EVALUATION OF THE RETURN OF ADULT CHINOOK SALMON TO THE ABERNATHY INCUBATION CHANNEL

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ABSTRACT

Adult returns of progeny of the 1964 year class of chinook salmon, *Oncorhynchus tshawytscha*, were determined for the Abernathy incubation channel, natural production, and hatchery sources. A total of 4,620,600 fry were released from the channel into Abernathy Creek (state of Washington) as unmarked fry. Natural production in the creek was estimated from spawning ground counts and fyke net sampling of migrants at 16,700 fry, or 0.36% of the total unmarked fish. A total of 557,649 hatchery fish were marked by feeding tetracycline, and 161,579 were both fin-clipped and fed tetracycline. All 2-, 3-, and 4-yr-old adult fish returning to the hatchery holding pond were examined for fin clips and fluorescent bands on the vertebrae. Returns from hatchery sources were 506 fish or 0.070%. Potential egg production was 865,000, or 76% of the original 1,142,604 eggs. Returns from the channel totaled 733 fish or 0.016%. Egg potential was 2,050,000, or 35% of the original 5,888,048 eggs. Returns attributed to Abernathy Creek totaled only three fish and egg potential was 0.2% of the original 2,880,000 eggs. Survival of this year class was considerably below the 9-yr average of 0.118%. Intuitively, costs favor incubation channel production over hatchery production. However, additional studies are needed to determine if contributions to the fisheries and survivals are comparable in years of better year class survival.

Spawning and incubation channels for salmon produce higher survivals of downstream migrants than do natural spawning grounds. Studies by Gangmark and Broad (1956), Lister and Walker (1966), Thomas and Shelton (1968), and others have shown that channels with flow and sediment control devices can produce many times as many migrant-sized fish as are produced by the parent stream. Little information is available on the percentage of fry produced in channels that return as adults. Such data are needed to determine the value of incubation channels for supporting and maintaining salmon runs.

In the present study, I compare the survival to the adult stage of chinook salmon, *Oncorhynchus tshawytscha*, from three sources: the Abernathy incubation channel (near Longview, Wash.); the Salmon-Cultural Laboratory hatchery adjacent to the channel; and natural spawning in Abernathy Creek.

MATERIALS AND METHODS

Problems were encountered in selecting the techniques to use to distinguish returning adults from the various sources. Fin-clipping presented two problems. First, fin-clipping of fry produced in the channel was undesirable mainly because of the small size of the fry (average weight, <0.5 g). The chance of injury or incomplete removal of fins would be high. Fin-clipping of hatchery fish has been shown to reduce adult returns by 43.3% (Weber and Wahle 1969). Second, the daily numbers of fry migrating varied widely (from a few thousand to over 120,000), depending upon water conditions. Fin-clipping at a practical rate would require that many fish be held beyond their normal migration date.

Marking channel and creek migrants with tetracycline would not be acceptable. Although marking fish in this manner using techniques developed by Weber and Ridgway (1962) had no detrimental effect on adult survival (Weber and Wahle 1969), the drug is normally administered in the food. The artificial feeding of channel fish might alter their characteristics and invalidate the survival evaluations. Attempts to mark small fish by immersion in solutions of tetracycline and 4% dimethyl sulfoxide have shown some favorable results (Richard C. Johnsen, pers. commun.), but the technique has not been sufficiently developed for reliable, large-scale marking.

For these reasons migrant fry from the incubation channel and Abernathy Creek were not

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marked. Rather, the numbers migrating downstream were determined and the returns were compared with returns from marked hatchery fish stocked in the creek. It is assumed that fish migrating from the channel and Abernathy Creek would have the same rates of survival. Table 1 summarizes the number, size, time of migration, and mark of each of the fish sources involved in the evaluation.

TABLE 1.–Summary of the number, size, time of migration, and mark of the various fish sources included in the evaluation.

Origin of migrants	Number	Size (g/fish)	Time of migration	Mark
Abernathy Creek	16,700	[1]0.5	[1]11/64-4/65	none
Incubation channel	4,620,600	0.5	12/64-4/65	none
Hatchery	61,000	8.2	5/65	2-OTC[2]
	445,500	4.8	5/65	2-OTC
	51,149	16.8	8/65	3-OTC
	161,579	16.8	8/65	3-OTC + fin clips

[1]Approximate size and time of migration based upon fyke net sampling.
[2]Oxytetracycline.

Migrants from the Incubation Channel

A total of 4,620,600 unmarked fry were released from the channel during the 1964-65 season. This number represents a 78.5% survival from the 5,888,100 eyed eggs planted. If the mortality of green eggs is also considered, the survival to migrant stage was 75.0%. A description of techniques for planting eggs and counting fry was given by Thomas and Shelton (1968).

Migrants from Abernathy Creek

Numbers of female chinook salmon which spawned in Abernathy Creek during the 1964 spawning season were estimated at 576 from spawning ground counts. On the basis of an average of 5,000 eggs per female, an estimated 2,880,000 eggs were deposited in the creek. Fry migrating downstream from this area were sampled with a fyke net, a method demonstrated to be reliable by Tait et al (1962). Recaptures from known numbers of marked fish released upstream indicated that the net sampled 13.3% of the migrating fish; the calculated survival of migrants from natural spawning was 16,700, or 0.58%. Flooding and superimposition of eggs during spawning are probably responsible for this low survival. These fish were unmarked and returning adults could not be distinguished from those which originated in the incubation channel.

Chinook salmon spawning area in Abernathy Creek extends for about 1 mile below the hatchery weir. Returns from natural spawners would not necessarily enter the hatchery holding pond.

Releases of Hatchery Fingerlings

All fish released from the Salmon-Cultural Laboratory hatchery were marked in some manner for later identification. Initially, all fish were marked in mid-April 1965 by feeding tetracycline after the technique developed by Weber and Ridgway (1962). All fish in a 100-fish sample examined in late April showed fluorescent bands on their vertebrae. Fish released into Abernathy Creek in May had two bands and those in August, three bands. These second and third marks were poor because the fish fed little, presumably because of the high level of drugs in the diet. Total hatchery fish released with only tetracycline marking totaled 557,649.

Two groups of fish used in a nutrition experiment received double fin clips, in addition to the tetracycline marks. These two groups served as controls in that the returning adults would be easily recognizable from the clipped fins, and a check of their vertebrae would indicate the persistence of the fluorescence. The fin-clipped groups, which numbered 161,579, were released in mid-August 1965.

Treatment of Adult Fish

All adult chinook salmon returning to the holding pond at the Salmon-Cultural Laboratory were examined during 1966-68. All fish returning as 2-yr-old jack salmon and as 3- and 4-yr-old adults were examined. Past records of age classification indicated that numbers of 5- and 6-yr-old adults in the Abernathy Creek spawning run are insignificant. Fish that returned to Abernathy Creek but not to the hatchery holding pond were not included in the evaluations. No attempt was made to sample the sport or commercial fisheries or to search the adjacent streams and hatcheries for strays. The evaluation is based only upon returns to the Salmon-Cultural Laboratory holding pond. No correction was made for strays from other hatcheries or streams that might enter the holding pond and be counted as survivors from the channel since their number would be insignificant (Worlund et al. 1969).

All adult fish were measured and the sex was recorded. Scales were taken for age determination. Age determinations of fish returning to the hatchery in previous years had indicated the size range for 2-yr-old jack salmon, but 3- and 4-yr-old fish could not be separated by size. During the 1966 spawning season, a vertebra was removed from all fish smaller than the maximum length previously found for 2-yr-old fish, for determination of tetracycline marks. During the 1967 and 1968 spawning seasons, a vertebra was also removed from all fish in the size range of previous 3- and 4-yr-old fish.

Vertebrae were scanned under ultraviolet light by the technique described by Weber and Ridgway (1962). Vertebrae with tetracycline marks were classified as hatchery fish. The age of fish without vertebra marks was determined by examination of the scales. All unmarked fish of the correct age were considered to be recoveries from either the channel or creek. Tetracycline bands were visible in the vertebrae of all fin-clipped salmon.

Adult returns from two sources–the hatchery or Abernathy incubation channel and Abernathy Creek–were determined by measuring and aging fish and by identifying those with fin clips and tetracycline marks on vertabrae. Potential egg production was calculated on the basis of 5,000 eggs per female, the average number found in chinook salmon returning to the hatchery in previous years.

RESULTS

Adult Returns from Hatchery-Reared Fingerlings

Table 2 presents adult return data for both 1) the fin-clipped plus tetracycline-marked group and 2) the tetracycline-marked groups. Survival of fish that had been marked with both tetracycline and fin clip was low; of 161,579 fingerlings released, only 20 returned. Disease and parasite problems encountered during the summer rearing season probably contributed to the low survival. Fish released before the warm-water season appeared to have better survival. The total survival was 0.070%.

TABLE 2.–Number of male and female adult chinook salmon returns from 719,228[1] hatchery-reared fingerlings released from the Salmon-Cultural Laboratory hatchery, 1965.

Age at return (years)	Males	Females	Potential egg production (thousands)
2	209	0	0
3	90	96	480
4	34	77	385
Total	333	173	865

[1]Of this total, 557,649 fish were released with tetracycline bands and 161,579 with double fin clips and tetracycline bands.

Adult Returns from Abernathy Incubation Channel and Creek

The percentage returns of fish from the Abernathy incubation channel (0.016%) was considerably lower than that from the hatchery (Table 3). The higher ratio of female fish, however, resulted in a relatively higher number of eggs per returning fish.

The numbers of returning fish that originated in Abernathy Creek were insignificant. If the survival rate after migration is assumed to be identical for channel and creek migrants, only 0.36% of the 736 returning unmarked adults–or about 3 fish–were from the creek.

TABLE 3.–Number of male and female adult chinook salmon returns from 4,620,600 fry released at the Abernathy incubation channel, 1965.

Age at return (years)	Males	Females	Potential egg production (thousands)
2	16	0	0
3	202	220	1,100
4	107	188	940
Total	325	408	2,040

DISCUSSION

Survival was low from chinook salmon of the 1964 year class released from most Columbia River hatcheries, as they were in this experiment. Reasons for the poor survival are largely unknown. Although the evaluation of survival from several year classes would have been desirable, comparisons of survival from the different sources of young fish provide information on the relative survival of channel-reared and hatchery-reared fish, as well as an insight into the potential survival from an incubation channel. Ideally, sufficient adults should return to a salmon hatchery to provide 100% or more of the original egg supply. Assuming about 5,000 eggs per female and a 50:50 ratio of males to females, a chinook hatchery is self-sustaining when the return is about 0.045%.

TABLE 4.–Potential egg production of adult chinook salmon returns in relation to original egg numbers from which they were produced.

Source of downstream migrants	Return of adult salmon		Salmon eggs		
			Original number	Potential production from adults	
	Number	Percent	(thousands)	Number (thousands)	Percent of original number
Salmon-Cultural Laboratory hatchery	506	0.070	1,143	865	76
Abernathy incubation channel	773	0.016	5,888	2,040	35
Abernathy Creek	3	0.016	2,880	7	0.2

Potential egg replacement of adult returns from the various sources is shown in Table 4. The adult return from the hatchery totaled 0.070%; however, more than 40% of the adult fish returned as 2-yr-old males. Only about 76% of the original eggs were replaced for this brood year. Although the percentage survival of hatchery fish was more than four times that of channel fish, the advantage in egg replacement was less than twofold. Even so, a channel could not operate long with a less than 35% replacement of eggs. If adults from natural spawning are assumed to enter the holding pond at an equal ratio with those from the channel, possible egg replacement from the creek source was only about 7,000.

The return of chinook salmon as 2-, 3-, and 4-yr-old, and sometimes as 5- and 6-yr-old fish, ensures overlapping of brood stocks. Consequently returns from year classes with poor survival are mixed with returns from other year classes, to help ensure that the hatcheries and streams may still have adequate egg supplies.

Production of salmon by incubation channels is usually evaluated only by the number of outmigrants produced and the total number of adults that return. The origins and ages of adults are seldom investigated.

Only relative comparisons can be made of survival from channel and hatchery releases due to variables such as time of release, size at release, and nutritional background. The channel had the sizable advantages of having very low costs for rearing the fry and no cost for food.

A 9-yr average of adult returns to the hatchery was 0.118%. Survival to adults from the 1963 year class of fish released by the hatchery was about 0.39%. There were no major differences in fish diet, times of stocking, or other known factors that might improve survival of this year class over that of the 1964 year class. If it is assumed that survivals of fish from the channel follow the same trends as do those from the hatchery, the more than fivefold greater hatchery returns for the 1963 year class would be reflected in channel production returns. This would provide more than sufficient egg production replacement. However, additional studies are needed to confirm this survival assumption.

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