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Comparative Study on Age Determination Using Scales and Otoliths of Walleye Pollock *Theragra chalcogramma* in the Bering Sea and the Gulf of Alaska

Jang-Uk Lee and Young-Hee Hur
Deep-sea Resources Division,
National Fisheries Research and Development Agency
Yangsan-gun, Kyongnam 626-900, Korea

Results comparing the scale and otolith ages for walleye pollock from the Donut Hole of the Bering Sea showed a significant discrepancy for fish older than 8 years old. For walleye pollock from the Shelikof Strait of the Gulf of Alaska, comparison between ages determined from the scale and otolith readings indicated that there were no differences for younger age groups, but for the ages 6 and older, discrepancies squeezed in somewhat amid the same age groups.

Introduction

The age is basic requirement of many fishery models for fish stock assessment. In order to obtain age data, most of fisheries biologists use hard structures such as scales, otoliths, fin-rays, verteberae etc. Scales were used first to determine age of walleye pollock from the North Pacific region (Ogata, 1956). LaLanne (1975, 1977) proposed using otoliths as age structure of walleye pollock. It is known, however, that the process is a time-consuming and tedious task due to the interpretation problem of annuli on the structures, especially from long-lived fish species. Chilton and Beamish (1982) pointed out that one of the most serious mistakes made by fisheries biologists is the failure to validate the determined age.

Age of walleye pollock has been determined for a long time mainly using scales and otoliths. It has been pointed out, however, that there are considerable inconsistencies between the ages determined from the scale and otolith readings, resulting that scale reading produced younger age than the otolith and fin-ray readings (Mcfarlane and Beamish, 1990). Even in comparison of age determined from thin-sectioned otolith with that by burning method for walleye pollock, it was reported that the thin section method was overaged compared with burning method. According to McLarlane and Beamish (1990), who examined age determination structures using scale, otolith and fin-ray of walleye pollock, the burnt otolith section is the only acceptable structure.

The purpose of this paper is to demonstrate substantial disagreements in age estimates and growth patterns obtained using scale and otolith (break and burn) of the walleye pollock stocks from the international waters of the Bering Sea (called Donut Hole) and the Shelikof Strait of the Gulf of Alaska in the North Pacific Ocean.

Materials and Methods

All fish samples used in this work were obtained by trawl nets from two geographic areas(Fig. 1). A total of 74 specimens from Korean trawlers operated in the international waters of the Bering Sea during April to May 1991 and 132 from the US research vessel Miller Freeman used for the survey of groundfishes resources in the Shelikof Strait of the Gulf of Alaska during March 1991. Each fish was measured for fork length to the nearest cm and body weight to the nearest g. Scales and otoliths were collected from each fish.

Approximately 10~20 scales were collected from pectoral and/or dorsal fins. They were immersed in distilled water for a day, washed with fresh water and dried under shadow. Among them, 5 or 6 scales, which are not regarded as regenerated, were selected and then mounted between two slide glasses. Otoliths were broken through the nucleus. The broken surface was ground by using soft grinding paper and then gently burnt in a very low flame of a small spirit lamp. Criteria and method for identifying an annulus on each structure was followed the procedures outlined by Chilton and Beamish(1982)(Fig. 2).

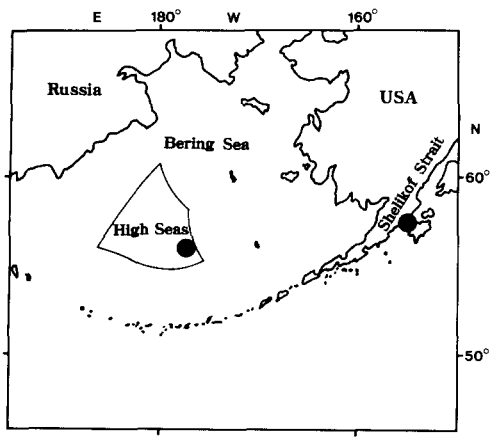

Fig. 1. Sampling areas where walleye pollock age materials were collected.

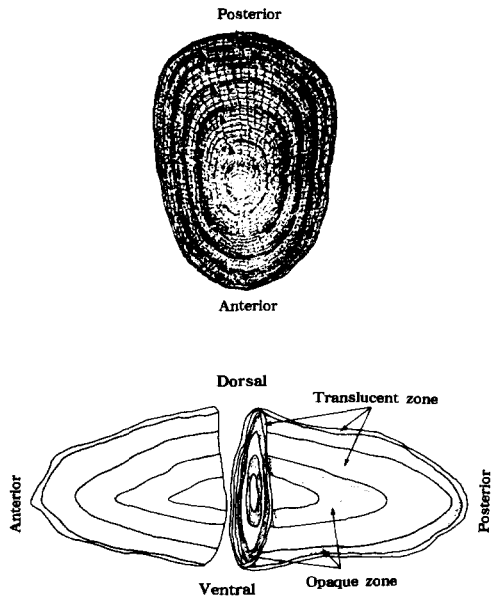

Fig. 2. Drawings of age structures of walleye pollock used in this study.
upper : scale(arrows indicate the counting area for age determination)
lower : otolith surface and cross section

The traditional von Bertalanffy growth formula(VBGF) was estimated, putting $t_0=0$, to compare growth patterns of walleye pollock using scales and otoliths. The empirical length-weight relationship was also constructed for each region.

Results

Age Determination

For the samples from the international waters of the Bering Sea, the scale reading produced much younger age groups than those from the otolith reading (Table 1). The ages estimated from the scale reading ranged from 4 to 9 years, and dominant age group consisted of ages 6 to 8 of which proportion accounted for about 76% of the total number of samples. The otolith method produced the older estimated ages. The range of determined age was from 4 to 18 years old with a dominant age of 12 years. In a comparison of scale-otolith age readings, discrepancies did not show significant difference up to 7 years of age, but no agreement existed for fish older than 8 between two age readings (Table 1). There were significant differences in the age frequency distributions produced using both the scale and otolith readings (ANOVA, $p < 0.05$).

For the Shelikof Strait stock of the Gulf of Alaska, no fish older than age 12 were present in the sample (Table 2). The scale reading produced age groups from 2 to 9 years old and otolith reading ranged between 2 and 11 years of age. High agreement was ob-

Table 1. Comparison of the scale and otolith ages for walleye pollock from the high seas of the Bering Sea

Otolith age (yr)	Scale age(yr)															Total
	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
4	1															1
5	1	3														4
6	1		3													4
7			3	3												6
8			3	1												4
9				1	1											2
10		3	3	1	1											8
11		2	2	2	2											8
12			2	8	10	3										23
13					1											1
14																
15		1														1
16		1	1	2	4	2										10
17				1												1
18				1												1
Total	3	10	17	20	19	5										74

Table 2. Comparison of the scale and otolith ages for walleye pollock from the Shelikof Strait of the Gulf of Alaska

Otolith age (yr)	Scale age (yr)										Total
	2	3	4	5	6	7	8	9	10	11	
2	9										9
3		39									39
4			9	3							12
5			1	22	3						26
6				4	18	1					23
7				1	6	7					14
8					2	1	1				4
9					1		1				2
10					1						1
11					1			1			2
Total	9	39	10	30	32	9	2	1			132

tained between two methods, showing 100% consistency at ages 2 and 3, respectively. Although disagreement increased gradually with increase of age, there was no significant difference in the age frequency distributions from the two methods (ANOVA, $p > 0.05$).

Results comparing the scale and otolith ages for walleye pollock from the Donut Hole showed a significant discrepancy from older age groups. For the Shelikof Strait pollock, the comparison of the ages determined from scale reading and the ages from otolith reading indicated that there were no differences for younger age groups, but for the ages 6 and older, discrepancies squeezed in somewhat amid the same age groups.

Growth Patterns

In the Donut Hole, fish samples consisted of very limited size ranges between 44 cm and 54 cm in fork length even though age estimates from otolith reading ranged from ages 4 to 18 (Fig. 3a). From this reason, fitting both the aged data from the scale and otolith readings to the VBGF was not possible. Comparing the distributions of length at

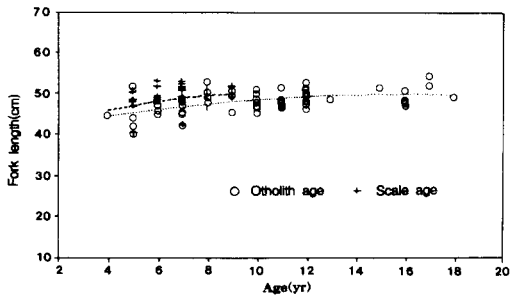

Fig. 3a. Growth patterns aged from otolith and scale of walleye pollock from the high seas of the Bering Sea.

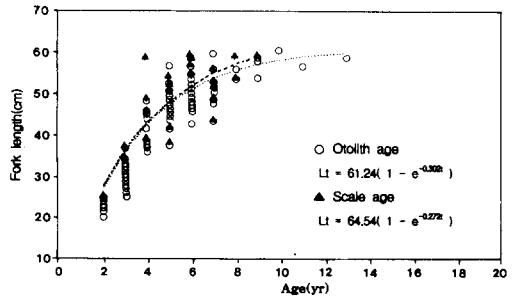

Fig. 3b. Growth patterns aged from otolith and scale of walleye pollock from the Shelikof Strait of the Gulf of Alaska.

age data between scales and otoliths, the larger lengths at age were determinded from the scale reading.

For the Shelikof Strait pollock samples, both data from the scale and otolith readings were well fitted to the VBGF, showing similar growth patterns (Fig. 3b). The VBGFs were estimated : $lt=64.54(1-e^{-0.272t})$ from scale ages and $l_t=61.24(1-e^{-0.302t})$ from otolith ages.

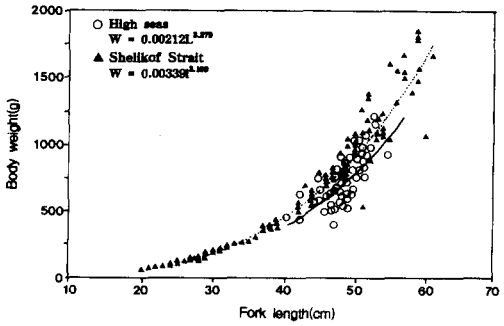

Fig. 4. Length-weight relationship of walleye pollock sampled from the high seas of the Bering Sea and the Shelikof Strait of the Gulf of Alaska.

The relationship between length (L, cm) and weight (W, g) of walleye pollock was presented (Fig. 4) : $W=0.00212L^{3.279}$ for the Donut Hole pollock($r^2=0.53$) and $W=0.00339L^{3.199}$ for the Shelikof Strait pollock ($r^2=0.99$).

Discussion

Age readings using scale and otolith of walleye pollock in the north Pacific Ocean showed different patterns in the age frequency distributions, resulting in younger age groups from scale structures and older age groups from otolith ones. In the Donut Hole pollock samples (Table 1), the walleye pollock of the 1983, 1984 and 1985 year-classes appear to be very strong groups in scale age readings, whereas the 1979 year-class is very dominant in otolith readings. The dominant ages were from the 1978 and 1979 year-classes according to age distribution data of the Donut Hole pollock provided by Polish scientists at the International Workshop on Bering Sea Pollock Stock Assessment held at the Alaska Fisheries Science Center in March 1991. Mcfarlane and Beamish (1990) and Moiseyev (1983) identified the 1977 year-class as being strong group from otolith surface reading of the eastern Bering Sea pollock. Wespestad and Traynor (1988) reported the 1978 year-class as being exceptionally strong through samples collected in the same area as well as the same method as Moiseyev (1983). For the Shelikof Strait samples (Table 2), the 1985, 1986 and 1989 year-classes were dominant from both scale and otolith ages, respectively. It is obvious that when total mortality coefficient estimates for the Donut Hole pollock stock are derived using catch curve method from the age compositions based on both the scale and otolith readings, two estimated values will make large difference. In case natural mortality coefficient is to estimate by indirect approaches using the growth parameters, it will be largely biased, depending upon the values used.

This study examined the same age structures as scales and otoliths used by Mcfarlane

and Beamish (1990) with the exception of fin-rays and otolith surface readings. For the Shelikof Strait stock (Fig. 11-C of their report), they produced age compositions with age ranges of 3 to 5 years, 3 to 6, 4 to 5, and 4 to 6 years from the scale, fin-ray cross section, otolith cross section and otolith surface readings, respectively. For the Donut Hole stock (Fig. 11-E of their report), age compositions ranged from ages 5 to 9, 3 to 11, 5 to 30, and ages 6 to 20 from the scale, fin-ray cross section, otolith cross section and otolith surface readings, respectively. These are comparable with the age compositions of this report (see Table 2), ranging from ages 2 to 9 and ages 2 to 11 from scale and otolith cross section readings of walleye pollock from the Shelikof Strait of the Gulf of Alaska, and from ages 4 to 9 and ages 4 to 18 from scale and otolith cross section of walleye pollock from the Donut Hole of the Bering Sea, respectively. Cause of these differences in age distributions might due to the fish sample sizes : 22 cm to 59 cm from this study and 35 cm to 39 cm from their report for the Shelikof Strait stock, and 44 cm to 54 cm in this report and 45 cm to 51 cm from their study. However, it was likely from this study that break and burn otolith section of walleye pollock was suitable age structure to estimate age composition of the fish. These phenomena seemed to imply the importance of choosing age structure for the ageing of fish, especially for long-lived animals.

References

Chilton, D. E. and R. J. Beamish. 1982. Age determination methods for fishes studied by groundfish program at the Pacific Biological Station. Can. Spec. Publ. Fish. Aquat. Sci. 60, 102p.

LaLanne, J. J. 1975. Age determination of walleye pollock (*Theragra chalcogramma*) from otoliths. NWAFC, NMFS Tech. Rep. 19p.

LaLanne, J. J. 1977. The validity and consistency of age determinations from otoliths of Pacific pollock (*Theragra chalcogramma*). INPFC Annual Report 1977 : 99-107.

McFarlane, G. A. and R. J. Beamish. 1990. An examination of age determination structures of walleye pollock (*Theragra chalcogramma*) from five stocks in the north Pacific Ocean. INPFC Bull. 50 : 37-56.

Moiseyev, E. I. 1983. Age composition and growth rate of the eastern Bering Sea Walleye pollock(*Theragra chalcogramma Pallas*). Izv. TINRO 107 : 94-101.(In Russian).

Ogata, T. 1956. Studies on fisheries and biology of important fish : Alaska pollock. Bull. Jpn. Sea Reg. Fish. Res. Lab. 1 : 5-20.

Wespestad, V. G. and J. J. Traynor. 1988. Walleye pollock. In condition of groundfish resources of the eastern Bering Sea and Aleutian Islands region in 1988. INPFC Doc. 3345 : 17-40.

Comparative Study on Age Determination Using Scales and Otoliths of Walleye Pollock

베링해와 알라스카만 명태의 비늘과 이석에 의한 연령사정 비교

이 장 욱 · 허 영 희
국립수산진흥원, 원양자원과

베링해 공해 및 알라스카만에서 표본된 명태의 동일 개체로부터 비늘과 이석을 사용하여 연령사정한 결과를 비교, 고찰하였다.

베링해 공해 명태 44~54cm 범위의 개체에 대한 연령사정 결과, 비늘연령은 4~9세, 이석연령은 4~18세로 나타났다. 동일개체의 두 연령형질간에 1~11세까지의 큰 차이를 보였으며, 특히 이석의 연령이 증가할수록 그 차이가 더욱 크게 나타났다. 알라스카만 명태 22~59cm 범위의 개체로부터 비늘 연령은 2~9세, 이석연령은 2~11세로 나타났다. 두 연령형질간의 연령사정 결과는 6세까지는 잘 일치하였고, 7세 이상에서는 이석에 의한 연령이 1~7세까지 높게 나타났다.