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Evaluation of the transplant of Pacific pink salmon (Oncorhynchus gorbuscha) to Newfoundland.

by

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Introduction

Introduction of various species of fish were commonly practised during the late 1800's and early 1900's. Attempts to establish pink salmon in Maine from 1906 to 1926 were not successful although there were runs for a number of years (Bigelow and Schroeder, 1953).

During 1956, 513,000 pink salmon eggs and an additional 225,000 fingerlings were planted in Goose Creek, Hudson's Bay, but no adult pink salmon have been reported from Hudson Bay and its tributaries (Ricker and Loftus, 1968).

Transplantation of pink salmon from the western Pacific to the Barents Sea and White Sea by USSR scientists was started in 1956 and initial results appeared promising (Kossov et al, 1960). Unfortunately, eggs laid by these returning fish failed to produce fry in any quantity, and subsequent transplantations were much less successful. Though fish of the second native generation spawned in the rivers in 1967, apparently the 1969 runs were very poor (Ricker, 1972). Although the great majority of the Kola Peninsula transplants returned to the same general geographical region into which they were released, for the most part, they failed to reach the river in which they had been hatched.

A study of introductions of pink salmon to Newfoundland was started in 1958 and in this paper a review is given of five transplants of eyed eggs which were made in the years 1959, 1962, 1964, 1965 and 1966 and an overall assessment is made of the native generations and possible reasons for the decline in numbers. General plans for the project were prepared at the Nanaimo Station of the Fisheries Research Board of Canada. Both pink and chum salmon eggs were considered initially but pink salmon eggs were finally recommended. The exploratory phase began in 1958 with exchange of information between the

Nanaimo and St. John's Stations of the Board and an inspection tour of 13 Newfoundland rivers. North Harbour River in St. Mary's Bay was selected because of the quality and quantity of gravel, proximity to the St. John's Station and Airport, and a minimum of interference to salmon anglers because the stock of Atlantic salmon in this river is very low. In the fall of 1958 about six thousand eggs were planted to determine survival to the fry emergence stage. During the summer of 1959 an egg case suitable for air transport was designed and a small egg channel was prepared in which a quarter of a million eggs were planted in the fall. The largest transplant was 5.9 million eggs in 1966, and no eggs have been transplanted since.

Current operations at North Harbour River consist only of maintenance of stream facilities, enumeration of pink salmon and other species and collection of environmental data.

Methods

Egg transportation

Eggs were collected from mature pink salmon on the spawning grounds of three British Columbia streams (Table 1, Fig. 1), fertilized, and incubated in an hatchery to the eyed stage. The eyed eggs were shipped to Newfoundland by air freight in insulated cases with a capacity of 100,000 eggs. Two types of shipping case were used, one constructed of wooden frame and fibreglass roof insulation, and the other entirely of foam plastic. The latter was preferred because of its lighter weight. The eggs were wrapped in cheese-cloth, placed on a layer of damp moss in the trays, and kept moist with water from melting ice in the top tray. The eggs were trucked 65 miles from St. John's Airport to North Harbour River in St. Mary's Bay on the south coast of Newfoundland (Fig. 2).

Egg planting

In all these experiments the eggs were planted in North Harbour River in two controlled flow channels, Stump and Herder's, ½ mile and 2½ miles from the river mouth, respectively (Fig. 2). Because of heavy silting Stump Channel was only used in the first transplant experiment which was in 1959. Eggs were measured in an adjustable container and the actual number in every tenth measure was determined by using a Swedish egg counter (Lindroth, 1956). They were planted 8 inches deep in trenches which were dug across the channel using specially adapted, pointed shovels. The eggs were poured into a trench from an insulated bucket and covered with gravel removed in digging the next trench below. During actual planting the flow of water was reduced so that the depth of water was about 1 inch over the gravel. The rate of planting was 179-400 eggs per square foot (Blair, 1968). The channels contained screened gravel to a depth of 1 foot. Gravel sizes were ½ inch to 2 inches in diameter in Stump Channel and 3/4 inch to 3 inches in Herder's Channel.

Fry count

In the egg channels the numbers of fry were estimated by weighing in water in 200 gram lots and by actual count of the number in each tenth weighing; small quantities were counted. The trapping device in Stump Channel in 1960 consisted of a fence of wooden framework covered with wire mesh and nylon netting with two funnels leading into small removable traps (1 by 1 by 3 feet) of similar construction. The same type of fence was used in Herder's Channel in 1963 but with one additional trap. This type of trap was unsatisfactory for large numbers of fry because it was difficult to clear the trap fast enough to keep the fry from suffocating. A Wolf trap (Wolf, 1951) was used in Herder's Channel in 1965 and was very satisfactory. During 1960, 1963 and 1965 actual counts of fry were obtained by this method. To avoid handling the fry, downstream migrants in the channel in 1966, 1967, were estimated by finding the rate of survival of eggs to the fry stage in perforated aluminum or plastic containers (25 eggs each) which were buried in the gravel. This method was also used in the river during 1968-72 as a check against the mark-recapture method. Since 1969 the total numbers of fry migrants in the main river have been estimated using the mark and recapture method and the modified formula suggested by Bailey (1951). Since 1969, also individual fry in the channel were counted when they were captured in the Wolf trap.

Fry movements

Searching for fry was done from the middle of May to the end of July whenever weather permitted and at irregular intervals after July. Numbers of fry seen were estimated. Observations in North Harbour Pond were made along the shore and near the sand bars at low tide. In North Harbour Arm and St. Mary's Bay a motor boat and row boat were used to search along the shore and in the small coves. A small nylon beach seine was used for sampling juveniles.

Fry predation in North Harbour Arm

During 1963, 1965-68 two fleets of standard gill nets were fished in North Harbour Arm during May-June to catch samples of fish in the area to determine if there was any predation on pink salmon fry. A fleet consisted of 6 sections of netting each of which was 23 metres long. The mesh sizes of the sections were 38, 51, 76, 102, 127 and 140 mm between the knots when meshes were stretched. During 1963, 1965-68, 1970, random samples of Atlantic salmon smolts, trout, eels and smelt migrating downstream were taken and their stomachs examined for evidence of predation on pink salmon fry.

Adult count

Adult pink salmon entering North Harbour River were counted at a fence 400 yards upstream from the river mouth. The fence was similar to one described by Blair (1957). In nearby rivers a periodic search was made for pink salmon but in other rivers reports of sightings or captures were verified and compiled. Since 1966

commercial catches in St. Mary's Bay were recorded on forms by the fishermen. In other areas during 1966-70 fishermen were interviewed to verify reports of catches. Beginning in 1971 report forms have been distributed to fisheries officers and wardens around Newfoundland and these are returned each autumn giving details of any pink salmon taken by the commercial and angling fisheries as well as those observed in rivers other than North Harbour River.

Samples of adult returns from the commercial fishery and in the river were obtained and examined for length, weight and sex.

Hydrographic data

Water temperatures were recorded using a continuous recorder. The averages and standard deviations of the water temperatures in North Harbour River during the entire run, the 75% mode and the peak week of the run were calculated as well as the temperature in North Harbour Arm during the fry run and during the month after the fry run (Tables 2 and 3).

Other species

The numbers of species of fish other than pink salmon were counted during their downstream and upstream migrations (Tables 4 and 5).

Results

Egg to fry survivals

During 1959, 0.25 million eggs collected during September 16 to 27 from Indian River, British Columbia, were transplanted to Stump Channel, North Harbour River (Table 1, Fig. 1). The winter of 1959-60 was fairly mild and the channel was iced over only from December 20 to the last week in February. The number of fry migrating from the channel in 1960 was 0.1 million (38%). This low rate of survival was thought to be due to excessive silting in Stump Channel so this channel was not used again for incubating eggs. Eighty fry were seen at the mouth of the river on May 23 and 24. On five different occasions from May 24 to July 3 fishermen reported seeing small fish presumed to be pink fry in North Harbour Pond and Arm.

The 1962 planting of 2.5 million eggs from Glendale River into Herder's Channel produced 2.2 million fry in 1963 for a survival rate of 87%. Fry were seen by Station personnel in the mouth of the river from May 30 to June 4, in the pond from May 20 to July 7, in the arm from June 24 to July 9 and out in the bay from July 2 to July 31. On 30 sightings the total number of fry seen was estimated to be over 27,000. They were last seen on July 31 in St. Mary's Bay about 22 miles from the mouth of the river.

During 1964, 3.4 million eggs were transplanted from Lakelse River to the egg channel. These were collected from September 24 to October 11, 1964, but the transfer and planting took place between January 12 and 25, 1965, instead of in the fall because the eggs were slow in developing. On trial shipments there was a 40% mortality on November 21 and only 0.7% on December 17, whereas in the latter transfers in January it was 0.2% which is the same as occurred in previous transfers. The winter of 1964-65 was mild with considerable snow and rain with the channel covered with ice from January 25 to the last week of March. The number of fry leaving the channel in 1965 was 2.9 million or 83% of the eggs planted. Fry observations indicated a rapid movement from the river to the bay; they were seen in the lower reaches of the river May 23-27, in the pond May 24-June 18 and in the bay June 8-July 13. The total number seen in 49 sightings was estimated to be 63,000, the last being on July 13 about 30 miles from the river.

During 1965, 3.3 million eggs were planted from November 25 to December 3, the collecting period being September 14 to 24. It was a moderate winter and the channel was covered with ice from mid-December until the first week in March except for a week in mid-January. The number of fry leaving the channel in 1966 was 3.0 million or 91% of the eggs planted, the highest survival in these experiments. They were seen in the mouth of the river from May 9 to 23, in the pond from May 16 to June 11, in the arm from May 25 to June 3, and in the bay from May 26 to June 28. The estimated number in 55 sightings was 138,000.

The fifth and final transplant consisted of 5.9 million eggs in 1966. These were collected during October 31 to November 11 from Lakelse River, B.C., and planted in Herder's Channel. It was a moderate winter and the channel was frozen over from January 1 until the last week of March. The estimated number of fry leaving the channel was 4.8 million or 82% survival. In addition there were an estimated 0.3 million fry from the 1966 spawning of 638 adults in the river giving a total fry run of 5.1 million. Fry were seen in the mouth of the river during May 17-23, in the pond during May 17 to June 8, in the arm during May 19 to June 8 and in the bay from May 31 to July 17.

The egg production since 1966 has been entirely from fish spawning naturally in the river. The estimated egg deposition, based on 1600 eggs per female fish, has ranged from 4.4 million in 1967 to 0.05 million in 1972. The egg to fry survival rate has ranged from 87% from the 4.4 million eggs in 1968 to 70% from 1.2 million eggs in 1971. However, survival rates have generally been in the region of 70-80% (Table 1, Fig. 4).

Fry predation

During 1963, 1965-68 and 1970 examination of stomach contents of samples of brook trout, brown trout, smolts, eels and smelt migrating downstream in North Harbour River revealed that brook trout were feeding more heavily than the other species on pink salmon fry (Table 6) at the rate of 1 fry for every fish examined. Brown trout contained 0.29 fry per fish examined while smolts, eels and smelt were feeding to a very minor degree on pink salmon fry.

During 1963, 1965-68 a total of 9688 fish were taken in standard nets fished in North Harbour Arm. Species caught ranged in descending order of numbers were cunner, herring, flounder, sculpin, smelt, cod, skate, brook trout, tom cod, mackerel, brown trout, Atlantic salmon and wolffish. Pink salmon fry were found in stomachs of only 20 of the 9688 fish examined. The species feeding on the pink fry were 15 brook trout, which ate a total of 26 fry, 2 sculpins (2 fry), 1 cunner, 1 cod and 1 herring each had 1 fry in their stomach contents.

In addition 89 cod and 19 Atlantic salmon taken by commercial fishermen were examined and none had fry in their stomachs. Also 1010 capelin seined in North Harbour Arm were examined and none contained any fry. Thus it appears that the most serious predator of pink salmon fry are the brook trout both in the river and near the estuary.

Fry distribution

During the years when regular searching was conducted for fry in St. Mary's Bay, the pink salmon fry were observed to leave North Harbour Arm and move along the western side of the bay (Fig. 3). The fry kept close to shore and frequented the tiny coves and inlets especially those with heavy seaweed growths which possibly served them as cover and a measure of protection from predators.

Distribution of juveniles

As in the case of the fry, the juveniles tended to favor the western side of St. Mary's Bay (Fig. 4). There were reports of juveniles at Arnold's Cove in nearby Placentia Bay during August-October. A few of these were obtained and their increase in average fork length is as follows: August 21-135.0 mm, October 5-188.2 mm, October 20-192.0 mm, and October 25-213.0 mm.

Adult returns

There was only one adult return to North Harbour River from the 1959 egg transplant. From the 1962 egg transplant there were 49 adult returns of which 25 returned to North Harbour River, the remainder being all taken in St. Mary's Bay (Fig. 5, 6).

There was a total of 638 adult returns from the 1964 egg transplant, all taken in St. Mary's Bay or in rivers flowing into that bay of which 419 were recorded in North Harbour River (Fig. 6). From the 1965 transplant of 3.3 million eggs there were 8500 returns, 5334 to North Harbour River, 1187 to the commercial fishery in St. Mary's Bay, 34 to two other rivers in St. Mary's Bay and the remainder to coastal fisheries and streams mainly along the northeast coast of Newfoundland (Fig. 6). There were 3 returns from Nova Scotia and 2 from Quebec. This large return during 1967 was produced by approximately the same numbers of eggs and fry that produced only 638 returns in 1966 (Fig. 5).

From the 1966 transplant of 5.9 million eggs, the largest transplant, there were 2426 adult returns in 1968, 1353 from North Harbour River, 762 from St. Mary's Bay and the remainder from the northeast coast of Newfoundland (Fig. 6). There appeared to be far less straying during 1968 than in the previous year.

The 1969 return of 2603 adults was produced from the natural spawning of 5334 parents during 1967. This is a substantial decrease in numbers from the parent stock. The returns outside St. Mary's Bay were from the northeast and northwest coasts of Newfoundland (Fig. 6). This return produced the highest number of strays outside North Harbour River (Fig. 8). The rate of straying during other years is fairly constant except for the 1969 return (Fig. 9). The 1970 run of 2091 was produced by 1353 parents which returned to North Harbour River (Fig. 7). Since 1970 the runs have been decreasing sharply until by 1972 and 1973 the returns to North Harbour River were 58 and 60, respectively (Fig. 9, Table 1). During 1973, in addition to the returns to St. Mary's Bay and Fortune Bay, there were 6 verified reports of adult pink salmon in northern Labrador. Adult pink salmon were reported to have been angled in streams and caught in nets set for Arctic char in the Nain area of northern Labrador during the mid and late 1960's.

Length distributions

Fork lengths were obtained from adult pink salmon returning to North Harbour River and captured by commercial fishermen in St. Mary's Bay during 1964, 1966-73. There are annual variations in the fork lengths of pink salmon with a tendency towards smaller fish since 1969 the first year of return of natural progeny (Fig. 10).

Possible Causes of Decline in Numbers

In the Pacific it has been indicated by Neave (1953) and Hunter (1959) that the marine mortality of pink salmon, exclusive of fishing, lies in the magnitude of 95% although severe departures from this figure have also been observed.

Vernon (1958) showed that the best single factor for predicting the return of Fraser River pink salmon appeared to be the mean April to August seawater temperature in the lower portion of Georgia Strait. There was an inverse relationship between the mean temperature and the subsequent survival rate. The seawater temperature possibly acted indirectly through the food supply or predator distribution or through the distribution of young pink salmon in relation to these factors. It was felt that possibly hot weather and warm water along shore could cause young pink salmon to stay farther offshore where predators might take a higher toll than in years of cool weather. In an attempt to demonstrate the relationship that temperatures in North Harbour River had on the survival rates of pink salmon, the survival rates of pink salmon per 1000 fry migrating to sea during 1965-72 were fitted by a least squares regression against the average surface temperatures in North Harbour River during the entire fry run, the peak week of the run and during the 75% mode of the run. Also the survival rates during 1965-72

were fitted to the average surface temperatures in North Harbour Arm during the entire fry run and during the month after the fry run. Additionally the survival rates during 1965-72 were fitted to the average water temperatures at the surface and at 25 meters during each of the months of June and July at Station 27 near Cape Spear (Fig. 2). In each case where a regression was fitted there was no significant correlation between survival rates and water temperatures in the river, arm or in the open sea.

Henry (1961) obtained a good correlation between first-year ocean growth (as indicated by number of scale circuli) and percentage survival over six years of observation. An 11% increase in numbers of circuli corresponded with a 22% increase in survival. The survival rates of pink salmon (adults/1000 fry) during 1964, 1966-71 were plotted against the first-year ocean growth using as the bases the numbers of circuli in the entire first-sea year, the number in the first half of the first-sea year and the number in the second half of the first-sea year. In each of the three regressions there was no significant correlation between any of the indices of first-year growth and the subsequent adult returns.

Hunter (1959) found that predation was an important factor in keeping the fry output low. Coho salmon smolts, Aleutian sculpin and prickly sculpins were the most important predators because of their abundance. Vernon (1958) states that in southeastern Alaska, herring were feeding on young pink salmon and attributed the fluctuations of Fraser River pink salmon to variable predation by the large herring populations in Georgia Strait. On the premise that predation by herring and mackerel might account for some of the variation in return of pink salmon and assuming that the predation rate would be proportional to stock sizes of herring and mackerel in the area, the return rates of pink salmon for the years 1965-72 were plotted against the stock sizes of herring in the St. Mary's Bay-Placentia Bay area and against the indices of relative abundance of mackerel in St. Mary's Bay (G. H. Winters, pers. comm.). Also the return rates of pink salmon for the even years 1966-72 were plotted against the herring stock sizes. In each of the three regressions no significant correlation was found between herring or mackerel stock sizes and the return rate of pink salmon.

It seems that the most serious predator on the pink salmon fry both in the river and in the outer estuary are the brook trout since the trout migrate downstream at the same time as do the pink salmon fry. It is also highly probable that the predation rate in North Harbour Pond, between the river and the estuary, is even higher than that in the river and estuary since the brook trout do not migrate directly to sea when they leave the river but inhabit the pond for periods varying from a few days to several weeks and in such an enclosed area the pink fry predation may be considerable. In view of the pattern of distribution and migration of the pink salmon fry along the west side of St. Mary's Bay during the summer, the high predation rate of fry by brook trout and the large sea run migrations of brook trout from Big Barasway River, Little Barasway River, Red Head River, Beckford's River and most notably Branch River, it is highly possible and probable that a significant portion of the sea mortality can be attributed to the brook trout predation.

In conclusion it should be noted that although the transplant to North Harbour River is an apparent failure this does not necessarily mean that further transplants of pink salmon to the Atlantic would not be worthwhile. In the first place, the level of transplanting envisaged (10 million eggs annually for three years) was not achieved and this may be a significant reason for the failure. With such low numbers the population would not be able to recover from one or two years of low marine survivals. On the other hand, eggs were taken from the eastern Pacific and planted in the western Atlantic. It may have been more useful to have taken eggs from the western Pacific, thereby not forcing the fish into a new ocean migration pattern. Finally, subsequent distribution of pinks on the Atlantic coast immediately prior to the spawning period suggests that a river on the northeast coast of Newfoundland rather than the south coast would have proven more successful.

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Table 1. Transplants of eyed eggs of pink salmon (Oncorhynchus gorbuscha) from British Columbia to North Harbour River, Newfoundland, during 1959, 1960 and 1964-66, eggs deposited by natural spawning fish during 1966-73, fry migrants and adult returns.

Transplant No.	Eggs		Fry migrants			Adult returns			British Columbia Donor		Newfoundland Egg Channel	
	Year	No. Millions	Year	No. Millions	% of eggs	Year	North Hr. R.	Total	Stream	Lat.	North Hr. R.	Lat.
1	1959*	0.25	1960	0.10	38	1961	1	1	Indian R.	49° N	Stump	47° N
2	1962*	2.5	1963	2.15	87	1964	25	49	Glendale R.	51° N	Herder's	47° N
3	1964*	3.4	1965	2.86	83	1966	419	638	Lakelse R.	54° N	Herder's	47° N
4	1965*	3.3	1966	3.00	91	1967	5334	8500	Lakelse R.		Herder's	47° N
5	1966	*5.9 (0.3)	1967	5.10	82	1968	1353	2426	Lakelse R.		Herder's	47° N
	1967	(4.4)	1968	3.80	87	1969	1116	2603				
	1968	(1.1)	1969	0.86	76	1970	1490	2091				
	1969	(0.9)	1970	0.67	72	1971	468	624				
	1970	(1.2)	1971	0.87	70	1972	58	117				
	1971	(0.4)	1972	0.27	72	1973	60	174				
	1972	(0.05)	1973	0.04	79	1974						
	1973	(0.05)	1974	0.04	71							

*Transplanted.
( ) Deposited naturally.

Table 2. Dates of entire runs, 75% modes of runs and peak week of runs of pink salmon fry in North Harbour River during 1960, 1963 and 1965-73.

Year	Entire Run	75% of Run	Peak Week
1960	April 11-May 31	May 12-18	May 15-21
1963	May 7-June 16	May 21-25	May 19-25
1965	April 29-June 19	May 26-June 5	May 30-June 5
1966	April 30-May 31	May 16-23	May 15-21
1967	April 30-May 31	May 16-23	May 14-20
1968	April 2-May 23	May 5-11	May 5-11
1969	April 16-May 16	April 20-May 3	April 27-May 3
1970	April 9-May 10	April 24-27	April 26-May 2
1971	April 14-May 5	April 22-27	April 25-May 1
1972	April 13-May 18	May 2-6	April 30-May 6
1973	April 19-May 18	May 6-10	May 6-12

Table 3. Means and standard deviations of surface water temperatures (°C) during entire fry run, 75% mode and peak week of fry run in North Harbour River and during entire fry run and one month after fry run in North Harbour Arm.

Year	North Harbour River						North Harbour Arm			
	Entire Run		75% mode		Peak Week		Entire run		Month after Run	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
1960	8.66	4.82	12.55	2.18	11.64	1.89	6.30	1.62	10.04	1.67
1963	9.29	3.98	11.35	3.14	11.14	3.13	5.50	0.71	10.11	1.00
1965	10.85	3.18	10.33	2.22	10.70	1.69	5.34	2.21	10.38	2.55
1966	8.58	3.49	9.38	2.55	8.64	2.24	6.58	1.78	8.00	1.98
1967	7.55	2.89	8.94	2.42	8.41	2.67	4.07	1.56	7.35	3.04
1968	6.51	3.13	7.43	1.11	7.43	1.11	3.70	1.15	7.19	1.64
1969	7.54	1.85	6.71	1.31	7.55	0.66	3.13	1.32	6.56	1.75
1970	6.57	3.34	8.09	3.33	8.32	2.67	5.19	1.26	7.03	0.88
1971	7.80	2.06	7.77	1.03	6.26	1.71	5.02	0.75	8.54	1.88
1972	6.23	2.20	6.15	1.78	6.21	1.72	2.78	1.05	7.85	3.40
1973	7.55	2.19	6.86	1.26	7.73	2.05	2.51	1.13	5.92	2.00

Table 4. Downstream count of all species (except pink salmon) in North Harbour River during 1961-73.

Year	Atlantic salmon		Trout				
	Smolts	Kelts	Brook	Brown	Smelt	Alewives	Eels
1961	1495		3719	1567	26		42
1962	2708	1	2740	961	21		86
1963	1810		1799	1161	10	1	47
1964	2511		2660	807	2	1	38
1965	423	1	3275	979	7		37
1966	977		2006	478	5		193
1967	790		1431	138	11	1	1
1968	650		1298	520	4		4
1969	No Count						
1970	No Count						
1971	671		2135	1045	443		178
1972	660		2024	1421	2652	3	9
1973	648		1513	1215	654	1	84

Table 5. Upstream count of all species (except pink salmon) in North Harbour River during 1961-73.

Year	Atlantic salmon			Trout				
	Salmon	Grilse	Total	Brook	Brown	Smelt	Alewives	Eels
1961	12	17	29	3737	639	3		2
1962	22	30	52	1359	342	37		
1963	No Count							
*1964	1	1	2	18	30			
1965	No Count							
*1966	2		2	42	213			
*1967	1	1	2	22	592			
*1968	1	2	3	44	318	1		
1969	14	25	39	751	483	46	1	1
1970	6	7	13	1478	919	1	1	
1971	11	14	25	1590	1119	6		
1972	1	5	6	1299	1365	8		
1973	3	1	4	1399	1287	233	7	

*Partial counts only. Fence not in operation until beginning of pink salmon run.

Table 6. Predation on pink salmon fry in North Harbour River by brook trout, brown trout, Atlantic salmon smolts, eels and smelt during 1963, 1965-68, 1970.

Species	No. of Fish examined	No. of fish with fry	No. of fry	Av. no. of fry/fish
Brook trout	1067	87	1091	1.02
Brown trout	332	25	95	0.29
Smolts	100	5	10	0.10
Eels	173	3	4	0.02
Smelt	310	1	1	< 0.01

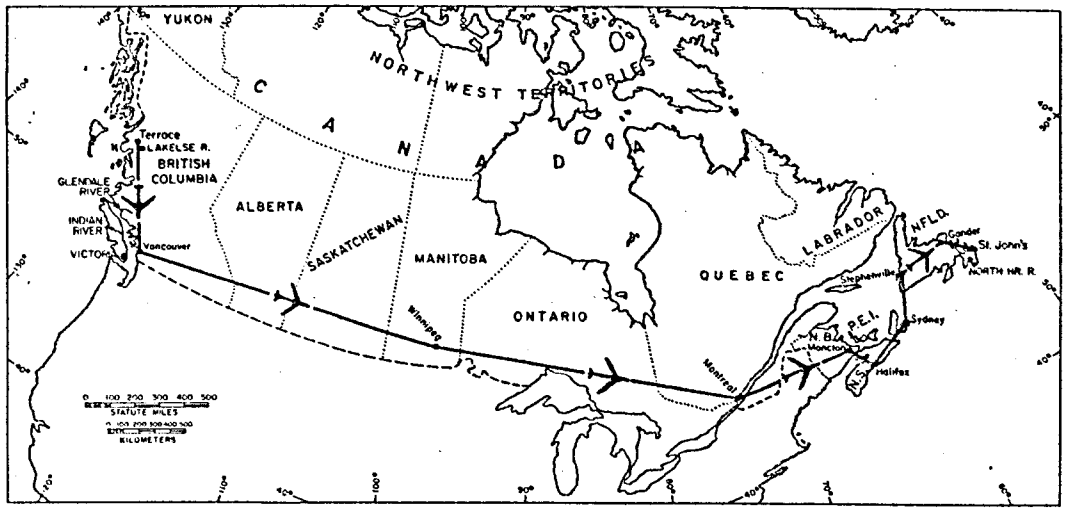

Fig. 1. Route of pink salmon eggs from British Columbia to North Harbour River, Newfoundland.

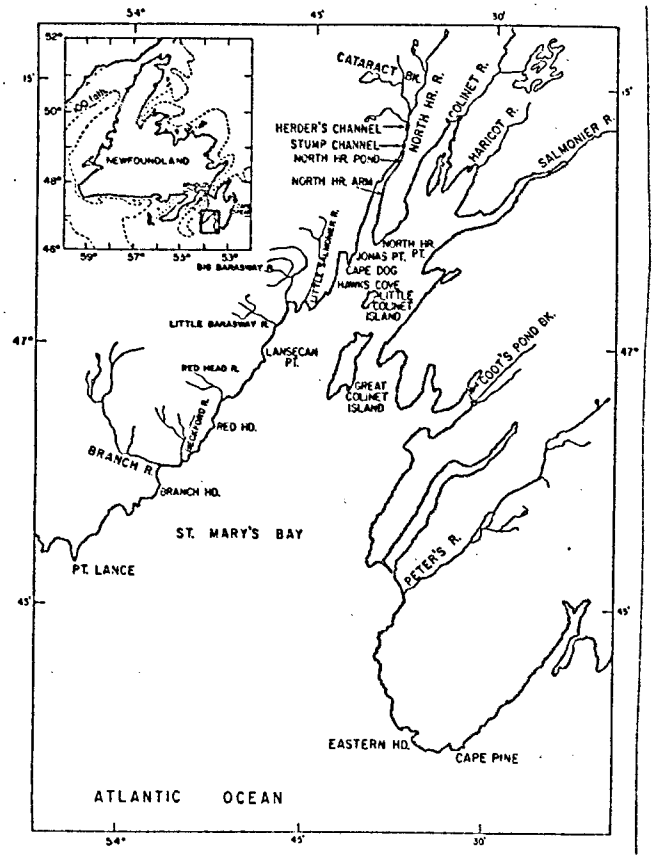

Fig. 2. Area map of St. Mary's Bay, Newfoundland, showing place names mentioned in the text.

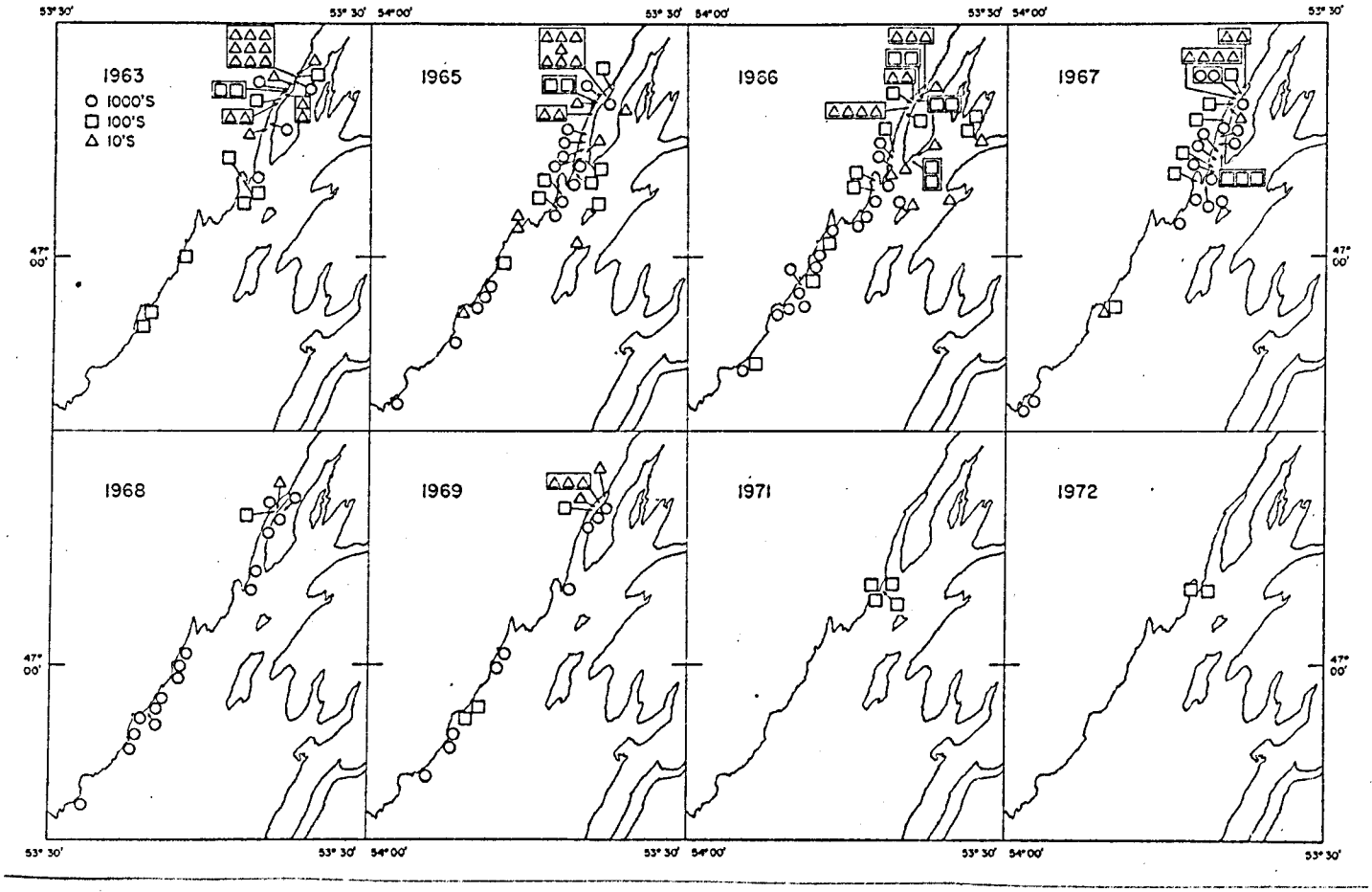

Fig. 3. Distribution and abundance of pink salmon fry in St. Mary's Bay during 1963, 1965-69, 1971-72.

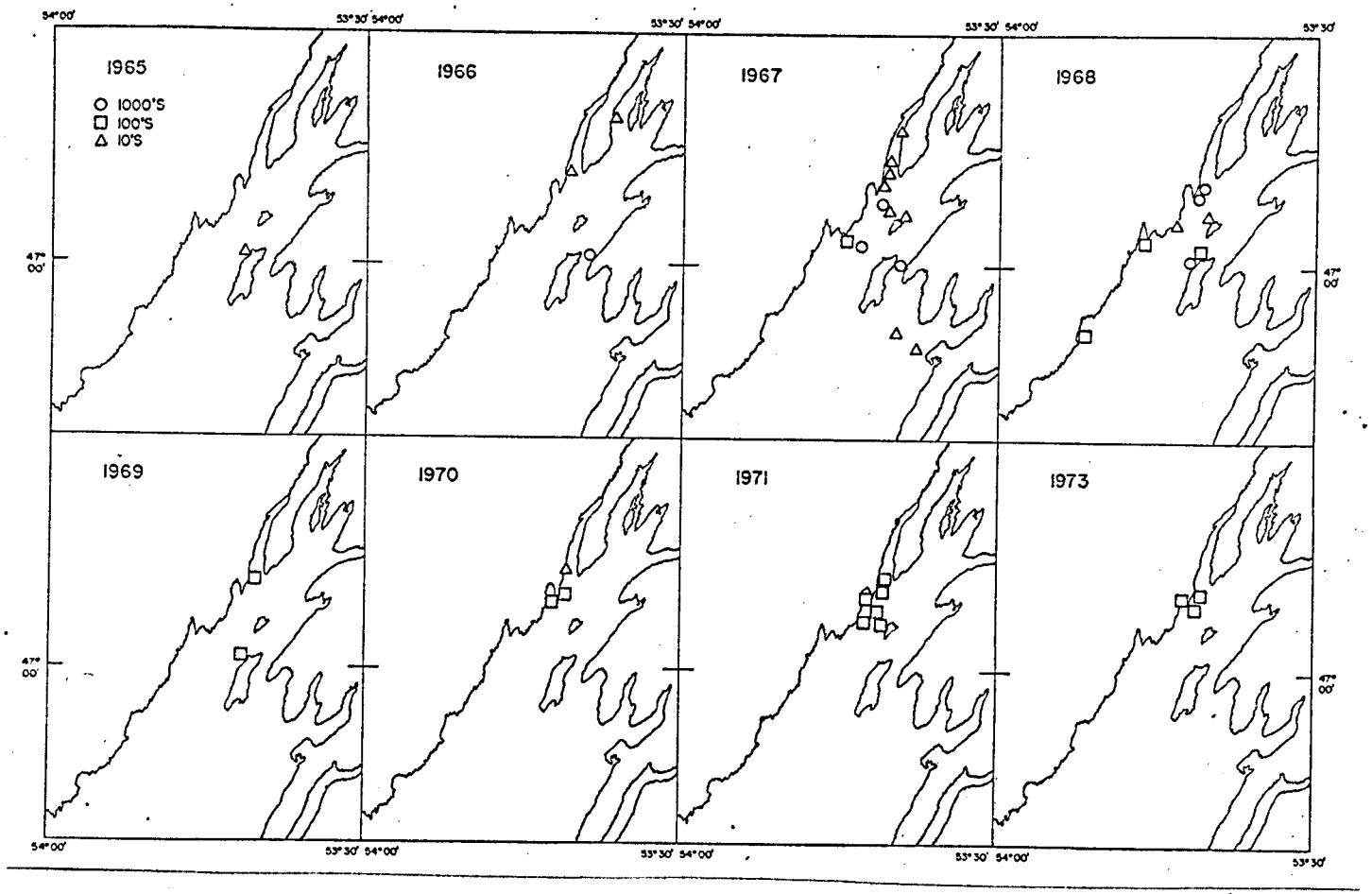

Fig. 4. Distribution and abundance of juvenile pink salmon in St. Mary's Bay during 1965-71, 1973.

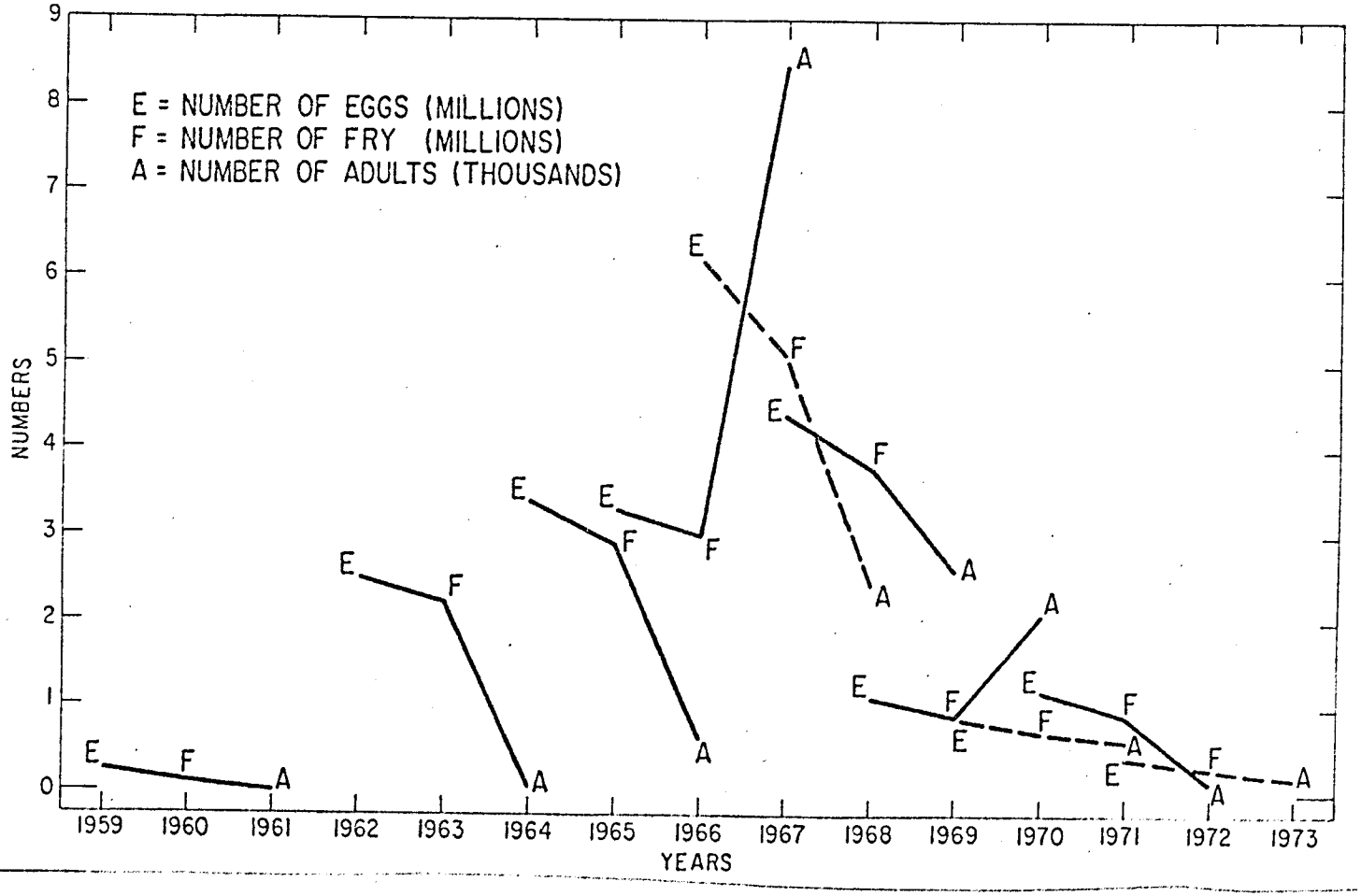

Fig. 5. Numbers of eggs, fry and subsequent total adult returns of pink salmon, 1959-73.

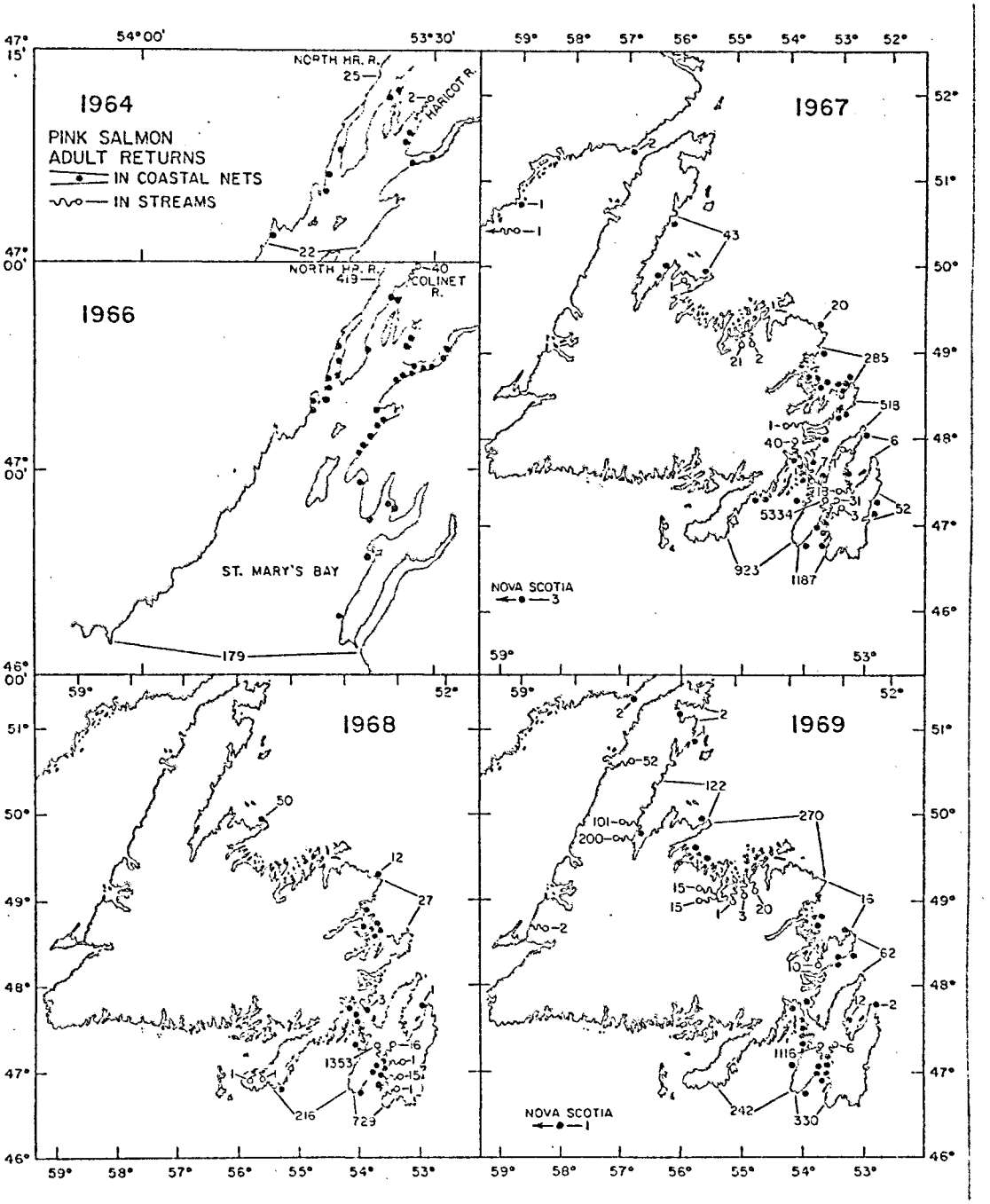

Fig. 6. Distribution of adult pink salmon during 1964, 1966-69 in North Harbour River, in coastal nets and other streams.

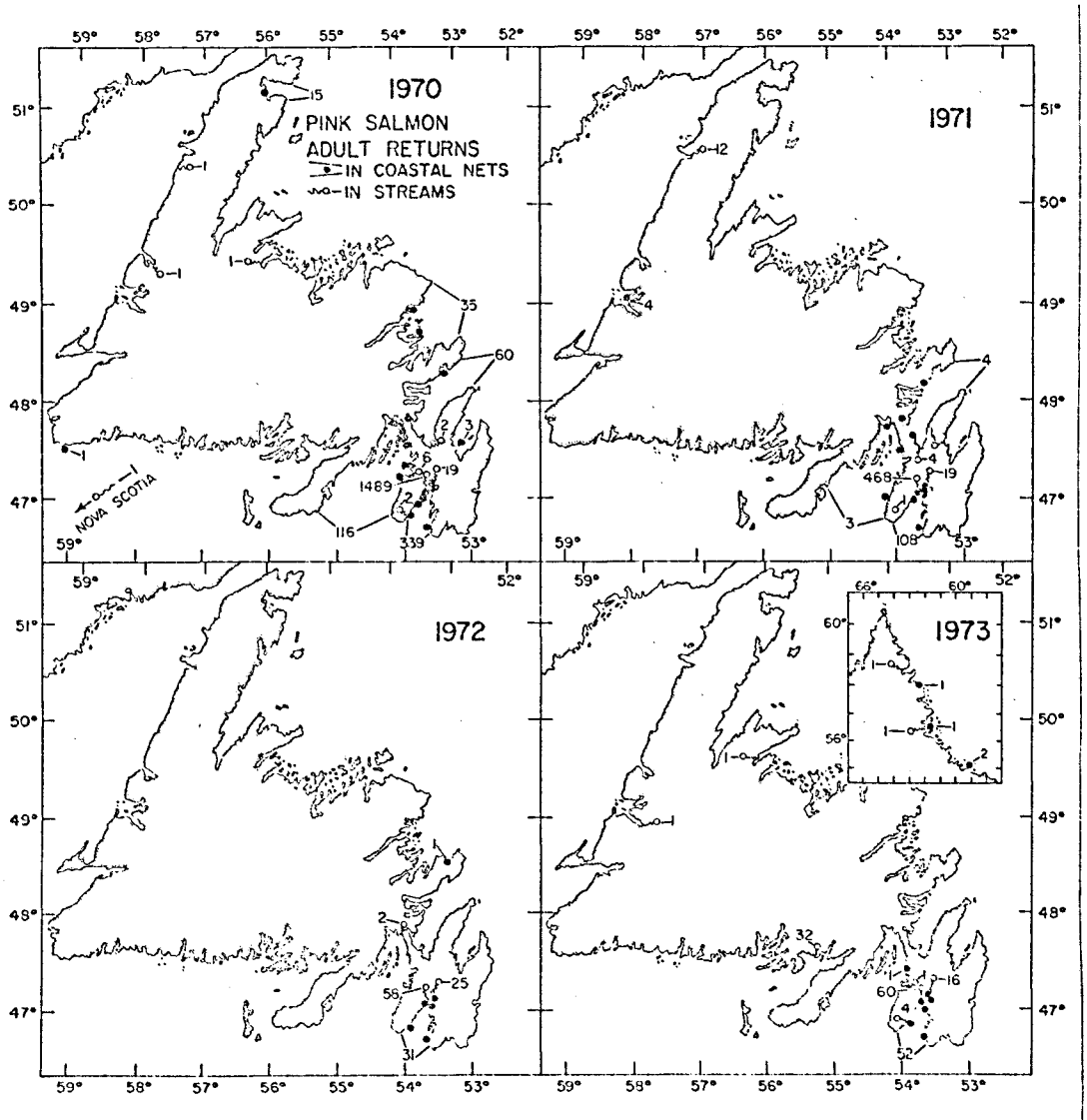

Fig. 7. Distribution of pink salmon adults during 1970-73 in North Harbour River, in coastal nets and other streams.

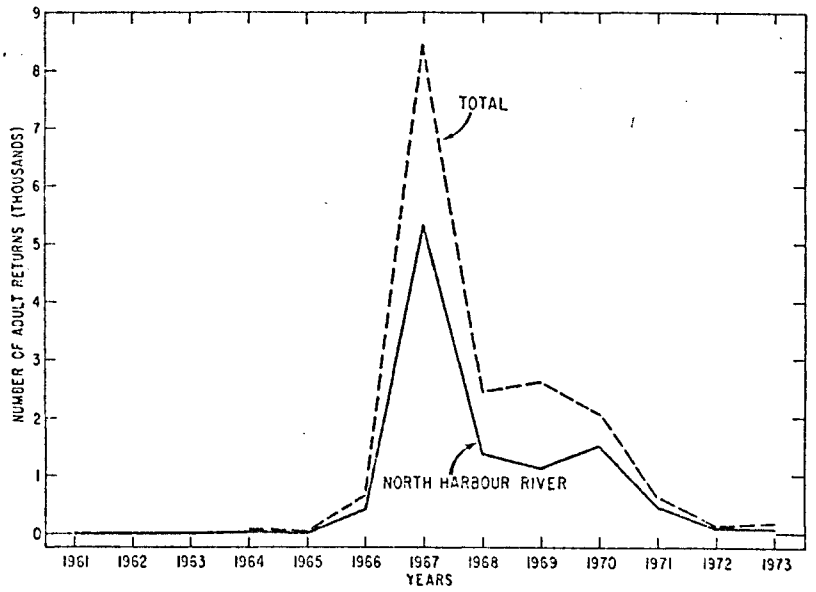

Fig. 8 Annual returns of pink salmon adults to North Harbour River (solid line) and total returns to all areas (broken line), 1961-73.

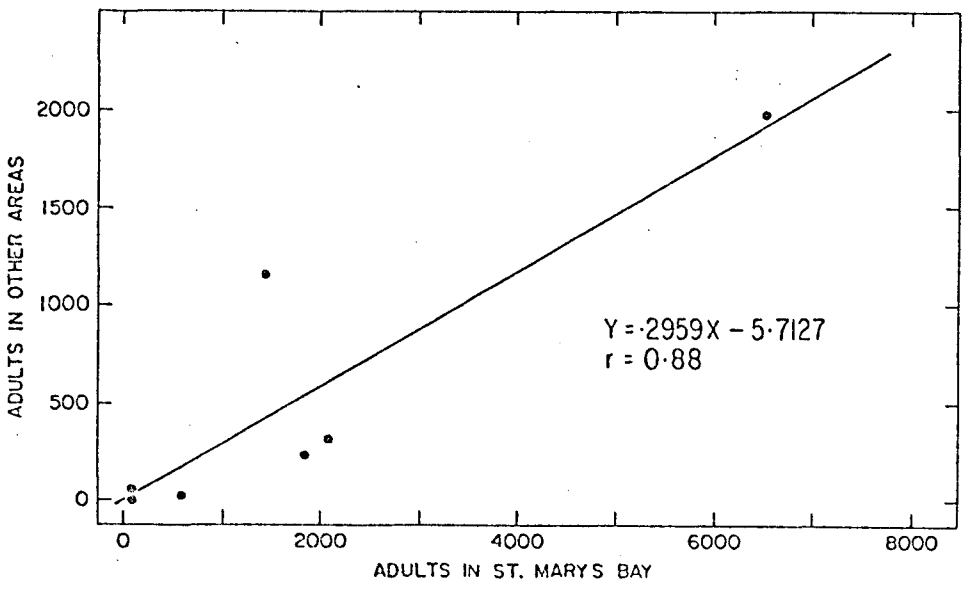

Fig. 9. Returns of pink salmon to St. Mary's Bay plotted against those reported from other areas during 1967-73.

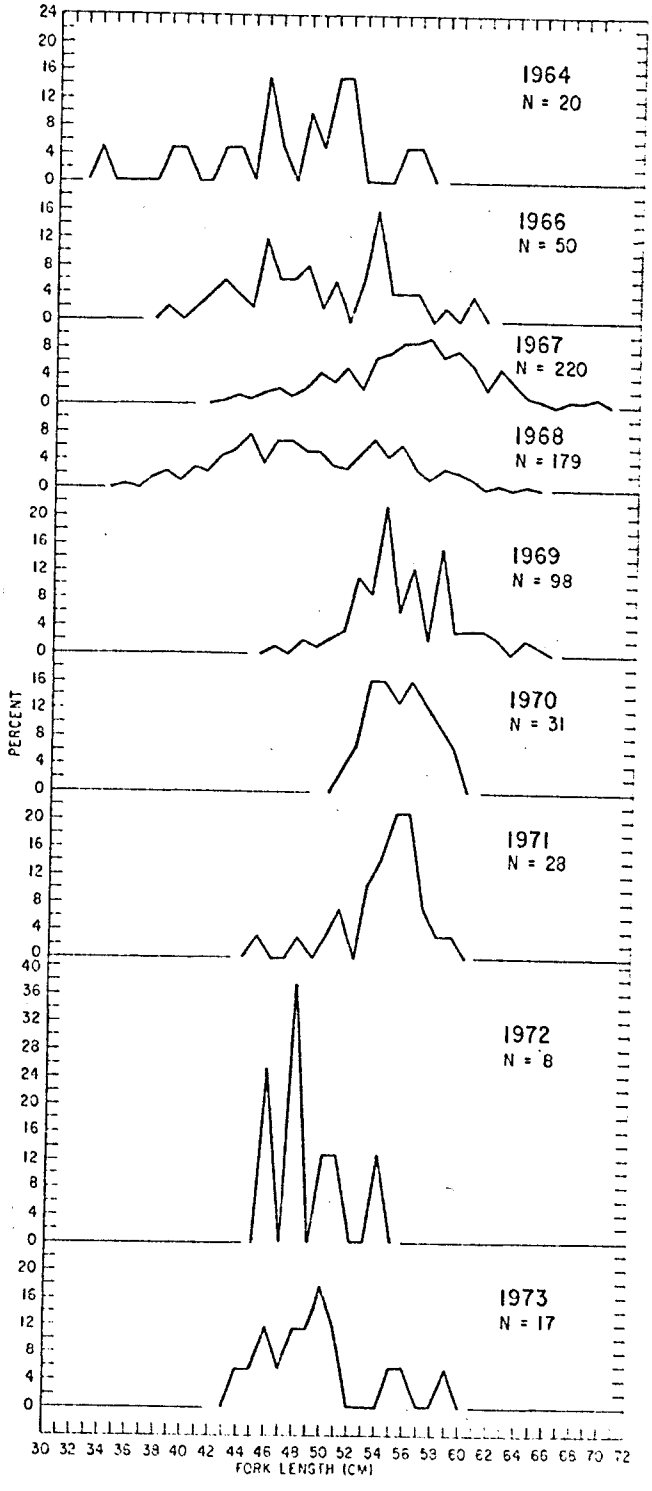

Fig. 10. Length distribution of adult pink salmon caught in commercial nets and taken in North Harbour River during 1964, 1966-73.