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

Climate and Bering Sea Fisheries: Beyond a Northward March

SURPRISING IMPACTS ON BERING SEA POLLOCK AND PACIFIC COD FISHERIES

While some other global scale research has suggested that a warming climate will propel marine species northward, our work has demonstrated that for the biggest fisheries in the Bering Sea, this has not occurred as expected. For pollock between 1999 and 2009, the fishery shifted northward in the summer, but this occurred in cold years more than warm years. Similarly, for Pacific cod, a larger cold pool (where bottom water temperatures are below 2°C) in <u>cold</u> years has led to fish being more concentrated in northern areas and consequently to more fishing in those areas (Figure 1).

How We Did It

A significant component of our research has been focused on identifying the mechanisms by which climate impacts fisheries. We use data on fishing locations, fish and fuel prices, and how these interact with biological survey information and environmental data. After collecting data and talking to fishermen, we used a variety of statistical methods to see how management, changing prices, and changing biological and environmental measures have impacted the fisheries (Figures 2 and 3).

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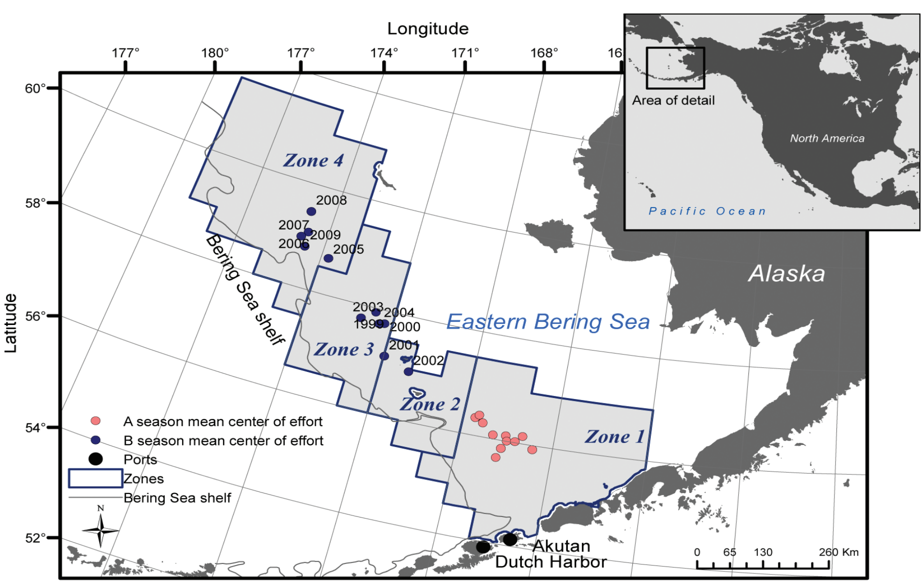
The Big Picture

The BEST-BSIERP Bering Sea Project recognized from its outset that humans are an important component of the ecosystem, and that we cannot understand the system without understanding how they use and adapt to the changing environment. By examining the response of largest Bering Sea fisheries to the changing environment, we have illustrated that people will not respond in a simple manner to the changing environment. A better understanding of how the fishery behaves in warm, low-abundance years will help inform how the fishery will react in the future. Managers can use this information to better anticipate how fisheries will interact with other parts of the ecosystem, which can contribute to better-managed fisheries.

Fig. 1



The Eastern Bering Sea and the fishing areas of the catcher–processor fleet. Points represent the catch-weighted mean center of the distribution of fishing hauls by season. Note the large distinction in the movement of the fishery over time that occurs in the summer fishery B season as well as the lack of movement in the winter fishery A season. [From Haynie, A. and L. Pfeiffer. 2013. "Climatic and economic drivers of the Bering Sea pollock (Theragra chalcogramma) fishery: Implications for the future." Canadian Journal of Aquatic and Fisheries Science. 70(6): 841-853, 10.1139/cjfas-2012-0265.]

SPATIALLY EXPLICIT INTEGRATED MODEL OF POLLOCK AND COD
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.

From this research, we have seen that abundance and environmental conditions both directly impact where the fisheries occur. Other BSIERP work has indicated that we are likely to see more low-abundance years with a warming climate (Mueter et al., *ICES* 2011), but in recent times, warm years have also been high-abundance years. As shown in Figure 3 and discussed in the Haynie and Pfeiffer ICES 2012 article referenced in Figure 2, we have not yet experienced a likely future state of warm, low-abundance conditions.

Why We Did It

Fishers are the apex predators of the Bering Sea ecosystem, and their spatial behavior can tell us a great deal about the way in which fish populations are shifting under changing climate conditions. After controlling for other factors, how has variation in climate conditions affected the spatial extent of Bering Sea fisheries? How do we expect predicted changes in future climate to impact fisheries and fishing communities? Informing decision-makers on how climate and fisheries are interacting is essential to the effective management of marine resources in the future. The decisions that managers make now will impact the welfare of fishers, communities, the nation, and the ecosystem over the next century.

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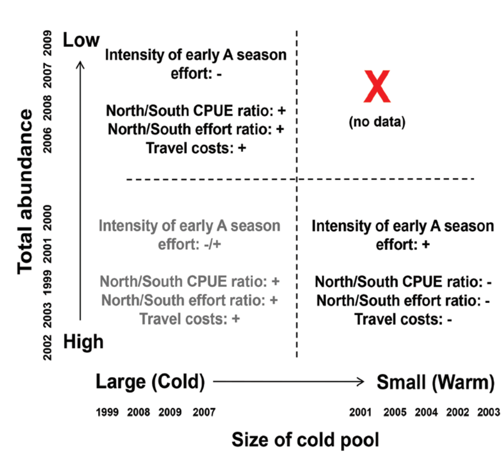
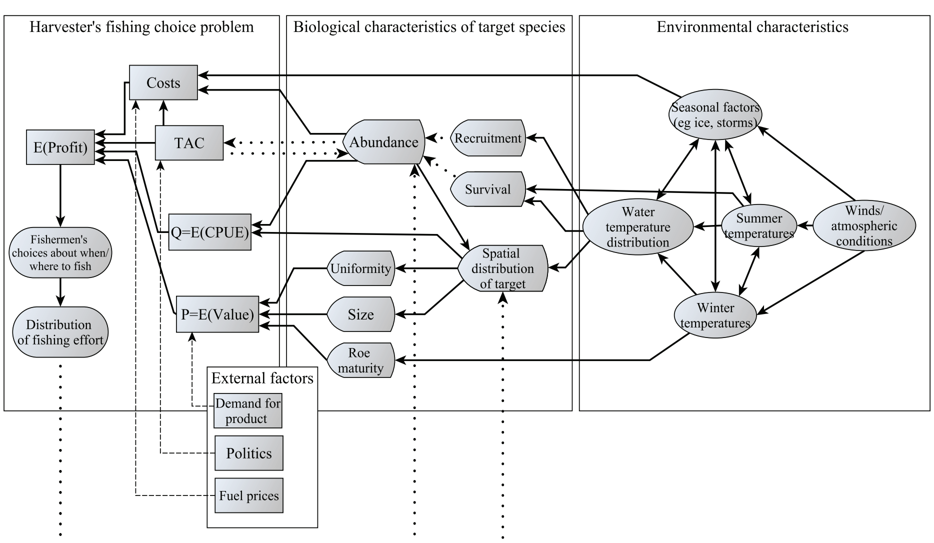
The Bering Sea Project is a partnership between the North Pacific Research Board's Bering Sea Integrated Ecosystem Research Program and the National Science Foundation's Bering Ecosystem Study. **www.nprb.org/beringseaproject**

Fig. 3



Summary of the effects of the size of the cold pool and total pollock abundance on the intensity of early A-season (winter season) effort, B-season (summer season) catch per unit effort (CPUE), B-season effort, and B-season travel costs. Years in the sample characterized by varying abundance and cold pool levels are listed on the horizontal and vertical axes. [Also from Haynie and Pfeiffer CJFAS 2013, referenced above.]

Fig. 2



A conceptual model of how the environment affects the distribution of fishing effort, including the total allowable catch (TAC) and the cost per unit effort (CPUE). Arrows represent the direction of causality, and dotted lines represent mechanisms that may occur on a non-contemporaneous time scale. [From Haynie, A. and L. Pfeiffer. 2012. "Why economics matters for understanding the effects of climate change on fisheries." ICES Journal of Marine Science, 69 (7): 1160-1167, doi:10.1093/icesjms/fss021.]

A catch of pollock on the NOAA ship Miller Freeman, *a fisheries oceanography vessel that works predominantly in the Bering Sea and the North Pacific Ocean.*