14. Growth of Age 0 and Age 1 Walleye Pollock in the Different Domains of the Eastern Bering Sea

Akira NISHIMURA

National Research Institute of Far Seas Fisheries, 5-7-1 Orido, Shimizu, Shizuoka 424-8633,Japan
Email: anishimu@enyo.affrc.go.jp

Abstract

Age 0 and age 1 walleye pollock, *Theragra chalcogramma*, were collected in the Bering Sea during the summers of 1989 and 1990. Age 1 pollock collected in the Chukchi Sea were also used in this study. Back-calculated growth patterns of the age 0 fish, and the size composition and diameter of the otolith's 1st annulus of age 1 fish, were used to compare geographic differences in growth patterns in the various domains within the area. Back-calculated growth patterns in the early life stage did not show any differences between the northern and the southern domain. However, age 1 fish from the southern domain had a larger size range than did those from the northern domains, including the Chukchi Sea, and the inner diameter of the first annulus of age 1 fish from the southern domain was larger than those from the northern areas. Maximum likelihood estimation was carried out to discriminate the age 1 fish between domains, using the inner diameter and the width of 1st annulus as the classifying variables. Ninety percent of age 1 fish from the Bering Sea were correctly classified into the northern and southern groups.

Introduction

Walleye pollock, *Theragra chalcogramma*, is widely distributed in the Bering Sea. The major questions in walleye pollock fishery management in the Bering Sea are stock structure and the causes of natural fluctuations in the biomass. Though larval and juvenile fish were found predominantly on the shelf area, distribution patterns show considerable interannual variability (Nishimura et al., 1996). Knowledge of recruitment and migration patterns is fundamental to understanding the dynamics of pollock populations. However, there are still large areas of uncertainty in this field. Although information has been accumulated on stock structure of pollock in the Bering Sea, there is little direct evidence. If there are geographical differences in their growth patterns, it might be useful as a natural tag for analyzing migration processes. In this report, I elucidate the growth of age 0 and age 1 walleye pollock in the various domains of the eastern Bering Sea.

Materials and Methods

Age 0 and age 1 walleye pollock were collected in the Bering Sea during July-October, 1989 and 1990. Samples were collected with a midwater trawl net, with a net liner

of 4 mm mesh inside the codend. Trawling was carried out at depths around 20-40 m (head-rope depth) within a few hours after sunset. Age 0 and age 1 pollock were frozen and stored. At the laboratory, fork length was measured and otoliths (sagittae) were dissected. Otoliths were measured along the longest axis, embedded in the epoxy resin, and ground with carbon paper perpendicularly to the otolith flat plane along the long axis (frontal section). For juveniles, the diameter of each increment was measured successively from the otolith outer margin to the nucleus area using an Otolith Analysis System (JANUS & Seas Labo). The diameter was converted into fork length using the otolith-somatic length relationship (Nishimura and Yamada, 1988). Back-calculated growth patterns in the early life stage were examined in the two domains. The survey area was divided into the northern and southern domains using 58°N latitude. For age 1 pollock, inner and outer diameters of the 1st annulus on the otolith frontal section were measured. Geographic differences in growth in the first year were examined using these meristic characteristics in the northern and southern domains of the Bering and Chukchi Seas. Grouping of areas were tested and quantified by a maximum likelihood estimation (Millar, 1986).

Results

Growth Estimation in the Larval and Juvenile Stage

Early growth patterns were back-calculated for 7 juveniles from the northern domain and for 23 juveniles from the southern domain collected in 1989. Although the number of fish from the northern domain was limited, the estimated growth pattern was not different from that of the southern domain. Early growth was also estimated for juvenile fish collected in 1990 (67 from the southern domain and 28 from the basin domain). An exceptionally slow growth pattern was found for the southern group. This slow growth was observed from the juveniles collected at the coastal side of the Alaska Peninsula. The growth pattern in the juvenile stage of the basin fish was a little slower than the typical growth in the southern domain, although they were similar in the early larval stage.

Growth Characteristic of Age 1 Fish

Age 1 pollock were collected in the northern domain in mid-September, 1989 and in late July, 1990. The fork length of age 1 fish ranged from 116 to 216 mm and the mode was observed at 150 mm. Age 1 fish were collected from the southern domain in early August, 1990. Size composition ranged from 154 to 214 mm, with modes at 175-185 mm. Age 1 fish were also collected from the Chukchi Sea during late July to early August, 1990. The size composition of these fish ranged from 68 to 141 mm with modes at 95 and 105 mm. Age 1 pollock collected in the southern domain had a larger size range than those from the northern domain including the Chukchi Sea (Fig. 1).

The average inner diameter of the 1st annulus was significantly different between the domains (t-test, $p<0.001$) and was largest in the southern domain and smallest in the

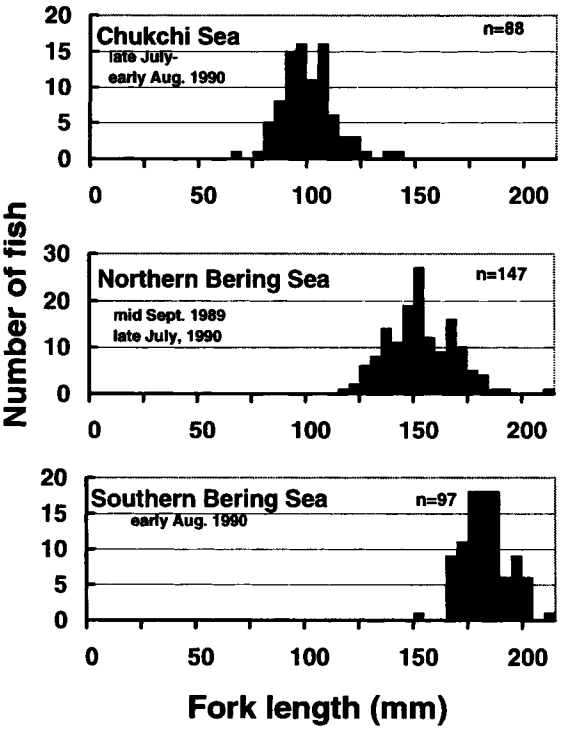

Fig. 1. Length frequency distributions of age 1 walleye pollock collected in the summer of 1989 and 1990.

Chukchi Sea (Table 1). The average width of the 1st annulus (outer-inner diameter) was 0.65 mm in the Chukchi Sea, 0.71 mm in the northern domain, and 0.26 mm in the southern domain. The inner diameter and the width of the first annual ring were plotted against the fork length at capture, and geographical differences were determined for this relationship (Fig. 2).

Grouping of Age 1 Fish

Age 1 fish were discriminated between the Chukchi group and the Bering group, using maximum likelihood estimation. The results indicated that 141 of 178 (79%) age 1 fish collected in the Bering Sea were correctly classified to the Bering group, and 29 of 42 (69%) age 1 fish collected in the Chukchi Sea were correctly classified to the Chukchi group (Table 2). A total of 50 individuals (23%) were erroneously classified in this estimation.

Age 1 fish from the Bering Sea were also discriminated between the northern group and the southern group, using maximum likelihood estimation. As shown in Table 3, 83 individual fish out of 99 fish (84%) from the northern domain were correctly classified to the northern group. Similarly, 77 individual fish of 79 fish (97%) from the southern domain

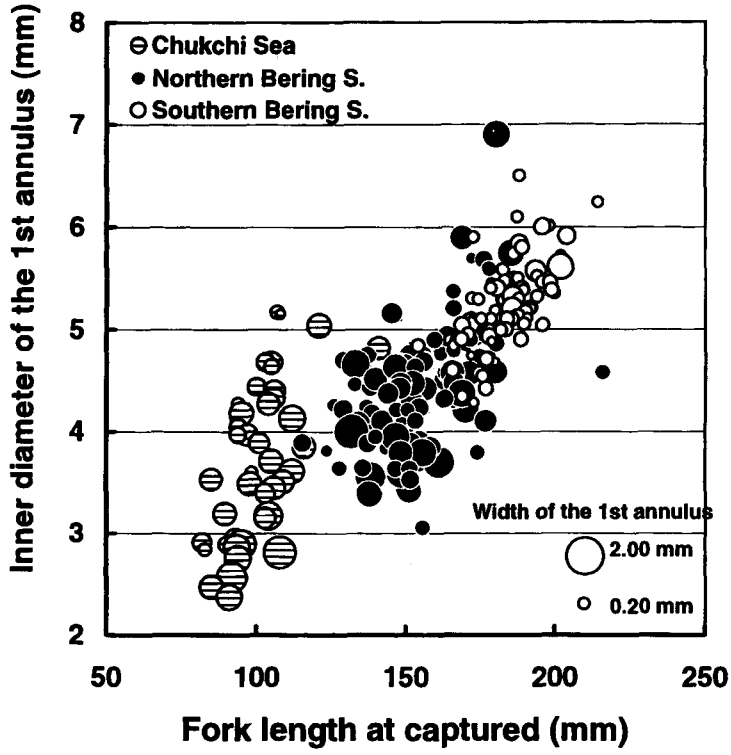

Fig. 2. Relationship between fork length at capture and inner diameter of the 1st annulus in the otolith of age 1 walleye pollock. Radius of each bubble represents the width of the 1st annulus.

Table 1. Diameters of the 1st annulus in the otoliths of age 1 walleye pollock collected in different domains in the Bering Sea and the Chukchi Sea.

	Diameter of the 1st annulus	
	Inner diameter	Outer diameter
Chukchi Sea	3.69 (2.37-5.17)	4.33 (3.03-5.80)
Bering Sea		
Northern area	4.44 (3.05-6.90)	5.15 (3.47-8.14)
Southern area	5.22 (4.28-6.50)	5.48 (4.44-6.70)

Average (Range)

Table 2. Results of classification between the Bering group and the Chukchi group by a maximum likelyhood estimation (Miller, 1987).

Area	Classification (No. of fish)		Percent correct
	Bering Sea	Chukchi Sea	
Bering Sea	141	37	79%
Chukchi Sea	13	29	69%
			77% (overall)

Table 3. Results of classification between the northen Bering Sea group and the southern Bering Sea group by a maximum likelyhood estimation (Miller, 1987).

Area	Classification (No. of fish)		Percent correct
	Northern Bering	Southern Bering	
Northern Bering	83	16	83%
Southern Bering	2	77	97%
			90% (overall)

were correctly classified to the southern group. A total of 160 fish of 178 fish (90%) were correctly classified, and 18 fish (10%) were misclassified in the Bering Sea. Average fork length at initiation of the 1st annulus formation was estimated at 87.4 mm in the Chukchi Sea, 102.9 mm in the northern domain, and 118.7 mm in the southern domain in the Bering Sea based on the otolith-somatic length relationship. The average fork lengths at termination of the 1st annulus formation were estimated at 100.6 mm in the Chukchi Sea, 117.4 mm in the northern domain, and 124.0 mm in the southern domain.

Discussion

Measurements based on ground otolith can result in biased estimates of length at

age. Though such bias is minimized during the larval and juvenile stage because otoliths are spherical, considerable bias might take place after the late juvenile stage because the otoliths develop fluting and become concave. To minimize the bias in estimation, frontal sections were used in this study. No obvious growth difference was observed between the northern and southern domains in the larval and juvenile stages. However, the number of juveniles from the northern domain was limited and further work will be needed considering interannual variability of the growth patterns. Though no obvious growth difference was observed between the northern and southern domains in the larval and juvenile stage, geographic differences in the size composition of age 1 fish were found. Also, geographic differences were evident in the estimated fork length at initiation and termination of the 1st annulus formation. These results suggest that oceanographic conditions in each domain primarily affect growth in the late juvenile to age 1 stages. Information from the 1st annulus is thought to be useful for analyzing growth in the first year. Age 1 fish from the northern domain showed smaller length at initiation of the 1st annulus formation and wider width of the annulus than those from the southern domain. Considering that winter comes earlier and the period of low water temperature is longer in the northern area, results obtained from 1st annulus analysis seem to be reasonable. The inner diameter and the width of the 1st annulus were useful indices in classifying age 1 fish into the southern and northern group on the eastern shelf area. This method is also useful for adult walleye pollock in the Bering Sea. Information from the 1st annulus may be useful as a natural tag to identify their nursery areas.

Acknowledgments

I thank Drs. K. Wakabayashi and D. K. Kimura for their helpful comments and review of the manuscript. I also thank Dr. Y. Sakurai of Hokkaido University for offering age 1 pollock from the Chukchi Sea collected by T/S *Oshoro Maru*.

References

Millar, R. B. (1987). Maximum likelihood estimation of mixed stock fishery composition. *Can. J. Fish. Aquat. Sci.*, **44**, 583-590.

Nishimura, A. and Yamada, J. (1988). Geographical differences in early growth of walleye pollock *Theragra chalcogramma*, estimated by back-calculation of otolith daily growth increments. *Mar. Biol.*, **97**, 459-465.

Nishimura, A, Mito, K. and Yanagimoto, T. (1996). Hatch date and growth estimation of juvenile walleye pollock, *Theragra chalcogramma*, collected in the Bering Sea in 1989 and 1990. *NOAA Tech. Report NMFS*, **126**, 81-87.