

Seasonal Growth Patterns of Pacific Salmon (*Oncorhynchus* spp.) in Offshore Waters of the North Pacific Ocean

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Seasonal growth patterns of Pacific salmon (*Oncorhynchus* spp.) in the North Pacific Ocean were explored using biological data collections from the Japanese salmon research programs. Seasonal change in fork length and body weight was similar between sockeye and chum salmon, and between pink and coho salmon. Seasonal change in condition factors was very similar among the five species, that is, condition factors increased in spring, peaked in summer, decreased in fall, and were lowest in winter. Average growth rate in weight during maturing stage was significantly higher than that in immature stage for sockeye, pink, and coho salmon. For chum salmon, there was no significant difference in growth rate between immature and maturing fish, but the growth rate of immature fish was higher than those of other species, especially at age 0.2. Growth rates during life stages when density-dependent growth may occur are higher than those in other life stages. We can hypothesize that higher growth rates require greater demands for food intake, which may lead to density-dependent growth during these rapid-growth seasons if prey resources are limited.



INTRODUCTION

There is a great deal of evidence that the sizes of Pacific salmon caught in commercial fisheries have varied from year to year in the North Pacific Ocean (Ricker 1995; Helle and Hoffman 1995; Bigler et al. 1996). To explain these changes in body size, several hypotheses - such as density-dependent growth, selection by size selective fisheries or artificial enhancement, and changes in ocean conditions - were suggested for some species and stocks (Ricker 1981; Kaeriyama 1989; Ishida et al. 1993, 1995). In general, most fish continue to grow throughout their lives (Moyle and Cech 1988). For Pacific salmon, there is substantial information on body size of out migrating juveniles and returning adults for many stocks. However, the growth of Pacific salmon during the marine rearing phase has not been defined precisely because of very limited ocean sampling, especially in winter (LeBrasseur and Parker 1964; Lander and Tanonaka 1964; Lander et al. 1966; LaLanne 1971). Three methods have been used to estimate marine growth of Pacific salmon: (1) seasonal changes in the average sizes of fish sampled at frequent intervals at sea, (2) tag-recovery data, and (3) fish lengths back-calculated from scales (Birman 1951; Taguchi 1961; Ricker 1964; LaLanne 1971;

Kaeriyama 1996). Japanese scientists have conducted salmon research in offshore waters since 1953. Biological data collected during this research was used to estimate marine growth of Pacific salmon.

The purposes of this study were to provide a basic description of the marine growth of five species of Pacific salmon, to compare these results with those from previous studies, and to discuss the relationship between seasonal growth pattern and density-dependent growth.

MATERIALS AND METHODS

Data (Appendix Tables 1 - 8) used for this study were collected by the following three salmon research programs: (1) the Spring and Summer Salmon Research Program, (2) the Winter Salmon Research Program, and (3) the Juvenile Salmon Research Program. In the Spring and Summer Salmon Research Program, fish were caught by non-selective drift gillnets (C nets with 10 different mesh sizes from 48 to 157 mm; Takagi 1975), special mesh drift gillnets (F nets with mesh sizes less than 48mm and greater than 157 mm), commercial drift gillnets (Nets with mesh sizes from 112 to 130 mm), and surface longlines on Japanese salmon research vessels from 1972 through 1995 in the North Pacific Ocean,

Okhotsk Sea, Bering Sea, and Gulf of Alaska. In this study, biological data collected by C and F nets were used. In the Winter Salmon Research Program, drift gillnets and surface longlines were used in the North Pacific Ocean in the winters of 1968 and 1969, and a trawl net was used in the North Pacific Ocean and Gulf of Alaska in the winters of 1992 and 1996. In the Juvenile Salmon Research Program, purse seines, small mesh gillnets (22 to 63 mm), and trawl nets were used in the western North Pacific Ocean and Okhotsk Sea in June-October of 1988-1995.

Fish were processed by recording fork length, body weight, sex, and gonad weight. A scale for age determination was removed from the standard International North Pacific Fisheries Commission (INPFC) preferred area of the body of each fish, if scales were present. Age was determined in the laboratory by visual examination of scale samples. Maturity was determined from gonad weights (Takagi 1961; Ito et al. 1974). In this study, average fork length (FL) in mm, body weight (BW) in g, and condition factor ($10^7 \times BW/FL^3$) were calculated by species, maturity, ocean age, and month. Growth rates are defined as increments in fork length or body weight per month (mm/mo or g/mo). Average growth rates are calculated by immature and maturing fish including negative values. All freshwater age groups, sexes, years, and gear types were combined. Data points calculated from less than 10 fish were excluded from the analysis. We did not analyze data by geographic area and stock, so growth patterns in this study are not for specific stocks, but for several stocks combined.

RESULTS

Fork Length

Seasonal change in fork length was similar between sockeye and chum salmon, and between pink and coho salmon. Juvenile sockeye salmon were about 210 mm in fork length in August and grew to 270 mm by the end of the first year. For immature sockeye salmon, the average fork length in July was 350 mm, 480 mm, and 540 mm for the second to the fourth year, respectively. For maturing sockeye salmon, the average fork length in July was 390 mm, 550 mm, 610 mm, and 620 mm from the second to the fifth year, respectively (Fig. 1). The average growth rate was 10 mm/mo for immature sockeye salmon, and 14 mm/mo for maturing sockeye salmon, but these differences were not significant (t-test, $P < 0.05$) (Table 1).

Juvenile chum salmon were about 150 mm in fork length in July and grew to 240 mm at the end of the first year (Fig. 1). For immature chum salmon, the average fork length in July was 340 mm, 460 mm,

520 mm, and 560 mm from the second to the fifth year, respectively. For maturing chum salmon, the average fork length in July was 400 mm, 520 mm, 590 mm, 620 mm, and 630 mm from the second to the sixth year, respectively (Fig. 1). The average growth rates were 14 mm/mo for both immature and maturing chum salmon but these differences were not significant (t-test, $P < 0.05$) (Table 1).

Pink and coho salmon grew linearly, although the growth slowed from October to January. The average fork lengths of pink and coho salmon were 250 mm and 340 mm at the end of the first year, respectively, and 500 mm and 620 mm in September of the second year, respectively (Fig. 1). There was no significant difference between the growth rates of immature and maturing fish for both species (t-test, $P < 0.05$) (Table 1). Chinook salmon appeared to have a linear growth pattern, although data were not sufficient to estimate growth rates (Fig. 1).

Body Weight

Seasonal changes in body weight were similar to those in fork length, but much more drastic, especially during the season of rapid growth. Juvenile sockeye salmon were about 100 g in body weight in August and grew to 230 g by the end of the first year. For immature sockeye salmon, the average body weight in July was 470 g, 1280 g, and 1950 g from the second to the fourth year, respectively. The average body weight of maturing sockeye salmon in July was 740 g, 2230 g, 3060 g, and 3280 g from the second to the fifth year, respectively (Fig. 2). The average growth rate of maturing sockeye salmon was significantly higher than that of immature sockeye salmon (t-test, $P < 0.05$) (Table 1). The body weight growth rates of maturing sockeye salmon at ocean age .2 and .3 were higher than those of other ages.

Juvenile chum salmon were about 40 g in body weight in July and grew to 140 g at the end of the first year. For immature chum salmon, the average body weight in July was 440 g, 1160 g, 1770 g, and 2170 g from the second to the fifth year, respectively. The average body weight of maturing chum salmon in July was 780 g, 1890 g, 2790 g, and 3260 g from the second to the sixth year, respectively (Fig. 2). The average body weights of immature chum salmon decreased during winter. The average growth rates of immature and maturing chum salmon were high and not statistically different (t-test, $P < 0.05$) (Table 1). The body weight growth rate of immature chum salmon at age 0.2 and 0.3 were higher than those of other ages.

The average body weights for pink and coho salmon were 170 and 480 g in December of the first year, respectively, and 1520 g and 3440 g in September of the second year, respectively (Fig. 2).

Fig. 1 Average fork lengths of Pacific salmon taken at sea by month. Open circles indicate immature fish and closed circles indicate maturing fish.

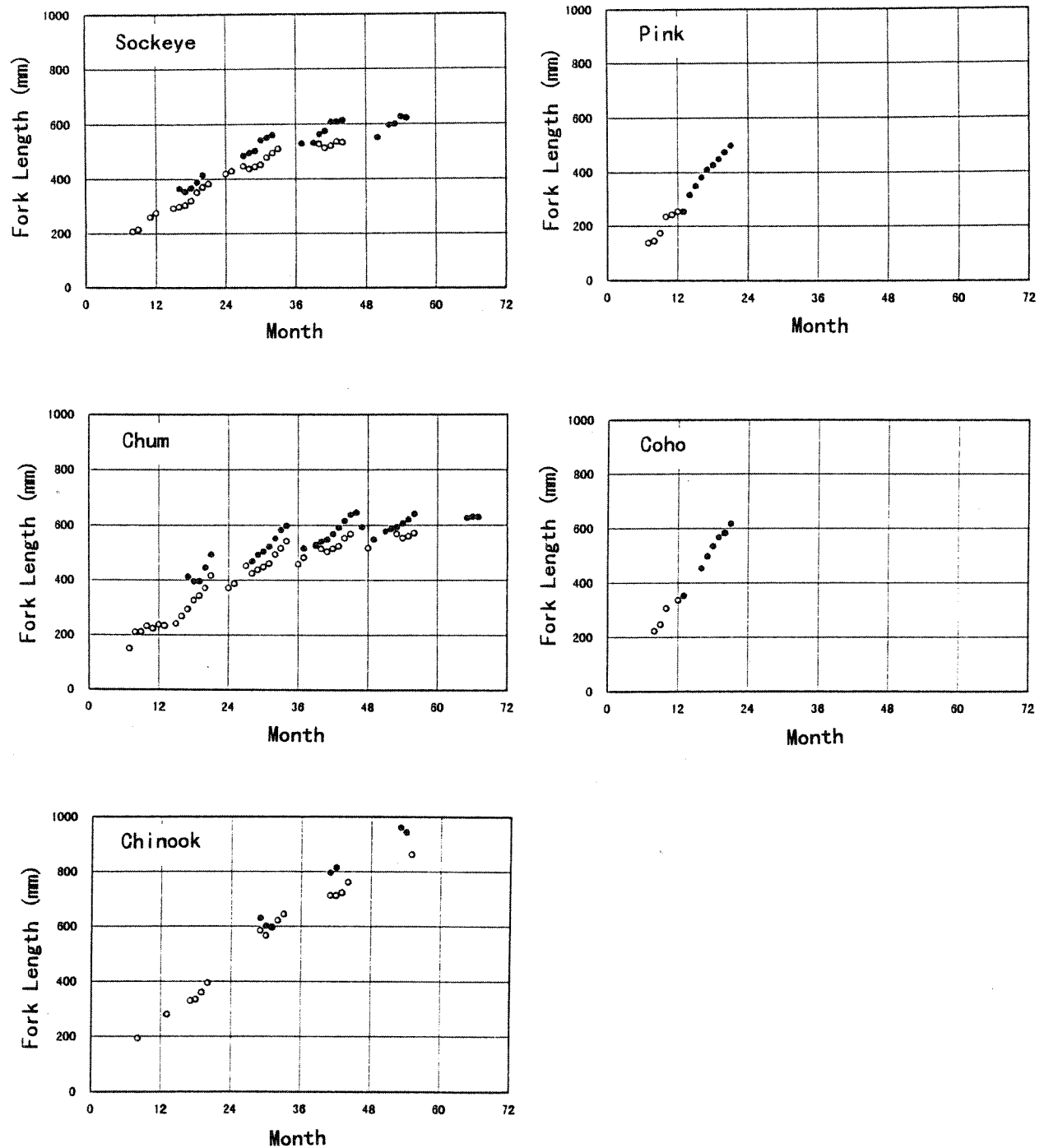
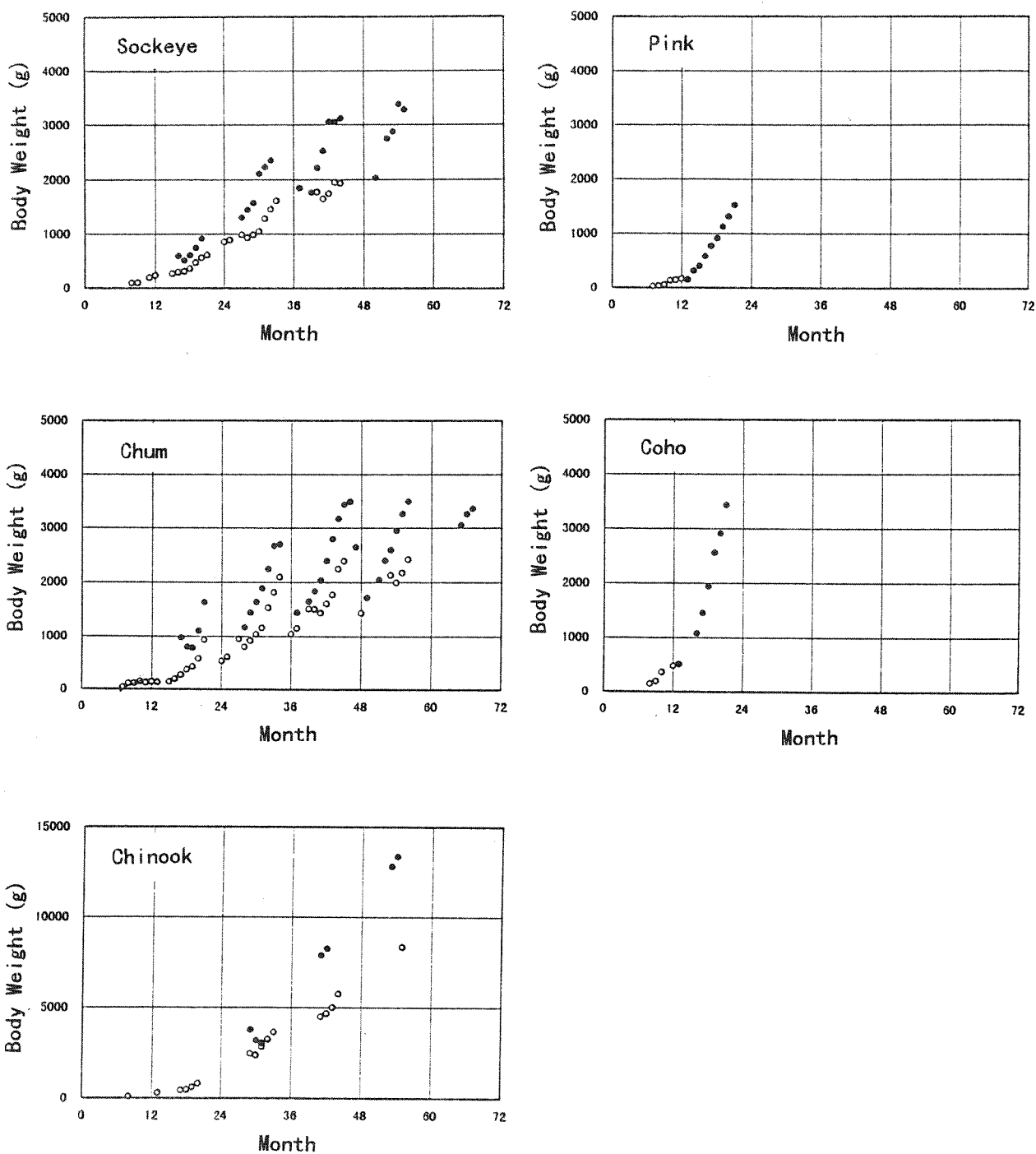


Table 1. Growth rate in fork length and body weight by species, maturity, and ocean age.

Species Ocean Age	FL/mo		BW/mo	
	Immature	Maturing	Immature	Maturing
Sockeye				
Age .0	11.5±6.0		20.5±26.8	
Age .1	15.0±9.4	12.5±16.6	57.5±35.7	80.3±114.5
Age .2	10.5±10.8	15.2±13.5	94.5±98.3	209.7±184.3
Age .3	1.7±13.0	16.7±15.1	39.5±145.1	273.1±239.4
Age .4		8.6±15.4		178.4±308.4
Mean±S.D.	10.2±10.9	13.8±13.9	63.5±88.6	192.4±206.1
Chum				
Age .0	17.4±26.3		20.8±38.7	
Age .1	24.4±15.3	20.1±33.9	111.6±117.0	163.6±321.6
Age .2	13.1±18.2	21.8±7.5	152.6±159.8	254.6±136.0
Age .3	9.7±15.5	8.0±25.9	140.1±171.6	124.3±408.0
Age .4	0.9±14.3	12.8±5.1	95.6±206.8	288.5±71.2
Age .5		2.1±3.8		153.2±75.9
Mean±S.D.	14.4±18.4	13.8±20.0	112.4±142.7	197.0±266.7
Pink				
Age .0	23.1±22.7		28.2±30.5	
Age .1		27.2±16.6		150.0±73.1
Mean±S.D.	23.1±22.7	27.2±16.6	28.2±30.5	150.0±73.1
Coho				
Age .0	41.7±25.6		105.5±88.3	
Age .1		39.9±11.7		398.2±204.8
Mean±S.D.	41.7±25.6	39.9±11.7	105.5±88.3	398.2±204.8

Fig. 2 Average body weights of Pacific salmon taken at sea by month. Open circles indicate immature fish and closed circles indicate maturing fish.



For both species, the average growth rate of maturing fish was significantly higher than that of immature fish (t-test, $P < 0.05$) (Table 1).

Condition Factor

Seasonal change in condition factors was very similar among the five species, that is, condition factors increased in spring, peaked in summer, decreased in fall, and were lowest in winter (Fig. 3). In addition to seasonal changes, condition factors of sockeye and chinook salmon showed increasing trends in peak and low values as ocean age increased. In contrast, the peak and low values of condition factors of chum salmon were stable regardless of ocean age (about 130 and 100, respectively). The condition factors of coho salmon were higher than those of pink salmon in all seasons.

DISCUSSION

Comparison with Other Studies

For sockeye salmon, we obtained a growth pattern similar to that presented by French et al. (1976) based on the seasonal size of fish sampled in the North Pacific Ocean and Bering Sea. In both areas, the growth of sockeye salmon was positive for most of the year. Continuous growth for sockeye salmon was also observed by Bilton and Ludwig (1966) using scale examination.

For chum salmon, the present estimates of body size for each age group were smaller than those provided in previous studies (Birman 1951; Kaeriyama 1996). The body size of chum salmon at the end of the first year was 240 mm in the present study, but 260-300 mm and 350-370 mm in the previous studies based on scale measurements. There are three possible explanations for this difference. Firstly, these differences may be stock specific as Birman (1951) examined a wild stock in the Amur River, and Kaeriyama (1996) examined a hatchery stock in Japan. In general, body sizes of out migrating juveniles of hatchery stocks are larger than those of wild stocks, because hatchery fish are fed artificially before release. The chum salmon in the present study are mixed stocks, so the difference in body size may be partly due to the difference of stocks or stock composition. Secondly, these differences may be temporal. Kaeriyama (1996) indicated that the average sizes of chum salmon in 1985-1992 were smaller than those in 1976-1980, and that this difference in growth was due to the changes in fish density. Most of the juveniles in the present study were collected after 1985. Therefore, the differences in sizes of juvenile chum salmon may be partly explained by differences in growth conditions due to fish density. Lastly, these

differences may be related to differences in methodology. Birman (1951) and Kaeriyama (1996) measured the widths between annuli on scales and estimated fork length by back-calculation using an estimated scale-length relationship. This relationship was developed using mature adults, and it has not yet been validated with juvenile fish.

For pink salmon, the present growth pattern is within the range of those provide by Ricker (1964), LeBrasseur and Parker (1964), and Takagi et al. (1981). There is a season of slow growth from October to January in the present growth pattern. A similar slow-growth season was also found by Ricker (1964). This slow-growth season for pink salmon corresponds to the time of annulus formation in December or January (Birman 1960; Bilton and Ludwig 1966). Average fork length at the time of annulus formation was estimated to be 28 cm by back-calculation (Birman 1960), while the average fork length in the present study was 25 cm in January.

Growth Rate and Density-Dependent Growth

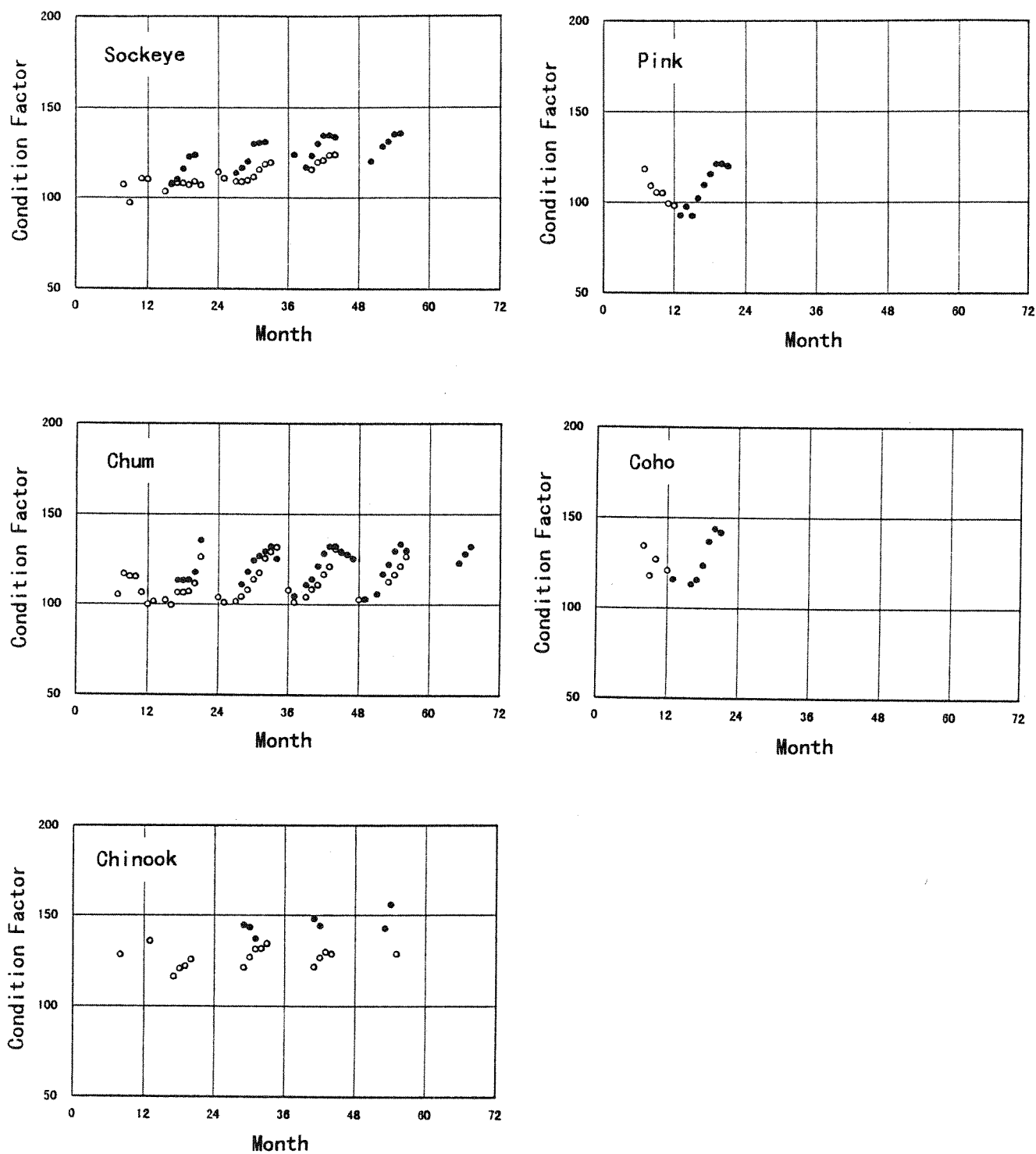
Average growth rate in weight during maturing stage was significantly higher than that in immature stage for sockeye, pink, and coho salmon. For chum salmon, there was no significant difference between immature and maturing fish, but the growth rate of immature fish was higher than those other species, especially at age 0.2.

It is reported that density-dependent growth in salmon occurs at a specific life history stage in the North Pacific Ocean. For sockeye salmon, density-dependent growth occurs in maturing fish in the last few months at sea (Rogers and Ruggerone 1993). For chum salmon, density-dependent growth occurs in the first through the fourth year, especially in the third year (Ishida et al. 1993; Kaeriyama 1996). For pink and coho salmon, growth variation in the second year at sea is related to abundance of pink salmon (Ogura et al. 1991, Ishida et al. 1995). Growth rates during life stages when density-dependent growth may occur are higher than those in other life stages. We can hypothesize that higher growth rates require greater demands for food intake, which may lead to density-dependent growth during these rapid-growth seasons if prey resources are limited.

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Fig. 3 Average condition factors of Pacific salmon taken at sea by month. Open circles indicate immature fish and closed circles indicate maturing fish.



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Appendix

Table 1. Fork length, body weight, and condition factor of immature sockeye salmon.

Ocean Age	Month	Fork Lenth				Body Weight				Condition Factor			
		No	Mean	±	S.D.	FL/dt	Mean	±	S.D.	BW/dt	Mean	±	S.D.
.0	1												
	2												
	3												
	4												
	5												
	6												
	7												
	8	375	207.1	±	15.7		96.2	±	22.9		107.2	±	10.9
	9	19	214.3	±	13.7	7.2	97.8	±	25.8	1.6	97.2	±	10.8
	10												
	11	21	258.9	±	14.0		193.2	±	33.1		110.6	±	7.0
	12	17	274.7	±	22.1	15.8	232.8	±	62.3	39.5	110.3	±	6.9
.1	1												
	2												
	3	53	291.9	±	31.9		265.3	±	86.9		103.5	±	10.7
	4	449	296.8	±	33.6	4.9	290.4	±	113.5	25.1	107.4	±	14.2
	5	1907	303.0	±	31.1	6.2	309.2	±	101.2	18.8	108.2	±	14.2
	6	6181	320.0	±	31.8	17.0	362.6	±	121.9	53.4	108.1	±	13.8
	7	12827	350.4	±	33.6	30.4	472.7	±	144.9	110.1	107.1	±	11.6
	8	3831	369.1	±	33.9	18.7	561.2	±	167.2	88.5	109.0	±	12.3
	9	313	381.9	±	33.7	12.8	610.5	±	190.2	49.3	106.9	±	12.0
	10												
	11												
	12	73	418.8	±	30.2		852.8	±	209.7		114.2	±	8.1
.2	1	30	428.7	±	33.9	9.9	889.0	±	209.6	36.2	110.7	±	5.7
	2												
	3	151	446.1	±	28.4		981.8	±	203.7		109.1	±	6.4
	4	558	436.7	±	34.3	-9.5	923.5	±	238.6	-58.3	108.8	±	7.9
	5	2627	444.9	±	31.9	8.2	980.9	±	232.4	57.3	109.7	±	9.5
	6	5708	452.2	±	30.7	7.4	1047.1	±	245.6	66.2	111.5	±	10.3
	7	16394	477.7	±	32.7	25.5	1280.9	±	302.4	233.8	115.6	±	10.8
	8	2897	494.7	±	33.6	17.0	1455.4	±	322.9	174.5	118.6	±	12.3
	9	271	509.9	±	32.0	15.2	1607.2	±	344.6	151.8	119.6	±	9.9
	10												
	11												
	12												
.3	1												
	2												
	3												
	4	22	527.2	±	53.1		1770.0	±	599.1		115.6	±	8.3
	5	117	512.8	±	36.2	-14.5	1641.4	±	4161.1	-128.6	119.7	±	12.8
	6	322	520.9	±	37.1	8.1	1739.1	±	455.1	97.8	120.8	±	12.4
	7	538	536.4	±	40.7	15.5	1946.4	±	501.3	207.2	123.5	±	12.4
	8	73	533.9	±	43.3	-2.5	1928.1	±	508.1	-18.3	123.8	±	9.0
	9												
	10												
	11												
	12												

Appendix (continued)

Table 2. Fork length, body weight, and condition factor of maturing sockeye salmon.

Ocean Age	Month	Fork Length					Body Weight				Condition Factor		
		No	Mean	±	S.D.	FL/dt	Mean	±	S.D.	BW/dt	Mean	±	S.D.
.1	1												
	2												
	3												
	4	20	363.6	±	70.2		592.0	±	388.0		108.0	±	9.6
	5	106	352.4	±	39.8	-11.2	506.2	±	187.6	-85.8	110.2	±	15.0
	6	326	367.0	±	44.1	14.5	606.5	±	319.3	100.3	116.0	±	15.8
	7	414	386.7	±	40.7	19.7	740.8	±	294.6	134.2	122.9	±	13.9
	8	183	413.8	±	42.6	27.1	913.1	±	398.9	172.3	123.8	±	13.2
	9												
	10												
	11												
	12												
.2	1												
	2												
	3	136	484.5	±	20.9		1299.9	±	184.5		113.6	±	5.6
	4	845	496.2	±	30.4	11.7	1442.8	±	303.1	142.9	116.5	±	9.4
	5	3187	503.0	±	40.6	6.8	1571.0	±	457.6	128.2	120.1	±	12.6
	6	6331	542.1	±	40.3	39.2	2109.9	±	516.2	538.9	129.8	±	13.2
	7	6710	550.9	±	42.5	8.8	2229.4	±	568.9	119.5	130.5	±	13.8
	8	370	560.4	±	38.4	9.5	2348.3	±	553.4	118.9	131.0	±	12.7
	9												
	10												
	11												
	12												
.3	1	14	528.9	±	20.5		1838.6	±	212.6		123.9	±	6.0
	2												
	3	36	530.9	±	23.4		1755.3	±	229.9		116.8	±	6.5
	4	435	562.4	±	32.9	31.5	2214.5	±	413.2	459.2	123.2	±	8.8
	5	2677	575.3	±	39.0	12.9	2518.5	±	598.3	304.0	130.0	±	11.5
	6	7277	608.5	±	36.8	33.2	3061.3	±	592.9	542.9	134.5	±	12.0
	7	5738	608.3	±	33.7	-0.2	3056.8	±	563.3	-4.5	134.7	±	12.7
	8	279	614.4	±	29.9	6.1	3120.6	±	522.4	63.8	133.6	±	10.4
	9												
	10												
	11												
	12												
.4	1												
	2	20	551.1	±	29.3		2029.5	±	383.1		120.1	±	8.8
	3												
	4	15	595.8	±	34.4		2745.3	±	542.1		128.3	±	8.7
	5	72	600.7	±	33.8	4.9	2870.4	±	555.5	125.1	131.1	±	12.0
	6	122	626.3	±	45.6	25.6	3380.4	±	757.5	510.0	135.3	±	12.0
	7	96	621.6	±	34.1	-4.7	3280.5	±	586.8	-99.9	135.7	±	13.2
	8												
	9												
	10												
	11												
	12												

Appendix (continued)

Table 3. Fork length, body weight, and condition factor of immature chum salmon.

Table 3. Fork length, body weight, and condition factor of immature chain salmon.													
Ocean Age	Month	Fork Length				Body Weight				Condition Factor			
		No	Mean	±	S.D.	FL/dt	Mean	±	S.D.	BW/dt	Mean	±	S.D.
.0	1												
	2												
	3												
	4												
	5												
	6												
	7	33	150.6	±	23.0		37.9	±	17.1		105.3	±	13.7
	8	88	209.9	±	32.4	59.3	113.1	±	45.3	75.2	116.9	±	17.4
	9	144	211.6	±	24.5	1.7	113.4	±	41.0	0.4	115.5	±	11.1
	10	416	232.2	±	21.1	20.6	148.1	±	44.7	34.7	115.3	±	8.7
	11	295	222.2	±	21.2	-10.0	119.6	±	33.5	28.6	106.6	±	7.9
	12	18	237.5	±	36.8	15.4	141.7	±	73.2	22.1	99.9	±	8.4
.1	1	215	233.3	±	18.8	-4.2	131.6	±	35.9	-10.1	101.4	±	7.0
	2												
	3	41	241.1	±	15.0		144.4	±	28.2		102.3	±	7.5
	4	302	268.4	±	22.6	27.3	194.2	±	54.5	49.8	99.3	±	13.9
	5	553	294.1	±	19.8	25.8	274.3	±	67.2	80.2	106.5	±	14.2
	6	4990	326.3	±	24.5	32.2	375.9	±	107.5	101.5	106.4	±	12.7
	7	23542	342.3	±	25.0	15.9	436.4	±	113.8	60.5	107.1	±	11.6
	8	5688	370.7	±	27.9	28.5	581.9	±	182.7	145.6	111.5	±	13.1
	9	236	415.8	±	31.6	45.0	935.7	±	275.5	353.8	126.4	±	15.8
	10												
	11												
	12	147	370.9	±	25.5		534.1	±	105.3		103.8	±	7.2
.2	1	75	386.0	±	43.9	15.1	612.6	±	259.2	78.5	100.9	±	9.4
	2												
	3	13	451.1	±	30.5		953.1	±	244.7		101.7	±	9.8
	4	478	423.3	±	32.2	-27.7	806.9	±	212.5	-146.2	104.2	±	8.6
	5	1367	436.5	±	32.9	13.2	918.8	±	253.0	111.9	108.1	±	10.4
	6	8612	447.6	±	32.5	11.1	1042.1	±	277.0	123.3	113.9	±	11.7
	7	25045	459.3	±	33.8	11.7	1163.2	±	311.7	121.1	117.6	±	13.4
	8	4921	492.3	±	38.0	33.0	1535.0	±	433.1	371.8	125.7	±	12.9
	9	440	515.4	±	39.9	23.1	1813.1	±	505.7	278.1	129.3	±	12.5
	10	22	541.0	±	20.1	25.6	2095.0	±	327.0	281.9	131.8	±	15.5
	11												
	12	76	457.2	±	29.4	457.2	1045.3	±	234.7	1045.3	107.9	±	11.5
.3	1	42	418.9	±	42.2	24.7	1152.1	±	306.7	106.8	101.0	±	9.9
	2												
	3	22	524.9	±	28.4	524.9	1512.3	±	223.9	1512.3	104.0	±	5.1
	4	182	513.6	±	42.6	-11.3	1509.1	±	461.3	-3.2	108.3	±	10.7
	5	696	503.5	±	34.5	-10.1	1440.2	±	360.9	-68.8	111.0	±	12.2
	6	3465	514.1	±	34.7	10.6	1607.9	±	367.0	167.7	116.8	±	12.2
	7	8355	523.9	±	35.4	9.8	1771.9	±	442.9	164.0	121.2	±	14.0
	8	970	552.4	±	37.9	28.5	2243.6	±	554.2	471.7	130.9	±	14.4
	9	79	568.3	±	30.0	15.9	2386.1	±	420.8	142.5	129.0	±	11.4
	10												
	11												
	12	19	517.0	±	35.4	517.0	1436.7	±	334.5	1436.7	102.8	±	12.4
.4	1												
	2												
	3												
	4												
	5	26	568.5	±	43.9	568.5	2132.7	±	687.7	2132.7	122.6	±	11.3
	6	142	553.0	±	41.2	-15.5	1992.7	±	461.8	-140.0	116.6	±	12.4
	7	335	560.2	±	42.0	7.2	2172.6	±	593.2	180.0	121.4	±	15.1
	8	23	571.2	±	51.3	11.0	2419.6	±	691.5	246.9	126.8	±	19.6
	9												
	10												
	11												
	12												

Appendix (continued)

Table 4. Fork length, body weight, and condition factor of maturing chum salmon.

Ocean Age	Month	Fork Length				Body Weight				Condition Factor			
		No	Mean	±	S.D.	FL/dt	Mean	±	S.D.	BW/dt	Mean	±	S.D.
.1	1												
	2												
	3												
	4												
	5	19	412.5	±	94.8		981.1	±	905.6		113.3	±	13.8
	6	107	394.9	±	76.2	-17.6	806.7	±	618.5	-174.4	113.2	±	14.9
	7	181	395.4	±	62.5	-0.5	781.6	±	542.5	-25.1	113.7	±	18.4
	8	51	445.0	±	56.3	49.7	1104.5	±	472.6	323.0	117.9	±	12.4
	9	16	492.8	±	37.5	47.7	1635.6	±	406.6	531.1	135.7	±	21.9
	10												
	11												
	12												
.2	1												
	2												
	3												
	4	245	468.0	±	41.0		1169.5	±	347.6		111.2	±	12.2
	5	915	492.0	±	38.2	24.1	1444.7	±	412.9	275.2	118.2	±	12.4
	6	2892	503.9	±	42.2	11.9	1640.7	±	500.2	196.1	124.5	±	15.4
	7	3691	522.7	±	49.2	18.8	1890.9	±	658.6	250.1	127.1	±	16.1
	8	790	551.7	±	49.4	29.0	2244.6	±	681.2	353.8	129.6	±	15.1
	9	97	582.7	±	42.5	31.0	2667.4	±	666.3	422.8	132.4	±	11.1
	10	37	598.9	±	35.0	16.1	2697.3	±	463.5	29.9	125.4	±	18.1
	11												
	12												
.3	1	51	515.0	±	38.0		1446.8	±	309.9		104.6	±	10.2
	2												
	3	115	528.8	±	26.9		1653.1	±	297.1		111.0	±	10.1
	4	2418	541.5	±	34.2	12.7	1835.4	±	416.8	182.2	114.0	±	11.1
	5	9329	549.1	±	35.0	7.6	2037.7	±	468.8	202.3	121.3	±	12.6
	6	19734	568.6	±	36.7	19.5	2394.1	±	542.4	356.5	128.5	±	14.0
	7	16745	591.3	±	42.5	22.8	2792.8	±	726.2	398.7	132.3	±	15.5
	8	1650	617.0	±	46.1	25.6	3170.3	±	823.1	377.5	132.5	±	15.9
	9	166	639.0	±	45.9	22.1	3435.4	±	837.7	265.0	129.5	±	13.3
	10	108	646.7	±	47.0	7.1	3492.1	±	766.2	56.8	127.7	±	11.5
	11	23	593.0	±	41.4	-53.7	2647.8	±	562.2	-844.3	125.5	±	9.4
	12												
.4	1	14	548.9	±	33.4		1720.4	±	313.2		103.1	±	8.5
	2												
	3	50	577.6	±	25.6		2047.0	±	290.2		105.9	±	9.6
	4	494	587.2	±	36.8	9.6	2396.9	±	533.8	349.9	116.9	±	12.0
	5	2246	593.8	±	36.2	6.7	2593.6	±	564.7	196.7	122.4	±	12.4
	6	5691	608.1	±	37.2	14.2	2948.2	±	615.2	354.6	129.8	±	13.5
	7	5216	621.7	±	40.8	13.6	3258.2	±	760.8	310.0	133.5	±	14.7
	8	281	641.8	±	46.5	20.2	3489.7	±	823.2	231.5	130.1	±	13.5
	9												
	10												
	11												
	12												
.5	1												
	2												
	3												
	4												
	5	44	626.5	±	28.1		3052.1	±	536.0		123.2	±	12.5
	6	134	631.3	±	36.4	4.8	3258.9	±	686.8	206.8	128.2	±	13.6
	7	163	630.7	±	45.5	-0.6	3358.4	±	790.1	99.5	132.1	±	14.6
	8												
	9												
	10												
	11												
	12												

Appendix (continued)

Table 5. Fork length, body weight, and condition factor of pink salmon.

Table 6. Fork Length, Body Weight, and Condition Factor of pink salmon.													
Ocean Age	Month	Fork Length					Body Weight				Condition Factor		
		No	Mean	±	S.D.	FL/dt	Mean	±	S.D.	BW/dt	Mean	±	S.D.
.0	1												
	2												
	3												
	4												
	5												
	6												
	7	56	138.7	±	9.1		31.8	±	5.8		118.5	±	11.3
	8	17	146.0	±	27.1	7.3	39.5	±	27.5	7.7	109.2	±	12.5
	9	90	173.7	±	18.0	27.7	58.1	±	25.5	18.6	105.4	±	12.4
	10	937	234.7	±	17.8	61.0	138.7	±	40.7	80.6	105.1	±	7.7
	11	707	243.1	±	38.5	8.4	145.7	±	38.5	6.9	99.2	±	8.4
	12	275	254.2	±	33.1	11.1	172.9	±	81.4	27.2	98.1	±	8.8
.1	1	215	254.2	±	18.7	0.0	154.9	±	36.7	-18.0	92.7	±	5.6
	2	239	316.9	±	28.6	62.7	318.5	±	93.0	163.7	97.6	±	7.9
	3	111	348.7	±	36.6	31.8	408.3	±	153.7	89.8	92.6	±	7.5
	4	12494	381.6	±	35.5	32.9	584.5	±	184.8	176.2	102.2	±	11.7
	5	50466	410.4	±	33.4	28.9	777.6	±	232.3	193.0	109.6	±	12.7
	6	129518	426.7	±	32.3	16.3	919.0	±	252.3	141.5	115.8	±	12.6
	7	126480	449.5	±	35.1	22.7	1128.9	±	322.5	209.9	121.3	±	13.0
	8	5884	474.7	±	32.4	25.2	1320.6	±	336.6	191.7	121.2	±	13.8
	9	1163	499.0	±	35.8	24.3	1523.1	±	397.6	202.6	120.1	±	13.5
	10												
	11												
	12												

Table 6. Fork length, body weight, and condition factor of coho salmon.

Ocean Age	Month	Fork Length				Body Weight				Condition Factor			
		No	Mean	±	S.D.	FL/dt	Mean	±	S.D.	BW/dt	Mean	±	S.D.
.0	1												
	2												
	3												
	4												
	5												
	6												
	7												
	8	540	222.5	±	26.2		153.5	±	62.3		134.4	±	13.4
	9	27	246.1	±	43.9	23.6	196.6	±	129.4	43.1	117.9	±	16.4
	10	28	305.9	±	16.8	59.8	364.6	±	55.6	168.0	127.0	±	10.5
	11												
	12	68	336.9	±	38.3		480.0	±	171.4		120.9	±	9.8
.1	1	57	352.9	±	34.1	16.0	513.9	±	158.2	33.9	116.1	±	15.7
	2												
	3												
	4	228	453.6	±	38.9		1080.7	±	288.3		113.3	±	12.0
	5	625	497.2	±	39.7	43.6	1450.4	±	358.0	369.7	115.9	±	10.6
	6	6439	534.9	±	43.0	37.7	1937.0	±	539.6	486.6	123.7	±	13.6
	7	15250	567.5	±	45.8	32.6	2557.8	±	690.1	620.7	136.9	±	15.8
	8	3802	582.8	±	47.5	15.2	2909.0	±	759.3	351.2	143.8	±	13.8
	9	76	617.1	±	54.4	34.3	3436.1	±	995.3	527.1	141.8	±	16.1
	10												
	11												
	12												

Appendix (continued)

Table 7. Fork length, body weight, and condition factor of immature chinook salmon.

Ocean Age	Month	Fork Length				Body Weight				Condition Factor			
		No	Mean	±	S.D.	FL/dt	Mean	±	S.D.	BW/dt	Mean	±	S.D.
.0	1												
	2												
	3												
	4												
	5												
	6												
	7												
	8	50	193.6	±	11.0		94.0	±	17.3		128.5	±	9.4
	9												
	10												
	11												
	12												
.1	1	29	281.0	±	14.6		304.3	±	52.2		135.9	±	6.4
	2												
	3												
	4												
	5	14	330.2	±	40.5		438.6	±	181.5		116.4	±	17.0
	6	323	334.9	±	42.7	4.6	478.7	±	278.7	40.1	120.7	±	12.9
	7	504	359.9	±	49.9	25.1	612.4	±	428.0	133.7	122.1	±	13.0
	8	71	394.9	±	46.7	35.0	816.3	±	371.0	204.0	125.8	±	9.7
	9												
	10												
	11												
	12												
.2	1												
	2												
	3												
	4												
	5	88	584.5	±	52.9		2471.9	±	636.0		121.3	±	12.1
	6	534	565.8	±	58.5	-18.7	2377.5	±	764.8	-94.4	127.0	±	12.3
	7	1275	595.2	±	55.5	29.4	2853.6	±	838.5	476.1	131.4	±	13.2
	8	145	622.6	±	50.7	27.4	3265.3	±	904.8	411.7	131.8	±	12.0
	9	23	645.6	±	33.7	22.9	3648.3	±	649.2	383.0	134.6	±	9.1
	10												
	11												
	12												
.3	1												
	2												
	3												
	4												
	5	91	712.5	±	53.2		4510.8	±	1302.4		121.6	±	11.6
	6	192	713.1	±	59.7	0.6	4690.9	±	1303.6	180.2	126.7	±	15.8
	7	239	722.9	±	60.6	9.8	5021.8	±	1431.6	330.8	129.9	±	13.0
	8	16	760.8	±	47.4	37.9	5763.1	±	1327.3	741.4	128.7	±	7.9
	9												
	10												
	11												
	12												
.4	1												
	2												
	3												
	4												
	5												
	6												
	7	10	862.4	±	47.9		8351.0	±	1505.6	8351.0	128.8	±	6.4
	8												
	9												
	10												
	11												
	12												

Appendix (continued)

Table 8. Fork length, body weight, and condition factor of maturing chinook salmon.

Table 8. Fork length, body weight, and condition factor of maturing chinook salmon.													
Ocean Age	Month	Fork Length					Body Weight				Condition Factor		
		No	Mean	±	S.D.	FL/dt	Mean	±	S.D.	BW/dt	Mean	±	S.D.
.2	1												
	2												
	3												
	4												
	5	33	631.0	±	66.3		3780.3	±	1452.5		144.6	±	16.6
	6	53	601.9	±	52.0	-29.1	3204.0	±	911.5	-576.3	143.4	±	11.9
	7	27	598.5	±	65.7	-3.4	3038.5	±	961.3	-165.4	137.2	±	17.0
	8												
	9												
	10												
	11												
	12												
.3	1												
	2												
	3												
	4												
	5	22	795.6	±	107.4		7894.1	±	3455.9		147.9	±	17.3
	6	40	813.9	±	105.7	18.4	8264.5	±	3498.1	370.4	144.2	±	14.4
	7												
	8												
	9												
	10												
	11												
	12												
.4	1												
	2												
	3												
	4												
	5	21	960.9	±	70.5		12819.5	±	2836.9		142.8	±	11.5
	6	32	943.8	±	81.1	-17.1	13378.1	±	3830.7	558.6	155.6	±	21.9
	7												
	8												
	9												
	10												
	11												
	12												