

321

MASS.
OC. COL

MASS.

EA31.2:E73/969-979

EXPERIMENTAL INTRODUCTION OF COHO SALMON

TO

MASSACHUSETTS COASTAL WATERS

UMASS/AMHERST
312066 0271 2686 9

Progress Report
December 1969 - June 30, 1979

EA 31.2 (E731)



GOVERNMENT DOCUMENTS
COLLECTION

JAN 04 1980

University of Massachusetts
Depository Copy

Compiled by
Kenneth E. Reback

Massachusetts Division of Marine Fisheries
100 Cambridge Street
Boston, MA 02202

PUBLICATION: #11646-22-300-11-79-C.R.

APPROVED by Alfred C. Holland, State Purchasing Agent

801/3-85

INTRODUCTION

In 1969, the Massachusetts Division of Marine Fisheries initiated an experimental program to determine the feasibility of introducing coho salmon, Oncorhynchus kisutch, to Massachusetts coastal waters. The ultimate objective of the program is to evaluate the potential of a marine recreational coho fishery within the state.

The coho was chosen for this program for several reasons. First and foremost was its reputation as an excellent game and food fish. Secondly, being an anadromous species with a finite life cycle, it is readily susceptible to management. Because of the coho's relative importance in the fisheries of the northwestern coastal states, the species has been extensively studied and its management techniques are well refined, as was demonstrated by the very successful introduction into Lake Michigan in the late 1960's. A final consideration was the fact that the coho is easily propagated and eggs readily available in quantities sufficient to support a fishery development program.

The following report summarizes the progress of the Massachusetts coho program over the past ten years. For the purpose of this report, the program has been divided into three phases: rearing and stocking; marine distribution; and, collection of spawning adults and egg procurement. Each phase of the nine year-classes is discussed individually.

A brief review of the coho salmon's life history, emphasizing differences between natural and artificially propagated populations and a description of the river system chosen for the introduction are also provided.

LIFE HISTORY

The coho salmon is indigenous to the Pacific coast of North America and like all Pacific salmon, dies after spawning. In a wild situation, the adults leave the sea during the fall and ascend their parent streams to spawn in gravel nests called redds. After hatching, the alevins remain in the gravel until their yolk sacs are absorbed, then emerge as fry. Shortly following emergence, the fry develop dark, vertical bars on their sides and are then called parr. Parr remain in freshwater until the spring of their second year when they transform into smolts and run to sea.

Cohos do not make extensive migrations at sea as do Atlantic salmon and, therefore, are not as susceptible to offshore commercial fishing pressure. They are, however, readily available to an inshore sportfishery during their marine stage. After a year and a half at sea, where they display remarkable growth, the adults return to freshwater to complete the cycle.

In an artificially propagated population, the returning adult salmon are captured and manually stripped of eggs and milt, either at the capture site or in a hatchery. The resulting juvenile salmon are hatchery reared through their entire freshwater stage. This procedure greatly increases survival of eggs and young fish and enables the biologist to control the number of salmon which enter the sportfishery. After 14-16 months the juvenile salmon, then in the late parr

and early smolt stages, are released in the selected stream and soon begin their seaward migration. After 16-18 months at sea, the fish return as adults to the stream in which they were stocked.

NORTH RIVER SYSTEM

The North River is formed by the convergence of the Indian Head River and Herring Brook. From this point it flows in an easterly direction through the towns of Hanover, Pembroke, Norwell, Marshfield, and Scituate to Massachusetts Bay (Fig. 1.). The river (Indian Head) is impounded at mile 13 by a ten-foot dam.

The stream consists of riffles and pools for approximately 1,000 yards below the dam, at which point slope and velocity decreases and stream width increases. Saltwater intrusion occurs as far inland as river mile 12 with wide daily and seasonal salinity fluctuation below this point. Stream temperatures also undergo extreme diurnal and seasonal variation, ranging from 32°F to over 80°F.

The North River basin is of high aesthetic value due to its excellent water quality and scenic nature. The shoreline of the river is characterized by woods and swamps graduating to extensive fresh and salt marshes. The marshes form an effective buffer zone between the river and the suburban development of the uplands.

The freshwater fauna of the North River system is typical of most warm water coastal streams in Massachusetts. The river is noted for its alewife and shad runs. Other anadromous species are white perch, blueback herring and lamprey eels. Some native brook trout exist in the river system. However, most salmonids are the result of stocking by the Massachusetts Division of Fisheries and Wildlife.

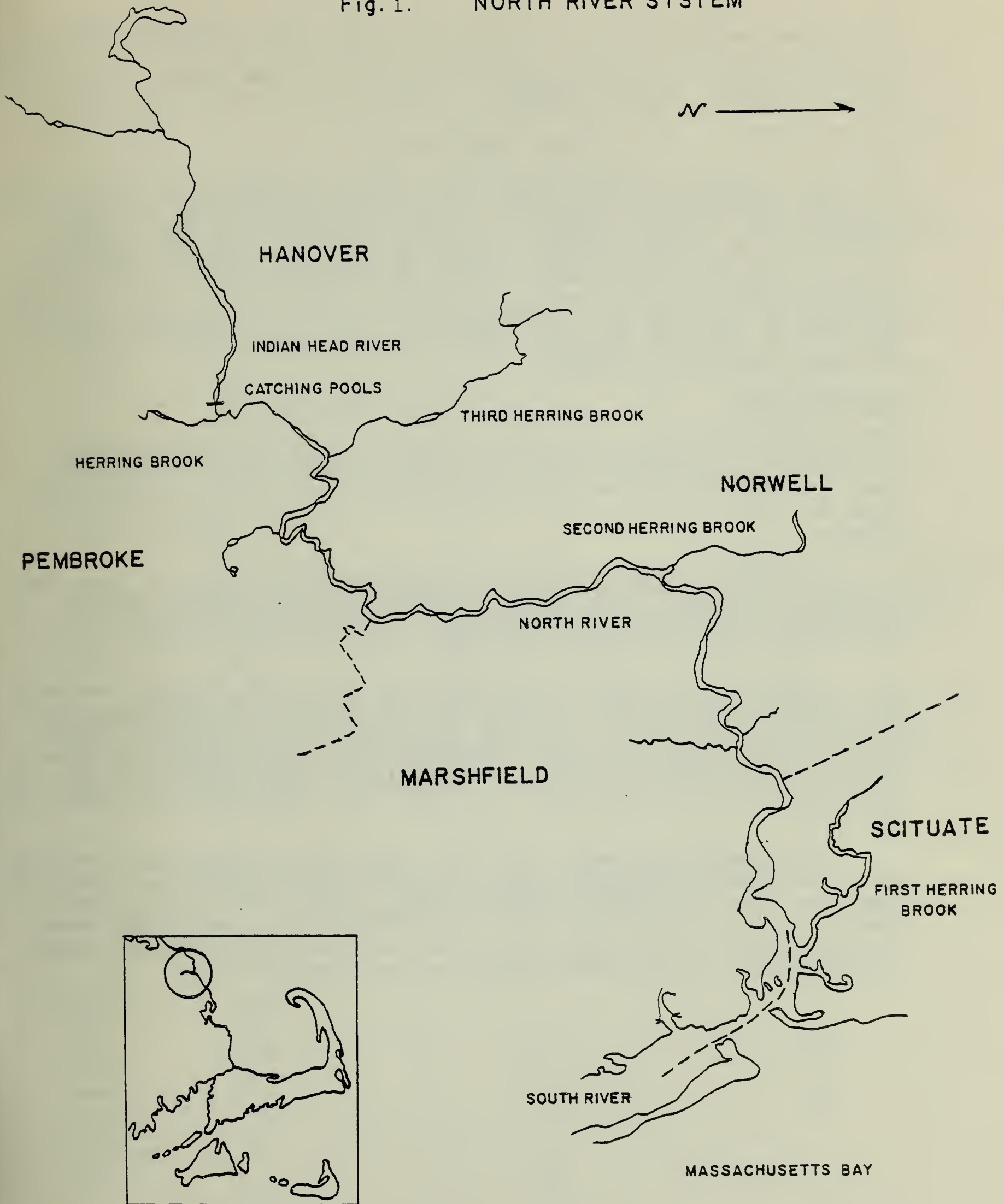
The North River was chosen for experimental coho introduction for several reasons. The water quality of the river system is suited to coho salmon during their spring smolting stage and during the spawning run in fall and winter. In summer, however, water temperatures in most areas of the river exceed the maximum at which salmon parr can survive. This in combination with a limited amount of potential coho salmon spawning area minimizes the possibility of an uncontrollable, self-perpetuating population becoming established.

Secondly, the dam on the Indian Head River provides a convenient collecting site for upstream migrants. Concrete weirs and steel fish traps have been constructed to entrap salmon for collection. The fishway at the dam is closed during the spawning run to prevent further upstream movement of the salmon.

Thirdly, the North River drains directly into the waters of Massachusetts Bay which are much colder and deeper than those south of Cape Cod. These conditions are characteristic of the coho salmon's native Pacific habitat and should facilitate the adjustment to Atlantic waters.

A further consideration in selecting the North River for coho introduction was its large estuary which could provide a sheltered location for a marine coho fishery should the experimental phase of the program meet with success. A substantial recreational fishery for striped bass presently exists in the estuary

Fig. 1. NORTH RIVER SYSTEM



and several launching ramps and a boat livery provide angler access. In addition, an important sportfishery is carried on in the waters adjacent to the mouth of the river for striped bass, bluefish, mackerel, cod, and winter flounder. The existence of these fisheries make it unnecessary to attract anglers to the area to evaluate public interest and fishery potential.

REARING AND STOCKING

One hundred thousand eyed coho salmon eggs were purchased from the Washington Department of Fisheries in 1970, 1971, and 1972. An additional 141,000 were purchased in 1974. The eggs arrived by air and were hatched and reared in Massachusetts hatcheries. The first year-class was hatched in 1970 in the Berkshire Fish Hatchery, operated by the Berkshire Chapter of the Isaac Walton League of America. The young salmon were then moved to the Division of Fisheries and Wildlife Hatchery in Palmer for final rearing. Subsequently, all coho salmon have been hatched and reared at the Palmer and Sandwich hatcheries of the Division of Fisheries and Wildlife under inter-agency agreement.

1970 Year-Class

The first shipment of 100,000 eyed coho salmon eggs from the Green River Hatchery of the state of Washington was received at Logan Airport on December 27, 1969. The eggs were set down in hatching troughs at the Berkshire Hatchery and began hatching on January 8, 1970. On April 15 the fish were moved to the Palmer Hatchery.

Fish were fed Strike Custom dry pellets, supplemented with beef liver, and Sivercup trout pellets. High mortality occurred during April and May and was attributed to the stress caused by the move from the Berkshire Hatchery. Total mortality from eyed egg to smolt was 39.0%.

During the first week in April, 1971, approximately 61,000 smolts averaging 21.6 g. (21/lb.) were stocked in the Indian Head River. River water temperature was approaching 10°C (50°F). Following stocking, schools of salmon were readily observed on quiet days, feeding at the water surface. Those examined for stomach contents contained larval and adult insects. The fish were slow to leave the river, some remaining until the last week of May, when water temperatures had reached 16°C (61°F).

Large numbers of juvenile salmon were present in the Indian Head River when the inland fishing season opened on April 17. Although the Indian Head River above Washington Street is closed to salmon fishing, it is open to augling for other species. Intense fishing pressure was noted during the first week of the season and large numbers of coho smolts were hooked and released. The mortality induced by this activity is unknown but may have been substantial.

1971 Year-Class

A second shipment of eggs was received from Washington on January 29, 1971. These eggs were hatched and reared at the Palmer Hatchery. Because of crowded conditions in the hatch house, the eggs were hatched in fifty-gallon barrels (Buss. et al 1968). Hatchery personnel encountered difficulties in cleaning the barrels and feeding fry and did not feel this was a satisfactory method for hatching and raising cohos at that facility. Approximately 10,000 eggs and fry died in the barrels. Because of late hatching, 1971 salmon were comparatively smaller than those of the 1970 year-class. However, an unusually warm fall provided additional growing time and enabled the fish to reach suitable size for stocking in the spring of 1972. Hatchery mortality from eyed egg to smolt was 35.2%.

Approximately 38,542 fish were stocked during the last week of March, 1972, while 26,000 were retained in the hatchery until May to achieve suitable size for release. Total stocking was 64,542 fish averaging 129 mm (5.07 in.) T.L. and 17.5 g. (26/lb.). Also included in this stocking were 1,300 fish held over from the previous year-class, which averaged 97.1 g. (4.7/lb.). Many of the fish from the first stocking remained in the river through April, but most had left the upper portion of the river by the middle of May when water temperatures exceeded 16°C (61°F). Smolts planted during May moved downstream almost immediately upon stocking.

1972 Year-Class

The 1972 year-class eggs arrived from Washington on December 28, 1971, and were brought to Palmer the following day. The eyed eggs were placed in hatching troughs and began hatching on January 7, 1972. Water temperatures ranged from 7°C (45°F) to 9°C (49°F) during this period. Growth was nearly identical to that of the 1970 year-class (Table 1). Hatchery mortality was 33.6%.

During the period of April 23 to May 3, 1973, 66,380 smolts were released in the Indian Head River. Average size was 22.7 g. (20/lb.) and 125 mm (4.9 in.) F.L. Water temperatures during stocking ranged from 12°C to 19°C (53°F - 66°F) and downstream movement began almost immediately. Fish were observed in the tidal portion of the river soon after stocking and a considerable distance at sea within the month.

TABLE 1.

A Weight Comparison of 1970, 1971, and 1972 Year-Class
Coho Salmon at Palmer Hatchery, Massachusetts
Division of Fisheries and Game

	<u>1970 No./lb.</u>	<u>1971 No./lb.</u>	<u>1972 No./lb.</u>
April	622		
May	332		
June	186	265	203
July	79	100	
August	51	62	60
September	39		38
October	26	43	
November		34	
December		26	
April	21	26	20

1973 Year-Class

The 1973 year-class was the first produced from eggs taken in Massachusetts. Approximately 133,000 eggs were taken at the West Elm Street collecting site from October 27 to November 28, 1972. The eggs were placed in troughs and began hatching on December 22. Water temperatures averaged 9°C (48°F). Nearly half the eggs taken during the latter part of the run had to be placed in a colder water supply 4°C (39°F). These eggs began hatching on February 18 and were not completely hatched until March 27, resulting in two distinct size classes. Approximately 76% of the green eggs hatched.

Warm water parr displayed a wide size range by June and required grading into two size classes. The fish hatched in colder water did not have a wide distribution. This eliminated the need for grading and prevented early smoltification. Mortality from green egg to smolt was 44.7%.

During the period April 22 to May 1, 1974, 73,580 smolts were stocked in the Indian Head River. Average length was 121 mm (4.75 in.) F.L. and average weight was 18.9 g. (24/lb.). River temperatures ranged from 10.0°C to 18.3°C (50°F - 56°F). The fish appeared to linger in the section of the river between Rt. 53 and the mouth of Third Herring Brook. This orientation of smolts to the Third Herring Brook area of the river may have resulted in the failure of many spawning adults to return further upstream to the catching site during the fall of 1975.

1974 Year-Class

The 1974 year-class was the second F₁ generation. Approximately 64,584 eggs averaging 0.26 g. (108/oz.) were collected from November 12 to December 12, 1973. The eggs were placed in cylindrical plexiglass hatching jars at the Sandwich Hatchery rather than in hatching troughs as was done in previous years. Hatching began on January 2, 1974, and was completed on February 4, 1974. Survival from green egg to swim-up fry was 91.6%. Total hatchery mortality, however, was 79.2%. Avian predation was responsible for much of the early losses. This was corrected by placing wire screen over the rearing pools.

On November 11, 1974, 4,426 fingerlings which had shown little growth, averaging 4.7 g. (97.5/lb.), were culled and stocked in the river to determine survival and growth under natural conditions. These fish remained in the collecting pool throughout the winter and grew to 14.7 g. (31.0/lb.) when last sampled on May 5, 1975, indicating the suitability of the Indian Head River as a nursery area during the colder months. These fish were not marked and returns could not be distinguished from those of the spring of 1975 stocking.

The 13,434 smolts stocked on May 6, 1975, averaged 138 mm (5.43 in.) F.L. and weighed 19.8 g. (23.0/lb.). Water temperature was 12.2°C (54°F). Downstream migration began almost immediately due to rapidly rising stream temperatures and salmon were observed near the mouth of the river on May 18, 1975.

1975 Year-Class

Because of poor adult return, no eggs were taken in 1974, and it was necessary to purchase eyed eggs from the state of Washington. Approximately 141,000 eggs were received on January 27, 1975, and were placed in plexiglass hatching jars at the Sandwich Hatchery. Water temperature was 9.5°C (49°F). Hatching began on February 3 and was completed on February 7, 1975. Survival from eyed egg to swim-up fry was 92.9% or 131,684 fry.

Sixty-five thousand fry were transferred to the Palmer Hatchery during the latter part of March to provide a comparison of the coho salmon rearing capabilities of the two facilities. Although recorded mortality by actual pick-up of dead fry was normal at both hatcheries, substantial unrecorded losses occurred during the summer at both Palmer and Sandwich. These are thought to have been caused by avian predation. Also, a water supply failure resulted in the loss of an additional 8,000 fry at Palmer.

Differential growth rates were observed at the hatcheries. On July 8, 1975, the fry at Sandwich weighed 4.3 g. (104.5/lb.) while Palmer's fry averaged 7.8 g. (58.9/lb.). Similar growth rates were maintained until late fall when the Palmer fish stopped feeding because of low water temperatures. During the period from November, 1, 1975, to February 1, 1976, average size at Palmer dropped from 16.2 g. (28.0/lb.) to 13.4 g. (33.8/lb.). During the same period salmon at Sandwich increased from 9.7 g. (47.0/lb.) to 15.9 g. (28.6/lb.).

The Sandwich Hatchery derives its water from a gravel-packed well system which maintains a nearly constant temperature of approximately 10°C (50°F). In contrast, Palmer is dependent on surface waters and temperatures fluctuate from 0°C (32°F) to 17°C (64°F).

During the period from March 29 to April 1, 1976, 48,132 salmon were stocked. Fish taken from the Palmer Hatchery averaged 17.0 g. (25.3/lb.) in weight and 115.2 mm (4.5 lb.) F.L. in length, while Sandwich fish weighed 19.6 g. (23.1/lb.) and averaged 123.9 mm (4.8 in) F.L. in length. Total mortality from eyed egg to smolt was 65.9%.

The salmon smolts were stocked in the impoundment above Elm Street on the Indian Head River. The impoundment was chosen over the catching pool stocking site in order to delay downstream migration and improve imprinting to the Indian Head River. The stocking date was earlier than in past years for the same reason.

In contrast to the 1971 stocking when the fish were also released prior to opening day of trout season, mortality due to incidental sportfish catches was minimal. This can be attributed to the relatively small size of the salmon and increased angler awareness of the coho program.

Water temperature during the stocking period ranged from 8.6°C (47.5°F) to 11.1°C (52.0°F) in the impoundment and 8.3°C (47.0°F) to 10.5°C (51.0°F) in the stream below the dam. While some fish immediately dropped over the dam, probably due to disorientation, the majority either remained in the impoundment or moved upstream as far as the next dam. No definite downstream migration was noted until April 19, 1976, when surface water temperature reached 19.5°C (67°F). Salmon were last observed in the river on May 20, 1976.

1976 Year-Class

A total of 16,071 green eggs were taken from the returning 1973 year-class during the period October 28 to December 9, 1975. Hatching success was 41.1%. On April 30, 1976, 6,555 fry remained in the hatchery at an average weight of 1.6 g. (316/lb.). By September 30, 1976, the salmon had grown to an average of 12.9 g. (35/lb.). Total mortality from green egg to stocking was 71.5%. This high loss occurred mainly in the egg stage, probably due to poor fertilization. Mortality from hatch to stocking was 32.4%.

On April 1, 1977, 4,462 smolts were released into the impoundment at Elm Street. Surface water temperature was 12°C (53°F) at the time of stocking. The fish averaged 20.9 g. (21.7/lb.) in weight and 127.6 mm (5 in.) in length. An additional 113 smolts were stocked on May 18 when water temperature was 68°F (20°C).

1977 Year-Class

The 1977 year-class was the second F₂ generation produced in the program. The returning 1974 year-class provided 107,892 green eggs during the fall of 1976. Egg taking began on October 27, 1976, and was not completed until January 27, 1977.

The eggs were placed in hatching jars at the Sandwich Hatchery. Incubation time was approximately 43 days at 49°F (9.5°C). Hatching success was 84%, resulting in 90,629 swim-up fry.

Due to the extended egg taking period, a wide size range of fry developed. By the end of July 1977, average weights ranged from 1.9 g. (244/lb.) to 6.4 g. (70.5/lb.). This size variation required grading and separation into four size groups to avoid cannibalism.

On April 7, 10, and 11 of 1978, 30,269 presmolts were released in the West Elm Street impoundment. Surface water temperatures at the release site ranged from 6.1°C (43°F) to 11.1°C (52°F). Numbers and sizes of the coho at time of release were:

<u>No.</u>	<u>Ave. Wt.</u>	<u>Ave. F.L. (mm)</u>
9,214	26.8g (17/lb.)	130.9 (5.1 in.)
8,528	19.5g (23/lb.)	125.2 (4.9 in.)
10,716	18.6g (24/lb.)	121.9 (4.8 in.)
1,811	13.2g (34/lb.)	110.5 (4.4 in.)

Total hatchery mortality from green egg to release was 71.8%. This high loss is believed to have been caused to a large extent by bird predation during spring and early summer.

Location of the young salmon within the river was monitored. A general upstream movement was noted during the first week after release. By the latter part of May, the cohos left the upper river and were most concentrated in the estuarine portion of the river. The salmon had left the system entirely by early June.

1978 Year-Class

A total of 107,822 green eggs were obtained from the returning adults of the 1975 year-class. Eggs were taken from November 4, 1977 to December 27, 1977. The eggs were placed in plexiglass hatching jars at the Sandwich Hatchery. Hatching success was 60.4%. This poor hatch was believed due to crowding of adults being held for ripening. The fish being held were also subject to harrassment in the form of snagging and spearing, further increasing stress and causing ovary damage in some cases.

The 65,120 fry comprising this F₁ generation exhibited a wide variation in growth rate. By mid-June 1978 two distinct size groups had formed. The larger cohos weighed 3.6 g. (126/lb.) while the remainder were 2.1 g. (215/lb.) or smaller. This growth differential continued and by September 1, 1978, the finger-

lings were graded into four groups averaging 31.8 g. (14.3/lb.), 20.4 g. (22.4/lb.), 9.5 g. (48.2/lb.) and 6.4 g. (71.0/lb.). During the following winter the larger fish lost their parr marks and appeared to have completely smolted. Prior to stocking, 2,377 of these large smolts, averaging approximately 3.0/lb., were marked with a right pelvic fin clip to determine any return rate differences between these and the smaller cohos.

A total of 46,436 salmon were stocked in the West Elm Street impoundment April 4-11, 1979. Surface water temperatures ranged from 5.6°C (42°F) to 8.9°C (48°F). Average weight of 43,179 cohos was 30.4 g. (14.9/lb.) and average length was 143.2 mm (5.6 in.) F.L. An additional 3,257 exceptionally large smolts weighed 156.4 g. (2.9/lb.) and average length was 249.9 mm (9.8 in.) F.L. Hatchery mortality from green egg to release was 57%. Considering the low hatching success, this indicates a considerable increase in survival of fry and fingerlings at least in part due to modification of raceway netting and resulting decrease in bird predation. River distribution of these fish followed a pattern much like that of the previous year-class. There was an initial downstream/upstream dispersement followed by a general downstream movement during early May. The young salmon lingered in the estuarine area until June.

Incidental sportfish catch mortality during the first two weeks was high due to the unusually large size of this year-class. Many large smolts were mistaken for stocked rainbow trout and retained by fishermen. Loss of the large, fin clipped smolts was estimated at 300.

DISCUSSION

Nine year-classes of coho salmon have been raised in Massachusetts hatcheries. Successful culture of cohos is possible using standard hatchery techniques and facilities. Abnormally high hatchery mortality in the 1974 and 1975 year-classes is attributed to excessive avian predation and was corrected by placing netting over rearing pools. The high losses in the 1976 year-class was largely due to poor fertilization of eggs taken from hatchery ripened females. A high fertilization rate was regained the following year when adults were held in the spawning stream for ripening.

Smolting cohos were stocked at average weights ranging from 17.5 g. (26.0/lb.) to 30.4 g. (14.9/lb.). Stocking of the year-classes was carried on from the last week in March to the second week in May depending on when a suitable average size was reached. Surface water temperatures during stocking ranged from 5.6°C (42.0°F) to 19°C (66.0°F). The cohos consistently left the river system by mid-June.

Juvenile salmon of the first four year-classes were stocked in the stream and catching pools at the base of the Elm Street dam. These fish moved downstream almost immediately and may have imprinted to some extent on tributary streams, resulting in spawning runs in these tributaries. To correct this, subsequent stocking was done in the impoundment above the dam and at earlier dates. Fish released in this manner remained in the upper sections of the river for up to a month and initial results indicate greatly improved imprinting on the Indian Head River.

MARINE DISTRIBUTION

Catch report cards were distributed to coastal bait and tackle shops to obtain information concerning the catch and marine distribution of coho salmon. Although there are many drawbacks to a voluntary catch report system, it does provide information at minimum expense and effort. When possible, reports were followed up and verified by Division biologists. Unconfirmed reports, although not used, tended to reinforce the data.

1970 Year-Class

During the summer of 1971, juvenile salmon were observed in the Merrimack River estuary and began appearing in anglers' catches. One fish bearing the Massachusetts fin clip (right pelvic) was seined from the mouth of the river by project personnel. The fish measured 320 mm (12.6 in.) T.L., and was captured along with several New Hampshire fish*. Other returns from the Piscataqua River, New Hampshire, indicated a northward movement after entering saltwater.

The first indication of successful imprinting and ocean survival was the return of ten "jacks" or precocious male salmon to the stocking site. These fish averaged 360 mm (14.2 in.) T.L., and were seined from the collecting pools by project personnel from October 12 through November 4, 1971.

Maturing coho salmon began to appear in catches during late June, 1972, from Cape Cod to New Hampshire. One verified catch on June 25, 1972, at the entrance to Old Harbor Creek, Sandwich, measured 550 mm (21.7 in.) T.L., and weighed 1.5 kg. (3.3 lbs.). Most of the salmon were caught incidentally by mackerel or striped bass fishermen.

The greatest number of reports (36) came from the Merrimack River area, mostly during July and August. Twenty-two of these were reported to have the New Hampshire adipose fin clip, thirteen were of unknown origin, and one was reported to have the Massachusetts right pelvic clip. Two salmon were caught in fish traps off Marblehead in September, one of which had a right pelvic clip. Two fish were also reported from the Jones River area, Kingston, in June and September.

In the North River itself, six confirmed catches were made during the period July to November. The fish ranged in size from three to eleven and one-half pounds.

1971 Year-Class

The juvenile fish appeared to follow the same general movement pattern as those of the 1970 year-class. One marked fish was observed in the catch of commercial bait seiners in the Merrimack River on July 31, 1972, and measured 363 mm (14.3 in.) T.L.

Thirteen jacks were captured by seining at the stocking site between October 2, 1972, and January 3, 1973. The fish averaged 322 mm (12.7 in.) F.L. and 0.37 kg. (0.8 lbs.).

During June, 1973, eight coho salmon were caught in the Swampscott fish traps. These included 1971 and 1972 year-class fish, reported by the trap operator to measure 6-20 inches. A single fish reported to weigh six pounds was taken in the same trap on July 5.

*In 1967 New Hampshire initiated an experimental coho salmon introduction in the Lamprey River.

Maturing fish appeared in anglers' catches during the first week of July in Cape Cod Bay. Four fish weighing 4-8 pounds were reported from the Sandwich area from July 2-5. A single 5½ lb. coho was reported from the Kingston area on September 22.

A total of eighteen salmon were reported caught in the North River from July 4 to December 2, 1973. Most of the fish were caught at or near the mouth of the river during September and October, and weighed in at local marinas. The average weight reported was 6½ pounds, with a range of 4-8½ pounds. The increased sportfish catch was undoubtedly due to the fact that some anglers were fishing specifically for salmon with some success. During the latter part of the run, a limited fly fishery developed in the upper portion of the river.

1972 Year-Class

Shortly after the 1973 stocking, juvenile salmon began to appear in commercial catches. A total of fourteen fish ranging from 165-256 mm T.L. were taken in Provincetown fish traps from May 16-20. A single fish reported as measuring 10 inches was taken in a Swampscott trap on July 2.

No jacks were captured during the fall of 1973. Maturing coho salmon again appeared in anglers' catches during July, 1974. Early season catches weighed from 2.2 - 4.1 kg. (4.8 - 9.0 lbs.). The area of reported marine sportfish catches was from Plum Island Beach to Duxbury Bay.

Six salmon were known to be caught by anglers in the North River from October 5 to November 23, 1974. Average weight was 3.2 kg. (7.0 lbs.). These fish were caught in the upper reaches of the river.

Evidence of predation was noted in returning adults. Pronounced scars occurred in 38% of the fish. Although speculative, it is believed that high mortality during the marine stage was caused by severe bluefish predation. Abnormally large concentrations of bluefish, Pomatomus saltrix, were present in the waters from Cape Cod to New Hampshire during the summer months of 1974.

1973 Year-Class

Young coho salmon began to appear in commercial catches in June, 1974. A fish trap operator working in the mouth of the Merrimack River reported catching nine salmon in June, three in July, and in August found what he thought to be coho remains in nearly all the bluefish that he cleaned. No jacks were taken during the fall of 1974.

Three unconfirmed reports of maturing coho salmon being caught in the Plum Island area by commercial gill netters and fish trap operators were received between June 25 and August 25, 1975. The first confirmed catch was received on August 26, 1975, when a 3.1 kg. (6.75 lb.) male was caught in the mouth of the North River. Another confirmed catch from the same area was a female weighing 3.6 kg (8.0 lb.) caught on October 10, 1975. One coho weighing 8 or 9 pounds was reported from the mouth of the Third Herring Brook in November of 1975.

1974 Year-Class

Juvenile coho salmon began to appear in commercial fishing gear in early July, 1975, in the Newburyport area. One bait dealer reported that two unmarked juvenile salmon were seined and released on July 5, 1975. No jacks were captured in the North River during the fall of 1975.

Only two catches of mature cohos were confirmed. A coho weighing between five and six pounds was taken on July 4 by a mackerel fisherman three miles off Plymouth. The second confirmed catch was a four pound male taken in Third Herring Brook on March 12, 1977.

1975 Year-Class

Only three angler catches of this year-class were reported during the summer of 1976. All were taken during the month of July and weighed one pound or less. Two were taken at the mouth of the Merrimack River and one at East Point, Nahant. Twenty-four jacks were recaptured in the Indian Head River during the fall of 1976.

Adult fish first appeared in May of 1977 when five cohos were reported taken in fish traps on the west side of Monomoy Island. Two cohos were taken on May 16 in a trap off Newport, Rhode Island. These fish were both males and weighed 2.5 and 4.0 lbs. On June 19, a 4 pound salmon was taken at the mouth of Scorton Creek, Sandwich, and on June 28 a coho weighing 3 pounds gutted was caught in the North River approximately $\frac{1}{2}$ mile upstream from the mouth. A 5 lb. 6 oz. coho was reported taken in a gill net located two miles south of the North River on July 4. On August 21 a 4 pound salmon was caught in the North River, west of Route 3A.

Two cohos were taken by anglers during the month of November. The first was caught in the Indian Head River on November 11 and weighed $7\frac{1}{2}$ lbs. The second was taken on November 12 in the Jones River, Kingston. This coho, which weighed 9 lbs. indicated that some spawning adults may be straying into the Jones River. The subsequent discovery of several cohos in a Jones River tributary confirmed this.

1976 Year-Class

No coho catches were reported during the summer of 1977. In November of 1977, three cohos were captured by anglers fishing for smelt in the Winthrop-Dorchester area of Boston Harbor. These fish were reported to be 13 to 15 inches in length. Two jacks were taken by Division personnel during the fall of 1977.

Two cohos taken during the summer of 1978 were identified by Connecticut state biologists. Both fish were captured in July and weighed 4-6 lbs. One was taken at Watch Hill, Rhode Island, and the other off Mystic, Connecticut. It was reported that many unconfirmed coho catches had been made in this area.

In 1978 two angler catches were reported from the North River area. A 5 pound coho was taken at the mouth of the river on August 8 and, on October 15, a mature male of unknown size was captured by an angler in the Indian Head River.

DISCUSSION

Catch reports indicated that, in general, juvenile fish moved northward upon leaving the river and spent their first summer in the waters off the Merrimack River area. During their second summer, the maturing fish tended to disperse throughout Cape Cod and Massachusetts Bay and became concentrated near the mouth of the North River as summer ended.

For several reasons, catch reports did not provide a basis for a comprehensive analysis of marine distribution. Difficulties in distinguishing Massachusetts cohos from those of New Hampshire, especially during the first summer, negated the value of many reports. In addition, the fact that New Hampshire requires a license to take coho salmon may have discouraged reporting of incidental catches by anglers fishing in waters adjacent to that state.

The number of catch reports received declined rapidly after the first two years (Table 2.). This may be attributed to a decrease in numbers of salmon available to the fishery due to unusually severe predation by bluefish. A similar reduction in spawning run recaptures for the 1972 and 1973 year-classes supports this hypothesis. Catch reports did not increase for the 1974 year-class despite a large spawning run return. It is believed that poor survival of the previous two year-classes caused a decline in public interest in the program and discontinuance of the small fishery specific to cohos which had developed within the river.

In order to adequately assess marine distribution of Massachusetts coho, it is necessary to increase the number of fish available to the fishery and to renew public awareness and interest in the program. This in combination with more extensive fish marking to insure proper identification of origin should provide sufficient data through the voluntary catch report method.

Table 2. Results of coho salmon program - December, 1969 - June 1979.

Year-Class	Eggs	% Hatchery Mortality	Stocked	Confirmed Sportfish Catches	Spawning and Recaptures	Total Recaptures	% Total Recaptures
1970	100,000*	39.0	61,000 (Spring 1971)	12	179 (Fall 1972) 10 jacks (Fall 1971)	201	0.33
1971	100,000*	35.2	64,542 (Spring 1972)	23	134 (Fall 1973) 13 jacks (Fall 1972)	170	0.28
1972	100,000*	33.6	66,380 (Spring 1973)	6	8 (Fall 1974)	14	0.02
1973 _{F1}	133,000	44.7	73,580 (Spring 1974)	3	45 (Fall 1975)	48	0.06
1974 _{F1}	64,584	79.2	4,426 (Fall 1974) 3,434 (Spring 1975)	2	124 (Fall 1976)	126	0.70
1975	141,000*	65.9	48,132 (Spring 1976)	8	187 (Fall 1977) 24 jacks (Fall 1976)	219	0.45
1976 _{F2}	16,071	71.5	4,575 (Spring 1977)	7	18 (Fall 1978) 2 jacks (Fall 1977)	27	0.59
1977 _{F2}	107,892	71.8	30,269 (Spring 1978)		2 jacks (Fall 1978)		
1978 _{F1}	107,882	57.0	46,435 (Spring 1979)				
1979 _{F3}	24,836						

*Eyed eggs from ...

COLLECTION OF SPAWNING ADULTS AND PROCUREMENT OF EGGS

An important aspect of the project is monitoring adult returns and determining the feasibility of utilizing these fish as a source of eggs. To do this, adult salmon were netted from the collecting pool on the Indian Head River with a 90 foot haul seine. Also, some adults were collected from other parts of the river system using a battery-powered 110-volt AC back-pack electroshocker. The fish were weighed to the nearest .01 kg. with a Chatillon autopsy scale and measured to the nearest millimeter, fork length, and total length on a standard measuring board.

Eggs from ripe females were stripped into stainless steel pans, using the incision method (Leitritz, 1969) and fertilized immediately. Care was taken to avoid exposing eggs to direct sunlight. The water-hardened eggs were placed in plastic bags inflated with oxygen and transported to the hatchery in insulated boxes. During the fall of 1975, the adult salmon were brought directly back to the Sandwich Hatchery and were either spawned or held for ripening.

Tissue samples were analyzed at the Division's Cat Cove Marine Laboratory for mercury, by flameless atomic absorption; and pesticides, by gas chromatography.

Condition or k-factors were determined using a program developed by the Massachusetts Cooperative Fisheries Unit (Mawson and Reed, 1970).

1970 Year-Class

The first adult salmon captured by Division personnel was taken on September 21, 1972. A few salmon returned during early October, but the peak of the run was from October 26 to November 28. During this period, water temperatures ranged from 4° to 15°C (39° - 59°F). Fish appeared to move into catching pools during periods of high stream discharge. Many fish were observed in the pools during the first week in December but could not be captured due to extremely high water. Sampling was resumed on December 12 but the fish were no longer present. Water temperatures ranged from 2° to 3°C (35° - 38°F) during this period.

During the first half of January, 34 fish were electroshocked in shallow stream areas of the river system. Most of these fish were spent and in various stages of deterioration.

A total of 179 adults were collected during the spawning run. Including jacks and verified sportfish catches, this represents a return of 0.33% of the fish stocked. This does not reflect total survival however, because many unverified catch reports were received and some fish were undoubtedly missed during sampling.

Although the return rate was low in comparison to native Pacific populations which can exceed 5%, more than enough adults in ripe spawning conditions were captured to duplicate the original smolt stocking. A total of 133,000 eggs were taken.

Average fork length (Table 3.) was 50 mm less than that of the parent stock at Green River Hatchery in 1969 (Senn and Satterthwaite, 1971), but 21 mm greater than the average reported for Puget Sound hatcheries in 1968 (Senn, 1969).

A limited sportfishery for spawning run cohos developed within the river. Generally, anglers considered these fish to be of good sporting quality.

A sample of fish were examined for concentrations of mercury and pesticides. Mercury was present in muscle tissues but did not exceed federally established limit for food fish (0.5 ppm). Pesticide levels, especially in the edible portions of the fish, were low and probably of little concern to the consumer (Table 4).

Table 3. Average Length, Weight, and Condition (K-factor) of Coho Salmon Prior to Spawning; North River, Massachusetts 1972-1976

	<u>Female</u>	<u>Male</u>	<u>Total</u>
	74	69	143
	632	650	641 (25.2 in.)
1970 Year-Class	663	687	674 (26.6 in.)
	2.80	2.97	2.88 (6.34 lb.)
	1.11	1.04	1.08
	22	49	71
	644	672	664 (26.1 in.)
1971 Year-Class	680	708	699 (27.3 in.)
	2.94	3.21	3.12 (6.90 lb.)
	1.08	1.02	1.04
	1	7	8
	562	695	678 (26.7 in.)
1972 Year-Class	-	745	-
	1.56	3.72	3.45 (7.6 lb.)
	0.88	1.03	1.01
	26	19	45
	683	654	671 (26.2 in.)
1973 Year-Class	714	682	701 (27.3 in.)
	3.44	2.90	3.21 (7.1 lb.)
	1.08	1.02	1.05
	50	66	116
	672	698	687 (26.8 in.)
1974 Year-Class	704	732	720 (28.1 in.)
	3.55	3.79	3.69 (8.1 lb.)
	1.17	1.11	1.14
	76	60	136
	618	653	632 (24.6 in.)
1975 Year-Class	647	684	66.4 (26.1 in.)
	3.04	2.72	2.86 (6.3 lb.)
	1.15	1.09	1.13
	9	8	17
	641.6	684.6	661.8 (26.1 in.)
1976 Year-Class	665.1	709.5	686.0 (27.0 in.)
	2.81	3.30	3.04 (6.7 lb.)
	1.06	1.03	1.05

Table 4. Mercury and pesticide concentrations (ppm)
in spawning adult coho salmon
North River, Massachusetts, 1972.

	Lindane	Heptachlor	H-Epoxyde	Dieldrin	Endrin	Mercury
Female Intestine (10/30/72)		.021				.06
Female Intestine (11/6/72)		.028	.002			.06
Male Intestine (10/26/72)		.164				.09
Female Muscle (11/6/72)		.006				.20
Male Muscle (10/26/72)		.003	.003	.008	.013	.17
Female Muscle (10/30/72)		.006	.001	.006	.013	.24
Eggs and Ovary (11/6/72)	.018		.003	.020		.04
Eggs and Ovary (10/30/72)	.010	.003	.007	.026		.03
Eggs (11/2/72)		.001	.007	.018		.04

Sixty-seven percent of the smolts of the 1970 year-class were marked with a right pelvic clip prior to stocking in order to distinguish ocean recoveries from fish stocked by New Hampshire, Rhode Island, and Connecticut. Marked fish, however, represented only 54% of those adults that were collected, indicating that a significantly ($X^2 = 13.564$) greater number of non-clipped fish survived. A study by Nicola and Cordone, (1973) determined that the removal of a ventral fin may reduce the survival of stocked rainbow trout by 60-70%. It is recommended, therefore, that unless a year-class is of sufficient size to absorb such losses, fin clipping be limited to small experimental lots to maximize returns.

1971 Year-Class

The 1973 spawning run was considerably later than that of 1972. Adults were not captured in the collecting pools until the first week in November and ripe fish were not present in good numbers until the last week in November. Although river temperatures were suitable during the entire month of October, lack of suitable stream flow may have delayed the run. Average daily discharge was 40.9 cfs for October as compared to 143 cfs for November (U. S. Geological Survey, 1975).

A total of 134 adult salmon were captured from November 2, 1973, to January 1974. Table shows the average length, weight, and condition of 71 adults captured in spawning condition. The table does not include spent females and males which had begun to deteriorate. During the period November 26 to December 12, when ripe fish were present in the catching pools, the water temperatures ranged from 6°C (43°F) to 9°C (48°F).

Approximately 64,500 eggs were taken from November 12 to December 12, 1973.

1972 Year-Class

The spawning run in the fall of 1974 was poor. Eight adult salmon (seven male and one female) were collected during the period from October 16 to November 21, 1974. Approximately 2,500 eggs were stripped from one female but were discarded because of poor quality. Mature fish were observed in the collecting pools during high water but moved downstream to the area of Third Herring Brook upon recession of the water and were never captured. Known return, including confirmed sportfish catches, represented 0.02% of the 66,380 smolts stocked in 1973 (Table 4.).

It is believed that this poor return was the result of abnormally heavy predation by bluefish which were unusually abundant in the waters north of Cape Cod during the summer of 1973.

In order to maintain program continuity, 141,000 eyed eggs were purchased from the state of Washington.

1973 Year-Class

Forty-five adult salmon (19 females, 26 males) were collected in the North River system during the period September 24 to December 4, 1975. Many mature salmon refused to stay in the collecting pools and moved downstream as each period of high water receded. The known return for the 1973 year-class including confirmed sportfish catches was 0.06% of the 73,580 smolts stocked in 1974 (Table 4.).

Fish that were not ripe were transported to the Sandwich Hatchery and held. The green females did not ripen satisfactorily and failed to produce viable eggs. A total of 16,071 eggs were obtained from the year-class, all from river ripened females.

1974 Year-Class

The first mature cohos of the 1974 year-class were captured in the catching pools on October 12, 1976. Water temperature was 12°C (53°F). Salmon continued to enter the catching pools until February 16, 1977. Water temperatures during this period ranged from 12°C (54°F) to 0°C (32°F). Several cohos were captured or observed in tributaries to the North River as late as March 12, 1977. A total of 124 cohos (74 males, 50 females) were captured during the spawning run.

The return rate for the 1974 year-class including sportfish catches was 0.7% of the 17,860 smolts stocked in 1975. This is the highest rate achieved by the program to date and matches the lower limit of Washington State return rates which ranged from 0.7% to 8.2% (Senn and Satterthwaite, 1971).

The average length, weight, and condition of 116 adults captured in spawning condition is shown in Table 2. Average size and condition exceeded those of past year-classes. This fact and the greatly improved return rate may be indicative of genetic adaption to the Massachusetts marine environment.

Observations of the past year-classes showed a definite relationship between stream discharge and movement of cohos into the catching pools. An attempt was made to measure this response with the 1974 year-class. The results are shown in Figure 2. For every substantial increase in discharge, there was a corresponding increase in number of fish captured. It was also observed in past years, that water temperatures below 16°C (60°F) triggered initial upstream movement of the spawning salmon, providing stream discharge was sufficient.

1975 Year-Class

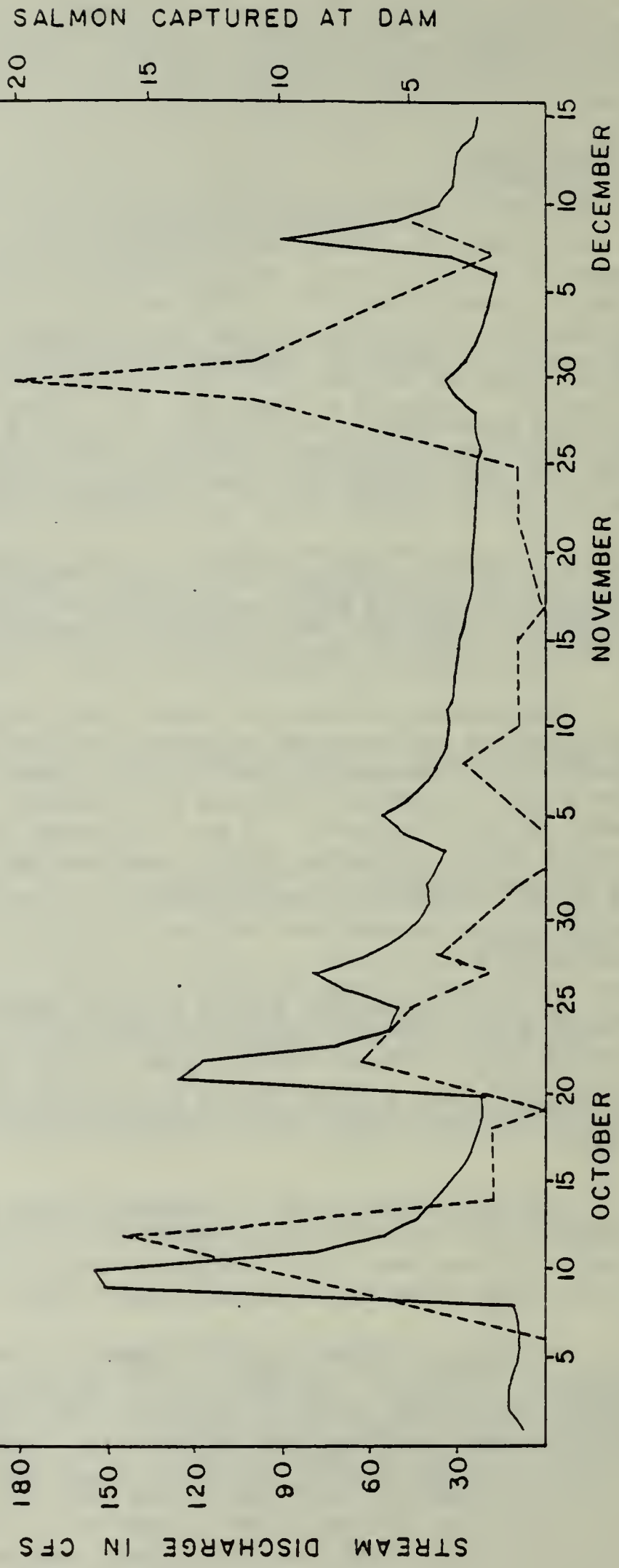
The first returning adults of this year-class were recaptured on September 26, 1977, when surface water temperature was 14.7°C (58.5°F). The spawning run continued until December 19. Water temperatures during this period ranged from 16.7°C (62.0°F) to 1.7°C (35.0°F). A total of 187 adults (88 females and 99 males) were recaptured which, combined with eight sportfish catches and 24 jacks, amounted to a return rate of 0.45%.

Reports of adult fish in Furnace Brook, a tributary to the Jones River, were investigated and confirmed on December 10. Six fish were sighted by a resident and the remains of two were identified as cohos by Division biologists. This was the first confirmed straying of Massachusetts cohos outside the North River system.

In order to assess any differences in returns of salmon raised in the Palmer and Sandwich hatcheries, 20,000 (41.5%) of the parr of this year-class had been marked with pelvic fin clips prior to release. Ten thousand Sandwich fish were given right pelvic clips and 10,000 Palmer salmon were marked with left pelvic clips. Of the 193 returning cohos checked for marks, 73 (37.8%) were clipped. Fifty-one bore the right pelvic (Sandwich) clip and 22 had left pelvic (Palmer) marks for a ratio of 2.3:1. The larger release size of Sandwich fish (23.1/lb.) as compared to that of Palmer (25.3/lb.) may have facilitated greater survival although other factors such as transport distance could also have been a contributing factor in the differing return rates.

FIG. 2. RELATIONSHIP BETWEEN STREAM DISCHARGE¹ AND SALMON MOVEMENT.
 INDIAN HEAD RIVER FALL 1976

No. Fish -----
 Discharge ———



¹ STREAM FLOW DATA FROM
 U.S. GEOLOGICAL SURVEY

1976 Year-Class

The first spawning run recapture of the 1976 year-class occurred on October 10, 1978, when water temperature was 11.7°C (53.0°F). The run continued to December 15. Water temperatures at the collecting site ranged from 12.8°C (55.0°F) to 0.5°C (33.0°F) during this period. A total of 18 adults (eight males, ten females) were recaptured. These along with two jacks taken in the fall of 1977 and seven sportfish catches provided a return rate of 0.59%.

Length, weight, and condition factor data for the 1976 year-class is given in Table 3. With such a small sample size (17 fish) however, these figures are not particularly significant.

A total of 24,836 eggs were taken from eight females and were fertilized with milt from 6 males.

DISCUSSION

Adequate techniques for collecting spawning run adults have been developed. Problems were encountered with salmon leaving the catching pools during high water periods but this has apparently been corrected with modifications to fish traps and barrier dams.

Cohos captured while still green were held within the fishway until ripe. This method is adequate when dealing with small numbers of fish but it will be necessary to develop a hatchery ripening procedure if the program is expanded. An attempt to hatchery ripen fish of the 1973 year-class met with no success.

The egg taking phase of the program has, in general, been very successful with hatching rates as high as 91.6%. Egg stripping and fertilization have been conducted at the catching site, but if large numbers of fish are to be handled, it would be desirable to move this procedure to an indoor hatchery facility.

SUMMARY

An experimental introduction of coho salmon, Oncorhynchus kisutch, into Massachusetts coastal waters was initiated in 1969. Ten year-classes have been released to date. Numbers of smolts stocked varied from 4,575 in 1977 to 73,580 in 1974. Return rates (sportfish catches and spawning run recaptures) ranged from 0.02% in 1974 to 0.70% in 1976 (Table 2).

Results of the program indicate that coho salmon raised to pre-smolt size in Massachusetts hatcheries and stocked in the Indian Head River, will return as adults in sufficient numbers to enable perpetuation of the population by means of artificial spawning. The small number of sportfish catches can be attributed to the fact that salmon were released in experimental quantities and no significant fishery specific to cohos developed. Exceptional predation by bluefish during some years may have further reduced the number of salmon available to the fishery. In addition, the apparent low return to the fishery may be an artifact of minimal catch reporting.

With the biological feasibility of introducing coho salmon to Massachusetts waters documented and development of a stock of fish genetically oriented to our coastal waters well underway, the program is now concerned with increasing stocking levels to facilitate a more meaningful assessment of sportfishery potential. In addition to compiling more data on marine distribution, future efforts will also be directed toward refining, recapture, and egg-taking and rearing techniques.

LITERATURE CITED

- Buss, K., D. Waite, and R. McCreary. 1968. Fifty-five gallon steel drums for trout egg incubation and fingerling rearing. In: Innovations for fish culturists, No. 1. Penn. Fish Comm.
- Leitritz, E. 1969. Trout and salmon culture. Fish Bul. No. 107. California Department of Fish and Game.
- Mawson, J.C. and R.J. Reed. 1970. Three computer programs: back-calculation, condition factor, and stomach content, CDC 3600 Fortran/Format. J. Fish Res. Bd. Canada 27 (1): 156-157.
- Nicola, S.J., and A.J. Cordone. 1973. Effects of fin removal on survival and growth of rainbow trout, Salmo gairdineri, in a natural environment. Trans. Amer. Fish. Soc. 102 (4): 753-757.
- Senn, H., and K. Satterthwaite. 1971. Evaluation of 1966 brood coho released from eleven Puget Sound and two coastal hatcheries. Final Progress Report. Washington Department Fisheries, Hatchery Div.
- Tody, W.H. 1969. Introductions of Pacific salmon to the Great Lakes. Paper presented at the annual meeting of the American Fisheries Society, New Orleans.
- U.S. Geological Survey, 1975, Water Resource Data for Massachusetts, New Hampshire, Rhode Island, Vermont, 1973, Water Resources Division, Boston.

