REPORT ON THE DENNYS RIVER SALMON STUDY

Under the auspices of the William Converse Kendall Memorial Fellowship of the University of Maine, a program of study has been in progress on the Dennys River in Washington County, Maine, to investigate the possibility of restoring to that river its once abundant salmon run. This study is intended to be also a preliminary to a plan in progress to reestablish the Atlantic salmon as an important game and commercial fish in those rivers of the New England states where it was once abundant.

The study is under the guidance of Dr. Gerald P. Cooper, Assistant Professor of Zoology, University of Maine and has received the hearty support and helpful assistance of the Fish and Wildlife Service, the American Wildlife Institute, Maine Department of Inland Fisheries and Game, and other interested parties in the United States and in Canada.

The Dennys River was chosen as a good site for several reasons: this river still supports considerable numbers of salmon and this population has presumably been maintained at least partially by natural reproduction; it is smaller in size than most other Maine rivers which now support salmon runs, thus lending itself particularly to such an intensive study; and it is free from pollution, and free from physical obstructions to the ascent of salmon.

Field work was begun in the fall of 1940. The spawning run was followed from the time of its entrance into the river until the completion of spawning activities. A count was made of the spawning fish, nests were marked, and the extent and location of the spawning

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areas mapped.

In the early spring of 1941 full time field work got underway with the installation of a two-way fish trap to record the movements of the fish in and out of the river. Daily records were kept of the air temperature, water temperature, and water level throughout the summer. Young fish were collected along the river for food-habits and growth-rate studies. Different census methods were used to determine the number of young fish in the river, the areas of stream utilized, and the proportion of different year classes. Food conditions were investigated by seining to determine the types and abundance of forage fishes, and by bottom-sampling to determine the types and abundance of bottom-food organisms. Some predaceous birds and fish were collected and their stomachs preserved in order to determine whether or not predation is the limiting factor which controls the abundance of young fish in the river. The water was analyzed at different locations along the river to determine the oxygen content and the degree of acidity in different sections of the stream. Physical features of the river were mapped; such as number and length of rips, length of dead-water, amount and type of cover, quality and quantity of bottom suitable for spawning, and the distance of these spawning areas from the mouth of the river.

There are two runs of salmon in the Dennys River; a spring run and a fall run. The spring run enters the river during the months of May and June as soon as the water has lowered somewhat from early-spring flood conditions. The heft of the run is ordinarily

during early June. Straggling fish may enter the river from time to time throughout the summer. Others hang outside in the estuary until fall. Those that enter the river pass the summer in the many deep, spring-fed pools.

Records have been kept of the anglers' catch during the past four years and are as follows:

Year	Total No. of fish	Total poundage
1938	66	686 lbs.
1939	35	332 "
1940	83	913 "
1941	12	113 "

The fall run comes into the river during the first part of October as soon as the fall rains bring the water up to a suitable level. The fall run is much heavier than the spring run. The fish move upstream quite rapidly; depending upon the volume of stream-flow. They go from 6 to 13 miles to spawning areas along the river. They may be found working on the lower spawning areas during the middle of October, though actual spawning does not occur until later. By the last of October they may be found distributed along the river from Camp Rips, which is two miles above tide water, to Gilman Dam, which is thirteen miles above the mouth of the river. Salmon are not known to spawn above Gilman Dam nor below Camp Rips. This allows them about 11 miles of stream approximately 30 per cent of which contains suitable bottom for spawning. Spawning occurs the last week in October and the first week in November. As soon as the spawning

activities have been completed they leave the spawning grounds and are not seen again until they appear in the lower river as kelt during the spring high-water.

During the spawning period in 1940, 249 nests were marked along the river. During the spawning period this fall, nearly 300 nests were counted along the river. Many areas were used for spawning that had not been used during the previous fall and the spawning areas that had been used the previous fall were used more extensively this year. All conditions indicated a larger number of salmon in the river than were there the previous fall.

Scale studies of 61 fish have given much valuable data on the life history of the salmon of the Dennys River which are as follows:

	Number of fish	Average weight
2.2	34	9.37 lbs.
3.2	18	9.54 lbs.
3.3	4	15 lbs.
Previously spawned	3	11 lbs.
Fish of long absence	2 (4 yr. at sea)	18 lbs.

These data indicate that, roughly, two-thirds of the smolt descend at the end of their second year in the stream - the other one-third descend as three-year-olds. This fact is substantiated by the proportion of year-classes in the stream which were found to be as follows:

Young fish in their first year	-	67 per cent
Young fish in their second year	-	25 per cent
Young fish in their third year	-	8 per cent

Another point of interest is the relation between the weight of the returned fish and the period of time spent at sea. It may be seen that fish that have spent two years in the ocean average about 9½ lbs. in weight, three years 15 lbs., and four years - which is extremely uncommon - 18 lbs. in weight.

The survey indicates a good population of young fish in the river, but that there is a tremendous mortality during the first few months of life, and more than 50 per cent mortality between the first and second years in the stream. The factors which limit the abundance of young fish in the stream have not yet been determined.

It is believed that the Dennys River supports a much larger number of returning adults than it would seem from the yearly anglers' catch; and that the reason for the small catch is a lack of water in the river during the month of June.

It has been shown by other workers, and by observation on the Dennys River, that the movement of the returning adults up the stream are dependent upon the volume of stream-flow. A quick run-off in the spring accompanied by little rainfall during the months of May and June will prevent the spring run of fish from entering the river. This year, due to extreme low water, the spring run of fish did not enter the river until late summer rains had raised the water level.

It is believed, and strongly supported by fact, that the solution

to the salmon-fishing problem on the Dennys River is to control the run-off by rebuilding one or more dams on the river and its tributaries, and by controlling the overflow at the outlet of Meddybemps Lake which is the source of the Dennys River.

Respectfully submitted,

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THE ATLANTIC SALMON IN THE DENNYS RIVER

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PREFACE

Under the auspices of the William Converse Kendall Memorial Fellowship[1] at the University of Maine, a program of study was undertaken on the Dennys River in Washington County, Maine, to investigate the possibility of restoring to that river its once abundant run of Atlantic Salmon (*Salmo s. salar*). This study was intended to be preliminary to a plan in progress to reestablish the Atlantic Salmon as an important game and commercial fish in those rivers of the New England states where it was once abundant.

The Dennys River was chosen as a good site for this study for several reasons: This river still supports a population of salmon which has been maintained at least partially by natural reproduction; it is smaller in size than most other Maine rivers which now support salmon runs, thus lending itself particularly well to an intensive study; and it is free from pollution, and free from physical obstructions to the ascent of salmon.

Field work was begun in the fall of 1940 with a preliminary investigation of the spawning habits of the salmon. Spawning areas were located, and redds were counted and marked.

In 1941 full-time field work was commenced in early Spring. A two-way fish trap was installed to record the movements of the fish in and out of the river. Daily records were kept of the air temperature, water temperature, and water level throughout the summer. Young salmon were collected along the river for food-habits and growth-rate studies. Different census methods were used to determine the number of young fish in the river, the areas of stream utilized, and the proportion of different year classes. Food conditions were investigated by seining to determine the types and abundance of forage fishes, and by bottom-sampling to determine the types and abundance of bottom-food organisms. Some predaceous birds and fish were collected and their stomachs analyzed as an attempt to determine whether or not predation was limiting the production of young salmon in the river. The water was analyzed at different locations along the river to determine the content of dissolved oxygen and the degree of acidity. Physical features of the river were studied, such as: number and length of rips, length of quiet water, amount and type of cover, quality and quantity of bottom suitable for spawning, and the distance of these spawning areas from the mouth of the river. Full time field investigation was continued until spawning activities in the fall of 1941 had ceased.

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[1] Established at the University of Maine in 1940 in honor of the late Dr. William Converse Kendall, venerable ichthyologist of Freeport, Maine, and, for many years, research biologist with the United States Bureau of Fisheries.

The writer wishes to express his deep appreciation for the support and cooperation of the many groups and individuals that made this study possible. The William Converse Kendall Fellowship was made possible through the foresight and efforts of Mr. S. Barry Locke, of the United States Fish and Wildlife Service, who contacted various organizations and individuals for their financial support. Among the organizations that made contributions were the American Wildlife Institute, in particular, and the Penobscot County Fish and Game Association, Mildrum Jewel Company, South Bend Bait Company, Ashaway Line and Twine Company, and L. L. Bean Company. The investigation was under the careful guidance of Dr. Gerald P. Cooper, Assistant Professor of Zoology, University of Maine.

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TABLE OF CONTENTS

	Page
THE RIVER	
Physical Features	1
Chemical Features	3
Fish Population	3
THE ADULT SALMON	
History	6
Investigation	7
The Ascending Adults	8
The Spawning Period	12
The Descending Adults	16
THE YOUNG SALMON	
Investigation	17
Habitat Preference	20
Population Density	21
Mortality	21
Sex Ratio	22
Growth	22
Food Supply	23
Food-habits	24
Predation	27
Disease and Parasitism	29
SUMMARY	30
CONCLUSIONS AND RECOMMENDATIONS	32
LITERATURE CITED	47
BIOGRAPHY OF WRITER	48
APPENDIX	49
RECENT RECORDS OF SALMON IN THE DENNYS RIVER, 1942-43	58

LIST OF ILLUSTRATIONS

Fig. 1.	A map of the important features of the Dennys River	34
" 2.	Weekly means of the water level, air temperature, and water temperature during the summer of 1941	35
" 3.	Meddybemps Lake viewed from the East	36
" 4.	Dennys River above Gilman Dam	36
" 5.	Ayer's Rips	37
" 6.	Quiet water below Ayer's Rips	37
" 7.	Clark's Rips	38
" 8.	The lower part of the spawning area below Clark's Rips	38
" 9.	The wreckage of the last dam on the Dennys River	39
" 10.	The original site of the fish trap	39
" 11.	The final location of the fish trap	40
" 12.	The upper part of the spawning area below Clark's Rips	40
" 13.	View of the trap; looking into the downstream box	41

Page

Fig. 14. View of the trap; looking into the upstream box 41
" 15. Three Spring run salmon from the Dennys River. . 42
" 16. Three young salmon from the Dennys River 43
" 17. Adult female taken in the trap at Bright Island Rips 44
" 18. Seining salmon from the trap at Bright Island Rips 44
" 19. A view of Little Falls 45
" 20. The location of the redd in the river at Elias' Meadow 45
" 21. A redd in coarse gravel 46
" 22. A redd in rubble and coarse gravel 46

LIST OF TABLES

Table 1. Chemical conditions of the water at eight stations along the river on August 21, 1941 3
" 2. A list of fish found in the Dennys River 5
" 3. Number and pounds of fish caught by angling over a six-year period 10
" 4. Life history data from scale readings 11
" 5. Range and average length and weight of young fish in the river 23
" 6. Growth, and sex ratio of two- and three-year salmon 23
" 7. Totals and frequencies of volumes and numbers of organisms in 54 bottom samples, and the calculated bottom fauna per square foot . . . 25
" 8. Totals and frequencies of volumes and numbers of organisms in 176 stomachs of two- and three-year salmon, and the calculated average volume and number per stomach 26
" 9. Stomach contents of 120 two-year salmon 27
" 10. Stomach contents of 56 three-year salmon 28
" 11. Daily water level, air temperature, and water temperature during the summer of 1941 49
" 12. Length, weight, sex, and growth history of 58 adult salmon (taken from the Dennys River from 1937 through 1941) 52
" 13. Lengths and weights of young salmon 53

THE RIVER

Physical Features

The Dennys River is in Washington County in the State of Maine. Its source is Meddybemps Lake (Fig. 3) which has an area of 7,245 acres, and is at an elevation of 174 feet above sea level; and it empties into the north branch of Cobscook Bay near the town of Dennysville. It is about nineteen miles in length and has an average width of about forty feet. After an initial fall of twenty feet in the first mile, it flows in quiet meanders across a flat and barren terrain (Fig. 4) for five miles until it reaches the site of the old Gilman Dam. From there on the character of the stream alternates between stretches of turbulent rips (Figs. 5 and 7) and the easy glide of quiet water (Fig. 6) until it dissipates itself in the estuary thirteen miles beyond.

The location and length of the various rips were determined and mapped (Fig. 1) along with other pertinent data, such as: locations of tributaries and springs, and the drop in elevation from start to finish of each rip.[1] The approximate lengths (paced-measure) of the rips listed from north to south are as follows:

Name	Length
Gilman Rips	400 yards
Gardiner's Rips	920 "
Bright Island Rips	2,640 "
Ayer's Rips	450 "
Clark's Rips	880 "
Stoddard's Rips	1,760 "
Little Falls	264 "
Camp Rips	1,841 "
Town Rips	1,760 "

A number of small, forest brooks empty into the Dennys River. In the summer of 1941 most of them were so low that a current was barely noticeable. The little amount of water they did supply was consistently below 75 degrees Fahrenheit. Another source of water, though of little importance to volume, is the many cold springs that have their outlet, either directly or indirectly, in the river. Two of these springs maintained a temperature of 38 degrees Fahrenheit throughout the summer. The favorite haunt of adult salmon and trout during the hot months of the year is where the cold water of these springs spreads over the bottom of the river.

Above Gilman Dam the river is choked with luxuriant growths of aquatic plants. Cat-tails line the banks and extend out into the shallow coves to merge with dense mats of water

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[1] Much valuable data were supplied by Mr. Russell Wilbur, Dennysville, Maine, U. S. Geological Survey.

lilies. In the open water submerged pondweeds form a carpet that undulates gently with the current. Near Meddybemps Lake the shores are thinly lined with birch and maple; farther downstream the river winds across the treeless basin of the old Gilman Dam pond. At Gilman Dam the river enters a forest of second growth hardwoods and softwoods, and is shaded by overhanging trees until it reaches the town of Dennysville. Aquatic vegetation is restricted to a few reaches of quiet water and many little coves along the margins.

The bottom is composed of sand, clay, and mud where the water runs quietly. Along the rips the water dashes wildly over a boulder-strewn bed which gradually gives way to rubble and coarse gravel and forms the riffle areas. Discounting the portion of the river above Gilman Dam, the river is about half quiet water and half rips and riffles.

Water and air temperatures and water level, at a point about one mile above tidal water, were recorded morning and afternoon on most days during the period from May 28 through October 15.[1] The temperatures were taken with a pocket thermometer. The thermometer was checked against a Negretti and Zambra instrument and found to be accurate within plus-or-minus 1 degree Fahrenheit. Readings of the water temperature were taken with the mercury bulb immersed in the water. Air temperatures were taken on the shore, well away from the water and not in direct sunlight. The water level was read from a ruled stake set in the center of the stream. The weekly means of these data have been recorded graphically in Figure 2. The highest water temperature was recorded simultaneously with the highest air temperature, and at the time of lowest water level. The temperature of the water during the entire period, except for three consecutive days during the middle of June, stayed well below 75 degrees Fahrenheit. The water volume, during most of the summer, was between forty and fifty cubic feet per second. These figures, however, are probably not indicative of normal summer conditions. The State of Maine during the early summer of 1941 experienced a dearth of rainfall; and, over most of the state, bodies of inland water were at a subnormal level. No effects to the young fish were observed to have been caused by this low water condition, but it did influence the entrance of the spring run of adult salmon. Also, a relation between water volume and water temperature was apparent. Instability of temperature from day to day and a wide spread between morning and afternoon temperatures were evident during June and July when the water level was low. Stability of temperature from day to day and little spread between morning and afternoon temperatures were evident during the months of August and September when the volume of water in the river had been increased by late summer rains.

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[1] The daily records are presented in Table 11 in the appendix.

Chemical Features

Samples of water to be analyzed for oxygen content and acidity were taken at intervals along the river. The locations of these stations may be found on the map (Fig. 1). Water for tests on oxygen content was collected in glass stoppered bottles of 250 c.c. capacity. Analyses were done by the Winkler method (American Public Health Association, 1933). The procedure of the method was followed immediately up to the final titration. The final titration was completed within one to seven hours after the sample was taken. The pH (a measure of acidity) was determined at the time of sampling by the use of LaMotte Indicator Solutions and LaMotte Color Standard Solutions. The results of oxygen tests in this text are expressed in parts-per-million (p.p.m.) by weight of dissolved oxygen in the water. The results of analyses of samples taken on August 21 are listed in Table 1.

Fish Population

Collecting in the Dennys River yielded 13 species of fishes (Table 2). Small fallfish, common shiners, and common suckers are abundant in the many pools and in the weedy, quiet water areas. At one locality a single sweep of a 30-foot Common Sense minnow seine netted 499 individuals of these species. Bass and pickerel inhabit the deep, slowly-flowing sections

Table 1

Chemical conditions of the water at eight stations along the river on August 21, 1941

Location	Time	Water temp.	Air temp.	Oxygen	pH
At Meddybemps	3:00 P.M.	68	70	8.0	6.8
Above Gilman Dam	1:30 P.M.	70	76	8.4	6.6
Above Bright Island Rips	4:00 P.M.	70	75	8.0	6.8
Below Bright Island Rips	4:30 P.M.	70	74	8.2	6.8
Above Camp Rips	12:00 M.	68	68	8.0	6.8
Below Camp Rips	11:30 A.M.	66	68	8.2	6.8
Above Town Rips	11:00 A.M.	67	72	8.0	6.8
Below Town Rips	10:00 A.M.	67	71	8.2	6.8

from Meddybemps Lake to the sea. Along the rips and riffles black-nosed dace, the larger fallfish, common shiners, young salmon and an occasional adult trout all compete for food and space. During the summer months young trout are found only in the tributaries to the river. Myriads of young eels ascend the river in the spring, and in the fall the adults from Meddybemps Lake descend the river on their way to the ocean. Alewives

move up and down the river during spring and early summer, en route to and from their spawning grounds in the lake; in the fall the young run downstream to the sea. An excellent opportunity was afforded to take notes on the migratory habits of the alewife by the use of a two-way fish trap that is described later in the text (p. 8). Due to their periodic abundance in the river, and to their possible effects to the salmon population, a brief account of their migration is merited.

In 1941 the alewife run entered the river the twentieth of May and reached its peak near the first of June. During the bulk of the run, forty barrels a day were dipped from the river below the fishway that leads into Meddybemps Lake. The number of ascending alewives diminished gradually through the month of June. By early July only a few scattered schools were going upstream. Stragglers continued to ascend throughout the summer. These fish which successfully completed the spawning journey made the circuit in ten or twelve days. Therefore, they were migrating simultaneously up and down the river soon after the run began. The peak of the upstream run passed through the upstream box of the fish trap (Fig. 14) from June 1 to June 3, and the greatest abundance of spent adults passed through the downstream box (Fig. 13) from June 12 to June 15.

The movements of alewives were influenced greatly by light conditions. On bright, sunny days they would swarm up the river in such numbers that the disturbance they caused in the water could be heard for a considerable distance. At night, or on cloudy days, no alewives could be seen ascending the river.

In early August the young alewives, which had been reared in the lake above, migrated down the river. The first schools passed through the downstream box August 14, and they continued to descend in great numbers until late fall. At that time they measured a little more than three inches in length and weighed about four grams each.

A correlation between the occurrence of white perch and alewives in the river was revealed. White perch appeared with the beginning of the downstream movement of the young alewives. Many were taken in the downstream box from then on until the disappearance of the alewives from the river. All were adults that had apparently followed the schools of young alewives out of Meddybemps Lake.

The morning of June 26, an adult shad, twenty inches long and weighing nearly three pounds, was taken in the upstream box of the fish trap. Shad have failed to run the Dennys River since the turn of the century, so this single record may be considered accidental and of little significance.

Table 2

A list of fish found in the Dennys River

Scientific name	Common name
Petromyzon marinus Linnaeus.....	Sea Lamprey
Pomolobus pseudoharengus (Wilson).....	Alewife
Alosa sapidissima (Wilson).....	American Shad
Salmo s. salar Linnaeus.....	Atlantic Salmon
Salvelinus f. fontinalis (Mitchill)....	Brook Trout
Catostomus c. commersonnii (Lacepede)..	Common Sucker
Leucosomus corporalis (Mitchill).....	Fallfish
Notropis c. cornutus (Mitchill).....	Common Shiner
Rhinichthys a. atratulus Hermann.....	Black-nosed Dace
Esox niger LeSueur.....	Common Pickerel
Lepomis gibbosus (Linnaeus).....	Common Sunfish
Micropterus d. dolomieu Lacepede.....	Small-mouthed Black Bass
Morone americana (Gmelin).....	White Perch

THE ADULT SALMON

History

When the first settlers arrived in 1786, the Dennys River was well stocked with salmon, trout, and shad (Talbot, 1886). As late as 1873 the total yield of salmon was estimated to have been one thousand fish per year. They were caught with set nets in tidal water and with dip nets and spears below the dam (Atkins, 1874).

In 1845 an impassable dam was built (Kendall, 1894) near what is now described as the "Millseat." Spawning grounds below the dam and on Cathance Stream, which is the largest tributary to the Dennys River, allowed sufficient natural propagation to perpetuate the run. In 1858 the dam and adjoining mill were destroyed by fire (Kendall, 1894) and the river was again passable to ascending salmon. About 1860 a new dam was erected a little more than a mile below the former. At one end of the dam a natural fishway made the river above accessible to salmon. In later years the fishway was improved from time to time. The first attempt to increase the salmon population of the river by artificial propagation was made by Mr. Benjamin Lincoln, a prominent resident of Dennysville. Mr. Lincoln planted approximately 250,000 young salmon in the river during the interval from 1874 to 1890, from eggs which he obtained from the State of Maine or from the United States Fish Commission and hatched at his own expense (Kendall, 1894). In 1898 a new fishway was erected and the old natural byway was blocked to conserve water. It is claimed that the new fishway did not serve its purpose well; also, that the intensive poaching, even to the extent of blocking the fishway, made severe inroads on the salmon population. In spite of netting, poaching, and impassable barriers salmon have persisted to run the river. In 1930 the last remaining dam was dynamited leaving the entire length of the river free from obstruction (Fig. 9).

In 1936 the Dennys River Salmon Club was formed with an initial enrollment of over 150 active members. Within four years the enrollment had increased to 750 members, scattered over the country from Maine to California. These members began at once to improve the river. They bought the nets of fishermen in the estuary, then petitioned the Sea and Shore Fisheries Commissioner to close the river to net and weir fishing. Since there was no opposition to the proposal, the petition was granted. In 1937 a law was passed by the Maine legislature which closed the entire river to net and weir fishing.

With the founding of the Dennys River Salmon Club a new impetus was given to restoration of the salmon by artificial methods. Numerous plantings were made by the federal and state hatcheries, as follows:

1936	May 21	120,000	Hatched in 1935
	May 25	120,000	Hatched in 1935
	June 8	120,000	Hatched in 1935
	July 5, 6	130,000	Hatched in 1935
1937	August 12	15,000	Hatched in 1936
	August 13	15,000	Hatched in 1936
1940	September 27	25,500	Hatched in 1940

In recent years the State of Maine Hatchery Division has directed considerable effort toward collecting eggs from our native Atlantic Salmon for propagation purposes. This has been partly due to the increased difficulty of procuring eggs from the Canadian Bureau of Fisheries. In the fall of 1938, 23 Atlantic Salmon were taken from the Dennys River during the spawning run and transported to the Federal Hatchery at East Orland, Maine, where they were stripped and the eggs hatched. In 1939 and 1940 the Hatchery Division erected a trap in the river above Bright Island to capture the ascending adults (Figs. 17 and 18). The fertilized eggs of the collected females were transported to the State Hatchery at Tunk Lake, Maine, to be hatched and reared. In 1939, six females produced 47,000 eggs, and from them 44,000 young were reared. In the fall of 1940, 25,500 of these young salmon were placed in the Dennys River. In 1940, eight females, five of which had already deposited some of their eggs, produced 25,000 eggs. There are now 20,000 young salmon from that lot of eggs being held at the Tunk Lake Hatchery for release in the river this spring.

Investigation

Data on the adult salmon in the river were compiled from many sources. The date of entry of salmon into the river was ascertained from direct observation and from records of the Dennys River Salmon Club. Records maintained by this organization furnished the number of salmon caught in the Dennys River each year. Life history data were obtained from a study of the scales of 58 fish. The time of spawning, number of spawning fish, and notes on spawning behavior were determined by direct observation on the spawning runs of 1940 and 1941.

In the fall of 1940, during the spawning period, an attempt was made to locate all of the redds (a group of egg pits; the proceeds of one female) along the river from Gilman Dam to the foot of Camp Rips. Those which were located were marked by tying a white, numbered disc in a conspicuous position near the redd. A record was kept for each redd of the date of marking and its position in relation to the numbered disc. In the fall of 1941 another attempt at complete census of redds was made over the same area, but no redds were marked. It is believed that nearly all of the salmon redds in the

river were located during both spawning seasons. This method is presumed to give a fairly reliable estimate of the number of adult females in the river.

A two-way fish trap was installed in the river in the spring of 1941 as an attempt to obtain an accurate count of the ascending adults. The trap consisted of a weir placed diagonally across the stream with a V-lead box trap at each end (Fig. 11). The box at the lower end of the weir faced upstream to catch descending fish (Fig. 13), and the box at the upper end faced downstream to catch ascending fish (Fig. 14). Each box, which measured 8 x 8 x 4 feet, was set on the bottom of the stream. Stones placed inside the boxes and on a shelf around the outside held them in place. On the end opposite from the V-lead, a sliding panel of 1/2 inch mesh iron screen allowed a current of water to pass through the boxes. The lead in the downstream box was built of wire and boards to prevent water from rushing into the box. The lead in the upstream box was constructed of one-inch mesh chicken wire in order to provide for an unobstructed flow of water. The weir was constructed of upright strips of hemlock boards, that were sawed to measure 6 feet x 1½ inches x 1 inch and nailed to cross-members of fir. The uprights were driven into the river-bed where this was possible, and a wall of stones and loose gravel was placed against the front to prevent the current from washing beneath the weir. In order to hold the weir in place against the current, a platform was constructed along the top cross-member and loaded with stones (Fig. 14).

The trap was first placed about 800 yards above tide-water (Fig. 10), but was moved later to a more favorable location, one and one-half miles up the river (Fig. 11). With the use of this trap it was anticipated that a count could be made of the ascending fish, that their movements in and out of the river could be recorded, and that some or all of them could be tagged for future studies. The unusual water conditions in the river during the entire summer, combined with an unexpected fall freshet, resulted in the failure to obtain much data on salmon by the use of the two-way fish trap.

The Ascending Adults

The Spring run of fish (Fig. 15) enters the river as soon as the water has receded from its spring high level and the temperature has risen above 50 degrees Fahrenheit; occasionally some of these fish are caught as early as April. Most of the "clean" fish which are caught are taken during the months of May and June and in the lower mile of the river. The time at which the fish enter the river is determined largely by the volume of stream flow, which causes their entry date to vary from year to year. The dates on which the first fish have been taken during the past six years are as follows:

1936.....May 23
1937.....April 28
1938.....April 24
1939.....May 27
1940.....May 20
1941.....June 2

The river in the summer of 1941 was at its lowest level in many years. The Spring run of fish appeared in the estuary the last week in May; but, because of the low water conditions, only a few straggly fish entered the river. No fish were caught by angling until the second day of June, and only eleven were taken during that entire month. The water was so low that it was intolerable to the salmon; for they were seen leaping in the estuary at every tide, but few entered the river until fall.

The Fall run of fish may enter the river as early as the latter part of August if summer rains raise the water level to a sufficient height. However, they usually enter during September. Ordinarily the bulk of the fish are well up to the spawning grounds by the first of October, but in the fall of 1941 the ascent of the river was not begun until the first week of October. On the evening of October 8, at 6:30 P.M., a large male salmon was the first of the spawning run to be taken in the trap. That morning a number of fish were seen concentrated below the trap. The next few days a fall freshet flooded the river, and most of the fish were able to escape upstream without going through the boxes of the fish trap. On October 18, they were seen on spawning beds along the river. Some had gone as far as the foot of Ayer's Rips, which is about five miles above the location of the trap.

Some deductions as to the movements of the fish into the river may be drawn from the record of catch by anglers. The data on the catch over a period of six years, as compiled by the Dennys River Salmon Club,[1] are summarized in Table 3.

The data indicate that in some years a few fish come in during the month of April. The bulk of the fish enter the river in June. Catches were few during July, except in 1940 when the Spring run entered late. In the years 1937 and 1938 the early entry of the Fall run is pictured by the increased catch during August. A comparison between the size of the Spring and Fall runs is not possible from these data because in most years the Fall run had not entered at the close of the fishing season.

The validity of these data on catch records in indicating the movement of salmon into the river is supported by observations on the salmon. With few exceptions the date of catch is within a few days of the date of entry, because most

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[1] The records were compiled mostly by the late Herbert H. Allan, president of the club.

of the fishing is done within a mile of the mouth of the river, and because fish that have been in fresh water more than a few days are extremely unwilling to take a fly. They will strike frequently, but will seldom "mouth" the fly and are rarely caught. When the salmon first enters the river he is "bright" with a greenish-black sheen to his back and with silvery sides. After a few days in the river he loses his brightness, his back becomes a dull brown, and the silver of his sides loses its polish. The sides of a fish which has been in fresh water for a week or more have a reddish coloration. The theory of a Spring and a Fall run is substantiated by two separate influxes of bright fish. Fresh-run fish are caught in the spring and again in the fall but seldom during the summer.

Table 3

Number and pounds of fish caught by angling over a six-year period

Month	Year					
	1936	1937	1938	1939	1940	1941
April	0	1	2	0	0	0
May	6	16	4	1	3	0
June	41	43	28	31	51	11
July	6	4	10	3	28	0
August	0	14	15	0	1	0
September	0	1	7	0	0	1
Total No.	47	79	66	35	82	12
Pounds	565	810	686	332	913	113

The growth history of a salmon is recorded on its scales. Most of the information on the life history of the salmon has been obtained by studying the scales from adult fish. Much has been written in support of the validity of scale-reading. The following is quoted from Kendall (1935):

> The scale of the salmon has been found to indicate its age by lines of growth. It is increased in size by additions of rings of scale substance, each addition making a circular line at its junction with the previously formed ring. If the fish grows fast the lines (sometimes called ridges or 'circuli') are widely spaced. If the growth is slow, the lines are closer together. A well-fed fish grows fast. On the other hand if it feeds but little, the growth is slow. It is believed, with abundance of evidence in support of the belief, that the salmon feeds but little in the winter. Therefore the lines of growth are more or less crowded. These groups

of crowded lines form rings known as winter rings or 'annuli'.

Again when the salmon ascends the river to spawn it feeds but scantily if at all, and at spawning time it has lost weight and loses still more after spawning. During this period the scale loses some of its periphery, which gives it an irregular appearance. When the fish resumes feeding in the sea, the more or less ragged scale is mended by scale substance, but a scar is left in the form of an irregular space without lines. This area is known as the 'spawning mark'.

The growth of the young salmon in the river is shown on the scales in the same manner, but the lines are finer and more closely set, so that the duration of the river life of a salmon is also learned from its scale. Thus by a scale it is possible to determine how long the salmon remained in the river before it went down to the sea as a smolt, how long it remained in the sea until it returned to spawn for the first time, and any further duration between spawning periods that there may be.

Study of the scales from 58 adult salmon[1] taken from the Dennys River has provided much valuable information. A summary of these data is given in Table 4.[2] Of these 58 fish 61 per cent had spent the first two years of their life in the stream, and the remaining 39 per cent had gone to the ocean at the end of their third year. Of the 58 salmon that were studied 90 per cent had spent two years in the ocean; 6 per cent, three years; and 4 per cent, four years. Those fish which had remained longer in the sea were invariably the larger. Of the 58 fish only three showed evidences of previous spawnings.

Table 4

Life history data from scale readings

(Stream-life in years is indicated by digit before the decimal, sea-life in years by digit after the decimal)

Growth history	Number of fish	Number of fish by per cent	Average weight in pounds
2.2	34	59	9.37
3.2	18	31	9.54
3.3	4	6	15.00
2.4	1	2	19.00
3.4	1	2	16.25

[1] Most of these scale samples were collected by members of the Dennys River Salmon Club for Mr. Raymond Dow of Bangor. The writer wishes to thank Mr. Dow for the use of these samples.

[2] A complete account of the scale readings is presented in the appendix (Table 12).

The Spawning Period

The spawning activities of salmon in 1940 and 1941 were carefully studied to obtain data on time, duration, localities, and behavior. During both years, the spawning activities started in the middle of October and were completed by the first of November.

The areas of stream bottom suitable for the deposition of eggs extend intermittently from the junction of Cathance Stream to Gilman Dam. Along these thirteen miles of stream approximately 30 per cent of the bottom area is composed of coarse gravel. The salmon were found on the spawning grounds a week or more before any egg depositing activities were observed. At that time many excavations were started and then vacated. Comparison of discarded sites with finished redds gave a good indication of the type of stream bottom preferred by the fish. The sites chosen for the construction of redds were located largely in the areas of stream below the various rips. In these places the bottom was composed of coarse gravel and the current was moderate. The preferred locations were in water from 13 to 18 inches in depth, and usually in riffle areas where there was a pool nearby. No redds were found in quiet water or in extremely rapid currents.

During the spawning period of 1940, 250 completed redds were counted along the river. That season the fish were spawning from Camp Rips to Gilman Dam. However, only a few were above Bright Island Rips. From Gilman Dam to Bright Island Rips, 12 redds were counted; 37 redds were counted from Bright Island Rips to Stoddard's Rips; and 200 from Stoddard's Rips to the foot of Camp Rips. In the fall of 1941 the run entered the river late and no fish were seen above Bright Island Rips. The redds counted and their locations may be listed as follows: Bright Island Rips, 13; Ayer's Rips, 5; Clark's Rips, 15; Stoddard's Rips, 60; Elias' Meadow, 125; Little Falls, 3; and Gamp Rips, 50.

Observations were made by the writer on more than one hundred salmon engaged in various activities related to spawning, and on at least ten females and their attendants engaged in the actual spawning act. Because there are few published data on this phase of the life history of the Atlantic Salmon, the writer feels it merits a brief discussion. The observations agree with published accounts of the spawning behavior of other salmonids (particularly the work of Smith, 1941, on spawning habits of cutthroat and eastern brook trouts, and Greeley, 1933, on the spawning habits of brook, brown, and rainbow trouts); and in most details with David L. Belding's (1934) account of spawning habits of the Atlantic Salmon.

The digging is done entirely by the female; no male was ever observed to share in the labor. When about to dig, the female rolls on its side, arches its body, opens its mouth, and extends its fins. The curvature of the body brings the caudal fin in position to drive a column of water directly downward against the bottom with sufficient force to dislodge sand and

coarse gravel. During digging the caudal fin does not normally come in contact with the bottom. A few vigorous sweeps are made; then the fish resumes a normal resting position for a short time before repeating the process. The fish, when digging, heads diagonally upstream, first toward one bank, then toward the other; this results in a depression that is broadly U-shaped, when viewed from a position directly above it. The moved gravel is piled about the depression on three sides. These excavations vary considerably in size. They may be from one to two feet in diameter and from eight to twelve inches in depth. The mound of moved gravel often covers an area of ten to fifteen square feet. At the bottom of the depression a pit is formed that furnishes a receptacle for the deposited eggs. Each individual pit has a capacity of about a quart, and contains stones that tumble into it as the finer supporting materials are washed away. The pit is free from silt and fine sand, which gives it a washed appearance. Each pit in the redd contains the product of a single deposition, and subsequent depositions in the redd may be scattered but tend to proceed in an upstream direction.

During the early part of the spawning period, digging proceeds slowly. As the season advances, the efforts become more hurried and more energetic. The females take little time for rest, and are watched closely by the attending males. The males struggle continually to obtain or maintain a favored position just downstream from, and slightly to one side of the female. At the peak of the spawning season, digging and courting activities proceed without let-up day and night.

In previous literature it has been stated that actual spawning seldom takes place during the day. The observations of the writer do not support this belief. Daylight spawnings were frequently observed. The actual spawning act was not observed at night but preparatory activities and courtship actions did not cease with darkness. Changes in the contour of the redd between darkness and daylight indicated deposition of eggs. It is the belief of the writer that spawning takes place whenever an egg pit is completed and the female is ready to expel a portion of her eggs--be it day or night.

In the fall of 1941, at the upper end of Elias' Meadow, the writer was fortunate to find fish spawning in a locality particularly favorable for observation. From a prone position on the bank the writer watched the spawning of salmon in a redd which was almost directly beneath and only six feet away. The river at this point is about forty feet wide and fifteen to eighteen inches deep, and the water flows fast over a coarse gravel bottom. Activities of fish during many spawning seasons have formed a bar of gravel that extends entirely across the stream. Above the bar a meander in the stream forms a pool about three-hundred feet long and sixty feet wide. Below the bar the river is narrower and the current is swifter.

The gravel bar was occupied by six adult fish; four males and two females. The females were digging almost directly

across from one another. They would dig for a second or two at one to three minute intervals for ten to fifteen minutes, then rest for an equal length of time.

The writer took his position on the bank shortly before 1:00 P.M. (October 23). At that time only the males could be seen. They were industriously chasing one another about the pool. At 1:04 P.M., a female approached the redd and started to dig. Two males immediately arrived on the scene and contested for the favored position near the female. The male in the favored position was a large individual of about sixteen pounds and the second male was only slightly smaller. Also attending the female were four small parr, one of them not more than four inches in length. They hovered near the female, or settled down into the depression away from the rushes of the large male. Between intervals of digging the female would lie over the excavation, often pressing her anal fin down into the forming pocket as though to test its completeness. At 1:10 P.M., while the female laid over the pit in the manner described as a testing process, the favored male swam into the depression and pressed his body close along her left side. His body was inclined so as to bring his vent near the vent of the female, directly over the pit. Both fish began to quiver almost imperceptibly. Immediately the second male moved in and pressed along the left side of the first male. A third male that had been attending the female across the river abandoned her and crossed the river to the spawning group. He assumed a position on the right side of the female. These four fish were all pressed tightly together and all quivered intensely. A faint, milky-white cloud rolled up around their bodies and drifted to the bottom of the depression. The action lasted for ten seconds. Spawning ceased as suddenly as it had commenced, and then the fish drifted slowly apart. It was then observed that the parr had been in the depression beneath the female. They left the site, as did the large males which moved across the river to where the other female was digging. For the next ten minutes (until 1:20 P.M.) the female that had just spawned worked vigorously to cover the orange colored eggs that could be seen laying in the pit. The act of covering the eggs was an entirely different maneuver than that used to dig the pit. The direction of movement was at right angles to the current. The motions were more careful and less energetic, and the gravel was pushed in from the sides. No males attended her at that time. From 1:20 P.M. until 1:40 P.M. she took a brief respite in deeper water about twenty feet downstream. All the while the males were courting the female across the way. At 1:30 P.M. this other female spawned with two or more males. While the full details of this second spawning could not be observed, it was noticed, however, that immediately after the spawning act the males left the site while the female worked vigorously to cover the eggs. At 1:40 P.M. the first female returned to her redd and commenced to dig a little way upstream and to one side of the recently deposited eggs. Two adult males and one parr immediately arrived on the scene. The parr laid directly beneath the caudal peduncle of the female. The males took positions to one side

and slightly downstream; the first male with his head opposite the dorsal fin of the female, and the second male in about the same relative position to the first male. They were not the original attending pair. Both were smaller and one had a badly torn dorsal fin. The first male whirled and chased the second male downstream, then returned and swam to the side of the female which had barely begun a new pit. Pressing their bodies together they quivered momentarily, then parted. Neither were any eggs deposited nor was there any noticeable emission of milt. When the writer left at 2:00 P.M., the female was still digging.

The following day the same site was visited for further observation. When the writer arrived at 11:15 A.M., the female was digging nearer the bank than where she was last seen at 2:00 P.M. the previous day. She was attended by two adult males and four brightly colored parr. The appearance of the stream bottom was much changed. At least four completed egg pits were visible that were not present the day before. It was noticed that the digging was disturbing a pocket of eggs. The boundary of the new pit was overlapping an older one. A few eggs, swollen and transparent, bounced along the bottom of the newly formed depression. The parr did not offer to eat them. From time to time, the male in first position would approach the female and quiver momentarily. This quivering seemed to be the only courtship action exhibited by the male. As the pit neared completion he would approach more often. He would change sides frequently, and sometimes in his haste to drive away an approaching suitor would jostle the female.

The livery of the parr resembled that of the adult males (particularly the reddish coloration of the sides). Their determination to win the favor of a female, so much larger than they, was extremely amusing to watch. They would dart at one another with more vigor, and more speed, than the adult males exhibited toward one another. Wherever fish were spawning, there were always a few parr present. It is likely that they aid somewhat in fertilizing the eggs. On August 11, parr which weighed from 68 to 78 grams and were from 182 to 184 mm. in length were found to have well developed testes. As early as 1840 Shaw reported the successful fertilization of salmon eggs with the milt of parr (Shaw, 1840).[1] Francis Day (1885) found that male parr or smolts, after their second year, may produce milt that is capable of fertilizing eggs.

At 1:07 P.M., while the female was lying over the newly formed pit, the male approached and pressing close to her in the manner previously described, started the rigid tremoring characteristic of the spawning procedure. The female was lying deep in the depression. A pit about ten inches in diameter and two or three inches in depth had been formed. It contained stones

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[1] Cited from Kendall, 1935.

2½ to 3 inches in diameter and had a capacity of about one quart. The vent of the female was directly over the cavity and the eggs were extruded into it. They could be seen streaming from her vent, orange in color, and surrounded by a faint cloud of milt from the male. Four of the parr could be seen beneath the female. They had assumed various positions in an effort to place their vent as near as possible to the vent of the female (one was completely "belly-up"). A second adult male arrived a moment later and took a position alongside the first male. All the fish were vibrating vigorously and a great deal of milt was expelled by the males. The entire procedure took nearly thirty seconds. When the fish parted, the pit was nearly full of eggs. Within a few seconds the female had completely covered the eggs with gravel.

Toward the end of the spawning season the activities of the fish slowed down. They behaved as though they were near exhaustion. Fighting among the males was less spirited, and the females dug less frequently. At this time the females were often observed to charge toward an attending male as though to repel his advances. After the spawning period, no fish could be found on the spawning beds but they could be seen lying quietly in the deep pools.

The Descending Adults

In the early spring, shortly after the ice leaves the river, descending "kelt" (spent fish) are caught in considerable numbers in the lower mile of the river. Local reports mention individual fishermen catching as many as 20 of these fish in a day. The fish are thin and emaciated and their flesh is extremely poor in quality. Their presence in the lower part of the river is of short duration. Scale studies indicate that only a small per cent of these kelt live to return for another spawning.

THE YOUNG SALMON

Investigation

During the summer of 1941, particular attention was given to the young salmon in the river. The different types of habitat were studied in order to determine the type preferred by the young salmon. Bottom samples were taken in the areas of stream occupied, to ascertain the kinds and abundance of bottom-food organisms. Collections of young salmon were made to study their food habits, their growth in the stream, and the proportions of the different year-classes present. An attempt was made to discover the factor, or factors, which might limit the productive capacity of the stream, such as: predation, chemical or physical condition of the water, or competition for space or food.

The first problem encountered was the choice of a method to capture young salmon for investigation. The methods commonly used are angling, trapping or netting, and poisoning or narcotizing. The method used must necessarily be determined by the information desired. If selectivity is to be avoided, the choice is limited, in the writer's opinion, to the use of a poison or a narcotic, until some better method is developed. The use of either of these agents is obviously limited.

Collections made by angling exhibited a high degree of selectivity. Of the fish collected in that manner, 85 per cent were in their third summer and 15 per cent in their second summer. No first-year fish were collected by angling. Most of the studies planned were inapplicable to a sample that did not represent all the year-classes.

The use of a Common Sense type of minnow seine proved to be a suitable method of sampling the fish population in the quiet water areas. In such areas the smoothness of the bottom and slowness of the current allowed an efficient use of the seine. In the rips and riffles areas, neither the composition of the bottom nor the speed of the current would allow satisfactory results with a seine. However, the combination of angling and seining effort brought to light the salient characteristics of fish distribution in the stream.

Several unsuccessful attempts were made to sample the composition of the fish population by blocking off a section of the stream, clearing the bottom as much as possible, and drawing a seine through the area. The young salmon were too adept at dodging from cover to cover to be caught in a seine, so it was necessary to resort to the use of a narcotic or a poison. The size of the stream prevented the efficient use of a narcotizing agent and a poison had to be employed.

Before a poison could be used, a number of precautionary measures had to be taken. The object was to obtain a small but

accurate sample of the fish population in a representative section of "salmon-water." The first step was to locate a site where a sample could be taken without harming desirable species of fish outside of the sampling area. The habits of the young salmon and the physical features of the river made it seem reasonable that such an area could be located. Finally, a site was located below Stoddard's Rips that seemed to possess the desired features. It is a short stretch of rips and riffles, somewhat apart from the main "rearing-grounds" or Stoddard's Rips, and it empties into a long stretch of quiet water. Angling efforts indicated that the larger year-classes were present in about the same abundance as in other areas of rips and riffles. Also, first-year fish could be observed in the riffles. Within the area, there were four redds which had been marked the previous fall. Below the section to be treated were three miles of stream where only bass, pickerel, minnows, and other rough fishes were found.

A section 1,100 feet long was chosen as a representative sample of "salmon-water." The upper 200 feet is in a rips section where the water flows fast along a bouldery bed. The next 400 feet consist of riffles. The stream is wider, the current slower, and the bottom composed of rubble and coarse gravel. Below that is a pool about 300 feet long with an average depth of around 28 inches. The bottom is gravelly and there is some scattered vegetation. The last 200 feet of stream is deep, with a bottom of mud and gravel and containing a few large boulders.

A wall of stones was constructed across the river at the upper and lower limits of the area. Seines were placed along the walls with the lead lines weighted to the bottom and the cork lines supported above the surface. By blocking off the area in this manner, no fish could escape upstream or downstream.

The average width of the section of stream which was treated was 65 feet. The depth and rate of flow varied considerably. It was estimated that the volume was approximately 32 cubic feet per second on the day the treatment was executed (July 25). The water temperature at that time was 70 degrees Fahrenheit at 12:00 noon. For the treatment, one pound of powdered derris root (5 per cent rotenone content) was mixed with ten quarts of water, then diluted to fifty quarts, and sprayed into the stream above the upper barrier. The application took thirty minutes and about fifteen minutes later the first fish "turned-up."

The resulting collection included all three year-classes of young salmon, and other kinds of fish that were in the area. Four large suckers that were in the lower pool suffered no apparent effects. Some of the young of small minnows that inhabit little eddies of water along the shoreline were not harmed. It was noticed that the salmon "turned-up" in a shorter period of time than other fish, and that the period of erratic behavior before death was also shorter in duration.

There was considerable evidence that all salmon were removed from the area of stream between the barriers. The barriers were left in the stream for two days and during that period of time only four first-year fish were found within the area. They were all dead and had apparently been overlooked the first day. The efficiency of the first treatment was not checked by further addition of poison. However, four hours of fruitless seining effort in the shallow pool, unsuccessful angling in the rips, and careful observation along the entire section indicated the absence of young salmon.

The treatment had no effect on the stream below the immediate vicinity of the operation. The spreading action of the flowing water rapidly diffused the poison and it was quickly diluted beyond its lethal point. The poison was partially effective for about 200 yards below the lower barrier. A few young salmon and some small minnows were killed within that distance. One large bass was found floundering but was still lively enough to escape capture. Beyond 800 or 900 yards, the concentration was totally ineffective. A thorough examination of the stream on subsequent days confirmed the belief that no harm, other than that already noted, had been done.

It is believed that the collection which resulted from this procedure furnished a representative sample of the salmon population in the stream. The facts which support this belief have been presented on p. 18.

All fish collected during the summer were preserved. Each collection was given a number and labeled as to location, date, method of capture, and other pertinent data. All young salmon were sorted provisionally into year-classes, weighed and measured in the laboratory. The weight of each fish was recorded to the nearest tenth of a gram, and both standard (tip of snout to last vertebra) and total (tip of snout to a line across longest caudal fin rays) lengths were recorded to the nearest millimeter. Sex was determined of the two- and three-year fish. The ages of the two- and three-year fish were verified by microscopical observation of their scales.

The contents of the stomachs of the two- and three-year fish were removed and analyzed in the laboratory. The analysis consisted of determining the kinds of food organisms present, the volume and number of each kind, and the total volume of food in each stomach. Volumes were determined by liquid displacement in a tapered-bottom graduate. Readings were made to the nearest 5.0 cu. mm. (.005 c.c.).

Bottom-food organisms were collected with a square-foot bottom-sampler. The sampler consisted of a cubical metal frame constructed so as to include one square foot of bottom. Two sides were covered with galvanized iron. The front was covered with fine mesh, iron screen and the back held open the mouth of a cotton bag net. The top and bottom of the sampler were open. The sampler was placed on the bottom with the screen facing the current. This position allowed the water to flow into the

sampler and pass out through the bag net. The open top allowed the operator to "stir-up" the square-foot sample of bottom, and to pick up and wash individually the larger stones. Bottom-food organisms that were disturbed by these activities were carried into the bag net by the current. In order to remove the organisms from the bag net, the sampler was taken ashore. The organisms were picked from the net and placed in individual, numbered vials, containing 70 per cent alcohol. A record was maintained of the date, location, depth of water, and type of bottom for each sample. Samples were distributed over the areas of stream occupied by young salmon and were taken throughout the summer period (from July 3 to August 25). Laboratory analysis of the samples consisted of determining the kinds of organisms found in each sample, along with their volume and number, and the total volume of food in the sample. Volumes were determined by liquid displacement in a tapered-bottom graduate. Readings were made to the nearest 5.0 cu. mm. (.005 c.c.).

Habitat Preference

Before it was possible to determine the amount of stream available to young salmon, their habitat preferences had to be studied. The choice of habitat may be controlled by one or more factors, such as: temperature, chemical conditions, cover requirements, food conditions, or reaction to water currents.

The rips and riffles areas of the Dennys River alternate with reaches of quiet water. During the summer months, young salmon were found in all areas of rips and riffles. Collections made by angling and by seining in the quiet water areas failed to produce any young salmon, with the exception of a single individual that was taken from a "spring-hole." In the areas of rips and riffles it was noticed that a preference was exhibited by the larger fish for areas with deep-water pools. Three-year fish and some of the larger individuals of the two-year class were found in deep pools along the rips, while most of the two-year fish occupied the riffles or shallow pools in swift water. Young fish in their first year were not seen except near redds of the previous fall. These observations were confirmed by the results of the collection made on July 25. A tendency toward segregation of the different year-classes was apparent. There was some overlapping, but most of the three-year fish were collected from the pool. Two-year fish were found at the head of the pool and along the riffles, and first-year fish were found near the redds of the previous fall.

The factors which controlled the selection of a habitat are not clear. Chemical analyses of the stream (Table 1) show very little variation in oxygen content and acidity between areas of quiet water and areas of rips and riffles. There was a consistent increase of 0.2 p.p.m. in the oxygen content (from 8.0 to 8.2 p.p.m.) in the rips and riffles. The pH (a measure of acidity) remained constant at 6.8. The temperature varied slightly in proportion to the amount of exposed boulders and the amount of shading. The amount and type of cover, and the

water current were extremely variable between reaches of quiet water and stretches of rips and riffles. Food conditions in the quiet water areas were sampled only by seining to determine the kinds and abundance of forage fishes. Subsequent investigation has shown that type of food to be of no importance to the young salmon. The results of these observations apparently eliminate temperature and oxygen as factors which control the selection of habitat by young salmon in the Dennys River.

In order to determine the total amount of suitable habitat, the areas of rips and riffles were measured (see page 1). The results showed that there were approximately six miles of suitable stream between Gilman Dam and tidal water; and no areas suitable for young salmon above Gilman Dam, except possibly for a short section just below Meddybemps Lake.

Population Density

The following discussion of fish population density is based on the assumption that the collection made with powdered derris root furnished a fairly reliable sample of the fish population of "salmon-water" (see p. 19). The composition of this collection was as follows: 630 salmon (94.1%); 32 fallfish (4.8%); 3 black-nosed dace (0.5%); 2 small-mouth bass (0.3%); and 2 common shiners (0.3%). The area had a total population of 669 fish of all kinds (plus 4 large suckers and some small minnows that were not affected by the derris). The area was 1,100 feet long and constituted approximately 3 per cent of all "salmon-water" in the river. The 630 salmon represented all three year-classes (Fig. 16) in the following proportions: 416 fish in their first year (66%), 162 fish in their second year (26%), and 52 three-year fish (8%). Since it was indicated that no spreading had occurred among the first-year group, their abundance can not be reckoned by linear distribution. Since it was indicated that the product of four redds was 416 young, the product of 250 redds (counted in the fall of 1940) should be about 26,000 fish. This number totaled with the number of two- and three-year fish, computed by linear distribution (1,019 per mile of "salmon-water" or 6,114 in all available water) gives an estimated population of about 32,000 young salmon in the river. This number does not seem unduly low, considering the rate of survival of first-year salmon collected around the four redds.

Mortality

Presuming that the carrying capacity of the stream is fairly constant year after year, the composition of the young salmon population for one year should be consistent with the expected population composition for any other year. An analysis of the population for mortality shows an extremely low rate of survival for the first-year group.

It is known from results of stripping that, on the average, a Dennys River salmon produces about 6,000 eggs. The

proportion of eggs to fry in the sample area (there were four redds within the area) showed a mortality of 98 per cent. The sample of two- and three-year fish is considered reliable; therefore the entire sample of July 25 may be analyzed as follows: 24,000 eggs produced 416 first-year fish-- a mortality of 98 per cent; these 416 fish can be expected to produce 162 second-year fish--a mortality of 72 per cent;[1] and the proceeds of 162 two-year fish will be 133[2] three-year fish--a mortality of 58 per cent. If an average number of eggs (6,000) be allowed for each of the 250 redds counted in the fall of 1940, the expected yield for the river would be approximately 1,500,000 eggs. The reckoned number of first-year fish, at two months of age, was 26,000; by the next year this number would be reduced to 4,629; and the following year, to 1,486. Thus, not more than one fish descends to the sea for every 1,000 eggs deposited in the stream.

14 I → 18 I → [illegible] → 2 sp.

Sex Ratio

It was interesting to note the proportion of males to females in the two- and three-year groups. Of the 52 three-year fish taken on July 25, 38 were males and 14 were females-- a 73 : 27 sex ratio. Of the 162 two-year fish 100 were males and 62 were females--a 62 : 38 sex ratio. The sex ratio exhibited by the two-year fish is difficult to explain because presumably none of that year-group had descended to the sea. The discrepancy between the sex-ratios of the two- and three-year fish may be somewhat explained by the fact that two-year females are larger (average) than two-year males (average) and a greater proportion of them descend to the sea.

Growth

It has been shown that growth of salmon is most rapid in the months of June and July, and occurs to a smaller extent in the months of August and September (Allen, 1940). Therefore, the fish collected on July 25, presumably had passed through their period of most rapid growth; their growth in length and weight is summarized in Table 5.[3]

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[1] This estimate is skewed by an augmentation to the two-year group of 25,500 hatchery fish in the fall of 1940.

[2] Fifty-two fish in the stream and 81 in the ocean. Scale readings indicate that 61 per cent of the second-year fish descend to the sea. Therefore, 52 fish represented 39 per cent of the proportion of that year-group.

[3] The complete data are listed in Table 13, in the appendix.

Table 5

Range and average length and weight of young fish collected on July 25

Age and No. fish	Measurement	Range	Average
1-year fish (105)	Total length (in mm.) Standard length (in mm.) Weight (in grams)	36 - 58 29 - 48 0.4 - 2.1	48 40 1.3
2-year fish (162)	Total length (in mm.) Standard length (in mm.) Weight (in grams)	89 - 135 74 - 113 6.5 - 24.6	108 91 14.2
3-year fish (52)	Total length (in mm.) Standard length (in mm.) Weight (in grams)	132 - 171 111 - 145 21.7 - 49.5	154 130 36.7

It has frequently been demonstrated that salmon which migrate to the sea at the end of their second year have grown more rapidly than those which stay over for a third year. Evidence to support this phenomenon in the Dennys River is the larger average size of the females in proportion to the males, in the second-year group, as compared to the smaller average size of the females in proportion to the males, in the third-year group, coupled with the discrepancy between the sex ratios of the two- and three-year fish (see Table 6).

Table 6

Growth, and sex ratio of two- and three-year salmon in the July 25 collection

Age	Measurement	Males (100)	Females (62)
2-year fish	Total length (aver.) Standard length (aver.) Weight (aver.) Sex ratio	100.6 mm. 84.9 mm. 13.1 grams 62	115.3 mm. 97.2 mm. 15.2 grams 38
Age	**Measurement**	**Males (38)**	**Females (14)**
3-year fish	Total length (aver.) Standard length (aver.) Weight (aver.) Sex ratio	156.5 mm. 132.7 mm. 39.9 grams 73	151.5 mm. 127.2 mm. 34.5 grams 27

Food Supply

In order to make it possible to compare the bottom-food utilized by the young salmon with the amount and kinds of bottom-food in the stream, the same method and the same degree of

accuracy were followed in the analyses of bottom-food samples and stomach contents. The bottom-food organisms present in the 54 samples represented seven major groups of animals of which the most important was the Class Hexapoda. Among the insects that were abundant, Anisoptera, Trichoptera, Chaulicodes, Plecoptera, and Tipulidae were predominant. The investigation of the bottom-food supply is summarized in Table 7.

Food-habits

Of the stomachs of 222 two- and three-year fish that were analyzed, 176 contained food and 46 were empty. Averages, in the summary of the food-habits, were computed on the basis of 176 stomachs. All food organisms present were in the class Hexapoda, with the exception of a small quantity of spiders. Of the eleven major groups of insects represented in the stomachs, those with aquatic habits (Ephemeridae, Trichoptera, Anisoptera, Plecoptera, Coleoptera, and Diptera) formed the bulk of the food. The Coleoptera were mostly riffle-beetles (Psephenus), and the Diptera were mostly blackflies (Simulium). A summary of the food-habits of these young salmon is presented in Tables 8, 9, and 10.

The seven groups of organisms (cited above) which made up the bulk of the food of the salmon also made up the bulk of the bottom fauna (compare Tables 7 and 8). Within these seven major groups, however, considerable selectivity in feeding was exhibited. The May-flies, for example, made up 25.4 per cent by volume of the stomach contents but only 3.2 per cent by volume of the bottom fauna; the Anisoptera made up 32.4 per cent of the bottom fauna and 12.6 per cent of the stomach contents; and the Tipulidae represented 8 per cent of the bottom fauna but were not present in the stomachs. This discrepancy was presumably due to availability or wilful selectivity, or a combination of the two.

The amount of bottom-food present in the stomachs at any one time represents a small proportion of the total amount in the stream. From analysis of the salmon population data, the density of young salmon can be placed at 1 fish per 114 square feet of stream bottom. The bottom-food in an equal area of stream would amount to 97.8 c.c. The average volume of food per stomach of two- and three-year fish was 0.063 c.c. (first-year fish constituted 66% of the population and they would consume considerably less), or not more than 0.06 per cent of the total volume of bottom-food in 114 square feet. On the basis of this figure, the amount of food in the stream represents more than 1,600 separate feedings per fish. In attempting to appraise the value of this quantity of bottom fauna as food for salmon throughout the year, it should be taken into account that the bulk of the samples were taken in late summer after the emergence of aquatic insects and, therefore, at a time when the volume of bottom-food was at a low point in its cycle.

Table 7

Totals and frequencies of volumes and numbers of organisms in 54 bottom samples, and the calculated bottom fauna per square foot. (The total volume of bottom-food organisms in all samples was 39,415 cu.mm.; the average volume per square foot was 729.9 cu.mm.)

Organism	Frequency of appearance in samples: by %	Volume by per cent of total	Organisms in all samples		Organisms per square foot of stream bottom (calculated)	
			Vol. in cu.mm.	No.	Vol. in cu.mm.	No.
Nematoda (Round worms)	4	0.03	15	3	0.28	0.06
Oligochaeta (Aquatic earthworms)	13	0.16	65	8	1.20	0.15
Hirudinea (Leeches)	9	0.15	60	6	1.11	0.11
Collembola (Springtails)	2	0.02	10	1	0.19	0.02
Neuroptera						
Sialis (Alder-fly larvae)	30	1.16	460	22	8.52	0.41
Chauliodes (Fish-fly larvae)	35	10.90	4,310	32	79.81	0.59
Ephemerida (May-fly naiads)	76	3.20	1,263	163	23.38	3.02
Odonata						
Anisoptera (Dragon-fly naiads)	78	32.40	12,805	131	237.12	2.42
Zygoptera (Damsel-fly naiads)	9	0.82	325	5	6.02	0.09
Plecoptera (Stone-fly naiads)	82	8.30	3,290	120	60.92	2.22
Coleoptera						
Psephenus larvae (Water-pennies)	56	3.14	1,240	73	22.96	1.35
Psephenus adults (Riffle-beetles)	24	0.40	161	37	2.98	0.68
Misc. beetle larvae	50	1.28	505	85	9.35	1.57
Trichoptera						
Caddis-fly larvae	78	20.00	7,895	1,059	146.20	19.61
Caddis-fly pupae	6	0.20	80	4	1.48	0.07
Diptera						
Tipulidae (Crane-fly larvae)	30	8.03	3,170	22	58.70	0.41
Chironomidae (Midge larvae)	85	1.26	497	194	9.20	3.59
Simulium (Black-fly larvae)	28	0.26	104	19	1.93	0.35
Misc. fly larvae	2	0.02	10	1	0.19	0.02
Misc. fly pupae	2	0.03	15	1	0.28	0.02
Gastropoda						
Planorbidae (Snails)	4	0.86	340	6	6.30	0.11
Amnicolidae (Snails)	7	0.15	60	5	1.11	0.09
Pelecypoda (Mussels)	9	6.94	2,740	5	50.74	0.09
Sphaeridae (Pill clams)	17	0.26	105	17	1.94	0.31
Petromyzon marinus (Lamprey)	2	0.03	15	1	0.28	0.02

Table 8

Totals and frequencies of volumes and numbers of organisms in 176 stomachs of two- and three-year salmon, and the calculated average volume and number per stomach. (The total volume of food in all stomachs was 11,045 cu.mm.; the average volume per stomach was 62.75 cu.mm.). The fish listed in Tables 8, 9 and 10 are 176 of the 214 two- and three-year fish listed in Table 13

Organism	Frequency of appearance in stomachs: by %	Volume by per cent of total	Organisms in all stomachs		Organisms per stomach (average)	
			Vol. in cu.mm.	No.	Vol. in cu.mm.	No.
Aquatic in origin:						
Neuroptera						
Chauliodes (Fish-fly larvae)	2	2.5	280	3	1.37	.005
Chauliodes (Fish-fly pupae)	5	1.4	155	9	.88	.051
Ephemerida (May-fly naiads)	55	25.4	2,805	276	15.93	1.568
Odonata						
Anisoptera (Dragon-fly naiads)	15	12.6	1,390	29	7.89	.164
Plecoptera (Stone-fly naiads)	7	5.3	585	19	3.32	.107
Hemiptera						
Gerridae (Water-striders)	1	.5	50	1	.28	.005
Coleoptera						
Misc. beetle larvae	5	1.4	155	8	.88	.045
Psephenus (Water-pennies)	6	1.8	200	12	1.13	.068
Trichoptera (Caddis-fly larvae)	45	21.9	2,420	283	13.75	1.607
Diptera						
Chironomidae (Midge larvae)	28	3.2	355	98	2.01	.556
Simulium (Black-fly larvae)	5	.5	55	11	.31	.062
Terrestrial in origin:						
Arachnida (Spiders)	2	.8	90	4	.51	.022
Neuroptera						
Sialis (Alder-fly adults)	2	1.4	160	5	.91	.028
Ephemerida (May-fly adults)	1	.7	80	4	.45	.022
Odonata						
Anisoptera (Dragon-fly adults)	1	.9	100	1	.56	.005
Plecoptera (Stone-fly adults)	1	.7	75	1	.42	.005
Hemiptera (Bugs)	1	.4	40	1	.22	.005
Coleoptera (Beetle adults)	17	7.8	860	39	4.88	.221
Lepidoptera (Moths)	1	.5	50	1	.28	.005
Diptera (Fly adults)	9	5.0	555	91	3.15	.517
Hemenoptera						
Clistogastra (Bees & Wasps)	5	3.1	345	6	1.96	.034
Formicidae (Ants)	3	2.2	240	11	1.36	.062

Table 9

Stomach contents of 120 two-year salmon
(Total volume of food in all stomachs was 5,880 cu.mm.;
the average volume per stomach was 49.0 cu.mm.)

Organism	Total vol. in cu.mm.	Per cent of total
May-fly naiads (Ephemerida)	1,930	32.8
Caddis-fly larvae (Trichoptera)	1,000	17.0
Dragon-fly naiads (Anisoptera)	920	15.5
Fish-fly larvae (Chauliodes)	280	4.7
Midge larvae (Chironomidae)	240	4.1
Stone-fly naiads (Plecoptera)	175	3.0
Water-pennies (Psephenus)	115	2.0
Beetle larvae (Coleoptera)	45	.8
Black-fly larvae (Simulium)	30	.5
All aquatic forms (total)	...	80.4
Beetle adults (Coleoptera)	400	7.0
Bees and Wasps (Clistogastra)	290	4.9
Flies (Diptera)	145	2.5
Dragon-fly adults (Anisoptera)	100	1.7
May-fly adults (Ephemerida)	80	1.3
Ants (Formicidae)	70	1.2
Spiders (Arachnida)	60	1.0
All terrestrial forms (total)	...	19.6

Predation

The influence of predation on the population of young salmon was not investigated as thoroughly as may be desired. When plans were formulated for the present study of salmon in the Dennys River, it was decided to make a preliminary survey of the factors which might possibly limit the abundance of the fish, and to follow this by intensive studies of those factors which seemed to be especially important. After a preliminary survey of predation, it was believed that other factors were of more importance, and the pursuit of these other studies did not allow time to conduct a thorough investigation of predation.

A permit was secured from the Fish and Wildlife Service to collect a few American Mergansers (Mergus merganser americanus) and Herring Gulls (Larus argentatus). The Maine State Department of Inland Fisheries and Game provided a permit to collect fish-eating birds not protected by federal law. During the summer only 4 gulls, 4 osprey, and 1 great blue heron were taken. None of the stomachs contained the remains of young salmon. Both the ospreys and the gulls had been

Table 10

Stomach contents of 56 three-year salmon
(Total volume of food in all stomachs was 5,165 cu.mm.;
the average volume per stomach was 92.23 cu.mm.)

Organism	Total vol. in cu.mm.	Per cent of total
Caddis-fly larvae (Trichoptera)	1,420	27.5
May-fly naiads (Ephemerida)	875	16.9
Dragon-fly naiads (Anisoptera)	470	9.1
Stone-fly naiads (Plecoptera)	410	7.9
Fish-fly larvae (Chauliodes)	155	3.0
Midge larvae (Chironomidae)	115	2.2
Beetle larvae (Coleoptera)	110	2.1
Water-pennies (Psephenus)	85	1.6
Water-striders (Gerridae)	50	1.0
Black-fly larvae (Simulium)	25	.5
All aquatic forms (total)	...	71.8
Beetle adults (Coleoptera)	460	8.9
Flies (Diptera)	410	7.9
Ants (Formicidae)	170	3.3
Alder-fly adults (Sialis)	160	3.1
Stone-fly adults (Plecoptera)	75	1.5
Bees and Wasps (Clistogastra)	55	1.1
Moths (Lepidoptera)	50	1.0
Bugs (Hemiptera)	40	.8
Spiders (Arachnida)	30	.6
All terrestrial forms (total)	...	28.2

feeding on alewives and the great blue heron had in his stomach only one large grasshopper.

Kingfishers (Megaceryle alcyon) were common near the estuary but rare along the river. The writer concluded that not more than six individuals frequented the length of river from Town Rips to Gilman Dam. It is possible, but not probable, that these few kingfishers caused a serious mortality among young salmon. It has been estimated that on the Northeast Margaree River, in Canada, kingfishers consume a minimum of 20 fish per day per bird; and that during the summer season of 1935 an estimated total of 210 birds had taken 330,000 salmon, plus 90,000 other fishes (White, 1936).

American Mergansers do not appear in the river until fall, but then considerable numbers of them are distributed along its entire length. On many occasions they were observed feeding in the areas inhabited by young salmon. In one instance

while the writer was taking notes on the spawning activities of salmon, a merganser caught and ate three parr from the redd under observation. It has been demonstrated that on the Margaree River, in Canada, the American Merganser is an important predator of young salmon (White, 1936, 1937 and 1939).

Among possible fish predators are trout, bass, eels and white perch. The trout population is constantly depleted by angling, the bass are mostly in the quiet water areas, and white perch and eels are periodic in appearance. However, all of them must contribute somewhat to the mortality among young salmon.

Mink are numerous along the river. A pup that had been weaned near the fish trap became quite unafraid of the writer and appeared morning and evening for his daily ration of alewives. On several occasions his hidden caches of fish were found beneath stones along the river bank. No salmon were among the store, but that does not imply that mink will not take salmon whenever and wherever it is possible.

Disease and Parasitism

No evidence of serious mortality caused by diseases or parasites among young salmon was discovered. A few young salmon in the collections were found to have spots of fungus (*Saprolegnia*). Some of them had various degrees of infection of the larval fluke *Neascus*, but they suffered from no apparent ill effects. Most of the stomachs contained roundworms, but it appeared that these were normal parasites of the insects upon which the fish fed and not parasites of the salmon. Nearly all of the bottom-food organisms, and particularly the caddis-fly larvae and May-fly naiads, which were recovered from the stomachs, were parasitized with roundworms. The number of such roundworms in stomachs which contained partially digested food was much greater than in stomachs with no food.

SUMMARY

1. The Dennys River is about 19 miles in length and has a fall of 174 feet from source to outlet.

2. The upper six miles are weed-choked and are not used by salmon.

3. The lower 13 miles are utilized by adult and young salmon, and are about half quiet water and half rips and riffles.

4. The bottom is composed of boulders, rubble and gravel in the rips and riffles areas; and sand, clay and mud in the areas of quiet water.

5. Water temperature is related to water volume. It is higher with low water and lower with high water; and its daily fluctuation is more at times of low water than at times of high water.

6. Low water throughout the early summer of 1941 presented an unusual condition.

7. Chemical analysis of the water at various locations along the river showed very little difference in acidity and in oxygen content.

8. Thirteen species of fish were collected from the Dennys River.

9. The migratory habits of the alewife were noted.

10. Adult white perch were found in the river only when young alewives were present.

11. Depletion of the salmon population, prior to the last decade, is believed to have been caused by obstructions in the river, commercial fishing and poaching.

12. The river is now free from obstruction along its entire length; and commercial fishing is prevented by state law.

13. The Dennys River Salmon Club was founded in 1936 and has been instrumental in recent attempts to replenish the supply of salmon by the introduction of artificially reared fish.

14. A two-way fish trap was erected to obtain a count of the ascending adults.

15. The bulk of the Spring run of fish enters the river during the month of June.

16. Most of the fish which return to the river are four years of age. They have spent two years in the stream, and two years at sea.

17. The bulk of the Fall run of fish enters the river during the month of October.

18. Spawning occurs in the Dennys River during the last two weeks in October.

19. During the spawning season of 1940 two hundred and fifty redds were counted along the river; and during the 1941 season two hundred and seventy-one redds were counted over the same area.

20. The spawning habits of the Atlantic Salmon are similar to those of other salmonid fishes. Spawning was frequently observed during the daytime.

21. Kelt appear in the lower part of the river in early Spring on their way back to the ocean.

22. During the summer of 1941 emphasis was placed on a study of the young salmon in the river.

23. Various methods were used to collect the young fish. Collections made by angling contained a preponderance of large individuals. Seining was inapplicable to areas which the young salmon inhabited. The size of the stream prevented the efficient use of a narcotizing agent, and therefore a poison was employed.

24. A site was chosen that was considered a representative area of "salmon-water." The poison was carefully applied and no harm resulted to other sections of "salmon-water."

25. Young salmon were found to prefer the rips and riffles areas of the river during the summer months.

26. The Dennys River contains approximately six miles of stream that is suitable for young salmon during the summer months.

27. The young salmon in the river are represented by 66 per cent of fish in their first year, 26 per cent in their second year, and 8 per cent in their third year.

28. A tremendous loss of young salmon during their early life was evident.

29. A greater percentage of males than females was found among two- and three-year salmon.

30. Females in their second year were larger, on the average, than males of the same age group; and a large percentage of the two-year fish that descend to the ocean are females.

31. The most abundant groups of insects in the bottom fauna were Anisoptera, Trichoptera, Chauliodes, Plecoptera and Tipulidae.

32. The most important items of food of young salmon were Ephemerida, Trichoptera, Anisoptera, Plecoptera, Coleoptera and Diptera.

CONCLUSIONS AND RECOMMENDATIONS

Several conclusions already given in this thesis, concerning the salmon in the Dennys River, are repeated here because of their bearing on recommendations given in the following paragraphs. The present population of adult salmon is adequate to produce a much greater population of young fish than are now present. The bottom fauna in the river is also sufficient to support a much larger population of young salmon. All of the spawning areas are not fully utilized, but this is not believed to be so important as the mortality among the young. The success of natural reproduction is decreased by a tremendous mortality from the time the eggs are deposited until two months after the young are hatched. It is concluded that what is needed is not necessarily a much larger population of spawning fish, but much better survival of the young. It is believed that present angling is not a very important factor limiting the production of salmon, because angling takes so small a percentage of the adult fish. The Spring run of fish did not enter the river until Fall because the water was too low. When late summer rains flooded the river they entered, ascended to the spawning areas, and successfully completed their spawning activities. For this reason the great bulk of the 1941 run was not available to angling at all. The six miles of stream above the site of the old Gilman Dam, with the possible exception of a short section of stream below Meddybemps Lake, are not suited to the salmon. This section of the river probably could be best utilized to store water for controlling flow in the stream below.

In making recommendations for the Dennys River two aspects of management must be considered. The only justification for the expenditure of funds and time in an attempt to increase the salmon population is that a compensating revenue will result from the effort. The first objective, therefore, is to increase the supply of salmon; and the second is to make available to fishermen the surplus of adults that are not needed to maintain an optimum population. Because a tremendous mortality is evident in the early life of young salmon that are the result of natural reproduction, it is recommended that efforts be concentrated on artificial methods of hatching and rearing the young fish. In view of the fact that mortality in the stream decreases as the young salmon grow older, it is recommended that hatcheries rear the fish until they are at least twelve months old, and preferably older. Because previous efforts to collect spawn from the Dennys River have been successful it would seem that the most efficient method of obtaining eggs would be to maintain a trap in the river each spawning season. In order to study the efficiency of artificial propagation, a portion of all fish planted in the river should be marked in such a manner that they could be distinguished from those fish that resulted from natural propagation.

Since the concentration of natural spawning is mostly on Stoddard's, Clark's, and Bright Island rips, and since these areas are inaccessible to hatchery trucks, it is recommended that artificial stocking be concentrated on Camp Rips and the rips

just below Gilman Dam, in the following proportion: 80 per cent on Camp Rips and 20 per cent on Gilman Rips. An annual stocking at the rate of 20,000 two-year salmon or 60,000 one-year salmon is recommended.

In order to make the surplus of returning adults available to fishermen, it is recommended that a plan be adopted to control the flow of water in the stream during the early summer. It would not be difficult to replace the old Gilman Dam which is above all areas of stream utilized by salmon. Water could be stored there during early summer and released before it became extremely acid or too warm in the pond. The existing dam at Meddybemps Lake should be used to maintain a constant flow of water during the summer. Other dams could be restored on Cathance Stream which is the largest tributary to the Dennys River, and would be of considerable value in regulating stream flow.

These recommendations, to regulate stream flow in order to afford better fishing, may be open to considerable criticism at the present, and may have to be revised from time to time as further studies show new aspects of the problem. The plan that is proposed is based upon the studies that are presented in this paper, and apply to conditions as they now exist in the Dennys River.

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BIOGRAPHY

Harry Allan Goodwin was born in the State of New Hampshire, Grafton County, at Littleton on July 12, 1915. He began his early education at the primary schools of that town and completed it at Hallsville Grammar School, Manchester, New Hampshire, in 1928. He completed his secondary school education at Manchester High School Central in 1932.

He entered Saint Anselm's College, Manchester, New Hampshire, in 1935, and graduated from that institution in June, 1939, with the Bachelor of Arts degree in Biology.

In September, 1939, he enrolled for graduate study at the University of Maine. In the fall of 1940, he was appointed to the recently established William Converse Kendall Fellowship to do research in Fisheries. In May, 1942, he received the degree of Master of Science in Zoology, upon completion of his thesis, entitled "The Atlantic Salmon in the Dennys River."

He is a member of the American Fisheries Society, the Atlantic Fisheries Biologists Society; and has contributed to the Fish Survey Reports for the Maine State Department of Inland Fisheries and Game.

APPENDIX

Table 11

Daily water level, air temperature, and water temperature during the summer of 1941

Date		Water level	Water temp.	Air temp.	Time (A.M.)	Water temp.	Air temp.	Time (P.M.)
May	28	11.0	58	52	6:00	59	64	6:00
	29	10.5	58	49	6:00	58	60	6:00
	30	10.0	56	46	6:00	57	60	6:00
	31	9.5	56	53	6:00	60	68	4:00
June	1	9.0	58	62	7:00	..	..	....
	2	7.0	58	62	7:00	..	..	....
	3	6.5	62	62	7:00	..	..	....
	4	6.0	59	62	7:00	..	..	....
	5	6.0	56	48	6:00	60	69	2:30
	6	6.0	59	55	6:00	60	68	4:00
	7	6.0	63	60	6:00	63	..	2:30
	8	5.5	62	59	6:00	63	68	3:00
	9	5.5	63	58	6:00	64	69	4:00
	10	5.0	65	63	6:00	66	..	1:00
	11	5.0	65	63	6:30	66	..	5:00
	12	5.0	67	64	6:00	..	..	....
	13	5.0	68	64	6:00	68	80	4:30
	14	5.0	68	66	6:00	68	82	4:00
	15	5.0	69	60	6:00	70	80	4:00
	16	5.5	66	55	6:00	70	79	5:00
	17	5.0	67	66	6:30	70	80	4:00
	18	4.0	70	78	6:00	72	82	3:30
	19	...	..	..	....	..	..	....
	20	...	..	..	....	83	88	3:30
	21	4.0	74	79	6:00	83	89	3:00
	22	4.0	78	75	6:30	82	88	2:30
	23	4.0	73	65	6:00	73	75	4:00
	24	4.0	73	60	7:00	73	70	3:00
	25	4.0	73	56	7:00	73	78	4:00
	26	4.0	64	56	7:00	73	80	3:30
	27	4.0	63	66	8:00	..	..	....
	28	4.0	66	78	8:00	66	76	1:00
	29	4.0	64	62	8:00	..	..	....
	30	5.0	64	59	8:00	66	..	4:00
July	1	5.0	64	56	8:00	66	..	2:30
	2	6.0	62	69	8:00	70	74	6:00
	3	7.5	66	56	8:00	72	69	5:30
	4	5.0	66	56	8:00	72	..	....
	5	5.0	64	76	8:00	..	..	....
	6	5.0	66	75	8:00	..	..	....
	7	5.0	64	55	8:00	66	..	1:00
	8	5.0	64	58	8:00	..	..	....
	9	5.0	62	58	8:00	..	..	....
	10	6.0	62	63	8:00	63	70	1:00

Table 11 -- Continued.

Date	Water level	Water temp.	Air temp.	Time (A.M.)	Water temp.	Air temp.	Time (P.M.)
July 11	5.0	61	60	7:30	70	72	1:00
12	....	..	..	....	..	..	....
13	7.0	60	53	8:00	..	..	....
14	13.0	62	53	8:00	66	66	4:00
15	12.0	62	74	8:00	70	88	3:00
16	10.0	63	55	7:30	70	85	3:30
17	9.0	64	54	7:30	..	..	....
18	8.0	63	60	7:30	..	..	....
19	8.0	63	58	7:30	..	..	....
20	8.0	63	60	7:30	..	..	....
21	8.0	63	60	7:30	70	76	5:30
22	8.0	64	67	8:00	70	76	5:30
23	7.5	64	58	8:00	..	..	....
24	7.0	64	60	7:30	74	79	3:30
25	7.0	64	60	7:30	70	80	1:00
26	9.0	68	64	8:00	..	..	....
27	11.0	66	60	8:00	..	..	....
28	13.0	64	59	8:00	70	76	5:00
29	11.0	62	60	8:00	68	80	3:00
30	....	..	..	....	..	..	....
31	....	..	..	....	..	..	....
Aug. 1	....	..	..	....	..	..	....
2	10.0	68	66	7:30	71	78	4:30
3	10.0	66	64	7:30	69	74	4:00
4	10.0	66	59	8:00	..	..	....
5	9.5	66	56	8:00	70	68	1:00
6	11.0	64	56	8:00	..	..	....
7	10.0	66	68	8:00	70	70	6:30
8	9.5	70	64	8:00	72	74	6:00
9	9.5	68	58	8:00	70	64	6:00
10	9.5	66	62	8:00	66	64	8:00
11	8.5	60	61	8.00	64	60	8:00
12	8.5	64	58	7:30	..	..	....
13	9.5	64	48	8:00	..	..	....
14	11.0	62	50	8:00	..	..	....
15	11.0	64	60	8:00	..	..	....
16	11.0	63	60	8:00	..	..	....
17	11.0	63	58	8:00	..	..	....
18	12.0	62	56	8:00	63	68	6:00
19	11.5	64	60	8:00	65	58	6:00
20	11.0	65	66	8:00	..	..	....
21	11.0	64	60	8:00	..	..	....
22	11.0	64	62	8:00	67	74	1:00
23	11.0	63	62	8:00	64	64	6:00
24	11.0	64	68	8:00	..	..	....
25	11.0	65	65	8:00	66	70	6:00
26	11.0	68	70	8:00	70	74	4:00
27	12.0	66	70	8:00	68	58	7:30
28	12.0	63	50	8:00	64	52	8:00

Table 11 -- Concluded.

Date		Water level	Water temp.	Air temp.	Time (A.M.)	Water temp.	Air temp.	Time (P.M.)
Aug.	29	....	..	..	....	..	..	....
	30	....	..	..	....	..	..	....
	31	....	..	..	....	62	68	5:30
Sept.	1	11.0	60	56	8:00	..	..	....
	2	11.0	60	58	8:00	..	..	....
	3	10.5	61	70	8:00	62	74	6:00
	4	10.0	62	69	8:00	..	..	....
	5	....	..	..	....	..	..	....
	6	....	..	..	....	..	..	....
	7	....	..	..	....	..	..	....
	8	....	..	..	....	..	..	....
	9	....	..	..	....	..	..	....
	10	....	..	..	....	..	..	....
	11	....	..	..	....	..	..	....
	12	11.0	..	..	....	62	62	4:00
	13	11.0	57	48	8:00	58	60	6:00
	14	....	..	..	....	60	66	5:00
	15	10.0	60	61	7:30	61	65	5:30
	16	10.0	62	63	7:30	63	64	4:00
	17	11.0	62	56	7:30	61	58	7:30
	18	11.0	62	52	7:00	60	62	6:00
	19	10.0	60	52	7:30	60	58	5:30
	20	10.0	62	60	7:00	60	58	7:00
	21	10.0	58	64	8:00	60	62	5:30
	22	10.0	62	64	6:30	60	62	6:30
	23	9.0	58	63	7:30	62	64	5:30
	24	7.0	58	62	6:30	60	62	5:30
	25	7.0	56	58	7:30	58	60	6:30
	26	7.0	60	62	7:30	64	68	5:00
	27	7.5	58	60	6:00	60	62	5:30
	28	8.0	58	62	8:00	56	58	6:00
	29	9.0	60	58	7:00	58	56	5:00
	30	10.0	58	54	6:30	56	54	5:30
Oct.	1	11.0	56	54	6:30	..	..	....
	2	....	..	..	....	..	..	....
	3	6.0	46	45	7:30	56	52	5:30
	4	6.5	58	64	7:30	60	66	6:30
	5	7.5	56	64	7:30	58	66	7:00
	6	9.0	56	62	7:00	60	64	6:30
	7	10.5	58	63	6:30	60	66	6:00
	8	11.0	56	62	6:30	58	64	6:30
	9	11.0	56	62	6:30	58	64	5:30
	10	11.0	58	60	6:30	58	64	5:30
	11	13.0	58	62	6:30	60	66	5:00
	12	15.0	64	60	5:30	66	62	6:30
	13	14.0	58	64	6:30	56	60	5:30
	14	13.0	58	64	6:30	56	62	5:00
	15	13.5	54	60	6:30	50	58	5:30

Table 12

Length, weight, sex, and growth history of 58 adult salmon (taken from the Dennys River from 1937 through 1941)

Date	Length: in in.	Weight: in lbs.	Sex	History	Condition
1937					
May 1	29	4 3/4	Female	2.2S	Kelt
" 2	31	6 1/2	Male	2.2S	Kelt
" 6	29	5	Male	2.2S	Kelt
" 18	28 1/2	8 1/2	Female	2.2	Clean
" 18	30	11	Female	3.2	Clean
" 21	29	10	Female	2.2	Clean
" 27	35	15 1/2	Female (?)	3.3	Clean
1938					
April 13	31 1/2	7	Male	2.2S	Kelt
" 23	32 1/2	8	Female	3.2+S	Kelt
" 23	31 3/4	6	Male	2.2S	Kelt
" 24	33 1/2	8 1/2	Male	2.2S	Kelt
" 24	29 1/4	5	Female	2.2S	Kelt
" 25	29 1/2	5 5/16	Female	3.2S	Kelt
" 26	29 3/4	4 3/4	Female	2.2S	Kelt
" 26	32 3/4	7 1/4	Female	3.2S	Kelt
" 26	35 1/2	8 1/2	Female	2.2S1S	Kelt
" 21	28 1/2	4 1/2	Female	2.2S	Kelt
May 4	29	6	Female (?)	2.2+S	Kelt
June 8	30	9 1/4	.....	3.2+	Clean
" 13	28	9	.....	3.2	Clean
" 15	29	9 3/4	Female	2.2	Clean
July 6	30	9 1/2	.....	2.2+	Clean
" 11	27	8 3/4	.....	3.2	Clean
Aug. 28	30 1/2	12 1/2	Female	2.2	Clean
" 28	29	10 1/2	Female	3.2	Clean
Sept. 1	30 1/2	10 1/2	Male	3.2	Clean
" 2	28 1/2	8 1/2	Female	2.2	Clean
" 3	36 1/2	16 1/4	Female	3.4+S	Clean
" 11	28 1/2	9	Female	2.2+	Clean
" 16	34	14	Male (dark)	3.3	Clean
" 17	30 1/2	11 1/2	Female	2.2	Clean
1939					
April 18	30	7 1/2	Female	2.2	Kelt
" 27	..	5 1/2	.....	2.2	Kelt
1940					
April 19	34	7 1/2	Female	3.3	Kelt
" 20	28	6 1/2	Female	2.2	Kelt
May 11	37	11 1/2	.....	3.3S1S	Kelt
" 20	24	8	.....	2.2	Clean
June 1	28	8 1/2	Female	2.2	Clean
" 2	29	8 1/2	Female	2.2	Clean
" 13	30	8 3/4	Female	2.2	Clean

Table 12 -- Concluded.

Date	Length: in in.	Weight: in lbs.	Sex	History	Condition
1940 (Cont.)					
June 22	..	.....	.....	2.2	Clean
July 5	36	19	Female	2.4	Clean
" 9	31	.....	Male	2.2	Clean
" 9	29	9	Female	2.2	Clean
" 10	34 1/2	12	Male	3.2S.1S	Clean
Oct. 26	..	6 3/4	Male	3.2	Kelt
1941					
June 2	31	11 1/4	Female	3.2	Clean
" 5	28 1/2	8 1/4	Male	3.2	Clean
" 11	30 1/2	11	Female	3.2	Clean
" 15	29	8 1/4	Female	2.2	Clean
" 16	29	9 1/2	Female	2.2	Clean
" 17	28 1/2	8 3/4	Female	3.2	Clean
" 17	27 1/2	7 1/2	.....	3.2	Clean
" 18	.....	11 3/4	.....	2.2	Clean
" 22	.....	10 1/2	.....	...	Clean
" 23	28	6 3/4	.....	2.2	Clean
" 29	31	10 1/2	.....	2.2	Clean
Sept. 8	30	8 3/4	Male	3.2	Clean

Table 13

Lengths and weights of young salmon

(1-year fish)

Date: 1941	Standard length: mm.	Total length: mm.	Weight: grams	Date: 1941	Standard length: mm.	Total length: mm.	Weight: grams
July 25	38	45	1.0	July 25	43	52	1.4
	34	41	0.6		35	42	0.8
	39	47	1.3		39	47	1.2
	45	55	1.9		50	61	2.3
	45	55	1.0		42	52	1.3
	46	57	1.9		46	57	2.0
	43	52	1.5		41	49	1.2
	46	56	1.9		36	43	0.9
	40	48	1.2		47	58	2.1
	44	53	1.6		37	44	0.8
	34	41	0.8		43	52	1.5
	52	63	2.7		43	52	1.3

Table 13 -- Continued

(1-year fish) -- Concluded

Date: 1941	Standard length: mm.	Total length: mm.	Weight: grams	Date: 1941	Standard length: mm.	Total length: mm.	Weight: grams
July 25	36	43	0.9	July 25	39	48	1.4
	45	55	1.8		32	39	0.6
	39	47	1.1		34	41	0.9
	41	50	1.3		38	46	1.2
	36	43	1.0		38	46	1.1
	36	43	1.0		36	43	0.6
	40	50	1.4		30	36	0.4
	38	47	1.0		33	40	0.9
	44	53	1.6		37	45	0.8
	47	57	2.0		35	43	0.8
	41	49	1.4		33	39	0.7
	44	53	1.4		35	43	1.0
	41	50	1.3		37	45	1.0
	43	53	1.6		34	41	0.8
	36	44	1.0		31	38	0.5
	42	51	1.5		33	40	0.9
	37	45	1.0		47	57	2.0
	42	51	1.5		45	53	1.5
	41	50	1.4		48	58	2.0
	37	45	0.8		45	55	1.6
	43	51	1.6		42	50	1.3
	43	52	1.6		44	54	1.7
	39	47	1.1		43	52	1.4
	42	50	1.4		43	52	1.3
	38	46	1.0		36	43	0.8
	46	55	2.0		44	53	2.0
	31	37	0.6		41	51	1.5
	39	49	1.3		38	46	1.3
	37	45	0.8		35	43	1.0
	39	48	1.1		42	51	1.6
	39	48	1.1		44	53	1.6
	37	44	0.8		30	48	1.0
	29	36	0.4		42	50	1.4
	33	40	0.8		33	41	0.8
	33	41	0.5		42	50	1.6
	35	42	0.7		44	53	1.7
	44	53	1.6		43	53	1.6
	38	46	0.8		40	49	1.3
	42	51	1.5		38	46	1.1
	36	43	0.6		41	50	1.6
	36	43	0.9				

Table 13 -- Continued

(2-year females)

Date: 1941	Standard length: mm.	Total length: mm.	Weight: grams	Date: 1941	Standard length: mm.	Total length: mm.	Weight: grams
June 5	114	135	26.1	July 25	91	107	13.5
July 25	106	127	20.0		96	116	14.2
	99	119	16.3		102	120	16.0
	104	123	16.4		109	128	23.0
	107	127	20.0		75	90	6.5
	95	111	13.7		87	104	10.5
	111	134	23.2		93	111	13.0
	104	122	18.7		99	118	17.2
	102	121	16.0		91	109	11.0
	101	120	16.5		85	101	10.0
	112	131	22.0		108	126	18.8
	95	115	15.0		105	123	17.5
	98	116	15.0		110	132	21.3
	119	127	20.0		101	121	16.3
	97	115	15.0		91	108	13.0
	109	130	20.5		82	100	9.8
	111	133	22.5		102	122	17.4
	100	120	16.5		105	125	18.0
	93	110	13.2		104	125	18.3
	95	112	13.5		89	106	11.0
	103	121	19.5		110	132	21.6
	113	135	24.6		96	114	14.5
	108	124	19.7		84	102	10.1
	98	117	15.5		104	126	20.3
	95	111	14.0		89	106	11.5
	98	117	15.7		88	103	10.8
	93	112	14.3		84	100	10.3
	94	113	14.6	July 26	91	107	11.5
	89	105	11.2		109	129	20.0
	102	121	16.3		100	119	15.0
	98	117	15.5	Aug. 11	90	105	14.0
	103	120	17.7				
	87	103	10.6				
	110	132	23.0				
	90	106	10.7				
	89	105	10.0				
	100	116	16.0				
	83	99	9.5				
	105	125	18.6				
	101	120	15.7				
	97	115	13.7				
	103	121	17.5				
	87	102	10.4				

Table 13 -- Continued

(2-year males)

Date: 1941	Standard length: mm.	Total length: mm.	Weight: grams	Date: 1941	Standard length: mm.	Total length: mm.	Weight: grams
June 5	107	127	23.7	July 25	107	128	19.1
July 25	108	126	21.8		95	112	14.9
	86	102	10.5		95	115	14.9
	99	118	16.7		90	107	10.5
	90	107	11.5		100	117	18.5
	91	109	14.0		84	98	10.0
	98	116	15.0		90	107	13.5
	104	124	18.9		104	123	18.7
	109	128	21.5		100	119	17.2
	102	119	17.5		98	117	18.0
	96	113	14.0		107	127	22.0
	101	118	17.3		98	113	16.0
	105	127	20.7		100	117	15.4
	88	103	11.3		97	112	14.2
	85	99	10.5		98	115	16.0
	97	115	15.7		84	100	10.5
	90	107	11.6		95	111	14.5
	90	106	12.0		83	98	10.0
	85	103	12.3		97	114	15.7
	102	119	18.0		98	118	16.5
	101	118	16.9		102	120	19.1
	87	105	11.0		98	117	14.5
	93	106	12.5		101	118	18.5
	87	103	10.8		88	105	11.9
	91	106	12.6		110	130	21.7
	104	123	19.5		94	112	14.5
	90	108	11.5		95	113	15.1
	88	106	12.5		97	114	16.0
	92	109	13.2		100	117	19.3
	96	114	14.8		97	114	14.2
	92	109	12.3		92	112	13.0
	99	116	15.5		92	110	14.3
	85	101	10.5		91	109	12.3
	86	104	10.6		78	92	8.2
	81	98	9.7		74	89	7.5
	106	125	20.5		85	103	11.5
	102	118	17.5		85	103	10.0
	110	130	21.5		86	104	11.3
	93	112	13.0		95	112	15.2
	103	122	18.5		93	110	13.2
	100	118	16.8		84	100	9.5
	82	96	10.0		101	120	17.6
	94	112	13.0		102	121	18.5
	86	102	10.8		90	113	13.6
	86	102	11.1		95	113	13.6
	100	118	16.2		107	127	23.7
	85	101	11.0	July 26	103	121	17.0
	100	117	18.0		98	115	17.2
	95	111	15.0		102	121	19.0
	95	112	13.4		106	133	19.5

Table 13 - Concluded

(3-year females)

Date: 1941	Standard length: mm.	Total length: mm.	Weight: grams	Date: 1941	Standard length: mm.	Total length: mm.	Weight: grams
July 25	132	160	39.0	July 25	115	140	23.5
	118	142	27.5		120	139	28.5
	142	171	46.2		142	168	42.7
	130	155	39.2		135	160	40.0
	138	166	43.2		131	152	33.6
	115	133	21.7		131	152	33.0
	121	143	29.0	July 26	130	154	37.7
	128	152	35.0		132	156	41.5
	125	147	34.5		131	153	34.5
	136	162	39.0		132	156	34.5
	134	160	41.0		124	150	35.2
	128	152	35.0	Aug. 11	133	157	40.8

(3-year males)

Date: 1941	Standard length: mm.	Total length: mm.	Weight: grams	Date: 1941	Standard length: mm.	Total length: mm.	Weight: grams
June 4	126	145	37.2	July 25	130	155	35.8
" 5	159	182	74.2		130	155	38.1
" 28	157	183	70.6		122	143	31.3
	136	157	43.2		126	148	34.5
July 25	155	183	68.0		132	154	39.3
	126	148	33.2		133	159	39.6
	144	173	52.3		137	161	46.8
	126	150	37.7		121	142	29.9
	140	165	41.3		141	165	42.8
	140	164	47.0		118	142	26.5
	142	165	48.3		135	159	43.0
	121	143	31.0		128	150	31.4
	111	132	24.0		130	153	38.8
	120	140	23.5		115	133	26.0
	141	166	48.3		139	164	42.8
	138	164	42.0		140	163	45.1
	133	156	40.0		140	164	43.6
	134	157	40.3		128	149	35.4
	135	158	41.0		121	143	31.0
	145	171	49.5	Aug. 11	155	182	68.2
	125	146	33.0		146	173	60.0
	141	162	46.4		160	184	78.0
	131	155	39.4		128	153	40.0
	139	163	44.5		152	180	57.0
	129	151	35.5		147	174	58.0
	145	170	56.2		138	163	51.0
	142	169	51.6		135	161	50.0
	149	171	59.0		127	150	40.4
	141	166	48.5		137	163	48.6
	141	167	47.1		127	151	35.3
	138	161	44.5				

RECENT RECORDS OF SALMON IN THE DENNYS RIVER, 1942-43

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University of Maine

In preparing this mimeographed copy of Mr. Goodwin's report, it has seemed desirable to give, in this appendix, the records on plantings, catch by anglers, and other available data on Atlantic Salmon in the Dennys River for the period since the spring of 1942 when Goodwin completed his report.

During the spring (May) of 1942, a total of 15,000 yearling salmon and 6,000 salmon fry were planted in the river at the foot of Camp Rips just above Robinson's Camp. The 15,000 yearlings were from eggs collected on the Dennys River in the fall of 1940, and hatched in the spring of 1941; thus, these fish were a little more than one year of age. Of these 15,000 yearlings, Mr. Goodwin marked 3,200, by clipping off the dorsal and adipose fins. The 6,000 fry were from Machias River eggs collected during the fall of 1941 and hatched during the spring of 1942. Plantings during 1943 consisted of 4,150 yearlings put in the river at the foot of Camp Rips during May; these fish were from Machias River eggs collected during the fall of 1941.

Two attempts were made during 1943, by G. P. Cooper and other members of the University of Maine Zoology Department, to obtain information on the distribution and survival of the 3,200 salmon which were marked by Goodwin and planted at Camp Rips during May of 1942. In each instance the party traveled by canoe from Meddybemps to Dennys Station. On the first trip (May 25 to 26) only one salmon parr was collected; it was taken on Camp Rips, but was not a "marked" fish. On the second trip (August 28 to 30) a total of 62 salmon parr were collected. These fish ranged in length from 5 to 8 inches. Five of them were taken on Camp Rips and 41 on Stoddard's Rips. None of the 62 parr were "marked" fish.

The catch by anglers of adult salmon (kelts not included) during the 1942 season was reported to be 75 fish, according to the following communication in a letter, dated January 1, 1944 and received by the writer, from Mr. John A. Longmore of West Pembroke: "I have been looking up the salmon catch on Dennys River for the summer of 1942; and Don Pheney has a record of a catch of 75 salmon.-----" As to the angler's catch for 1943, Mrs. H. H. Allan of Dennysville, on August 28, 1943, informed the writer that she had kept an actual record of approximately 130 salmon being caught. Mr. Longmore informed the writer, on August 30, that he estimated the catch for 1943 at approximately 175 fresh-run fish (kelts not included); he believed that Mrs. Allan did not get the records of all fish.

Figures given in Goodwin's report on angler's catch of fresh-run salmon for 1936 to 1941, inclusive, plus the above figures for 1942 and 1943, are as follows:

Year:	1936	1937	1938	1939	1940	1941	1942	1943
Salmon:	47	79	66	35	82	12	75	130-175

The records of the numbers of salmon redds on the different rips of the Dennys River, obtained by Goodwin during the 1940 and 1941 spawning seasons, may be regarded as a type of census of adult salmon in the river. Similar records for the 1942 and 1943 spawning seasons have been obtained by Mr. Bertrand E. Smith, manager of the Moosehorn National Wildlife Refuge at Calais, Maine. The complete records for these four seasons of the numbers of salmon redds found on the different rips, together with the length in yards (from Goodwin's report) of each rips, are as follows:

Name of Rips	Length in yards	Records by Goodwin 1940*	Records by Goodwin 1941	Records by Smith 1942	Records by Smith 1943
Gilman's.....	400	12	0	8	0
Gardiner's.....	920		0	12	4
Bright Island..	2,640	37	13	38	28
Ayer's.....	450		5	5	2
Clark's.....	880		15	28	5
Stoddard's.....	1,760	200	185	169	219
Little Falls...	264		3	0	0
Camp.....	1,841		50	211	195
Town.....	1,760	0	0	0	3
Totals....	10,915	249	271	471	456

* Note that Goodwin's figures for 1940 are partial totals for 2 or 3 rips combined.