A Biophysical Modeling Approach to Understanding Red King Crab Larval Drift in Bristol Bay, Alaska

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Introduction

Red king crab (*Paralithodes camtschaticus*, RKC) larvae spend months in the water column and have specific habitat requirements upon settlement, which implies that the location of larval release relative to oceanographic processes and suitable juvenile habitat is important for determining recruitment success or failure in a given year. Southwestern Bristol Bay is thought to be an important release area because seawater flow through Unimak Pass and along the Alaskan Peninsula likely facilitates advection to favorable nearshore benthic habitat. Yet the strength and direction of these currents can differ in warm versus cold years (Stabeno et al., 2012). In addition, the extent of the cold pool, a body of cold (<2°C) subsurface water that occurs in the winter/spring and varies with winter conditions (e.g., the extent of sea ice) alters crab migration patterns and spatial distribution (Fig. 1).

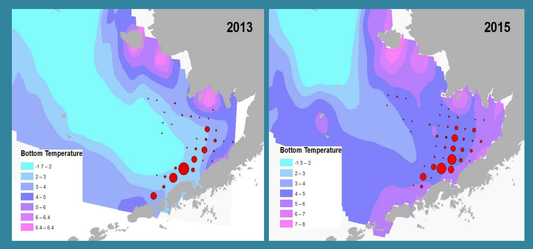

Figure 1. 2013 and 2015 are examples of recent years with contrasting bottom temperature conditions. The cold pool (<2°C) is indicated by light blue. Red dots indicate mature female red king crab abundance based on NOAA survey data. The size of the dots correspond to relative abundance.

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Selected reference: Stabeno, P.J., Kachel, N.B., Moore, S.E., Napp, J.M., Sigler, M., Yamaguchi, A., Zerbini, A.N., 2012. Comparison of warm and cold years on the southeastern Bering Sea shelf and some implications for the ecosystem. Deep Sea Research Part II: Topical Studies in Oceanography. 65, 31-45.

The recommendations and general content presented in this poster do not necessarily represent the views or official position of the Department of Commerce, the National Oceanic and Atmospheric Administration, or the National Marine Fisheries Service.

Objectives

- Improve an existing hydrodynamic model (based on the Regional Ocean Modeling System, ROMS) by focusing on the Bristol Bay region and developing a finer scale (2 km by 2 km) horizontal resolution grid.
- Modify an existing individual-based model (IBM), developed for snow crab (*Chionoecetes opilio*) larval transport, for red king crab.
- Run model simulations to develop larval trajectories and predict post-larval settlement locations.

ROMS Features

Model grid: 2 km resolution

Model forcing: NOAA Climate Forecast System Reanalysis data

Model validation: Drifter tracks at 20 m and 40 m depths

Model years: Hindcast: 1999, 2005, 2007; Forecast: (2030-3020)

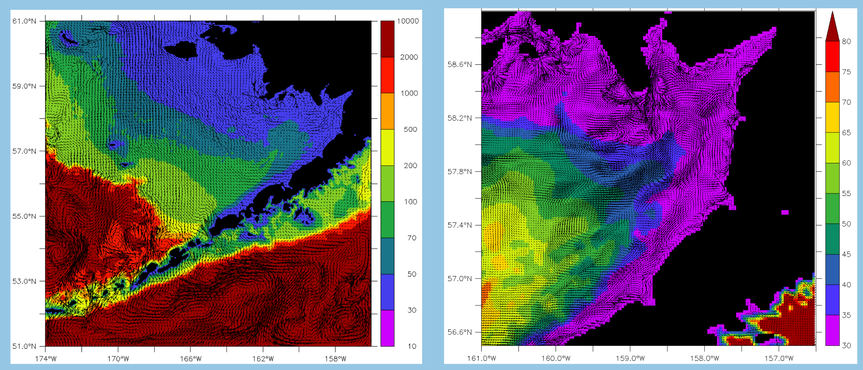

Figure 2. Left: Model grid (2 km resolution) with sample surface velocities (weekly averages) for May 14, 1999. Every 5th vector is plotted. Right: Close-up of the model grid in Bristol Bay. All velocity vectors are plotted. Colors correspond to bathymetric depth in meters. Vector scale is shown in m s^{-1}.

IBM Features

Initial spatial conditions: 1) Estimates of location and density from NOAA surveys
2) Locations of hypothetical relevance

Hatch timing: April 1 – June 15

Growth: Temperature dependent

Behavior: Larval vertical migration, post-larval habitat selection

Habitat: Sediment and invertebrate data (cobble, shell, and structural invertebrates are examples of good RKC settlement habitat)

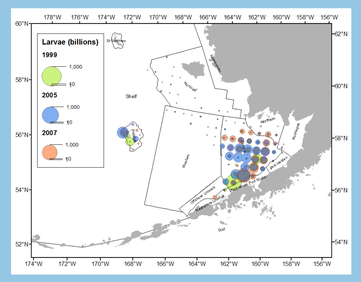

Figure 3. Initial spatial conditions for 1999, 2005, 2007, which are considered cold, warm, and intermediate years respectively. NOAA survey data are used to estimate larval density and spatial distribution at the time of hatch. Polygons are used to compare rates of connectivity and retention among regions.

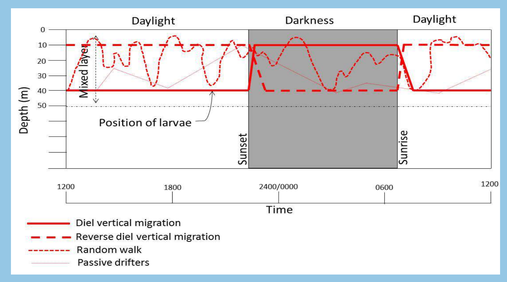

Figure 4. Larvae have four different diel behaviors in the IBM: diel vertical migration, reverse diel vertical migration, random walk, and passive drift.

Preliminary Sensitivity Analyses

- ROMS horizontal resolution influences direction and extent of advection.

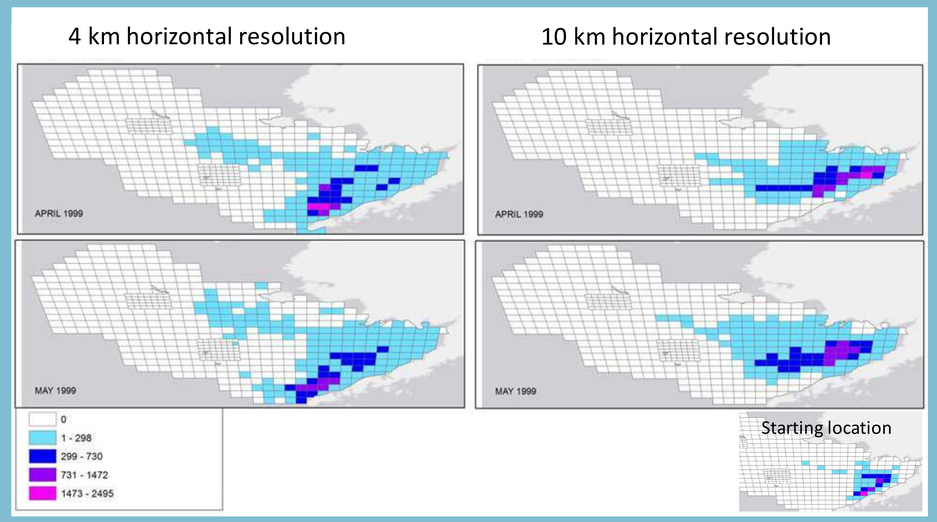

Figure 5. Distribution of particles after four months using high (4 km) and low (10 km) resolution ROMS models. Particle release occurred in April and May 1999. The total number of particles tracked is color coded.

- Advection patterns are generally consistent from a given location, regardless of the number of particles tracked.

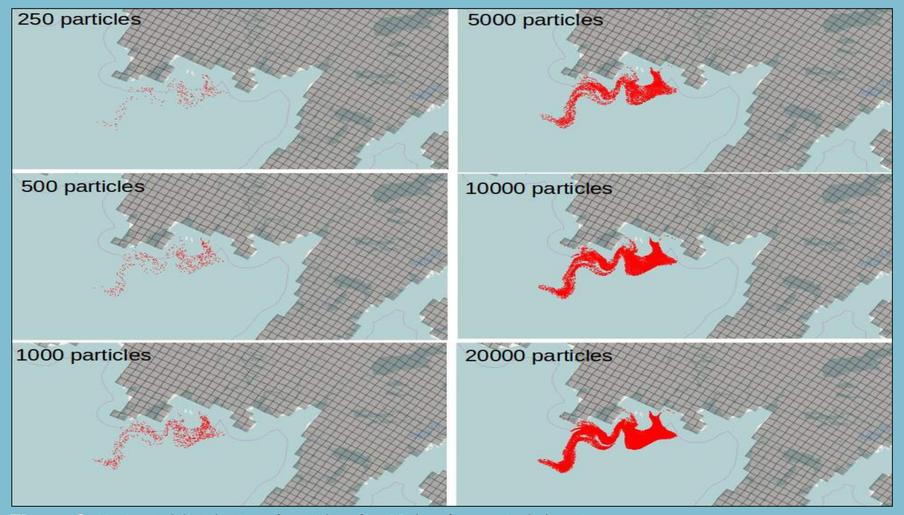

Figure 6. Horizontal distribution of particles after 30 days from a single location.

Upcoming Simulations and Model Results

1. Predict trajectories and post-larval settlement under:
   - Contrasting temperature conditions (1999, 2005, 2007) using the 2 km ROMS model.
   - Contrasting initial spatial (real and hypothetical), temporal release, and behavioral scenarios.
2. Filter out post-larval settlement positions based on data-driven habitat maps (substrate preference).
3. Build post-larval settlement maps for each model year and simulation scenario.