Historical Trends of Salmon Fisheries and Stock Conditions in Japan

Osamu Hiroi
Research Division, National Salmon Resources Center
2-2 Nakanoshima, Toyohira-Ku, Sapporo 062, Japan

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Artificial salmon hatchery operation in Japan can be described from various aspects such as salmon resources, resources management, economic effects, and future prospects. Almost all the salmon resources in Japan have been supported by artificial propagation. Recent annual total salmon catch increased to about 300 thousand tons, in which the coastal catch accounted for over 80 percent. With regard to the species composition of commercial catch, the chum catch is the largest, about 230 thousand tons (about 80 percent). Resource management coupled with active propagation made the set net fishery for chum and pink salmon stable. Economic returns from harvesting (about 50-80 billion yen) in the coastal fishery vis-a-vis expenses (about 10-14 billion yen) for artificial propagation of salmon is about 5-8 times.

INTRODUCTION

Almost all the salmon resources in Japan have been supported by artificial propagation. Species subject to artificial propagation programmes in Japan are: chum salmon (*Oncorhynchus keta*), pink salmon (*O. gorbuscha*), masu salmon (*O. masou*) and kokanee salmon (*O. nerka*). Smolt cultured from the lake-living kokanee, a land-locked sockeye salmon, have been released on a pilot basis in natural rivers with a view to developing sockeye resources. Only a limited number of chinook salmon (*O. tschawytcha*), coho salmon (*O. kisutch*) and sockeye salmon (*O. nerka*) are caught in the coastal sea or the North Pacific Ocean. Coho salmon are becoming cultured in cages or in freshwater ponds. To promote efficient artificial propagation of salmon, it is important to make a model of some aspects of behaviour in the life cycle of the fish, especially those concerned with spawning migration, spawning, breeding, development, smoltification, downstream migration and feeding migration.

EFFECTS ON RESOURCES

Annual Catches of the Japanese Salmon Fisheries

Annual catches of the Japanese salmon fishery are shown in Table 1. Total catches of salmon fluctuated between 100-160 thousand tons from 1965 to 1982, and increased to over 170 thousand tons since 1983, reaching about 303 thousand tons in 1995 in spite of a gradual decrease in the distant water catches, from 120 to 12 thousand tons, following to the cease of salmon fisheries among open areas of the North Pacific Ocean since 1990. Almost all the coastal catch comes from artificial propagation in Japan. The percentage of coastal catch has increased to over 60 percent since 1979 and over 80 percent since 1986. Since 1981, the total annual commercial catch has been 112-231 thousand tons (73-85 percent) for chum, 12-35 thousand tons (5-16 percent) for pink, 2.5-4.0 thousand tons (0.9-2.5 percent) for masu, 0.5-7.8 thousand tons (0.2-3.3 percent) for sockeye, 3.2-26.0 thousand tons (1.9-12.1 percent) for coho and 0.3-1.4 thousand tons (0.1-0.9 percent) for chinook. Recently, production of pen-cultured coho salmon has increased to 25 thousand tons in 1991-2 (see Table 1).

Annual Adult Returns and Return Percentage for Salmon Released from Japan

Annual adult returns for chum released from Hokkaido and Honshu Islands are shown in Table 2 and Figure 1. The numbers of chum fry released from both Hokkaido and Honshu Islands, have increased to 1900 from 470 million fish, from 1965 to 1981, and have stabilized at about 2000 million fish since 1982. Adult returns to rivers and coastal

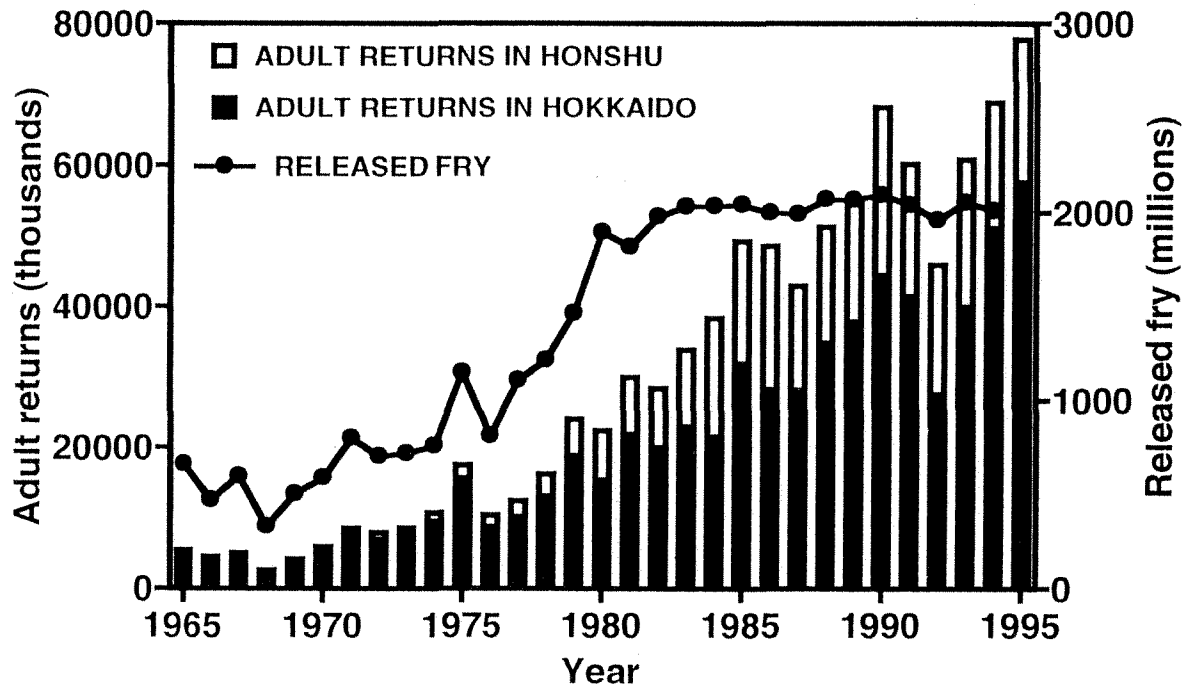
Table 1. Annual catches in the Japanese salmon fishery.

Year	Far-seas catch (thousand tons)	Coastal Sea catch (thousand tons)	Freshwater catch (thousand tons)	Total (thousand tons)	Percentage of coastal catch	Pen-culture coho (thousand tons)
1965	126.8	18.8	3.6	149.2	12.6	
1966	110.1	16.5	2.2	128.8	12.8	
1967	128.3	20.1	3.0	151.4	13.3	
1968	102.2	11.6	1.4	115.2	10.1	
1969	122.1	19.2	2.0	143.3	13.4	
1970	95.8	22.1	1.9	119.8	18.4	
1971	102.3	37.0	2.6	141.9	26.1	
1972	92.6	27.0	2.0	121.6	22.2	
1973	97.2	38.8	3.0	139.0	27.9	
1974	88.5	44.0	2.9	135.4	32.5	-
1975	92.8	66.5	7.0	166.3	40.0	-
1976	84.4	41.7	3.9	130.0	32.1	-
1977	64.3	52.2	3.7	120.2	43.4	-
1978	42.7	60.1	4.1	106.9	56.2	0.1
1979	43.5	87.5	6.5	137.5	63.6	0.4
1980	43.4	79.1	9.4	131.9	60.0	1.9
1981	43.2	106.6	8.9	158.7	67.2	1.2
1982	43.6	92.7	9.3	145.6	63.7	2.1
1983	43.3	117.8	9.0	170.1	69.3	2.8
1984	36.4	120.9	9.0	166.3	72.7	5.0
1985	35.5	167.6	11.4	214.5	78.1	7.0
1986	20.9	146.5	10.0	177.4	82.6	7.5
1987	20.5	140.2	8.6	169.3	82.8	12.2
1988	15.5	151.8	10.8	178.1	85.2	16.5
1989	18.4	173.7	13.3	205.4	84.6	19.8
1990	11.9	211.3	15.9	239.1	88.4	23.6
1991	16.5	198.2	13.4	228.1	86.9	25.7
1992	23.4	155.9	10.2	189.5	82.3	25.5
1993	26.1	204.0	14.4	244.5	83.4	21.1
1994	23.8	216.1	21.1	261.0	82.8	22.8
1995	33.0	251.0	19.3	303.3	82.8	15.0

Table 2. Annual chum salmon runs (thousands) to Hokkaido and Honshu.

	Hokkaido			Honshu			Total		
Year	Coastal Sea	Rivers	Total	Coastal Sea	Rivers	Total	Coastal Sea	Rivers	Total
1966	3408	396	3804	451	187	638	3859	583	4442
1967	3908	592	4500	370	142	512	4278	734	5012
1968	1902	236	2138	260	115	375	2162	351	2513
1969	3595	578	4173	313	134	447	3908	712	4620
1970	4651	627	5278	424	149	573	5075	776	5851
1971	6806	845	7651	652	245	897	7458	1090	8548
1972	6343	614	6957	698	229	927	7041	843	7884
1973	7724	597	8321	616	238	854	8340	835	9175
1974	9026	601	9627	901	224	1125	9927	825	10752
1975	14217	1557	15774	1463	362	1825	15680	1919	17599
1976	8342	463	8805	1361	271	1632	9703	734	10437
1977	9466	742	10208	1873	374	2247	11339	1116	12455
1978	12284	863	13147	2667	394	3061	14951	1257	16208
1979	17751	1151	18902	4518	608	5126	22269	1759	24028
1980	13786	1660	15446	5873	1099	6972	19659	2759	22418
1981	20296	1630	21926	7251	727	7978	27547	2357	29904
1982	18270	1770	20040	7448	894	8342	25718	2664	28382
1983	21235	1778	23013	10052	776	10828	31287	2554	33841
1984	19741	1831	21572	15880	895	16775	35621	2726	38347
1985	29461	2413	31874	16559	888	17447	46020	3301	49321
1986	26218	1999	28217	19206	1201	20407	45424	3200	48624
1987	26560	1567	28127	13937	837	14774	40497	2404	42901
1988	32514	2315	34829	15489	968	16457	48003	3283	51286
1989	34973	2903	37876	15722	991	16713	50695	3894	54589
1990	41210	3264	44474	22171	1539	23710	63381	4083	68184
1991	39071	2390	41461	17346	1353	18699	56417	3743	60160
1992	26014	1534	27548	17180	1164	18344	43194	2698	45892
1993	37220	2789	40009	19407	1357	20764	56627	4146	60773
1994	46986	4204	51190	16211	1468	17679	63197	5672	68869
1995	53793	3899	57692	18395	1690	20085	72188	5589	77777

Fig. 1 Annual changes in adult returns and released fry for chum salmon from Japan, 1965-1995.



seas totalled over 10 million fish 1974, over 20 million fish since 1979, over 30 million fish since 1983, over 40 million fish since 1985, over 50 million fish since 1988 and over 60 million fish since 1990 (except 1992). The largest return, about 78 million fish, was seen in 1995. Over 70 million fish are also expected in 1996. Annual chum fry to adult return rate by brood year for chum released from Hokkaido and Honshu Islands are shown in Table 3. The adult return rate has stabilized at over 2 percent since 1968, over 3 percent since 1984 and over 4 percent since 1987 except 1988 in Hokkaido, and between 1.6-2.5 percent since 1975 in Honshu. Recently, the largest return rate in Japan has been estimated at about 3.8 percent in 1991. In one local stock of Hokkaido, a return rate over 13 percent was recorded. The recent rapid increase in adult returns and return rates are due not only to an increase in the number of fry released by expansion and improvement of hatchery facilities, but also to effective use of spring waters and full protection of river fish from coastal fishing, and prolonged feeding periods (two to five months) prior to release.

Annual changes in adult returns and the return rates of pink salmon from Hokkaido are shown in Table 4 and Figure 2. The numbers of released pink fry have fluctuated between 16 to 150 million fish from 1969 to 1986, and have been regulated at 120-150 million fish since 1987. The adult returns to rivers and coastal seas fluctuated between 0.4-2.7 million fish with a clear trend of increasing in odd years and of decreasing in even years from 1969 to 1986. Without a difference in odd years and even years, they increased to over 3.8 million fish since 1987 except 1990 and over 8 million fish since 1991. The largest return, about 17 million fish, was seen in 1994. In 1996, they expect over 19 million fish. The adult return rate for pink fry released from Hokkaido has stabilized at over 5 percent since 1989. The largest return rate, about 12 percent, was seen in the 1992 brood.

For the masu salmon in Hokkaido, since 1986, 3.1-8.0 million fry or smolts have been liberated and 264-869 thousand adults have been caught in the coastal seas near the home stream, corresponding to a return rate of 8-28 percent.

For the sockeye salmon, since 1982, 31-2015 thousand fry or smolts have been liberated and 0.4-8.2 thousand adults have been caught in the coastal seas near the home stream, corresponding to a roughly return rate of 0.1-2.5 percent.

RESOURCE MANAGEMENT

To promote an effective use and adequate control of salmon resources maintained by artificial production, it is necessary to keep an appropriate

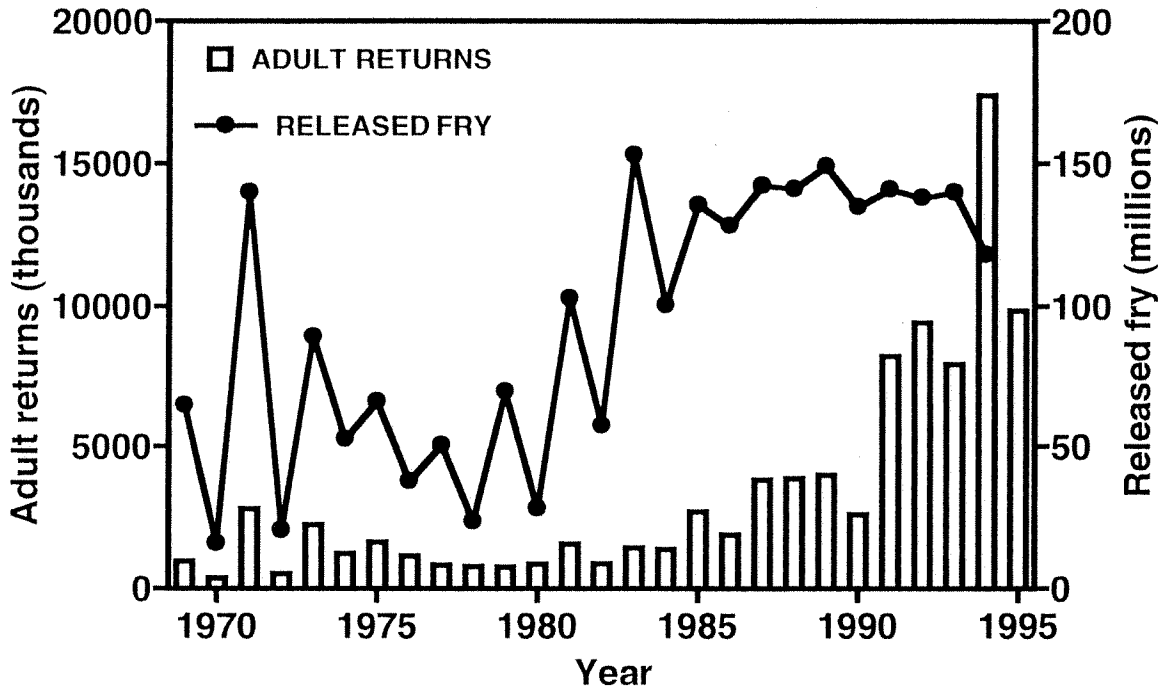
Table 3. Annual chum fry to adult return rates by brood year. Figures in brackets indicate number or rate of adult returns after four years.

Year	Hokkaido			Honshu		
	Liberated Fry (thousands)	Adult Returns (thousands)	Return Rates (%)	Liberated Fry (thousands)	Adult Returns (thousands)	Return Rates (%)
1962	280743	3025	1.08	138267	(718)	(0.52)
1963	272106	4983	1.83	116476	(572)	(0.49)
1964	334463	2119	0.63	139575	(415)	(0.30)
1965	549278	2572	0.47	109836	(497)	(0.45)
1966	272036	5943	2.18	196469	(653)	(0.33)
1967	434729	8110	1.87	161240	(987)	(0.61)
1968	207438	4881	2.35	121193	(1017)	(0.84)
1969	361571	8737	2.42	139536	(1004)	(0.72)
1970	442101	10110	2.29	144673	(1275)	(0.88)
1971	575986	12913	2.24	222516	1351	0.61
1972	475805	11909	2.50	224946	1898	0.84
1973	445510	9036	2.03	271223	2588	0.95
1974	484849	11342	2.34	271708	2414	0.89
1975	801991	21322	2.66	343988	5546	1.61
1976	523221	13092	2.50	287133	6889	2.40
1977	693222	20872	3.01	412625	7422	1.80
1978	779269	23917	3.07	433177	8341	1.93
1979	873489	18809	2.15	589905	10174	1.72
1980	1146346	26810	2.34	750113	(17085)	(2.28)
1981	1079708	31919	2.96	738055	(17693)	(2.40)
1982	1145880	28326	2.47	864601	(20393)	(2.36)
1983	1146763	28330	2.47	885534	(14769)	(1.67)
1984	1139496	35154	3.09	895018	(16448)	(1.84)
1985	1131739	41855	3.70	910476	(16709)	(1.84)
1986	1072605	39864	3.72	927853	(23247)	(2.51)
1987	1054616	43283	4.10	937447	(19044)	(2.03)
1988	1097165	31753	2.89	972496	(18646)	(1.92)
1989	1122345	46438	4.14	945954	(20652)	(2.18)
1990	1100957	(50705)	(4.61)	993257	(18164)	(1.83)
1991	1051520	(57277)	(5.45)	989287	(20501)	(2.07)
1992	1008750			950878		
1993	1083954			968786		
1994	1053813			955940		

Table 4. Annual adult returns and the return rates for pink salmon from Hokkaido. Figure in bracket indicates a number reported en route.

Year	Liberated Fry (thousands)	Adult returns (thousands)			Return rate (%)
		Coastal Sea	Rivers	Total	
1969	64556	858	103	961	4.35
1970	15873	329	43	372	3.28
1971	139687	2535	274	2809	1.61
1972	20390	470	51	521	6.07
1973	89091	2048	202	2250	1.83
1974	52460	1115	122	1237	2.18
1975	65864	1484	147	1631	1.25
1976	37558	1054	88	1142	2.04
1977	50390	710	116	826	1.49
1978	23398	719	47	766	3.69
1979	69433	597	153	750	2.25
1980	27918	796	68	864	3.16
1981	102703	1370	193	1563	1.39
1982	57277	762	120	882	2.40
1983	152790	1051	378	1429	1.77
1984	100290	1110	266	1376	1.89
1985	135414	2116	590	2706	2.83
1986	127998	1499	396	1895	3.02
1987	142085	2987	841	3828	2.81
1988	140968	3320	544	3864	1.84
1989	148953	3386	600	3986	5.52
1990	134598	2222	375	2597	7.00
1991	140824	7041	1174	8215	5.63
1992	137847	8469	950	9419	12.61
1993	139821	7543	387	7930	7.05
1994	117920	15481	1907	17388	(16.24)
1995		9035	820	9855	
1996		(17004)	(2143)	(19147)	

Fig. 2 Annual changes in adult returns and released fry for pink salmon from Japan, 1969-1996.



management of coastal commercial catches to ensure that the adequate stock size returns to rivers. Coastal maturing salmon migrating near home streams are caught by several kinds of fishery, set net and drift net, etc. Recently, the share of set net fishery is the largest of those in coastal commercial catches. Set net fishery for chum and/or pink has increased both in number of licenses issued and in earnings, coupled with the rapid increase of resources. In Hokkaido, to accomplish the adequate size of salmon runs to secure the proper production capacity of the resources, the Government has stipulated various regulation such as fishery-term and distance from shore for the chum and pink set net fishery for each of the respective districts. These regulations are subjected to review every five years. In each year, moreover, temporary removals of set net during the fishery season have been required in cases where the level of spawning run has been considered to be inadequate. The adequate levels are estimated for respective districts by resources analyses, on the basis of the presumed number of adult returns to both rivers and coastal seas. Thus, the set net fishery for chum and pink, recently, became stable thanks to resource management with active propagations.

ECONOMIC EFFECTS

Expenses for the artificial propagation of migrating salmon in Japan are Y 10-14 billion, while harvests from the coastal catch of the adult return are worth Y 50-90 billion, more than five times the expense since 1985.

FUTURE EFFECTS

With regard to chum and pink salmon, resources have reached a stable level by artificial propagation, efforts to select adults with a long freshwater life during anadromous migration are now being paid for. These fish take premium prices because of the silvery body colour observed in coastal seas near home streams. On the other hand, further efforts are needed to increase resources for the districts or prefectures with low level production and to secure higher return rates.

With regard to masu and sockeye which are among the most valuable species in the salmon family, it is important to accomplish most rapidly the artificial propagation technique by using the smolt-release methods, to increase resources, and to raise return rates.