation of such interactions. A high resolution (~900m) application of the Hybrid Coordinate Ocean Model has been developed focusing on the Florida Keys (FKEYS-HYCOM model). In order to downscale the effects of these large scale flows to scales appropriate for the study of reef related processes, GODAE products (North Atlantic ATL-HYCOM and global HYCOM models, the U.S. contribution to GODAE) have been employed to provide boundary conditions to a succession of regional (Gulf of Mexico, GoM-HYCOM) and local (South Florida, SoFLA-HYCOM) models (Kourafalou et al., 2008); see <http://coastalmodeling.rsmas.miami.edu>

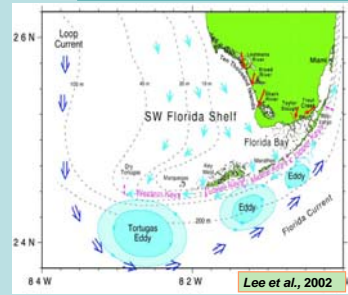
Eddies that travel along the Loop Current/Florida Current front are known to be an important mechanism for the interaction of nearshore and offshore flows. They enable upwelling in the vicinity of the Reef Tract and they influence transport and recruitment pathways for coral fish larvae, as they carry waters of different properties (such as river-borne low-salinity/nutrient-rich waters from as far as the Mississippi River) and waters containing larvae from upstream sources, or entrained from nearby spawning grounds. As such, they play an important role in the circulation around the Reef Tract and connectivity pathways with the Gulf of Mexico and the Caribbean at large. The FKEYS-HYCOM nested model is able to simulate both mesoscale and sub-mesoscale eddy passages during a targeted 2-year simulation period (2004-2005), forced with high resolution/high frequency atmospheric forcing (Kang et al., 2008). Coupling with the ecological population connectivity BOLTS model (Biophysical Larval Tracking System) allows simulations of larval transport, taking into account not only the dispersion of active physical larvae, but also the interaction of factors influencing larval survival, habitat selection and condition at settlement.

Coastal value added products to GODAE include the prediction of changes in the position of the Florida Current front and the evolution of eddies entering the model domain, as shown through comparison to high resolution SeaWiFS data.

Acknowledgements:

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The complex South Florida coastal system



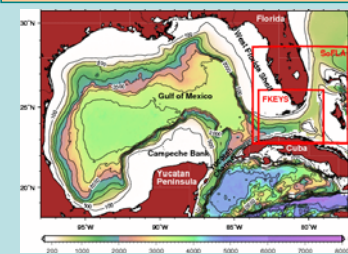
COMPLEX TOPOGRAPHY

- Broad SW Florida shelf
- Narrow Atlantic Florida Keys shelf
- Shallow Florida Bay
- Deep Straits of Florida

COMPLEX DYNAMICS

- Wind-driven shelf flows
- Buoyancy-driven shelf flows (river runoffs)
- Intense coastal to offshore interactions (Loop Current/Florida Current front and eddies)

Multi-nested approach to downscale GODAE products



GOM-HYCOM (nested in ATLHYCOM)

1/25° resolution, uses the Navy Code for Data Assimilation (Cummings, 2005)
idm=517 jdm=343 kdm=20
98.00°W–77.36°W 18.90°N–30.71°N

SoFLA-HYCOM (nested in GoM-HYCOM)

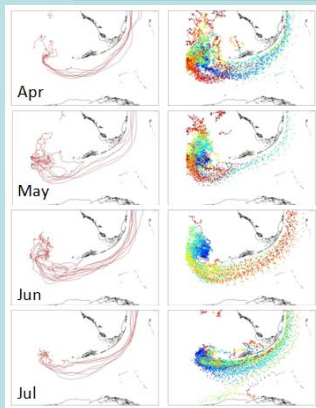
1/25° resolution (with corrected topography around the Florida Keys Reef Tract)
idm=161 jdm=163 kdm=20
83.76°W–77.36°W 22.78°N–28.61°N

FKEYS-HYCOM (nested in SoFLA-HYCOM)

1/100° resolution (~900m)
idm=437 jdm=361 kdm=26
83.36°W–79.00°W 22.78°N–26.05°N

COAMPS-27km atmospheric forcing
nDBDB2 topography with 2 m minimum water depth

Biophysical Larval Tracking System (BOLTS) Coupled with FKEYS-HYCOM



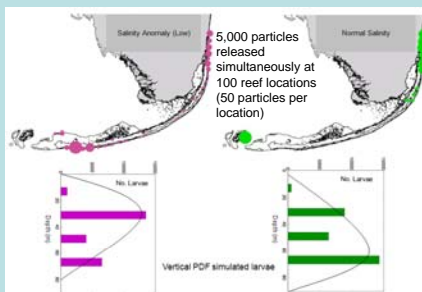
Passive 30-day near surface advection of larvae released at a single location in the Dry Tortugas Ecological Reserve.

Particle displacement (left) and distribution (right) integrated over a 30-day period show looping trajectories and accumulation of particles into small eddies (see orange-red particles).

The color-code of particles indicate their age from day 1 (blue) to day 30 (red); areas with blue and cyan particles indicate strong advection, while areas with concentration of red particles represent retentive flow and/or the end of the 30-day advection.

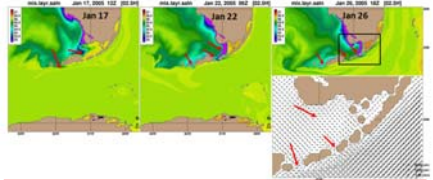
Larvae responses to the environment changes

Bluehead wrasse (*Thalassoma bifasciatum*) recruitment distribution



Salinity around the Keys has pronounced influence on the behavior of coral fish larvae. Under the low (normal) salinity condition, bluehead wrasse have maximum number of recruits at shallower (deeper) depths and higher settlement around lower and middle Keys (upper) Keys.

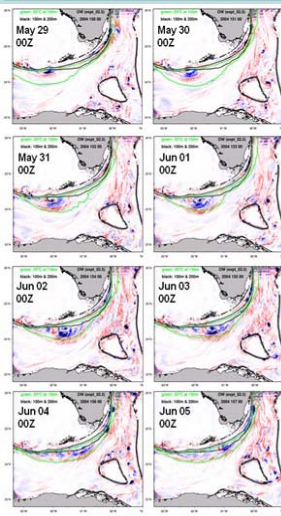
Low salinity intrusions in Florida Bay and the Florida Keys



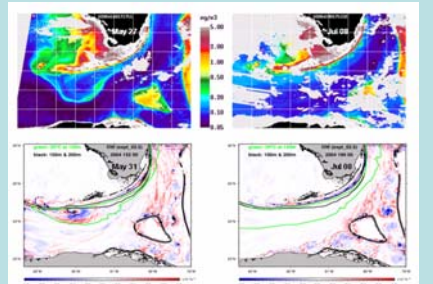
Florida Bay typically exhibits hypersalinity conditions in the dry season. Model simulations confirm data findings that a drop in salinity is possible during winter, through intrusions of low salinity waters from regional rivers. Waters along the Florida Keys Reef Tract experience these changes through the passages to Florida Bay.

Frontal eddies along the Reef Tract

The **Okubo-Weiss parameter (Q)** represents a balance between the magnitude of vorticity and deformation (Veneziani et al., 2005). Since this parameter typically assumes high negative values inside coherent vortex cores while it becomes highly positive in the area immediately surrounding the vortex cores, it is very useful in identifying vortices and rotating structures, like eddies in the ocean.



A series of daily Okubo-Weiss parameter maps from May 29 to Jun 5, 2004 show both mesoscale (order of 100km diameter) and submesoscale (order of 10km diameter) eddies along the Florida Keys Reef Tract. The influence of topography on eddy evolution is marked by black lines (100m and 200m isobaths) and the Florida Current front is traced through the green lines, which give the contours of 20°C at 150m.



The FKEYS model results are validated with observations. Examples of a mesoscale Tortugas eddy (left) and a series of submesoscale eddies along the Florida Keys Reef Tract (right) are in good agreement with eddies captured by SeaWiFS chlorophyll-a high resolution data analysis

References:

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