Spring Bloom on Central Georges Bank in 1999: Its Origin and Fate

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Abstract

The possible sources and transport time scales of water parcels on the central portion of Georges Bank (inside 60-m isobath) have been estimated to examine the origin and fate of the spring phytoplankton bloom in that region. An "off-line" Lagrange particle trajectory approach was used in this study. The hydrodynamic flow field was interpolated from hourly model outputs of FVCOM (Finite Volume Coastal Ocean Model), which was driven by the realistic meteorological forcing from MM5 model output, with inclusion of SST and observed current velocity data assimilation. Particle trajectory results show that the "blooming" water in the southern part of the central bank during February and March was mainly from the northern edge of the bank, and was relatively older than the "non-blooming" water in the north. The water parcels on the central bank had an average exposure time (time spent inside the 60- m isobath) of about 20 days, and tended to leave south- or southwest-ward. Moreover, particle trajectory results also suggested that, for 1999, the phytoplankton bloom on the central bank had a limited potential contribution as food source for zooplankton population in the deeper flank areas.

Methods

Figure 2. The schematic of the modeling approach. The Finite Volume Coastal Ocean Model (FVCOM) is driven by the realistic wind and sea surface heat flux forcing output from a meteorological model (MM5), with inclusion of SST and observed current velocity data assimilation. The model provided the hydrodynamic factor for the Lagrange particle trajectory experiments.

"Offline" Lagrangian particle tracking uses the 3-D velocity fields generated from FVCOM to solve the follow equation,

\[ \frac{dx}{dt} = u(x,t) \]

where \( x \) is the particle position at a time t, and \( u \) is the velocity interpolated from the surrounding model grids in space and from hourly model output in time. The equation is solved by a classic 4th order 4-stage explicit Runge-Kutta method with a time step of 2 minutes.

Results

1. Source and age of water parcels

Particles were released in the middle depth from the edge of the 60-m isobath on January 1, 1999 (Figure above) and samples were taken on year day 45, 75, and 101. The time for each particles spent inside the 60-m isobath is calculated as the relative age of water parcel. The source of the water parcels inside the red square is identified by tracing back its original location of release.

2. Residence time and exposure time of water parcels

Particles were released inside the 60-m isobath. Residence time is how long a water parcel will remain inside the 60-m isobath before exiting. Exposure time is the total time for each particle spent inside the 60-m isobath. Different from residence time, exposure time allows the water parcels to exit and re-enter the domain.

3. Relocation of water parcels

Particles were released inside the 60-m isobath. The percentage of particles moved to a pre-defined zone is recorded to estimate the relocation of the water parcels from the central bank to the flank area between the 60- and 100-m isobaths, which is divided into three zones labeled 1, 2 and 3 in the figure above.

Summary

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Acknowledgement

The following information is derived from the particle trajectory experiments:

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