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

Young Fish in a Warm Bering Sea

THE FATE OF WALLEYE POLLOCK LARVAE

A single female walleye pollock can produce millions of eggs in her lifetime. If even three of her millions of potential offspring survive to adulthood, the female has not only replaced herself and her mate, but she has added one more to the overall population. In this case, population growth is positive. However, numerous factors act to cull the number of young that survive, and evidence suggests that walleye pollock populations are either stable or declining in the North Pacific. At the same time, there is mounting evidence for gradual warming in the Bering Sea, a major spawning area for walleye pollock. We asked the question, "Do warming conditions affect the survival of young walleye pollock? Do they affect their distribution? Their growth?"

How We Did It

We examined larval walleye pollock (*Gadus chalcogrammus*) distribution and abundance under colder-than-average and warmer-than-average conditions in the Bering Sea. To examine long-term trends, we relied on a series of historical samples collected by the National Oceanic and Atmospheric Administration/Alaska Fisheries Science Center (NOAA/AFSC) Fisheries Oceanography and Coordinated Investigations program. NOAA has been conducting plankton surveys in the eastern Bering Sea since the mid 1980's. Fish eggs and larvae (ichthyoplankton) are collected with small mesh nets that strain ocean water and accumulate the early life stages of fish (Figure 1). Samples were preserved and identified, and data were archived in a database of larval fish collections. We used database-derived data on walleye pollock eggs, larvae, and early juveniles collected on plankton surveys conducted between 1988 and 2010 to calculate the mean geographic center-of-distribution for eggs, larvae, and juveniles over the continental shelf during warm periods and cold periods. We also determined mean size of pollock larvae and mean mortality rates during warm and cold periods. Finally, we examined shifts in the timing of peak egg abundance to address

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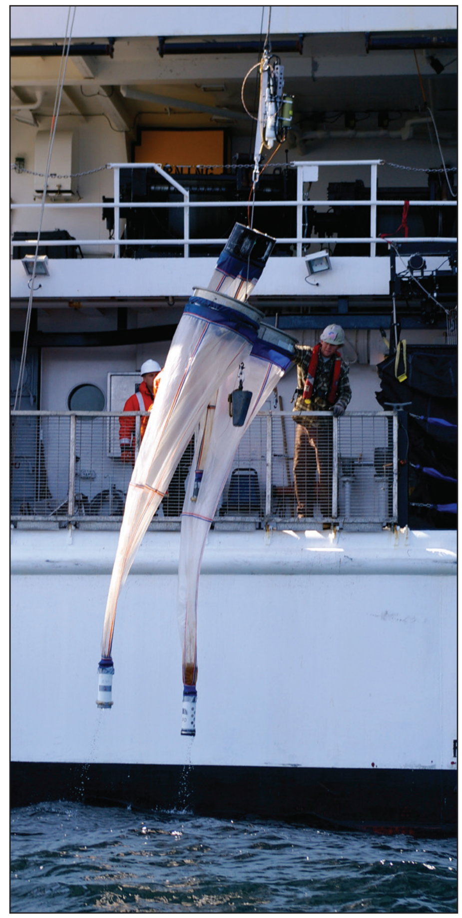
Fig. 1



Walleye pollock eggs and larvae are collected using small mesh plankton nets.

The Big Picture

Our study demonstrates that shifts in ocean temperatures affect young walleye pollock larvae both directly and indirectly. Direct impacts include growth effects, metabolism, and development. Indirect effects include temporal shifts in the timing of spawning and climate-mediated influences on ocean currents that deliver larvae to nursery areas. Our conclusion: future changes in ocean temperatures will alter rates of growth, development, and survival of pollock larvae, and can contribute to eastward shifts in the distribution of eggs and larvae.

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the hypothesis that the timing of pollock spawning may be delayed under cold conditions.

What we found:

- There is evidence of a shift in the timing of spawning of adult walleye pollock by as much as 30 days between warm and cold years, with timing of peak egg abundance occurring in March in warm years and April in cold years.
- All stages of larval walleye pollock were distributed over the middle shelf in warm years and over the outer shelf in cold years (Figure 2).
- Mean growth rates of larval walleye pollock were reduced in cold years relative to warm years (Figure 3a).
- Mean mortality rates of larval walleye pollock were elevated in cold years relative to warm years (Figure 3b).

Why We Did It

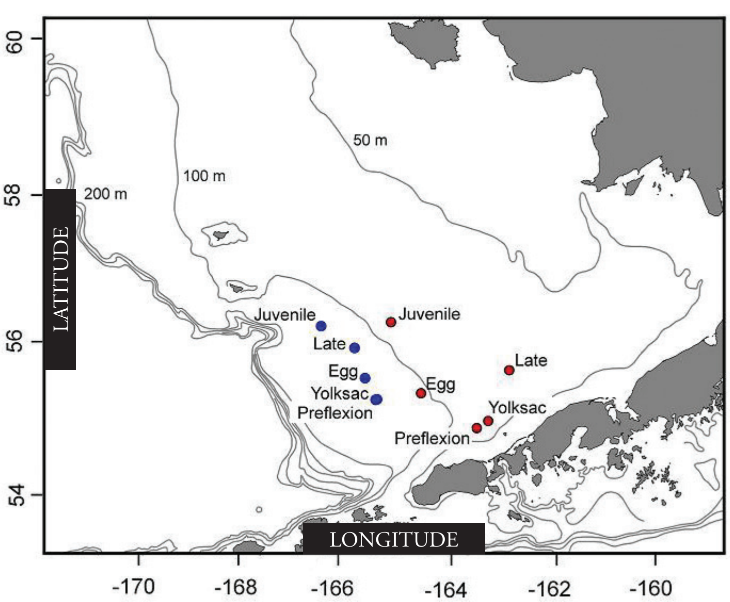
Walleye pollock larvae hatch out relatively underdeveloped, lacking the fins that promote swimming abilities, so they tend to be transported at the mercy of predominant ocean currents. Climate-mediated shifts in ocean flow deliver larvae to different habitats during warm and cold periods, potentially affecting the type and densities of zooplankton prey that developing larvae need for growth and survival. This is important for young fish since survival to the juvenile phase of life is a critical step in successful recruitment to the fishery.

In addition, fast growing larvae that occur at warm temperatures have higher metabolic requirements, necessitating access to ample, high quality prey resources to sustain good growth. However, other work has determined that the zooplankton prey available to walleye pollock larvae in warm years is of poorer quality than that available in years when temperatures are cold. Prolonged feeding by fast-growing larvae on low-quality prey jeopardizes overall survival and recruitment. In fact, recent evidence suggests that fewer pollock larvae ultimately survive to become 1-year olds when conditions were warm during the larval period compared to when they were cold.

Janet Duffy-Anderson, NOAA/AFSC
Franz Mueter, University of Alaska Fairbanks (UAF)
Tracey Smart, University of Washington (UW)
Elizabeth Siddon, UAF
John Horne, UW

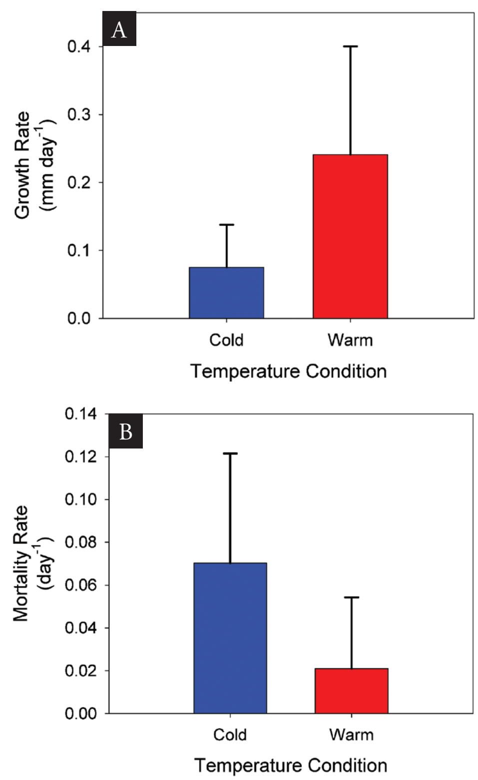
The Bering Sea Project is a partnership between the North Pacific Research Board's Bering Sea Integrated Ecosystem Research Program and the National Science Foundation's Bering Ecosystem Study. **www.nprb.org/beringseaproject**

Fig. 2



Distributions of all early life history stages (eggs, yolksac larvae, preflexion larvae, postflexion larvae, juveniles) of walleye pollock are shifted eastward over the middle continental shelf in warm years and westward over the outer continental shelf in cold years.

Fig. 3



Larval growth rates (A) are reduced in cold years relative to warm, and larval death rates (B) are increased in cold years relative to warm.