Circulation and transport on the Northeastern Gulf of Mexico Shelf using a high-resolution ROMS model

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Introduction

Several studies over the past decade have demonstrated the immense variability of the West Florida Shelf (WFS) and Gulf of Mexico (GOM) shelf circulations on various time scales (e.g. He and Weisberg 2002, Morey et al. 2005, Weisberg et al. 2005). However, further questions remain about the ramifications of the shelf circulation on the cross-shelf transport. A relevant example is the onshore transport of pelagic gag grouper (*Mycteroperca microlepis*) larvae from spawning grounds along the WFS break (~70m depth) in February – April to inshore sea grass beds (<5m depth) some 45-60 days later. Previous collaborative works between biologists and physical oceanographers (e.g. Fitzhugh et al. 2005) have resolved little about the mechanisms responsible for onshore transport of these larvae in the spring. Furthermore, Fitzhugh et al. (2005) have voiced the need for three-dimensional modeling approaches in order to better understand the complexity of this problem. We assess the circulation and subsequent transport in the Big Bend Region (BBR) of the WFS using a high-resolution modeling approach (Figure 1).

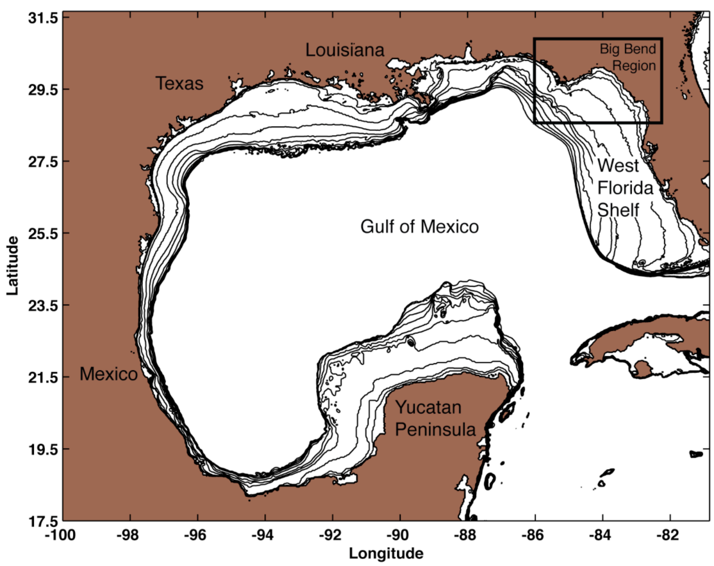

Figure 1. Gulf of Mexico with ROMS model domain indicated by the black box in the northeast corner.

Objectives and Methods

This study is focused on simulating the shelf circulation in the BBR for several different years, although only results for 2007 are provided herein. We use a 30 arcsec (800-900m) resolution Regional Ocean Modeling System (ROMS) configuration with 25 vertical layers, North American Regional Reanalysis (NARR) 3-hourly winds, 16 river sources, COARE 3.0 bulk flux algorithm, and open boundary conditions forced by the Global HyCOM model. Only the spring (01 Feb – 30 Jun) circulation is assessed, as this is the time during which gag spawn and their larvae are subsequently transported inshore.

The location of gag larvae in the water column is unknown, and surface currents at this time of the year are typically offshore. Thus, various water depths are tested in this model to determine the layer in which particles will most successfully arrive inshore. Furthermore, basic Ekman layer theory and upwelling circulation theory suggests onshore transport should occur in the bottom layer during this time of the year (with mean winds from the North – Northwest). To test this theory, trajectories are calculated for particles released in bottom, surface, and mid-depth layers at various spots along the northeastern GOM shelf break.

Results

Results for 2007 indicate an overwhelming number of particles in the bottom layer arrive inshore, associated with a large upwelling event (Figure 2). Furthermore, few particles advected in the surface layer or at mid-depth reach the inshore sea grass beds in the BBR (< 5m) (Figure 3). In the surface layer and at mid-depths, only 0.04% of all particles released are advected shallower than 5m in the BBR, however 7.67% of all particles released in the bottom layer are advected shallower than 5m in the BBR. A maximum success rate of over 99% of particles released in a single day occurs in early April for the bottom layer (Figure 3). This evidence supports the idea of larval transport in the bottom layer, and emphasizes the usefulness of three-dimensional models toward this interdisciplinary study.

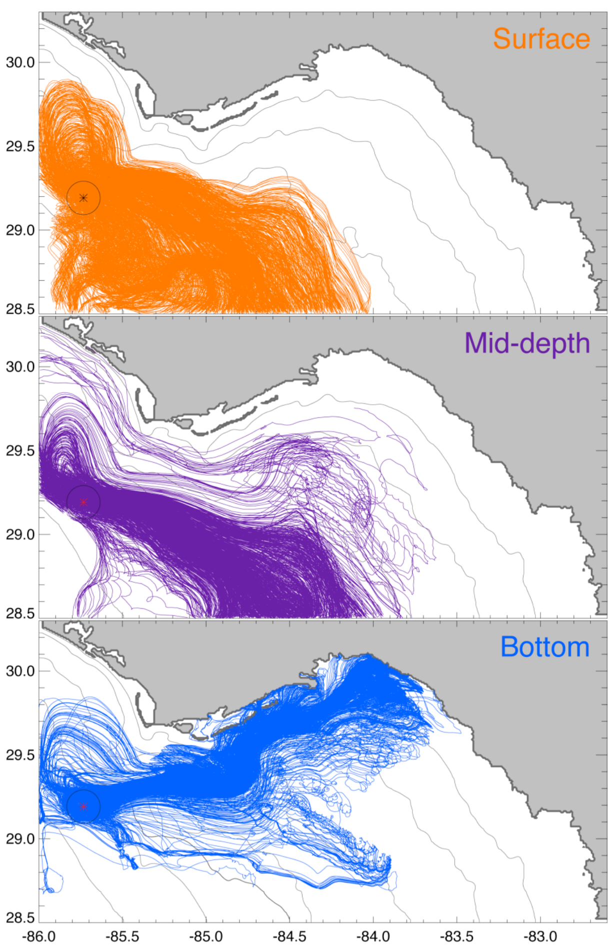

Figure 2. Particle trajectories in layers 1, 13, and 25, for bottom, mid-depth, and surface layers, respectively. 25 particles are seeded every 3 hours for one week beginning on 31 March 2007 about a 0.1-degree radius of a single seeding location. Each particle is followed for 45 days.

References

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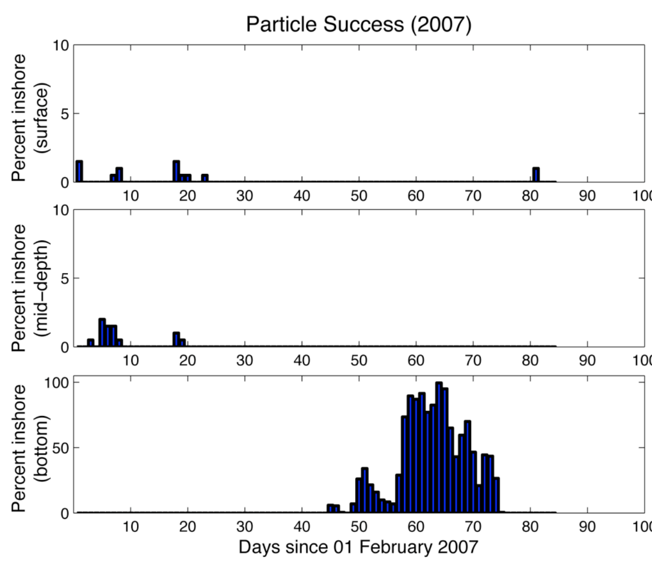

Figure 3. Success rate of particles reaching water shallower than 5m to the east of Cape San Blas within 45 days of being seeded. Days represent the day on which particles were seeded. Note the percentage different scales.