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Spatial and Temporal Variability in Fork Length of Young Yellowtail in the Japan Sea

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Abstract

Comparison of the fork length composition of 0-year old yellowtail *Seriola quinqueradiata* TEMMINCK *et* SCHLEGEL between August and December from 1968 to 1994 between areas revealed that the average fork length is smaller in the eastern coastal area along the Japanese mainland than in western areas in the Japan Sea. Since the average fork length in October is inversely correlated ($P < 0.01$) with the abundance index of 0-year old yellowtail, it is suggested that density affects the growth of young yellowtail. Age was determined from the number of rings on scales for 195 specimens which were caught at Sado Island in December 1967. Ages determined ranged 0 to 4 and the average fork length at each age is close to that of the Pacific Ocean in the early 1960's and in the Japan Sea in the late 1980's but considerably different from that in the Japan Sea in the late 1950's.

Key words：*Seriola quinqueradiata*, growth, age determination, scale, density-dependent effect

Introduction

The yellowtail *Seriola quinqueradiata* is an important species for coastal fisheries in the Japan Sea. The growth of yellowtail has been examined from the relationship between age and fork length in the Pacific Ocean (KAWAI 1967; KOTO 1985) and in the Japan Sea (MITANI 1959；MURAYAMA 1992a). MURAYAMA (1992a) pointed out that there are significant differences in growth rate between areas and that the growth of yellowtail had changed remarkably in the Japan Sea between the late 1950's and the late 1980's. It is therefore necessary to study the spatial and temporal variation in growth, using data collected over a long time period. In this study, differences between areas and interannual fluctuations in fork length of 0-year old yellowtail are examined using the fork length composition and age determined from rings on scales.

Materials and Methods

The Shimane Prefectural Fisheries Experimental Station, Tottori Prefectural Fisheries Experimental Station, Tajima Fisheries Experimental Station of Hyogo Prefecture, Kyoto Institute of Oceanic and Fishery Science, Fukui Prefectural Fisheries Experimental Station, Ishikawa Prefecture Fisheries Research Center, Toyama Prefectural Fisheries Experiment Station, Niigata Prefectural Fisheries and Marine Research Institute, Yamagata Prefectural Fisheries Experimental Station,

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Akita Prefectural Institute for Fisheries and Fisheries Management, and Japan Sea National Fisheries Research Institute have measured the fork length of yellowtail caught by mainly set net and purse seine fisheries in the coastal area along the mainland of Japan. The coastal area along mainland of Japan was divided into four areas of A, B, C, and D from the west to east as shown in Fig. 1 to examine spatial differences in fork length. Although data on fork lengths are available since 1956, I have used in this paper data between 1968 and 1994 because of the scarcity of data before 1968. Histograms of fork length by 2 cm intervals were made for each area of A, B, C, and D for each month. Since most of the 0 - year old fish are distinguishable from the histograms and abundant fork length data are available between July and December, the monthly average fork length of 0 - year old fish was calculated for each area between July and December from 1968 to 1994.

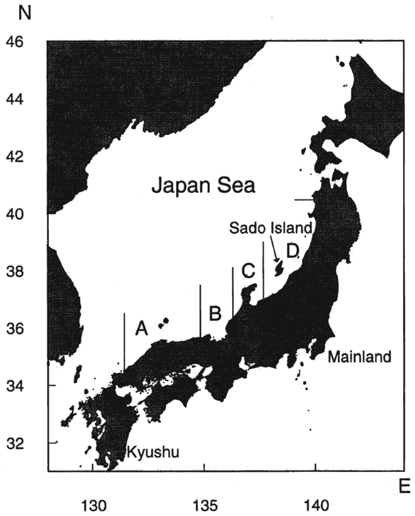

Fig. 1 . Map of the Japan Sea shows the four areas (A-D) used in this study.

Further, scale samples were taken by the Japan Sea National Fisheries Research Institute from yellowtail caught by the set net fishery at Sado Island (Fig. 1) in December 1967, and remained unexamined. Scale samples were placed between two slide glasses and the annual rings on the scales counted on the screen of a profile projector. Age was determined from 0 to 4 years based on the ring formation, a clear ring forms during winter of each year (MITANI 1959 ; KAWAI 1967). The total number of fish for which age was determined was 192.

Factors that might affect the fork length of yellowtail include water temperature and yellowtail abundance. Records of average water temperature at a depth of 50 m in the coastal area of mainland Japan, i.e., the Tsushima Current area, from 1968 to 1994, were provided by the Japan Sea National Fisheries Research Institute (NAGANUMA and ICHIHASHI 1985 ; HIRAI personal communication). The water temperature was averaged for the four seasons of winter (Jan.-Mar.), spring (Apr.-May), summer (June-Aug.), and autumn (Sep.-Dec.). The abundance index of 0 - year old yellowtail in area B and in area C was calculated by dividing the catch in weight of 0 - year old fish by the third power of the average fork length FL^3 in October.

Results

1 Fork length of 0-year old yellowtail

Table 1 shows the mean values, 1968-1994 of the monthly-averaged fork lengths of 0 - year old yellowtail from July to December in each area. Average fork length is slightly smaller in area D than in other areas. Yearly averages of the monthly-averaged fork length data in each area were compared using a paired-sample t test for all combinations of areas as shown in Table 2. Absolute values of t are significant in the combinations of area D with other areas from September to November. There are also significant differences between area A and area C in September, between area B and area C in November and December. The average fork length is significantly smaller in the eastern areas compared to western areas.

Data in October in area B and area C are most abundant. Figure 2 shows the average fork length for these areas in October and the year-to-year fluctuations are fairly large. To analyse the interannual fluctuations in average fork length of 0 - year old yellowtail, correlations of fork length in October with water temperature during the four seasons and the abundance index of 0 - year old yellowtail in area B and area C were examined. There are significant inverse correlations ($P < 0.01$) between fork length and the abundance index for both area B and for area C (Fig. 3). Water temperature has no significant correlation with fork length ($P > 0.1$). To examine any compound effect of water temperature and abundance on the interannual fluctuations in fork length, multiple linear regression analyses were made. Akaike information criterion (AIC) was adopted to determine whether a variable is necessary for the model or not. AIC is defined as AIC = $-2 \ln L_{max} + 2q$, where, L_{max} is the maximum likelihood and q the number of parameters (SAKAMOTO *et al.*, 1985).

Table 1. Mean values of the monthly-averaged fork lengths of 0 -year old yellowtail from July to December between 1968 and 1994 in each area. Areas correspond to those shown in Fig. 1. Figures in the upper, middle, and lower part of each cell represent the average fork length in cm, standard deviation and number of replicate years, respectively.

Area	July	Aug.	Sep.	Oct.	Nov.	Dec.
A	16.2	25.5	31.7	34.5	36.1	36.0
	3.22	6.58	2.15	2.22	2.86	3.68
	3	4	9	8	10	6
B	17.7	22.7	28.7	33.5	36.8	37.2
	2.16	2.98	3.17	2.31	1.87	1.85
	21	23	22	22	19	18
C	17.2	22.4	28.7	33.9	35.7	34.9
	2.34	2.22	2.19	1.67	1.89	2.13
	24	27	26	27	24	25
D	19.4	21.0	26.3	30.2	31.7	31.6
	6.72	1.53	3.55	3.21	2.97	2.69
	5	14	15	15	14	10

Table 2. Comparison of average fork length of 0-year old yellowtail between areas. Figures represent t values and figures in parentheses degrees of freedom.

Month	Area	B	C	D
Aug.	A	—	—	—
	B		1.17 (22)	1.81 (13)
	C			2.19 (13)
Sep.	A	1.69 (7)	2.53* (8)	2.71* (8)
	B		-0.50 (21)	3.08** (13)
	C		—	2.62** (14)
Oct.	A	0.029(7)	1.49 (7)	4.42** (5)
	B		-0.597 (21)	4.55** (14)
	C			4.87** (14)
Nov.	A	-1.22 (9)	0.817 (9)	3.42** (8)
	B		2.52* (16)	3.99** (11)
	C			5.36** (12)
Dec.	A	-1.47 (5)	0.866 (5)	—
	B		4.06* (15)	5.24** (8)
	C			3.92* (8)

*$P<0.05$; **$P<0.01$.

Models which minimize the AIC value are optimal. Water temperature in winter was not eliminated from the multiple linear regression model for area B (AIC = 74.3 with abundance index in area B and water temperature in winter; AIC = 78.9 with abundance index only), while using only abundance index in area C is the best model for area C (AIC = 78.0 with abundance index; AIC = 79.3 with abundance index and water temperature in winter).

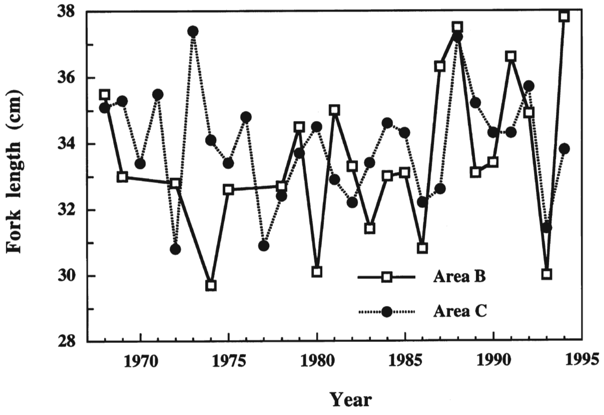

Fig. 2 . Yearly changes in average fork length of 0 -year old yellowtail in October in area B and area C.

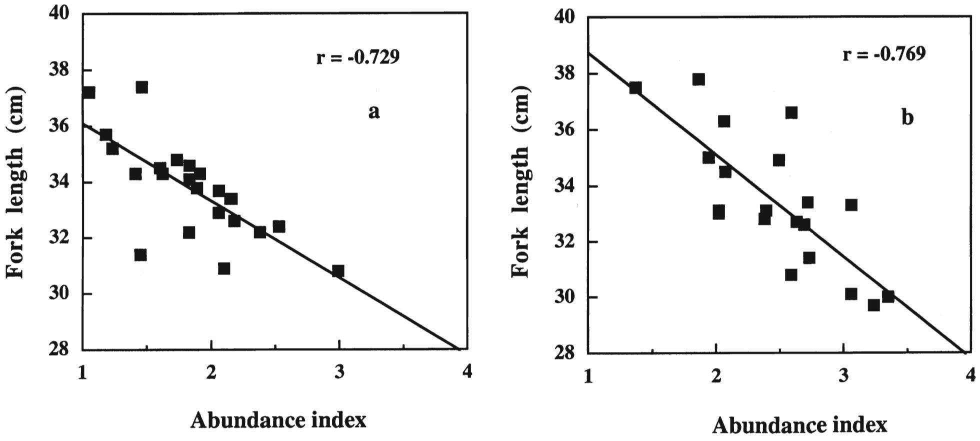

Fig. 3 . Plot of average fork length in October as a function of the abundance index of 0 - year old yellowtail in area B (a) and area C (b).

2 Age determination using scale

Table 3 shows the average and standard deviation of the fork lengths for each age group determined from the number of rings on scales. Standard deviations become larger as age increases. Figure 4 shows a plot of the average fork length as a function of age. In Fig. 4 , each age starts in January and ends in December. Results of other studies are also plotted in Fig. 4. Kawai (1967) and Koto (1985) determined a growth curve for the yellowtail inhabiting the Pacific Ocean, and Mitani (1959) and Murayama (1992a) studied the yellowtail inhabiting the Japan Sea. Murayama (1992a)'s results of age determination are plotted using small squares in Fig. 4. Average fork length at each age at Sado Island in 1967 is very close to the growth curve of Kawai (1967) and plots of Murayama (1992a).

Table 3. Average and standard deviation of fork length at each age determined from the number of rings on scales. Specimens were caught by the set net fishery at Sado Island in December 1967.

Age	Average (cm)	Standard deviation (cm)	Number of specimens
0	40.5	1.04	20
1	58.4	1.99	69
2	69.0	2.31	45
3	81.9	3.20	52
4	86.5	3.67	6

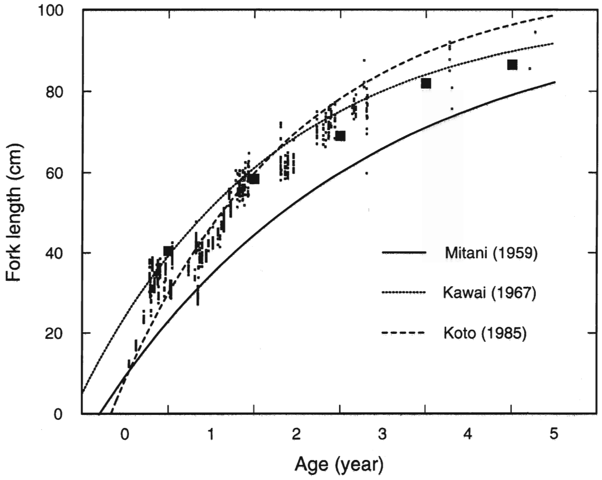

Fig. 4 . Average fork length at each age in 1967 determined from the number of rings on scales. Small squares represent data of MURAYAMA (1992a) and large solid squares represent the results of this study.

Discussion

The average fork length of 0 - year old yellowtail is significantly smaller in eastern areas, especially in area D, than western areas. NISHIOKA*[1] and NISHIOKA *et al.* (1985) also pointed out that fork lengths are smaller in eastern areas than western areas in the Japan Sea. MURAYAMA (1992a) concluded that the growth rate is smaller in the Japan Sea than in the northern coastal area of Kyushu examining the annual rings on the vertebral centrum of yellowtail caught between 1987 and 1989. MURAYAMA (1992b) attributed this spatial difference in growth rates to the difference in water temperature, because the differences in fork length from Kyushu to area C corresponded with spatial changes in water temperature and the results of rearing examinations by HARADA (1965) show that the degree of difference in average water temperature is large enough to produce discernible differences in fork length. Spatial differences observed in this paper can also be explained by the difference of water temperature. However, no clear cut effect of water temperature on interannual fluctuations in the average fork length of 0 - year old yellowtail was found. Instead, the abundance index of 0 - year old yellowtail is inversely correlated with the average fork length in October in area B and area C. The density of 0 -year old yellowtail probably affects the growth. Another plausible hypothesis is that the recruitment of fish born in the later period of spawning season varies greater than that of fish born in the earlier period. NISHIOKA *et al.* (1985) and MURAYAMA (1987) pointed out that the frequency distributions of fork length of 0 - year old yellowtail are often a mixture of two or three normal distributions. MURAYAMA (1987) attributed this plurality of distributions to the difference in spawning grounds and spawning season. If the fork length of the earlier-born fish is larger than the later-born fish, and the abundance of 0 - year old yellowtail fluctuates mainly by variation of the later-born fish abundance, the average fork

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*[1] Report of meeting of Buri Yoho Renraku Kaigi (1984)

length would be inversely correlated with the abundance of 0 - year old yellowtail.

MURAYAMA (1992a) suggested that the growth of yellowtail between 1987 and 1989 differed remarkably from the growth in late 1950's, because the fork length at each age in 1987-1989 was far from the growth curve that MITANI (1959) calculated using samples from area B between 1956 and 1958 as shown in Fig. 4. The average fork length at each age in 1967 is very close to that in 1987-1989, and minimum of average fork length of 0 - year old fish in October (24.3 cm in area D in 1980) is in the range of the plots of MURAYAMA (1992a) and close to the growth curve of KOTO (1985). Therefore I conclude that the growth of young yellowtail has not changed remarkably since 1967.

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日本海に分布するブリ幼魚の尾叉長の海域差と経年変動について

檜山　義明

日本海本州沿岸域で漁獲されたブリ*Seriola quinqueradiata* TEMMINCK *et* SCHLEGELの尾叉長組成から得られた1968～1994年の８～12月各月の平均尾叉長を比較し，東部海域では西部海域より尾叉長が小さい傾向があることを明らかにした．10月の尾叉長とブリ０年魚の資源量指数との間に有意($P < 0.01$)な負の相関があったことから，ブリ幼魚の成長に個体群密度が影響することが示唆された．1967年12月に佐渡島の定置網で漁獲されたブリ192個体について，鱗による年齢査定を行った．０～４年魚までの尾叉長は，1960年代前半の太平洋及び1980年代後半の日本海で推定された値に近かったが，1950年代後半の日本海の値とは若干異なっていた．