

Distribution of Age-1 and Age-2 Walleye Pollock in the North Pacific: Sources of Variation, Implications for Higher Trophic Levels, and Climate Change
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Summary Statement:

The overall objective of our proposed research is to: 1) examine the horizontal and vertical distribution of age-1 and age-2 walleye pollock in the Gulf of Alaska (GOA) and eastern Bering Sea (EBS), 2) relate observed patterns to predominant physical (temperature, salinity, latitude, longitude, bathymetry) and biological (prey availability, diet) characteristics, and 3) examine the implications of these results on birds and mammals. To this end, we have: 1) collected age-1 and age-2 walleye pollock from the eastern GOA (August, September, 2001), 2) conducted a retrospective analysis of historical (1990-1996) walleye pollock consumption in the EBS, 3) begun a series of laboratory experiments designed to: a) define and quantify the effects of size and temperature on juvenile pollock food consumption and growth rate, and b) examine the effects of vertical thermal gradients on vertical distribution of age-1 and age-2 pollock, and 4) continued analyses of historical hydroacoustic data to relate patterns of sub-adult walleye pollock distribution to predominant physical (temperature, salinity, latitude, longitude, bathymetry) in the EBS.

Our original proposal was a two-year project and we have requested support for Year 2. Analyses of all biological samples collected from the GOA (August, September) will take approximately 1 year. Laboratory experiments will continue in Year 2 and additional time is needed to analyze and interpret results. Extrapolations to higher trophic levels will take place upon completion of all other data analyses. We hope that the PCCRC will continue to support this project through Year 2 to ensure the completion of all its components.

Status of Specific Objectives:

Collection of age-1 and age-2 walleye pollock:

We collected age-1 and age-2 walleye pollock on two separate research cruises (August and September, 2001) in the GOA to study factors affecting horizontal and vertical distribution.

In August, a cruise was conducted off the east side of Kodiak Island, AK. While the primary objective of this cruise was to collect echo integration data to determine distribution of adult walleye pollock, collections of age-1 (~80 individuals) and age-2 (~40 individuals) pollock to be used in data analyses relative to this study were made at select stations. Collections were made using an Aleutian wing trawl and a PNE bottom trawl. Fish were frozen whole and are currently being stored at the AFSC. Stomachs will be excised and contents will be sorted and identified.

In September, a cruise was conducted between Shelikof Strait and the Shumigan Islands, AK. The primary objective of this cruise was to map age-0 pollock densities over an area of high

spatial heterogeneity, though abundance/distribution of age-1 and age-2 walleye pollock were also determined for use in this investigation. In addition, acoustic data were collected throughout the cruise, age-1 (~90 individuals) and age-2 (~100 individuals) walleye pollock were collected at select stations for stomach content analyses, and zooplankton/physical data were collected concurrently to provide information on potential sources of segregation of the age-1 and age-2 cohorts.

Stomach content analyses of field-collected age-1 and age-2 pollock:

Samples have been collected from the field (see above) and we anticipate beginning to analyze the stomach contents of age-1 and age-2 pollock in January, 2002. Zooplankton samples have also been collected from the field (see above) and are in the process of being sorted. We anticipate completion of these samples within one year. Data from zooplankton samples will then be compared to stomach content data to examine potential biotic sources of segregation (prey availability). This will provide new information on cohort-specific distribution of pollock in the GOA and will examine potential sources of underlying spatial variation.

Retrospective analysis of age-1+ pollock diet in relation to size (Bering Sea):

Walleye pollock diet was compiled from an existing data base (NOAA/Alaska Fisheries Science Center) that includes individuals of age-1+ captured throughout the EBS shelf (1990-1996). Results indicated that the diet of juvenile pollock changed with size, especially with respect to cannibalism and consumption of copepods. The importance of cannibalism changed from 5.5% in age-1 pollock to 46.9% in early age-2 (16-20 cm SL) and 28.6% in later age-2 pollock (21-25 cm SL). Cannibalism ranged between 1.1 and 11.0% in later and larger individuals. Copepods in diet changed from 54.0% to 20.8% and 28.0% in age-1, early and late age-2 pollock, respectively. Copepods in diet ranged between 47.0% and 50.1% in later age classes. All other major prey items included in diet did not considerably change among age classes. Most of the prey pollock consumed by larger pollock were age-0 (< 100 mm SL).

Experimental analysis 1: juvenile pollock energetics

Juvenile pollock go through radical ontogenetic changes in physiology during the juvenile stages. Some of these changes can influence the relationship between juvenile pollock feeding, growth and temperature. The objective of this part of the experimental analysis was to quantitatively define the effect of size and temperature on juvenile pollock food consumption and growth rate. Age-0 pollock collected during summer 2001 in Port Townsend, WA, were used for these experiments. The relationship between size, temperature, growth and consumption is being evaluated in fish ranging from 45 mm (0.8 g) to 76 mm (3.6 g) in size. If sufficient numbers of fish survive in the laboratory, we plan to continue the experiments as fish grow through the winter until they reach age-1 (about 150 mm).

Experimental analysis 2: juvenile pollock vertical distribution

We are looking at the effects of vertical thermal gradients on vertical distribution of age-1

and age-2 pollock. The experimental protocol consists of three treatment types, one on food (fed to satiation vs. starved), another on temperature (homogeneous vs. stratified) and the other on time of day (day vs. night). Experimental runs were conducted in vertical tanks of about 15,000 L where fish were videotaped to record their vertical distribution in the tank (similar to methods outlined in Sogard and Olla 1994, 1996). So far, we have completed the experimental work on age-2 pollock and plan to conclude the experimental work on age-1 pollock during spring and summer 2002. Results from the age-2 experiments have already been digitized and stored in a database file, and we are in the process of making them available for statistical analysis.

Hydroacoustic analyses of pollock distribution in the Eastern Bering Sea:

In this aspect of the project, we are comparing and contrasting vertical and horizontal distribution for Bering Sea walleye pollock observed from summer echo integration-trawl surveys conducted between 1994 and 2000, examining key biological, spatial, temporal and physical factors. We are currently analyzing the relationships between pollock size/age and distance off bottom stratified by known physical-geographic regions of the Bering Sea (e.g., east and west of 170° W longitude, middle shelf (50 to 100 m isobath), and outer shelf (100 to 200 m isobath)) within and between years. We are also using acoustically determined pollock distributions to examine the relationship between fish distribution and water temperature, and examining the possibility that temperature has a threshold effect on pollock distribution. We have some preliminary results comparing vertical distribution of pollock in 1999 (a very cold year) with 1997 (a warm year). Pollock average distance off bottom appeared to be greater in 1999 than in 1997. This may be due to the size/age composition of most of the population in 1999 comprising more smaller/younger pollock than in 1997. Additionally, in 1999, in some areas pollock seemed to be avoiding pockets of extremely cold water, (colder than 1° C). These results will be further examined and tested, and will include analyses of 1994, 1996, and 2000 pollock distributions.

Extrapolations to higher trophic levels:

This portion of the project will be completed after data are analyzed from all other portions of the project. We will examine available data on the distribution and foraging ecology of seabirds and marine mammals in the EBS and in the GOA and compare it to derived data on vertical and horizontal distribution of age-1 and age-2 walleye pollock. Patterns of spatial overlap between immature pollock and higher trophic level predators will be examined, with particular emphasis on rookeries for Steller sea lion pups and nesting areas for seabirds.

