Spatial distribution and ontogenetic movement of walleye pollock in the eastern Bering Sea

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Introduction

Walleye pollock (*Theragra chalcogramma*) is a key species in the Bering Sea and North Pacific ecosystems as well as the target species for one of the world's largest fisheries. Because of its semi-pelagic habit and interannual variability in distribution, the ontogenetic movement pattern and factors influencing the spatial distribution of this species are not well understood. Examination of the age-specific spatial distribution of walleye pollock in the eastern Bering Sea (EBS) relative to physical factors and population density may yield insights into their ontogenetic movements, as well as their population structure.

Interannual variability

Bottom-trawl surveys of the EBS continental shelf have been conducted every summer since 1982 (Figure 1). Centroids (the mean center of abundance) were calculated for ages 1 through 8 in every year based on the catch-per-unit-effort (CPUE) at each station in the standard survey area. The dispersed scatter of age-specific centroids indicates a high degree of interannual variability in the center of abundance across ages and years (Figure 2).

Temperature relationships

Walleye pollock have been shown to avoid water below 0 °C (Francis and Bailey 1983). The southern extent of cold water over the EBS middle shelf domain (Figure 3) is the major influence on the mean bottom temperature encountered during each survey. We categorized the surveys into cold (°C < 2), intermediate (2 ≤ °C < 3) and warm (°C ≥ 3) years based on the mean bottom temperature (Figure 4). The average centroids for warm years are further on-shelf than the average centroids for cold years (Figure 5) indicating that the broader dispersal onto the shelf in warmer years was detected by this method. Intermediate years were not depicted here, but were most similar to cold years.

Density relationships

A general ontogenetic pattern of movement can be seen in both the warm and cold years with the average center of abundance shifting southeastward with increasing age. However, the centroids for a few yearclasses (75, 76, 77, 78, 89, 90) were shifted further southeast than the other yearclasses (Figure 6). There appears to be a relationship between low adult biomass when these yearclasses were 2 year olds (Figure 7) and this increased southeastern distribution. Density dependent factors may play an important role in the spatial distribution of a yearclass, in particular, the degree to which a yearclass occupies the southeastern portion of the EBS shelf.

Yearclass variability

Walleye pollock biomass is mostly supported by occasional large yearclasses. The spatial distribution of three of these large yearclasses (82, 89, 92) differed considerably (Figure 8). The 82 yearclass was most dense over the northwest area of the EBS shelf. The 89 yearclass also occupied the southeast area of the shelf in high densities (see also Figure 6). The 92 yearclass appeared to be confined to the northwest area of the EBS shelf with some very high densities occurring north of the west end of the standard survey area. In a simulation study examining the physical transport from a major spawning location, the 92 yearclass of larvae was transported further west than all other yearclasses (Wespestad et al. 1997). This may be an indication that the initial juvenile distribution of a yearclass can persist for years and subsequently affect the observed spatial distribution of the yearclass as adults.

Caveats

Several considerations must be kept in mind when viewing the results of this approach. These are bottom trawl data and walleye pollock is a semi-pelagic species. Bottom trawl selectivity increases with age as walleye pollock become increasingly demersal. Converting lengths to ages can smear the true distribution of a yearclass, especially for older fish where there is more overlap in the length of different ages. We attempted to minimize this by using separate age-length conversions for the northwest and southeast areas of the EBS shelf and confining our analysis to younger ages. Border effects also need to be considered where high densities of walleye pollock may move out of, or into, the survey area (as possibly has happened for the 1992 yearclass in Figure 8).

Conclusions

- The age-specific spatial distribution of walleye pollock is quite variable.
- The effect of water temperature can be detected by plotting centroids of the age-specific spatial distribution. Warm years allow walleye pollock to move further on-shelf.
- An ontogenetic pattern of movement is apparent in the average age-specific centroids.
- Density dependent factors may affect the extent of the southeastward ontogenetic movement of a yearclass.
- The spatial distribution of a yearclass as juveniles may persist and affect the observed spatial distribution of that yearclass as adults.

Citations

Francis, R.C. and K.B. Bailey. 1983. Factors affecting recruitment of selected gadoids in the northeast Pacific and eastern Bering Sea. Pages 35-60 in W. Wooster (ed.), From year to year. Washington Sea Grant, University of Washington, Seattle.

Wespestad, V.G., L.W. Fritz, W.J. Ingraham, Jr., and B.A. Megrey. 1997. On relationships between cannibalism, climate variability, physical transport and recruitment success of Bering Sea walleye pollock, *Theragra chalcogramma*. ICES International Symposium, Recruitment Dynamics of exploited marine populations: physical-biological interactions. Baltimore, MD, Sept 22-24.

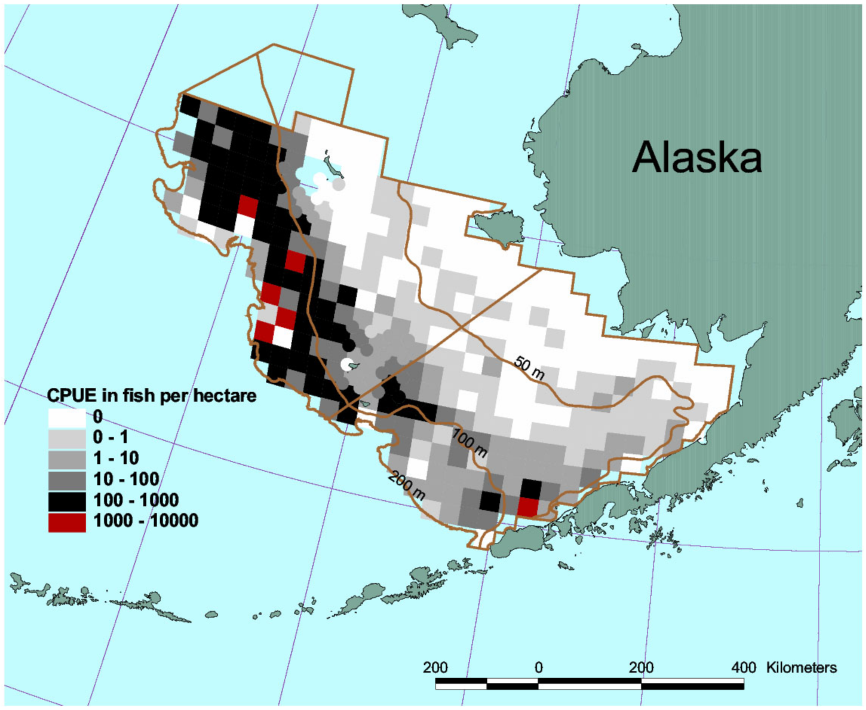

Figure 1. The standard area of the eastern Bering Sea bottom trawl survey showing the CPUE of age-6 walleye pollock in 1990 (a year with intermediate mean bottom temperatures). The outlined northern area is not part of the standard area.

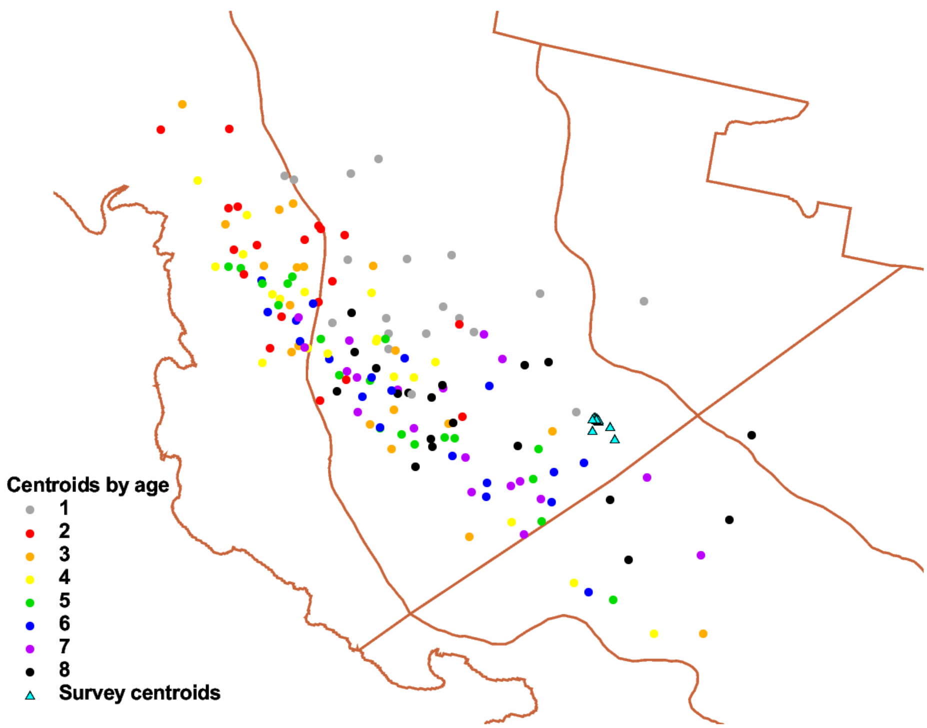

Figure 2. The centroids by age of walleye pollock in the 1982 through 2000 standard surveys.

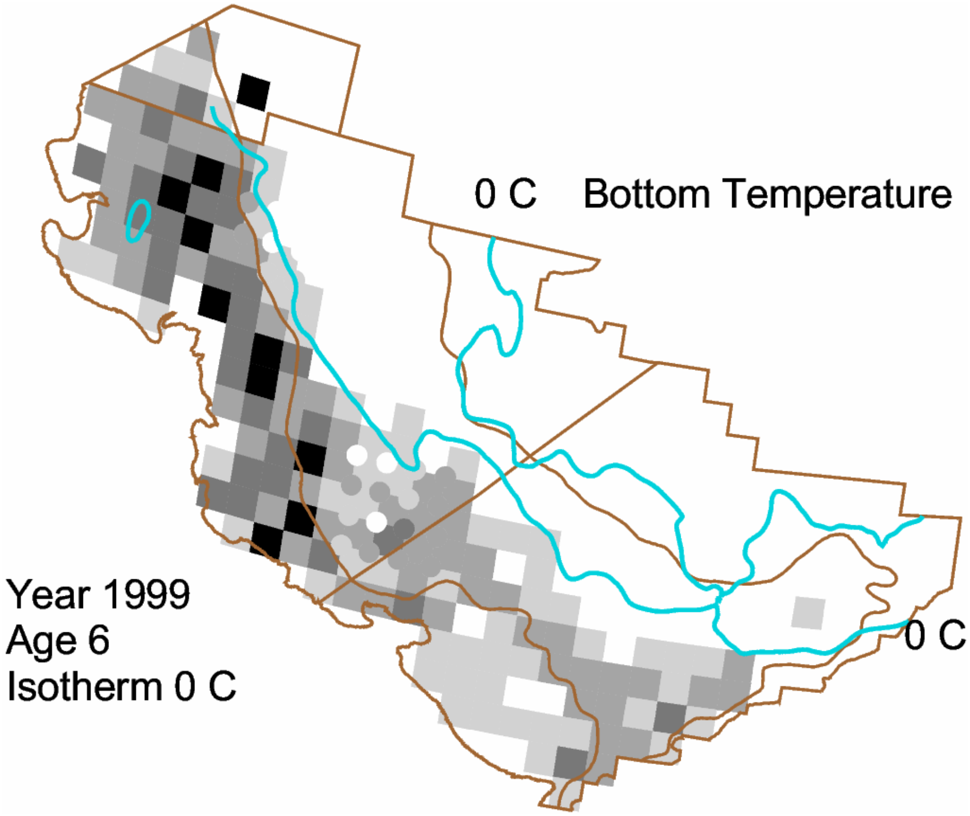

Figure 3. The spatial distribution of the CPUE of age-6 walleye pollock in 1999 (a cold year) in relation to the bottom water 0°C isotherm.

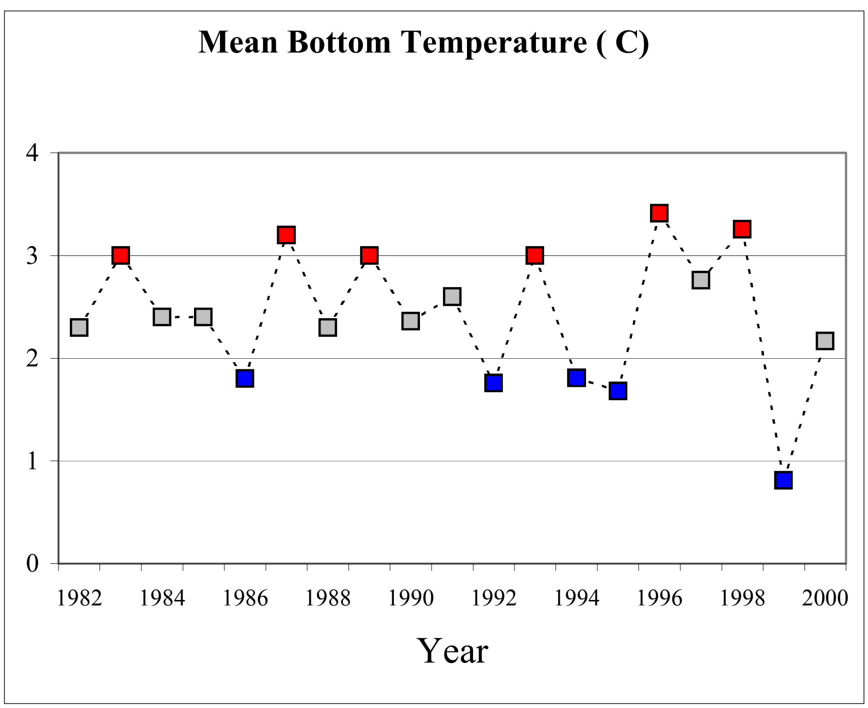

Figure 4. Mean bottom temperature of the standard survey area for 1982 through 2000 surveys.

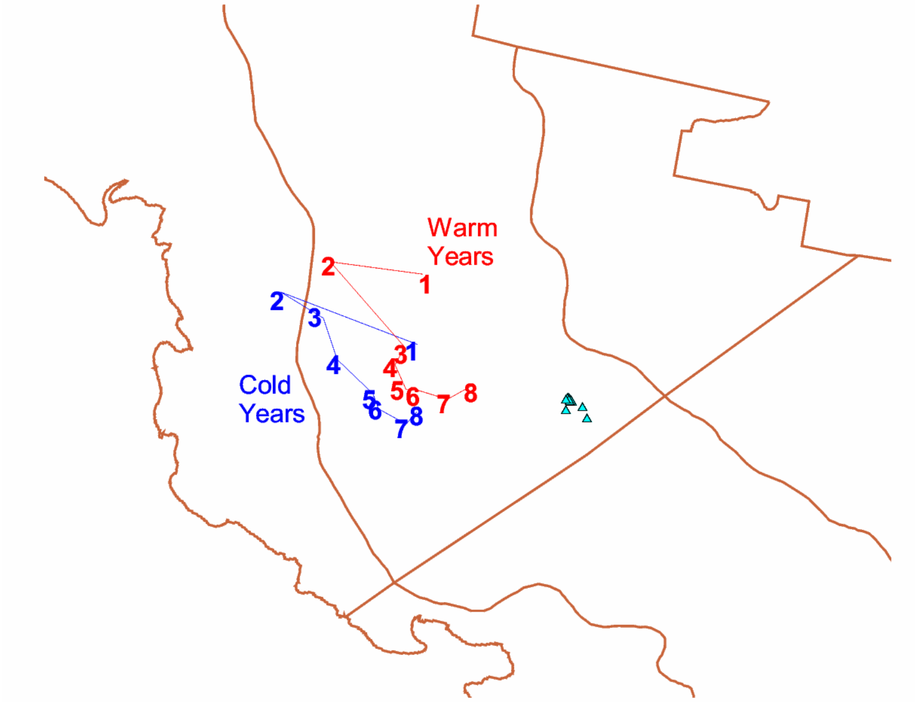

Figure 5. The average centroids, ages 1 through 8, for warm (red) and cold (blue) survey years.

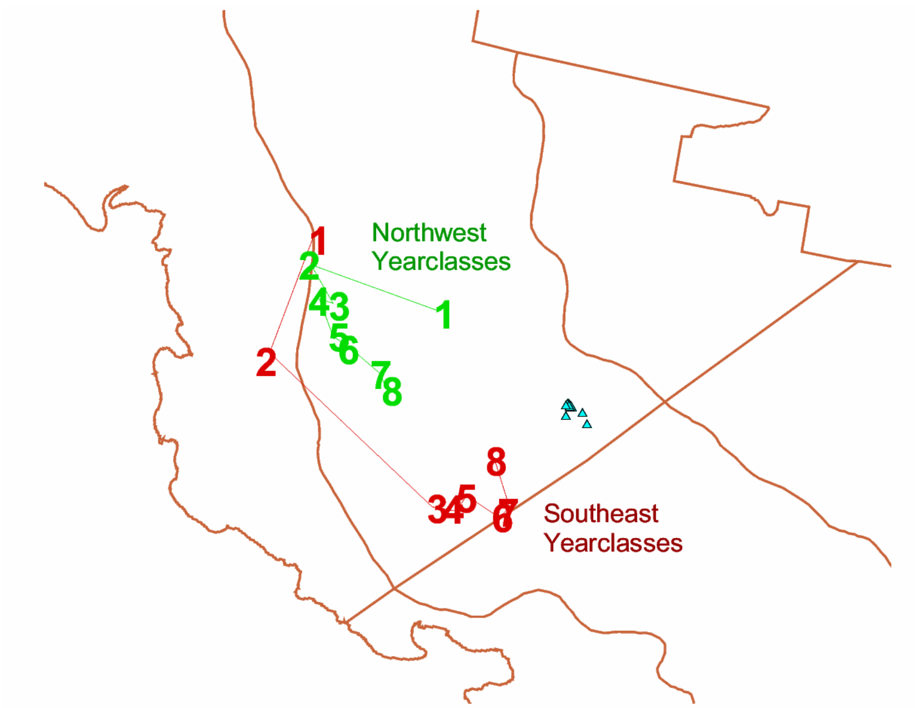

Figure 6. The average centroids, ages 1 through 8, for walleye pollock yearclasses that remain concentrated in the northwest area of the EBS shelf and that shift southeastward.

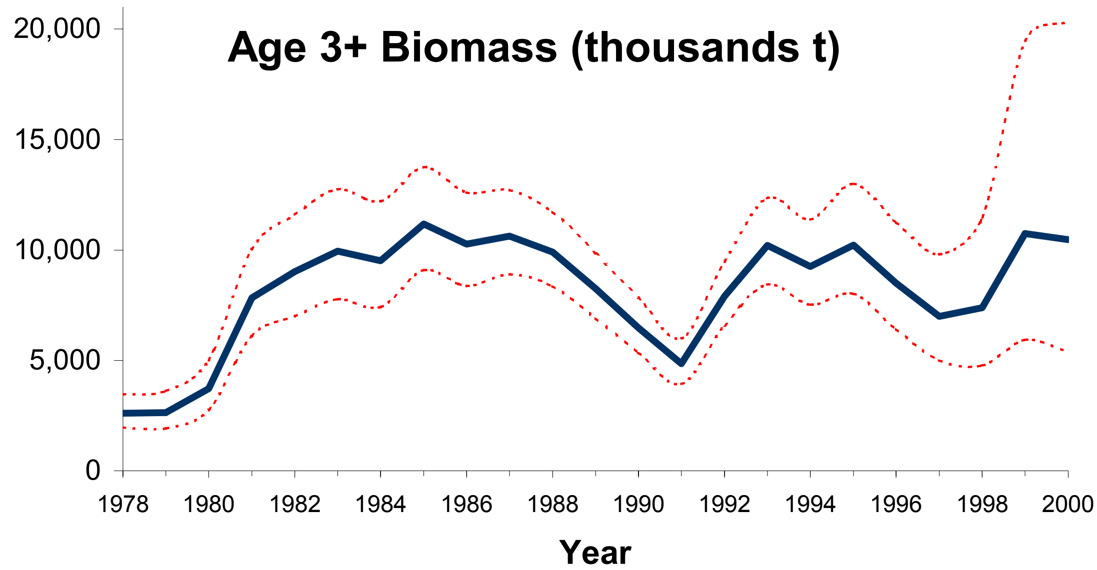

Figure 7. Estimated age 3+ EBS walleye pollock biomass with 95% confidence limits.

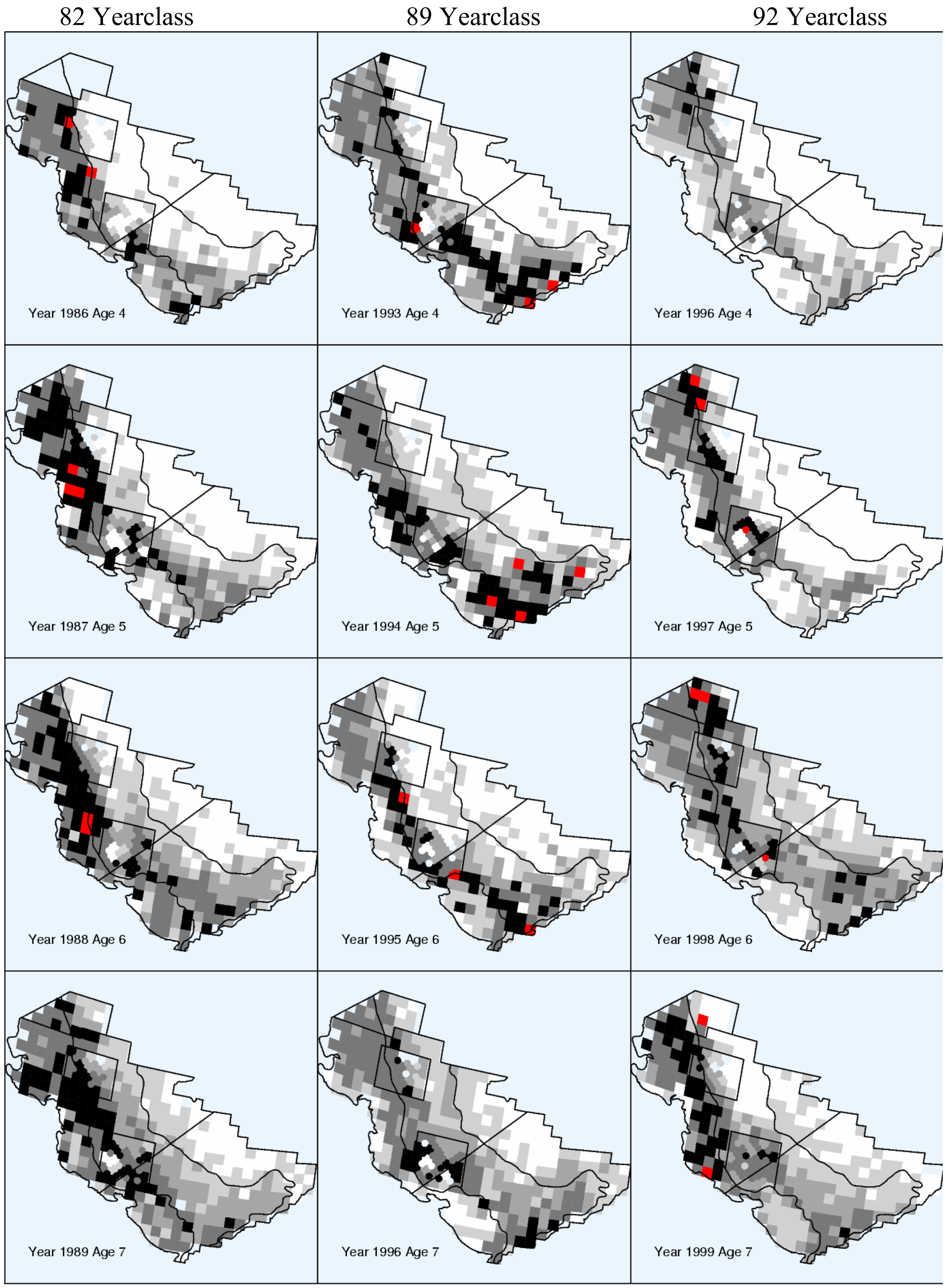

Figure 8. The spatial distribution of the bottom trawl survey CPUE of walleye pollock, ages 4 through 7, for three strong yearclasses 82, 89, and 92.