Study of body and scale growth of young coho salmon, *Oncorhynchus kisutch* (WALBAUM), in hatchery

Mamoru KATO*

Abstract

Growth of body and scale, and time of check formation were studied by using young coho salmon in hatchery of Northwest Fisheries Center, Seattle, Washington, U. S. A.

In the experiment (A), fork length and body weight were increased from summer to fall when the water temperature decreased from 14.4℃ to 10.0℃. Then they ceased to increase in November when the temperature was 10.0℃, while they began to increase in February under the temperature of 5.6℃. In the experiment (B), they were increased from March to June, then nearly ceased in July and again rapidly increased in August when the temperature rose from 7.8℃ to 14.4℃ from March to May and remained 14.4℃ from June to August.

Body growth was much related to variations of fish metabolism as same as scale growth. But there was time lag between cessation of body growth and that of scale growth. Cessation of scale growth preceded that of body growth.

Three kinds of checks were found in scales of young coho salmon for a year. The first check was formed of 22% of fish around April, the second one was formed of 90% of fish in June and July and the third one was formed of 97% of fish in October and November. The former two checks were false age mark and the latter one was true age mark. Checks were formed when growth of scale characteristics varied with variation of fish metabolism. Check formation preceded cessation of body growth; when checks were formed, body growth was still rapid.

The difference between the present result of age determination and that of other reports seems to be bigger than that depending on variations among years and local groups. It is thought that the difference is sizably caused by reading of false age mark.

Introduction

Japan Science and Technology Agency sent the author to Northwest Fisheries Center, National Marine Fisheries Service in Seattle, Washington, U. S. A. to study the fresh water life of Pacific salmon from September 1974 to August 1975.

The initial purpose of the study was to compare hatchery salmon growth with natural growth, but owing to the difficulty in obtaining natural fry, the study was almost entirely confined to hatchery fish.

It is well known that the growth of fish depends on water temperature, food amount, light, space and crowding (BRETT *et al.*, 1969; BILTON and ROBINS, 1971a, 1971b, 1971c; SWIFT, 1955). The growth of scale is also related to these factors through the growth of fish

Received August 24, 1977. Contribution No. 160 from the Far Seas Fisheries Research Laboratory.
* Far Seas Fisheries Research Laboratory

body (BILTON and ROBINS, 1971a, 1971b, 1971c; MAJOR and CRADDOCK, 1962; BILTON, 1973).

An experiment using young coho salmon, *Oncorhynchus kisutch* (WALBAUM), reared in hatchery was carried out to know growth of fish body and scale, and time of check formation in relation to water temperature and food amount. In this report the relation between water temperature and body growth (expressed by fork length and body weight), growth of scale (number of circuli and scale radius), and time of check formation are presented.

"Checks" formed by closely spaced circuli occur at various times of the year as a result of many factors. "Age mark" is one of them and breaks out in winter. It has more extend range from fall to spring. Checks other than age mark are called "false age mark".

I. Materials and methods

Rearing experiment (A) was carried out from mid-September 1974 to late April 1975. The coho salmon used in this experiment were spawned in November 1973 and hatched out in February 1974 in incubators of Northwest Fisheries Center. They were held in a 6 meter diam circular holding tank located outdoors from March to June. On June 10 of 3,000 fish were transferred to a 1.5 meter diam circular holding tank that was also located outdoors. Rearing experiment (B) was conducted from early March to mid-August 1975. The coho salmon were spawned in November 1974 and hatched out in February 1975 in the same place as the experiment (A). They were also held in 6 meter diam circular tank located outdoors from March to May. In late May about 3,000 fish were transferred to 1.5 meter diam circular tank located outdoors. In both experiments, water temperature was controlled not to exceed 14.4℃ in summer. But otherwise the temperature was allowed to fluctuate as did the water source. The fish were fed 5 days a week and the amount of food was 2% of body weight per day in the experiment (A) and from June to August in the experiment (B), 6% from March to April and 4% in May in the experiment (B). Oregon moist pellets were used as food.

Measurements were made every 10 days (there were small fluctuation from 8 to 11 days) on 20 to 36 fish. The fish were anaesthetized with M. S. 222, then measured their fork length and body weight, taken scale samples, and returned to the tank.

Scales sampled were preserved in slide glasses and examined by microprojector. Scale image were enlarged to 100× and measured along the longest scale axis from the center of nucleus to the edge. The narrowly spaced circuli of the check preceding more widely spaced first circulus is reffered to here as check circulus. Measurements carried out in each scale were as follows:

1. Number of checks
2. Number of circuli from nucleus to edge
3. Number of circuli from nucleus to checks
4. Scale radius from nucleus to edge
5. Scale radius from nucleus to checks

As other materials, Mr. R. MAJOR, Northwest Fisheries Center, permitted the author to use the body length and weight records, and scale samples of smolt coho salmon caught in Yakima River, Washington, 1959 to 1963. In addition, Washington State Fish and Game Department gave the author scale samples of adult coho salmon caught in the Pacific Ocean faced to Washington State, 1965 to 1966. These scale samples were measured by the same manner mentioned above.

II. Experiment (A)

1. Body growth and water temperature

Range of water temperature

The fluctuation of water temperature during the experiment was associated with changes in the air temperature that occurred through the seasons of fall, winter and spring. Water temperature decreased from 14.4℃ to 5.6℃ from mid-September to early January and then remained at about 5.6℃ until late February. From early March to late April when the experiment ended, it rose from 6.1℃ to 11.1℃ (Fig. 1).

Growth in fork length

Increases in fork length were rather rapid in fall, slow in winter, and greatest in spring. The fork length increased from 82 to 102 mm from mid-September to mid-January, and from 105 to 127 mm from last January to late April. At the time of near cessation of growth in late November, the water temperature was 10.0℃, while in early February when growth be-

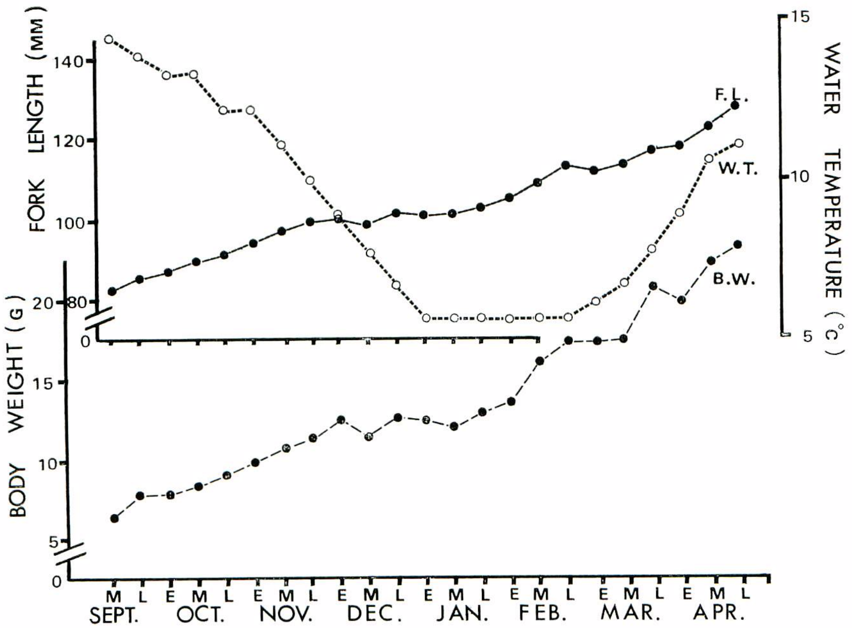

Fig. 1. Growth of fork length and body weight of rearing coho salmon and water temperature in the experiment (A).

gan to be rapid it was 5.6℃. Thus the increase in fork length showed a very low level at a relatively high water temperature (10.0℃) whereas the increase in growth rate starting in late winter began at a much lower water temperature (5.6℃) (Fig. 1).

Growth in body weight

Increases in body weight following much the same pattern as those in fork length. Body weight increased from 6.3 to 12.3 g from mid-September to early December, then remained at about the same level until late January. The body weight began to increase again in early February and reached 23.3 g by late April (Fig. 1).

2. Growth of scale

The growth of scales was studied in regard to the two scale characteristics: number of circuli and scale radius. Their growth rates varied by season. The author divided the growth of scales into six periods (I–VI) based on the variation of the growth rates (Table 1). Variations of average number of circuli (N), average scale radius (R) and their daily growth ration in each period are as follows:

In regard to increases in number of circuli, it was rapid from 17.7 to 19.6 from mid-September to late October, very rapid from 19.6 to 24 from late October to late November, then very slow from 24 to 24.8 from late November to late December, and again rapid from 24.8 to 30.8 from late December to late April (Fig. 2). The daily increment of number of circuli was low from late November to mid-December (0.027) and late January to early March (0.032) and high (0.147) from late October to mid-November. It was intermadiate in other periods ranging from 0.040 to 0.048. It was by far the greatest in October and November which corresponds to the period when most of checks were formed.

In regard to elongation of scale radius, it was rapid from 0.38 to 0.42 mm from mid-September to late October, then slow from 0.42 to 0.46 mm from late October to late December, and very rapid from 0.48 to 0.67 mm from early January to late April (Fig. 2). The daily elongation of scale radius also varied by season. It was rather similar to the periods I, IV, V and VI ranging from 0.0010 to 0.0018 mm. It was much slower in periods II (0.0006 mm) and III (0.0006 mm) (Table 1).

Table 1. Scale growth of rearing coho salmon in the exeriment (A).

	I	II	III	IV	V	VI
	Middle September ~	Late October ~	Late November ~	Late December ~	Late January ~	Middle March ~ Late April
Growth of scale radius	mm 0.04	mm 0.02	mm 0.02	mm 0.04	mm 0.06	mm 0.09
Scale radius/Day	0.0010	0.0006	0.0006	0.0013	0.0012	0.0023
Increase of number of circuli	1.9	4.4	0.8	1.2	1.6	2.4
Number of circuli/Day	0.048	0.147	0.027	0.040	0.032	0.048
Distance between circuli	0.021	0.005	0.025	0.033	0.038	0.038

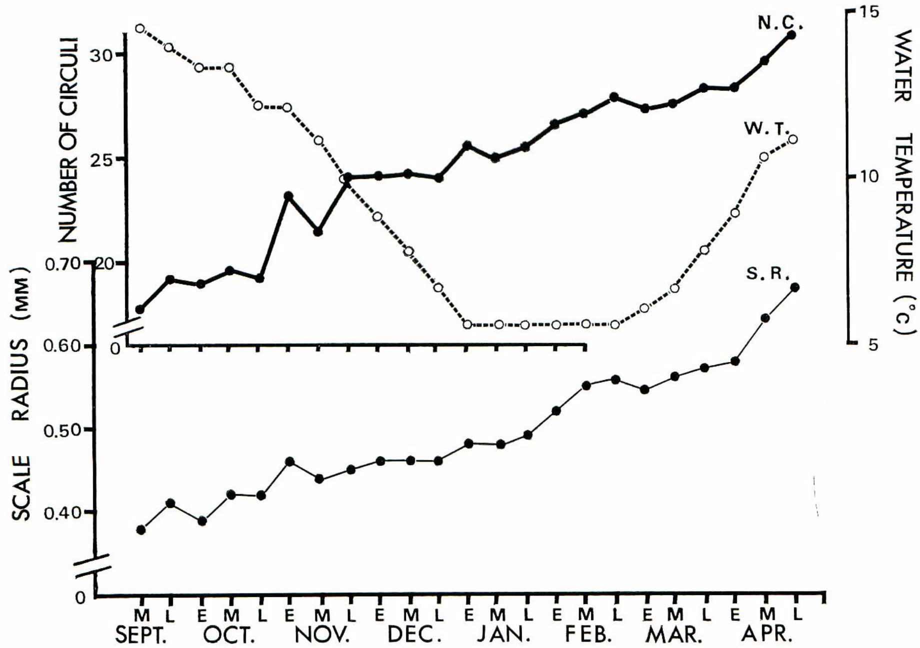

Fig. 2. Growth of number of circuli and scale radius of rearing coho salmon and water temperature in the experiment (A).

Also shown in Table 1 is the distance between circuli in each of the growth periods. The distance between circuli was increased much slower in the period II than in other periods which indicates that the formation of the checks was most successful in this period.

The relation of growth rate between N and R is almost paralleled through all the periods except the period II. R/N is caluculated to show distances between circuli in Table 1. Comparing the values of R/N for the periods I–III, II is less than one-fourth to I and III. From this fact it can be known that the checks were formed in the period II.

The relation of growth rate between number of circuli and scale radius was not always parallel through the experiment.

3. Time of check formation

At the begining of the experiment in mid-September, many fish had already formed two checks: the first check (A_1) was formed at 5.9 circuli on average from nucleus, ranging from 4 to 9, and the second check (A_2) was formed at 14.8 circuli, ranging from 11 to 19. A_1 occurred in about 22% of fish, on the contrary A_2 did in about 90% of fish. It was estimated by back caluculation based on elongation of scale radius that A_1 was formed around April and A_2 was formed from June to July.

In late September, the third check (A_3) commenced to be formed in 10% of fish. By late October 35% of fish had A_3 and by early November 75% of fish had the check. A_3 was formed in 97% of fish by mid-December. More than 60% of the check were formed during late October to mid-November (Fig. 3). A_3 was formed at 21.2 circuli on average from nucleus (ranging from 17 to 27) and 0.43 mm of scale radius from nucleus (ranging from 0.32 to 0.53 mm). At that time, average fork length was 93 mm, ranging from 84 to 109 mm.

During the period of A_3 check formation, water temperature ranged from 13.9℃ to 7.8℃. It ranged from 12.2℃ to 11.1℃ from late October to mid-November when more than 60% of checks were formed. No checks were formed after late December when water temperatures were around 5.6℃ and body growth had nearly stopped. No check formation occurred in March and April of the following year, when body growth was very rapid.

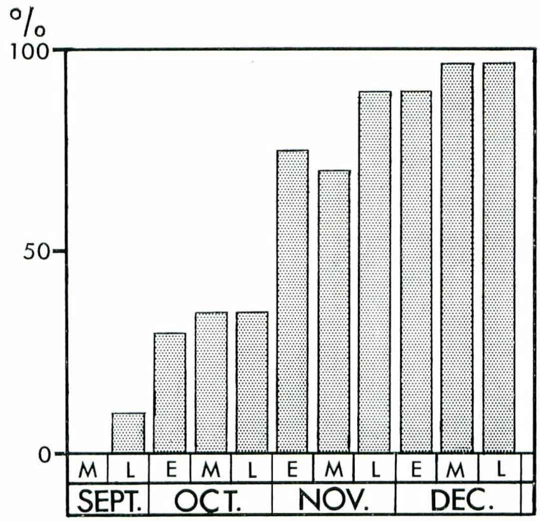

Fig. 3. Time of A_3 formation (percent of fish with A_3 check).

The results obtained from the experiment (A) indicated that neither cessation nor progress of body growth caused check formation. Growth rate of body from October to mid-November was lower than that from March to April and higher than that from December to January.

III. Experiment (B)

1. Body growth and water temperature

Range of water temperature

Water temperature rose rapidly from 7.8℃ to 13.3℃ from early March to mid-May and it was 14.4℃ from late May to the end of experiment, mid-August (Fig. 4).

Growth in fork length

Increases in fork length were slow in March and rather rapid after April till August. The fork length was increased from 39 to 44 mm from early March to early April, and from

47 to 80 mm from mid-April to mid-August. The increase per day was 0. 017 mm before early April and 0. 028 mm after mid-April. No cessations were found in the increase of fork length through the experiment (Fig. 4).

Growth in body weight

Increases in body weight were slow in March to May, rapid in June, then very slow in July and again rapid in August. The body weight was increased from 0. 5 to 2 g from early March to mid-May, from 2 to 4. 7 g from late May to late June, then 4. 7 to 4. 9 g from early to late July and from 4. 9 to 6. 4 g from late July to mid-August. The increase per day was 0. 021 g before May, 0. 075 g from mid-May to late June, then nearly 0 g in July an 0. 075 g from early to mid-August (Fig. 4).

2. Growth of scale

No circuli was found by early March in the fish of the experiment (B). The first circulus began to be formed in 17% of fish by mid-March, 87% by late March and 100% by early April. More than 60% of fish formed the first circulus during late March. Scale radius from nucleus to the first circulus ranged from 0. 06 to 0. 08 mm and the fork length at the time of first circulus formation was 43. 1 mm on average.

The author divided the growth of scale into three periods (I–III) based on the variation of growth rates (Table 2): I. mid-March—early June, II. Mid-June—mid-July, and III. late July—mid-August. The increment of average number of circuli and scale radius for either period or day, and the distances between circuli in these periods are as follows:

Number of circuli

It increased rapidly from 0. 4 to 9. 5 in period I, then changed comparatively slow increment from 10. 3 to 11. 5 in period II and again backed to rapid increment from 11. 9 to 14. 5

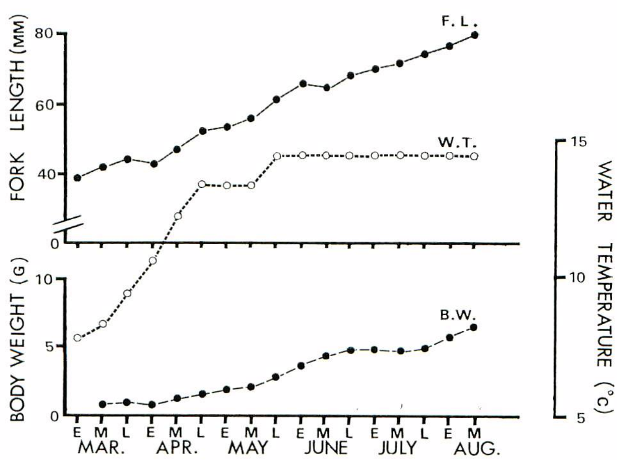

Fig. 4. Growth of fork length and body weight of rearing coho salmon and water temperature in the experiment (B).

in period III. The daily increment was 0.098 in period I, 0.045 in period II and 0.130 in period III (Table 2) (Fig. 5).

Scale radius

The elongation of scale radius was the same pattern as in the increment of number of circuli. It was rapid from 0.13 to 0.29 mm in period I, then changed to very slow from 0.29 to 0.31 mm in period II and backed to rapid from 0.31 to 0.36 mm in period III. The daily elongation was 0.0019 mm in period I, 0.0005 mm in period II and 0.0025 mm in period III (Table 2) (Fig. 5).

The distance between circuli (R/N) was 0.019 in period I, 0.011 in period II and 0.019 in period III (Table 2). This indicates that the checks were formed in period II.

Table 2. Scale growth of rearing coho salmon in the experiment (B).

	I	II	III
	Middle March～	Middle June～	Late July～Middle August
Growth of scale radius	0.17 mm	0.02 mm	0.05 mm
Scale radius/Day	0.0019	0.0005	0.0025
Increase of number of circuli	8.8	1.8	2.6
Number of circuli/Day	0.098	0.045	0.130
Distance between circuli	0.019	0.011	0.019

3. Time of check formation

The first fish which formed the check (B_1) in their scales occurred in early June. The rate of occurrence of fish possessed the check was 33% by early June, 69% by mid-June, 80% by late June, 92% by mid-July and 94% by late July. The check (B_1) occurred at 10.7 circuli from nucleus on average, ranging from 9 to 13, and at 0.29 mm on average scale radius, ranging from 0.22 to 0.35 mm. Average fork length and body weight at the check formation were 68 mm (ranging from 58 to 75 mm) and 4.9 g (ranging from 3.0 to 6.6 g), respectively. No other checks were found in the experiment (B).

IV. Discussion and conclusion

1. Growth of body

In regard to cessation of body growth in winter, water temperature is not essential factor to explain why it occurred not in January and February when the water temperature was lowest, but in November and December. In the experiment (A), body growth ceased during early December and early January and water temperature during the period decreased from 9℃ to 5.6℃. When body growth began to increase again in mid-January, it was 5.6℃.

According to STAUFFER (1973), when body growth of young coho salmon reared in Minter Creek Hatchery, Washington State, ceased to grow up from November to December, water temperature decreased from 9℃ to 5.5℃. At the time of new increment of body growth in

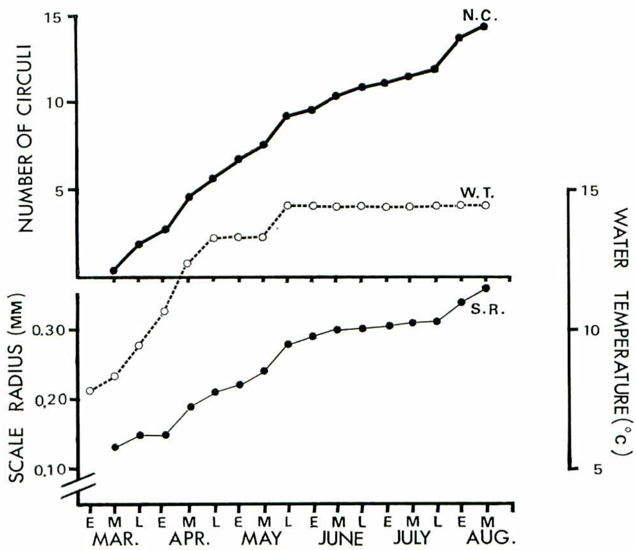

Fig. 5. Growth of number of circuli and scale radius of rearing coho salmon and water temperature in the experiment (B).

mid-January, water temperature was less than 5°C. In coho salmon reared in Hoodsport Hatchery, Washington State, the body growth nearly stopped during mid-November and late December when water temperature decreased from 7.2°C to 5.6°C. While it was less than 6°C when body growth began to increase in January (GOTO, 1975) (Fig. 6).

These facts indicate that the cessation of body growth does not occur during the period of lowest water temperature, but occurs during the period of lowering water temperature, and that new increment of body growth begins with lowest water temperature. In order to prove the problem, some other factors which play more important role in regulation of body growth than water temperature must be considered. The fish reared in hatcheries were given sufficient supply of food through all rearing periods. That is to say, young coho salmon of hatcheries in Washington State were fed in a ration of about 1% of body weight per day during winter months when water temperature ranged from 3°C to 7°C. In summer when water temperature rose up to 15°C, the ration was increased to 3–4% of body weight (STAUFFER, 1973; GOTO, 1975). The ration was constantly 1.5% of body weight (2%per day in 5 days a week) in the experiment (A). Therefore food would not act for these coho salmon as a main factor to stop the body growth.

SWIFT (1955) reported that seasonal variations in growth rate of brown trout reared in hatchery depended on water temperature and day length. Considering that day length is shortest in the period from December to January through a year, day length may play an important role to the cessation of body growth.

KUBO (1966) suggested in a study of masu salmon that growth of the fish was much related to smolt metamorphosis which began in fall.

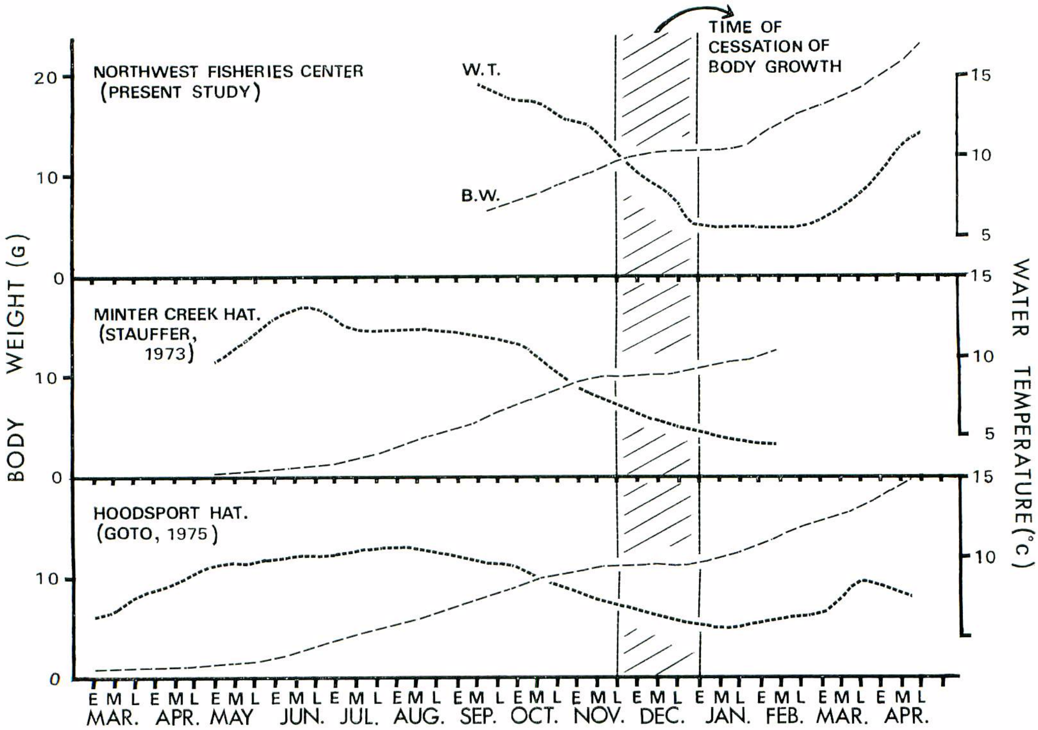

Fig. 6. Growth of body weight of coho salmon and water temperature in hatcheries.

It is thought that the lowering water temperature and shortening of day length induce begining of smolt metamorphosis, and then the metamorphosis causes check formation (described later) and cessation of body growth.

In regard to cessation of body growth in summer, SWIFT (1955) found that the growth rate fell during June and early July when the fish were most active. In the experiment (B), growth rate remained at low level during late June and July. As SWIFT (1955) described, water temperature higher than a certain value and peak activity of thyroid gland affected by day length at maximum lead to an increase in energy for maintenance, and thus reduce the energy available for growth, resulting cessation of body growth.

As to optimum water temperature for fish growth, BRETT (1969) reported that general physiological optimum occurred at 15℃ on sockeye salmon in fresh water. On brown trout in hatchery, maximum growth rate occurred between 8℃ and 12℃, and between 15℃ and 16℃ (SWIFT, 1955).

Since maximum water temperature in the experiment (B), 14.4℃, is thought to be nearly optimum water temperature for the growth of coho salmon, it might be considered that the cessation of body growth from late June to mid-July mostly depended on the day length at maximum as pointed out by Swift (1955).

2. Check formation

Three kinds of checks were found in fish of the experiment (A) and one check in fish of the experiment (B) (Fig. 7).

A_1, A_2 and B_1 are false age mark because they were formed in spring and summer. A_1 was formed among 22% of fish in the experiment (A) around April. No check, however, was found in the experiment (B) at the same period. A_2 and B_1 were found among more than 90% of fish during June and July (mostly June).

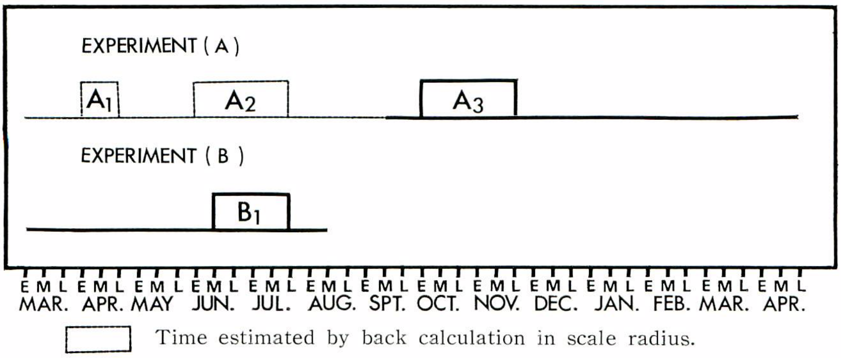

Fig. 7. Time of check formation.

As the author did not observe scales at the time of A_1 formation, there are nothing to explain the variations of fish body and conditions of enviroment when A_1 was formed. When B_1 (and maybe A_2) occurred in June, water temperature was constantly 14.4℃ and body growth was rapid, while increment of number of circuli and elongation of scale radius decreased, resulting to check formation. It had been generally accepted that starvation induces the check formation of salmon (MAJOR and CRADDOCK, 1962). In spite of suffucient supply of food through a year, checks occurred in both experiments. Therefore, it is though that starvation is not necessary condition to the check formation. On the other hand, BILTON and ROBINS (1971b) reported on scale of young sockeye salmon that food intake was increased, then the rate of circulus formation would increase, resulting in more closely spaced circuli and the formation of a check. Increase rate of number of circuli and scale radius fell in June and July, while body growth (especially body weight) ceased to increase in July in the experiment (B). In other words, when most of B_1 check occurred, body growth was still rapid. This indicates that cessation of growth of scale characteristics precedes that of body growth. Therefore, there was time lag between cessation of body growth and check formation in the experiment (B).

As well as body growth, growth of scale characteristics would be influenced by activity of thyroid gland through day length; day length at maximum in June leads maximum increase of fish activity, and then reduces growth rate of scale characteristics.

A_3 was recognized as true age mark, which was mostly formed during late October to

November. During the period, water temperature was lowering but body growth was still rapid. This indicates that there was also time lag between cessation of body growth and check formation as same relation as found in the experiment (B). No other check occurred not only when the body growth ceased from December to January but also when the water temperature was lowest from January to February. KUBO (1966) found in a study of masu salmon scales that checks were formed in mid-October when the water temperature was higher than winter. He suggested that variations of scale pattern were caused by metabolism of calcium, phosphate and protein associated with smolt metamorphosis.

Table 3. Age composition of coho salmon in fresh water life period.

Area	Ages				Reference
	0.	1.	2.	3.	
Quatsino Bay, British Columbia	0%	100%	0%	0%	GODFREY (1965)
Fraser River, British Columbia	3.3	96.7	0	0	GODFREY (1965)
West Coast of Vancouver Is., British Columbia	1.9	97.9	0.2	0	GODFREY (1965)
Langara Is., British Columbia	0.4	98.7	0.9	0	GODFREY (1965)
Minter Creek, Washington 1947	0	99.9	0.1	0	SALO and BAYLIFF (1958)
1948	0	99.4	0.6	0	
1949	0	99.8	0.2	0	
1950	0	99.5	0.5	0	
Columbia River, Washington	0	90.0	10.0	0	DRUCKER (1972)
Waddle Creek, California	0	100	0	0	SHAPOVALOV and TAFT (1954)
Pacific Coast, Washington	0	82.3	16.7	1.0	present study
Yakima River, branch of Columbia River, Washington	0	79.6	20.2	0.2	present study

It is thought that check formation in fall is derived from the lowering water temperature and shortening of day length which lead to smolt metamorphosis accompanied by variations of fish metabolism and growth rate of scale characteristics.

As mentioned above, checks are formed when variations of fish metabolism are affected by water temperature and day length in various cases. This means that more than two checks can be often formed on salmon living a year in fresh water. If the result can be applied to coho salmon originated from other hatcheries and natural rivers, special attention should be paid to scale reading.

The author examined scale samples of adult coho salmon caught in the Pacific Coast of Washington State, 1965–1966, and of smolt coho salmon caught in Yakima River, a branch of Columbia River, 1959–1963. The rate of fish with more than two checks in fresh water life period was 17.7% and 20.4% on average, respectively (Table 3). According to other reports relating fresh water age of coho salmon near Washington State (SHAPOVALOV and TAFT, 1954; SALO and BAYLIFF, 1958; GODFREY, 1965; DRUCKER, 1972), the rate of more than two year old fish is less than 0.9% in British Columbia, less than 0.6% in Minter Creek, Washington State, 10% in Columbia River and 0% in Waddle Creek, California (Table 3). In these reports, method of age determination was not clarified. If it is the case that their age determination was carried out by scale reading and one check was recognized as one year life of fish, the difference between the present study and other reports seems to be bigger than that depending on variations among years and local groups. It is thought that the difference is sizably caused by reading of false age mark.

Acknowledgements

The author is very grateful to Dr. DAYTON L. ALVERSON, Center Director of Northwest Fisheries Center, who afforded the opportunity for the study in his laboratory. The author would like to express his appreciation to Dr. F. FUKUHARA, Mr. R. MAJOR and Mr. R. BAKKALA, Northwest Fisheries Center, for offering useful suggestion and advice to the study. The author also indebted to Mr. K. TAKAGI, Far Seas Fisheries Research Laboratory, who made valuable criticism on the report.

References

BILTON, H. T. 1973: Effects of starvation and feeding on circulus formation on scales of young sockeye salmon of four racial origin, and of one race of young kokanee, coho and chinook salmon. The proceedings of an international symposium on the ageing of fish. Union Brothers Limited, 40–70.

BILTON, H. T. and G. L. ROBINS 1971a: Effects of feeding level on circulus formation on scales of young sockeye salmon (*Oncorhynchus nerka*). *J. Fish. Res. Bd. Canada*, **28** (6), 861–868.

BILTON, H. T. and G. L. ROBINS 1971b: Effects of starvation, feeding, and light period on circulus formation on scales of young sockeye salmon (*Oncorhynchus nerka*). *J. Fish. Res. Bd. Canada*, **28** (11), 1749–1755.

BILTON, H. T. and G. L. ROBINS 1971c: Response of young sockeye salmon (*Oncorhynchus nerka*) to prolonged periods of starvation. *J. Fish. Res. Bd. Canada*, **28** (11), 1757–1761.

BRETT, J. R., J. E. SHELBOURN, and C. T. SHOOP 1969: Growth rate and body composition of fingerling sockeye salmon, *Oncorhynchus nerka*, in relation to temperature and ration size. *J. Fish. Res. Bd. Canada*, **26** (9), 2363–2394.

DRUCKER, B. 1972: Some life history characteristics of coho salmon of the Karluk River system, Kodiak Island, Alaska. *Fish. Bull.*, **70** (1), 79–94.

GODFREY, H. 1965: Salmon of the North Pacific Ocean—part IX. Coho, chinook and masu salmon in offshore waters. 1. Coho salmon in offshore waters. Int. North Pac. Fish. Comm, Bull., (16), 1–39.

GOTO, S. 1975: Benefit cost analysis of Hoodsport Hatchery using three species of salmon: coho, chinook and chum. M. S. Thesis, Univ. Wash, 1–101.

KUBO, T. 1966: A growth pattern of scales of juvenile masu salmon (*Oncorhynchus masou*) during smolt metamorphosis. *Sci. Rep. Hokkaido Salmon Hatchery*, (20), 11–20 (in Japanese with English summary).

MAJOR, R. L. and D. R. CRADDOCK 1962: Marking sockeye salmon scales by short periods of starvation. U. S. Fish. Wild. Serv. Spec. Sci. Rep. Fish., (416), 1–16.

SALO, E. O. and W. H. BAYLIFF 1958: Artificial and natural production of silver salmon, *Oncorhynchus kisutch*, at Minter Creek, Washington. Wash. De. Fish., Res. Bull., (4), 1–76.

SHAPOVALOV, L. and A. C. TAFT 1954: The life histories of steelhead rainbow trout (*Salmo gairdneri gairdneri*) and silver salmon (*Oncorhynchus kisutch*) with special reference to Waddel Creek, California, and recommendations regarding their management. Calif. Fish Game, Fish. Bull., (98); 1–375.

STAUFFER, G. D. 1973: A growth model for salmonids reared in hatchery environments. Ph. D. Thesis. Univ. Wash., 1–213.

SWIFT, D. R. 1955: Seasonal variations in the growth rate, thyroid gland activity and food reserves of brown trout (*Salmo trutta* Linn.). *J. Exp. Biol.*, (32), 751–764.

ふ化場におけるギンザケ稚魚の体と鱗の成長

加　藤　　守

要　約

この報告は，筆者が科学技術庁の在外研究員として，1974 年 9 月から1 年間米国シアトル市の北西漁業センターにおいて行ったギンザケ稚魚の体と鱗の成長及び鱗の年齢標示形成期の研究をまとめたものである。

実験「A」では尾叉長と体重は，夏から秋にかけて水温が 14.4℃ から 10.0℃ に下降する間は順調に増加し，10℃を割る 12 月に増加がやみ，年間最低水温である 5.6℃ が続いている 2 月に再び増加を開始した。実験「B」では，両者の増加は 3 月から 6 月までは順調で，7 月に止まり，8 月から再び開始された。この間の水温は，3 月から 5 月までは 7.8℃ から 14.4℃ に上昇し，それ以降は 14.4℃ に調節されていた。

鱗の成長形質（鱗紋数と鱗径）も体の成長と同様の変化を示したが，両者の間には時間的な「ずれ」がみられた。両実験において，まず鱗の成長が停滞（すなわち年齢標示形成）し，次いで体の成長が停滞した。体も鱗もその成長の停滞には，水温だけでなく，日照時間も大きな役割を果していると考えられる。

年齢標示形質は実験「A」において，A_1，A_2 及び A_3 の 3 個，実験「B」においては B_1 1 個の形成が観察された。A_1 は 4 月ごろに，A_2 と B_1 は 6～7 月に形成されたと推定され，それぞれ 22% と 90% の魚に形成されているのが観察された。しかし，これらはいずれも疑年齢標示と考えられる。A_3 は 10～11 月に，97% の魚に形成されているのが観察され，真の年齢標示と考えられた。

ワシントン州付近に生活するギンザケの淡水年齢を，1 個の年齢標示が淡水1 年生活を示すものとして査定すると，従来報告されたものに比較して，淡水 2 年魚以上の割合がかなり多くなることを示した。これは，疑年齢標示を真の年齢標示とみなしたことに起因すると考えられ，ワシントン州付近に生活するギンザケ稚魚の鱗には，かなり多くの割合で疑年齢標示が形成されることが示された。