Inter-annual Variability of Springtime Zooplankton Transport into Cape Cod Bay and the Implication to Right Whale Foraging Activity

MWRA

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Abstract

Based on modeled and observational results, a significant correlation is found between the coastal transport in Massachusetts Bay (MB), *Calanus finmarchicus* abundances in Cape Cod Bay (CCB) and North Atlantic right whale sightings in CCB during spring (1997-2003). Zooplankton is normally transported from MB into CCB every spring, providing the key external population source to right whale. Disruption of this operational mode such as in March 2002 would have dramatic consequences to the *C. finmarchicus* abundances and hence the right whale foraging in CCB.

Introduction

Cape Cod Bay (CCB) (Figure 1) serves as a high-use feeding ground for the endangered North Atlantic right whales during late winter and spring. The principal prey of right whale are calanoid copepods, especially *Calanus finmarchicus*, which is a zooplankton species in cold temperate waters. Due to the shallow depth, *C. finmarchicus* population in CCB needs to be renewed every year from external sources, either the Stellwagen Basin or the Gulf of Maine. In spring, the normally southward coastal current in Massachusetts Bay (MB) (Geyer et al., 1992) transports zooplankton into CCB, providing possibly the only external source of zooplankton to CCB. Hence it is important to understand the variability of this transport and the *C. finmarchicus* population in MB.

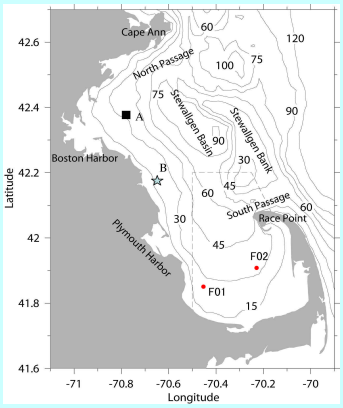

Figure 1 Bathymetry in MB and CCB. Also shown are the locations of USGS buoys A and B and the MWRA zooplankton sampling stations in CCB (red dots). Dash line indicates the boundary of critical habitat for right whale.

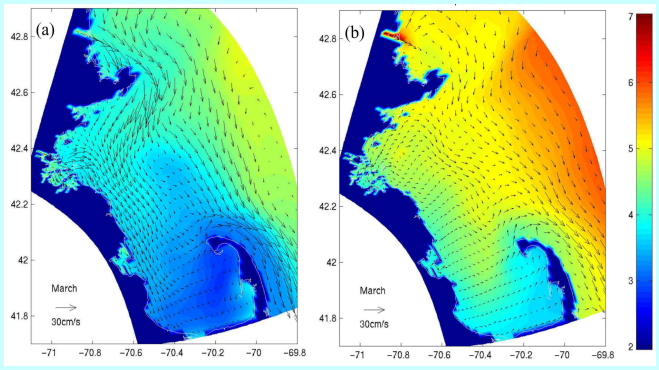

Figure 2 Modeled mean surface circulation in March (a) 2000 and (b) 2002

Methods

The inter-annual variability of coastal transport in MB during 1997-2003 is compared with zooplankton abundances and the right whale sightings in CCB. We focus on March during which right whales reach the activity of the year in CCB.

The inter-annual variability of transport in MB (Figures 2 and 3) is examined using the modeled results of a long-term simulation and mooring measurements in MB maintained by the USGS. The model is based on the ECOM-si (Blumberg, 1991), and has been improved and calibrated extensively against a suite of hydrographical data (HydroQual and Signell, 2001; Jiang and Zhou, 2004). Meteorological condition is measured in MB by the NOAA buoy 44013 (Figure 2).

The zooplankton abundances are measured by net-tows with 21 cruises in western MB and 6 cruises in entire MB and CCB supported by MWRA (e.g., Libby et al., 2001). Data from the two stations located in CCB (Figure 1), which are regularly visited in March every year, is used (Figure 4a). The aerial survey of right whales are conducted by Center for Coastal Studies, and the total sightings in March are calculated without distinguishing animal duplications (Figure 4b).

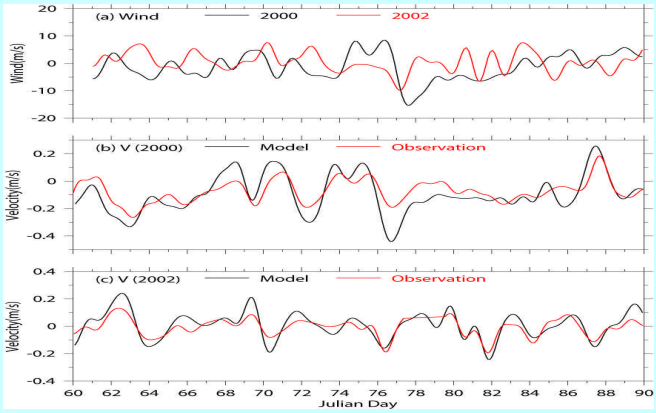

Figure 3 (a) Observed N-S wind at USGS buoy A in 2000 and 2002. (b) Modeled and observed N-S velocities of surface currents in 2000 at USGS buoy B. (c) Same as (b) but in 2002. Note the different scales in (b) and (c). All data were 25-hour low-pass filtered.

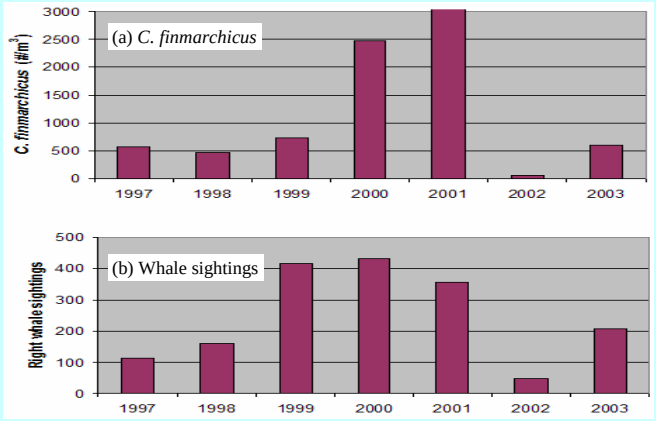

Figure 4 (a) *C. finmarchicus* abundances and Right whale sightings in CCB during March.

Results and Discussion

Surface circulation in March 2002 is unique in that the coastal current is weak and flowing offshore and the GOM intrusion is weak as well, in sharp contrast to typical situation (Figure 2). This is mostly due to weak surface winds in March 2002 that frequently switch directions as opposed to prevailing northerly winds during normal years (Figure 3).

Both *C. finmarchicus* abundance and right whales sightings in March 2002 are unusually low as well (Figure 4). Moreover, significant correlation exists (r^2=0.42) between the right whale sightings and the *C. finmarchicus* abundances in CCB during 1997-2003, indicating low food availability in 2002 may have forced right whales leaving CCB for other areas such as the Great South Channel.

The low *C. finmarchicus* abundances in CCB during March 2002 may be explained by the reversed coastal transport that would dramatically reduce the zooplankton input to CCB. This indicates that circulation pattern and strength in MB and CCB plays an important role in the population development of zooplankton in CCB.

An operational forecast system forecasting hydrographical conditions is being developed at UMass Boston, and this will help management for right whale recovery.

Acknowledgements

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