Recruitment, development and mortality of Calanus finmarchicus in the Georges Bank region

Xingwen Li1, Dennis J. McGillicuddy1, Jr., Edward G. Durbin2

1 Applied Ocean Physics and Engineering Department, Woods Hole Oceanographic Institution, Woods Hole, MA 02543, USA
2 Graduate School of Oceanography, University of Rhode Island, South Ferry Rd, Narragansett, Rhode Island 02882, USA

Abstract

An adjoint data assimilation approach was used to quantify the time-space-stage specified physical and biological controls on Calanus finmarchicus. Three stages over Georges Bank and its surrounding regions. Large seasonal and spatial variations are present in the modeled supply sources, mortality rates, and model control fields. Partially recovered off-shelf initial conditions show that the inshore bloom in the Gulf of Maine, and the Scotian Shelf are major off-shelf source regions of early stage nauplii. 58% of the inshore sources of young nauplii are mainly confined on Georges Bank, especially on the Northeast Peak. These in-shelf sources of young nauplii are able to produce the bank with nauplii in late summer, becoming copepods in spring. Large mortality rates of stages N5 - C1 between January - February are the main regulators to limit the population increase rates. In the meantime, advection and mixing processes transport species from source regions on Georges Bank to surrounding waters in the Gulf of Maine, the continental slope and South Atlanta Bight. Between April - May, the population dynamics on the bank are driven by molting from lower to higher stages. Between May - June, abundances of copepods drop sharply on Georges Bank, especially on the Crest. Large mortality rates are mainly responsible for the population decline. In addition, down-stream transport of advection and down-gradient transport of turbulent mixing enhance the June decline. Mortality rates of N5 to C1 are large between January - March and May - June. Mortality rates of C2 and C4 are large between April - June. Calanus finmarchicus are most vulnerable to death at stages N4 and C1, but most unlikely to die at stages C3 and C5. When they mature to adults, their mortality rates are large in the warm water of early summer.

Objective

To infer and interpret the first order inferences of the population dynamics of Calanus finmarchicus, species, by combining a multi-stage physical-biological model with the observations, i.e., the seasonal cycle of vertically-integrated distributions (Figure 1) of N3 to C5 stages from 5 years of GLOBEC observations.

Model description

forward model:

2.5 Vertical averaged off-line version of a finite element hydrodynamic model (Lynch et al., 1996).

Mismatch climatology physical environment.

\[ \nabla \nabla \left( \begin{array}{c} H \nabla \nabla \end{array} \right) - \sum_{i} F_{i} = \sum_{i} \left( H \nabla \nabla \right) \frac{\partial}{\partial t} + \sum_{i} F_{i} \left( \frac{\partial R}{\partial t} + \frac{p}{\partial t} \right) \left( \frac{\partial R}{\partial t} + \frac{p}{\partial t} \right) \right)

C: vertically-averaged zooplankton concentration.

R: -input sources and mortality of N3.

\[ \delta_{R} \left( \frac{\partial R}{\partial t} + \frac{p}{\partial t} \right) \left( \frac{\partial R}{\partial t} + \frac{p}{\partial t} \right) \right)

\frac{\partial}{\partial t} \left( \frac{\partial R}{\partial t} + \frac{p}{\partial t} \right) \left( \frac{\partial R}{\partial t} + \frac{p}{\partial t} \right) \right)

Control variables:

1. spatially varying R, \( R \) over the whole model domain, and the off-shelf initial fields. All control variables are allowed to vary independently at corresponding model nodes. The first guess of those control variables are all set to zero.

A quasi-Newton algorithm for solving large nonlinear optimization with simple bounds (Byrd et al., 1995) is used to minimize the cost function.

Results

The constrained model successfully reproduces the most salient features of the observations. Partially recovered off-shelf initial conditions. By middle January, GIB and its surrounding regions of the GOM and the Scotian Shelf have already been populated with young nauplii. Moderate abundances of C1 - C2 also appear.

References