BEST-BSIERP
Bering Sea PROJECT
UNDERSTANDING ECOSYSTEM PROCESSES IN THE BERING SEA 2007–2013

The Early Life of Walleye Pollock on the Eastern Bering Sea Shelf

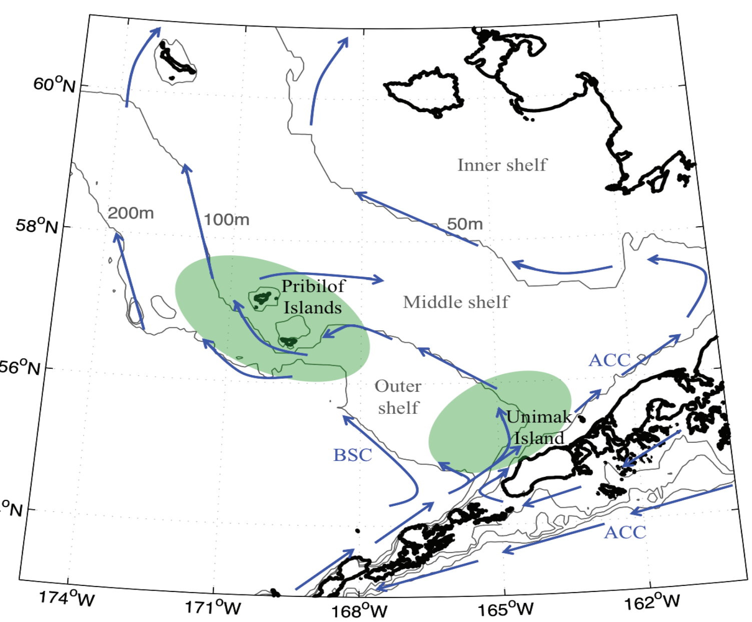
DISTRIBUTION SHIFTS IN WARM AND COLD YEARS

Fish eggs and larvae are very vulnerable within the first few months after being spawned. They are only a few millimeters long, and rely on ocean currents to take them from the spawning grounds to their nursery areas. Due to starvation and predation, less than one percent survive. To maximize their chances, adult fishes have evolved to spawn their eggs at the times and places that will lead to successful transport and higher survival rates of their larvae.

In the eastern Bering Sea (Figure 1), sea ice may affect when and where adult Walleye Pollock (*Gadus chalcogrammus*) spawn their eggs, and current patterns affect where the eggs and larvae drift. This area recently experienced an exceptionally warm period (2001-2005) followed by a prolonged cold period (2007-2012). During cold years, winter sea ice extended farther south and offshore, creating a large, cold pool of bottom water that adult pollock avoid. In the warm years this cold pool was much smaller and there appeared to be stronger flow to the east and onto the shelf. Research cruises observed that pollock eggs and larvae were found further onshelf in warm years than in cold years. We wanted to know how

continued on page 2

Fig. 1



The dominant currents (blue lines) and Walleye Pollock spawning areas (green ovals) of the Eastern Bering Sea. The Alaska coastline is shown in black and the 50, 100, and 200 m isobaths in gray. ACC – Alaska Coastal Current; BSC – Bering Slope Current.

The Big Picture

Spawning time, spawning location, and transport by currents affect the location and survival of fish eggs and larvae. The eastern Bering Sea recently experienced several warmer-than-average years followed by colder-than-average years. Observations of the spatial distribution of Walleye Pollock eggs and larvae indicated that larval distributions were shifted from the outer continental shelf towards the middle shelf in warm years. We used a computer model to simulate how pollock eggs and larvae are transported by currents, grow over time, and move up and down in the water column. Simulations suggest that differences in adult spawning location between warm and cold years play a bigger role than differences in water transport alone or differences in the time of spawning.

THE VARIABLE TRANSPORT OF POLLOCK EGGS AND LARVAE OVER THE BERING SHELF: A MARRIAGE OF PHYSICS AND BIOLOGY
A component of the BEST-BSIERP Bering Sea Project, funded by the National Science Foundation and the North Pacific Research Board with in-kind support from participants.

differences between cold and warm years resulted in this pattern.

How We Did It

We developed a model that simulated the transport, biology, and behavior of individual pollock eggs and larvae. Simulated spawning areas were based on where adult pollock in spawning condition have been found. Tens of thousands of eggs were "released" in the model at seven spawning times. We compared where different size classes of eggs and larvae were located in warm (1996, 2002, 2003, 2005) and cold (1997, 1999, 2000, 2006, 2008-2012) years by calculating the center of the distribution of each size class. We considered four different scenarios. In each, the ocean currents were specific to the simulated year and were based on observed climate conditions, while spawning areas and times differed among scenarios: (a) Spawning time and location were the same for warm and cold years. (b) Spawning locations were the same, but spawning time was 40 days later in cold years, simulating the possibility that adult fish waited for sea ice retreat before spawning. (c) Spawning time was the same, but the spawning areas were increased in size in warm years, simulating the expansion of spawning adults into areas without sea ice. (d) Spawning time was the same, but the spawning areas were reduced in size in cold years, simulating avoidance of sea ice-covered areas by adult fish.

When spawning time and location were held constant (Figure 2a), and when spawning time was 40 days later in cold years (Figure 2b), the centers of distribution of pollock eggs and larvae did not differ much between warm and cold years, suggesting that climate-related differences in ocean circulation and delays in spawning time are not sufficient to cause observed changes in distributions. The distribution of simulated eggs and larvae resembled observations when spawning areas were expanded in warm years (Figure 2c). The simulation that produced distributions most comparable to the observations was when spawning areas were decreased offshore in cold years (Figure 2d), but the differences between warm and cold years were not as large as those observed. We conclude that the dissimilar distributions of eggs and larvae in warm and cold years most likely resulted from spawning area shifts in response to changes in the presence and extent of sea ice.

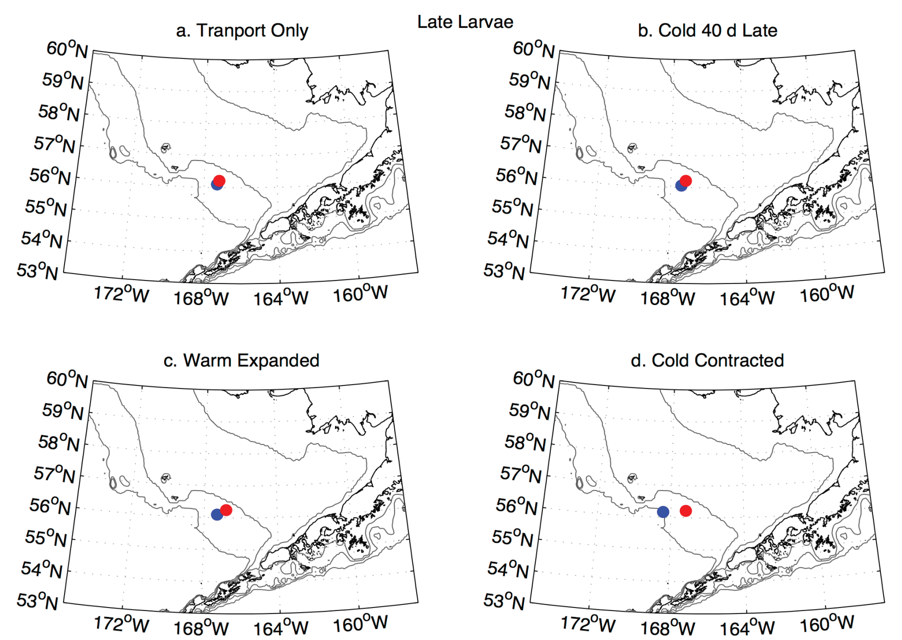
Why We Did It

Related studies have shown differences in prey availability between warm and cold years, and fewer pollock surviving to adulthood in recent warm years with less sea ice. We are currently investigating the cause of these observations. We need a better understanding of these connections because climate change and the associated warming of the arctic and subarctic not only affects the pollock population and therefore the entire ecosystem of the eastern Bering Sea, but also the people who depend on pollock for their livelihood.

Colleen M. Petrik, University of Alaska Fairbanks (UAF)
Janet T. Duffy-Anderson, National Oceanic and Atmospheric Administration (NOAA) Alaska Fisheries Science Center
Franz Mueter, UAF
Katherine Hedstrom, UAF
Enrique Curchitser, Dept. of Environmental Sciences and Institute of Marine and Coastal Sciences, Rutgers University

The Bering Sea Project is a partnership between the North Pacific Research Board's Bering Sea Integrated Ecosystem Research Program and the National Science Foundation's Bering Ecosystem Study. **www.nprb.org/beringseaproject**

Fig. 2



Modeled centers of gravity of late stage (10-40 mm Standard Length) larvae in cold (blue) and warm (red) years for all 4 scenarios: (a) spawning time and location were the same for warm and cold years (the red dot is on top of the blue dot); (b) spawning locations were the same, but spawning time was 40 days later in cold years; (c) spawning time was the same, but the spawning areas were expanded in warm years; (d) spawning time was the same, but the spawning areas were contracted in size in cold years.