INTRODUCTION INTO AYSEN CHILE OF PACIFIC SALMON

No. 10

Growth and Maturation of Pink Salmon *(Oncorhynchus gorbuscha)* Reared in Sea Pen at Ensenada Baja Fish Farm, Aysén–Chile

By

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and

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Dedicated all the people who have encouraged me in this work. (K.S.)

Dedicado a mi familia y a todas las personas que han trabajado y cooperado con la Piscicultura de Ensenada Baja. (M.H.P.A.).

"INTRODUCTION INTO AYSEN CHILE OF PACIFIC SALMON"

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Kohsuke Shimazu and Mario Humberto Pucci A.

SUMMARY

Pink salmon *(Oncorhynchus gorbuscha)* have been reared to maturity in a floating sea pen in southern Chile in what we believe to be the first instance of the successful maturation of this species in the Southern Hemisphere.

A parent stock from northern Japan provided eyed eggs which are shipped by air to a hatchery in southern Chile. There they were hatched and reared in fresh water before being transferred to the sea pen. When fish from this pen reached maturity, they were spawned artificially. From their fertilized eggs, the first generation of native Chilean pink salmon have been produced.

INTRODUCTION

In 1973, 150,000 eyed eggs of cherry salmon *(Oncorhynchus masou)* were shipped from Japan to Chile to initiated a program for transplanting salmon stocks to the Southern Hemisphere. Since 1974, 1-3 million eyed eggs of chum salmon *(O. keta)* have been shipped annually from Hokkaido for incubation at a hatchery constructed on the Claro River at its junction with the Simpson River near the town of Coyhaique in Chile's XI Region (Aysén). Through 1976, the unfed fry were released into the Simpson River. Beginning in 1977, the fry have fed before being released and, since 1979, some have been retained for rearing in sea pen at Ensenada Baja, a small bay at the head of Aysén Fjord.

Although some chum salmon reared in sea pen have reached maturity and their gametes have been used to produce a generation of native Chilean fish, none of the chum salmon released to migrate to the sea have yet returned.

In 1979, the Servicio Nacional de Pesca (SERNAP) of Chile and the Japanese International Cooperation Agency (JICA) joined forces in a cooperative project which has as its objective the promotion and development of salmon aquaculture in Chile (Nagasawa, 1981).

Since none of the chum salmon released into Chilean waters had returned from their seaward migrations, it was decided to try pink salmon, a species with a shorter life cycle and, a shorter migration range. Like chum, however, pinks exhibit a tolerance for salt water very early in their lives. Accordingly, 300,000 eyed, pink salmon eggs were shipped from Japan to Chile in 1981. Although the eggs hatched normally, difficulties were encountered in getting the

fry to start feeding and with disease, causing a high rate of mortality. The 2,500 alevins that survived were considered too few to realese to take their chances in an unknown ocean. They were transferred instead to a sea pen where they were reared to maturity. This paper sumarizes our experiences with the rearing of these pink salmon in a sea pen.

MATERIALS AND METHODS

1. Rearing Site.

The pink salmon were reared in a floating net pen in Ensenada Baja, a small bay at the head of Aysén Fiord (45°47′ S; 72°45′ W). The bay is 1,800 m in long, 1,000 m wide with a maximum depth of 9 m (Fig. 1). The surface area is 1.6 Km^2. It is connected to the head of the fjord by a narrow channel 400 m long, 160 m wide and 4 m deep. Its environmental characteristics are summarized in Table 1.

TABLE 1. Environmental Characteristics of Ensenada Baja

Tidal range	2.4 m (max.)
Tidal current	25 cm/sec (max.)
Salinity range	30 o/oo (winter) – 0 o/oo (spring, summer)
Transparency range	0.5 - 7.0 m
Temperature range	2° - 20 °C

The dimensions of the net pen were 5 x 5 x 4m depth. It was placed at the deepest part of the bay (9 m).

2. Experimental Fish

Eggs and sperm from pink salmon returning to the Honorai River in northern Hokkaido were taken in September, 1981. When the eggs reached the eyed stage, 300,000 were selected and shipped from Japan to Chile by air. They arrived at the hatchery in Coyhaique on October 31. Hatching began on Nov. 20 and by the end of December, 1981, 89 °/o had survived to swim-up. The fry began feeding on January 1, 1982 when their body weight averaged 0.21 g each. In the outdoor pond at the hatchery, the fry became nervous and many failed to start feeding. During January, wide variations of temperature (6.8° - 21.8°C) adversely affected the fry. By the end of April 98 °/o had died. During May, the average water temperature declined to under 10°C, and the health of the surviving fry improved. On June 3, 1982, 2,500 fingerlings averaging 8,0 g in body weight and 10.3 cm fork length, were transferred by tank truck from the hatchery at Coyahique to the net pen at Ensenada Baja. They remained in the pen for 300 days.

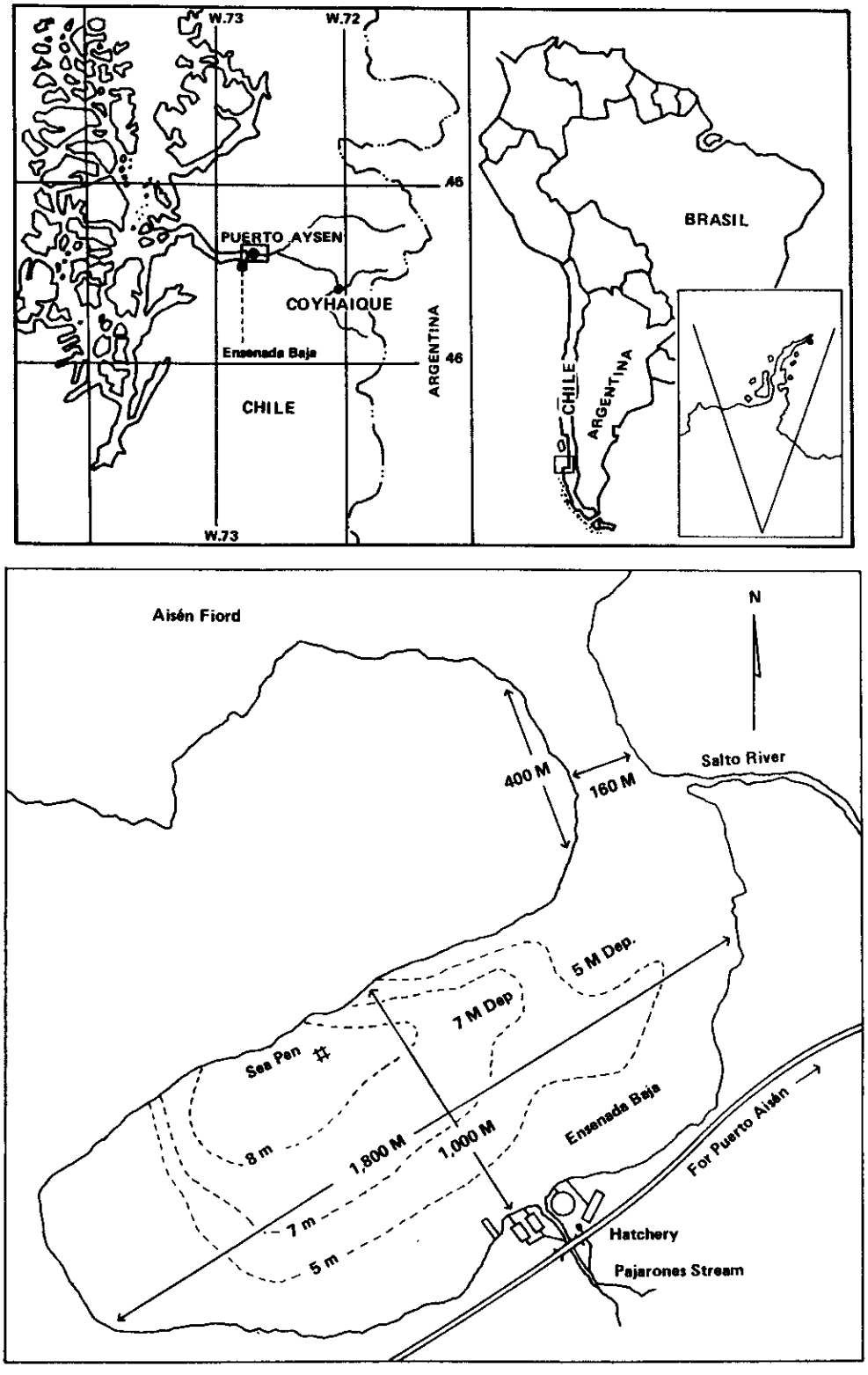


Figure 1 Map Showing Location of Ensenada Baja and Salmon Hatchery

3. Feed.

After transfer to the pen, the fish were fed a dry diet produced in Japan consisting of 45 - 48 %o crude protein, 4 %o fat, under 16 %o ash and 8 %o moisture. During June, they were fed a crumble with a particle diameter of 2.2 mm; in July, pellets of 2.5 mm diameter, from August through October, 3.2 mm pellets, and from November, 1982, through March, 1983, 4.5 mm pellets. The fish were fed to satiety twice daily except for 47 days out of the 300 days in which they were kept in the pen when it was impossible to do so for reasons of bad weather, the need to sample or the need to change the net. On such days the fish were not fed.

4. Measurement.

Body weight, depth and fork length were measured at the end of each month for samples of 30 - 50 fish randomly selected from the pen stock. These specimens were anesthetized with MS-222 (Sandoz-Sankyo K.K.), measured and then returned to the pen.To observe the rate of sexual maturation, specimens were removed from the pen at the end of October and at the end of each month thereafter. These specimens were killed and the gonads removed and weighed immediately.

5. Water Temperature and Salinity.

Surface water temperatures in the pen were recorded twice daily (at about 10 A. M. and 5 P.M.). To establish salinity profiles for the bay, water samples were taken from the surface and at depths of 3 and 5 m at monthly intervals. From September, salinity samples were taken from the surface and from a depth of 5m at weekly intervals. An Akanuma type aerometer was used to measure the specific gravity of the water samples. Salinities were calculated from the specific gravity values recorded.

6. Egg Taking and Artificial Fertilization.

On March 30, the entire stock was taken from the sea pen and transported back to the freshwater pond at the hatchery. There they were sorted, and the ripe fish were spawned. All of the fish were spawned by April 4. The eggs were fertilized by the dry method.

RESULTS

1. Growth in Body Weight.

Monthly measurement of the body weight are shown in Table 2, and their frequency distribution in Figure 14.

Since most of the fish were precocious and matured sufficiently 15 months from swim up, almost all of them weighed less than 1,000 g. Growth measured by the body weight was calculated as follows:

TABLE 2. Rearing Record in 1982 - 83

Month	Jan.	Feb.-May.	Jun.-Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Final
The first day	Jan. 1	Jan. 31	Jun. 4	Jul. 31	Aug. 31	Sep. 30	Oct. 30	Nov. 26	Dec. 24	Jan. 28	Feb. 26	Mar. 28
No. of rearing days	–	–	57	31	30	30	27	28	35	29	31	Final
Initial No. of stock	267.000	–	2,500	2,200	2,180	2,160	1,990	1,970*	580	566	553	540
Losses. mortality (%)	–	–	2.0	0.9	0.9	0.9	0.5	0.9	0.7	0.5	0.5	–
sampling (No.)	–	–	–	–	–	150	10	20	10	10	10	–
Daily growth rate (% BW)			1.91	2.15	1.70	1.56	1.71	2.06	0.87	1.08	–	–
Growth multiple (BW)			2.96	1.95	1.67	1.60	1.59	1.78	1.36	1.37	0.82	–
Feeding rate (% BW/day)			3.6	2.8	3.2	2.6	2.5	3.5	3.4	2.3	1.1	–
Food convers. rate (%)			48.6	74.2	50.8	60.0	66.2	43.3	33.3	51.3	–	–
Aver. water temp. (oC)	13.7	9.5	5.9	6.7	8.3	9.9	13.2	13.7	16.8	15.2	12.9	–
Rearing site	Fry Canal	Pond.	Sea Pen	Sea Pen	Sea Pen	Sea Pen	Sea Pen	Sea Pen	Sea Pen	Sea Pen	Sea Pen	Pond
No. of sample (Initial)				50	50	50	50	50	30	30	30	30
Average BW (g)	0.21	0.30	8.0	23.7	46.2	77.2	123	195	347	483	660	541
Range				8.8 - 56.2	22.0 - 87.0	32.0 - 120	44.0 - 260	95 - 350	105 - 565	250 - 720	340 - 1,080	228 - 930
Average FL (cm)	3.2	3.5	10.3	14.5	17.5	20.1	23.3	25.0	29.9	31.5	34.7	34.6
Range				10.7-18.9	13.8-204	16.0-23.4	16.2-30.2	20.7-31.0	208.-34.8	21.5-39.2	29.2-41.2	26.3-39.8
Average BD (cm)	–	–	–	2.4	3.1	3.8	4.5	5.2	6.6	8.2	9.0	8.4
Range				1.7 - 3.6	2.4 - 3.9	2.7 - 4.6	3.3 - 5.9	3.8 - 6.8	4.0 - 8.3	7.0 - 9.7	6.3 - 12.0	6.2 - 11.2
Average Cond. Factor	–	–	–	7.6	8.4	9.2	9.2	11.3	12.5	15.1	15.5	12.7
Range				6.7 - 9.3	6.8 - 11.1	7.5 - 11.4	7.5 - 11.6	9.2 - 13.7	10.7 - 13.8	11.0 - 19.6	11.4 - 21.1	9.5 - 16.6
BD/FL x 100	–	–	–	16.8	17.8	18.7	19.5	20.3	21.8	26.3	25.9	24.2

* Releasing 1,350 fish

W = Body weight
D = Rearing days

(1) The first stage: Jan. 1, to Jun. 3, 1982
0.21 g to 8.0 g BW
$W = 0.1771\ e^{0.02463D}$ ($r = 0.9953$).

(2) The second stage: Jun. 4 to Dec. 23,1982
8.0 g to 347 g BW
$W = 8.430\ e^{0.01830D}$ ($r = 0.9991$).

(3) The third stage: Dec. 24, 1982 to Feb. 25, 1983
347 g to 660 g BW.
$W = 344.82\ e^{0.01003D}$ ($r = 0.9993$).

(4) Totalling the three stages: Jan. 1, 1982 to Feb. 25, 1983
0.21 g to 660 g BW.
$W = 0.26426\ e^{0.019957D}$ ($r = 0.9927$).

2. Body Weight of Maturing and Immature Fish.

From January thereafter, maturing females gonad indixes were higher than 5 %. In contrast, the indexes for the immature females remained smaller than 1.3 % (Fig. 7).

Body weight was compared between maturing fish and immature fish as follows:

Date of sampling	Age	BW of maturing fish(g)	BW of immature fish(g)
Jan. 27, 1983	13 months	490, 480, 340, 290	390, 250
Feb. 25, 1983	14 months	955, 730, 520	595
Mar. 28, 1983	15 months	750, 610, 387, 270	378

The body weight of immature fish were consistently at the lower end of the sample distribution.

3. Condition Factor

Pink salmon, up to 50 g body weight were very slender with a condition factor from 7 to 8.

Then, as the body weight increased the condition factor also went up, especially at the end of January and February, 1983, when it reached 15 (Table 2). This value was the average of all samples measured.

4. Growth in Fork Length

Fork length increased by 4.3 cm in December, 1982, prior to the development of the gonads and by only 1.6 cm in January, 1982, after the gonads began to develop. On the average, however, fork length increased constantly 2 to 3 cm per month (Fig. 12). Growth curves for both stages of rearing, in pond and cage, are shown in Figure 3.

The relationship between the body weight and fork length was calculated as follows: (Figure 5).

$$W\ (g) = 0.00402 \times FL\ (cm)^{3.234} \qquad (r = 0.9983)$$

5. Growth Expressed as Body Depth.

Growth expressed as body depth took the form of an exponential curve as shown at Figure 4.

Measured body depth increased at an almost constant rates until January, 1983, although visually, the hump seemed to appear abruptly in January. This may be because the rate of growth of fork length declined sharply in January to one third the rate of the preceding month. The growth of body depth which was rather high in December, 1982, maintained almost the same rate in January. This unevennes of the growth in different dimensions appeared as an abrupt deformation (Figure 11, 12).

The ratios of the body depth to fork length are shown in Table 2 and their distribution in Figure 17. From this table and figure, it can be seen that the ratio body depth/fork length increased from July to the end of February, 1983, one month before full maturity.

6. Maturation

Male: Until the end of November 1982 when the average weight of the fish was 165 g, the gonads were thin, weighing 0.1 to 0.2 g with gonad indices of 0.1. By the end of December, 1982 (the summer solstices in Chile), the developing gonads weighed 0.7 to 5.7 g with gonad indices ranging from 0.3 to 1.3.

The gonad index (GI) was calculated as follow:

$$GI = \frac{\text{Gonad weight (g)}}{\text{Body weight (g)}} \times 100$$

Subsequently, during January and February, the gonads developed rapidly to their maximum weight from 47 to 79 g. The gonad indices ranged 6.2 to 10.8, averaging 9.3.

Although the gonads weight and gonad indices reached their maximum at February, 1983, none had yet reached full maturity. By the end of March they had matured and it became possible to collect milt by pressing the body. At this time the gonads were smaller averaging from 24 to 55 g than the month before and the gonad indices ranged from 7.3 to 10.7 averaging 8.2 (Figure 6 and Table 3).

Table 3 Measurements of Ripening Fish

Date	Sample	Body Weight (g)		Gonad Weight (g)		Gonad Index	
		Aver.	Range	Aver.	Range	Aver.	Range
Male							
Oct. 31 1982	1	75	75	0.2	0.1	0.13	0.13
Nov. 25 1982	3	180 - 195	187	0.2	0.1 - 0.2	0.09	0.06 - 0.11
Dec. 23 1982	4	210 - 565	410	3.6	0.7 - 5.7	0.80	0.33 - 1.28
Jan. 27 1983	4	410 - 610	478	21.0	15.3 - 29.5	4.56	2.51 - 6.14
Feb. 25 1983	6	435 - 1.080	679	60.4	38.7 - 78.6	9.26	6.24 - 10.8
Mar. 28 1983	5	230 - 730	483	37.8	24.3 - 55.3	8.16	7.32 - 10.7
Female							
Oct. 31 1982	3	95 - 240	150	1.3	1.1 - 1.6	0.96	0.67 - 1.26
Nov. 25 1982	6	130 - 165	145	1.2	0.9 - 1.9	0.84	0.64 - 1.15
Dec. 23 1982	5	215 - 515	374	4.6	2.3 - 8.5	1.26	0.74 - 2.02
Jan. 27 1983	4	290 - 490	400	31.0	18.5 - 43.5	8.60	5.44 - 13.2
Feb. 25 1983	3	570 - 955	735	112.0	71.0 - 168.5	14.8	13.2 - 17.6
Mar. 28 1983	4	270 - 750	504	83.8	44.1 - 118.3	16.8	16.3 - 18.8
Apr. 4 1983	16	300 - 870	534	101.1	54.8 - 162.0	19.0	14.9 - 23.1

Female: The ovaries also remained undeveloped until the end of November, 1982, weighing 0.6 to 1.9 g and with the gonad indices ranging from 0.6 to 1.2. Then in December they began to develop. By the end of December they weighed 1.0 to 8.5 g with the gonad indices ranging from 0.6 to 2.0. Then, during the two months of January and February, 1983, they developed rapidly, reaching their maximum weight of 71 to 168 g. The gonad indices ranged from 13.2 to 17.6, averaging 14.8 but at this time the eggs had not yet ripened and retained the ovarian membrane.

One month later the ovaries reached full ripeness with the gonad indices ranging from 15.8 to 18.8, averaging 16.8 as shown in Figure 7 and Table 3. On the last spawning day of April 4, the gonads indices of 16 spawned females ranged from 14.9 to 23.1, averaging 19.0.

In the body weight range of 300 to 870 g, about 500 g body weight fish corresponded with a maximum gonad indices. Smaller fish and also bigger fish had lower gonad indices. With females, there was no difference in the weight of the ovaries at the end of February and March, 1983. During this time as the body weight decreased with maturation, the gonad indices increased relatively.

The Sex Ratio: By February and March of 1983, there were no immature males evident in the samples, although some females remained unripened (one out 4 or 5 per sample). The unripen ovaries weighed less than 4 g with the gonad indices of 0.6.

On March 30, 1983, all of the adults were transported from the sea pen to the fresh water pond. They were spawned on March 31, April 1 and April 4, 1983. During this time, 59 out of 540 adults remained silvery and unripened.

We have assumed that all the males were fully ripened and that 78 °/o of the females ripened 15 months (1 +) after swim up. The sex ratio estimated was 50.9 °/o male to 49.1 °/o females.

7. Record of Spawning (n = 16) April 4th.

	Aver. (females)	Standard Dev.	Range
Body weight (g)	534.4	145.9	300 – 870
Hardened eggs weight (g)	101.1	27.2	54.2 – 162
Number of eggs	707.3	157.7	415 – 960
Number of eggs in 5g	30.3	3.6	27 – 37
Number of eggs in 20 cm	32.0	1.1	29 – 33

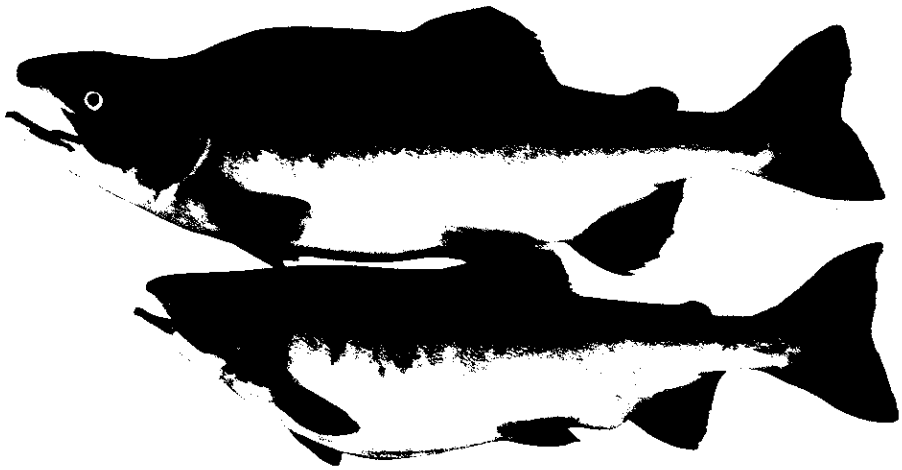
The fertilized eggs developed to the eyed stage on May 9, 1983, after accumulating 308 temperature (°C) units. Because of the inflow of mud into the incubator caused by unexpected heavy rains, some of the eggs were damaged. Although it was not possible to estimate the egg mortalities accurately, survival to the eyed stage appeared to be low (under 50 °/o). The alevins hatched out on July 5, 1983 (585 temperature units). When the alevins swimmed up August 10, 1983 (721 temperature units) the survival rate from eyed eggs was 74.7 °/o.

8. Circuli Formation on Scales

A scale sample taken from a 12-months old fish at the end of December, 1982 had 32 - 33 circuli. By the end of February, 1983, when it was 14-months old (one month before it attained full ripeness), there were 37 - 38 circuli (Plate 1 - C).

From the focus to the 14 - 15 circuli, bands of circuli are packed closely. Beyond that, the bands are widely spaced. This meant that the average rate for the deposition of circuli was about 2.7 per month. It was estimated that the compactly –spaced bands of circuli corresponded growth in fresh water and that the widely– spaced bands of circuli corresponded to rapid growth in saltwater.

A



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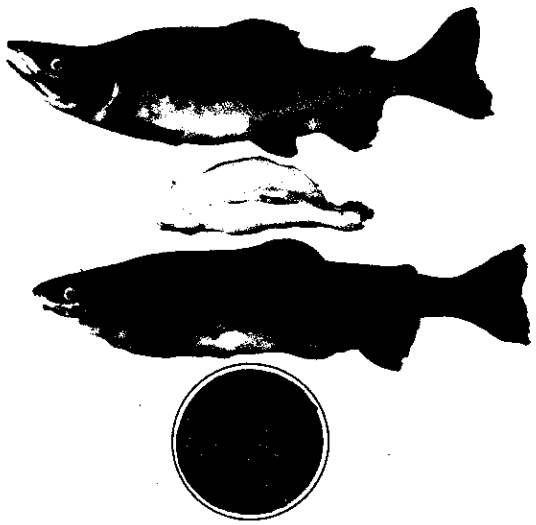

♂ F.L 39.7 cm.
B.W. 730 gr.
G.W 55.3 gr.

♀ F.L 40.8 cm.
B.W 750 gr.
G.W 118.3 gr.

GJ-81
28 Mar. 1983
Ensenada Baja

C

Explanation of Plate 1: Pen cultured pink salmon.

A. Matured male (above) and female (below). B. Matured fish and their gonads.

C. The scale of 14 month male, 475g body weight, 32.5cm fork length, Feb. 25 1983.

It is winter in Chile from June to August, and there was no deposition of annuals rings on the scales of the cultured fish during these months.

9. Water Temperature and Salinity

The average temperature of the surface water reached it's minimum of 4.1 °C in June, then gradually increased to it's maximum of 18.2 °C in January, the average temperature through out the year was 10.7 °C. Each days temperature varied from 2.0 °C to 20.2 °C. The appetites of the pink salmon did not change by these low and high temperatures.

Surface salinity varied from 12 to 31 o/oo in the winter (from June to August) then began to decline with the onset of spring in September. Thereafter, at depth of Om and 3m the salinity stayed almost between 0 to 7 o/oo until May. At a depth of 5m the salinity stayed over 20 o/oo until November (Figure 10).

DISCUSSION

Pink salmon fingerlings weighing from 8.0 to 46 g, grew at a daily rate of 1.91 to 2.15 °/o while the water temperature fluctuated from 3 to 8 °C.

The transfer of pink salmon fingerlings from fresh water to sea water of 20 to 30 o/oo salinity seemed to stimulate their growth. The pink salmon seemed to be able to maintain their growth at low water temperatures. In brackish water, at temperatures between 3 and 4 °C, pink salmon fingerlings of 8 g average body weight were able to maintain their appetites and rates of growth. At this weight the feeding rate was 3.6 °/o and the daily growth rate was 1.91 °/o. From Puchi and Shimazu (1983 unpublished), chum fingerlings weighing an average of 2 g and subjected to the same conditions, had less appetite and grew more slowly. The feeding rates of the chums were 1.5 - 1.8 °/o and their daily growth rates were 1.04 - 1.29 °/o.

After the pink salmon reached a weight of 50 g, the growth rate began to decline, but some months later, prior to the beginning of gonad develpment, high rates of growth measured by body weight, fork length and body depth were again achieved. This trend is similar to that reported by Nomura (1963) for rainbow trout, in which the growth fluctuated in response to their reproductive cycles. In the following months, the growth rates of the pink salmon again declined sharply. In January and February, 1983, the growth rates declined to 0.87 - 1.08 °/o per day, half that of the previous month.

At this stage, the fish began to swim more slowly and to show poorer appetite than before. The skin changed from silvery to greenish brown in color and humps began to appear on the backs of the males.

In March, 1983, the water temperature remained between 16.5 to 10.8 °C. The appetite of the fish continued to decline and there was some loss of body weight. The average

condition factor fell from 15.5 to 12.7 (Table 2). The ratio of body weight to fork length also fell (Figure 13).

Since the fish grew until their gonads started to develop (about the time of summer solstice when water temperature approach the annual maximum), it would seem that fish culturists desiring to produce large adults within a single year, must take special care during the early stages of growth when rearing pink salmon in the Southern Hemisphere.

By the end February the fish had grown to their maximum size. The average body weight was 660 g and the average fork length 34.7 cm. Comparing these sizes with the sizes of adult pink salmon in Hokkaido (Sano and Kobayashi 1953), the average body weight of the fish reared in Esnenada Baja was 59 °/o lighter and the average fork length was 32 °/o shorter than these in Hokkaido.

Terao et al (1973) reported thet pink salmon reared in sea pens grew from 39.3 g to 560 g average body weight over a period of 263 days. In Ensenada Baja they grew from 8.0 g to 660 g for 237 days. In Terao's study, the salinity ranged from 29 to 37 o/oo. In Ensenada Baja, it ranged from 0 to 31.6 o/oo. The minimum water temperatures were 3.3 °C in the former and 2.0 °C in the latter. Brett, J.R. (1974) determined that pink salmon reared in a tank for 270 to 280 days grew from 3 g to 230 g at a water temperature of 15 °C and a salinity of 28 o/oo. In Ensenada Baja, a similar growth rate was observed over a period of 210 days at water temperatures ranging from 2°C to 17.5 °C, and at salinities ranging from 0 o/oo to 31.6 o/oo.

The ratio of body depth to fork length increased steadilly until December. During January there was a marked increase (Figure 17), that corresponded with the appearance of humps on the backs of the adults.

Ota (1965) and Kato (1975) reported that with rainbow trout, the gonad indices of male fish reached a maximum two or three months before maturation. With the pink salmon that we observed, the maximum value for the gonad indices occurred only month bofore maturation. During the interval from the summer solstice to the autumnal equinox, the gonads grew to their maximum weight in the first two months and by the third month became fully ripe.

At Ensenada Baja, the penned pink salmon were spawned from March 31 to April 4, 1983. Eggs from the parent stock in Japan had been taken on September 22, 1981. The time of spawning in Chile was about six months sooner than had been in Japan. From Uchihashi et al. (1979), chinook salmon in New Zealand spawn from the beginning of April until the end of May.

Terao et al. (1973) reported that with pink salmon reared in sea pens, eggs could been taken from 500 g females and milt from 130 g males. The number of eggs from such females averaged 633. In case of our pink salmon at Ensenada Baja, the minimum size for ripe females was 270 g. The smallest ripe male weighed 170 g. The average egg count for the female was 707.

Nomura (1963) reported that rainbow trout, the larger fish the larger the relative

weight of the ovary. Pink salmon also showed the same tendency. However, some of the 500 g females produced much than the average number of eggs. Threfore, the coefficient of correlation was not high (Figure 8).

Sano and Kobayashi (1953) reported that, on the scales of pink salmon caught along the Okhotsk Sea coast (the source of the pink salmon eggs shipped to Chile), there were 22.2 circuli on the average. In Ensenada Baja, the scales of 12-months old fish had 32 - 33 circuli by the end of December. This corresponds to the number of circuli on the scales of 2-years-at-sea pink salmon caught in the Gulf of Alaska in April reported by Bilton and Ludwing (1966).

CONCLUSIONS

From our experience with pink salmon eggs shipped from Japan, incubated in Chile and reared in a floating net pen in the brackish water of a fjord, we observed that:

(1) The fish adapted well to their new circumstances, grew at a rapid rate and matured early.

(2) In the brackish water the growth of the fish was comparable to that reported for fish cultured in full-strength sea water.

(3) The pink fingerlings adapted to low water temperatures better than chum fingerlings.

(4) Sharp change in form, behavior and growth rate were observed in the fish in the sea pen at Ensenada Baja as soon as the gonads began to develop.

From these observations, we have drawn the following conclusions:

(1) The fact that most of the males and approximately 80 % of the females reached full ripeness at the age of 1 year (15 months after swim-up and one half year sooner than normal), was probably caused by the transport of the eggs from the Northern to the Southern Hemisphere where the seasons are reversed.

(2) Since they matured early, the adult fish in the cages at Ensenada Baja were 32 % shorter in average fork length than these of the parent stock in Japan. By improving the conditions of early culture and by transferring the fingerlings to sea pens at a body weight of 1 g, it should be posible to produce larger adults and more eggs in the future.

(3) By retaining brood stock in sea pens it should be possible to provide a source of eggs sperm for producing pink salmon satisfactory adapted to the Southern Hemisphere.

(4) Further studies are needed to determine the reason why small, 500 g females produced much more than usual number of eggs. For observing the maturation of the fish which do not mature the first year, the study should be repeated with much more fish over a longer period.

(5) Since the eggs were incubated when water temperatures were high during the summer, hatch-out and swim-up were accerated and feeding was started in January, three months earlier than for fish reared in Japan. The number of circuli on the scales of first year pinks in Ensenada Baja was muchs greater than for fish reared in the Northern Hemisphere.
The lack of a winter band on the scales of the fish reared in Ensenada Baja was due to the fish maintained a good appetite and were regularly fed.

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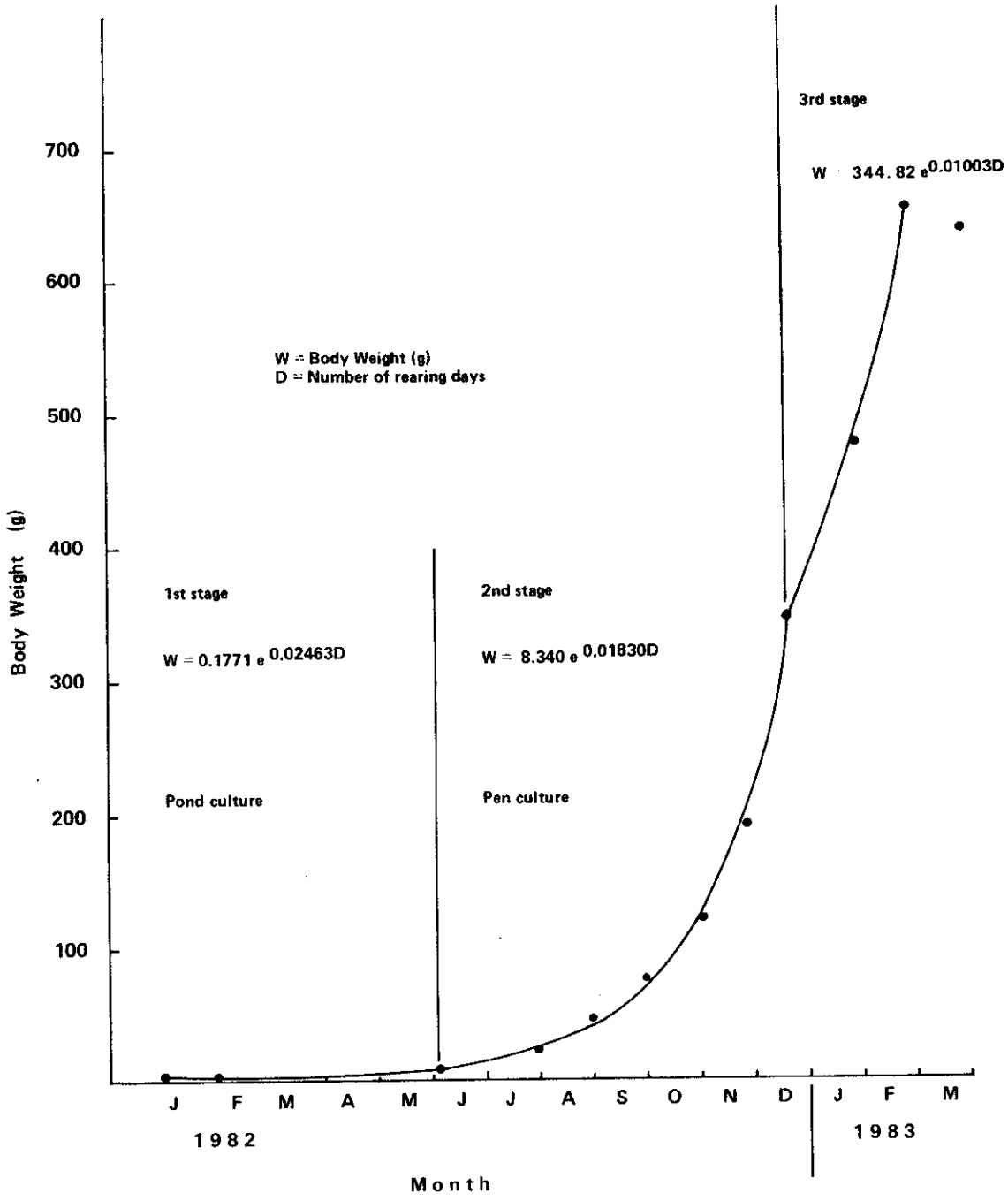

Figure 2. Growth of Cultured Pink Salmon Expressed as Body Weight.

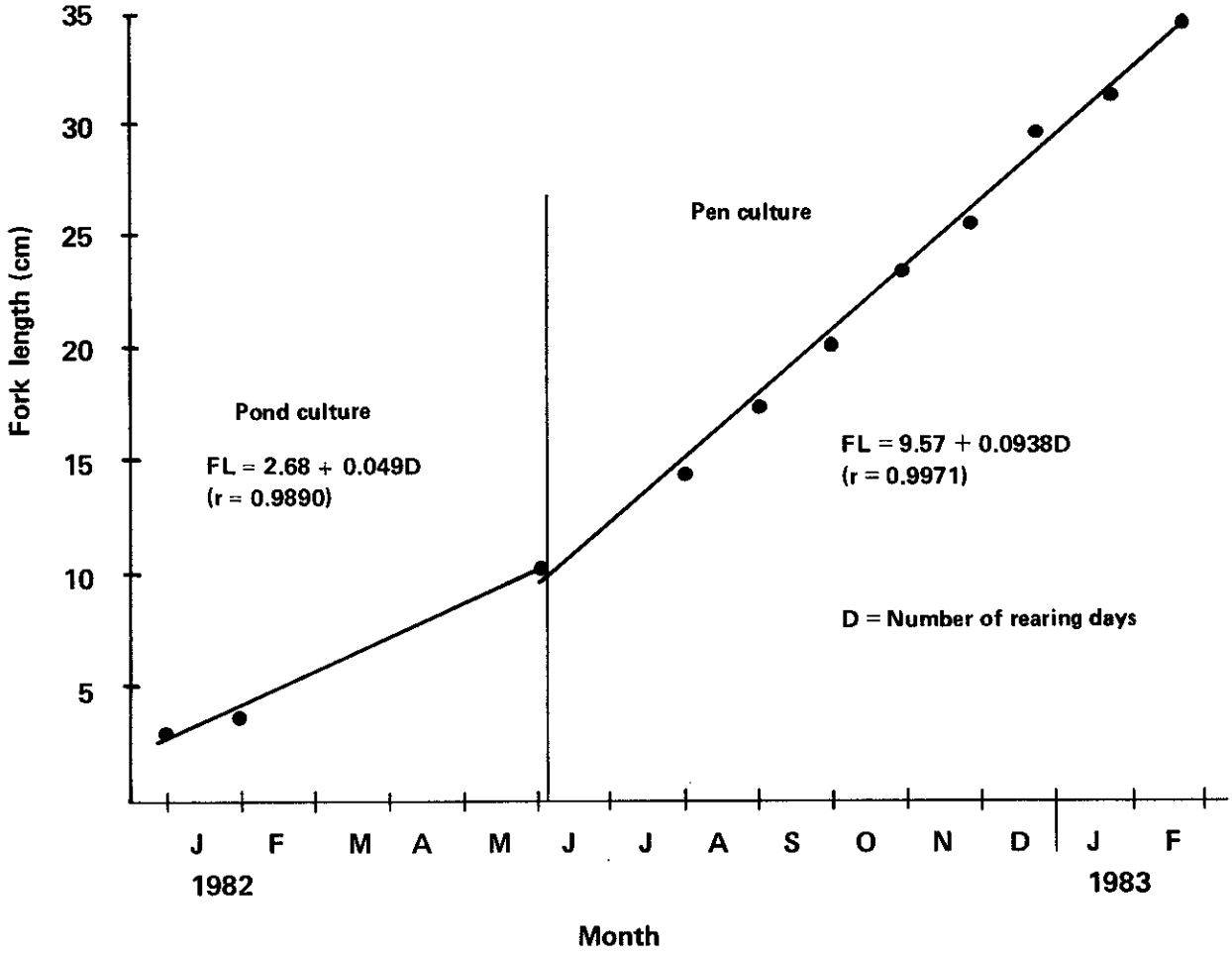

Figure 3. Growth in Fork Lenght of Cultured Pink Salmon.

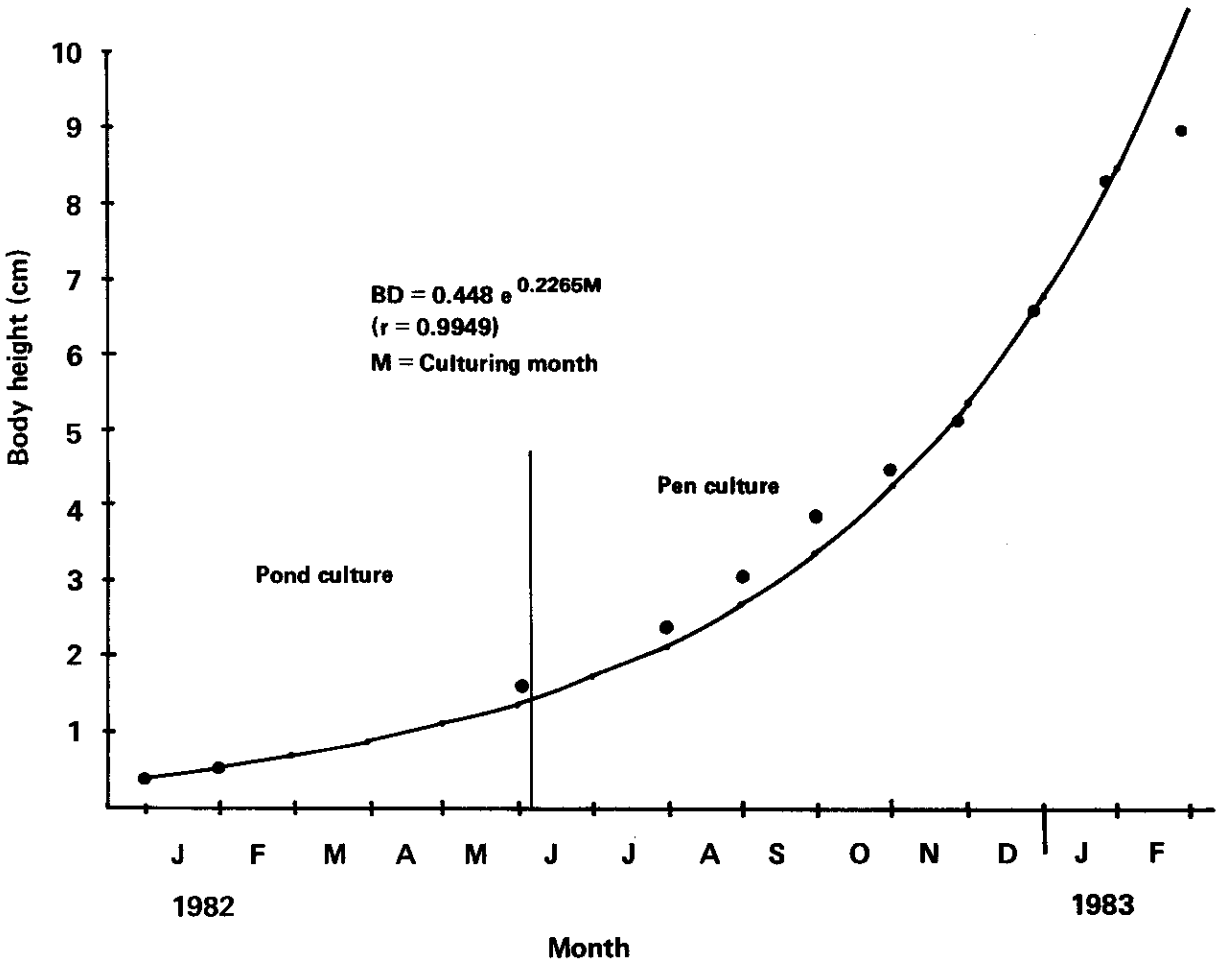

Figure 4. Growth of Cultured Pink Salmon Expressed as Body Depth.

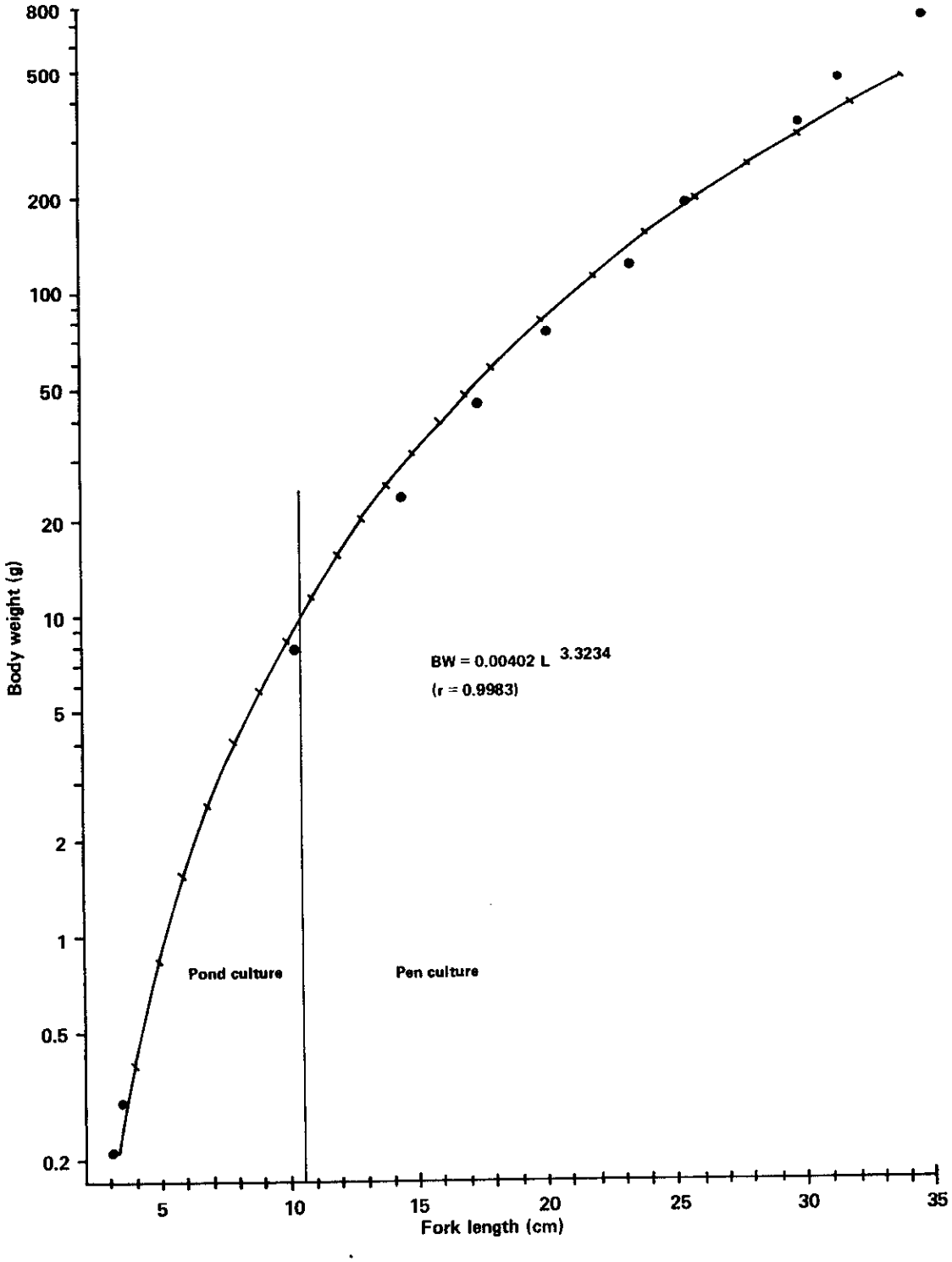

Figure 5. Relationship Between Fork Lenght and Body Weight of Cultured Pink Salmon.

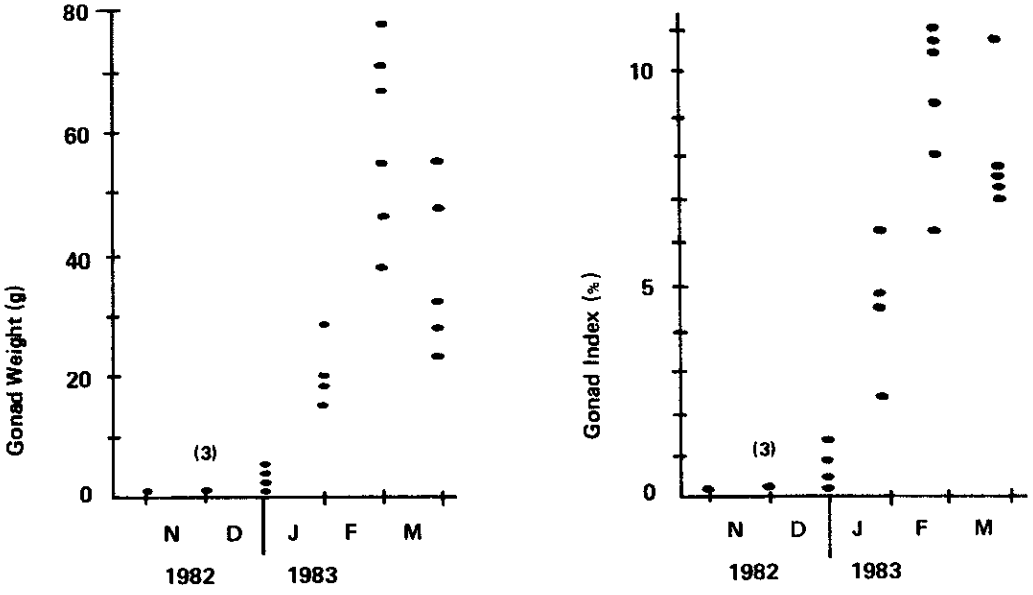

Figure 6. Monthly Change of Gonads Weight and Indices of Cultured Pink Salmon. Males.

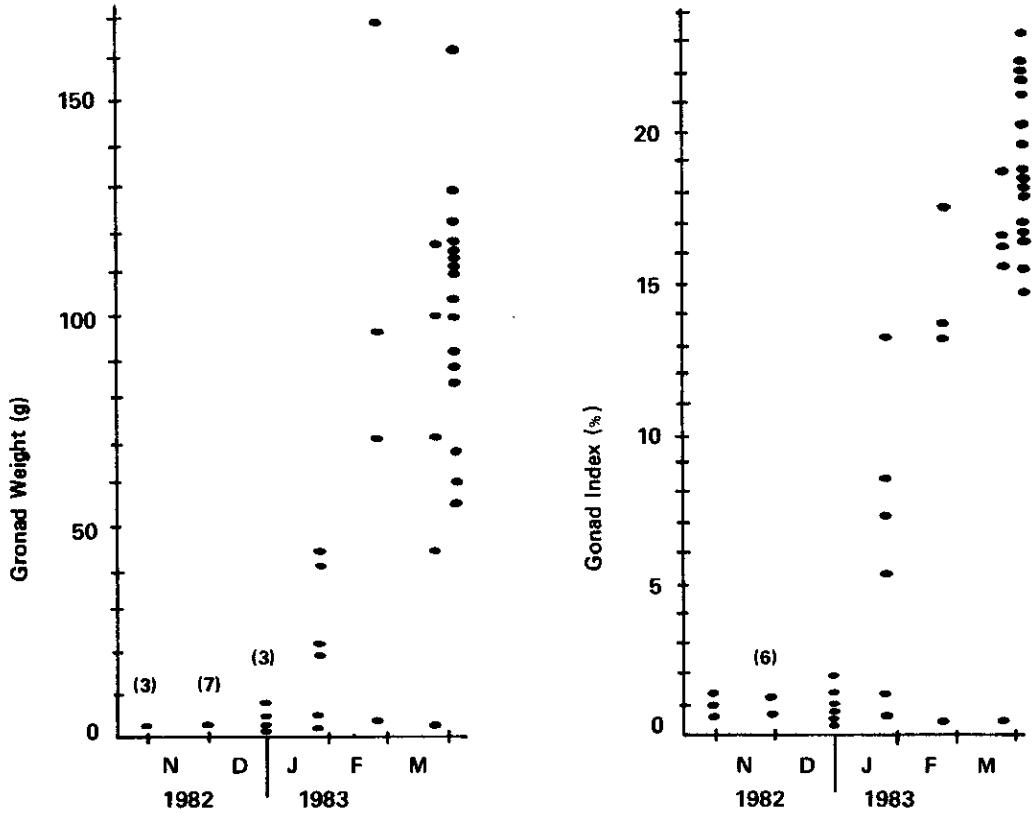

Figure 7. Monthly Change of Gonads Weight and Indices of Cultured Pink Salmon. Females.

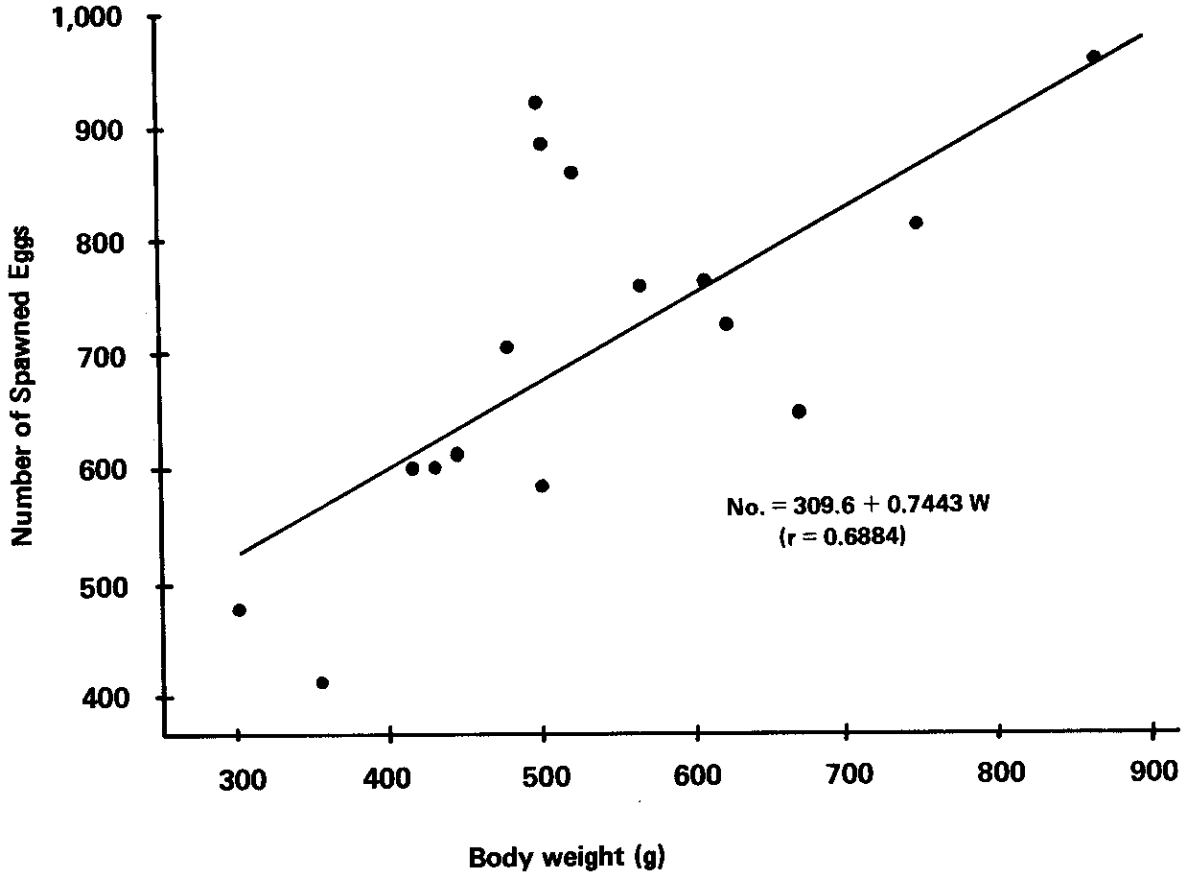

Figure 8. Relationship Between the Number of Sapawned Eggs and Body Weight of Cultured Pink Salmon.

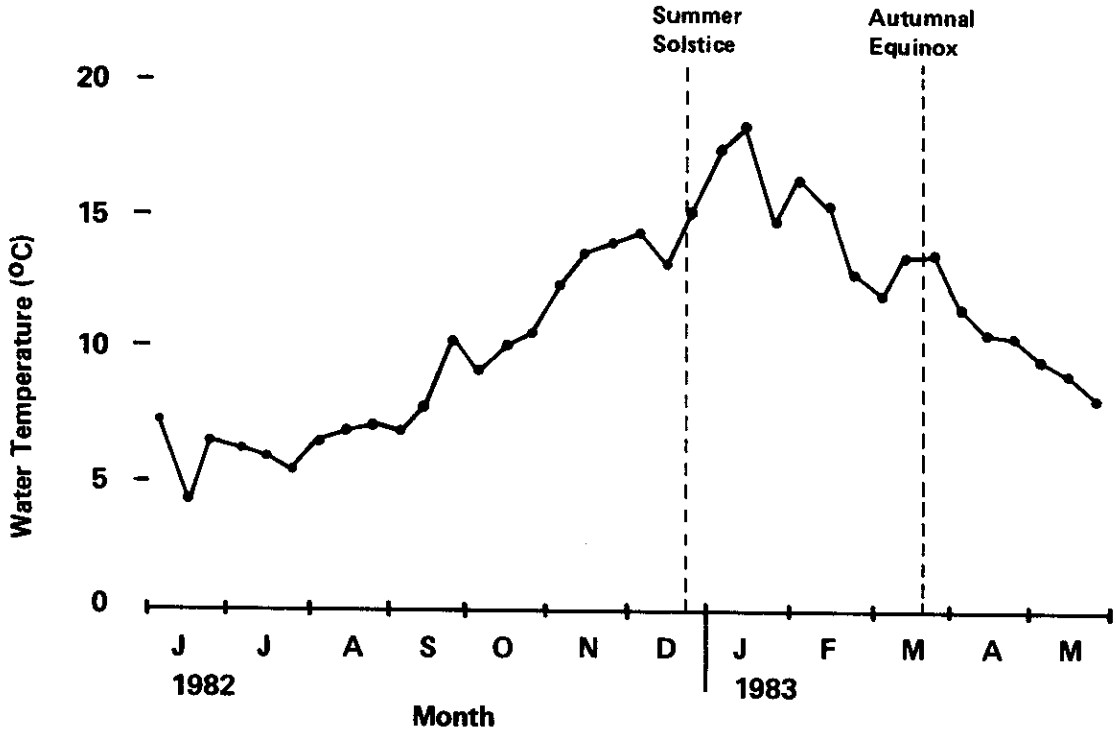

Figure 9. The Fluctuation of Average Water Temp. in Ensenada Baja

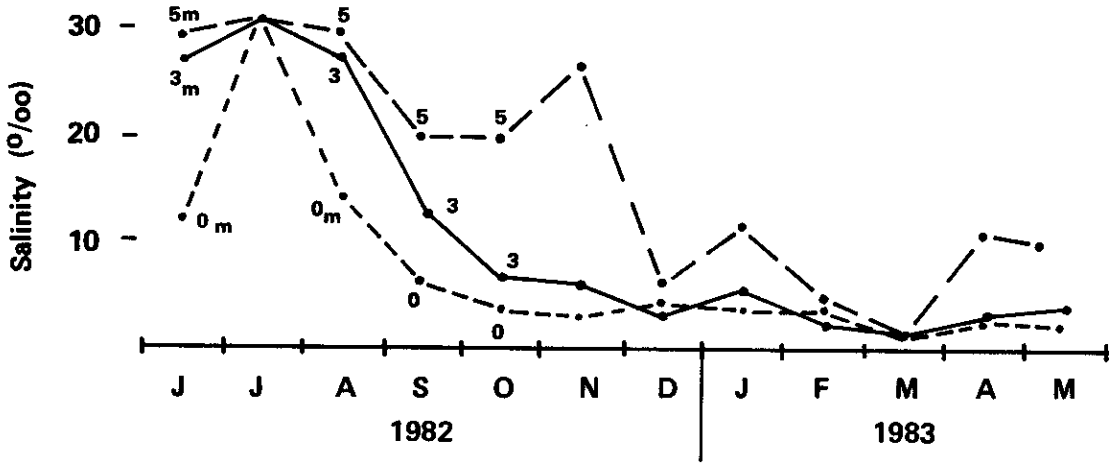

Figure 10. The Fluctuation of Salinity in Ensenada Baja

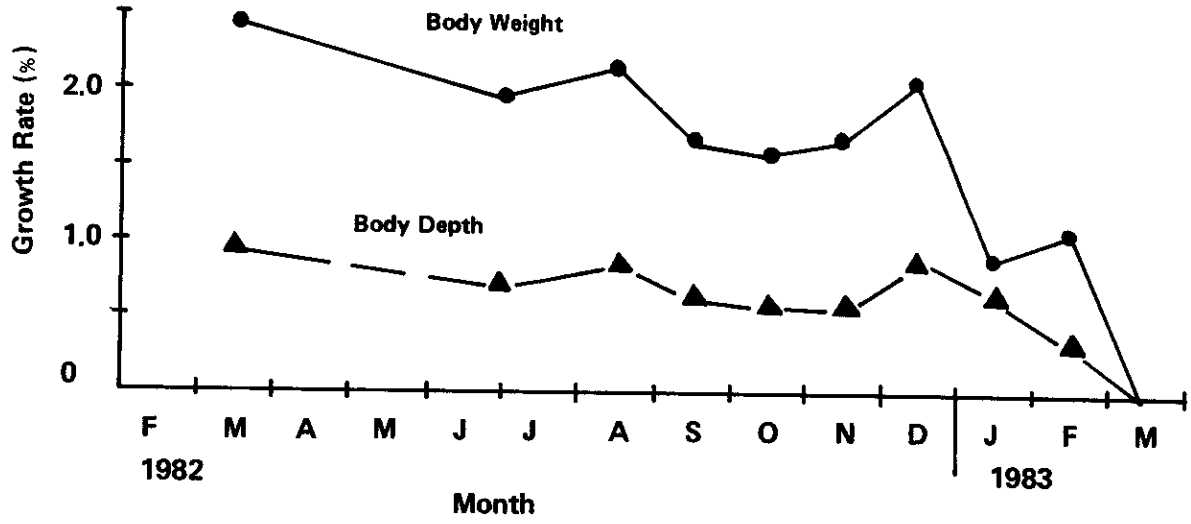

Figure 11. Daily Growth Rate Expressed as Body Weight and Body Depth of Cultured Pink Salmon.

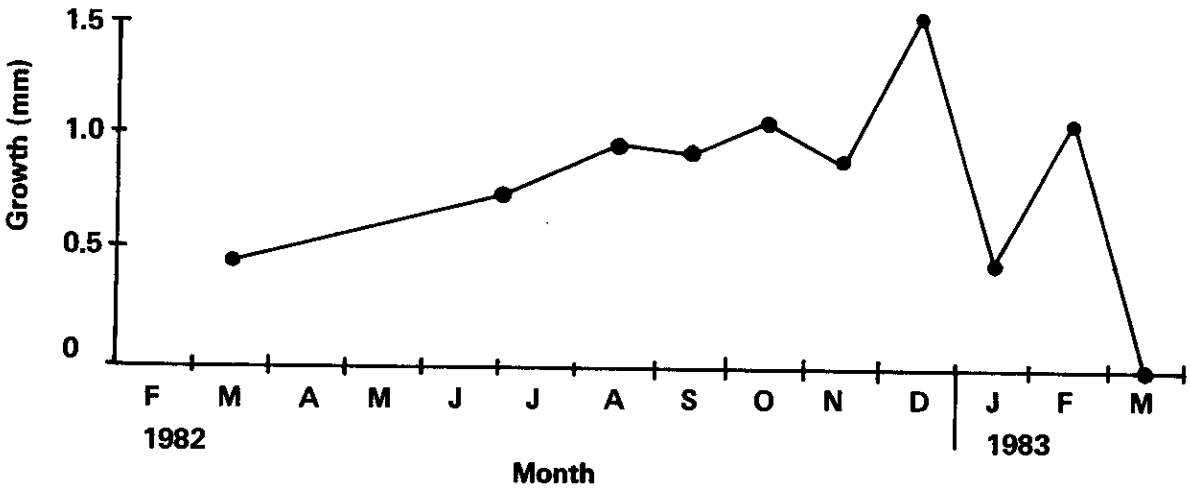

Figure 12. Daily Growth in Fork Length of Cultured Pink Salmon.

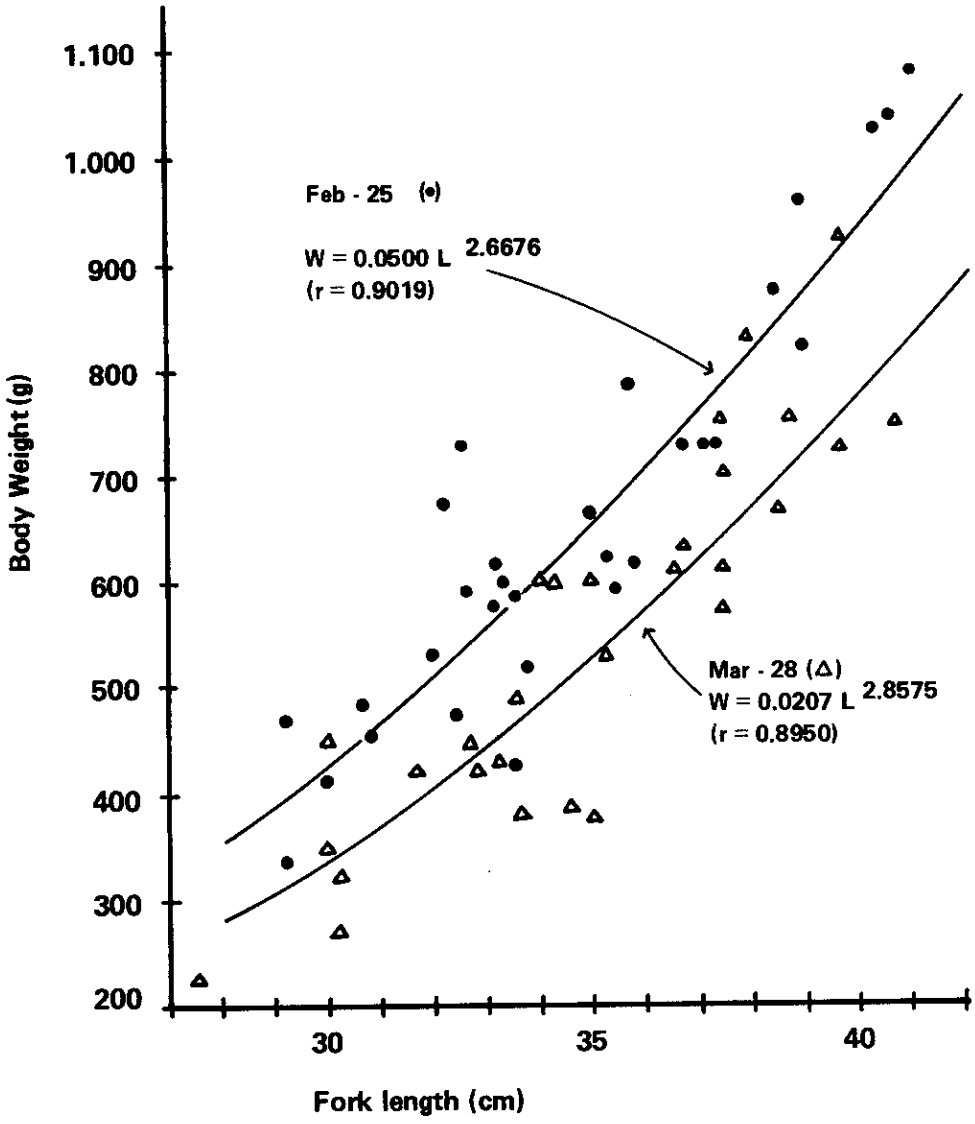

Figure 13. Relationship Between Fork Lenght and Body Weight in Ripening Fish (Feb. 25) and Fully Ripe Fish (Mar. 28)

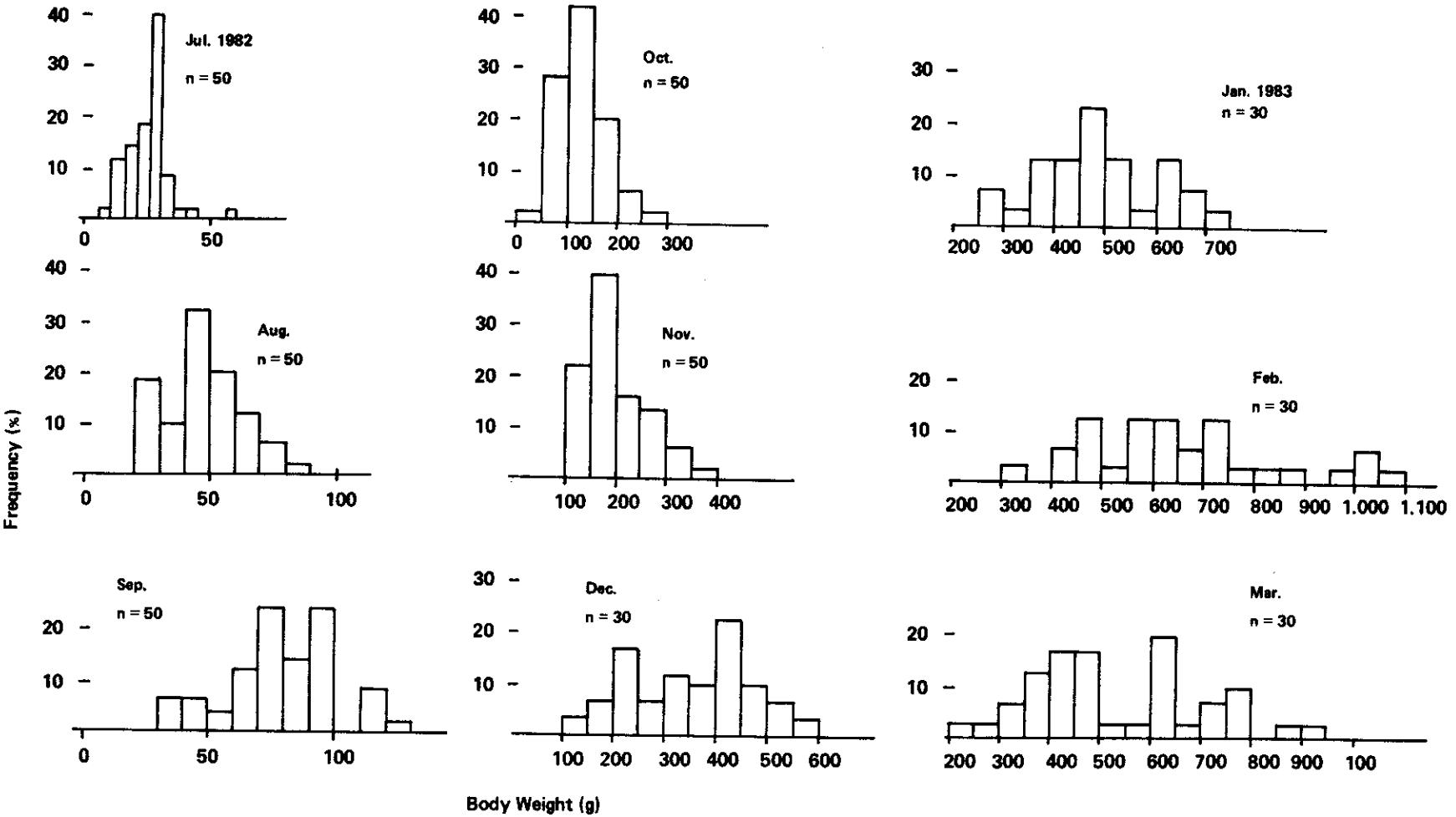

Figure 14. Frequency Distribution of Body Weight.

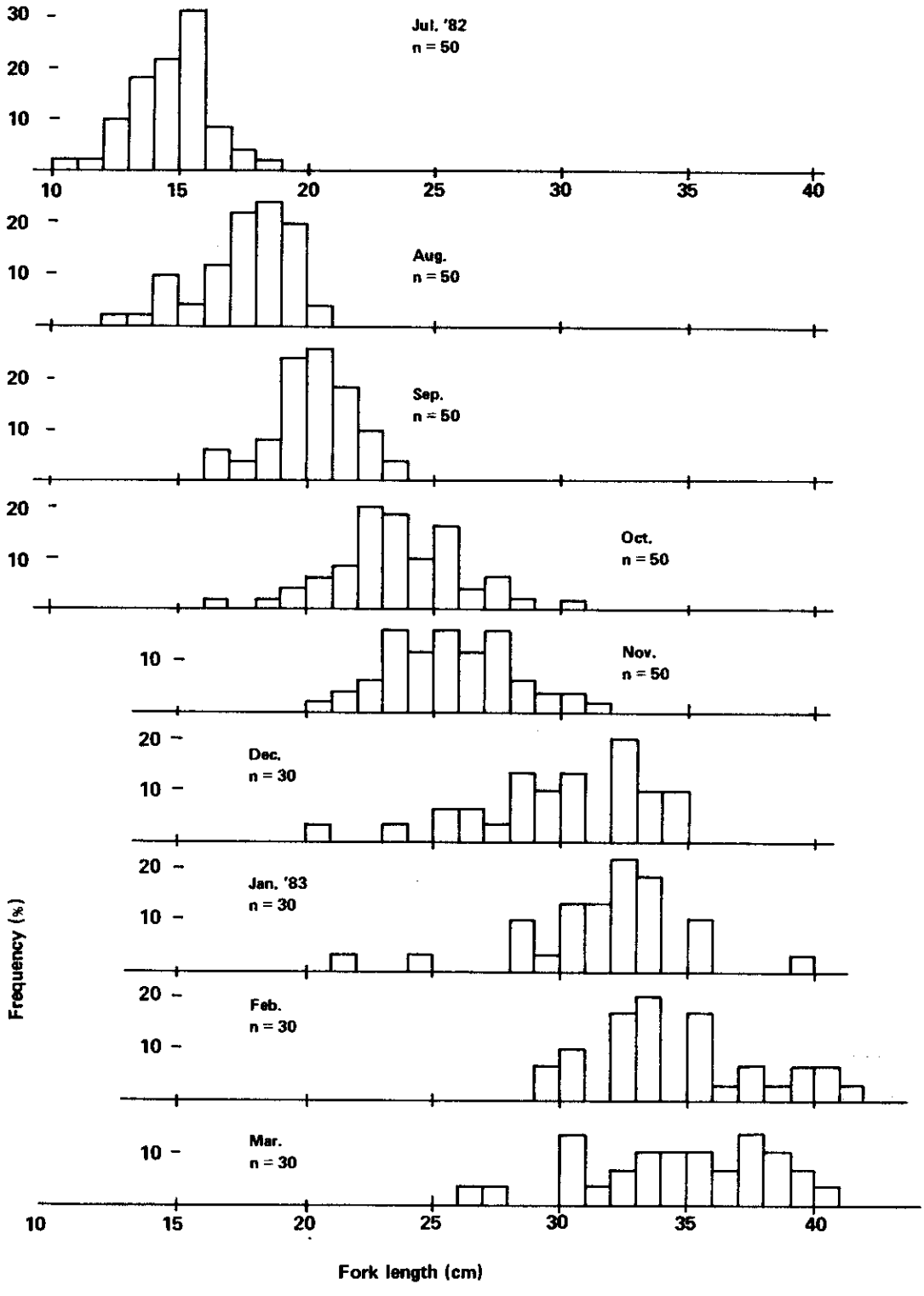

Figure 15. Frequency Distribution of Fork Lenght.

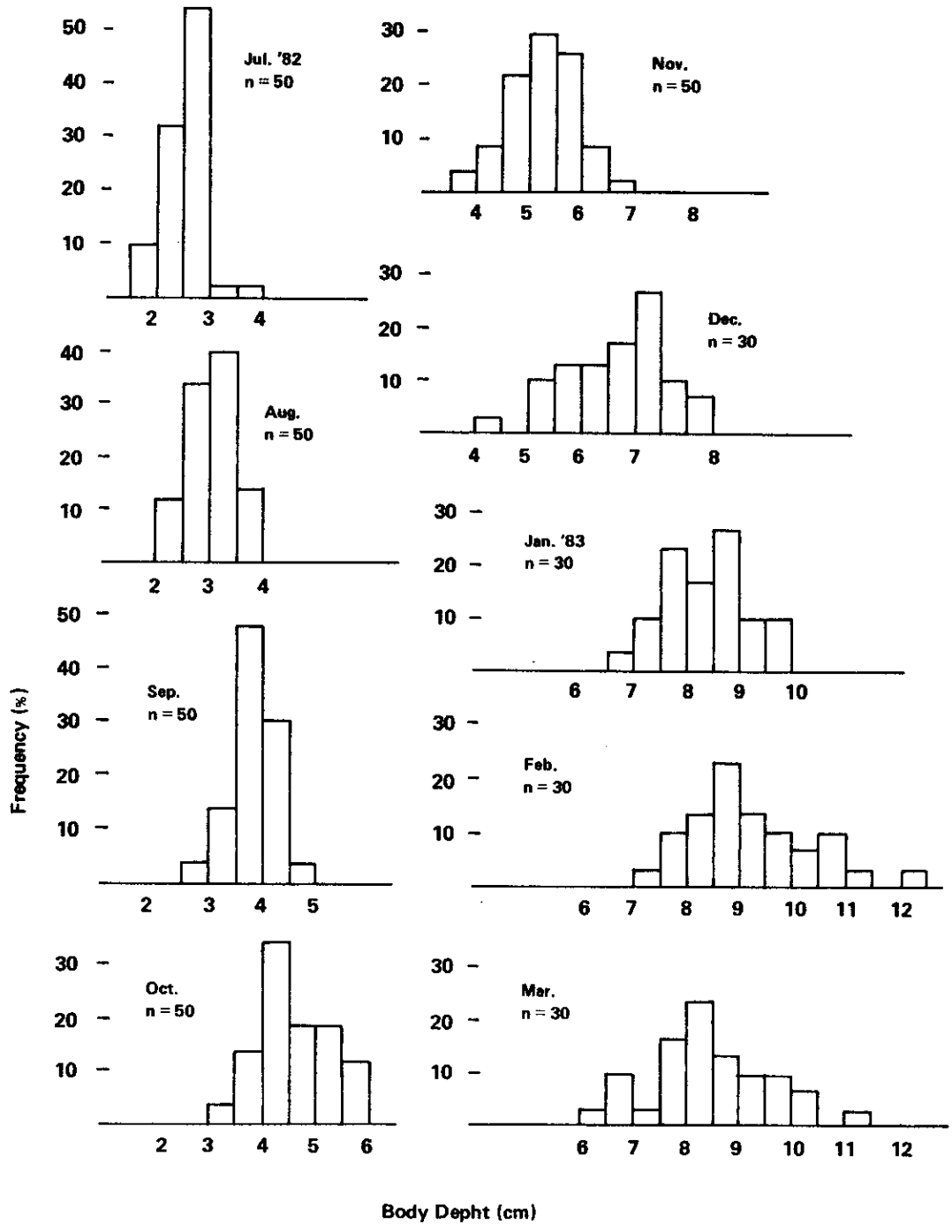

Figure 16. Frequency Distribution of Body Depth.

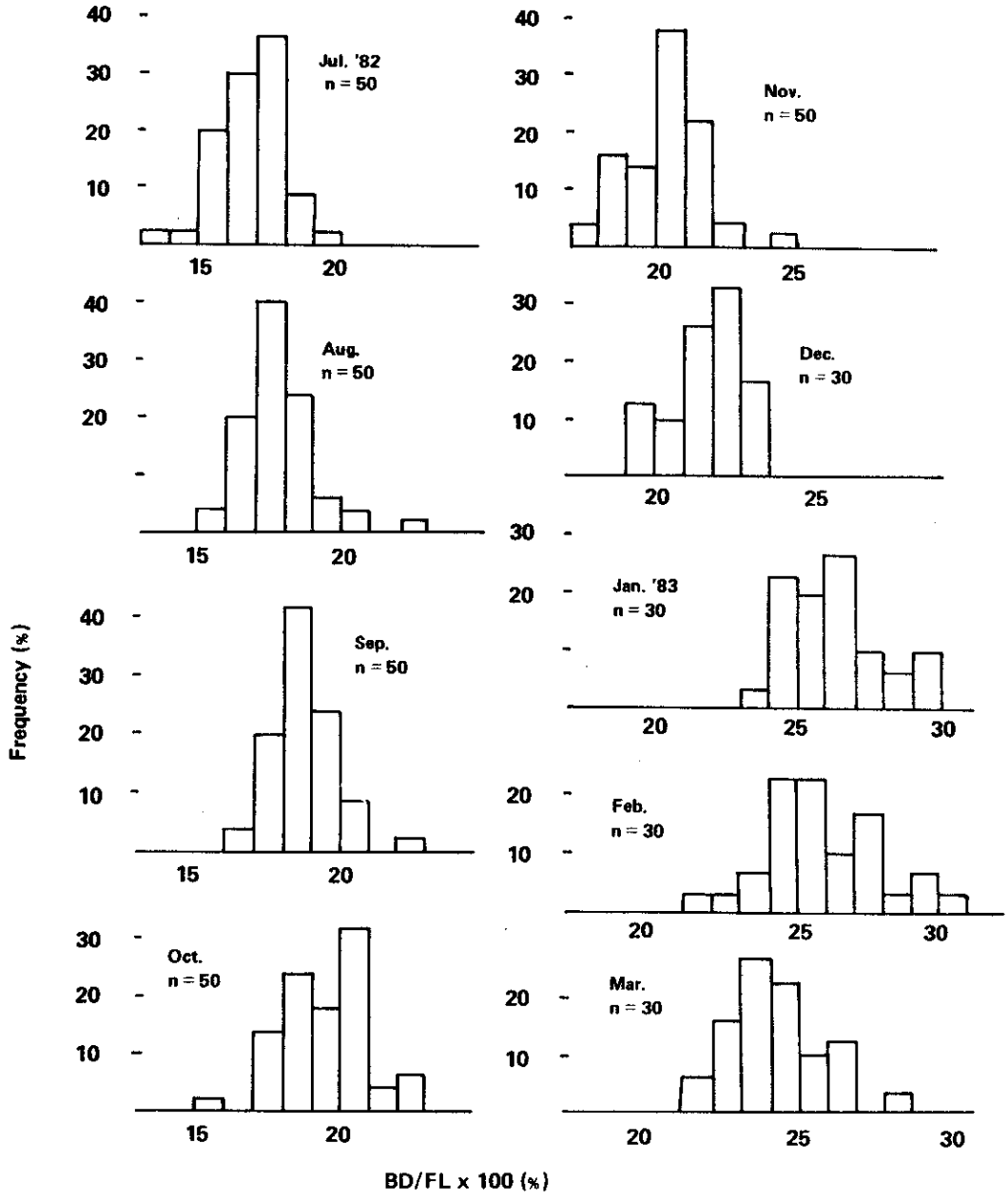

Figure 17. Frequency Distribution of BD/FL.