Northwest and Alaska Fisheries Center Processed Report*

ARTIFICIAL RECRUITMENT OF PINK AND CHUM SALMON IN JAPAN AND EASTERN U.S.S.R.

by

W. J. McNeil

January 1977

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Northwest Fisheries Center
2725 Montlake Boulevard East
Seattle, Washington 98112

* This report does not constitute a publication and is for information only. All data herein are to be considered provisional.

ARTIFICIAL RECRUITMENT OF PINK AND CHUM SALMON IN JAPAN AND EASTERN U.S.S.R.

by

W. J. McNeil*

January 1977

*Northwest and Alaska Fisheries Center Auke Bay Fisheries Laboratory
National Marine Fisheries Service, NOAA
P. O. Box 155, Auke Bay, AK 99821

Contents

ARTIFICIAL RECRUITMENT OF PINK AND CHUM SALMON IN JAPAN AND EASTERN U.S.S.R.

W. J. McNeil

INTRODUCTION

The June 1976 issue of Marine Fisheries Review (National Marine Fisheries Serv., 1976) discusses the harvest of 15 million chum salmon in the coastal waters and rivers of Hokkaido Island, Japan, in 1975. These fish were mostly produced by hatcheries at a cost equivalent to $0.22 per adult. Each fish was worth $10.93 to fishermen; thus one dollar invested in artificial recruitment generated $50.00 worth of raw product.

There is little doubt that 1975 was the best season in the history of Hokkaido salmon fisheries. Trends of artificial recruitment of salmon on Hokkaido suggest, nevertheless, that even better fishing seasons lie ahead due to an actively expanding and successful hatchery program.

Less known to North American observers is a massive Soviet pink and chum salmon hatchery program centered on Sakhalin Island, U.S.S.R. In 1976, the Soviets produced as many juvenile salmon in hatcheries on Sakhalin and in the Kuril Islands as the Japanese produced on Hokkaido.

The purpose of this report is to summarize and assess information on artificial recruitment of pink and chum salmon from Japanese and Soviet hatcheries. Trends in artificial recruitment of juvenile fish and estimates of marine survival are developed here to project future growth of salmon ranching.

Much of the data on hatchery production of salmon in the U.S.S.R. is from unpublished statistics given to me by Soviet observers. Other useful sources of data on Japanese and/or Soviet salmon hatcheries include Atkinson (1976), Day and Moore (1959), Japan Salmon Resources Conservation Association (1966), Mathews and Senn (1975), Okamoto (1975), and U.S. Tokyo Embassy (1975).

Japanese and Soviet hatchery technology relies on substrate incubators, where alevins repose on gravel in shallow channels with a horizontal flow of water. Stocking densities generally range from 15,000 to 30,000 alevins per square meter of gravel surface. The raceways are darkened to further simulate conditions in a natural spawning bed.

Most chum salmon hatcheries use relatively warm spring and ground water. Pink salmon hatcheries, on the other hand, commonly use stream water with cold temperatures during winter. Chum salmon fry are usually fed for a short period (15 to 45 days) before release to insure that their time of emigration to sea coincides with optimal environmental conditions in the marine environment. Pink salmon fry are usually released as unfed fry because of their later time of emergence from substrate incubation channels.

PRODUCTION OF JUVENILE SALMON

Approximately 1.5 billion chum and 0.5 billion pink salmon were released from Japanese and Soviet hatcheries in spring 1976. Hatcheries are mostly located on northern Honshu, Hokkaido, and Sakhalin Islands. Table 1 gives numbers of pink and chum salmon released. Such statistics are useful for charting general trends in artificial recruitment of pink and chum salmon in the western Pacific region and to predict the future expansion of artificial recruitment.

TRENDS IN ARTIFICIAL RECRUITMENT

Honshu, Hokkaido, and Sakhalin hatcheries (including Kuril Islands) together contribute 90% or more of the total number of juvenile pink and chum salmon produced by artificial methods in Asia. Honshu hatcheries produce chum salmon almost exclusively, and production is increasing steadily (Figure 1). Hokkaido hatcheries produce the largest number of chum salmon, and production is increasing at a more rapid rate than on Honshu (Figure 1). Production of chum salmon from Sakhalin hatcheries has declined moderately in recent years, but production of pink salmon has continued to expand at a very rapid rate (Figure 1). For all Honshu, Hokkaido, and Sakhalin hatcheries combined, artificial recruitment of pink and chum salmon has doubled every 10 years over the past 2 decades. This corresponds to a 7.3% annual rate of increase (Figure 2).

MARINE SURVIVAL

Marine survival of hatchery chum salmon from Hokkaido Island presently ranges between 2.0 and 2.5% (Atkinson, 1976; Mathews and Senn, 1975; Okamoto, 1975). Rate of exploitation of hatchery fish returning to coastal waters ranges between 80 and 90% and averages about 87% (see Mathews and Senn, 1975 for pertinent statistics).

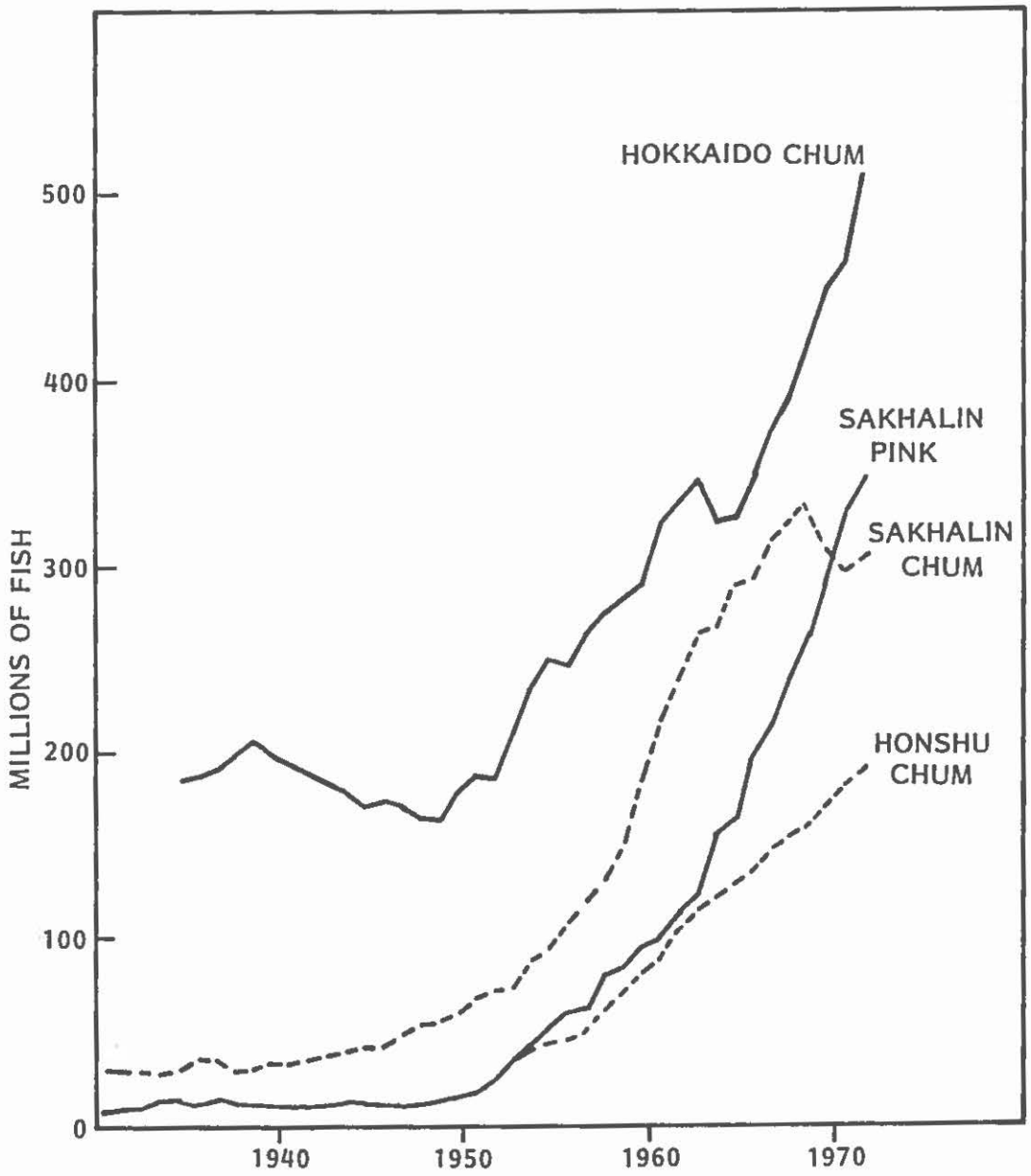

Figure 1. Ten-year moving average of artificial recruitment of juvenile pink and chum salmon in Asia.

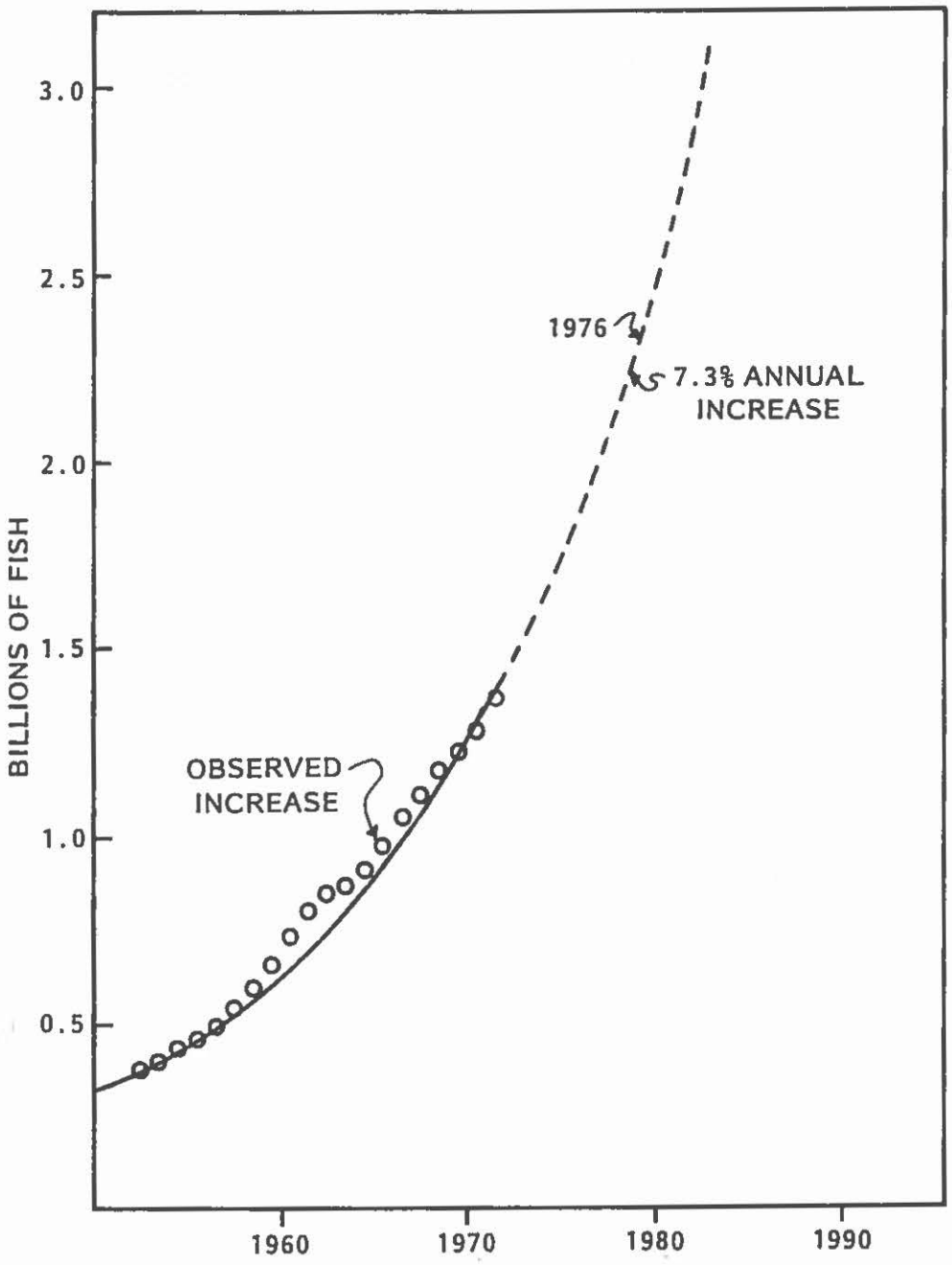

Figure 2. Curve for 7.3% annual increase of number of juvenile pink and chum salmon from hatcheries on Honshu, Hokkaido, and Sakhalin Islands. Plotted points are observed ten-year moving average.

Marine survival of chum salmon from hatcheries in northern Honshu is not as well documented as for Hokkaido. However, it has been reported to me by knowledgeable observers that the rate of return to coastal fisheries is probably somewhat less than 1%, on the average.

Substantial, but unknown, numbers of Honshu fish are intercepted by land-based fisheries on Hokkaido, which would inflate calculated returns to Hokkaido and deflate those to Honshu. Marine survival of Honshu fish is expected to show marked improvement in the years ahead in response to a fry feeding program which was fully adopted on Honshu in 1971, several years after adoption of a similar program on Hokkaido (Atkinson, 1976). Evidence supporting this expectation was provided by excellent returning runs of hatchery fish to Iwate Prefecture on the northeast coast of Honshu in 1975, with marine survival approaching 2% according to Japanese observers.

Marine survival of Sakhalin chum salmon can be evaluated from rate of return to hatcheries and rate of exploitation in coastal fisheries. Adult chum salmon returning to five Sakhalin hatcheries over an eight-year period (40 observations) averaged 0.42% of the number of juveniles released (Kanid'yev et al., 1970). Unpublished information has been supplied to me by Soviet workers on coastal catch and total run of chum salmon returning to Sakhalin (Table 2). These data show that an average of 81.7% of the total returning run was caught in Soviet coastal fisheries. The total rate of return of hatchery fish to coastal waters can therefore be calculated:

$$0.42\% \text{ escaping} = 18.3\% \text{ of total return}$$

or

$$\text{total return} = \frac{0.0042}{0.183} = 0.023$$

The estimated 2.3% return of hatchery chum salmon to Sakhalin is in general agreement with returns estimated for nearby Hokkaido Island.

Data for estimating marine survival of hatchery pink salmon from Sakhalin Island are more limited than for chum salmon. According to Soviet workers, average rate of return of pink salmon to hatcheries is about 3 times higher than for chum salmon. This conclusion is reinforced by Kanid'yev et al. (1970) who report an average of 1.62% of pink salmon returning to the Lesnaya River where the Lesnoi hatchery is located. Unfortunately, I have received no statistics to estimate rate of exploitation of pink salmon in coastal fisheries, but I have been advised that pink fisheries on Sakhalin are managed to conserve wild stocks. This implies that rates of exploitation are held between 50% and 70%. Marine survival of hatchery pink salmon appears, therefore, to lie in the range of the 2% to 5%.

Estimates of marine survival used in this report for Japan and the U.S.S.R. include mortality from high seas fishing as well as from natural causes. Thus, estimates of survival based on numbers of maturing fish returning to coastal fisheries are conservative to the extent that high seas fishing influences rates of return to coastal waters.

OUTLOOK

Artificial recruitment of pink and chum salmon from Japanese and Soviet hatcheries has grown at an annual rate of 7.3% over the last two decades (Figure 2). Estimated marine survival of hatchery fish ranges from almost 1% for Honshu chum salmon to as high as 5% for Sakhalin pink salmon. An overall average of about 2% marine survival seems justified in projecting contributions of hatchery fish to the harvest of pink and chum salmon in Asiatic waters.

There is every indication that Japanese and Soviet pink and chum hatcheries are economically successful. For example, Atkinson (1976) estimates that cost per adult chum salmon originating from Hokkaido hatcheries ranges from $0.22 to $0.67. With a current value to fishermen of almost $11.00 per fish, each dollar invested in hatchery production yields up to $50.00 in raw product. Even after subtracting a modest cost for harvesting fish, return on investment remains very favorable. The economic stimulus exists, therefore, for continued growth of hatchery programs in the Far East.

Approximately 2 billion juvenile pink and chum salmon were released from hatcheries in Japan and the U.S.S.R. in 1976. This contrasts with about 0.5 billion of all species of salmon released from hatcheries and spawning channels in North America. If current trends continue, about 4 billion juvenile salmon will be released from Japanese and Soviet hatcheries by 1986. These statistics imply a potential annual harvest in Asia of 40 million hatchery pink and chum salmon by 1980 and 80 million by 1990, based on an assumed 2% marine survival.

The total Alaska harvest of five species of salmon has averaged about 40 million fish over the last 10 years, while the total North American (Canada plus U.S.) harvest has averaged about 80 million fish. Thus, the hatchery program in Asia could approximately match all Alaskan salmon fisheries within four years and all North American salmon fisheries within 14 years, assuming that production remains static in the eastern Pacific. However, artificial recruitment of salmon into the eastern Pacific is also expected to expand. It may eventually become necessary to limit artificial recruitment of salmon to assure a proper ecological balance of higher trophic level fishes grazing in the North Pacific Ocean and contiguous seas.

The outlook, then, is for continued rapid expansion of artificial recruitment of salmon in the western Pacific accompanied by the emergence of a more extensive salmon ranching program in the eastern Pacific. It is conceivable that more salmon will be reproduced by artificial than by natural processes before the turn of the century if salmon ranching continues to demonstrate economic advantage over natural recruitment.

Table 1.--Production of juvenile pink and chum salmon from hatcheries in Japan and eastern U.S.S.R.

	Millions of fish							
Year of release	Honshu I.		Hokkaido I.		Sakhalin I.		Other areas	
	Chum	Pink	Chum	Pink	Chum	Pink	Chum	Pink
1976	250[1/]	--	750[1/]	50[1/]	400[1/]	400[1/]	100[1/]	--
1975	--	--	--	--	294	486	--	--
1974	230	--	600	--	248	448	89	9
1973	184	--	570	39	347	270	66	--
1972	225	--	476	20	247	397	105	--
1971	212	--	576	172	412	206	34	1
1970	145	--	442	16	218	423	--	--
1969	140	--	362	--	376	231	--	--
1968	120	--	207	--	199	416	--	--
1967	161	--	435	--	330	221	--	--
1966	196	--	272	--	306	219	--	--
1965	110	--	549	--	420	103	--	--
1964	140	--	334	--	443	105	--	--
1963	116	--	272	--	268	67	--	--
1962	138	--	281	--	186	168	--	--
1961	85	--	359	--	201	19	--	--
1960	65	--	203	--	172	116	--	--
1959	64	--	314	--	147	141	--	--
1958	81	--	417	--	168	82	--	--
1957	54	--	362	--	82	116	--	--
1956	35	--	140	37	90	85	--	--

Table 1.--Continued.

Year of release	Honshu I.		Hokkaido I.		Sakhalin I.		Other areas	
	Millions of fish							
	Chum	Pink	Chum	Pink	Chum	Pink	Chum	Pink
1955	39	--	248	42	99	38	--	--
1954	39	--	269	7	87	13	--	--
1953	21	--	171	28	66	17	--	--
1952	26	--	160	25	80	1	--	--
1951	35	--	189	34	86	11	--	--
1950	43	--	222	9	57	23	--	--
1949	24	--	181	12	65	5	--	--
1948	27	--	156	3	45	30	--	--
1947	--	--	137	6	--	--	--	--
1946	--	--	142	--	--	--	--	--
1945	--	--	165	--	--	--	--	--
1944	--	--	129	--	39	5	--	--
1943	--	--	207	--	40	7	--	--
1942	--	--	193	--	19	5	--	--
1941	--	--	210	--	29	8	--	--
1940	--	--	199	--	58	24	--	--
1939	--	--	253	--	47	4	--	--
1938	--	--	201	--	14	22	--	--
1937	--	--	190	--	35	12	--	--
1936	--	--	189	--	22	22	--	--
1935	--	--	197	--	33	14	--	--

Table 1.--Continued.

	Millions of fish							
Year of release	Honshu I.		Hokkaido I.		Sakhalin I.		Other areas	
	Chum	Pink	Chum	Pink	Chum	Pink	Chum	Pink
1934	--	--	224	--	27	10	--	--
1933	--	--	144	--	30	9	--	--
1932	--	--	95	--	45	12	--	--
1931	--	--	177	--	34	10	--	--
1930	--	--	176	--	20	11	--	--
1929	--	--	--	--	24	4	--	--
1928	--	--	--	--	41	5	--	--
1927	--	--	--	--	34	6	--	--
1926	--	--	--	--	11	6	--	--
1925	--	--	--	--	10	2	--	--

[1/] Preliminary estimate.

Table 2.--Rate of exploitation of chum salmon returning to coastal waters of Sakhalin Island, U.S.S.R.

Year	Coastal catch (1,000 fish)	Total run (1,000 fish)	Rate of exploitation (%)
1935	1,867	2,254	82.8
1936	1,516	1,922	78.9
1937	1,799	2,335	77.0
1938	1.971	2,495	79.0
1939	2,034	2,698	75.4
1940	2,339	2,952	79.2
1941	1,764	2,385	74.0
1942	1,578	2,231	70.7
1943	1,254	1,918	65.4
1944	1,223	1,816	67.3
1945	1,805	2,438	74.0
1946	1,244	1,657	75.1
1947	1,877	2,238	83.9
1948	2,401	2,809	85.5
1949	2,730	3,212	85.0
1950	3,907	4,396	88.9
1951	2,629	2,923	89.9
1952	1,757	2,069	84.9
1953	1,916	2,128	90.0
1954	3,145	3,530	89.1

Table 2.--Continued.

Year	Coastal catch (1,000 fish)	Total run (1,000 fish)	Rate of exploitation (%)
1955	2,142	2,436	87.9
1956	1,401	1,583	88.5
1957	2,455	2,903	84.6
1958	2,157	2,646	81.5
1959	1,355	1,708	79.3
1960	1,423	1,728	82.3
1961	2,860	3,287	87.0
1962	2,825	3,195	88.4
1963	3,573	3,933	90.8
1964	3,421	4,013	85.2
		Mean	81.7

LITERATURE

Atkinson, C. E. 1976. Salmon aquaculture in Japan, the Koreas, and the U.S.S.R. In D. H. Rosenberg (Ed). Proceedings of the Conference on Salmon Aquaculture and the Alaskan Fishing Community. Univ. of Alaska Sea Grant Rpt. 76-2:79-154.

Day, A. M., and M. Moore. 1959. A review of the Japanese salmon fishery. Processed report 26 p. Oregon Fish Commission.

Japan Fisheries Resource Conservation Association. 1966. Propagation of the chum salmon in Japan. 55 p.

Kanid'yev, A. N., G. M. Kostyunin, and S. A. Salmin. 1970. Hatchery propagation of the pink and chum salmons as a means of increasing the salmon stocks of Sakhalin. J. Ichthyol. (Engl. Trans. Vopr. Ikhtiol.) 10:249-259.

Mathews, S. B., and H. G. Senn. 1975. Chum salmon hatchery rearing in Japan, and in Washington. Univ. of Washington Sea Grant TA 75-3:24 p.

National Marine Fisheries Service. 1976. Returns to Japanese Salmon Hatcheries better than expected. Marine Fisheries Review 38(6):35.

Okamoto, Y. J. 1975. A preliminary study of the chum salmon stock rehabilitation program. Processed report, 43 p. Pacific Rim Development Research Associates.

U.S. Tokyo Embassy. 1975. Unpublished data on Japanese salmon hatchery statistics for 1970-73.