Sources of Variability in Gulf of Maine Circulation

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ABSTRACT

Variability in the circulation of coastal oceans must ultimately be driven by changes in the meteorological conditions which force currents in the coastal ocean, and by variability in the waters entering the coastal ocean from elsewhere. If a coastal ocean is to be accurately understood and modeled, the external forcing which drive the largest portions of the circulation variability must be observed adequately. Thus some method of comparing the relative importance of various sources of circulation variability must be developed, so that there is confidence that the most important sources of variability are included in any analysis or modeling. This is done for variability in the time-integrated transport.

The relative importance of various sources of circulation variability in the Gulf of Maine are then quantified, with an emphasis on variability on times longer than tidal or weather-band timescales. It is found that the variability forced by fluctuations in the winds and the inflow from the Scotian Shelf to the Gulf of Maine produce roughly comparable amounts of circulation variability. However, changes in the density structure of the GoM produce changes in time-integrated transport that are an order of magnitude larger, at least in the central Gulf of Maine. The changes in the large-scale density gradients that cause circulation variability are governed by mixing processes in the Gulf and by changes in the water masses entering the Gulf of Maine. Unless the density and transport of the waters entering the Gulf of Maine are routinely observed, numerical models will fail to capture much of the variability in the circulation of the Gulf. An analysis is given of the minimal set of observations needed to allow numerical models of the Gulf of Maine to adequately resolve the true variability in the circulation.

There is an increased desire to understand the sources of interannual variability the ecosystems of coastal oceans, and thus of the variability of the ocean circulation that govern these ecosystems. In order to understand the circulation variability, the relative importance of the sources of this variability must be understood. In the analysis below, the relative importance of various sources of circulation variability in the Gulf of Maine (GoM) is quantified. The analysis will show that many current models fail to capture the majority of the variability in the circulation on the ecologically and societally relevant timescales of a few months and longer. The models do not fail because of any inherent flaw, but because observations are currently unable to adequately constrain and force these models adequately.

The transports driven by the currents in the GoM control many important ecological processes, and the examination of circulation variability below will focus on time and space scales of broad ecological interest. The transport of near surface waters from the northeast GoM to the southwest and then onto Georges Bank move copepods from the gulf where they can successfully reproduce onto the bank where they are food for economically important larval fish [*Hannah et al.*, 1998]. Transport along the coast of Maine can move