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Preliminary analysis of sablefish (*Anaplopoma fimbria*) otolith measurements from Northern Pacific in 1984

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Abstract: Sablefish otoliths (sagittae) collected from four areas (Northern California, Gulf of Alaska, Bering Sea, and Aleutian Islands) in 1984 were used to determine age by the section otolith aging method, and to measure otolith radius and thickness. The relationship between otolith ratio (radius/ thickness) and age was linear in the four areas. There was no statistical difference in the comparison of the age-otolith ratio relationship between the Gulf of Alaska, Bering Sea and Aleutian area; however, that of Northern California was found to be significantly different from the other three. These results are in keeping with the two-population hypothesis of previous tagging studies. Thus, sablefish otolith measurements might be a sensitive characteristic for discerning sablefish population structures. Further studies of otolith morphometric analysis including shape might provide an even clearer picture of sablefish populations.

Keywords : *Sablefish, otolith measurements, North Pacific*

1. Introduction

The sablefish, or black cod, *Anoplopoma fimbria* (Pallas), is one of the commercially important Pacific coast groundfish species, inhabiting the continental shelf and slope from Baja California through the Bering Sea to Kamchatka and northern Japan (HART, 1973; SASAKI, 1985). Results of analysis of sablefish tag-recapture growth data suggest that there may be at least two populations of sablefish: an Alaska population ranging from the Bering Sea and Aleutian waters extending down through the Gulf of Alaska to northwest Vancouver Island, Canada; and a west-coast population extending from southwest Vancouver to Baja California (KIMURA *et al.* 1998; MALONEY and SIGLER, 2008). Here we made a preliminary analysis of age-otolith measurements using specimen from four areas (Northern California, the Gulf of Alaska, Bering Sea and Aleutian Islands) to determine whether otolith measurements provide a clue as to differences in sablefish populations.

2. Materials and Methods

Sablefish otolith samples collected by bottom trawl vessels in Northern California from April to August in 1984, and by bottom longline vessels under the US-Japan Joint Survey ranging from the Gulf of Alaska and Aleutian Islands to the Bering Sea from June to September in 1984, were used to determine age using the section ag-

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Table 1. Sample sizes and ranges of fork length (cm) of sablefish age and otolith measurements, ranges of age assignments from the section aging methods for sablefish collected by bottom longline in the Gulf of Alaska, Aleutian Islands, and Bering Sea in 1984 and by bottom otter trawl in Northern California in 1984.

Area	Female otolith ages and measurements		
	Sample Size	Length Range (cm)	Section age range (year)
Gulf of Alaska	942	43–99	3–42
Aleutian Islands	418	46–106	2–48
Bering Sea	600	44–99	2–50
Northern California	305	37–90	1–22
Total	2265	37–106	1–50

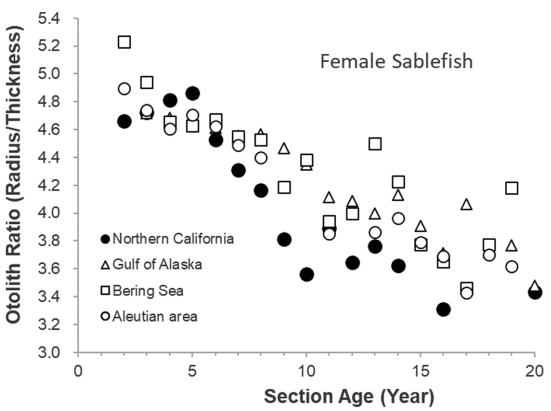

Fig. 1 Mean otolith ration (otolith radius/otolith thickness) -age relationship of female sablefish, using otolith collected in Northern California, Gulf of Alaska, Bering Sea and Aleutian Islands in 1984.

ing method (BEAMISH and CHILTON, 1982) and measure otolith radius and thickness by ocular meter of dissecting microscope in O.U. (Ocular Unit). Only female data were used for the analysis. Mean otolith ratio (otolith radius/otolith thickness) was linearly related to section age, and linear model parameters were obtained by least-squares analysis. As the number of data was limited, we used samples only in the age range of 2–20 years and more than three data at an age to estimate linear model parameters. All presented statistical tests were performed at the 5% significance level to compare age-otolith ratio relationships for the four sites.

3. Results

A total of 2,265 sablefish otoliths collected in 1984 were successfully aged by section methods (Table 1). The assigned section age ranged from 1–50 years. In Northern California, the maximum age was 22, much younger than in the other three areas.

Mean otolith ratio (otolith radius/otolith thickness) decreased in a linear fashion with section age from four different areas (Fig. 1). The use of regression analysis to establish the relationships between otolith ratio and section age showed that otolith ratio was highly correlated with section age for females for each area (Table 2).

The fitted regression lines were compared among areas. Variances among four areas were found to be heteroscedastic, using Bartlett's test of homogeneity of variance ($\chi 2 = 9.227$, df = 3). Analysis of covariance (ANCOVA) techniques were used to compare otolith ratio-section age relationships by pairwise. There were no significant differences between regressions in the Gulf of Alaska, Bering Sea and Aleutian Islands, however the regression from Northern California

Table 2. Slopes, intercepts, and correlation coefficients (r) for regression lines relating mean otolith ratio (radius/thickness) to section age for female sablefish, using otoliths collected in the Gulf of Alaska, Aleutian area, Bering Sea, and Northern California in 1984.

Area	Female		
	Slope	Intercept	r
Gulf of Alaska	−0.070	5.010	−0.962
Bring Sea	−0.074	4.992	−0.936
Aleutian Islands	−0.077	4.992	−0.969
Northern California	−0.096	4.969	−0.909

Table 3. Summary of comparison of slope and intercepts of regression line for otolith ratio (otolith radius/otolith thickness) to section age for female sablefish, using otoliths collected in the Gulf of Alaska, Bering Sea, Aleutian Islands, and Northern California in 1984.

Hypothesis	Test	Slope			Intercept		
		statistics	df	Result	statistics	df	Result
Northern California vs Gulf of Alaska	F	2.045	1,29	Accept	20.907	1,31	Reject
Northern California vs Bering Sea	F	0.207	1,25	Accept	13.436	1,27	Reject
Northern California vs Aleutian Islands	F	0.934	1,27	Accept	14.251	1,29	Reject
Gulf of Alaska vs Bering Sea	F	1.176	1,28	Accept	0.077	1,30	Accept
Gulf of Alaska vs Aleutian Islands	F	0.627	1,30	Accept	1.323	1,32	Accept
Bering Sea vs Aleutian Islands	F	0.250	1,26	Accept	0.218	1,28	Accept

was highly significantly different from the other three (Table 3).

4. Discussion

Knowledge regarding the population structure of a species is essential to effectively assess and manage fisheries. Sablefish are widely distributed along the North Pacific Ocean from the Aleutian Islands and Bering Sea to Baja California (SASAKI, 1985). For the wide distribution of sablefish, tag release-recovery studies have revealed that at least two populations potentially exist along the coast of north America: one extending northwest from northern Vancouver Island thorough the Gulf of Alaska, Aleutian Islands, and the Bering Sea; and the other extending south from southwest Vancouver Island to Baja California (KIMURA *et al.*, 1998). Results of this preliminary analysis of sablefish otolith morphometrics implies the possibility of stock separation. Further sablefish otolith morphometrics analysis may expose a much clearer population structure. Otolith morphometrics, including shape analysis, are widely used in studies to separate populations for different species, for example, horse mackerel, *Trachurus trachurus* (ABUANZA *et al.*, 2008), cod, *Gadus morhus* (STRANSKY *et al.*, 2008), and Pacific sardine, *Sardinops sagax* (JAVOR *et al.* 2011).

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