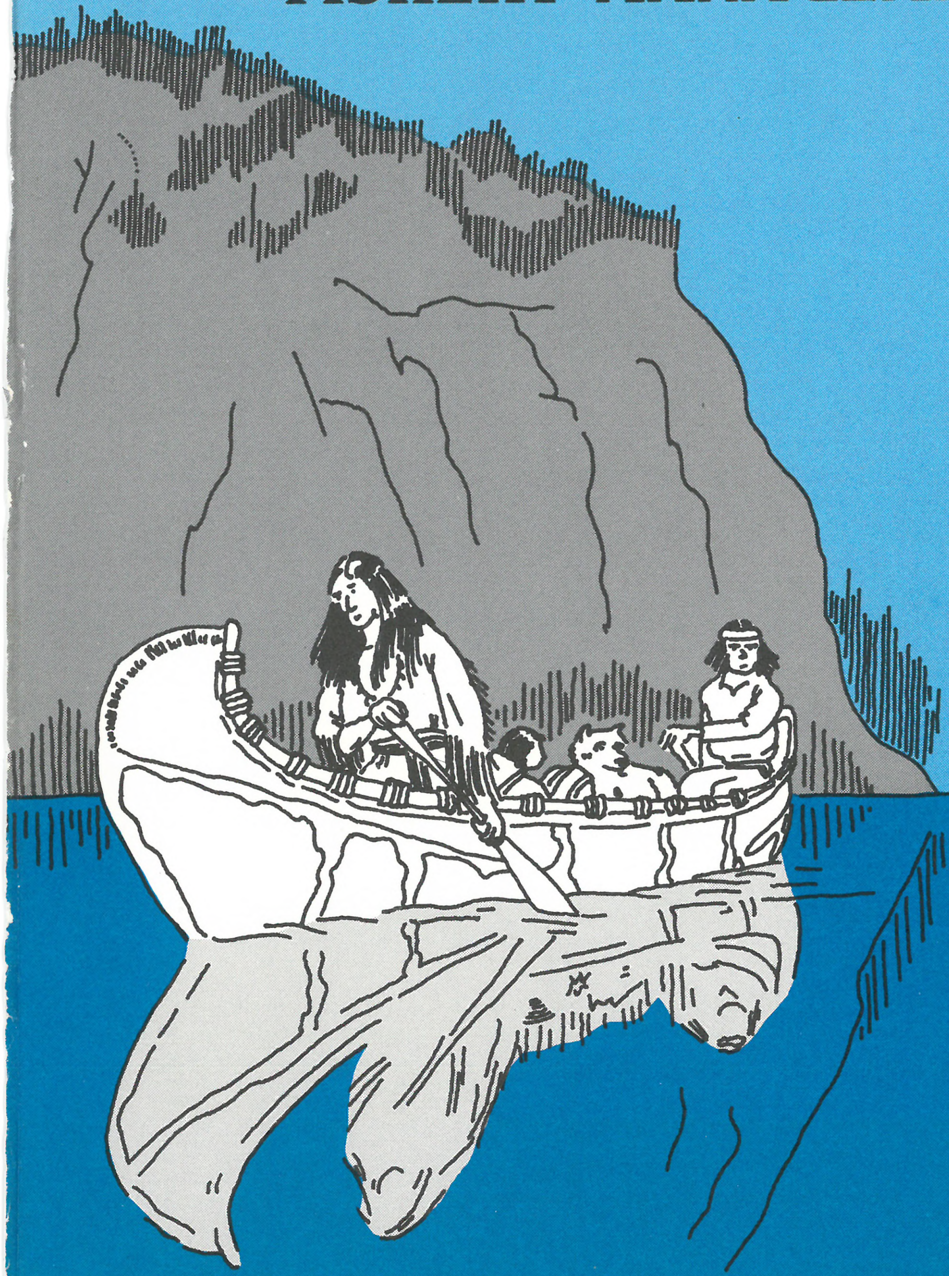
MOOSEHEAD LAKE
FISHERY MANAGEMENT



MAINE DEPARTMENT OF
INLAND FISHERIES
AND WILDLIFE

FISHERIES RESEARCH
BULLETIN NO. 11

Guide poling canoe on East Outlet of Moosehead Lake.

MOOSEHEAD LAKE FISHERY MANAGEMENT

BY

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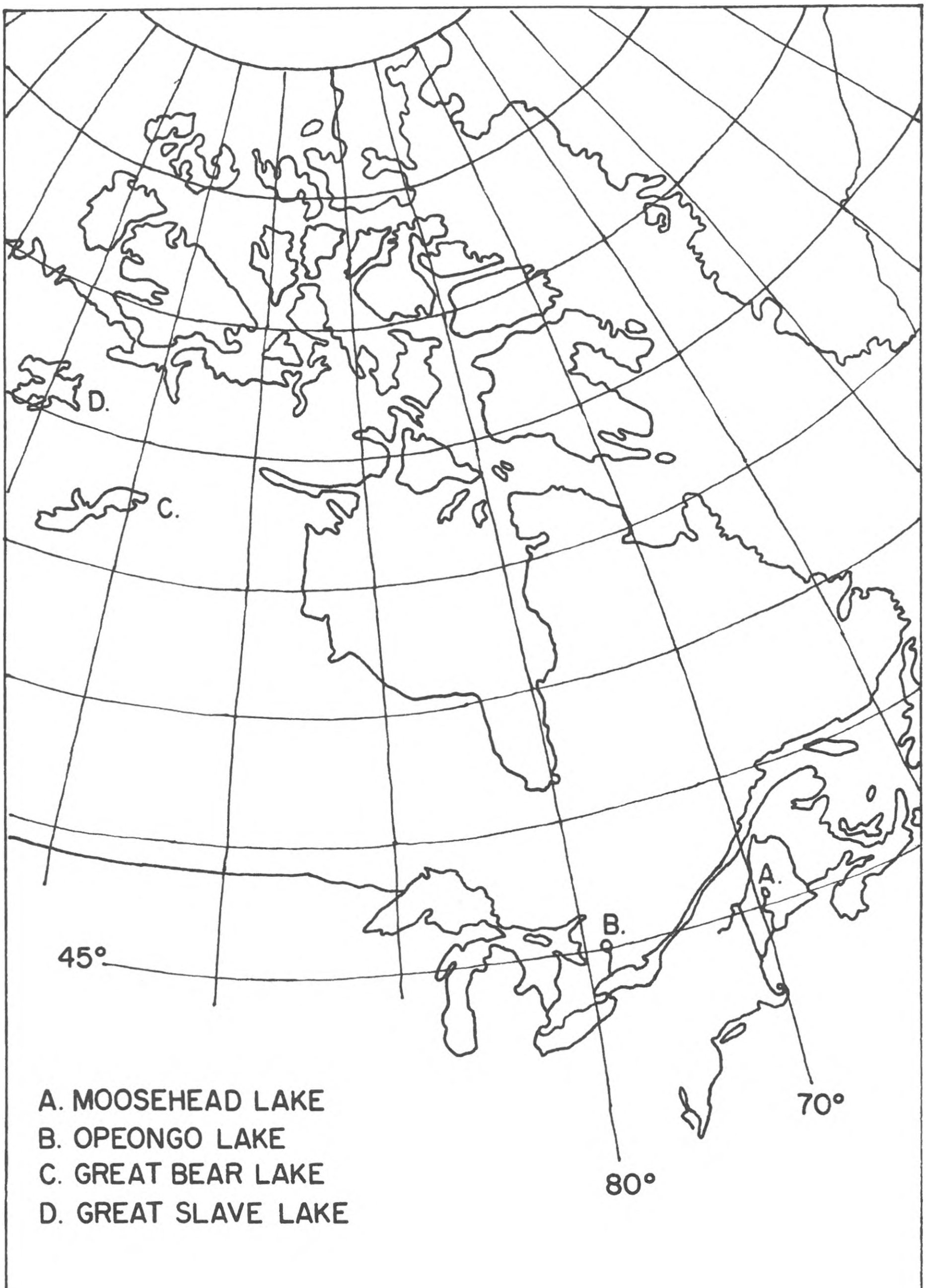

D.
C.
A.
B.
45°
70°
80°
A. MOOSEHEAD LAKE
B. OPEONGO LAKE
C. GREAT BEAR LAKE
D. GREAT SLAVE LAKE

INTRODUCTION

Moosehead Lake holds a special significance to Maine people, and to many others who have enjoyed vacations in Maine. It is not the fishing alone that one remembers about this large, deep, clear body of water, but it is perhaps a feeling of returning to the time when Europeans had not yet settled on this continent. Exploring the many isolated coves and rocky, forested shores, one can easily imagine a birch bark canoe, paddled silently by a native American, emerging from a morning mist enveloping Mt. Kineo, the source of material used for arrow points, and the focal point of many Indian legends.

Moosehead Lake history has passed through the phases of discovery, hunting and trapping, early logging, resort hotels, and sporting camps for the wealthy, and it is now well into the stage of individual seasonal homes, condominiums and 4-season resorts. The impact of these changes on the water quality and fisheries of the lake is difficult to assess. There are indications that water quality has changed little from its "pristine" condition of over a century ago. However, comparing the present fishing quality objectively with the lightly exploited condition and fishing habits of anglers at the turn of the present century is little more than a qualitative evaluation.

The primary purpose of this publication is to document and evaluate the information and data available on the past status of the fisheries of Moosehead Lake, to summarize the results of a 12-year study of the present fisheries, and to tender recommendations for the management of these sport fisheries in the future. Much of the information on fishing quality and catch composition during the first half of the present century is a summarization and interpretation of scattered records, sporting magazines, personal communication with native guides, some records kept by Wardens, hatchery records, and the published survey of Moosehead Lake done by Cooper and Fuller (1944). The author has called upon his knowledge and experience as a professional fishery biologist working in the Moosehead Lake Region since 1955, to review, interpret and summarize information and data from the pre-project period, for a general comparison with information and data acquired during the first 10 years (1967-1976) of a continuing study of Moosehead Lake and its fisheries.

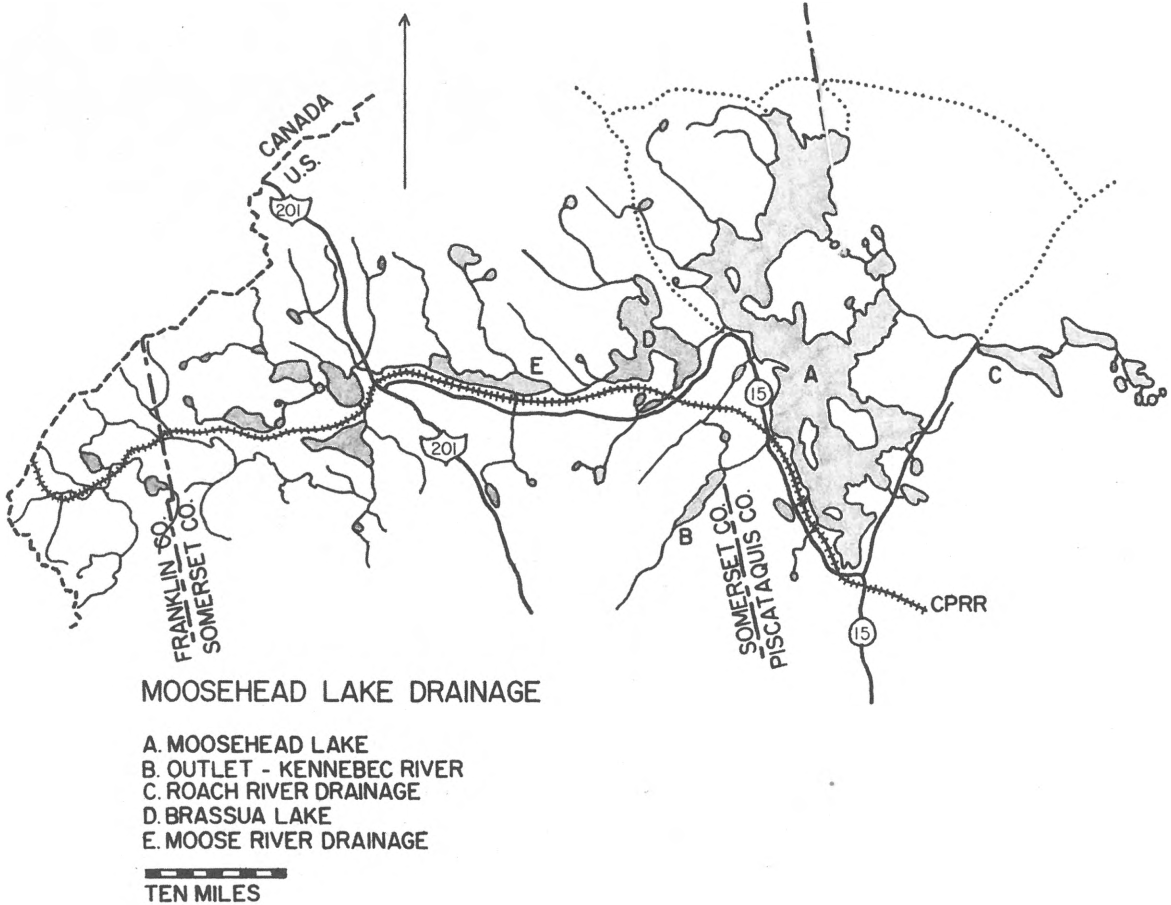


Figure 1. *Moosehead Lake drainage.*

THE MOOSEHEAD LAKE DRAINAGE

Moosehead Lake drains an area of about 1,266 square miles. By far the largest portion of the basin (about 18 Townships) is drained by the Moose River and its tributaries. The Moose River originates at the height of land on the Canadian-U.S. Border west of Jackman. There are about 91 lakes and ponds with surface areas of 10 acres or larger in the Moose River drainage. These have a combined surface area of nearly 23,000 acres. Brassua Lake, the largest, with 7 other lakes and ponds over 500 acres each, comprise 19,000 acres (85%) of the total. Most of the remaining 83 waters are less than 100 acres in area. Because the Piscataquis County line follows the western shore of Moosehead Lake, all of these waters are in Somerset and Franklin Counties. Many small ponds (less than 10 acres) are not included in this report.

Table 1. — Number and acreage[a-b] of waters 10 acres and greater in the Moosehead Lake drainage.

	No.	Acres
Moose River Drainage		
Franklin County	12	449
Somerset County	79	22,254
Total (Moose River)	91	22,703
Roach River Drainage		
Piscataquis County	13	5,426
Total (Roach River)	13	5,426
Moosehead Lake & Other Tributaries		
Somerset County	6	505
Piscataquis County	15	3,045
Moosehead Lake	1	74,890
Total (Moosehead and small tributaries)	22	78,440
Total (entire drainage)	126	106,569[c]

[a] Moosehead = 70% of total

[b] 13 waters 500 acres plus = 101,467 (95%)

[c] 166.5 mi^2; 431 km^2

The second largest drainage system is the Roach River on the eastern side of Moosehead Lake. This system is much smaller than the Moose River system and includes all or portions of 7 townships. There are 13 great ponds (10 acres and over) in this drainage with a total surface area of 5,426 acres. First, Second, and Third Roach Ponds, all over 500 acres each, have a combined area of 4,810 acres or 89% of the total in the drainage (Table 1).

The remaining 21 lakes and ponds that drain into Moosehead Lake amount to 3,550 acres. These are all on small streams that empty directly into the lake. The 126 waters including Moosehead Lake add to 106,569 acres (166.5 mi^2) of lakes and ponds of 10 acres or greater. Moosehead Lake's area of 74,890 acres is 70% of the total. The 13 waters of 500 or more acres comprise 101,467 acres or 95% of the grand total surface acreage. Biological surveys have been completed for 66 (52%) of the waters in the drainage; however, the 66 surveyed waters comprise about 104,800 acres or 98% of the total acreage.

The 60 waters that have not been surveyed are mostly either remote ponds too small to land a float plane on, or bog-type ponds or dead-water areas. Some of these will be surveyed as the need arises or as a matter of course.

Except for 2 lakes and a section of river with towns virtually on their shores, most of the waters in the drainage have not been influenced greatly by civilization. There are no mining or manufacturing operations dumping large quantities of wastes that would lower the water quality or introduce toxic substances into these waters. There are approximately 3,200 dwellings occupied during the entire year, and an additional 1,000 seasonal dwellings occupied only occasionally near the waters of this drainage basin. An all-weather highway (Route 15) from the Bangor area to Greenville, the southernmost point on Moosehead Lake, follows the western shore of Moosehead Lake to the mouth of Moose River then follows, generally, the Moose River to Jackman where it intersects a major route (Route 201) connecting populated areas of southern Maine with the Canadian Province of Quebec. Another public road follows the eastern shore of Moosehead Lake for 19 miles where it crosses the Roach River at the outlet of First Roach Pond. Several gravel surface roads owned and maintained by large landowners make vehicular access possible to most of the large lakes and ponds in the drainage. However, many of the smaller ponds are not accessible by conventional-drive vehicles and some are accessible only by trail or canoe.

It is safe to state that over 95% of the Moosehead drainage area is forested, and in various stages of cutting and growth. The area is rich in logging history, and most of the roads and settlements evolved around logging and possibly hunting, fishing, and trapping activities.

Between the early 1800's and the near-present, most of the waters in the drainage were used to transport and store long logs or short wood (pulpwood). Men and supplies were transported by water or along water routes to and from the numerous remote logging camps. Until less than 5 years ago (1975), pulpwood was transported out of Moosehead Lake down the outlet, the Kennebec River, all the way to Augusta which is close to the head of tidewater. A 2-mile portage which was made with the aid of horses and wagons from Moosehead Lake's northeastern tip called Northeast Carry, allowed men, horses, and supplies to go from the railroad head at Greenville, travel 40 miles by steamboat to Northeast Carry, then cross the carry to the West Branch of the Penobscot River, where by water routes and short overland carries they could transfer to the St. John and Allagash drainages.

At some time or other during the period between the early 1800's and as late as the 1950's, timber dams were built on the outlets of practically every lake, pond, or bog large enough to provide sufficient water storage for driving logs, either part way down the Moosehead drainage to a local sawmill, or into Moosehead Lake to be stored near sawmills or "boomed" down to the outlet to continue down the Kennebec River. Some of the rafts or "booms" held over 3,000 cords of pulpwood. At the present time there are only 3 timber dams, that hold water, remaining in the entire drainage. Remains of many old timber dams, in various stages of decomposition, may be seen throughout the area. On some streams the remains of 2 or 3 such structures, one a short distance below the other, may be seen. The only "permanent" dams remaining in the drainage are the large concrete structures on the outlets of Brassua Lake and Moosehead Lake, and small concrete dams on Crocker Pond, Squaw Pond, and First Roach Pond.

DESCRIPTION OF MOOSEHEAD LAKE

Moosehead Lake, situated in the mountainous section of west central Maine has an area of 117 square miles and a perimeter of 190 miles. This large picturesque lake is extremely irregular in outline with a length of 35 miles and a maximum width of 15 miles. The lake has at least 50 islands ranging from less than one to more than 5,000 acres. Moosehead Lake has several well-defined basins up to 240 feet deep. The present rough configuration and basins of the lake were probably shaped by the gouging and damming effect of the last glacial advance 10,000 to 15,000 years ago. Geologically, Moosehead is a relatively young lake. Its sharp points have not weathered extensively and only relatively small portions of the basins are filled with silt. Moosehead Lake is quite sterile; nutrient values are very low, aquatic vegetation and algae are scarce, and the bottom deposits are mainly inorganic. Water quality determinations conducted at various times throughout the year disclosed little oxygen depletion at any depth. At this latitude (45 degrees), and with frequent strong winds causing some mixing of the epilimnon and metalimion, surface temperature rarely exceeds 70°F. for prolonged periods. Past and present abundance of profundal vertebrate and invertebrate species and paucity of tubicifid (sludge) worms attest to the highly oligotrophic status of the lake.

The shoreline of Moosehead Lake is predominately rocky and bouldery with many beautiful ledges protruding from the water near the shore and on islands. Only the sheltered portions of shallow coves have deposits of mud, silt, or sand. There is an extensive shallow sandy area at the extreme northeastern end and some small scattered sand or pebble beaches in different locations. The prevailing winds are from the North, resulting in good circulation patterns in practically all parts of the lake. The forests extend practically to the high water mark and are composed of red spruce, balsam fir, eastern hemlock, eastern white pine with small stands of red pine and eastern larch. Sugar maple, red maple, paper birch, yellow birch and northern white cedar are scattered throughout the stands or appear in clusters on favorable sites. Natural openings in the forest were probably very scarce originally, as there are no marshes or deltas around the shores. A few homesteads, sporting camp sites, and hotel sites were cleared beginning around 1840, but some of these were abandoned and are now partially overgrown with trees.


FOREST TYPE CLASSIFICATION


Forest Type Legend
SOFTWOOD
MIXED WOOD (SOFTWOOD DOMINANT)
MIXED WOOD
MIXED WOOD (HARDWOOD DOMINANT)
HARDWOOD
CUT OVER AREAS
SCARIFIED AREAS
UNCLASSIFIED
WATER

LANDSAT

In 1972, the National Aeronautics and Space Administration (NASA) launched a one-ton satellite, called LANDSAT, into an orbit 500 nautical miles above the earth — it is still there, still doing its job, aiding scientists, biologists, foresters, sociologists, etc. with a myriad of useful information.

The picture on the opposite page is a black and white reproduction of the truly amazing and detailed 1975 LANDSAT scan of the Moosehead Lake area. The original map is in nine colors, each representing a different land cover type. In this case, the interest was primarily in forest types, so the data sent from LANDSAT was interpreted accordingly.

In its simplest form, LANDSAT is a reflective meter, measuring and classifying the differences in reflectance from each different type of forest stand and transmitting this data back to earth in the form of digital data. Using computers, technicians then assign whatever graphic qualities (e.g., colors, shades of grey, even number arrays) they wish to each different type of data — the result, especially in color, is astoundingly detailed!

The Maine Fish and Wildlife Department is utilizing these LANDSAT images in much the same way as aerial photographs are used. They analyze ground cover types, pinpoint suitable habitat types, record changes in ground cover types over periods of time, etc. But the LANDSAT can cover in one scan of this area what it would take 4,000 aerial photographs to cover — and much more objectively!

As with any technological advance, LANDSAT has its problems. One obvious one is cloud cover. From 500 miles up, clouds which have no effect whatsoever on aerial photography frequently block LANDSAT scans — the northeastern United States suffers from frequent cloud cover, which makes this problem particularly bad for this region. Also, for fine detail of a small area, aerial photography is still the answer — LANDSAT's finest scanning area (one bit of data) is 1.14 acres.

What work has been done so far with LANDSAT in Maine has been accomplished by cooperation between the Maine Departments of Conservation, Inland Fisheries and Wildlife, and Environmental Protection, the University of Maine at Orono, and NASA technicians. Its future, as far as fish and wildlife is concerned, looks promising. For more information about LANDSAT, see the Summer 1982 issue of MAINE FISH AND WILDLIFE Magazine (article beginning on page 15).

The earliest known dams on the two outlets of Moosehead Lake were built around 1834. These dams raised the elevation of Moosehead about 7 feet. Present concrete structures are in the approximate same locations and probably maintain a slightly higher water level although the water usage regime is quite different. From recent observations of the shoreline at low water levels it appears that, except for some shallow areas, the original shoreline was not changed appreciably by the impoundment as most of the original banks were steep. However, the lower portions (as much as a mile) of the tributaries were inundated, thereby reducing the amount of spawning and nursery area for salmonids substantially on some streams. I cannot assess the effect of the change in water depth and possible siltation around aboriginal lake trout spawning areas.

There are two communities with permanent residents living near the shores of Moosehead Lake. Rockwood, at the mouth of Moose River on the western side, evolved from a few settlers, guides, and lumbermen to its present (approximately 150) residents. Their numbers may actually have decreased from the period of large hotels and sporting camps around the turn of the century. At the southern end of the lake is the town of Greenville, incorporated in 1836. The population of Greenville increased from 326 in 1850 to the present 1,900 inhabitants. There are approximately 900 dwelling units with frontage on Moosehead Lake, but more than 75% of these are occupied only seasonally by vacationers. The large, old hotels and sporting camps so popular during the late 1800's and early 1900's are mostly gone. The largest of these, the Kineo House, had facilities for 400 guests and employed 100 to 200 persons for various services, including guiding hunters and anglers. At one time there were 3 railroads with stations on Moosehead Lake; the Maine Central had a track to Rockwood, and the Bangor and Aroostook and the Canadian Pacific had stations in Greenville. The Canadian Pacific is the only railroad remaining, probably because it is a through line to St. John, New Brunswick.

Natural barrier below the original Indian Pond.

FISH AND FISHERIES IN THE MOOSEHEAD LAKE DRAINAGE

After the last ice age (10,000-15,000 years ago) and the subsequent uplift of the de-glaciated areas, many natural barriers (high falls), some existing still, and some changed by erosion and man, prevented some or all fish species from becoming established in the upper reaches of many watersheds. The stronger swimmers, or possibly some species following the retreat of the ice sheet at an early and opportune time, ascended farther up the river drainages than others. It appears that the more primitive species, especially the salmonids, had some advantage in this respect, as they could effect the change from salt water to fresh water more rapidly.

From limited knowledge and research of recent local history it appears that Caratunk Falls in the town of Solon on the Kennebec River limited the ascent of most fish species of recent origin, and only the powerful swimmer and jumper, the Atlantic salmon, surmounted these falls. Atlantic salmon are reported to have spawned in the Dead River which empties into the Kennebec many miles above these falls. However, there is no record of Atlantic salmon reaching Moosehead Lake. Apparently the falls at the foot of the original Indian Pond, several miles below Moosehead Lake, stopped all fish. Consequently the Moosehead Lake drainage had a very limited association of fishes until man decided he could "improve" this situation by adding a few more species.

As late as the 1870's the only game species, so called, present in these waters were brook trout and lake trout. Whitefish, suckers, and cusk were present and utilized by man mainly for food. Minnows, chubs and a few lesser known species were present in some waters. Some ponds were totally devoid of fish, and many waters contained brook trout only. (See Table 2 for list of fishes in the Moosehead Lake Drainage.)

Between the 1860's and 1870's, Federal, State, and some private groups learned to strip female fish of their eggs, fertilize the eggs with sperm from the males, and hatch them in containers equipped with flowing water. Young fish were reared by the millions and stocked into many waters. The theory was that heavily fished waters could be kept well stocked. Of greater consequence was the discovery that many species could be transported and introduced into most waters almost at will. At that time, the habits and requirements of most fish species were not well known, and, fortunately, many of the "trial-and-error" introductions failed. Waters in the Moosehead drainage were spared irreparable harm because white perch, bass, pickerel and other "warm-water" species were not introduced there. Pacific salmon were stocked but failed because

Table 2. Fishes of Moosehead Lake

Common Name	Scientific Name
Landlocked salmon	*Salmo salar*
Brook trout	*Salvelinus fontinalis*
Lake trout	*Salvelinus namaycush*
Rainbow smelt	*Osmerus mordax*
Lake whitefish	*Coregonus clupeaformis*
Round whitefish	*Prosopium cylindraceum*
Yellow perch	*Perca flavescens*
Brown bullhead	*Ictalurus nebulosus*
White sucker	*Catostomus commersoni*
Longnose sucker	*Catostomus catostomus*
Burbot (cusk)	*Lota lota*
Pumpkinseed sunfish	*Lepomis gibbosus*
Freshwater sculpin	*Cottus cognatus*
Threespine stickleback	*Gasterosteus aculeatus*
Fallfish	*Semotilus corporalis*
Lake chub	*Hybopsis plumbea*
Creek chub	*Semotilus atromaculatus*
Pearl dace	*Semotilus margarita*
Finescale dace	*Phoxinus neogaeus*
Northern redbelly dace	*Phoxinus eos*
Common shiner	*Notropis cornutus*
Golden shiner	*Notemigonus crysoleucas*
Smallmouth bass[a]	*Micropterus dolomieui*

[a] May become established.

their habitat requirements were not well known, or were ignored. Landlocked salmon and rainbow smelts were introduced successfully during the 1880 to 1890 period.

Scattered records of fishing success in the Moosehead Lake drainage were collected from the Maine Sportsman Magazine, old sporting camp logs, newspapers, and the memories of men who fished or guided anglers. Reports of catches of hundreds of brook trout and lake trout weighing hundreds of pounds with many trout weighing from 2 to 6 pounds were common. Lake trout were not exploited heavily and were found principally in Moosehead Lake and 2 or 3 other waters, so they are not mentioned as often as brook trout. However, some reported catches included lake trout over 20 pounds.

During the late 1800's, a regulation prohibiting the sale of trout and salmon, and limiting the catch of an individual to 50 pounds, was passed, but law enforcement was almost non-existent and large catches continued for some time.

The 1930's marked a decline in good fishing. There was a brief respite of a few years during World War II when traveling was difficult and most young men were in the armed forces. This period allowed fish populations to recover somewhat, and fishing was good for a few years in the late 1940's and early 1950's. However, accelerated use of automobiles, the availability of jeeps, increased logging road construction, and general improvement of working conditions with more vacation time etc., resulted in a gradual increase of fishing intensity in all but the most remote waters. Remote waters large enough to land float planes upon were not spared the increased demand for fishing. In many instances, stringent regulations with low bag limits were not implemented until too late. Well adapted native populations were sometimes so depleted that complete closure to fishing would have been necessary to restore these native populations to something near their former levels.

An unfortunate incident occurred in the Moosehead Drainage in the late 1950's: Yellow perch were discovered. Yellow perch spread to most of the large waters in the Moose River drainage and dense populations developed during the first 10 years after their appearance. The old timber dam at First Roach Pond, recently replaced with a concrete structure, has stopped their movement past this point. However, they are present immediately below the dam and some unfortunate event could allow the perch to pass through this barrier at any time. The initial high abundance of yellow perch caused severe reductions in the trout populations of the waters involved. Gradual subsidence of the perch to normal populations has allowed trout to increase somewhat, but it is doubtful if trout can overcome completely the competition for food and space and possible predation by yellow perch.

Another incident which may alter the fish population structure and sport fisheries of Moosehead Lake occurred in September of 1975, but was not discovered until the summer of 1977. Apparently a small group of selfish persons conspired to introduce smallmouth bass into Moosehead Lake. Their purpose was to increase their incomes by attracting non-resident bass anglers to the area. They caught and kept alive an unknown number of bass at Sebec Lake and illegally transported the fish to Moosehead Lake. The first of these (3 fish) were caught by anglers in 1977. During 1979 we found evidence of natural reproduction in Prong Pond (a tributary water) and in Long Pond a short distance down the West Outlet of Moosehead Lake. It is quite likely that smallmouth bass will become well established and abundant in the drainage within the next 10 years, as the rocky shorelines of Moosehead Lake are ideal habitat for the species. The bass will undoubtedly displace brook trout from the shorelines and result in the decline of the good brook trout fishery the lake has produced since its discovery.

Comparing present day fishing in the Moosehead drainage with fishing statewide, there are many waters in the drainage where good fishing for salmon, trout, and lake trout may be enjoyed. However, the research of old records and personal interviews indicate there is little comparison with the catches (size and numbers of trout especially) of the early 1900's and even into the 1940's.

"When I was a boy, fish were so big that they dragged on the ground."

HISTORY OF MOOSEHEAD LAKE FISHERIES

Information on the original or early abundance and sizes of brook trout, lake trout, and salmon from New England inland waters, especially Maine, is scarce and presented mostly as incidental material from accounts of voyages. Kendall (1924) wrote on this subject, but much of his material was about Atlantic salmon. Kendall quoted one Rich (1883) who had lived most of his life in the Rangeley Lakes Region of Maine. Before the area became widely known to anglers Rich said "Every brook, every stream, every pond and lake was literally full of them (meaning trout) and at spawning time the stream mouths were black with them. Spawn takers took 500 trout in 5 rods of stream." The Reverend Zadock Thompson in his history of Vermont stated when the country was new, trout of 2 to 3 pounds abounded in the larger streams, but they were soon depleted, and now are found mainly in the smaller streams and weigh up to ½ pound only.

Because Maine, especially the central and northern portions, was a greater distance from populated areas and transportation methods were slow and often non-existent, depletion of many of our inland waters did not occur until the late 1800's and early 1900's. Nonetheless, Maine went through the same process of depletion and subsequent "trial-and-error" stocking of several exotic species including Chinook salmon, brown trout, black bass, rainbow trout, walleyed pike, and even the potentially very destructive carp. We have remnants as reminders of some of these introductions, including carp, to this day.

Access to Moosehead Lake was by buckboard and stagecoach only until the late 1800's when railroads were extended to Greenville. Thoreau wrote about his canoe trip the length of Moosehead Lake in the 1840's during which he mentioned that his guide caught some 4-pound lake trout while he and his companion hiked to the summit of Kineo. A note in Harper's Monthly of August, 1875 said that fishing was not what it used to be and that the largest lake trout then weighted 27 pounds and a 5-pound trout (squaretail) was a big one. Until salmon were introduced to Moosehead Lake in 1879 (Smiley 1884), all the fishing was for trout (squaretails) and lake trout (togue). Smelts were introduced around 1892 as a forage species for the salmon. However, few salmon were caught before the 1900's. Camp Comfort records note the first salmon caught by their anglers was a 4½ pound fish caught in 1895. The Maine Sportsman (1893) stated, "Salmon have been put into the lake but only a few have been caught. Guides and all people interested in preserving the fish interests of the region are agreed in their opinion that these waters should be stocked with fish natural to them and that it is a waste of money and energy to put in sea salmon and other fish which might prove destructive to trout." These comments are surprising coming at the time when strong pressures for all kinds of introductions were being exerted in most circles interested in fish and wildlife. Private hatcheries and hatcheries built and operated by fish "protective" associations sprang up all over the state including one at Kineo (Moosehead) where salmon and trout fry were reared and put into the lake.

Many accounts of the trout fishing, especially, are noted in the Maine Sportsman magazines of the 1890's. The following examples are presented here: June 1894, Cowan Cove — good trout fishing — 29 trout weighed 35½ pounds, Saturday, 30 trout weighed 31 pounds, the largest about 4 pounds (one person fishing). July 1894, W.H. Gannett, Augusta publisher, "From a week at Moosehead with wife and daughter. In one day's fishing caught 21 trout weighing 52¾ pounds. Of these 13 were squaretails weighing 34¾ pounds — one weighed 5¼ pounds the largest taken from the lake this season. Mrs. Gannett caught a 4¼ pounder." At that time the legal weight limit was 50 pounds per person daily bag and possession limit, and the season ran from May 1 to October 1 as it does today.

One might suggest that the lake was not fished much in those days, but this is debatable as there were several hotels and large sporting camps catering to anglers and hunters around the turn of the century. I have estimated there could have been up to 1,000 anglers fishing the lake at times from shortly after ice out through June. Another flurry of fishing occurred in September. One difference was that there was little serious fishing during July and August. Practically all the fishing was from canoes, each paddled by an experienced guide.

It is quite probable that over 50,000 pounds of trout and lake trout were harvested from Moosehead Lake annually during the late 1800's. Some salmon were in the catch at that time, but they were not significant. In 1895, the weight limit was reduced from 50 to 25 pounds plus one fish. A reduction to 15 pounds occurred around 1908 and remained so until about 1942. Even with a 15-pound limit it would have been possible for anglers to have harvested over 50,000 pounds of salmonids from the lake annually. I have what I believe to be good harvest estimates beginning with 1967, and in 1968, under an 8-fish, 7½ pound limit anglers probably harvested 45,000 pounds of salmonids that year. Details of these harvests are presented in this report.

One fairly good record of fishing on Moosehead Lake was compiled from a log kept at Camp Comfort. A group of several professional and business men from Massachusetts had a set of camps built on the shore of Moosehead Lake for their exclusive use. Beginning in 1894 and through 1953 (60 years) an average of 7 men per week fished mainly during the first 5 weeks after ice out each year. Each man fished from the bow of a canoe paddled by a guide. A large power boat transported the men and towed the canoes to different areas of the lake where they fished from the canoes. Usually the group went ashore for noonday meals, cooked over an open fire by guides and camp help. A cook and helper were employed for the period the camp was open. Reportedly there was some competition among the sports and guides for the largest fish and the best catch of the day. The camp log, which is not complete but nearly so, includes number of anglers, number of trout, salmon, and lake trout caught each day. A record of all trout 4 pounds and over, salmon 5 pounds and over, and lake trout 8 pounds plus was kept. For the 60 years the largest trout taken was 5¾ pounds, salmon 7½ pounds, and lake trout 17¾ pounds. The last 5-pound salmon was recorded in 1945 and the last 4-pound trout was caught in 1950. These anglers fished close to shore for brook trout most of the time, consequently the record of lake trout, especially of large lake trout, is not representative of large fish of this species that the lake can and has produced over the years. Eight-pound lake trout were caught commonly, and I have many records of lake trout over 20 pounds with the largest weighing over 29 pounds. Summaries of Camp Comfort records are presented in Tables 3 and 4 as published by the club, and Tables 5 and 6 compiled from further analysis of the data by the author.

The author of the Camp Comfort publication notes that all men in camp did not fish every day, and many days no one could fish because of stormy weather. Therefore, catch per man-day data should probably be increased by at least 20%. From Table 6 it is evident these anglers probably averaged 4 fish per day on days fished. During most of the years of their activity, a 15-pound limit was in effect, but the 15-pound limit was always interpreted to mean 15 pounds plus one fish as one could have less than 15 pounds of fish and catch another 4 or 5 pound fish, as was usually the case. The largest fish could be legally used as the last fish caught. As stated previously, it is apparent that weight and not numbers was limiting the total catch until the 7½ pound or 8 fish limit was passed in 1968. With the recent decrease in average size of salmonids in the angler's catch it became possible to catch 8 fish without attaining the 7½ pound limit. Guides who were active in the 1930's have related to me that each guide had a wooden fish box of certain dimensions which, when filled, held approximately 15 pounds of fish, and that there were very few days when the fish box was not filled, or could not have been filled. On many days the box was filled in less than ½ day of fishing. During the fishing day some fair-sized fish were released, depending upon the preference of the "sport" as to species and size. As stated before, lake trout were not sought and were probably released often. The guides have also stated that salmon and lake trout less than legal length were not common.

A guide personally known to me believes the quality of fishing began to decline during the late 1930's. This does coincide with the time (1942-1968) when successive changes in regulations to decrease numerical and weight limits from 25 pounds or 25 fish to 7½ pounds or 8 fish occurred. These were mostly statewide regulation changes which were not necessarily the result of a decline in Moosehead Lake fishing quality alone, but they certainly would have been influenced by the guides and recreational interests of the Moosehead Lake region. The 1930's may possibly have been the beginning of the period of better road networks and more common use of automobiles for recreational purposes by other than the wealthy "sports."

As stated previously, the most recent reduction in legal weight limit to 7½ pounds did little to reduce the steady decline in fishing quality, especially for trout, and the stocking of hatchery fish tended to obscure the decline in wild fish populations. As the average size of the fish in the catch decreased and more young fish were stocked, anglers probably made up their weight limit of 7½ pounds by taking 7 or 8 one-pound fish whenever it was possible to do so. People closely associated with Moosehead Lake emphasize the fact that the fishing was very good for larger fish during the late 1940's and early 1950's. A sporting camp operator could, with some instruction, send sports out without a guide and have them return with 3 to 5-pound lake trout caught while trolling with spoons and sewed on bait. As mentioned earlier, the "flurry" was attributable to the "rest period" of World War II.

In a survey of Moosehead Lake, Cooper and Fuller (1945) analyzed warden census reports from 1935 to 1943. Although these records are too crude to be used for catch per unit effort, they do show that, as Cooper found in his netting operations, the catch composition was approximately 40% trout, 35% lake trout, and 25% salmon. The average catch per angler day could have been between 3 and 4 fish. Warden census reports for 1959-1965 analyzed by this author indicate a catch composition of 36% trout, 38% lake trout and 26% salmon — not much different from the 1940's. However, the catch per angler day apparently decreased from over 3 to less than 2 fish. The catch composition and catch per angler day for the past 10 years (project years) is discussed in detail later in this report. During these years (1967-1976), the proportion of salmon in the catch went up to more than 60% and the catch averaged less than 1 fish per day for all anglers combined. However, we have records of anglers averaging almost 2 fish per day and guided anglers averaging almost 3 fish per day, for the season, in recent years.

Table 3. — Fishing records[a] kept by Camp Comfort on Moosehead Lake.

	Week after ice out					60-year
	1st	2nd	3rd	4th	5th	total
Trout caught	4,384	4,433	3,760	1,744	97	14,418
Salmon caught	662	595	271	53	20	1,601
Lakers caught	589	1,068	1,165	570	27	3,419
Not kept separate		119	149			268
Total	5,635	6,215	5,345	2,367	144	19,706
No. weeks camp open	36	39	24	9	2	
No. days camp open	255	275	172	65	14	
No. fish caught/week	156.5	160	222	263	72	
No. fish caught/day	22.1	22.6	31	36.4	10.4	
Ave. no. men in camp per week	7.2	6.8	7.3	8.9	5.0	
Ave. no. fish caught per man per week	21.7	23.2	30.4	29.9	14.4	

Table 4. — Fishing records[a] kept by Camp Comfort on Moosehead Lake.

Years	Fish caught	No. weeks camp open	Caught per week	Ave. no. fishermen per week	Fish caught per man per week
1894-1903 Incl.	6,010	19	317	9.6	33
1904-1913 "	2,581	20	129	7.6	17
1914-1923 "	2,080	15.7	132	6.2	21
1924-1933 "	3,899	23.7	164	7.7	21
1934-1943 "	2,005	17	118	7.	17
1944-1953 "	2,881	18.3	157	8.	19
Total	19,706				

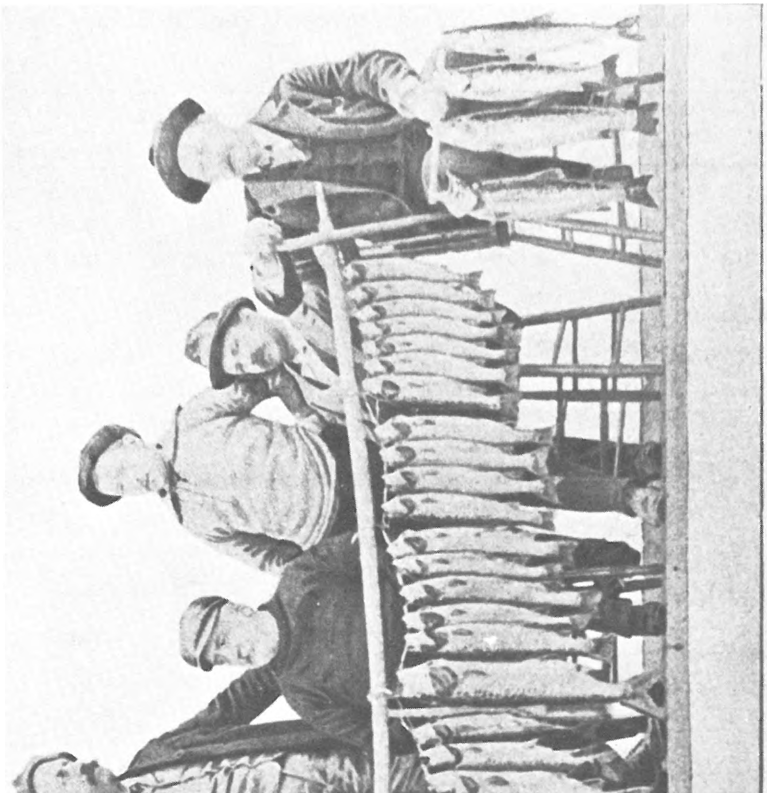
[a] Reductions in legal weight and numbers occurred during the years Camp Comfort was operating. These changes certainly had some effect on the number of fish taken from the lake. Non-resident anglers were restricted to one day's bag and possession limit at all times. For these anglers it was quite likely that the weight limit had the greater effect, as they probably did not keep many small fish.

Table 5. — Author's analysis of fishing records kept by Camp Comfort on Moosehead Lake.

Species	60 year total	Proportion of catch	Trophy fish Size	No.	Proportion
Trout	14,416	0.742	4 lbs plus	44	.0031
Salmon	1,601	0.082	5 lbs plus	49	.0306
Lake trout	3,419	0.176	8 lbs plus	27	.0079
Not identified	268	0.014	—	—	—
Totals	19,706	—	—	120	.0061

Table 6. — Sixty-year totals and means for fishing success from analysis of Camp Comfort records by author.

After ice out	Man-days	Fish per man-day Trout	Salmon	Lake Trout	Total
Week 1	1814.4	2.42	0.36	0.33	3.11
Week 2	1856.4	2.44	0.33	0.59	3.35
Week 3	1226.4	3.15	0.23	0.98	4.36
Week 4	560.7	3.11	0.09	1.02	4.22
Week 5	70.0	0.39	0.29	0.39	2.06



THE RESULT OF ONE DAY'S TROUT FISHING, AT KINEO, MOOSEHEAD LAKE.

From: Scenic Gems of Maine, 1898.

THE MOOSEHEAD LAKE STUDY

Beginning about 1955, persistent complaints of poor fishing success, and a decrease in average size of the fish caught were investigated and found to be justified. Rumors of pesticides (DDT) used for control of black flies, log driving, lake drawdowns, lack of forage, and insufficient stocking of hatchery fish were circulated. Strong pressures from local interests resulted in increased stocking of hatchery salmon, some lake trout, and brook trout. The stocking of hatchery fish did little to improve the fishing quality and, in fact, probably aggravated the situation with greater numbers of "short" salmon being caught by anglers.

A long term study partially funded under the Dingell-Johnson Federal Aid to Fish Restoration Project F-22-R, was initiated in 1967. The principal objective of the study was to determine the causes related to a general decline in the average size and abundance of salmon, lake trout, and brook trout in the sport fisheries of Moosehead Lake. Several jobs were planned, among the more important of which were the following:

1. Physical, chemical, and biological characteristics of the lake.
2. Extent and importance of natural reproduction.
3. Importance of hatchery fish.
4. Estimate of angler use and harvest.
5. Investigation of food habits and growth rates.
6. Effects of commercial water usage.

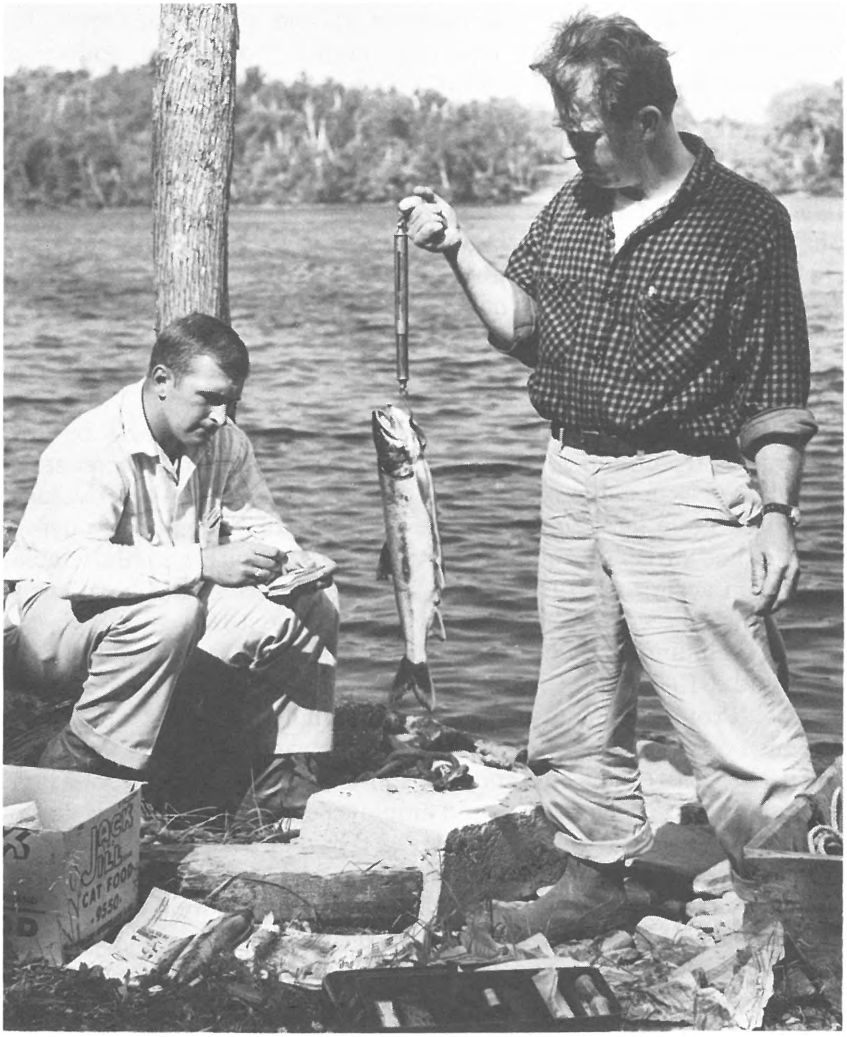
Studies of fish populations in large ecosystems can, and perhaps should, be continued indefinitely. However, for practical reasons the information acquired must be evaluated, summarized, reviewed, and made available to interested groups, and more importantly, recommendations for managing the system must be proposed even though such recommendations may be temporary or contingent. After the 12th year of studies, most of the data have been evaluated and some management recommendations have been implemented. Monitoring should continue for several years, perhaps indefinitely, to ascertain results and possibly to make additional changes or refinements as fish populations respond to the changes.

Managing a sport fishery is largely a matter of regulating the angler catch to allow sufficient escapement for reproduction and growth, being careful not to overtax the basic productivity of the waters with too many young game fish requiring large amounts of forage for rapid growth. A most desirable management procedure, complete closure to fishing for a year or more, is not usually practicable especially where a local economy is dependent upon the recreational activities provided by a large lake. Also, extreme changes in length limits, bag limits, or duration of fishing season are not easily implemented under our system of public hearings and legislative mandates. We must justify our recommendations and also appeal to the emotions of the sportsmen to change habits and practices of long standing. As an example, we may have determined that a reduction in bag limit on native lake trout from 8 fish to complete closure, or, at the most, a 1-fish limit may be necessary to improve the population structure in a certain lake. But we may not be successful in implementing a bag limit of less than 2 fish. Consequently, it may take many years, if ever, for the population to recover to its greatest potential as a sport fishery of high quality.

Although Cooper and Fuller made an excellent survey of Moosehead Lake in 1944, over 20 years had elapsed by the time the proposed study was planned, and we thought it necessary to determine what, if any changes had occurred. With a Raytheon recording fathometer mounted in a 32-foot boat powered by an inboard marine engine, we completed a sounding of the lake during the summer of 1967. Bottom contour profiles were made at ½-mile intervals oriented perpendicular to the long axes of the various bays and coves. From these charts a current depth map was produced and printed for distribution to interested persons (Appendix V).

Water quality determinations were made summer and winter at several locations down to the deepest levels. Included were temperature, dissolved oxygen, pH, alkalinity, secchi disc readings for water clarity, and conductivity. Detailed analyses for minerals were made from samples taken at 2 stations during summer and winter. Most of these procedures were repeated for several years to encompass differences among years. Except for a possible decrease in total phosphorus, water quality determinations and analyses revealed little change since the survey of Cooper and Fuller (1945), and since Clarke (1924) analyzed Moosehead Lake water.

The ice usually leaves the lake between April 25 and May 19, but generally during the first or second week of May. During May the surface temperatures remain in the 40's (F) and the spring overturn occurs. Heavy winds keep the water mixed, and stratification cannot begin. In June, surface temperatures increase to the 50's (F), and may reach 60°F. At 50 feet and 100 feet the temperatures are in the low 40's. Stratification may begin if a prolonged period of calm weather prevails. In July, surface temperatures may go as high as 72°F, but at 50 feet and 100 feet, temperatures will generally not exceed 50°F. At this time stratification occurs, with the thermocline generally between 20 and 50 feet. Stratification depth varies by years, and it is different in the different basins. In August, maximum surface temperatures are reached with the 4-year maximum at 73°F. The maximum temperature at a depth of 50 feet for the four years was 57°F, and at the 100 foot depth 52°F. The thermocline is



Biologists record data following netting operation.

slightly depressed, and it is between 25 and 55 feet in depth. In September, heavy winds and cool nights reduce the epilimnic temperatures to the 50's and low 60's (F). The 50 foot and 100 foot temperatures are correspondingly increased as some mixing occurs, and what remains of a thermocline is between 50 and 75 feet. In October, surface temperatures decrease to the 40's and low 50's (F). The 50 foot and 100 foot temperatures are in the 50's (F), and the thermocline disappears although a small layer was found between 90 and 95 feet. The fall turnover is probably complete in late October or early November, as homothermous conditions in the 40's (F) were found in early November. The fall turnover could vary by a matter of weeks depending upon the prevailing air temperatures and wind velocities. See Appendices I - IV.

With the recent information about acid rain caused by air pollutants from industrialized areas, we expected some decrease in pH. However, a comparison of the present and the 1944 pH values indicates little detectable change. Cooper and Fuller (1945) using the method of Robinson and Kemmerer (1930) with perchloric acid oxidation according to Robinson (1941) did some total phosphorus analyses and recorded values between .014 and .016 mg/liter. These values seem unusually high compared with the 1974 values between .006 and .013 mg/liter, total phosphorus recorded by the Environmental Protection Agency (1974). Assuming the 1944 and 1974 findings are comparable, a possible explanation lies in the fact that until the late 1940's, hotels and sporting camps accommodating large numbers of sportsmen and employees were contributing large amounts of phosphorus from untreated human and kitchen wastes. Most accommodations included flush toilets, bathrooms, and served meals. We know that at least the larger hotels and lodges had sewer pipes emptying directly into the lake. It is probable that untreated wastes from an estimated 1,000 or more persons went directly into the lake during the summer months.

Recent analyses of Moosehead Lake water by the U.S. Environmental Protection Agency (1974) and by the Maine Department of Environmental Protection disclosed low orthophosphorus (.005-.009 mg/liter) and chlorophyl A (.001-.003 mg/liter) values. The addition of phosphorus to samples indicated a phosphorus-limited situation up to the .013-.016 mg/liter level. The lake would become nitrogen-limited above the .016 mg/liter phosphorus level. Addition of nitrogen alone had no effect. These parameters plus secchi disc values of 10 to 30 feet are quantitative evidence that Moosehead Lake water is relatively infertile, and that the water quality could not have changed appreciably since the area became stable and forested following the recession of the last glaciers. Results of the analyses discussed plus high dissolved oxygen extending to all depths indicate a low biological productivity rate consistent with most oligotrophic lakes of eastern North America.

Using the mean depth value of 55 feet and an approximate value of 16-20 mg/liter for total dissolved solids in Moosehead Lake water, we may use a formula developed by Ryder (1965) to estimate the potential production (yield). The estimate for Moosehead Lake is approximately 1 pound per acre per year or a total of 75,000 pounds per year (See Appendix VI). This quantity is the amount that could be harvested safely year after year if we wanted to use all species and all sizes.

The potential harvest of salmon, trout, and togue by sports fishermen will be discussed later in this paper.

The biological assessment of a lake requires much more complex procedures than the physical assessment, because constantly changing animal populations (fish in this instance), some of which are being harvested for sport under legal restrictions are involved. Some of the fish populations are a mixture of native and stocked individuals with the stocked fish introduced into the lake environment at different sizes and ages to compete with individuals adapted from birth to the lake or its tributaries.

Cooper and Fuller (1945) did intensive netting and seining to determine the species and status of fishes inhabiting Moosehead Lake. However, they could not determine the origin of the salmon, togue, and trout they captured, because all 3 species were stocked in various numbers, ages, and sizes from State hatcheries.

The studies of Cooper and Fuller (1945) also included an extensive series of bottom samples to determine the kinds and abundance of invertebrates present in and on the bottom substrates. Fish stomach contents were examined to determine food habits and possible correlation with the abundance of food items in the environment. Some plankton studies were conducted to determine important groups and relative abundance of these minute animals and plants. Although the value of short term plankton studies is questionable because of great fluctuations in abundance in time, one should not underestimate the importance of plankton. Phytoplankton (tiny floating plants) contain chlorophyll and convert mineral or inorganic nutrients to organic or plant material. Insects and small fish require the smaller forms for their sustenance and adult game species such as salmon and trout, require small fish for their livelihood. Some fish species such as suckers and minnows may feed directly on the phytoplankton.

Except for depth sounding, water chemistry, and fish species determination, this study was planned to acquire the information needed to manage the game fish populations in such a way that the experienced angler may have the opportunity to catch salmon, togue, and trout weighing 1 to 2 pounds on a regular basis, and occasionally a much larger fish. Extensive netting, trapping, electrofishing, creel census, and stomach analyses disclosed the presence of 22 species of fish (Table 2). Although we cannot be certain how many of the 22 species inhabiting Moosehead were present prior to man's activities in the area, it is quite probable that all but 3 of these were here before the arrival of Europeans. We know landlocked salmon and rainbow smelts were introduced purposefully around 1890, and yellow perch were introduced by some unknown agent around 1958. On the other hand, the American eel inhabited Moosehead Lake until a high dam built several miles below the lake in the mid-1950's apparently stopped migration of the elvers. The remaining adults gradually disappeared. It is possible elvers may return to the lake when the concrete face of the spillway becomes eroded enough, and other conditions are favorable, to allow elvers to crawl over the 90-foot barrier.

Through the ice of Moosehead Lake — 24 pounds, 39 inches long!

CENSUS OF ANGLERS AND HARVEST

Anglers are one of the important sources of information on the status of game fish populations in a lake. From angler counts and interviews we can determine fishing effort and success, the species harvested, and combined catch of all the species exploited. By examining anglers' catches we can measure lengths and weights and obtain scales for age determinations. Anglers usually allow us to remove fish stomachs to determine what the fish have been eating. Where hatchery fish are stocked, they may be marked by removing one or more fins, or identified by some other means, so when anglers' catches are examined, hatchery fish can be identified. If all fish of hatchery origin have been marked for several years the relative abundance of wild fish may be assessed.

Since the beginning of the Moosehead Study in 1967, we have marked all salmon, lake trout, and brook trout of hatchery origin. During the ensuing 12 years, by checking angler catches, we followed several year classes of salmon and lake trout in the fishery until they were no longer present. Brook trout stockings were discontinued after 2 years because of poor returns to the angler. From the creel census we have obtained an approximation of the relative abundance of wild salmon, lake trout, and brook trout compared to known stockings of hatchery counterparts, and by counting anglers regularly from aircraft we were able to estimate total angler-trips during the open water and winter fishing seasons.

By determining mean daily angler success for each species from thousands of personal interviews, and the mean number of angler days from aircraft counts, we estimated total catch for each of the two fishing seasons and total annual harvest from the lake. We divided the lake into 10 naturally convenient areas and recorded all counts and angler interview data separately by areas. Measuring, weighing and determining the ages of fish in anglers' catches enabled us to apportion the mean lengths and weights of each species; by age classes, and the total poundage of each species harvested from the lake.

Marking and stocking known numbers of fish was routine and required little effort, but estimating the annual angler harvest with reasonable accuracy (± 25% or less error at the 95% confidence level) on such a large lake required some innovation.

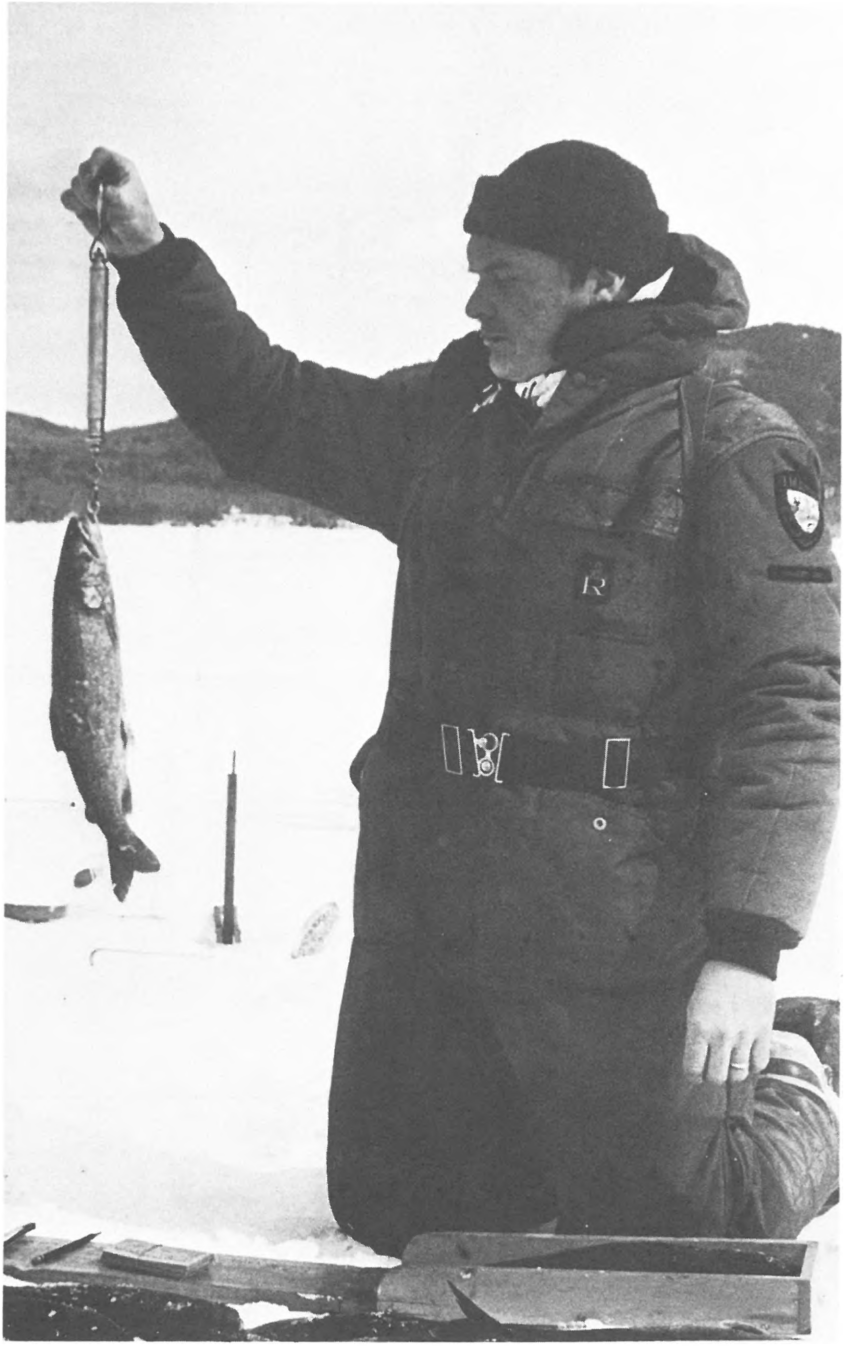
We employed one or more clerks to interview as many anglers as possible at landings, sporting camps, or, during the winter, on the ice. We designed a form to leave with sporting camp operators and with some anglers checked at the beginning of their trip. From thousands of angler interviews processed by computer, with the output in the form of tables indicating the mean number of anglers present on the lake at each hour of the day, we constructed curves used to expand aerial counts made during the hours of high angler numbers (Table 7, Figures 2 and 3).

Preliminary angler counts made each hour of the day on one day revealed the time of highest angler use was between 10:00 a.m. and 2:00 p.m. Subsequent data from the first and succeeding years of angler interviews verified preliminary findings. Data generated during the first year of the project (1967) determined the effort that would be required to obtain results more or less dictated by the problems.

Table 7. — Number and percentage of anglers fishing Moosehead Lake at each hour of the day, summer, 1978.

Hour	No. anglers	Percent of total
0	0	0
1	0	0
2	0	0
3	0	0
4	1	0.04
5	92	3.75
6	563	22.93
7	942	38.37
8	1,198	48.80
9	1,294	52.71
10	1,150	46.84
11	1,045	42.57
12	826	33.65
13	677	27.58
14	522	21.26
15	521	21.22
16	484	19.71
17	543	22.12
18	542	22.08
19	541	22.04
20	464	18.90
21	303	12.34
22	30	1.22
23	0	0
24	0	0

NOTE: Total was 2,455 anglers.



Winter census of Moosehead Lake anglers.

Figure 2. *Winter angler trips by hour of day.*

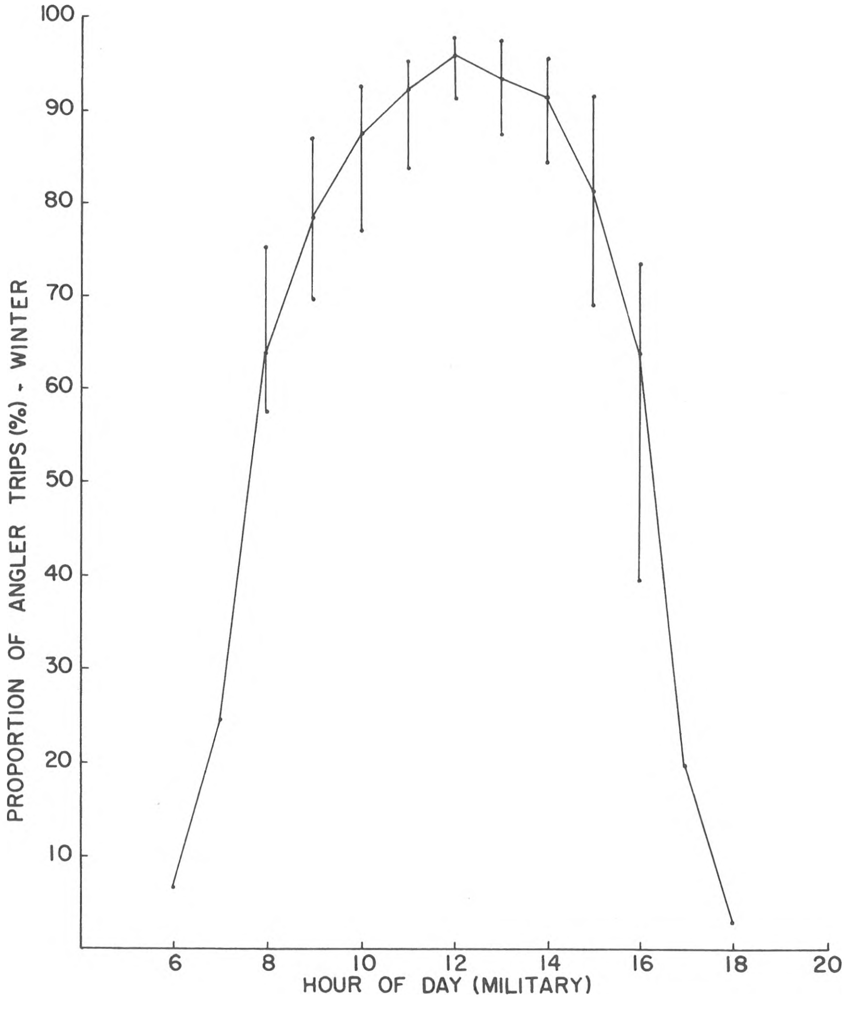
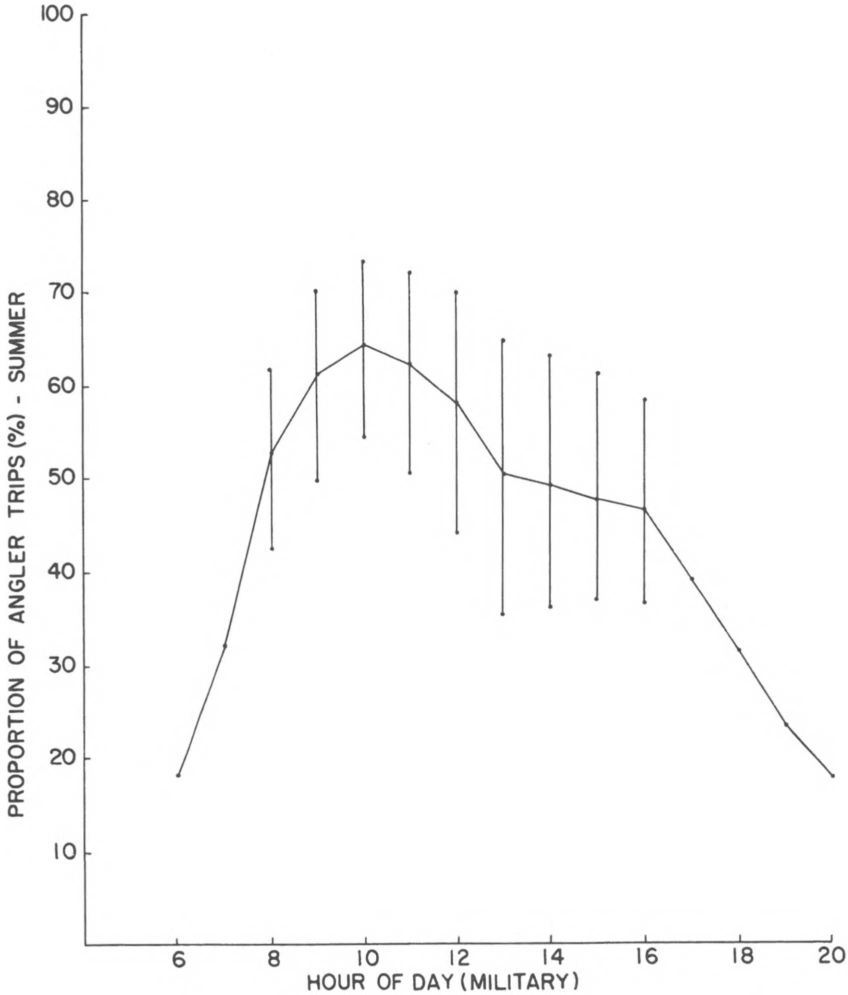


Figure 3. *Summer angler trips by hour of day.*



Estimating anglers

For the first 2 years of the study (1967, 1968) aerial counts, usually employing small (Cessna, Supercub) Fish and Wildlife Department aircraft, were made on one weekend day and one week day throughout the open water and winter fishing seasons. Saturday and Sunday counts were alternated, and the week day counts were varied to sample all days nearly equally. The large variation among counts of week day anglers coupled with small numbers of anglers, especially during the winter fishery with its short season (small number of counts) resulted in some estimates that did not meet our criteria of a mean within ± 25% at the 95% confidence level. During 1969, we increased our counts of anglers (by aircraft) to 1 weekend day and 2 week days. This improved our results somewhat, but some flights were cancelled because of weather or higher priorities. To be on the safe side and make the scheduling somewhat simpler we went to an alternate day count schedule beginning with 1970. This schedule automatically alternated all days and added one more week day count every other week. An attempt was made to make up flights cancelled because of bad weather or for other reasons. We have maintained this regime since 1970. A table of counts is presented in Appendix VII.

Prior to the 1974 open-water fishing season we reviewed the 1967-1973 data to determine the possibility of reducing the 4 to 5 months of aerial counts which were difficult to schedule or often cancelled because of other priorities. The data review disclosed an unusually stable ratio between monthly angling effort and total effort for the season. Table 8 is a listing of angler estimates for each of 7 years with 95% confidence limits, using counts for the entire

Table 8. — Comparison of estimates of anglers on Moosehead Lake by all season counts vs. June and July counts. Confidence intervals (95%) are in parentheses[a].

	5-month method	June and July method
1967	31,023 (28,321 - 33,725)	31,946 (29,636 - 34,256)
1968	29,766 (26,108 - 33,424)	29,694 (25,314 - 34,074)
1969	27,320 (24,927 - 29,713)	26,607 (24,356 - 28,858)
1970	25,647 (23,647 - 27,647)	26,534 (24,302 - 28,766)
1971	27,838 (26,134 - 29,542)	26,534 (24,817 - 28,251)
1972	35,244 (32,728 - 37,760)	35,622 (32,758 - 38,486)
1973	33,881 (31,289 - 36,473)	29,088 (26,796 - 31,380)

[a] No count 4th July week in 1973 may have caused low estimate.

season compared with the estimated anglers for the entire season extrapolated from June and July counts only. The low estimates for 1973 (June and July method) we believe was the result of not counting anglers during the 4th of July week. Aircraft were not available during this important holiday period in that year. Bartlett's test for homogeneity of variances (Zar 1974), (P .05), showed no significant difference between variance for June and July and variance for May, August, and September. Beginning with 1974, estimates of anglers for the open water season were made from June and July counts only. Angler interviews at access points and camps were continued for the entire season as previously. Estimates of anglers during the summer and winter fishing seasons are presented graphically in Figure 4.

Because some boats have cabins on them, and the exact number of anglers could not always be determined from the aircraft, and some winter anglers were inside of fish houses and could not be seen, the mean number of anglers per party was determined from hundreds of angler interviews for the current season by census personnel. Consequently the count by aircraft during the open water season was of boats in the process of fishing (rods and lines could be seen) and any individuals on wharfs or wading in the inlet river. During the winter season one could easily determine the presence of anglers in a fish house (pack baskets, snow sleds, tip-ups, etc.) and individuals or parties fishing in the open were easily counted. The mean number of hours an angler (party) fishes during the trip (day or portion of) was easily determined very accurately from the hundreds of interviews conducted during each fishing season. Catch per hour or angler trip, by species, and data on average size of each species caught were all determined from angler interviews. The section of the lake anglers fished was also recorded during the interview.

With our mean of anglers fishing each day of the season and the total number of days in that season, we estimated the total angler days spent on the lake. Knowing the mean catch by species plus lengths, weights, etc., we determined total catch of salmon, lake trout, and brook trout, and the total weight of each species harvested. Sample estimates and the procedure followed are presented in Appendix VII.

Bar graphs of angler trips (Figure 4), fish per angler trip (Figure 5), total fish by species (Figure 6), and pounds of fish by species (Figure 7), are presented in the following pages. The graph for angler trips with separate values for winter and summer is quite disturbing. The increasing trend of the past few years for both winter and summer anglers coupled with corresponding increases in total harvest practically dictates a further reduction in bag limits. Management implications are discussed later. Numerical values including average sizes, weights etc. by species, pounds per acre, sample sizes, all separate by seasons, may be found in Appendices VIII, IX, and X.

Figure 4. *Angler trips.*

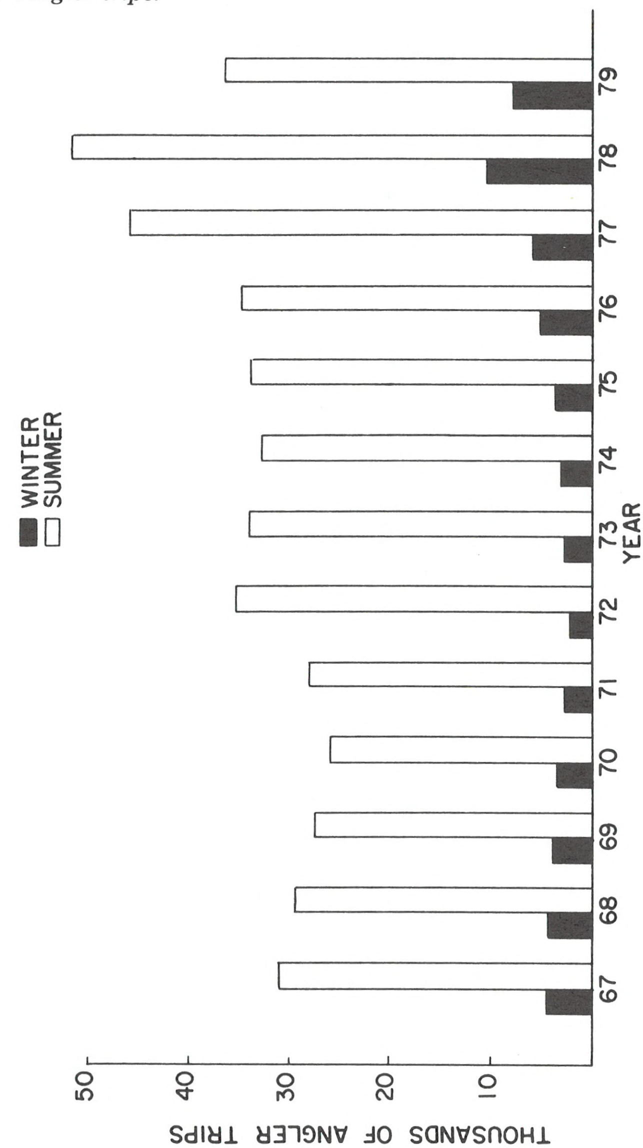


Figure 5. *Fish per angler trip.*

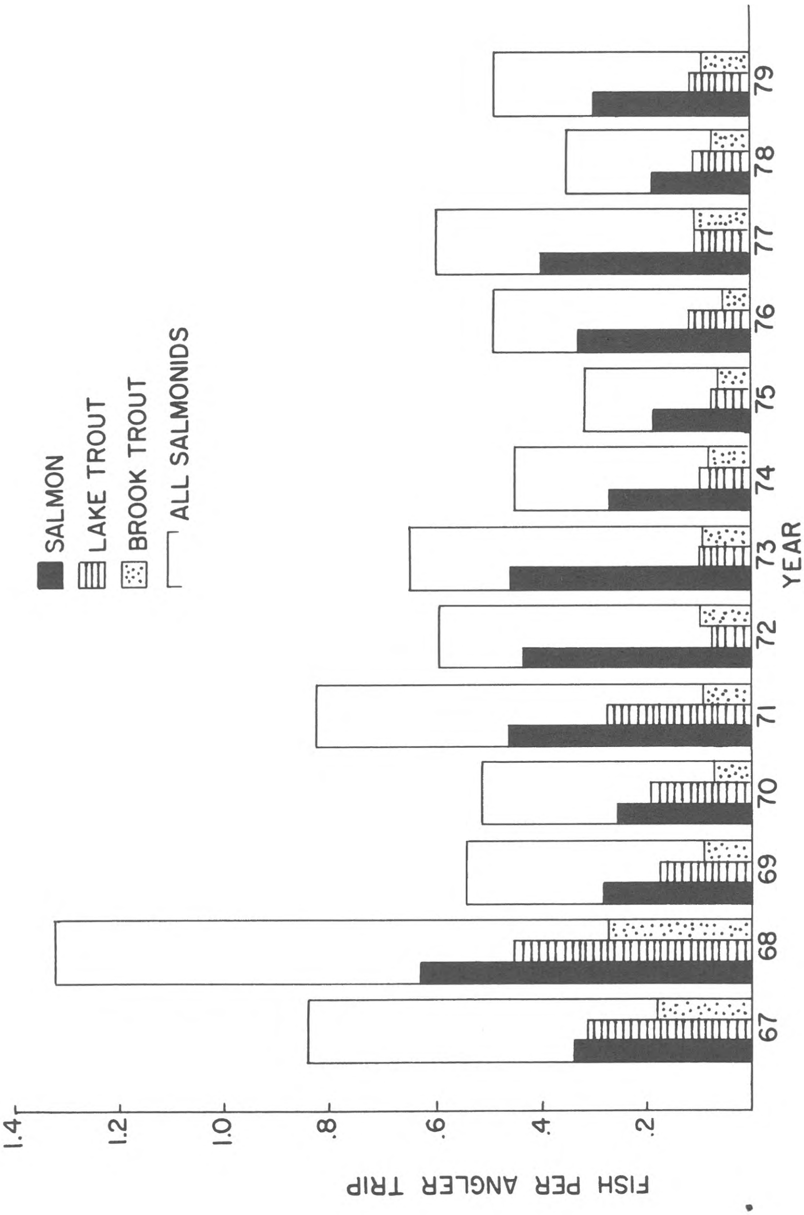


Figure 6. *Catch by species.*

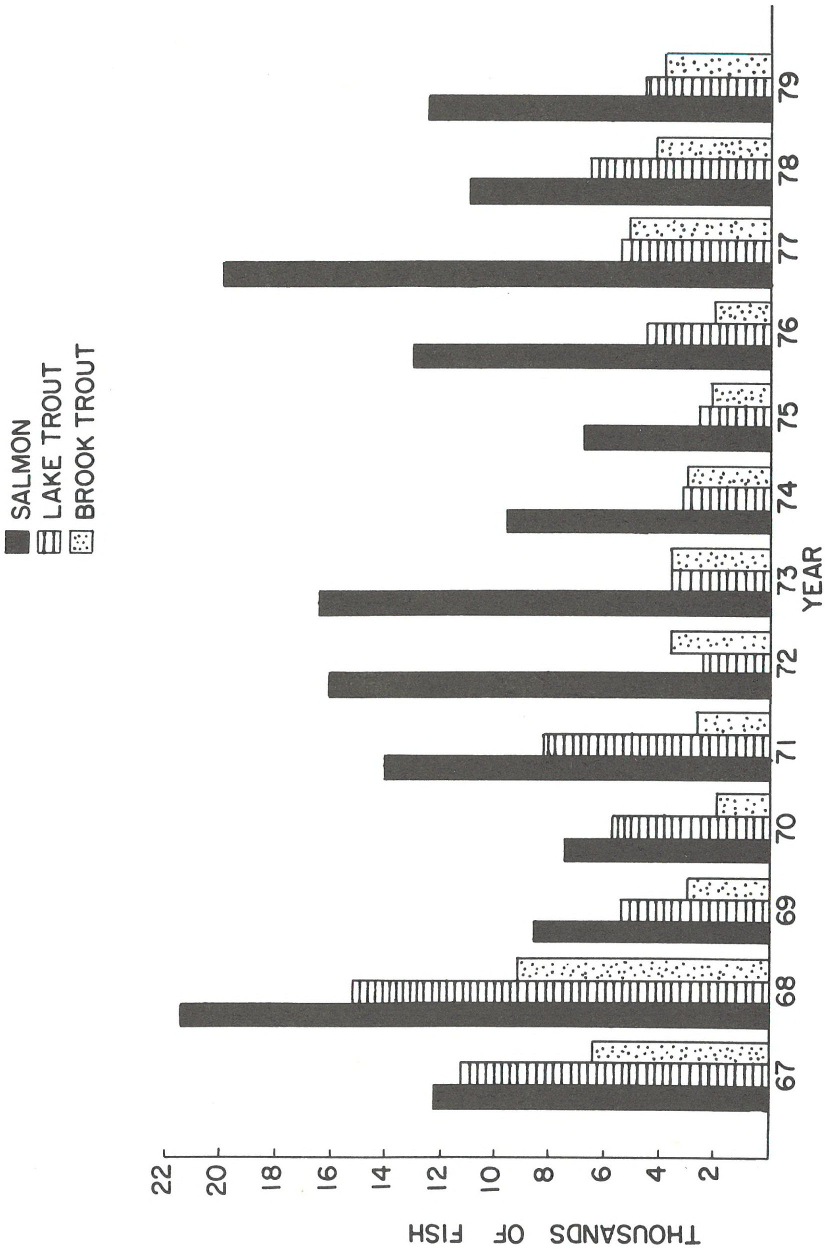
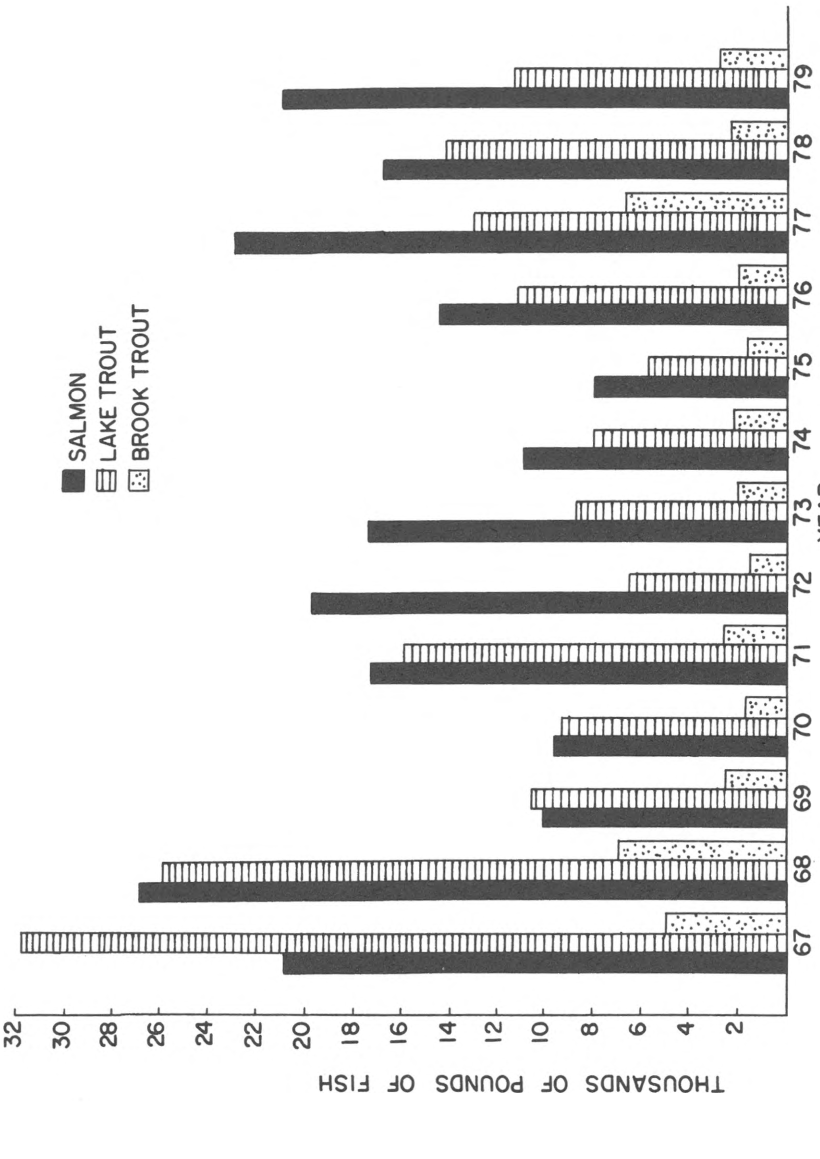


Figure 7. *Weight harvested.*



Deep trawling for young lake trout.

LAKE TROUT

Lake trout (togue) are long lived (15 years plus) carnivorous fish closely related to brook trout. Lake trout require well oxygenated cold water for survival and clean, rocky, windswept shoals for spawning. These requirements are met in deep cold-water lakes like Moosehead and many other Maine lakes.

Moosehead Lake, with a maximum depth of 240 feet and an average depth of 54 feet, has about 55,000 acres of water area ideally suited for lake trout. During the hottest summers encountered during the study, water temperatures of 55°F or colder were present below the 50-foot depth. Most of the shorelines are rocky, with many rocky windswept shoals available for togue spawning.

We are certain that lake trout are native to Moosehead Lake, as they are mentioned in the earliest records; they were usually called "lakers." Brook trout were generally called "squaretails." From scanty early records, it appears that large lake trout (over 20 pounds) were caught during the 1800's, but we cannot even guess at the numbers. In 1896, an article in Harper's monthly magazine stated that a 40-inch, 29-pound lake trout taken from Moosehead Lake that year was the largest caught in 25 years.

The heaviest lake trout from Moosehead Lake, that we are reasonably certain of, was caught in 1937 by Mrs. Charles Judkins, wife of the Kineo Hotel manager at that time; this fish reportedly weighted 32 pounds. Gene Letourneau, outdoor sports columnist for the Waterville Sentinel, informed me that he saw the fish and kept a record of it. This is also the heaviest lake trout recorded, although unofficially, for Maine waters. The Maine Department of Inland Fisheries and Wildlife lists a 31-pound, 8-ounce lake trout caught from Beech Hill Pond, Hancock County, in 1958 as the official state record. A 28-pound, 12-ounce lake trout was recorded officially from Moosehead Lake in 1961.

With fish this size, a full or empty stomach can easily result in a 2 or 3 pound difference in weight. Lake trout 18 pounds or over may measure from 36 to 42 inches long. The 28-pound fish we have measured are usually 39 to 42 inches long; however, we have recorded a 40.6-inch fish that weighted only 18 pounds. See Appendix XI for a table of some large lake trout from Moosehead Lake. During the 1960's, we recorded 36 lake trout weighing 15 pounds or more and 21 of these weighed 20 pounds or more. We are certain that many more large fish were caught and not weighed or recorded by the Fish and Wildlife Department during this period. Beginning about 1968, the numbers of large lake trout reported began to decline, even though we were in a better position to obtain angler harvest information. Only 17 fish weighing 15 pounds or more have been recorded since 1968. Moosehead Lake had lake trout over 15 pounds recorded in "The One That Didn't Get Away Club" every year through 1972. We had none recorded for 1973 and 1974, only one for 1975, none for 1976 and 1977, and one for 1978. We do have a few large fish recorded, that were not entered in the "club," during those years. Only three of the large fish recorded since 1968 were over 20 pounds.

The earliest record of hatchery lake trout stocked in Moosehead Lake is 1926. In that year, 25,000 fry hatched from eggs of Michigan (Great Lakes) origin were stocked. Between 5,000 and 75,000 fry, hatched from eggs of unrecorded sources, were stocked in Moosehead Lake in 18 of the 27 years from 1926 through 1952. Between 1,000 and 60,000 fingerlings, usually 2 to 4 inches long, were stocked every year from 1935 through 1942. None were stocked from 1953 through 1958. From 1959 on, but not every year, only spring yearlings were stocked. See Appendix XII for a detailed stocking record. Although we have little information on the success of the early stockings of hatchery fry and fingerlings, our recent findings and results of studies on lake trout by other biologists indicate that fry and fingerling lake trout stocked in waters with established wild populations have little chance of surviving. Webster, Bently, and Galligan (1959), reported that returns on marked yearling lake trout were four times the return on marked fingerlings. There is little information on the success of stocking fry as they are not easily marked; however, there is evidence that some populations may have been established by stocking lake trout fry in Maine waters.

In order to assess the quality and importance of the fishery for lake trout in the past, and for comparison with the fishery of the project years (1967-1979), we reviewed all available data and determined that we could use information on the winter fishery back to the analysis of Warden reports Cooper and Fuller (1945) made for the period 1935-1944. For the period of 1953-1958, I received information from District Warden Norman Harriman who was quite meticulous with his records and had kept the original data since he began working for the Department in 1952 and was assigned the northern half of the lake. The data for the period of 1959-1966 came from an intensive effort made by the Fishery Research Division to obtan statewide census data by providing wardens with instructions and special booklets to record the information. These data include the number of hours fished for each angler or party, whereas the older records included only the number of anglers and number of fish of each species checked on that day.

The period of 1967-1971 is within the Moosehead study years when the legal length limit on lake trout remained, as in the past, at

14 inches; while the period of 1972-1979, also within the study years, had the higher length limit of 18 inches on lake trout. We have no information for the years 1945-1952.

To put all the information on a comparable basis we extended all pre-study data to full days of 6.9 hours. This mean angler day was determined during the project years of 1967-1971. The statewide warden census for which hours were recorded disclosed that this particular warden's census was normally made at such a time that the average angler checked by him had fished 5.6 hours. Using the catch per hour figure, we extended these data to 6.9 hours to make all comparisons on a catch per angler day basis. The principal assumption made is that the warden's habits, when checking anglers, did not change appreciably over the years. For the periods of 1935-1944 and 1953-1958, we had to assume the same average 5.6 hours at checking time and extend the data to a 6.9 hour day, because these checks included only the number of anglers and numbers of fish by species. We are well aware of the limitations of these data; however, we feel the comparisons are worth noting and recording for this study and for future studies by biologists who would not be personally familiar with the information and the individuals.

Table 9 is a compilation of all available data on the status of the winter lake trout fishery until the legal length limit was increased from 14 to 18 inches. The period of 1967-1971 was the first of the study years for which reliable estimates were made annually. Mean lengths of fish from netting operations for 1944 and for 1958 were used in the absence of angler data for this parameter.

Data used for this abbreviated table may be found in Appendix XIII. The catch-per-angler column from 1953-1971 discloses a significant decline in success beginning with 1956 and continuing through 1959. If we consider 1967 and 1968 (first 2 project years) as base years when we estimated between 4,000 and 5,000 angler trips during the winter, and apply a conservative mean of 4,000 angler trips for the previous years, we may estimate harvests of 6,000 pounds of lake trout each winter. Using 30,000 angler trips the same way for the summer fishery we may postulate an annual harvest of 13,000 lake trout. Using a mean weight of 32 ounces, the total weight of the estimated annual harvest would exceed 26,000 pounds. The 32-ounce mean weight is very conservative, especially for the earlier years. We estimated harvests of 31,700 pounds and 25,800 pounds, respectively, for 1967 and 1968. The harvest declined drastically in 1969 and has not exceeded 15,000 pounds since 1968. The 31,700 pound harvest of 1967 is probably an anomaly as a high mean weight was the result of several large fish (10-23 pounds) in our census sample. However, if past average weights were higher, as some anglers and guides say, the annual harvest could have exceeded 30,000 pounds.

Table 9. — The winter lake trout fishery for Moosehead Lake, 1935-1971.

Years	Lake trout per angler	Mean for period	Mean length (inches)
1935-1944	—	0.80	18.7[a]
1953	0.6		
1954	1.0		
1955	1.0		
1956	0.5		
1957	0.4		
1958	0.4		18.8[a]
		0.64	
1959	0.4		18.8[a]
1960	0.7		
1961	0.6		
1962	0.8		
1963	1.0		17.0
1964	0.8		17.2
1965	0.8		
1966	1.0		16.4
		0.76	
1967	0.6		17.9
1968	0.6		17.1
1969	0.4		17.3
1970	0.4		17.0
1971	0.5		16.5
		0.52	

[a] From netting samples.

Year	Mark	Number
1968	Both ventrals	50,000
1970	Left pectoral	30,000[a]
1972	Left ventral, dorsal	50,000
1973	Both ventrals	50,000
1974	Left pectoral	50,000
1975	Right ventral	50,000

[a] Shortage of fish in 1970.

It is difficult to determine exactly what happened to the lake trout population during the 1950's. The complaints of poor catches in the late 1950's are corroborated by low catch rates indicated in our analysis of Warden activity reports for those years. A drop from 0.87 for the 3 years (1953-1955) to 0.43 for the next 4 years is quite substantial. From the information we have, it appears there was a decline in the catch of medium-sized lake trout (3-5 pounds) for which the lake was noted during the 1940's and early 1950's. Following this decline there was a recovery in numbers during the 1960's. However, the average size of the fish was 16-17 inches compared to the earlier average size of nearly 19 inches. As mentioned previously, the decade of the 1960's was one during which many large (over 20 pounds) fish were recorded. Although this seems inconsistent with a decline in the catch, it does follow a classic pattern not fully understood until recently.

If a substantial portion of the medium and large size fish is removed from a previously unexploited or lightly fished lake trout population, the young fish respond with increased growth and survival. However, there is a period of poor fishing while the young fish are growing to legal size, as lake trout are slow growing and long lived, and there are usually many age classes in the population. If the fishing is allowed to continue at even a moderate rate some large fish and many, barely-legal-sized fish will be caught. Perhaps the greatest danger at this point, and I believe this is what occurred at Moosehead Lake during the 1960's, is the loss, or great reduction, of the large, mature females which are needed in sufficient numbers to produce future generations with few missing or low year classes. Without special low numerical limits, the actively feeding young lake trout attaining the legal length limit are easily over-harvested. We witnessed this occurrence at Moosehead Lake during the 1960's, when many anglers were checked with weight limits (7½ pounds) of 14 to 18-inch fish averaging less than 24 ounces. Under these conditions, a legal limit could contain 6 to 8 young lake trout which would not have been mature for 2 or 3 more years. Apparently the first 2 years of the study (1967-1968) were the last years when large catches of small lake trout occurred. In 1967 an estimated catch of 11,000 and in 1968, 15,000 lake trout were harvested. The next year the catch dropped to 5,300 fish. The catch per angler trip, a better indicator of fishing success, does not show such a drastic change because the total number of anglers also decreased. However, a decrease in lake trout per angler from 0.6 to 0.4 is a decrease of ⅓ and quite significant. Over 90% of those fish were 7 years old or less and if we eliminate those fish that were 8 years old and older (10%), the remaining 90% averaged less than 17 inches in length and about 24 ounces in weight.

For the Moosehead Lake Study we stocked marked yearling lake trout from 1968 through 1975. The fish were marked at the hatcheries by excising a fin or a combination of two fins approximately one month prior to stocking. The fish were usually boated out and stocked over deep water areas. The initial plan was to stock 50,000 marked yearlings every other year, but we changed to every year stocking beginning in 1972. Allotments are shown below:

Prior to the project (1966), a stocking of 76,990 yearling lake trout was made. Some of these (5,000) were marked right ventral and 13,000 were marked left ventral. See Appendix XII for the complete lake trout stocking record.

Year	Mark	Number
1968	Both ventrals	50,000
1970	Left pectoral	30,000[a]
1972	Left ventral, dorsal	50,000
1973	Both ventrals	50,000
1974	Left pectoral	50,000
1975	Right ventral	50,000

[a] Shortage of fish in 1970.

Sampling Methods

Information on the lake trout from Moosehead Lake was collected by several methods. Because we decided to undertake a formal census of anglers and their catches, it follows that much of our information on lake trout came from this source. Proportionally, winter censuses resulted in larger samples of lake trout (Table 10) than summer samples, as anglers are not mobile, they are easily reached and interviewed, and their catches easily checked. Winter samples of wild lake trout ranged from 52 to 377, and summer samples from 16 to 104. Totals were 1,538 and 661, respectively, for the 13 years. Summer and winter combined samples of marked (hatchery) lake trout were 362 or 14% of the total. (See Appendix X for detailed sample date from creel census). The "proportion of hatchery fish" column should not be interpreted to mean that these are exact proportions in the total catch, although they are approximate. We supplied record books to a few anglers who kept a record of their fishing trips for us. Mr. Ansel Hill, an engineer retired from civil service, has kept an excellent record for us since 1974. Mr. Hill's record is the only one we have that includes lengths and marks (clipped fins) of short fish returned to the water. During the 6 years of his record keeping, Mr. Hill caught 262 legal-sized lake trout and hundreds of short ones plus many salmon and brook trout. Since creel census workers seldom see short fish returned to the lake, Mr. Hill's record is invaluable.

Ansel Hill's record follows:

Year	Salmon	Trout	Togue	Totals	Angler-days
1974	37	29	31	97	93
1975	22	28	37	87	113
1976	28	22	23	73	80
1977	66	7	67	140	145
1978	19	35	43	97	117
1979	6	16	61	83	71
	178	137	262	577	619
Means	29.7	22.8	43.7	96.2	103

Another important source of information on lake trout was from gillnetting operations undertaken at irregular intervals. The netting samples were needed to evaluate the status of lake trout smaller than the minimum legal length anglers are allowed to keep and for a series unbiased by the 14-inch and later the 18-inch legal length limit. Of course any minimum length limit has an effect on the entire population. These nettings were done from June to September depending upon work schedules. Some short term netting operations were conducted during early October to locate lake trout spawning areas and size of mature fish actually engaged in spawning activities.

Except for netting on spawning areas, nets were set overnight and consisted of several 400-foot x 6-foot gillnets with stretched mesh sizes of 1½, 2, 2½ and 3½-inch. Where netting was conducted to sample small lake trout, as many as 8,200-foot nets consisting of 50-foot sections of 1, 1½, 2, and 2½-inch stretched mesh sizes were used. These were usually set at depths of 40 to 80 feet. After learning that Moosehead Lake lake trout spawn in mid-October, we gill netted for spawning fish starting the beginning of October in areas we suspected the fish to be using. Moosehead Lake has so much typical lake trout spawning rubble around the shores, islands, and on shoals, that locating those areas being used was greatly a matter of chance. Netting for spawners was done in shallow water with gill nets but the nets were tended every hour or less so that fish could be released alive. These were held only long enough to determine the length and sex. A few lake trout were captured in trapnets usually set for salmon and several were captured in the fishway trap at the outlet dam.

Table 10. — Census samples of lake trout from Moosehead Lake, 1967-1979.

Year	Winter No. lake trout		Summer No. lake trout		Total Annual		Proportion of hatchery
	W[a]	H[b]	W	H	W	H	
1967	85	—	39	—	124	—	0
1968	133	—	16	—	149	—	0
1969	136	—	51	—	187	—	0
1970	212	6	42	1	254	7	0.027
1971	377	3	59	3	436	6	0.014
sub-totals	943	9	207	4	1,150	13	0.011
1972	51	—	20	2	71	2	0.027
1973	76	5	37	5	113	10	0.081
1974	80	9	51	11	131	20	0.132
1975	136	27	59	12	195	39	0.167
1976	54	23	58	14	112	37	0.248
1977	81	22	72	26	153	48	0.239
1978	65	71	53	31	118	102	0.464
1979	52	53	104	38	156	91	0.368
sub-totals	595	210	454	139	1,049	349	0.250
TOTALS	1,538	219	661	143	2,199	362	0.141

[a] Wild.

[b] Hatchery.

From 1967 through 1978, 223 wild and 54 hatchery-reared lake trout were netted and killed for age, growth, feeding, sex, and population information; these ranged in length from 5 inches to 42 inches and in weight from half an ounce to 28 pounds. Details on netted lake trout are given in Table 12 under "Age and Growth of Wild Lake Trout."

In early April, 1971, we placed a trap in the fishway of the East Outlet of Moosehead Lake to determine use of the structure by salmon and brook trout; trapping continued until November. This practice was repeated each year through 1975. In addition to salmon, brook trout and some other species, seven large lake trout (all wild) were caught in 1971. These fish were marked by cutting a small piece of the upper caudal and released in the lake above the dam. The temporary marks were applied to identify those fish that might go down through the dam and up through the fishway again during the same season. During the 1972 trapping, eight large lake trout (all wild fish) were caught and four of them evidently had had their caudal fins clipped the previous year. We then decided to tag lake trout caught in the fishway in future years. During the 1973, 1974 and 1975 trapping of the fishway, we caught and tagged 15 lake trout from 17 to 25 inches long. Only 2 of the 15 were of hatchery origin. Several tagged fish were recaptured in the trap, several were killed by Moosehead Lake anglers, and one was killed at Indian Pond, a few miles downstream. Details on tagged lake trout are presented under the section on exploitation.

All of the methods used to collect information on lake trout are either biased or deficient. However, by evaluating and combining the information from the different sources we believe we can assess the condition of the population and recommend certain management procedures to maintain and possibly improve it.

Age and Growth

Recent studies of lake trout using otoliths instead of scales to determine ages have disclosed significant discrepancies among ages of lake trout determined from scales. The discrepancies, or errors, in scale examinations may occur in fish less than 4 years old and tend to increase in magnitude with increase in age. Otoliths are small calcareous concretions, or bodies, located within the inner ear of bony fishes. The lime is deposited on the outside of the otolith at varying rates throughout the year, and a section of the otolith examined under proper light and magnification may be used to determine the age of fish just as scales are "read" for this purpose.

For Lake Mistassini in Quebec where Dubois and Lagueux (1968) collected scales and otoliths from more than 500 lake trout and assigned ages to them by the scale method and by the otolith method of age determination. The following (Table 11) discloses significant differences.

Table 11. — Lake Mistassini lake trout. Dubois and Lagueux (1968).

Age	Scales	Otoliths
III	1	1
IV	14	9
V	45	14
VI	90	32
VII	119	50
VIII	168	35
IX	69	48
X	25	34
XI	7	47
XII	6	44
XIII		26
XIV		41
XV		17
XVI		17
XVII		18
XVIII		12
XIX		13
XX		6
XXI		5
XXII		12
XXIII		9
XXIV		6

As a result of scale examinations to determine their ages, 82% of the Lake Mistassini fish were clustered in four age groups (VI-IX) and none were determined to be older than XII. Age determinations made from the otoliths of these fish place only 33% in the VI - IX age groups with 38% over X, and all groups well represented up to XXIV (24 years). The population age structure indicated by age determinations from scales is similar to that of the Moosehead Lake population structure as it was determined from the scales of samples netted in 1944 by Cooper and Fuller and similar to samples netted by me in 1958.

Annual harvests of 30 to 50% of these populations rapidly depleted, or would deplete, the older fish, and the fishing quality would deteriorate because these large (old) fish were accumulated over a period of at least 24 years under conditions of very light fishing intensity. If a fishery manager believed these populations of lake trout were being replaced every 10 years or so instead of 24 years, as the otolith age determinations imply, decreasing the bag limits and increasing the length limits would have little effect until the harvests were low enough to allow a gradual recovery of the populations over a long period of time. This situation has confused and frustrated fishery managers for some time.

Perhaps this is an extreme case, and for some waters, where the growth rate of lake trout is more constant, ages determined by the scale method may be adequate for management purposes. Lake Mistassini is situated approximately 10 degrees of latitude farther north than Moosehead Lake, but comparisons of ages and lengths of marked hatchery-reared fish stocked into Moosehead Lake with the wild fish found there indicate a significant difference in the age and growth structure from ages assigned to the wild fish by the scale reading method.

From the beginning of the study we assumed we could determine the ages of wild Moosehead Lake lake trout, by the scale method, well enough through the 8th year to acquire the information we needed for management purposes. After receiving sufficient returns on known age fish, we began to doubt our age assessments of wild fish by scale reading and delved further into this subject. During the 1944 survey of Moosehead Lake Cooper and Fuller netted 191 lake trout and during our study we netted 223 lake trout. Both groups were assigned ages by the scale reading method. Even though we now question the ages of the lake trout in these two samples, we will use the data for comparison purposes; as it is likely that any two or more experienced biologists would assign similar ages to any sample of fish scales, or at least the differences would tend to cancel out. Apparently the problem is mostly one of underestimating the ages because the annuli are not present, or not apparent. A comparison of the ages and lengths of the fish in these two samples (Table 12) indicates little change in growth patterns during the past 30 years or so. Also, the composition by age groups is not much different among ages 4 through 7, comprising 74% of the 1944 sample and 79% of our recent sample. The 1944 sample does have a higher proportion of fish 7 years and older. Although part of this difference could have resulted from differences in scale readings or by the change in the legal length limit from 14 to 18 inches in 1972, the evidence (large fish records, old census data etc.) of a greater abundance of large fish 30 years or even 20 years ago is convincing. The third sample in Table 12 is of known-age fish stocked from 1968 through 1975. Comparing growth increments of wild fish with that of the known-age fish we find an increasing growth rate through age IV, then a sharp decline for the next 2 years. The next years are fairly stable, but the one 9-year-old indicates a decrease in length. We measured three more 9-year-olds during 1980. They were 18.3, 19.4

and 20.0 (mean 19.25) inches long. All but one of the three were shorter than the mean of 19.9 for the 8-year-olds. Growth increments for wild and hatchery lake trout from back calculations are presented in Table 13. These data result in a smoother progression in lengths from one year to the next, probably because all lengths are measured at the annulus instead of at the time fish were caught. Data are limited to 8-year-old fish for the hatchery group but the basic differences between known age and questionable age fish remain evident. The growth data for known-age fish compared with that of their wild counterparts points to one of at least two possibilities. Either the known-age fish grow at a much slower rate after age V, or we are underestimating the ages of wild fish as their age increases. Upon checking the scales of known-age fish we found we often could not assess their ages properly and that the errors resulted in ages younger by 1 or 2 or more years than the actual ages. Webster, Bently and Galligan (1959) conducted trials in reading scales from known-age lake trout with similar results. Because we had no marked lake trout older than age IX we could not proceed beyond that age.

Table 12. — Mean total length[a] gillnetted lake trout in Moosehead Lake.

	Wild 1944 (Cooper)				Wild 1967-1978 (Project Years)				Hatchery G.N.[b] 73-79 Hill 77-80			
	Mean len.	Number	%	Increment	Mean len.	Number	%	Increment	Mean len.	Number	%	Increment
I					5.91	3	1		6.85	3	1	
II	9.96	13	6		9.76	7	3		9.12	8	3	2.27
III	11.02	13	6	1.06	11.38	14	6	3.85	11.83	32	14	2.71
IV	14.61	32	17	3.59	14.61	27	12	1.62	15.09	55	24	3.26
V	16.06	43	23	1.45	16.69	54	24	3.23	17.18	59	26	2.09
VI	18.39	33	17	2.33	18.07	70	31	2.08	18.16	41	18	0.98
VII	21.10	33	17	2.71	20.00	27	12	1.38	18.99	19	8	0.83
VIII	22.36	15	8	1.26	23.66	12	5	1.93	19.92	12	5	0.93
IX	24.61	3	2		23.94	3	1	3.66	18.74	1	1	—
≥X	29.41	6	3		33.11	6	3					
Means				2.06				2.54				1.87

[a] Observed lengths.

[b] G.N. = gillnet

The negative or no growth pattern between ages VIII and IX coincides with the spawning age of our lake trout. The only known-age female from this group for which we can verify spawning did so in the fall of its 7th year and was caught the following winter. Measurements of lake trout tagged at Allagash Lake, Maine (unpublished data) during egg taking operations in October, 1979, and recaptured during the egg-taking operations in October, 1980, assures us that negative growth (in length) occurs in individual fish and indicates this phenomenon may be common among mature females, and less common but present in males. Below is a listing of female lake trout lengths trapped, stripped of their eggs, tagged and released in October, 1979, and subsequently trapped and measured in October, 1980:

1979 Length (inches)	1980 Length (inches)	Net growth (inches)
20.98	20.67	− 0.31
22.13	22.17	+ 0.04
25.35	25.20	− 0.15
25.67	25.51	− 0.16
23.15	22.72	− 0.43
24.02	23.70	− 0.32
22.64	22.36	− 0.28

Mean of − 0.23 inches.

Table 13. — Back calculations of lengths of wild hatchery lake trout from Moosehead Lake.

	Wild			Hatchery		
Age	Number	Length (in)	Increment	Number	Length (in)	Increment
I	120	4.90	4.90	113	5.40	5.40
II	120	7.21	2.31	113	8.08	2.68
III	120	10.03	2.82	113	10.92	2.84
IV	120	13.00	2.97	113	13.78	2.86
V	120	15.71	2.71	108	16.07	2.29
VI	118	18.06	2.35	83	17.45	1.38
VII	73	19.96	1.90	57	18.91	1.46
VIII	27	21.91	1.95	14	19.41	.50
IX	3	25.05	3.14			
X	1	27.64	2.59			
Main increment age 2-8			2.43			2.00

We also recovered 59 tagged males during the same operations with the following results: Three exhibited negative growth, 5 exhibited no growth, and 51 exhibited some growth. The mean growth of the 59 males was 0.31 inches for the year.

As further evidence of extremely slow growth in lake trout and for those who may question the validity of growth data from tagged fish, we have additional data on untagged lake trout from Allagash Lake. In October, 1972, (egg taking) 255 females were given an adipose fin clip. These fish were not measured, but from our 1978-80 data spawning females are over 20 inches and most are over 21 inches long. In October, 1979, at least seven fish with the adipose clip were recaptured. They ranged from 24.2-27.2 inches with a mean of 25.6 inches. After being at large for 7 years, (and probably 14 or more years old) their growth was between 3.2 inches (minimum) and 5.8 inches (maximum) with an average annual increment between 0.46 and 0.83 inches. The Allagash Lake fish are native wild fish of unknown ages, or with their minimum ages (annuli) determined from scales. With so much supportive data indicating that the marked fish stocked in Moosehead are behaving and growing like the wild fish, we may justify the use of these known-age fish to determine the habits and parameter of the wild population.

Maturity

After examining the reproductive tracts and reading the scales of 169 lake trout netted from Moosehead Lake during 1944, Cooper and Fuller (1944) reported that most of these fish matured to spawn during their 6th or 7th summer of life. Cooper did not include the lengths and sex of individual fish in his report, consequently we cannot compare accurately his findings with ours. Our examinations of hundreds of lake trout gonads and scales would lead to similar conclusions if we combined males and females. However, considering females only, we estimated that approximately 50% of them would spawn, or would have spawned, at the end of their 7th year, over 75% at the end of their 8th summer, and practically all would spawn at the end of their 9th summer (October, usually). During netting operations on Moosehead Lake spawning areas in 5 different years between 1969 and 1978, 50 lake trout were examined. Twelve were females and 38 were males. Only two, both males, were of hatchery origin. The smallest female was 20.7 inches long, and of those whose scales were examined the youngest exhibited 7 annuli making it at least in the fall of its eighth year. The smallest male, one of the two males of hatchery origin, was 19 inches long and in the fall of its 7th year (known age). Subsequently, during a winter fishery, we checked three known-age females, all in the winter of their eighth year. One

(22.4 inches) had spawned the previous fall and the other two (19.9 and 20.5 inches, respectively) were classified as immature.

We, like several other biologists working with lake trout, have found that determination of maturity in lake trout from examining gonads is not reliable except for a short period before and after spawning. Some fish with eggs appearing large enough to be classified as mature and apparently large enough to spawn that year evidently do not spawn the same fall. The practice of averaging lengths of males and females is also misleading if it is to be used to determine legal length limits to protect a certain portion of females to maturity. Many males spawn at least one year earlier and at a smaller size than females. DeRoche and Bond (1955) in their tagging studies of spawning lake trout captured for egg taking operations at Cold Stream Pond, Maine, determined that the average female matured to spawn in the fall of its 7th year at a length of 18.1 inches, and the average male matured during its 6th summer at a length of 17.2 inches. The bulk of the spawning fish ranged from 18 to 20 inches in length, and they were at the end of their 7th year.

A 1979 study of lake trout from an egg taking operation at Allagash Lake, Maine (unpublished data) revealed that of 172 females trapped and stripped of their eggs only two were slightly less than 20 inches long. Fifteen fish were 20 to 21 inches long and most (81%) were 21 to 26 inches long. These fish were tagged but scales were not taken. During the following (winter, 1980) fishing season several of the tagged females were killed by anglers and scale samples were taken. None of these scales exhibited less than 7 annuli. Scales were also taken from untagged females during the winter fishery. Of six untagged females exhibiting 7 annuli, only two were judged to have spawned the previous fall, indicating that less than 50% of females that were at least 7-plus years old matured to spawn that fall. Of the 270 males tagged in the fall of 1979 a few (5%) were a little less than 18 inches long and most (66%) were between 18 and 20 inches long. Scales taken from recaptured males during the 1980 winter fishery disclosed some with 6 annuli, indicating that males probably do not spawn before they are in the fall of their seventh year.

Canadian research on lake trout (Healey 1978) has given us much valuable information on growth and maturity of this species. Although there is a great variation in the age of maturity of lake trout in Canadian lakes, and the assessment of ages and condition of maturity may be questioned, especially the older information, the general patttern is that approximately 50% of the females are maturing when they are from 6 to 15 years old. This is somewhat dependent upon latitude with the earlier maturing fish from the more southerly waters. There are notable exceptions to this, however. The length of females at 50% maturity from Canadian waters is much less variable and ranges from a little less than 20 inches to 26 inches with a large grouping around 22 inches. Our study and the Canadian studies agree quite well on length and age of lake trout at first maturity, but unfortunately we know little about the spawning frequency of female lake trout. Some Canadian studies quoted by Healey (1978) indicate that female lake trout in some waters may spawn every year, while in some other waters they may spawn only every other year or perhaps only every third year. We have some evidence that Allagash Lake fish may not spawn every year, but our Moosehead Lake study was not planned to address this question, as we did not want to risk trapping and tagging large numbers of lake trout on the spawning area.

Natural Reproduction

From the beginning of the Moosehead Lake study one of our objectives was to determine the extent and success of natural reproduction by lake trout. Much of our effort toward this objective was expended in gillnetting suspected spawning areas with large mesh nets during the month of October to locate concentrations of fish along shallow rocky shorelines and shoals offshore. Additional effort was expended in sampling areas of moderate depths (40 to 80 feet) during the open water season to locate young wild fish residing in those areas. The ongoing creel census also provided us with important information and estimates of the contribution of wild lake trout to the fishery.

Netting the shoals and shorelines for the presence of spawning lake trout was done between October 2 and October 30 each year, except 1977, from 1969 through 1979. Usually eight 100-foot sections of 3½ and 4-inch (stretched mesh) gill nets were set in the shallow areas (6 to 20 feet) during the daytime and tended at least every hour to determine the presence or absence of lake trout in those areas. As many as five areas were sampled in some years. Since Moosehead is a large, irregularly-shaped lake with nearly 200 miles of shoreline and many islands and shoals, we sampled only a small portion of the potential spawning areas. Some areas were sampled more than once over the years and the one area (Spencer Bay) where lake trout were found consistently was sampled in most years.

Lake trout were found on the shoals as early as October 5 and as late as October 18. At these times the temperatures ranged from 50°F to 47°F. Fish were gone from the shoals by October 19, and eggs were observed by SCUBA divers on October 20, and October 23, in different years. Females captured on October 12, 1973, and on October 5, 1976 were not ripe (eggs could not be extruded easily), but on October 16, 1969 the eggs ran out of some females being examined. As a result of checking the Spencer Bay traditional spawning shoal we have determined that spawning occurs about October 15 and certainly between October 12 and October 18 in most years. The water temperature at spawning is normally between 52°F and 46°F, or roughly around 50°F.

From 1969 through 1979, at least 19 different areas of the lake were netted between October 2 and October 30. Some of these areas included several islands, shoals or a few miles of shoreline. The presence of lake trout was established at only 6 of the 19 sites. Success meant that from one to five lake trout were captured or, in some instances, suckers were caught and found to have lake trout eggs in their stomachs. We are confident that, in addition to Spencer Bay shoals, at least three other areas are used regularly. A concentrated effort on these areas over several years would yield information comparable to that obtained at Spencer Bay. Captures of lake trout at the three other sites (Sandy Bay, Sugar Island and Center Island) occurred about mid-October when the water temperatures were near 50°F. Netting activity can be very limited at that time of year on Moosehead Lake due to bitter winds, cold rain or other priorities. Because we believed the spawning population of lake trout in Moosehead Lake to be at dangerously low levels, we were reluctant to disturb these fish any more than necessary. Undoubtedly other areas are, or were, used for spawning at high lake trout population levels. Spawning time, place and temperature for lake trout at Cold Stream Pond, Maine were described by DeRoche and Bond (1955). Time and water temperatures coincide with our findings at Moosehead Lake. However, the description of the Spencer Bay Shoal spawning area at Moosehead Lake should be documented.

Spencer Bay is a relatively isolated area of approximately 4,000 acres with a maximum depth of 40 feet at full lake (elevation 1,029), and most of this area is less than 30 feet deep. A major tributary (Roach River) enters the bay at the farthest end from the main lake. The shoal used for spawning is near the center of the bay and was probably an island before the original lake level was raised approximately 7 feet. The peak of the shoal is presently submerged about 2-3 feet at high water and is composed of large, irregularly shaped, and some, flat rocks. The actual mound of rocks which could have been an island at one time is quite small (less than 200 feet in diameter); this area is exposed at low water. Surrounding this mound is a level band of rocks 6-12 inches in diameter which has at least 2 feet of water covering it at low water level. A section of this lower band, or shelf, approximately 10 x 100 feet is the focus of spawning activity. Beyond this shelf is a drop-off of 4 feet or more with a mud bottom common to most of the bay. We had a biologist and an assistant, using SCUBA, search this area on October 20, 1971 for egg deposition. At that time the lake level was down to 12.80, or approximately 5 feet below high water. The divers found many eggs among the rocks on the shelf area with 3-4 feet of water over them. We supposed that, at high water levels which we have had in some years at spawning time, the fish would perhaps spawn at the higher levels on the shoal and that the eggs would be exposed during a winter drawdown of the lake. However, on October 23 in 1973, when the lake level gauge read 17.25, or almost full-lake, we had divers inspect the area again. The divers found some eggs in the same area where they were located in 1971 and no eggs were found on top of the shoal even though it was covered with 2-3 feet of water. From these observations we must conclude that, at this particular spawning area, lake trout are more site specific than depth specific in their spawning habits. We also checked this spawning area on February 25, 1972 by boring five holes extending from the center of the shoal outward across the spawning area. The water level was down to 12.42 or only 0.4 feet below the level at the spawning time the previous October, or down a little over 5 feet from full-lake. The ice was 2 feet thick and there was 2-3 feet of water between the ice and the rubble bottom where the eggs were deposited. The water temperature under the ice was 33 °F and 34 °F at 4 feet, or about 34 °F in the rubble where the eggs should have been. If the lake had been drawn down 2 feet more the eggs would have been subjected to the 33 °F temperature. We do not know if this one degree difference would have any adverse effect upon the eggs. It is possible that a fall drawdown, after spawning, leaving the eggs covered by a foot or two of water only may result in strong wave action which could wash the eggs out of the rubble and expose them to predation, mechanical damage, or freezing.

Netting the deep areas of the lake with small mesh gill nets (down to 1-inch stretched mesh size) to sample small lake trout was disappointing. We caught a few small fish, as young as 1 year old, but this method is highly biased as evidenced by the much higher numbers of older fish caught. The catches of the different age groups followed a definite pattern: no young-of-the-year, very few one-year-olds, increasing numbers through age VI, then a steady decrease in numbers. Other fishery scientists have experienced the same problem of attempting to assess the relative numbers of young lake trout. Apparently the small fish are not as vulnerable to capture, either because they are relatively inactive, or we are unable to locate the areas they inhabit. It is also possible that the smaller fish must remain hidden from the larger ones to survive. The nettings did establish the presence of one-year-old lake trout. Even after stocking 50,000 yearling lake trout annually we were unsuccessful in capturing any in some years and only 3 or 4 at the most.

A useful indicator of the status of natural reproduction is the angler catch of wild fish. Under present management regulations we have had fairly consistent annual harvests. The 18-inch legal length limit established in 1972 immediately reduced the annual catch from a mean of over 6,000 to the recent 7-year mean of 3,100 fish. The stocking of 50,000 hatchery yearling lake trout (marked) has resulted in annual catches ranging from 1,300 to 2,900 fish with a mean of 1,890 fish for the past 3 years (the 3 better years), when several year classes were in the fishery. The annual catches of wild and hatchery fish are listed below:

	Years						
	1973	**1974**	**1975**	**1976**	**1977**	**1978**	**1979**
Wild fish	3,024	2,595	2,125	3,358	4,021	3,668	2,996
Hatchery fish	373	514	429	994	1,333	2,786	1,544
Catch per angler	.095	.088	.069	.109	.104	.104	.105
Wild fish per angler	.083	.073	.057	.084	.078	.059	.070

	Winter fishery by year							
	1973	**1974**	**1975**	**1976**	**1977**	**1978**	**1979**	**1980**
Wild fish	665	536	711	998	1,332	1,219	687	1,803
Hatchery fish	45	61	142	425	361	1,355	700	420
Catch per angler	.266	.194	.234	.276	.285	.252	.175	.230
Wild fish per angler	.249	.174	.195	.196	.224	.119	.087	.187

The low catch of wild lake trout per angler in 1978 resulted from an unusually large number of anglers with many of them probably trolling for salmon during the summer. This was also the year of the high catch of hatchery fish. The winter catch per angler of wild lake trout may be less subject to variations caused by open water anglers trolling lures, flies, and baits close to the surface, predominately for salmon.

The winter catch of wild fish per angler indicates a decrease for 1978 and 1979, but a recovery in 1980, which we added as the data became available. Since many of the wild legal-size fish are probably 6 to 10 years old, they are the progeny of spawners from the period before the change from the 14 to the present 18-inch legal length limit, and the increase in the population we projected may be a generation or two away. Since age assessments for lake trout by the scale reading method are questionable, it follows that our catches of lake trout by year classes are also questionable. It is likely, however, that errors in reading scales from fish of one source are somewhat consistent. Annual catches of wild and hatchery-reared lake trout follow:

	Annual catch by year class						
Wild year class	**1967**	**1968**	**1969**	**1970**	**1971**	**1972**	**Mean**
Angler catch	2,769	3,200	2,722	4,089	2,949	3,245[a]	3,162
Hatchery year class	**1967**	—	**1969**	—	**1971**	**1972**	**Mean**
Angler catch	641		1,754		2,167	2,998[a]	1,890

[a] Annual catch of 8-year-olds estimated by proportion from the 1980 winter catch.

These indicate much greater variations among hatchery year class contributions than among their wild counterparts. We believe that some of the variations among hatchery year classes are due to differences in the quality of the hatchery product and the handling methods. These have improved greatly in recent years. The largest group (1972 year class) of hatchery fish is indicative of the potential harvest from a stocking of 50,000 yearlings (6%). These results are consistent with returns from other Maine waters. The section on survival and exploitation includes a table (Table 22) estimating total numbers of wild lake trout in Moosehead Lake. The estimate of almost 66,000 one-year-old fish is credible when we compare annual harvests of wild lake trout with those of hatchery origin resulting from stocking 50,000 yearlings. If we assume mortality rates of hatchery reared lake trout and those of wild lake trout are similar except for an initial stocking mortality, we must conclude that our fairly consistent annual catch (mean of 3,162) of wild fish results from similar numbers of yearlings. This will be discussed in detail in the next section (survival and exploitation).

Survival and Exploitation

Survival is usually determined as the ratio of a cohort, or year class of animals surviving from one year to the next, or as a mean number surviving per year over a certain portion of their life span. This may be accomplished by marking a known number of fish, or other animals, and sampling them over the years to determine the proportion caught from one point in time to the next (usually years). The Heinke (1913) method and its modifications, Jackson (1939) and more recently Robson and Chapman (1961) is used when large, unmarked samples are available from netting or from a sport fishery. These methods are based on knowledge of the ages of the fish in the samples.

Assuming that wild and hatchery-reared lake trout are growing at similar rates, we may proceed to formulate our population parameters; growth, survival, exploitation, and structure around our known-age fish. These conditions would not obtain where hatchery fish have been stocked recently in waters devoid of lake trout or under unusually high exploitation.

Most of the available information on lake trout indicates a growth rate of 2-3 inches, or in some instances more, per year until age V. After their 5th year their annual growth rate decreases to less than one inch. It appears that the decrease in growth rate is associated with the onset of maturity evidenced by the appearance of gonad material, or about the time when sex can be determined visually. Among Moosehead Lake known-age fish, a decrease in growth rate is evident between the ages of V and VI when the growth increment is reduced from a mean of 2.6 inches for ages I through V (Table 13) to a mean of one inch between the ages of V and VI. The decrease in growth rate continues with increasing age. Since maturity in lake trout is associated with size as well as age, the larger individuals of the same age group (those that grew more rapidly in their early years) tend to grow at a slower than average rate when they approach the size of maturity. Gillnettings and data provided by a few anglers who kept complete records of the small fish returned to the lake enabled us to accumulate growth information on the four marked hatchery year classes from the 1972-1975 stockings of 50,000 yearlings, from age I through age IX. From these data we constructed a table of age frequency by one-inch classes (Table 14).

Knowing that the hatchery yearlings are approximately one inch longer than the wild yearlings and that they retain this advantage through age V, we adjusted the distribution of lengths backward one inch to make the distribution of known-age fish conform to that of the wild or questionable age fish. With this new table (Table 15) we used an age frequency distribution, by one-inch classes, of the angler catch sample (Table 16) of marked hatchery fish and adjusted

Table 14. — Hatchery lake trout — age frequency by one-inch classes, Moosehead Lake.

Length class (inches)	Age II	III	IV	V	VI	VII	VIII	IX	Total
6									
7	1								1
8	4								4
9	1	5							6
10	1	4							5
11	1	7							8
12		10							10
13		4	6						10
14		2	13						15
15			7	5	2				14
16			9	14	1				24
17			2	17	10	3			32
18			1	13	17	6	4	2	43
19				5	8	6	2	1	22
20				1	2	4	5	1	13
21							3		3
22									
23									
24									
Total	8	32	38	55	40	19	14	4	210
Percentage 18 inches or larger				35	68	84	100	100	

this table to what an angler-caught sample of hatchery fish would be without the one-inch advantage in length at the younger ages (Table 17). We then assigned ages to an angler-caught sample of wild fish (Table 18) based on the proportions of ages and frequencies of known age fish in Table 17. Finally, that portion of a gill-netted sample of fish growing into the fishery (Table 19) was adjusted to conform to the age distribution in Table 14. The 660 wild fish sample (Table 18) for which we assigned ages may now be used as a basis to assign ages to the mean annual harvest of 3,089 wild lake trout listed.

The mean annual harvest of known age hatchery fish is also listed. All wild fish more than 9 years old are combined and listed as 10 or greater. A small number of 4-year-old hatchery fish is omitted.

Age	Known Hatchery Number	Known Hatchery Percent	Adjusted wild Number	Adjusted wild Percent
V	386	24	99	3
VI	590	37	1,483	48
VII	466	29	1,137	37
VIII	132	8	253	8
IX	14	1	52	2
≥X	0		65	2
Totals	1,588		3,089	

Table 15. — Adjusted distribution of lengths of hatchery lake trout, Moosehead Lake.

Length class (inches)	Age II	III	IV	V	VI	VII	VIII	IX	Total
6	1								1
7	4								4
8	1	5							6
9	1	4							5
10	1	7							8
11		10							10
12		4	6						10
13		2	13						15
14			7	5					12
15			9	14	2				25
16			2	17	1				20
17			1	13	10	3			27
18				5	17	6	4	2	34
19				1	8	6	2	1	18
20					2	4	5	1	12
21							3		3
22									
23									
24									
Total	8	32	38	55	40	19	14	4	210
Percentage 18 inches or larger.	0	0	0	10.9	67.5	84.2	100.0	100.0	

Using our known-age fish we can compute some survival estimates using the Robson-Chapman (1961) unbiased estimate formula. For this purpose we elected to use Mr. Pete Hill's angler catch data because it includes the short fish and enables us to begin survival computations at age V. The following (Table 20) includes all marked fish caught by Mr. Hill by ages and year class (marks) for 1975 through 1980.

Table 16. — Angler-caught hatchery lake trout, Moosehead Lake.

Length class (inches)	IV	V	VI	VII	Age VIII	IX	Total
18		22	57	26	5	1	111
19	2	5	26	26	4	1	64
20		2	9	12	2	1	26
21			4	5	3		12
22			0	2	1		3
23			1				1
24							0
Total	2	29	97	71	15	3	217

Table 17. — Adjusted catch of hatchery lake trout, Moosehead Lake.

Length class (inches)	IV	V	VI	VII	Age VIII	IX	Total
18		5	57	26	5	1	94
19		2	26	26	4	1	59
20			9	12	2	1	24
21			4	5	3		12
22			0	2	1		3
23			1				1
24							
Total		7	97	71	15	3	193

Table 18. — Assigned ages of angler-caught wild lake trout, Moosehead Lake.

Length class (inches)	Number	Age IV	V	VI	VII	VIII	IX	≥X	Total
18	283	0	15	172	78	15	3		283
19	177		6	78	78	12	3		177
20	110			41	55	9	5		110
21	44			15	18	11			44
22	21				14	7			21
23	11			11					11
24	7							7	7
≥24	7							7	7
Total		0	21	317	243	54	11	14	660
% of catch			3.2	48.0	36.8	8.2	1.7	2.1	

Table 19. — Assigned ages of gill-netted wild lake trout, Moosehead Lake.

Length class (inches)	Age VI	VII	VIII	Total
12				
13				
14	5			11
15	15	2		26
16	27	2		32
17	17	13	4	36
18	4	14	5	27
19	2	12	9	27
20		2	4	13
21				6
22				
23				
24				
Total	70	45	22	
% ≥ 18 inches	9	62	82	

Table 20. — Angler-caught hatchery trout, Moosehead Lake. (Pete Hill)

	BV	LP	LVD	BV	LP	RV			%
	L[a] S[b]	L S	L S	L S	L S	L S	All	Total	legal
III						0-2	0-2	2	0
IV			0-1	0-17	1-8	0-3	1-29	30	3
V			1-7	8-14	3-17	3-1	15-39	54	28
VI		3-1	6-2	4-5	3-0	1-0	17-8	25	68
VII			4-3	7-0	4-0		15-3	18	83
VIII	1-1		2-0	7-0			10-1	11	91
IX			1-0				1-0	1	100
	1-1	3-1	14-13	26-36	11-25	4-6	59-82	141	

[a] legal

[b] short

Using totals of legal and short fish we derived the following values for mean annual survival. A decrease in survival with age is evident:

Survival Values

Age V	through	IX	.476
Age V	through	VIII	.468
Age VI	through	IX	.443
Age VII	through	IX	.310

We determined mean annual survival rates by year classes for some year classes where the sample was large enough. For the year class marked "LVD" we computed the following survival rates:

Age V	through	IX	.561
Age V	through	VIII	.539
Age VI	through	IX	.478

For the year class marked "BV" we obtained a survival value of 0.50 for ages V - VIII. Survival values of hatchery lake trout from some other Maine waters are listed below:

Water	Method	Year	Ages	Annual survival Means
St. Froid Lake	Angler	1978	V-VIII	.425
St. Froid Lake	Angler	1979	V-VIII	.480
St. Froid Lake	Angler	1980	V-VIII	.535
St. Froid Lake	Angler	1973-1980	V-VIII	.484
St. Froid Lake	Gillnet	1978	V-VIII	.436
Sebec Lake	Gillnet	1976-1980	V-VIII	.565
Nickerson Lake	Gillnet	1971-1979	V-VIII	.383
St. Froid Lake	Angler	Year class	1970	.356
Sebec Lake	Gillnet	Year class	1972	.542

Because survival values from other Maine waters agree well with our results we are confident that a mean value of 45% for Moosehead Lake fish between the ages of V through IX (in the fishery) of hatchery origin is close to the true value. Where age IV fish could be used in some estimates, the survival values increased sharply to over 60%, confirming our belief that for the younger fish, those not in the fishery, survival must be close to 70% to produce the number of legal-size fish harvested. Knowing we have an initial mortality upon stocking we feel justified using a 50% survival value for the first year (age I-II), a value of 70% from age II until they attain the 18-inch length limit, and a 45% value from then on. Calculated survival values for lake trout samples taken by gill netting are usually higher than those taken from angler censuses because gillnet samples are biased toward larger fish.

Although we find no precedent for the following procedure, we see no reason why we cannot compute survival values using length classes instead of age classes. Since length classes are empirical, precise and are as, or more important than age classes, when working with angler catches, we believe this method has much promise, especially where age determinations are difficult and, at best, questionable. Using length frequencies, by one-inch classes for known-age fish 18 to 23 inches long (from the fishery), we computed a mean annual survival value of 44%. Using length frequencies for a comparable group of wild fish 18 to 23 inches long from the fishery the survival value is 52%. However, samples of wild fish from the fishery include fish up to 30 inches and then a grouping of fish over 30 inches long, and if we determine survival values including all the groups in the wild fish samples we get 54%. Because the survival values obtained by the length-frequency method for known-age fish are almost identical to those obtained by the age frequency method, we feel justified in using the length frequency method to obtain survival values for the wild fish.

Using survival values determined for known-age (hatchery-reared) fish samples plus our own estimated mean annual angler catch (by ages) of these fish as they appeared in the fishery, we constructed a life table (Table 21) for the 50,000 yearlings stocked in each of 4 successive years. The proportions of fish 18 inches or greater, the estimated harvest, and the estimated numbers of mature females were determined from our annual angler counts and angler census data. A tenuous estimate of 100 nine-year-old fish was made from a reliable winter 1980 census when three of these fish appeared in the census sample. From these we determined the rate of exploitation at each age and the estimated numbers of fish of any or all size classes per acre before and after the fishery. Having constructed the life table (Table 21) for the hatchery fish we did the same (Table 22) for the wild fish. The principal difference between the two sets of data is that the number of one-year-old wild lake trout was unknown. However, this number was derived by working backward from the time they entered the fishery. The proportion of wild 5-year-olds entering the fishery is also very small compared with that of the hatchery fish, and we have a fair proportion of wild 9-year-olds plus all the fish over 9 years old combined as a group.

Table 21. — Life table of hatchery lake trout, Moosehead Lake.

Age	Number	Percentage ≥ 18 in.	No. ≥ 18 in.	Harvest	Exploitation (%)	No. mature females
I	50,000					
II	25,000					
III	17,500					
IV	12,250					
V	8,575	35	3,001	426	14	
VI	5,252	68	3,571	771	22	
VII	2,784	84	2,339	690	30	585
VIII	1,365	100	1,365	301	22	683
IX	614	100	614	100	16	307
	123,340 (1.64/acre)		10,890 (.15/acre)	2,288 (.03/acre)	21	1,575 (.02/acre)

Table 22. — Life table of wild lake trout, Moosehead Lake.

Age	Number	Percentage ≥ 18 in.	No. ≥ 18 in.	Harvest	Exploitation (%)	No. mature females
I	65,966					
II	46,176					
III	32,323					
IV	22,626					
V	15,838	9	1,425	99	7	
VI	10,873	62	6,741	1,483	22	
VII	6,600	82	5,412	1,137	21	1,353
VIII	3,809	100	3,809	253	7	1,905
IX	2,095	100	2,095	52	2	1,048
≥X	1,152	100	1,152	65	6	576
	207,458 (2.77/acre)		20,634 (.28/acre)	3,089 (.04/acre)	15	4,882 (.07/acre)

Mean exploitation values for the wild and hatchery populations (Tables 21 and 22) should be close to actual conditions. However, the values computed for individual age groups reflect conditions at the approximate mid-points of the winter and summer harvest periods of January, February, March and May through September. A large proportion (38-47%) of the harvest occurs during the winter fishery, but, when the 5-year-olds are entering the fishery only 28% of the 5-year-olds that will attain legal length that year are caught during the winter. This proportion increases to 40 or 50% at ages VI and VII as an increasing number of these fish become available with age. The catch, by ages, also varies considerably among years; these are the means for the 3 years of 1977-1979. The population densities for all age groups are reasonable estimates. The estimate of 207,458 wild lake trout resulting in a per acre figure of 2.77 fish is within the range of estimates (1.61-5.99) for several waters listed by Healey (1978). If we add the 1.64 per acre estimate of hatchery fish for a total of 4.41 per acre we are still within Healey's listed range of estimates. At this writing (1979), we have no hatchery lake trout less than 5 years old remaining in Moosehead Lake because we have not stocked these since 1975. Our estimates of 0.02 mature hatchery females and 0.07 mature wild females per acre (total 0.09) would result in a total of mature fish (males and females) of over 0.18 per acre as the males mature earlier than the females. The 0.18 plus mature fish per acre value is within the range of 0.09-1.13 listed in Healey's (1978) table. An ongoing study of the Allagash Lake, Maine (unpublished data) lake trout population and fishery based on

429 mature fish tagged during the fall 1979 egg-taking operation, with subsequent recoveries of tagged fish during the winter and open water 1980 sport fisheries yielded the following results: an estimated 0.25 mature females per acre, 0.88 fish per acre 18 inches or greater, and an estimated exploitation rate of 4.9%. Until recently this 4,260 acre lake was not easily accessible and a one fish limit hopefully will keep it in lightly exploited condition to maintain a large population of mature fish to supply our hatcheries with lake trout eggs. The average lake trout in the catch weighs 4 pounds. At Allagash Lake with an exploitation rate of one-third that of Moosehead Lake, we estimated 3 times the number of mature females and 4 times the number of all legal size lake trout. Because we believe the lake trout population of Moosehead Lake is low compared to the 1950's, we are confident our estimates are well within reason.

Lake Trout Harvests

General harvest estimate methods were discussed in the angler census and harvest section, and at the beginning of the lake trout section. We also covered earlier, Ryder's (1965) Morphoedaphic Index method for determining fish production in lakes results in an approximate 0.6 pounds per acre per year (total of 45,000 pounds) for Moosehead Lake for all species in the fishery. With the foregoing and results from several studies in Canadian Waters (Healey 1978) that harvests of 0.5 pounds/acre/year are excessive, we set a goal of 0.26 pounds/acre/year (20,000 pounds) for harvests of lake trout from Moosehead Lake.

We believe the water quality, temperatures, high average depth and a preponderance of rocky shorelines suited for spawning make this lake better suited for lake trout than for salmon. The demand for lake trout fisheries has increased during the past 20 years. With winter fishing increasing in popularity and deep-water trolling methods and equipment available to most anglers, the lake trout has become highly esteemed as a sport and food fish. Our estimated catch computations for the years of 1967 and 1968 (Table 23) indicate the 20,000 pound goal was likely exceeded for the first 2 years of this study and probably for some of the years preceding the first estimates.

By adding a probable catch of 2,500 5-year olds to the 1961 year class (Table 24), we may assume catches of more than 10,000 lake trout for both the 1961 and 1962 year classes. A catch of almost 2,400 seven-year-olds from the 1960 year class (not included in table) indicates a high harvest from that year class as well. It appears that continued high harvests during the 1950's and 1960's coupled with probable increased egg mortalities from more frequent

Table 23. — Estimated lake trout harvests, Moosehead Lake.

Year	Winter Number	Winter Pounds	Summer Number	Summer Pounds	Total Number	Total Pounds
1967	2,914	4,832	8,272	26,884	11,186	31,716
1968	2,575	4,225	12,580	21,645	15,155	25,870
1969	1,428	2,182	3,953	8,340	5,381	10,522
1970	1,337	1,981	4,357	7,294	5,674	9,275
1971	1,457	2,043	6,786	13,937	8,243	15,980
18-inch limit						
1972	277	757	2,186	5,596	2,463	6,353
1973	710	1,554	2,752	7,172	3,462	8,726
1974	597	1,322	2,553	6,555	3,150	7,878
1975	853	1,885	1,701	3,667	2,554	5,562
1976	1,423	3,271	2,929	7,824	4,352	11,095
2-fish limit						
1977	1,693	3,999	3,661	8,905	5,354	12,904
1978	2,574	5,417	3,880	8,665	6,454	14,082
1979	1,387	3,197	3,153	7,957	4,540	11,154
1980	2,223	5,477				

Note: 14-inch length limit prior to 1972. 8-fish limit prior to 1977.

winter lake drawdowns resulted in a rapid decline in the lake trout population during the 1960's. The 18-inch legal length limit enacted in 1972 plus an agreement with the Kennebec Power Company on post-spawning lake drawdowns should result in a gradual recovery of the population.

A 2-fish limit regulation imposed in 1977 should also prevent over-exploitation if the number of anglers fishing the lake does not continue to increase as it did between 1976 and 1979.

An examination of total annual harvest (Table 23) gives us some cause for optimism. The catch in numbers has increased gradually over the past several years with a total weight up to over 14,000 pounds in 1978. The catch of lake trout per angler is holding steady at 0.1 with the weight of lake trout per angler at 0.25 pounds (See Appendix X for complete harvest data). The fish are averaging close to our goal of 40 ounces, but the total catch in numbers is only about 50% of our goal of 8,000 fish.

Examining the estimated harvest of wild and hatchery year classes (Table 24) producing the fisheries during the project years, we have to consider especially, the change in length limit from 14 to 18 inches, which decreased the harvest by about 60%. The line of demarcation is shown in Table 24. Except for the harvest of over

Table 24. — Estimated angler catch by year classes, Moosehead Lake.

WILD LAKE TROUT

Age	1961	1962	7000 UNM 1963	10164 UNM 1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
I						0	0	0	0	0	0	0	0	0
II					0	0	0	0	0	0	0	0	0	0
III				0	0	0	0	0	0	0	0	0	0	0
IV			102	805	0	6	19	0	0	0	0	0	0	0
V		2,354	2,927	1,216	1,289	2,817	0	0	41	0	0	75	19	22
VI	4,472	7,407	2,301	2,905	2,774	1,137	1,964	1,738	903	1,597	1,188	1,797	1,592	
VII	2,984	1,246	749	1,294	193	857	530	1,033	1,272	2,150	1,499	1,063		
VIII	304	134	476	573	203	232	145	329	484	307	262			
IX	12	121	11	65	54	39	41	54	0	35				
X	31	0	0	41	5	119	70	46	22					
Total	7,808	11,262	6,566	6,899	4,518	5,207	2,769	3,200	2,722	4,089	2,949	2,860	1,611	22

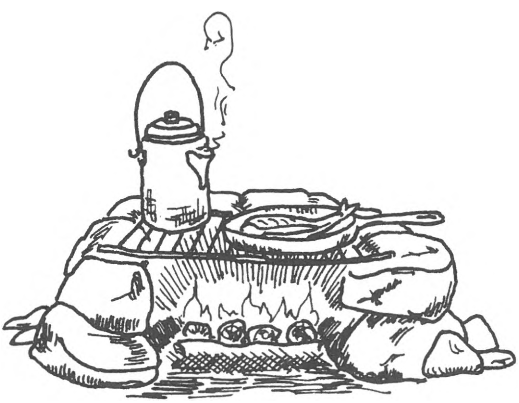
HATCHERY LAKE TROUT

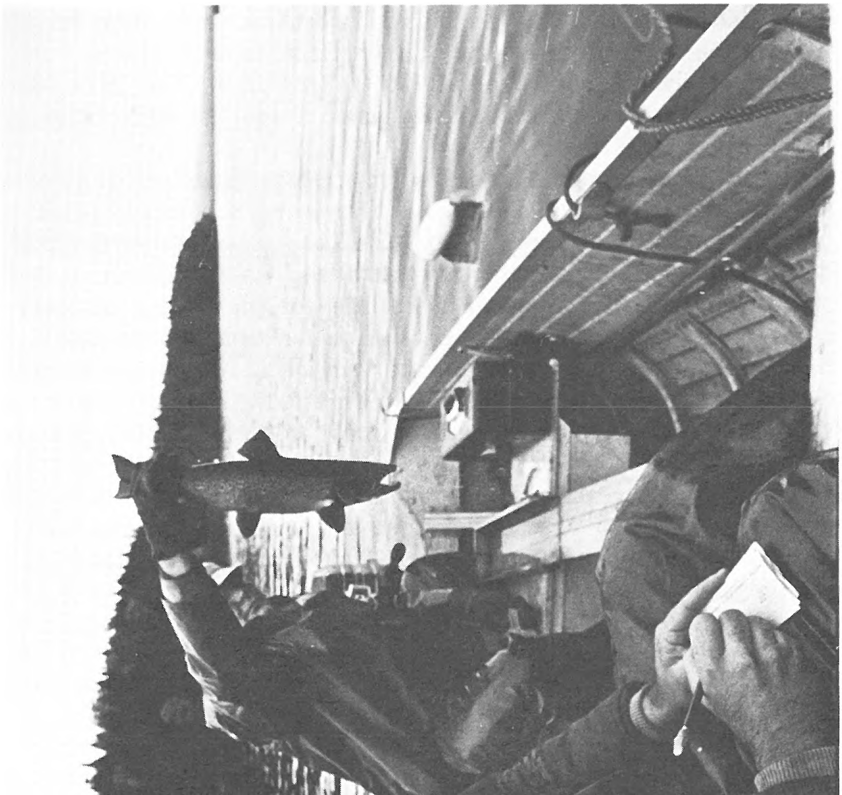
Age	77,000 RV/LV 1965	50,000 BV 1967	30,000 LP 1969	50,000 LVD 1971	50,000 BV 1972	50,000 LP 1973	50,000 RV 1974
I		0	0	0	0	0	0
II	0	0	0	0	0	0	0
III	0	0	0	0	0	0	0
IV	31	227	140	0	0	37	177
V	573	104	507	454	531	231	491
VI	484	233	400	566	1,532	217	
VII	445	7	499	846	535		
VIII	0	29	199	301			
IX	0	41	0				
X	0	0	0				
Total	1,533	641	1,754	2,167	2,598	485	668

4,000 fish from the 1970 year class of wild fish, most year classes fully in the fishery under the 18-inch limit have produced fairly regular catches ranging from 2,700 to 3,200 fish. The 1972 year class, not completely through the fishery, may produce close to 3,200 fish.

Production from hatchery-reared year classes has been quite erratic. We have reason to believe that differences in hatchery production lots, stress from transfers and transportation, and stress from boating the fish for long distances to deep water without proper aeration, resulted in delayed mortalities of the young hatchery-reared lake trout. The 1972 year class, not completely through the fishery, and similar returns from stocking other Maine waters indicate returns of 5 to 10% is all we can expect, at this time, under an 18-inch legal length limit. Returns may be higher where growth rates are unusually high resulting in attainment of legal size at an early age (3 or 4 years). High length limits and low bag limits established recently for Moosehead Lake and some other waters have resulted in survival of hatchery-reared lake trout to older ages. During the past year (1980) anglers caught increasing numbers of 9, 10, and 11 year old fish of hatchery origin. We discontinued stocking hatchery-reared lake trout in 1975, but the last two groups of 50,000 yearlings each are still contributing substantial numbers to the fishery (Table 24).

If we consider that the number of wild spawning adults was low in 1972 when we imposed an 18-inch minimum length limit, that these fish are at least 7 years old when they mature to spawn, and that their offspring do not enter the fishery in substantial numbers until they are 6 years old, it is still to early to expect much improvement in the population. Detailed census and harvest information for the summer and winter fisheries, by years for 12 years, may be found in Appendix X.





Fall trapnetting of salmon at Greenville Junction.

SALMON

Landlocked salmon (*Salmo salar*) are not indigenous to the Moosehead Lake drainage. They were introduced to Moosehead Lake in 1879 (Smiley 1884). At that time fry were stocked, and we have no record of the numbers and sizes stocked during the early years. One record (Maine Sportsman 1894) noted that 15,000 salmon were at Kineo in October, for Moosehead Lake. This record indicates a stocking of fall fingerlings. The next record is for 1902 when 60,000 salmon were stocked with no indication of size. The numbers of salmon stocked increased dramatically between 1910 and 1920 with stockings of 50,000 to 100,000 fall fingerlings put into the lake and its tributaries. In some years a few thousand salmon were stocked in nearby waters tributary to Moosehead Lake. Salmon were also stocked in Jackman area waters, about 25 miles upstream. Salmon became firmly established and probably reproduced naturally in many of the larger lakes in the drainage around the early 1900's. Salmon stocking continued to the present. We have documented all salmon stocking records we could locate for Moosehead Lake in Appendix XIV. Many of the early (1800's) introductions and subsequent stockings were made with fry stocked in April, May or June, although some records show stockings possibly made in August. Classifying these stockings into the proper age categories was often done by interpreting the size of fish and time of stocking. Fish stocked in the fall with lengths given as 2-4 inch were recorded as fall fingerlings and fish stocked in the spring with accompanying length range of 4-6 inch were recorded as spring yearlings. In some instances size was not given. From 1902 through 1979 these records disclose a total of nearly 5 million salmon stocked into Moosehead Lake and its immediate tributaries, an average of 64,000 annually including 4 or 5 years for which we have no record or no stocking occurred. We have no information about the mortality of salmon stocked as fry, but estimates of mortality for fall fingerlings (Havey and Warner 1970) indicate a mortality of 65% for the first 12 months after stocking. These studies were made under controlled conditions with selected fish transported in aerated tank trucks. We must assume mortality of fry and fingerlings transported in milk cans on trains and buckboards, and released in streams and lakes among large trout was extremely high.

The earliest record of salmon caught from Moosehead Lake is that from the Camp Comfort Log (1953). This was a 4½ pound salmon caught in 1895. Undoubtedly many other salmon were caught around the turn of the century by the Camp Comfort group, but they recorded salmon weighing a minimum of 5 pounds, and the first of these, a 5¼ pound fish was recorded in 1902. From 1902 through 1953, 49 salmon from 5 to 7½ pounds were recorded. The last one on record was a 7¼-pound fish caught in 1945. Included in the 49 salmon above were 16 weighing between 6 and 7 pounds, and 6 weighing 7 pounds or more. Another salmon catch record we have is from Wilson's (Cooper and Fuller 1945), a sporting camp operating since 1865 with some fish recorded since 1884. The earliest record of salmon from Wilson's was about 1897, a 3½-pound fish and the largest recorded (no date) weighed 9½ pounds. The second largest was an 8-pound salmon caught in May, 1922. Several salmon over 6 pounds are recorded. Maynard's Sporting Camps have recorded some salmon weighing over 7 pounds. Gene Letourneau, outdoor sports writer for the Waterville Sentinel and other newspapers guided sports on Moosehead Lake during the 1940's. Mr. Letourneau states positively that during the early 1940's he personally saw a 10¼-pound salmon that was caught off Black Point, near Beaver Creek, Moosehead Lake. The fish was caught on a fly by a woman whose name he does not know.

During the survey of Moosehead Lake n 1944, Cooper and Fuller (1945) netted many salmon with several from 3½ to 4½ pounds, but none larger. During the present study (1967-1979) we measured and weighed more than 4,000 angler-caught salmon and only 3 of these weighed 5 pounds or more. The heaviest weighed 5½ pounds. A few more probably weighed over 4 pounds but had been eviscerated prior to checking. We have had reports of other salmon weighing over 5 pounds caught by anglers, but they were not included in our creel census samples. From unofficial reports, old records, and our study, it appears the number of large salmon (over 5 pounds) has declined over the years. This subject will be addressed in the age and growth section of this report.

Sampling Methods

Most of the sampling methods — gillnetting, creel censuses, etc. described in the lake trout section were employed and yielded information on salmon. Yearling salmon marked by fin excision were stocked during the project years (Appendix XV) beginning with 50,000 in 1967, 1969, then annually from 1971 through 1975. In 1976 we reduced the stocking rate to 25,000 annually, and this rate is continuing although marking was discontinued after 1979. Wild salmon parr production in the Roach River was estimated by electrofishing 500-foot sections in each of 6 years. This method was also employed to assess salmon populations and/or occurrence in other tributaries. The fishway at the outlet dam was trapped for several years to determine the extent and timing of salmon and trout movements through this structure and to estimate numbers of young salmon passing upstream into the lake. Two Oneida Lake type trap nets were set near the mouth of Roach River in the fall of 1976 to

Tending fishway trap at East Outlet.

sample the run of salmon entering this tributary to spawn. Salmon have well-developed homing instincts. When mature, salmon return to the site where they were reared naturally or stocked as yearlings. At the time of maturity it is possible to capture salmon easily at the stocking sites. In October 1969, 1970 and 1976 through 1980, one Oneida Lake-type trap net was set to capture marked hatchery-reared mature salmon returning to one particular stocking site.

The census and interview of anglers during the winter and summer fisheries through the project years was perhaps the more productive of the methods employed to obtain information on salmon, but salmon samples obtained by this method are limited by the minimum legal length limit of 14 inches, and they are highly biased for year classes entering the fishery at the 14-inch limit. Hatchery-reared salmon are abundant in the fishery during their 4th summer, and wild salmon during their 5th summer of life. Salmon are not readily caught in gillnets set on the bottom of the lake, therefore the numbers of salmon in these samples are not large. Most wild Moosehead Lake salmon remain in the tributary streams over a second winter after hatching, consequently they do not appear in most samples until their 3rd summer.

Age, Growth, and Maturity

The wild salmon of Moosehead Lake begin their lives in rivers and streams, and they may spend 1, 2, or 3 years in the parent stream before moving into the lake. Because young salmon grow much more slowly in streams than they do in the lake environment, it is important that studies of wild salmon growth consider this event. During a trapping operation and study conducted on the fishway of the East Outlet of Moosehead Lake from 1971 through 1975, we determined that young salmon, reared in the river below, entered the lake during June and July of their second, third or fourth summer. None moved into the lake during their first summer after hatching although this movement is known to occur from inlet streams in these and other waters (Havey and Warner 1970). At the East Outlet fishway trap we learned that the young salmon moving upstream into the lake during their second summer averaged 6.9 inches in length. Back calculations disclosed these young fish averaged 4.1 inches in length at age I (Table 25). Salmon parr moving into the lake in their third summer (age II in table) were smaller (3.9 inches) at their first annulus, and the few moving in their fourth summer were the smallest at their first annulus. However, the successive groups were increasingly larger (observed length in table) when they did move into the lake with a mean greater than 11 inches for those moving in their fourth summer. The ranges in lengths of all three groups overlap at the time of movement.

Table 25. — Observed and back calculated lengths of young salmon passing through the East Outlet Fishway, Moosehead Lake.

Age	Stream life and mean length (inches) 1 year	2 years	3 years	Observed length (inches)	Ranges in length (inches)
I	4.1			6.9	5.2 - 9.5
II	3.9	7.6		9.7	6.8 - 12.4
III	3.5	6.5	9.8	11.2	9.3 - 12.7

Table 26. — Percentages of salmon with 1, 2, and 3 years of stream life in three lakes.

	Stream life 1 year	2 years	3 years
Sebec Lake	1%	91%	8%
Moosehead Lake	19%	79%	2%
Chesuncook Lake	46%	52%	2%

The proportions of 1, 2, and 3-year stream life salmon varies among waters and somewhat among years. A comparison of 3 salmon lakes (Table 26) indicates variation among lakes may determine, to a great extent, the sizes and ages of salmon in the sport fisheries. Sebec Lake with the lowest percentage of 1-year stream life fish and the highest percentage of 3-year stream life fish is known for an abundance of slow growing salmon. Chesuncook Lake with a high proportion of 1-year stream life salmon is known for large salmon, and Moosehead Lake is intermediate. How the stream life pattern of wild salmon affects the age, growth and subsequent salmon fisheries of Moosehead Lake is demonstrated in Table 27. The proportions of 1, 2, and 3-year stream life salmon with their lengths at capture, at the different ages, comprising an estimated combined catch of 17,237 salmon in the 1977, 1978 and 1979 sport fisheries show faster growth and a higher exploitation rate (lower survival) for the 1-year stream life group. The single 6-year old, 1-year stream life fish is probably not indicative of the average length for this group. The 2-year stream life fish comprise the bulk (79%) of the fishery and most of these are caught as 4 and 5-year old fish. Some 3-year stream life fish enter the fishery at age IV+ but the numbers are very low. Small numbers of 7-year old salmon are caught by anglers. Some of these are large (over 5 pounds) fish and some are in poor condition and caught as 22 or 23-inch fish weighing no more than a couple of pounds. All the 7-year old salmon we have had in our samples were 2-year stream life fish. Differences in growth of wild salmon with different years of stream life are displayed graphically in Figure 8. The legal length of 14-inches is marked with a horizontal line, and indicates none attained the 14-inch length limit before age III. However, these are mean length at the beginning of the growing season (annulus). Many of these salmon attain the 14-inch limit during the fishing season, and are harvested by anglers as legal-size fish (Table 27).

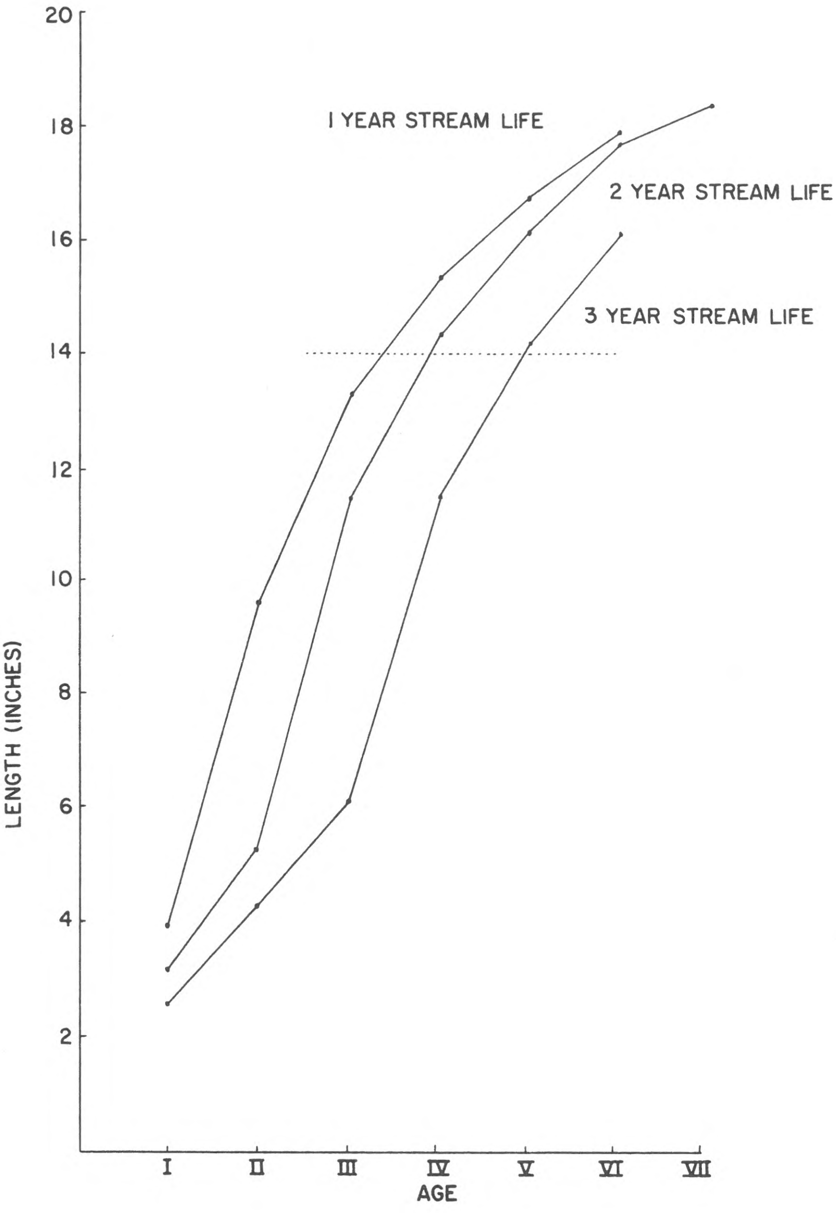
Table 27. — Combined harvest of wild salmon in 1977-1979. Ranges are in parentheses.

	Stream life							
	1 year		2 years		3 years		All	
Age	Mean length,	No.	Mean length,	No.	Mean length,	No.	Mean length,	No.
II	14.7 (14.0 - 15.0)	119	—		—		14.7 (14.0 - 15.0)	119
III	15.3 (14.0 - 17.8)	1,411	14.0 (14.0 - 18.0)	1,189	—		14.9 (14.0 - 18.0)	2,600
IV	17.3 (15.0 - 19.6)	1,459	15.8 (14.0 - 20.5)	6,541	15.0 (14.3 - 15.4)	145	16.1 (14.0 - 20.5)	8,145
V	18.5 (17.1 - 20.7)	216	17.3 (14.8 - 21.5)	5,330	17.6 (15.2 - 20.0)	83	17.4 (16.3 - 21.5)	5,629
VI	18.4 (-)	12	18.3 (16.3 - 20.5)	521	18.2 (16.7 - 21.0)	96	18.3 (16.3 - 21.0)	629
VII	—		21.2 (19.3 - 23.2)	115	—		21.2 (19.3 - 23.2)	115
Means	16.4 (14.0 - 20.7)	3,217	16.5 (14.0 - 23.2)	13,696	16.6 (14.3 - 21.0)	324	16.4 (14.0 - 23.2)	17.237
Percent of total	19		79		2			

NOTE: Catch figures are weighted for years and mean lengths are weighted for numbers caught.

Since 1966 all hatchery-reared salmon stocked in Moosehead Lake have been spring yearlings. Generally 4 to 6 inches long until 3 or 4 years ago, they now average about 7 inches in length at the time of stocking in late May or early June. The only wild yearling salmon

Figure 8. *Salmon stream life.*



comparable in size to the stocked salmon are the 1-year stream life fish. When these enter the lake in June or July they range from 7 to over 8 inches in total length, and this is almost the same as the length of hatchery-reared yearlings at this time. The data in Table 28 compare these 2 groups. Wild 2-year stream life salmon are approximately one year behind the hatchery-reared salmon in their growth, but they are nearly equal in length by their seventh summer (age VI+). Of several year classes (1967-1975) of hatchery-reared salmon now through the fishery, an estimated 69,388 were harvested by anglers as legal-size fish. An estimated 1,600 (2%) of these were caught during their third summer (Table 29). In 3 separate years no 2-year olds were recorded in our census. The years 1978 and 1979 were the first that any wild 2-year old salmon appeared in our census, an estimated 45 and 35 fish, respectively. Over two-thirds of the stocked salmon harvested by anglers were 3-year olds (fourth summer). Among the wild salmon (Table 29) the spread in the catch is greater: small numbers of wild 7-year old salmon are harvested in most years.

Table 28. — Comparison of hatchery-reared yearling and wild, 1-year stream life salmon, Moosehead Lake.

	Total length (inches)	
Age	Hatchery[b]	Wild
I	7.8	6.9
II	12.5	12.0
III	15.4	15.6
IV	16.8	17.3
V	18.5	18.5
VI	18.8	18.4[a]

[a] Single fish

[b] Hatchery fish are means from 1967-1979.

The time of year that young salmon attain the 14-inch length limit is quite important in the management of the fishery. Trapping salmon during the spring, summer and fall enabled us to determine the mean lengths and approximate proportions of legal-size fish at the time of sampling. It appears that the 2-year old hatchery-reared salmon caught by anglers attain legal length some time after late June, because none were 14 inches long in the 71 fish mid-summer sample. By October, about 65% of fish in this age group are legal-size. Apparently a small number of wild 2-year old salmon (1 in sample of 4) attained the 14-inch limit by late fall. However, the small sample of 4 mid-summer 3-year olds did not include a legal-size fish. This occurrence may be related to the more abundant 2-year stream life salmon entering the lake during the third summer, because 85 percent of the 34 fall caught 3-year olds were over 14 inches long (Table 30).

Table 29. — Catch of salmon from year classes 1966 through 1974, Moosehead Lake.

	Age					
Hatchery	II	III	IV	V	VI	Total
Number stocked	—	—	—	—	—	371,800 (s.y.)
Number caught	1,607	46,992	18,785	1,745	259	69,388
Percent caught at each age	2	68	27	3	<1	19

	Age					
Wild	II	III	IV	V	VI	Total
Number caught	0	6,584	28,030	11,147	1,581	47,342
Percent caught at each age	0	14	59	24	3	

Salmon harvested by anglers over the project years appear to have increased in average length and weight (Table 31). The increase is not spectacular, but does indicate food conditions may have improved. Fulton's condition factor, the ratio of weight to the cube of the length expressed as "K" is often employed to compare the condition of individuals, groups, or populations of fish (usually of the same species). The "K" should be close to unity. Large fish usually have higher "K" factors than small fish. Mean condition factors for wild and hatchery-reared Moosehead Lake, angler-caught, salmon for certain years, with standard errors, are presented in Table 32. Total length in millimeters and weight in grams were used in the formula $K = (W \times 10^5)/L^3$ to compute the values. Values for wild and hatchery-reared fish are not greatly different. However, most recent (1979) values are higher than the 1969 values indicating an improvement in the food situation.

To determine the proportion of male and female salmon maturing at the different ages requires a sample of fish from the lake population before any of the mature fish acquire the urge to ascend the streams. A sample of 63 salmon gillnetted during the project years

Table 30. — Seasonal growth of wild and hatchery salmon, Moosehead Lake.[a]

	Hatchery								
	Spring			Mid-summer			Fall		
Age	Number	Length (inches)	Percent legal	Number	Length (inches)	Percent legal	Number	Length (inches)	Percent legal
I	0	5.3	0	2	7.1	0	7	11.3	0
II	26	11.4	0	71	12.6	0	93	14.3	65
III	5	14.4	80	15	15.1	87	122	16.5	100

	Wild								
	Spring			Mid-summer			Fall		
Age	Number	Length (inches)	Percent legal	Number	Length (inches)	Percent legal	Number	Length (inches)	Percent legal
I	0			0			0		
II	0			4	10.1	0	4	10.6	25
III	0			16	12.6	0	34	14.8	85
IV	0			6	15.3	83	21	16.6	100

[a] Spring trapnetting, 5/4-6/9
Mid-summer fishway trap, 6/21-6/23
Fall trapnetting, 10/1-10/28

(Table 33) was used for this purpose. These fish were taken during the summer and the gonads examined for status of maturity. Salmon (125) captured on spawning runs in 2 tributary streams were also classified as males or females and scale samples removed to determine their ages (Table 34). We assumed all salmon on spawning runs were mature. Spawning runs of salmon were not trapped extensively, because we elected not to disrupt natural spawning activities during this study. Practically no 2-year old salmon mature to spawn in the fall of their third year. Examination of the gonads of 3-year old salmon taken during the summer indicates 11% of the females and the same percentage of the males would have spawned that fall. However, on the spawning run only 7% are females, indicating many males mature in late summer and early fall. Warner (1962) found almost the same ratio of 3-year old males to females at Cross and Long Lakes in northern Maine. The females were spawning for the first time. Netted salmon checked for maturity during their fifth summer (small sample) indicated 71% of the males and 57% of the females would spawn that fall. This is consistent with data from the spawning run. These and the 5-year old fish

Table 31. — Mean lengths and weights of angler-caught salmon, Moosehead Lake, 1967-1979.

Wild

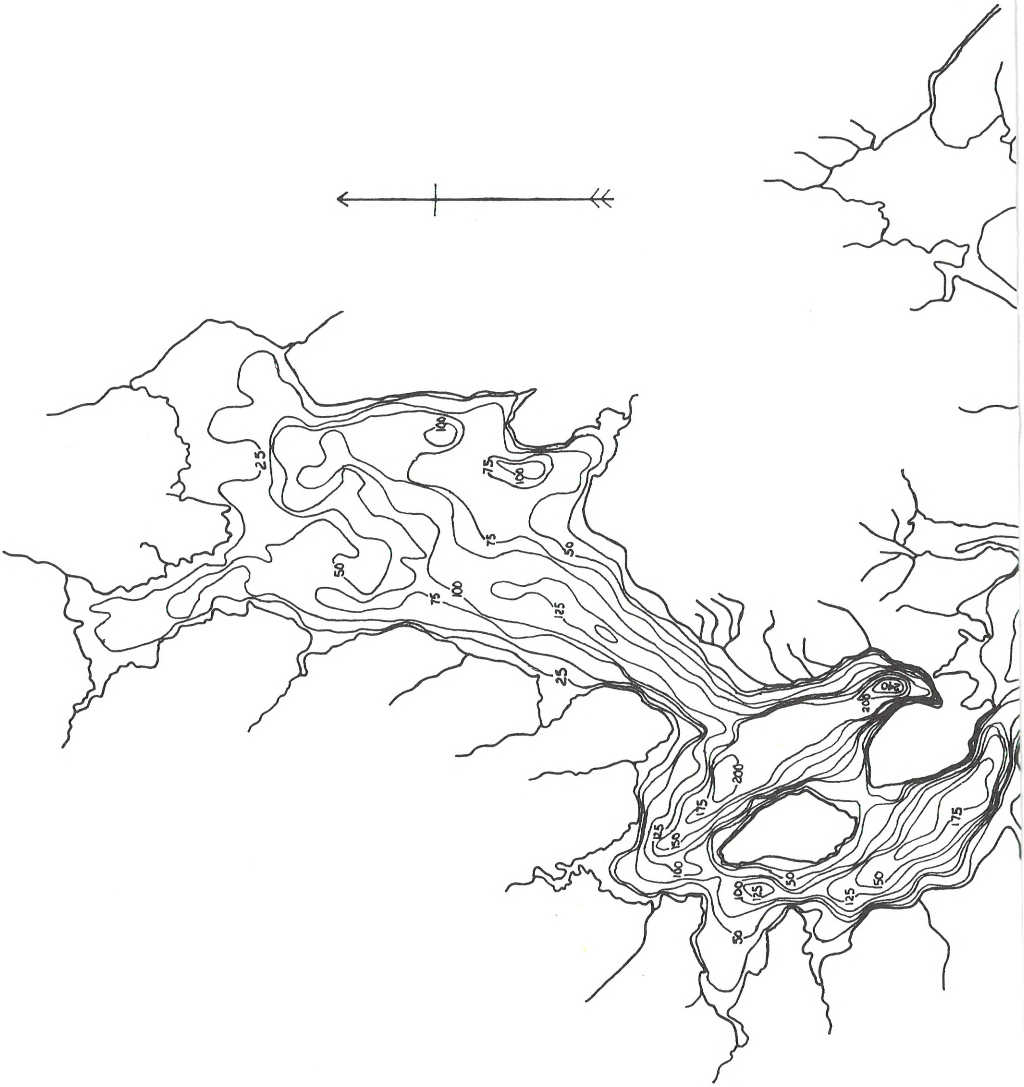
Age	1967 - 1971 Length (inches)	1967 - 1971 Weight (ounces)	1972 - 1976 Length (inches)	1972 - 1976 Weight (ounces)	1977 - 1979 Length (inches)	1977 - 1979 Weight (ounces)
II	--		--		14.6	
III	14.7	17	14.8	16	15.0	17
IV	15.9	21	15.6	19	16.0	22
V	17.2	25	16.7	21	17.3	26
VI	19.3	39	18.9	32	18.3	34
VII	19.1	28	19.7	49	20.7	51
Mean	16.1	22	15.8	19	16.3	23

Hatchery

Age	1967 - 1971 Length (inches)	1967 - 1971 Weight (ounces)	1972 - 1976 Length (inches)	1972 - 1976 Weight (ounces)	1977 - 1979 Length (inches)	1977 - 1979 Weight (ounces)
II	14.2	14	14.3	14	14.4	15
III	15.3	18	15.1	16	15.9	20
IV	16.3	20	16.5	20	17.5	28
V	16.5	19	18.0	26	19.1	37
VI	--		20.2	33	17.7	28
VII	--		--		--	
Mean	15.4	18	15.6	18	16.4	23

Table 32. — Fulton's condition factor[ab] for salmon by inch class, Moosehead Lake.

Year of capture	Wild inch-class 14	15	16	17	18	19	20
1969	0.83 (.04)	0.85 (.02)	0.81 (.03)	0.86 (.03)	0.75 (.06)		
1972	0.89 (.04)	0.82 (.02)	0.82 (.02)	0.82 (.08)	0.93 (.07)		0.85
1975	0.83 (.03)	0.82 (.02)	0.78 (.02)	0.81 (.07)	0.85 (.02)	0.86 (.05)	
1978	0.97 (.07)	0.97 (.04)	0.82 (.07)	0.86 (.07)	0.88 (.02)	0.84	
1979	0.89 (.04)	0.94 (.03)	0.89 (.03)	0.90 (.03)	1.14 (.06)	1.05	



MOOSEHEAD LAKE

CONTOUR INTERVAL
25 FEET

Table 32. *(cont.)*

Year of capture	Hatchery inch-class 14	15	16	17	18	19	20
1969	0.88 (.03)	0.81 (.03)	0.82 (.02)		0.50		
1972	0.82 (.03)	0.76 (.03)	0.78 (.02)	0.78 (.02)	0.97 (.06)	0.87 (.06)	
1975	0.82 (.03)	0.75 (.03)	0.77 (.02)	0.71 (.11)	0.83		
1978	0.99 (.08)	0.96 (.03)	0.87 (.03)	0.92 (.03)	0.91 (.03)	1.00 (.07)	0.86
1979	1.02 (.14)	0.94 (.06)	0.94 (.03)	0.93 (.03)	0.92 (.02)	0.86 (.10)	1.06 (.06)

[a] Condition factor computed using total length.

[b] Figures in parentheses are standard error, where no standard error is shown, the sample is only one fish.

Table 33. — Age, sex and maturity of wild salmon netted at Moosehead Lake.

Age	Males Number mature	Males Number immature	Females Number mature	Females Number immature	Totals	Percent mature Males	Percent mature Females	Percent mature All
II+	—	All	—	All	5	0	0	0
III+	2	16	2	16	36	11	11	11
IV+	5	2	4	3	14	71	57	64
V+	3	—	4	1	8	100	80	88
Totals	10	18	10	20	63			

Table 34. — Age and sex ratios on salmon spawning runs at Moosehead Lake.

	Age III	IV	V	VI	VII	Totals
Males	43	31	12	1	1	88
Females	3	22	12	—	—	37
Totals	46	53	24	1	1	125
Percent Females	7	42	50	0	0	30

constituted the bulk of the run as they did at Cross and Long Lakes.

Scales from 221 wild salmon checked during the 1979 sport fishery were examined to determine age, years of stream life and spawning marks. The estimated total catch for each age group with the percent contribution of each stream life group to that total are pre-

Table 35. — Stream life of wild salmon from 1979 fishery at Moosehead Lake.

	1 Year			2 Years			3 Years			Total		
Age	Number	(%)	Length (inches)	Number	(%)	Length (inches)	Number	(%)	Length (inches)	Number	(%)	Length (inches)
II	35	100	14.00							35		14.00
	None spawned									None spawned		
III	567	76	15.60	176	24	14.35				743		15.30
	12 spawned at II			None spawned						12 spawned at II		
IV	653	19	16.95	2,790	81	16.22				3,443		16.36
	36 spawned at III			282 spawned at III						318 spawned at III		
V	71	4	19.57	1,649	91	17.45	83	5	17.60	1,803		17.54
	12 spawned at IV			35 spawned at III			None spawned			35 spawned at III		
				247 spawned at IV						259 spawned at IV		
				70 spawned at III, IV						70 spawned at III, IV		
VI	12	3	18.39	306	87	18.78	35	10	17.09	353		18.60
	12 spawned at V			71 spawned at IV			None spawned[a]			71 spawned at IV		
				71 spawned at V						83 spawned at V		
				12 spawned at II, IV						12 spawned at II, IV		
				35 spawned at III, V						35 spawned at III, V		
Total	1,338	21	16.45	4,921	77	16.72	118	2	17.45	6.377		16.68
	Survival IV-VI .115			Survival IV-VI .323			Survival V-VI .230			Survival IV-VI .310		

[a] One known to have spawned at age V from Roach River.

sented in Table 35. Mean lengths by ages and survival for each stream life year class are also included. Sex was undetermined for fish checked by creel census workers. Spawning marks observed on 3-year old salmon with a 1-year revealed a few of these spawned at age II+; these were undoubtedly males. None of the 2-year stream life salmon had spawned at age II and none of the 83, 3-year stream life fish had spawned at age IV or at age V. After examining additional 3-year stream life salmon scales we did find one that had spawned at age V.

Yearling hatchery salmon stocked in lakes at convenient access points are quickly imprinted by some memory mechanism to return to the specific stocking location upon maturing. We have taken advantage of this behavior to sample stocked fish annually for several years. Oneida Lake-type trap nets are set with their long lead into shore, and the box barely under water. The fish are marked temporarily with a caudal clip to estimate the numbers returning to the site. Although we cannot determine the proportion of each age group attaining maturity, we can determine the numbers of each age group, by sexes (Table 36). The data in Table 36 are the result of 4 years of trapping at one site on Moosehead Lake. We trapped during the month of October only, and the catch has averaged about 150 salmon annually. Trapping results disclose that many males mature in the fall of their third summer (II+) and that they are probably all mature in the fall of their fourth year. No males older than IV+ were captured on any of the 4 years of trapping. Very few hatchery-reared females mature to spawn in the fall of their third year (II+), but most are mature in the fall of their fourth year (III+). Some age V+ and VI+ females returned to this site. We cannot explain the loss of males after age IV+ when males and females were present in equal numbers at age III+ and IV+.

Table 36 — Concentration of hatchery-reared salmon on spawning site at Moosehead Lake.

Age	Males		Females	
	Number	Percent[a]	Number	Percent[a]
I	0	—	0	—
II	98	28	9	3
III	178	52	177	65
IV	70	20	72	27
V	0	—	9	3
VI	0	—	6	2
Totals	346		273	

[a] Percent is proportion by age for each sex.

Natural Reproduction

Salmon spawn in streams and rivers where the current flows moderately to swiftly (0.2-0.9 ft/sec. in Roach River) over bottom materials composed of gravel and rocks. Warner (1963) analyzed salmon redd materials and determined that 72% (by weight) of the gravel was between 0.25 and 1.50 inches in diameter with only 13% greater than 1.50 inches. The remainder was silt and sand. Streams or rivers, often called thoroughfares, connecting two or more lakes appear to be preferred probably because slightly warmer temperatures during the summer favor growth and survival as opposed to spring-fed tributaries that seem to be preferred by brook trout and where young salmon grow very slowly. Lake outlets, usually larger than the inlets, may support spawning runs of salmon where there are no dams to impede their movements, or where efficient fishways are provided for salmon to return after dropping downstream, and for the young to enter the lake.

The adult female salmon digs a pit several inches deep and extrudes some of her eggs into the pit. One or more male salmon immediately deposit sperm over the eggs to fertilize them. The current flowing across the pit causes an eddy which keeps the eggs and sperm rolling around in the bottom of the small pit, mixing the two thoroughly. The female then resumes digging above the first pit, and this action results in the lower pit being covered with washed gravel and small stones. Fine particles are washed downstream by the fast current. The eggs remain in the pits during the winter and must absorb oxygen from water flowing below the surface through the gravel. Salmon appear to sense areas where there is an underground flow through gravel and the use of these same areas year after year keeps the gravel loose. The eggs hatch in April, and the alevins or fry gradually force their way upward through the spaces in the coarse gravel or stones. The fry select locations near rocks or debris for shelter and begin to feed on small organisms drifting within their sight. As the fry grow and gain greater swimming ability, they gradually disperse up or down stream to nursery areas needed for shelter and nutrition. Nursery areas, so called, are characterized by rocks and fast current. Because rocks increase the total area available for insect production and shelter, the highest production of salmon parr per unit area (100 square yards) is in the rocky riffles characterized by rough rocks of all sizes. The potential for wild salmon production in streams is highly dependent upon the amount of nursery area. The amount of spawning area required is small compared with the amount of nursery area needed to produce sufficient numbers of salmon parr to the size (smolt size) where they acquire the urge to move out of the stream and into a lake. The smolt size for Moosehead Lake salmon appears to be about 5 inches or greater with the average for 1-year stream life salmon about 7 inches (Table 25).

Warner (1963) estimated a survival of 93% of the eggs to just before hatching in the thoroughfares of the Fish River chain of lakes. Warner also estimated an abundance of 63 to 90 young-of-the-year salmon per 100 yds.^{2} of nursery area. Meister (1962) obtained a 2-year average of 26.5 young-of-the-year salmon during an intensive study of Atlantic salmon, and Havey and Warner (1970) give a mean of 27.3 young-of-the-year per 100 yds.^{2} for a long list of Maine streams. Survival from age 0+ to age I+ appears to range from 20 to 50%. At Squaw Brook, tributary to Moosehead Lake, we estimated 28 young-of-the-year and 14 yearlings per 100 yds.^{2} as a 6-year mean indicating a survival of 50%. Squaw Brook supports a brook trout population, and the combined salmon and trout totals range from 30 to 95 (mean of 46) per 100 yds.^{2}. Our estimates of yearling salmon for Roach River, our best nursery area, ranged from 4.2 to 17.6 (mean of 7) per 100 yds.^{2}, (Table 37), with some young brook trout occupying the same areas. The young salmon designated as 2-year stream life fish can be censused during their second summer but not in their third summer, because they leave the streams sometime between late fall and early the next year. Consequently we have no reliable estimate of survival from age I+ to II+ and cannot estimate directly the number of smolts contributed to the lake from the different streams.

Table 37. — Estimated parr production in Moosehead Lake waters.

Name	100 yd^2 units	Parr per 100 yd^2	Estimated production	Source
East Outlet	2,745	—	271[a]	Trapping Fishway
Roach River	2,502	7.0	17,472	Electrofishing
Moose River	1,722	7.0	12,054	Roach River mean
Squaw Brook	66	14.7	973	Electrofishing
Socatean Stream	264	6.1	1,610	Electrofishing
North Brook	176	5.7	995	Electrofishing
7 other Streams[b]	572	5.7	3,260	Estimates
Totals	8,047	—	36,635	

[a] May be much higher counting older fish and dropdowns.

[b] Electrofished to determine occurrence only.

The East Outlet with the greatest potential for producing salmon (2,745 100 yd^2 units) which should result in a production of approximately 19,000 yearlings produces pitifully small numbers (Table 37). Over a 6-year period of trapping the fishway for upstream migrants an average of only 271 smolts per year were counted entering the lake. The number of parr (1-year olds) would be at least double, but still extremely low. An additional 200 larger wild salmon (less than 14 inches long) were passed through the fishway but scales from these exhibited some degree of lake environment growth. Either they came down from Moosehead Lake or they spent some time in Indian Pond below, then came up through the fishway. They can be considered a contribution to the lake. A total of 471 smolts would have suffered about 50% mortality over their second winter so they would equal approximately 1,000 yearling parr.

The Roach River with its 7-mile stretch of mostly rocky riffles and pools appears to produce the highest number of yearling parr. With 2,502 100 yd.^{2} units and an average of 7 per unit (a high of 14+) has an estimated potential of over 17,500 parr, and has probably produced over 25,000 on some years. At an easily accessible spawning site on Roach River we have, in different years, counted more than 100 large salmon digging and spawning in an area about 300 feet long by 50 feet wide. The lower end of the river near the lake has another gravel area where we have seen many salmon redds. We know salmon spawn in the Moose River but have not attempted to estimate parr production because of the deep swift areas where electrofishing is ineffective. Moose River has a 1½ mile stretch of suitable nursery area where we used the mean rate of 7 parr per 100 yds.^{2} for estimates. In 1956 and 1957 a spawning run of large trout in Socatean Stream (Moosehead Lake tributary) was trapped and some areas electrofished to estimate brook trout populations. In 1956, 30 adult salmon and in 1957, 42 adult salmon were trapped while moving upstream to spawn in addition to more than 1,000 adult brook trout. A few salmon smolts were trapped moving downstream in June, in late September, and some in November. The time of movement of the parr from Socatean Stream is informative indicating that parr may move out of a stream most anytime, and estimates made from electrofishing during the low water periods of June to September may underestimate parr production for some streams.

We have electrofished many of the smaller tributary streams around Moosehead Lake and have found young salmon in most of them. In addition, we have also seen a few adult salmon spawning in several of the smaller tributary streams. From this information on potential nursery areas and actual estimated production we have estimated total potential production of yearling wild salmon (Table 37). We believe our estimate of 36,635 parr produced in the immediate drainage and outlet is low for several reasons. Many parr leave the streams early in their second summer and are not included in mid-summer censuses. Secondly, we know that some young salmon move down from the upper lakes in the drainage. Thirdly, our estimated catch of legal-size salmon has steadily increased from an average of 5,200 to over 6,000 for 1978-1979. A catch of 6,000 adults may be estimated to originate from over 40,000 yearlings. Parr production could conceivably be increased considerably as indicated by estimates of more than 14 parr per 100 yds.^{2} on the Roach River for some years and a mean of over 14 for Squaw Brook.

Survival and Exploitation

Survival of fish is defined as the number remaining from one year to the next, or from any period in their lives to another period. Usually we speak of survival as including an entire year, because it is difficult to determine survival for shorter periods of time, especially for wild populations. In streams, the winter period is critical for young salmon. In lakes perhaps the highest mortality occurs when salmon attain the legal length limit for the fishery. At that time they are actively feeding and growing, and they are highly vulnerable to angling methods.

Although survival during egg incubation has been shown to be as high as 93% under nearly ideal conditions (Warner 1963), survival from hatching to the following fall is probably less than 10% (Meister 1962). Population values for young-of-the-year and yearling salmon in many Maine streams have been determined by electrofishing methods. The mean ratio of these two year classes is a good measure of survival. Meister (1962) estimated survival between age 0+ and I+ to be between 41 and 59% for young Atlantic salmon in Cove Brook. Mean survival from the fingerling to yearling stage for 5 consecutive years at Barrows Stream, Maine (Havey and Warner 1970) was 21% (range: 7.5-55.6%). Sampling of Big Squaw Brook, a tributary to Moosehead Lake, by electrofishing in 8 different years, resulted in an estimated survival between 50 and 60% from fingerlings to yearlings. For survival from yearling to the time of entry into the fishery (usually age III) a mean annual survival rate of 70% is indicated for hatchery-reared salmon (Havey and Warner 1970). Survival for Moosehead Lake wild salmon for ages IV-VI is estimated at 0.115 for the 1-year stream life fish, 0.323 for 2-year stream life fish and 0.230 for 3-year stream life fish (Table 35) from age V to VI. Samples of 3-year stream life fish are small and they appear in the fishery in very low numbers. The 1-year stream life salmon have been exploited quite heavily by age IV. A mean annual survival value of 0.310 was computed for the 3 groups combined. Survival of wild salmon for 7 year classes (Table 43) caught in the fishery ranges from 0.159-0.305 with a mean of 0.239 for ages IV-VII. A recent sample of 63 gillnetted wild salmon has enabled us to estimate a survival of 0.356 for ages III-V. Netted samples include the 3 and 4 year olds not large enough to be included in the fishery, and the higher survival indicated is probably closer to the actual value.

Survival of hatchery-reared salmon stocked in Moosehead Lake as yearlings, and recovered in trapnets (Table 38) was estimated by sex for two year classes for ages III-VI. Males suffered significantly higher mortalities during those years, as evidenced by the survival rates and by the absence of 5 and 6 year olds. The mean annual survival rate of 0.261 for combined sexes and year classes is almost identical to the mean of 0.265 determined for 7 years of angler harvest date (Table 42) for hatchery-reared salmon. The means for both angler-caught wild and angler-caught, hatchery-reared salmon agree very well although the age groups involved differ by one year. The one year difference was covered in the discussion on age and growth.

By the same methods employed for lake trout we constructed separate "life tables" for hatchery-reared and wild salmon populations of Moosehead Lake. Beginning with stockings of 50,000 yearling salmon at an estimated survival rate of 70% prior to the time they enter the fishery in significant numbers, and an estimated sur-

Table 38. — Salmon survival (by sex) for 1973 and 1974 year classes of hatchery-reared fish at Moosehead Lake.

	Year class 1973		Year class 1974	
Age	Male Number	Female Number	Male Number	Female Number
III	58	40	96	75
IV	27	33	21	18
V	0	4	0	5
VI	0	3	0	3
Survival	.243	.388	.153	.270

	Year class 1973	Year class 1974	Combined (1973, 1974)
III	98	171	269
IV	60	39	99
V	4	5	9
VI	3	3	6
Survival	.320	.211	.261

vival rate of 35% for the years they are in the fishery, we estimated the numbers of each age group present in the lake (Table 39). From sources other than angler harvest data (gillnetting etc.), we determined the proportions of legal-size fish at each age. For reasons explained in the harvest section (Table 42) we used only the Enfield hatchery stock to determine means of estimated harvests for each group. From these parameters, we determined exploitation values for each age group, and a mean value of 38% for a typical exploited population of hatchery-reared salmon living in Moosehead Lake.

Table 39. — Life table for hatchery-reared salmon at Moosehead Lake.

Age	Hatchery-Enfield	Percent ≥ 14 inches	Number ≥ 14 inches	Mean harvest (number)	Exploitation (%)
I	50,000 (spring yearlings)			0	
II	35,000	5	1,750	200	11
III	24,500	90	22,050	9,654	44
IV	8,575	100	8,575	3,494	41
V	3,001	100	3,001	305	10
VI	1,050	100	1,050	74	7
Totals					
	122,126 (1.62/acre)		36,426 (.49/acre)	13,727 (.18/acre)	38

For wild salmon, we do not know the numbers of yearlings, but assuming the 70% survival rate for salmon prior to their entry into the fishery and the 35% rate for those well into the fishery, the known proportions of legal-size salmon at each age, and the mean estimated harvest at each age, we constructed a similar table (Table 40). Computations for wild salmon required pro-rating the 40% entering the fishery as 3-year olds and working backward to compute abundance for 2-year olds and for 1-year olds. Actually the number of 1-year olds has to be somewhat higher than the 26,000 shown in the table because most wild salmon enter the lake as 2-year olds and suffer a mortality close to 50% during their second winter in the streams. This would increase the estimate of 1-year olds to something close to the estimated production (Table 37) of 36,000 yearling parr. The mean exploitation of 33% for wild salmon and 38% for hatchery-reared salmon is slightly higher than most values given by Havey and Warner (1970), but we believe it is not too high. Many marked, hatchery-reared salmon stocked in Moosehead Lake are caught below the dam on the East Outlet and 3 miles below where this river enters Indian Pond, the next lake downstream. These fish are not included in our estimated catches for Moosehead Lake. Many wild salmon from the Moosehead Lake population are also caught in Roach River, the principal spawning inlet, and these fish are not included in our estimated catches of wild salmon.

Table 40. — Life table for wild salmon at Moosehead Lake.

Age	Number of wild salmon	Percent ≥ 14 inches	Number ≥ 14 inches	Mean harvest (number)	Exploitation (%)
I	26,024			0	
II	18,217			0	
III	12,752	40	5,101	856	17
IV	7,141	100	7,141	3,142	44
V	2,499	100	2,499	1,058	42
VI	875	100	875	124	14
VII	306	100	306	20	7
Totals	67,814 (.90/acre)		15,922 (.21/acre)	5,200 (.07/acre)	33

Salmon Harvest

Harvest estimates were made from creel census records and aircraft counts as explained in the creel census section. Estimates are based on angler days which are within ±20% accuracy at the 95% level of confidence. Detailed census records, known ages for every hatchery-reared salmon group stocked, and age determinations from scales of the wild salmon were employed in estimating harvests by year classes and by age groups. Except for the young and old fish which occur in low numbers, reliability of estimates for each age should be acceptable, because sample numbers were unusually high and provided good distributions. Where sample numbers were considered low, similar samples were combined, or, if not available, the deficiencies were noted in the text. All estimates tend to be slightly low because, as stated earlier, many salmon of Moosehead Lake origin caught in the principal inlet annd outlet rivers were not included in the census. Catches from these areas would increase annual harvests by something close to 500 salmon (less than 4%). From the following table (Table 41) it is apparent that the harvest of wild salmon has been fairly stable over the years. However, significant fluctuations occurred in the annual catches of hatchery-reared fish resulting in fluctuations of total harvests. Some low catches of hatchery-reared salmon resulted from stocking every other year in

Table 41. — Salmon harvest for project years at Moosehead Lake.

Year	Hatchery	Wild	Unknown[a]	Total
1967	—	—	12,255	12,255
1968	746	—	20,714	21,460
1969	3,912	—	4,586	8,498
1970	1,726	—	5,687	7,413
1971	7,812	6,022	128	13,962
1972	7,014	8,939	64	16,017
1973	12,754	3,617	—	16,371
1974	5,739	3,707	—	9,446
1975	3,239	3,417	—	6,656
1976	8,329	4,540	—	12,869
1977	14,823	5,127	—	19,950
1978	5,016	5,843	—	10,859
1979	6,070	6,377	—	12,447

[a] Unknowns include hatchery fish from various stockings of unmarked fish prior to the study.

Table 42. — Harvest of hatchery-reared salmon by year class at Moosehead Lake.

Year class	Thousands stocked	Age II	III	IV	V	VI	Total	Percent return	Survival III-VI
1966	C[a] - 50	746	3,912	1,582	66	0	6,306	12.6	.236
1967	—								
1968	E[a] - 50	144	7,684	5,355	153	37	13,373	26.8	.304
1969[b]	C - 20.4	62	1,279	349	174	3	1,867	9.2	.281
1970	E - 50	380	12,252	3,007	180	68	15,887	31.8	.187
1971	C - 50	0	2,521	2,117	261	18	4,917	9.8	.354
1972	C - 50	0	664	760	26	0	1,450	2.9	.032
1973	E - 50	275	7,240	2,962	293	118	10,888	21.8	.269
1974	E - 50	0	11,440	2,653	592	—	14,685	29.4	(.207)
1975	E - 25	377	1,937	1,019	—	—	3,333	13.3	(.256)
1976	E - 25	133	4,094	—	—	—	4,227	16.9	
1977	E - 25	247	—	—	—	—	247	0.9	
Totals[c]	300	1,545	34,273	15,783	979	241	52,821		
1966-1973 Means[c]	50	257	5,712	2,631	163	40	8,803	17.6	.265

[a] Hatchery source (Casco, Enfield)

[b] Stocked in tributary lake

[c] Completed year classes (1969 omitted)

the early years of the project. After the annual stockings of 50,000 (1970 on) were in the fishery, the low catches were mainly caused by poor survival of young salmon resulting from long hauls from one of the hatcheries. Total catch data are the sum of summer and winter catches. Winter catches averaged less than 1,000 salmon annually over the project years but increased gradually from less than 3% in the early years to about 10% in recent years.

The mean harvest of 8,800 salmon (Table 42), by year classes, from 6 stockings of 50,000 each, now through the fishery (17.6% returns) does not reveal the full potential for hatchery-reared salmon because of the problems of low survival for young salmon trucked about 160 miles from the Casco hatchery (Table 42, hatchery source). Mean returns from 4 stockings of 50,000 yearlings each from the Enfield Hatchery, a distance of about 70 miles, were 13,700 (27.4%). Mean returns from the Casco Hatchery were 4,224 salmon (8.4%) to the angler. Beginning in 1976 we reduced the stocking rate to 25,000 marked yearling salmon annually (0.33 per acre). The 1975 year class from the reduced stockings (not through the fishery) has yielded 3,300 through age IV for a return of 13.3%. The 1976 year class appears to be better with a return of 16.9% through age III only. During 1980 (not shown) small numbers of 7 and 8-year old (1973 and 1974 classes) salmon of hatchery origin were caught by anglers.

Table 43. — Harvest of wild salmon by year class at Moosehead Lake.

Year class	Age II	III	IV	V	VI	VII	Total	Survival IV - VII
1966	0	716	3,907	1,087	265	21	5,996	.241
1967	0	287	3,620	1,410	59	0	5,376	.231
1968	0	1,315	4,729	922	82	0	7,048	.159
1969	0	2,535	2,476	975	101	0	6,087	.249
1970	0	139	2,018	645	170	62	3,034	.288
1971	0	632	2,304	1,282	97	55	4,370	.305
1972	0	367	2,941	1,088	94	0	4,490	.236
1973	0	147	3,432	1,935	353	—	5,867	(.316)
1974	0	448	2,603	1,803	—	—	4,854	(.290)
1975	0	1,111	3,443	—	—	—	4,554	
1976	45	743	—	—	—	—	788	
1977	35	—	—	—	—	—	35	
Totals	0	5,991	21,995	7,409	868	138	36,401	
1966-1973 means[a]	0	856	3,142	1,058	124	20	5,200	.239

[a] Completed year classes

For the wild salmon, a companion table (Table 43) of harvests by year classes is presented. Prior to the 1966 year class it was not possible to isolate wild salmon because varying numbers of unmarked fingerling and yearling hatchery-reared salmon had been stocked. The estimates of wild salmon are low because many (less than 500) wild salmon caught by anglers in the Roach River (a tributary) were not included in the census. Most of these are fish ascending the river in late summer, and they are harvested through September in a fishery restricted to fly fishing with a daily limit of one salmon. Year classes of wild salmon have maintained unusually stable returns to the fishery indicating recruitment is fairly stable, and probably limited to the estimated production of about 36,000 yearling parr annually, with approximately half of these entering the lake as 2-year olds. Those entering the lake as 1-year olds would increase these estimates slightly. The highest proportion of wild salmon from any year class is caught at age IV (fifth summer) with a mean of 3,100 fish. Recent increases in growth have resulted in higher catches of 3-year olds and even a few 2-year olds. Increased growth among wild salmon will tend to increase the total harvest of them. The harvest of wild salmon has included some 7-year old fish in most years. One of our objectives was to reduce the salmon population to provide an annual harvest of approximately 12,000 fish with an average weight of 20 ounces for a total crop weight of 15,000 pounds. The following harvest data for 1978 and 1979 show that we have attained our objective in numbers harvested, but by reducing the numbers stocked it appears we may have increased the food supply for the remaining fish resulting in a much higher average weight. For complete salmon harvest data refer to Appendix X.

Year	Wild	Number Hatchery	Total	Ave. weight	Total pounds
1978	5,843	5,016	10,859	24.6 oz.	16,685
1979	6,377	6,070	12,447	26.8 oz.	20,820

BROOK TROUT

Long before landlocked salmon were introduced, Moosehead Lake was known for its abundant, large brook trout *(Salvelinus fontinalis)* locally called "squaretails." The term "laker" was reserved for lake trout, and brook trout or "brookies" was used for the smaller, stream-dwelling trout or charr. The literature abounds with studies of brook trout, but most of the studies pertain to stream-dwelling trout or hatchery-reared trout stocked in ponds.

In Maine, especially the northern half, we have many large, mostly oligotrophic, lakes supporting popular fisheries for brook trout (squaretails) up to 23 inches long, with some weighing over 6 pounds. The biology of trout in these large lakes has been largely ignored, or it is assumed to be similar to brook trout residing in streams and small shallow trout ponds. Many of these large lakes have been, and some are still, stocked with large numbers of the popular landlocked salmon and/or with various strains of hatchery-reared brook trout without considering possible deleterious effects of these introductions upon the indigenous populations of highly desirable, lake-dwelling brook trout. As early as 1893, guides and other persons were concerned when they said that Moosehead waters should be stocked with fish natural to them, and that other species might prove destructive to trout.

Large catches of trout were common, and the old "Maine Sportsman" magazines include many accounts similar to these: June, 1894 — "Cowan Cove, good trout fishing, 29 trout weighing 35½ pounds." "Sandy Bay 6 men — 65 trout from 2 to 5 pounds." July, 1894 — "One day of fishing for a man, wife and daughter — 21 trout weighing 52¾ pounds. Of these, 13 were squaretails weighing 34¾ pounds. One weighed 5¼ pounds — largest taken from the lake (Moosehead) this season." Some of these notes may be exaggerated as are many fishing notes in newspapers and sporting magazines. However, the picture is one of excellent fishing for trout. I was surprised to learn that a 5 or 5½ pound squaretail was considered a record fish for Moosehead Lake in the late 1800's, because from personal observations as the Regional Biologist since 1955, trout weighing over 5 pounds and some 6 pounds were caught almost every year.

The Camp Comfort records (1953), which I used liberally for this paper, demonstrate the importance or prominance of brook trout during the 60 years (1894-1953) these records were kept. Of the 60-year totals of the 3 species, 18% were lake trout, 8% were salmon and 74% were squaretails. These men, employing guides and using canoes without motors, fished the shallow waters the first 4 weeks after ice-out. Their methods may have been biased against lake trout, but salmon, common from the 1930's on, should have been highly vulnerable. The Camp Comfort records indicate a rarity of trout over 4 pounds, which was the weight designated for their record fish. The recorded weights are undoubtedly accurate because of the competition among members and guides. During the 60 years, only 44 trout weighing 4 pounds or more were recorded. Twelve (12) of these weighed 5 pounds or more and the heaviest of all caught in 1950 weighed 5¾ pounds. Wilson's Sporting Camps recorded a few 6-pound trout between 1887 and 1922. The heaviest trout we have recorded from Moosehead Lake was 25¼ inches long and weighed 7 pounds and 8 ounces, which was caught in 1959. Since the 1950's I have personal knowledge of many squaretails weighing over 5 pounds, several over 6 pounds, plus the above record of 7½ pounds. Possibly some larger trout were caught.

During their survey of Moosehead Lake in 1944, Cooper and Fuller (1945) netted 120 brook trout with several weighing from 3 to 5 pounds; the largest was 5 pounds 5 ounces. From computations based upon areas and volumes of habitat present, Cooper and Fuller estimated the ratio of salmon to brook to lake trout to be 9:11:11, or 29% salmon, and 35.5% each of brook trout and lake trout. Warden angler checks of 4,076 anglers fishing Moosehead Lake during May and June from 1935 through 1944 counted 6,522 fish. Of these, 49% were brook trout, 32% were salmon, and 19% were lake trout. From 1952 on, in May and June, Wardens checked 5,000 anglers with 5,500 fish, and of these 57% were brook trout, 21% were salmon, and 22% were lake trout. Some of the brook trout were probably caught in streams. During our study (1967-1979) anglers caught an estimated 286,400 salmonids. Of this total 59% were salmon, 24% were lake trout, and 17% were brook trout. Our gillnetting samples (combined) for this study included 31% salmon, 28% lake trout and 41% brook trout, compared to Cooper and Fuller's 1944 actual netted sample of 10% salmon, 55% lake trout and 35% brook trout. We believe the differences between the two gillnetted samples are real, because we are certain the lake trout population has decreased while the salmon have increased in abundance. Our sample of brook trout in the angler census is low, because many trout caught from docks and shoreline points were not included in the sample. We estimate the proportion of brook trout is somewhere between 25 and 40%. Cooper and Fuller (1945) determined over 40% of the Moosehead Lake water area and 45% of the volume are suited for brook trout. Although all areas of the lake will support brook trout most of the year, shallow coves may become too warm (71-75 °F) in some years, and the deepest areas are seldom frequented by brook trout. Most gillnet catches of trout were made between 15 and 30 feet during the summer.

Brook trout have been stocked into Moosehead Lake at least since 1895. In most years until 1934, brook trout fry were stocked in numbers from 20,000 to 200,000 (Appendix XVI). Beginning in 1934 and as late as 1958, fry were stocked along with fall fingerlings and spring yearlings until the beginning of this study in 1967, when we terminated brook trout stocking. Recent studies of hatchery reared brook trout stocked in Rangeley Lakes, Maine disclosed very low survival and contribution to the sport fisheries. In 1971 we stocked 50,000 and in 1972, 75,000 marked fall fingerling brook trout into Moosehead Lake to answer criticism of trout stocking curtailment; results will be discussed later in this report.

Sampling Methods

All of the sampling methods used for lake trout and salmon provided data on brook trout: gill netting, trapnetting, electrofishing of streams, trapping the East Outlet fishway, and the intensive census of anglers. Two stockings of marked hatchery reared trout were made and subsequently sampled in the creel census of anglers and gill netting. Most tributary brooks, streams, and rivers were sampled by electro-fishing, trapping or by visual observation for the presence or absence of trout. Estimates of abundance were made for some streams by electro-fishing methods. These were often made in conjunction with estimates of young salmon. A study of an important spawning run of brook trout in Socatean Stream, a medium-size tributary stream (unpublished data), was conducted in 1956 and 1957 by this author, and results of the study were available for this report.

Age, Growth, and Maturity

Brook trout grow well in Moosehead Lake. For such a large body of water, the surface temperatures remain surprisingly low throughout the summer. Of the many water temperature series made throughout the year and over several years, typical July temperatures ranged from 60° to 72°F, and August temperatures ran from 64 to 73°F; although, in some years after a hot, calm period we have recorded a surface temperature of 75°F. Sudden winds however, quickly lower the surface temperature to the 60's (F) again. With the shoreline predominantly rocky, insect production is high, and young trout grow rapidly to 8 and 9 inch lengths during their second summer.

The growth rings on Moosehead Lake trout scales, unlike those from many waters, are quite clear and their ages may be determined with confidence. Cooper and Fuller (1945) remarked that the scales of these trout were quite easily read and that there was little question about the validity of their age determinations except for a few old individuals. The oldest sample (120 trout) of the lengths, weights and ages of Moosehead Lake brook trout is the sample netted by Cooper and Fuller in 1944 (Table 44). These competent fishery scientists recorded their data for every fish. They gillnetted these trout along with other species at all depths and in all areas of the lake in mid-summer. Their sample included trout from age I through age VI, although they caught only one age I trout. The Socatean Stream sample of 651 trout is from a spawning run of more than 1,200 trout trapped in 1957 from July 15 through November 5, with the peak of the run about September 15. Most of these fish had completed their growth for the year, and their average lengths are a little higher than the other groups. Combination of all gill-netted brook trout during the project years (1967-1979) resulted in a sample of 143 trout ages I through V which can be compared with Cooper and Fuller's sample. The angler census sample of 249 trout may also be compared with gill netted samples except for age I fish which may be biased by the 6-inch legal length limit and angler rejection of small trout. The last 2 samples in Table 44 agree unusually well at all ages, and, except for the additional growth on the Socatean trout, they agree well with that also. However, the 1944 sample indicates trout of ages II through V were substantially smaller. Our only explanation for this difference is poor food conditions or unusual abundance during those years. Presented below for comparison are average lengths at given ages for brook trout netted from many Maine waters during summer surveys from 1937 through 1953.

	Age					
	I	II	III	IV	V	VI
Length (inches)	8.8	10.2	13.6	16.1	18.8	20.7

Based upon the above statewide analysis, Moosehead Lake brook trout are at least average in length for their age. Although we have no statewide average available for weights, we are including this information for Moosehead Lake trout below:

Length (inches)	6-7	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Weight (ounces)	1.2	1.9	3.5	5.0	6.8	9.0	12.3	15.3	18.0	23.0	27.3	33.3	39.3	45.0	51.3

The weights were taken from the Socatean Stream spawning run and include both sexes.

Table 44. — Comparison of brook trout lengths at Moosehead Lake.

Age	Source and year			
	Cooper (1944)	Socatean (1957)[a]	Gillnetting (1967, 1973, 1978)	Census (1974-1978)
I	8.3 (1)	7.5 (51)	7.7 (49)	8.2 (19)
II	9.3 (52)	10.9 (190)	10.4 (52)	10.7 (102)
III	12.1 (28)	14.6 (264)	13.0 (35)	13.5 (90)
IV	14.3 (25)	17.1 (108)	16.1 (6)	16.5 (29)
V	19.5 (8)	19.1 (35)	18.9 (1)	18.9 (5)
VI	20.7 (6)	19.9 (3)	—	20.5 (4)[b]
Mean annual increment	2.5 inches	2.5 inches	2.8 inches	2.5 inches

[a] Spawning run.

[b] No age VI in 1974-1978 samples, samples from earlier (1968, 1971, 1972) census were used.

Biologists agree that many wild female brook trout spawn at age I+ or in the fall of their second year of life. Combined samples totaling 155 brook trout gill-netted during this study for which age, sex, and maturity status were determined (Table 45) disclose a high proportion of the age I females were mature in their second summer and would presumably have spawned that fall. It is also interesting that not all females were mature at age III. The sample of trout older than III was too small to state without reservation that all female trout IV or older are mature. For male trout the proportion of mature fish was similar, except that all the 3-year olds were mature. Gonads of a few trout examined were not sufficiently developed to determine sex.

From the large run of trout in Socatean Stream the ages of 363 females and 251 males were determined. Of the females 18 (5%) and 22 (9%) of the males were 1-year-old fish. The sex of 11 of the 51 Socatean Stream trout whose scales were read as age I was undetermined, because the trout were not killed, and sex by external characteristics is not always prominent on young trout. The proportion of mature 1-year old females in gillnetted fish is much greater (21% of females and 13% of males). However, this could be the result of the great difference in sample sizes. Both samples do show that a number of 1-year old females mature and some were checked in the spawning run.

Moosehead Lake brook trout commonly attain the age of V+ and about 3% of the trout in 10 years of trout harvest data were VI+ (in their seventh summer). Only one (1) 7-year old was recorded in the angler census. Many large trout caught by anglers do not appear in the random census sample. One brook trout we tagged (numbered jaw tag) during the Socatean stream spawning run in September of 1956, whose age we determined to be VI+, was recaptured by an angler in July of 1958 at the age if VIII+. Another trout tagged at the same location in 1957, whose age we assessed at V+ at the time, was recaptured by an angler in 1961 at the age of IX+. This age may be unprecedented among brook trout. Scott and Crossman (1973) in their "Freshwater Fishes of Canada" say brook trout never live more than 8 years in the eastern portion of North America.

Table 45. — Maturity of gillnetted brook trout, Moosehead Lake.

Age	Females (no.)	Percent mature	Males (no.)	Percent mature
I +	29	45	13	54
II+	27	89	30	83
III+	21	95	17	100
IV+	4	100	4	100
V+	1	100	0	—

Natural Reproduction

Brook trout are noted for their attraction to cool water. They select areas of natural upwellings of cool ground water in streams, lakes and ponds for spawning. In northern Maine and Canada underground flows are required for the eggs to survive while buried in gravel for approximately 6 months. There is some evidence that brook trout can home to their parent stream when displaced and for spawning (O'Connor and Power 1973). At Socatean Stream I found a minimum return of 26% of the estimated surviving trout tagged one year returning to spawn again the next year. At Socatean Stream in 1957, trout males and females were trapped at a weir as early as mid-July. By the end of July as many as 20 per day were captured; these were 8 to 12 inches long. Throughout August the sizes and numbers of trout trapped and tagged while moving upstream increased to 60 on September 3, after a rain, and to 100 on September 4. These were 10 to 18 inches long. No trout moved downstream before October 20. A total of 1,250 trout were trapped moving upstream with the peak around September 15. By October 18, female trout were extruding eggs when handled and some were

Study of spawning run of brook trout in Moosehead Lake tributary.

seen spawning about that time. By November 10 spawning was completed. Spawning activity was similar to that previously described for salmon. The females dug small pits and deposited unknown numbers of eggs which were quickly fertilized by one or more males. The larger males, paired with large females, were always occupied by chasing other males, and, in some instances, a smaller male fertilized the eggs while the large male was a few yards away in pursuit of other males. Spawning occurred between October 16 and November 6 at distances from 1 to 6 miles upstream from Moosehead Lake. I observed more than 100 trout, some estimated over 4 pounds spawning in another tributary on October 19, 1955 and on October 26, 1956. I observed some eyed eggs on April 1, 1957 and on May 6 the same year some trout fry were observed out of the gravel near the redds. From these observations it is evident the eggs may be buried from mid-October to perhaps mid-April (6 months).

The number of eggs per female trout of various lengths and weights was determined by Vladykov (1956) and ranges from 100 for 6-inch fish to 750 for 12-inch trout, or approximately 900-1,000 eggs for a 1-pound trout (13-14 inches). For the Socatean Stream spawning run of 704 female trout from 6 to 21 inches long, we estimated that from 725,000 to 856,000 eggs could have been spawned. Apparently, a large proportion of the young fry that hatched in Socatean Stream moved down from the spawning sites, over low falls, into a long deadwater area and possibly into the lake. Using an inclined plane-type fry trap we caught 10 fry in one hour, moving down on May 6 when the water temperature was 40°F. Some were observed moving down on May 4 (water temperature 33-35°F). The yolk sacs of these fry appeared to be only barely absorbed. Farther down stream in slow moving areas, we set some improvised floating minnow-type traps made of ¼-inch minnow seining material with short floating wings of the same material. When we caught no fry after observing thousands along the stream banks, we watched the traps and observed fry turning downstream and passing through the ¼-inch mesh and over the wings. These fry were moving downstream at fairly rapid rates very close to the banks and barely under water. The only reference to similar behavior we found is by Webster (1975).

Some natural reproduction of brook trout occurs in practically all the tributaries to Moosehead Lake, and also in known spring areas along the shoreline. Some of the shoreline spawning areas are traditional and well known by local people who spent much time on the lake in the fall. Socatean Stream is locally known as the principal trout spawning tributary. It is fed almost entirely by small headwater brooks from heavily forested areas. An estimate of the number of trout fry produced in the lake and its tributaries would have to exceed 2 million. Of course, not all trout reared in the tributaries move to the lake. These tributaries have large resident populations and we have not determined if they are discrete or if they and the lake residents comprise a single gene pool.

Jaw-tagged brook trout.

Survival and Exploitation

Survival of brook trout from the egg to hatching, like most salmonids, has been determined to range from 79% in Canadian waters, to 80% in New York State and to 90% in Wisconsin (McFadden 1961). However, a mortality of 50-60% is reported to occur between hatching and a length of about 2 inches, and survival between ages 0 and I may be as low as 21% (McFadden 1961). For Moosehead Lake tributary streams, we estimated a survival of approximately 38% from age 0+ in September to I+ the following September, and a survival of 48% for age I+ to II+ for the same period. The stream was closed to all fishing. Survival from I+ cannot be estimated for trout caught by anglers in Moosehead Lake, because anglers catch higher numbers of age III trout than of ages II and I. In one gill netting sample we caught the following:

Age	I	II	III
No.	25	18	6

Employing the Robson-Chapman formula (1961) mean annual survival from ages I-III was estimated at 38.5%, with a much higher survival between I and II than between II and III. These results agree fairly well with the stream survival of 48% between I and II. The lower survival between II and III may be attributed, at least partially, to fishing mortality, because over 30% of angler trout harvests are 2-year olds, and to a high mortality (48%) during spawning activities where 27% of the spawning trout at Socatean Stream were 2-year olds.

Using the 1944 gill-netted sample (Cooper and Fuller 1945) below, we estimated a mean annual survival of 52% for trout of ages II-VI.

Age	I	II	III	IV	V	VI	Total
No.	1	52	28	25	8	6	120

The 1957 Socatean Stream run of trout came from Moosehead Lake, and the data indicate a survival of 31% for ages III-VI.

Age	I	II	III	IV	V	VI	Total
No.	146	342	477	228	53	4	1,250

Gill netted trout samples caught during this study when pooled (below) result in an estimated survival of 35% for ages II-V.

Age	I	II	III	IV	V	VI	Total
No.	49	52	35	6	1	0	143

Mean estimated numbers of trout caught by anglers for 7 complete year classes are presented below:

Age	I	II	III	IV	V	VI	Total
No.	355	908	1,014	440	112	1	2,830

Estimated survival for these is 30%.

We summarized the above information on trout survival in tabular form (Table 46). The Socatean Stream spawning run study of 1,225 brook trout tagged at a weir while on their upstream migration disclosed the following information (Table 47) on trout mortality. The 61% mortality value derived from this study agrees reasonably well with the 69% mortality estimated by the Robson-Chapman formula for this sample. Survival values of 30 to 35% estimated for recent netting and harvest also agree reasonably well with the Socatean Stream values. The 1944 sample (Cooper and Fuller 1945) results in an estimated survival of 52%. This appears high but old catch records indicate trout were undoubtedly more abundant during the 1940's.

There is very little information available on exploitation of brook trout from large lakes. From the Socatean Stream study, we estimated 628 tagged trout returned to the lake (Table 47). Of these 628 fish, anglers reported catching 165 during the next winter and summer fishing seasons for an estimated annual exploitation value of 24%. The second year after tagging anglers caught 19 additional tagged trout. Using the 39% annual survival value on the 628 trout supposedly in the lake in the second year (245 trout), the 19 that were caught results in an exploitation rate of 8%. This seems low but large (older) fish in small numbers in large lakes are generally caught at lower rates. Anglers caught 3 tagged trout in the third year and 2 in the fourth year after tagging for a total exploitation of 27% over the 4 years after tagging. Tag losses plus unreported tags would tend to offset each other. If more trout returned to the lake than we estimated, our exploitation rate of 24% is high. We have no estimate of total trout catches during those years, but if it was similar to those around 1967 and 1968 (mean of 7,751) the exploitation rate of 24% indicates a total fishable population of 32,300 brook

Table 46. — Survival of brook trout in Moosehead Lake, compared with other sources.

Stage	Survival (%)	Habitat	Source
Eggs to hatching	80	Stream	New York, Canada
Hatching to 2 inches	50	Stream	Moosehead Lake tributary
Sept 0+ to Sept I+	38	Stream	Moosehead Lake tributary
Sept I+ to Sept II+	48	Stream	Moosehead Lake tributary
I+ to III+	39	Lake	Moosehead Lake 1978 gillnetting
II+ to VI+	52[a]	Lake	Moosehead Lake 1944 gillnetting
III+ to VI+	31	Lake[b]	Moosehead Lake spawning run (Socatean Stream 1957)
III to VI	30	Lake	Moosehead Lake angler-catch (complete year classes 1967-73)
II to V	35	Lake	Moosehead Lake 1967-1978 gill-netting (samples pooled)

[a] Old catch records also indicate trout abundance greater.

[b] Trout came from Moosehead Lake — trapped in stream.

Table 47. — Parameters for Socatean Stream Spawning run study — 1957.

	Males	Females	Total
Tagged going upstream	449	776	1,225
Checked going down	148	403	551
Came downstream later (estimate)[a]	15	62	77
Presumed died in stream	286	311	597
Stream mortality (percent)	63.7	40.1	48.7
Killed by anglers next year	51	114	165
Total mortality (per cent)	75.1	54.8	61.0
Angler exploitation (per cent)	31.6	25.2	24.0

[a] Estimated from tag returns from trout not checked going downstream.

trout in the lake. Since we believe our estimated catches of brook trout are low, however, the total exploitable population could be as high as 50,000 trout. Exploitation of wild salmon in Moosehead Lake is estimated at 33%, and of wild lake trout 15%.

Angler Recovery of Stocked Brook Trout

In 1971 we stocked 50,000 marked hatchery-reared, fall-fingerling brook trout. The next summer an estimated 1,075 (2.2%) were caught by anglers as 1-year old fish. The following year (1973) anglers caught an estimated 151 as 2-year olds. These trout averaged 7.4 inches in length at I+ and 12.4 inches at II+. None were seen in angler catches after this. Total contribution to the fishery was 2.45% of the numbers stocked. As 2-year olds the stocked fish were 1.7 inches longer than the average wild trout at age II. In 1973 we stocked 75,000 marked trout (same age). The year after stocking, anglers caught 140 and in the second year (age II) anglers caught 78. None were seen thereafter. Their average size was 7.3 inches at I+ and 10.3 inches at II+. These were smaller than wild trout of the same ages in angler catches, and the return from the numbers stocked was less than 0.2%. Similar erratic results were obtained from stocking other large Maine waters with fall fingerling brook trout. DeSandre, et al. (1977) reported low returns from fall fingerlings stocked in the Rangeley Lakes, Maine. These trout contributed from 5 to 30% of combined wild and stocked trout caught as 1-year olds and 4 to 5% of trout caught as 2-year olds. When 1-year old trout were stocked, 72% were caught as 1-year old, 25% as 2-year old, and 3% caught as 3-year old fish. The stocked spring yearlings comprised 10-36% of the total of hatchery and wild trout caught as 2-year olds. Apparently the 2-year old wild trout are the preferred minimum size and wild 2-year olds comprise the bulk of the trout fishery (30-50%).

Brook Trout Harvest

Estimates of annual brook trout harvests by anglers fishing Moosehead Lake were made by the same methods employed for lake trout and salmon. Census clerks interviewed anglers, checked fish for the presence of missing fins, and measured and weighed all the salmon, lake trout and brook trout in their catch. Estimates of total angler days were made following counts made from aircraft combined with interview data as explained earlier in this report.

A large proportion of the brook trout is caught very close to the shore, especially in coves where streams enter the lake, early in the spring — sometimes before the ice is out of the main body of the lake. Success for trout is also good for anglers trolling in shallow

Table 48. — Annual Brook trout harvests from Moosehead Lake, 1967-1979.

Age	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	Means
						1,075LV		140RP						
I	0	906	62	263	120	453	262	421	36	0	382	367	478	382
							151LV		78RP					
II	1,641	3,623	626	395	546	1,187	1,705	1,035	864	444	1,352	2,252	1,496	1,338
III	3,094	2,740	961	680	1,572	754	1,176	1,027	999	889	1,254	1,408	1,643	1,400
IV	1,368	928	778	144	188	113	98	273	170	633	1,575	39	161	497
V	274	22	251	303	125	0	52	93	3	47	573	19	0	136
VI	0	906	186	140	60	18	0	7	0	0	0	0	0	101
VII	0	0	62	0	0	0	0	0	0	0	0	0	0	5
Total	6,377	9,125	2,926	1,926	2,611	3,600	3,444	2,996	2,150	2,013	5,136	4,085	3,778	3,859
Winter catch prop. [a]	.01	.01	.03	.04	.01	.01	.02	.03	.10	.15	.03	.17	.20	

[a] Winter catch shown as a proportion of annual harvest.

waters using artificial flies, lures and sewed-on bait. These methods will also catch salmon and an occasional lake trout. A large-but-unknown fraction of the trout harvest occurs from docks and other access points throughout the summer while families are living in seasonally occupied camps. These anglers normally use worms for bait, and use a plastic float on the line so that they can observe their line for hits while enjoying other activities. During the first 11 years of this study winter anglers accounted for a small (4%) proportion of the annual catch. During those years, and many years before, it was illegal to fish within 300 feet of the shoreline during the winter. This regulation was eliminated beginning with the winter of 1978, and consequently the winter catch in 1979 increased to 20% of the annual trout harvest.

Estimated harvest of brook trout for all years are presented in Table 48 and details are in Appendix X. Total harvest estimates should be within 20% at the 95% level of confidence, but estimated harvests at each age are tenuous because numbers are low for young fish and for old fish.

The means for all years should have a high reliability. Estimated trout harvests by ages for 7 year classes completely through the fishery (1967-1973) with means for each age group are presented in Table 49. The total numbers harvested from successive year classes indicate a gradual increase since year class 1970. Increases in trout catches correspond with a gradual increase in utilization (angler-days) beginning in 1972, while the catch per angler-day shows little change over the same period.

Table 49. — Harvest estimates for complete year classes of wild brook trout in Moosehead Lake, 1967-1973.

	Year class							
Age	1967	1968	1969	1970	1971	1972	1973	Mean
I	906	62	263	120	453	262	421	355
II	626	395	546	1,187	1,705	1,035	864	908
III	680	1,572	754	1,176	1,027	999	889	1,014
IV	188	113	98	273	170	633	1,575	436
V	0	52	93	3	47	573	19	112
VI	0	7	0	0	0	0	0	1
Total	2,400	2,201	1,754	2,759	3,402	3,502	3,768	2,826

Table 50. — Brook trout harvest[a] distribution by season at Moosehead Lake.

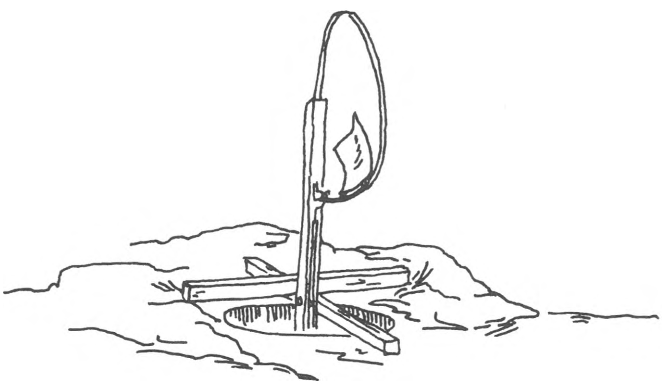
	Winter				Summer				Combined			
Age	No.	Mean Lgt (in)	Mean Wgt (oz)	Total Wgt (lb)	No.	Mean Lgt (in)	Mean Wgt (oz)	Total Wgt (lb)	No.	Mean Lgt (in)	Mean Wgt (oz)	Total Wgt (lb)
I	0	—	—	—	355	8.5	4.6	102.1	355	8.5	4.6	102.1
II	13	10.3	7.1	5.8	895	10.5	7.1	397.2	908	10.5	7.1	403.0
III	66	12.7	11.2	46.2	948	13.2	13.5	799.9	1,014	13.2	13.4	846.1
IV	28	14.9	19.7	34.5	408	16.7	24.9	635.0	436	16.6	24.6	669.5
V	4	18.9	38.6	9.7	108	19.4	40.9	276.0	112	19.4	40.8	285.8
VI	1	21.1	49.3	3.1	0	—	—		1	21.1	49.3	3.1
Total	112[b]	13.3	14.2	99.3	2,714	12.5	13.0	2,210.3	2,826	12.5	13.1	2,309.6

[a] Harvest is mean of completed year classes 1967 through 1973.

[b] Winter contribution only 4% of catch. These year classes were harvested during the period when it was illegal to ice-fish within 300 feet of the shoreline. In later years the winter catch has contributed up to 20% (1979) of the total annual harvest of brook trout.

Again the estimated harvests by age groups are tenuous because they are the same samples analyzed by year classes. Harvests by age groups for winter and summer seasons (Table 50) disclose the small proportions of the annual harvests that are caught by winter anglers. However, the catch per angler day for winter anglers has increased from 0.02 to 0.06 trout (Appendix VIII), and the total winter harvests have increased proportionately. The catch per angler-day for summer anglers (Appendix IX) has not increased appreciably, indicating the removal of the 300-foot winter restriction has probably resulted in the higher winter catches and the greater annual harvests not accounted for by increases in total angler days expended on the lake.

Our long-term goal for mean annual brook trout harvests from Moosehead Lake was 5,000 trout with an average weight of 16 ounces (5,000 pounds total). The goal was met in 3 individual years, based on our estimates. However, it appears that the 16 ounce average weight for trout may be too optimistic. Greater harvests are accompanied by higher proportions of small (young) fish in the catch and a proportional decrease in average length and weight. We believe Moosehead Lake with its 190 miles of predominately rocky shorelines should sustain an annual harvest of 5,000 or more brook trout annually, but it appears that the mean weight of these trout will be in the order of 10 to 12 ounces, resulting in a harvest of about 3,000 pounds.



FOOD OF SALMON, LAKE TROUT AND BROOK TROUT

The food and feeding habits of fish may vary with time of day, season, size and age of the fish and availability of food items. Some studies have disclosed varying degrees of preferences by some species or individuals for certain food items. Food studies may be conducted by several methods, the most common being the examination of the contents of the stomachs of dead fish caught by anglers or obtained by other methods such as netting. These studies are necessarily biased by the nature of the food itself (soft and digested rapidly as opposed to hard and persistent), the time and method of collection, and possibly the method of analysis. Fish caught by anglers or by gill nets often regurgitate some or all of their stomach contents. Some fish are inveterate bait robbers, and their stomachs may contain several bait fish or worms stolen from anglers' hooks.

Because rainbow smelts were introduced into Moosehead Lake during the 1880's, we can only speculate about the food habits of brook trout and lake trout before this occurrence. Stomach contents of lake trout and brook trout from lakes without smelts, however, exhibit a greater variety of food items and large quantities of the small invertebrates, especially the water fleas (cladocerans), even in lake trout weighing a few pounds. Food studies made by Cooper and Fuller (1945) during the 1944 survey of Haymock Lake, where smelts were absent, revealed that 2 to 3½-pound lake trout were feeding on small suckers, sculpins, sticklebacks, lake chubs, cusk and, as stated earlier, many of these fish 14 to 25 inches long had thousands of water fleas in their stomachs. Brook trout fed on the same items indicating that the two species were competing directly for food during part or most of the year. It is likely that, prior to the introduction of smelts, lake trout and brook trout in Moosehead Lake were consuming practically the same food items as the lake trout and brook trout of Haymock Lake, or other Maine lakes with similar species. In some Canadian lakes with few or no other fish species present, lake trout diets may be almost entirely plankton and insects. Under these conditions, lake trout grow much more slowly, and they may not exceed a weight of 10 pounds. Where lake trout diets are largely fish their weight may exceed 25 pounds. The plankton-feeding lake trout are highly prized for their flavor and because of their greater abundance in those lakes.

The food studies conducted by Cooper and Fuller (1945) on Moosehead Lake fish caught with gill nets mainly during July and August disclosed very high occurrences and volumes of smelts in the stomachs of salmon, lake trout, and brook trout (Table 51). The low volume of smelts in lake trout is misleading; because several large

Table 51. — Numbers, volumes, and volume percentages of food items found in the stomachs of Moosehead Lake salmonids sampled during the summer of 1944 (Cooper and Fuller 1945).

	Salmon			Lake trout			Brook trout		
Number examined	30			185			117		
Number with food	25			136			97		
	Number of items	Volume (cc)	Volume (%)	Number of items	Volume (cc)	Volume (%)	Number of items	Volume (cc)	Volume (%)
Smelts	279	86.71	88	353	292.77	28	415	199.41	62
Minnows	5	7.80	8	7	16.60	2	25	60.30	19
Yellow perch[b]									
Suckers	0			15	573.00	55	0		
Whitefish	0			0			0		
Cusk	0			1	40.50	4	0		
Sculpin	0			50	24.30	2	0		
Three-spine sticklebacks	3	1.90	2	39	29.70	3	44	23.85	7
Salmonids	0			5	34.20	3	0		
Unidentified fish remains	2	2.10	2	4	4.14	[a]	7	2.38	1
Crayfish	0			0			0		
Snails	0			0			0		
Leeches	0			2	.68	[a]	3	.48	[a]
Insects	—	.49	[a]	—	17.54	2	—	34.65	11
Totals		99.00			1,033.43			321.07	

[a] Volume less than 1%.

[b] Yellow perch not present.

lake trout (8-14 pounds) had large suckers in their stomachs, and the relative sizes and volume of the few large suckers, and one large cusk, comprised 55% of the volume, even though the 136 lake trout stomachs contained 353 smelts. More impressive is the number of smelts (415) found in 97 brook trout stomachs comprising 62% of the volume of all food consumed. Salmon had fed almost exclusively on smelts (88% by volume). Most smelts were less than 4 inches long and judged to be the most abundant of all the fishes. Small sculpins were found to be an important forage species for lake trout, and large numbers of 3-spine sticklebacks were present in lake trout and brook trout stomachs. Sticklebacks were abundant in very shallow water along the shore and fairly abundant in stomachs of lake trout netted from waters at least 50 feet deep.

During the first several years of the Moosehead study (1967-1971), cursory field examinations of stomach contents of salmon, lake trout and brook trout were made on convenient occasions. We listed but did not count or measure volumes of food items found in each stomach. We were interested mainly in recording the presence or absence of smelts, other fish species and insects. With the introduction of yellow perch to the lake during the late 1950's, we also wanted to determine the extent of utilization of young yellow perch for forage, especially by lake trout, because this occurrence has been reported in the literature (Martin 1954; 1970). Results of the field examinations are summarized in Table 52. Although these can not be compared with the 1944 study by Cooper and Fuller, because their report did not include the number of stomachs containing each of the food items (occurrence), and we did not determine volumes or number of each of the items, the 1967-1971 data do indicate smelts had decreased in abundance since the 1944 study, and that salmon, lake trout, and even brook trout were consuming small numbers of young yellow perch. Sticklebacks, which were decreasing in abundance and became practically absent by the early 1970's, were found in 1% of the salmon, 3% of the brook trout and in none of the lake trout stomachs. Insects, noticeably low in the 1944 study, were found in a high percentage of the 1967-1971 fish stomachs. There appears to be little noticeable difference in the utilization of minnows at the time of the two studies. Of the minnows, lake chubs and creek chubs were consumed most frequently.

During the winters and summers of 1972, 1973, and 1974, we conducted an intensive study of the food of Moosehead Lake salmon, lake trout, and brook trout. Creel census personnel were instructed to remove stomachs from salmonids checked during the census. Because many anglers eviscerate their fish prior to the end of their

Table 52. — Occurrence of food items in the stomachs of Moosehead Lake salmonids sampled during the summers of 1967 through 1971.

	Salmon		Lake Trout		Brook trout	
Number examined	93		98		85	
Number with food	67		62		62	
	Number of stomachs	Percentage	Number of stomachs	Percentage	Number of stomachs	Percentage
Smelts	17	25	27	43	8	13
Minnows	3	4	7	11	5	8
Yellow perch	2	3	2	3	1	2
Suckers	0		2	3	1	2
Whitefish	0		1	2	0	
Cusk	0		1	2	0	
Sculpin	0		0		0	
Three-spine stickleback	1	1	0		2	3
Salmonids	0		5	8	0	
Unidentified fish remains	1	1	17	27	7	11
Crayfish	0		0		0	
Snails	0		0		1	2
Leeches	0		0		0	
Insects	40	60	11	18	45	73

trip, we did not obtain food data from all fish examined. Stomachs were placed in polyethylene bags, and a scale envelope with information on species, length, weight, area caught and scale sample for age determination attached. Some stomachs were collected by the operators of 2 sporting camps. These were segregated by species only; we provided 3 large jars containing a 10% formalin solution and labeled for each of the 3 species. All stomachs were examined in the laboratory; stomach contents were separated, identified and counted as indicated in Tables 53-56. Volumes of each species or groups were determined by displacement in water. Identifiable fish species were measured, and scale samples were taken from smelts whenever possible.

I elected to combine summer season food analysis data for the 3 years, because summer diets were similar during those years. I followed the same procedure for the winter data. The summary of occurrence of food items for the open water fishing seasons of 1972-1974 (Table 53) may be compared with Table 52 compiled for the 1967-1971 open water seasons. However, greater reliance should be placed upon the 1972-1974 study. Smelts were found in fewer salmon and brook trout stomachs, but in more lake trout stomachs. The occurrence of minnows was higher in salmon, but lower in lake trout and brook trout stomachs examined. The occurrence of insects was noticeably higher in all 3 species. Yellow perch were found again in a small percentage of salmon and lake trout with none in brook trout, during the 1972-1974 study.

The volumes and volume percentages of the 1972-1974 study provide interesting comparisons with those of Cooper and Fuller (1945). Salmon in the 1944 samples had consumed an average of 11.2 smelts per fish comprising 88% of the total volume of all their food. Minnows comprised 8% and insects less than 1% of the total volume. In our 1972-1974 study (Table 54) salmon averaged only 0.27 smelts per stomach and comprised only 20% of the volume of food. Minnows comprised 16% and insects 51% of the volume. Total volumes were similar. Lake trout stomachs in the 1944 sample contained an average of 2.6 smelts each, and comprised 28% of the volume of food consumed. Suckers comprised 55% of the volume, sticklebacks 3%, and cusk 4%. In the 1972-1974 study lake trout stomachs averaged 2.1 smelts each, but these comprised 62% of the volume, with minnows comprising 4%, suckers only 5%, yellow perch 6%, and gamefish (salmon) 11%. Brook trout sampled in 1944 had unusually large numbers of smelts in their stomachs (4.3 smelts per trout), comprising 62% of the volume of food consumed. Minnows comprised 19%, sticklebacks 7%, and insects only 11% of the volume. The 1972-1974 study disclosed a vastly different diet for

Table 53. — Occurrence of food items in the stomachs of Moosehead Lake salmonids sampled during the summers of 1972, 1973 and 1974.

	Salmon		Lake trout		Brook trout	
Number examined	730		157		193	
Number with food	580		115		175	
	Number of stomachs	Percentage	Number of stomachs	Percentage	Number of stomachs	Percentage
Smelts	76	13	61	53	6	3
Minnows	59	10	5	4	3	2
Yellow perch	4	[a]	7	6	0	
Suckers	0		2	2	0	
Whitefish	0		1	1	0	
Cusk	0		2	2	0	
Sculpin	0		0		0	
Three-spine stickleback	0		0		0	
Salmonids	0		4	3	2	1
Unidentified fish remains	141	24	34	30	13	7
Crayfish	1	[a]	1	1	3	2
Snails	0		0		2	1
Leeches	0		1	1	0	
Insects	432	74	44	38	165	94

[a] Percent of occurrence less than 1%.

Table 54. — Numbers, volumes, and volume percentages of food items found in the stomachs of Moosehead Lake salmonids sampled during the summers of 1972, 1973 and 1974.

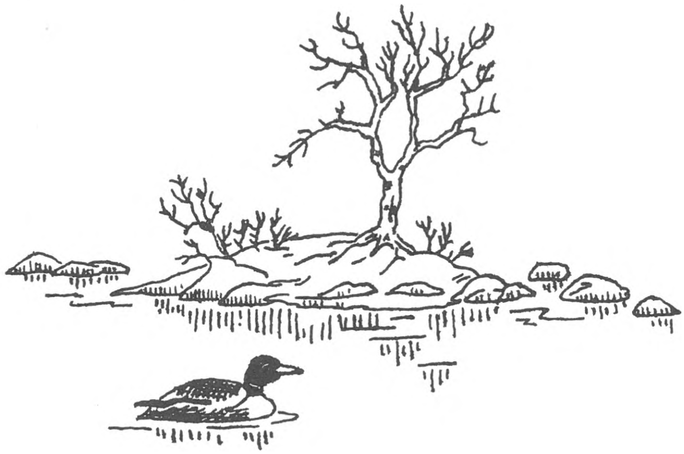
	Salmon			Lake trout			Brook trout		
Number examined	730			157			193		
Number with food	580			115			175		
	Number of items	Volume (cc)	Volume (%)	Number of items	Volume (cc)	Volume (%)	Number of items	Volume (cc)	Volume (%)
Smelts	155	411.50	20	243	719.75	62	16	43.00	9
Minnows	97	329.00	16	6	46.00	4	5	24.00	5
Yellow perch	4	18.75	1	11	73.50	6	0		
Suckers	0			2	52.50	5	0		
Whitefish	0			1	23.50	2	0		
Cusk	0			2	19.00	2	0		
Sculpin	0			0			0		
Three-spine stickleback	0			0			0		
Salmonids	0			4	131.00	11	2	34.00	7
Unidentified fish remains	—	230.25	11	—	73.50	6	—	11.25	2
Crayfish	—	trace	[a]	—	.25	[a]	3	2.75	[a]
Snails	0			0			—	7.75	2
Leeches	0			—	.25	[a]	0		
Insects	—	1,023.25	51	—	16.00	1	—	376.50	75
Totals		2,012.75			1,155.25			499.25	

[a] Volume less than 1%.

brook trout. Only 9% of the volume was comprised of smelts, 5% of minnows, 9% of other fish, no sticklebacks, and 75% of insects. Both studies included brook trout weighing from 1 to 3 pounds.

A comparison of the two studies discussed certainly indicates smelts were much more abundant in 1944 than they were during the 1972-1974 period. A mean of 11.2 smelts per salmon for 1944 compared with 0.27 for 1972-1974 prompted me to compare sizes of smelts involved in the two studies. Totaling the number of smelts (1,047) found in the salmon, lake trout, and brook trout, and the total volume (578.9 cc) we obtain a mean of 0.55 cc per smelt in 1944. In our study 414 smelts with a volume of 1,174.3 cc resulted in a mean of 2.84 cc per smelt or a mean volume per smelt 5.2 times that of the 1944 study. Some length measurements given for the 1944 smelts produce a mean total length of 2.05 inches with a range of 0.9 to 5.8 inches. A high proportion of smelts were less than 2 inches long. Smelts in our 1972-1974 studies averaged 3.79 inches in total length.

Another interesting difference (not shown in tables) was the occurrence of Cladocerans (water fleas) in the 1944 lake trout and brook trout stomachs. Lake trout stomachs contained more than 2,200 Cladocerans with a volume of 3.6 cc and a volume percentage of 0.4. Brook trout stomachs contained more than 900 Cladocerans with a volume of 4.6 cc and a volume percentage of 1.4. Evidently, Cladocerans consumed by brook trout were much larger than those consumed by lake trout. Longnose sucker stomachs examined in 1944 contained Cladocerans comprising 94% of the volume of food items consumed. We did not examine sucker stomachs during our study, and we found no noticeable quantities of Cladocerans in lake trout or brook trout stomachs.



By comparing the 1944 food study with the 1972-1974 food study, we concluded that small (likely young) smelts were much more abundant in 1944 than they were during the 1972-1974 period, and that these "young" smelts were probably widely distributed. Young smelts commonly occur in large schools at different depths including the surface and near the shoreline at certain times during the summer. We have seined young smelts off beaches in depths of 3 to 6 feet, and we have seen large schools "dimpling" the surface during the summer. Intact smelts which we could measure, and from which we could remove scales for age determination, were taken from salmon in 1973. The mean length of these smelts was 3.79 inches with a range of 2.0 to 5.9 inches. Lengths and ages are presented below:

Age	Number	(%)	Total length (inches)[a]
I	7	(13)	2.28 ± 0.12
II	13	(26)	2.84 ± 0.26
III	25	(47)	4.27 ± 0.14
IV	8	(15)	5.18 ± 0.28

[a] 95% confidence limits.

Because smelt age determinations were not made during the 1944 study, we can only speculate about the age structure of the smelt population at that time. It is likely that the 1944 smelts were not much different from the 1973 smelts. Maximum sizes in both samples differ very little, and the large numbers of smelts less than 2 inches long in the 1944 samples were probably less than one year old. The age distribution in the 1973 sample may indicate a population at a low point in its cycle of abundance, or the sample was not representative. The reclamation of three Maine lakes supporting smelt populations (Rupp 1968) disclosed more than 90% of the smelts recovered were young-of-the-year and one year olds. The small percentages of 2 and 3 year olds varied widely among the 3 lakes. We are confident the Moosehead Lake smelt population was low when the 1973 sample was taken, and that they have increased in abundance since that time. Heavy predation on the young-of-the-year smelts by large numbers of hatchery-reared salmon plus the introduction of yellow perch may have contributed to the decline in the smelt population during the 1960's.

The 1972-1974 food studies were also conducted during the winter fishing season. A summary of occurrence of food items (Table 55) and volumes (Table 56) make interesting comparisons with the summer data. Smelts were found in 85% of the salmon and 79% of the

Table 55. — Occurrence of food items in the stomachs of Moosehead Lake salmonids sampled during the winters of 1972, 1973 and 1974.

	Salmon		Lake trout		Brook trout	
Number examined	176		151		11	
Number with food	139		115		7	
	Number of stomachs	Percentage	Number of stomachs	Percentage	Number of stomachs	Percentage
Smelts	118	85	91	79	0	
Minnows	3	2	2	2	1	14
Yellow perch	0		2	2	0	
Suckers	0		4	3	1	14
Whitefish	0		0		0	
Cusk	0		0		0	
Sculpin	0		1	1	0	
Three-spine stickleback	0		0		0	
Salmonids	0		0		0	
Unidentified fish remains	23	17	24	21	3	43
Crayfish	0		0		1	14
Snails	0		0		1	14
Leeches	0		0		0	
Insects	4	3	1	1	3	43

Table 56. — Numbers, volumes, and volume percentages of food items found in the stomachs of Moosehead Lake salmonids samples during the winters of 1972, 1973 and 1974.

	Salmon			Lake trout			Brook trout		
Number examined	176			151			11		
Number with food	139			115			7		
	Number of items	Volume (cc)	Volume (%)	Number of items	Volume (cc)	Volume (%)	Number of items	Volume (cc)	Volume (%)
Smelts	313	593.25	96	305	1,001.50	82	0		
Minnows	3	2.50	[a]	3	31.00	3	1	1.50	8
Yellow perch	0			3	26.00	2	0		
Suckers	0			3	92.00	7	1	9.00	46
Whitefish	0			0			0		
Cusk	0			0			0		
Sculpin	0			1	.50	[a]	0		
Three-spine stickleback	0			0			0		
Salmonids	0			0			0		
Unidentified fish remains	—	24.50	4	—	73.50	6	—	8.50	44
Crayfish	0			0			—	trace	[a]
Snails	0			0			—	.50	2
Leeches	0			0			0		
Insects	—	trace	[a]	—	trace	[a]	—	trace	[a]
Totals		620.00			1,224.50			19.50	

[a] Volume less than 1%.

lake trout stomachs. The small number of brook trout (7 with food) contained no smelts, few minnows, yellow perch and suckers; some unidentified fish remains comprised the remainder of food consumed. Insects were practically absent. Volumetrically, smelts comprised even greater percentages of salmon and lake trout food. The total volumes of food per salmon, lake trout, and brook trout are strikingly similar for each of the above species. Differences in the amounts (approximately 4 cc per salmon, 10 cc per lake trout, 3 cc per brook trout stomach) among species may be attributed to the differences in the average size (salmon 17-19 oz., lake trout 40-41 oz., brook trout 10-12 oz.) of the fish harvested by anglers.

Evidence that Moosehead Lake smelts have increased in abundance since the 1972-1974 food study is found from results of the cursory field stomach examinations made by creel census personnel checking anglers' catches of salmonids during the summer seasons of 1975-1981. Only the occurrence of smelts and other easily identified food items were recorded during this period. These data are summarized for salmon, lake trout, and brook trout in Table 57. The 1975-1981 data on smelt occurrence are encouraging when compared with the 1972-1974 study; they indicate a two-fold increase in occurrence for salmon and lake trout. The utilization of smelts by brook trout increased from 3% in the earlier study to a mean of more than 20%, with a high of 71% for 1981.

Especially significant is the increase in young smelts. Many young-of-the-year smelts were observed in brook trout and lake trout stomachs. The increase was corroborated by data obtained from gill-net catches made in 1975, 1976, and 1978. These data demonstrated a two-fold increase in the number of smelts per lake trout stomach.

The importance of smelts as a forage species for salmon in Maine has been discussed by several investigators (Kendall 1935; Cooper and Fuller 1945; Havey and Warner 1970). The question of preference for versus availability of smelts has also been discussed. Where smelts occur in the presence of brook trout and lake trout, they appear to be a preferred forage fish above other small fish species. Moosehead Lake anglers using smelts for bait were observed to be much more successful in catching salmonids than anglers who were using various minnows or other baits. This appears to be more significant during the winter when live bait is used more extensively than it is during the early open-water fishery, when streamer flies and other artificial lures may be trolled from moving water craft. It has been repeatedly emphasized by Maine Fisheries Biologists that management for landlocked salmon is not practicable in the absence of smelts. The same biologists have reiterated that salmon depen-

Table 57. — Occurrence of smelts in the stomachs of Moosehead Lake salmonids sampled during the summers of 1975 through 1981.

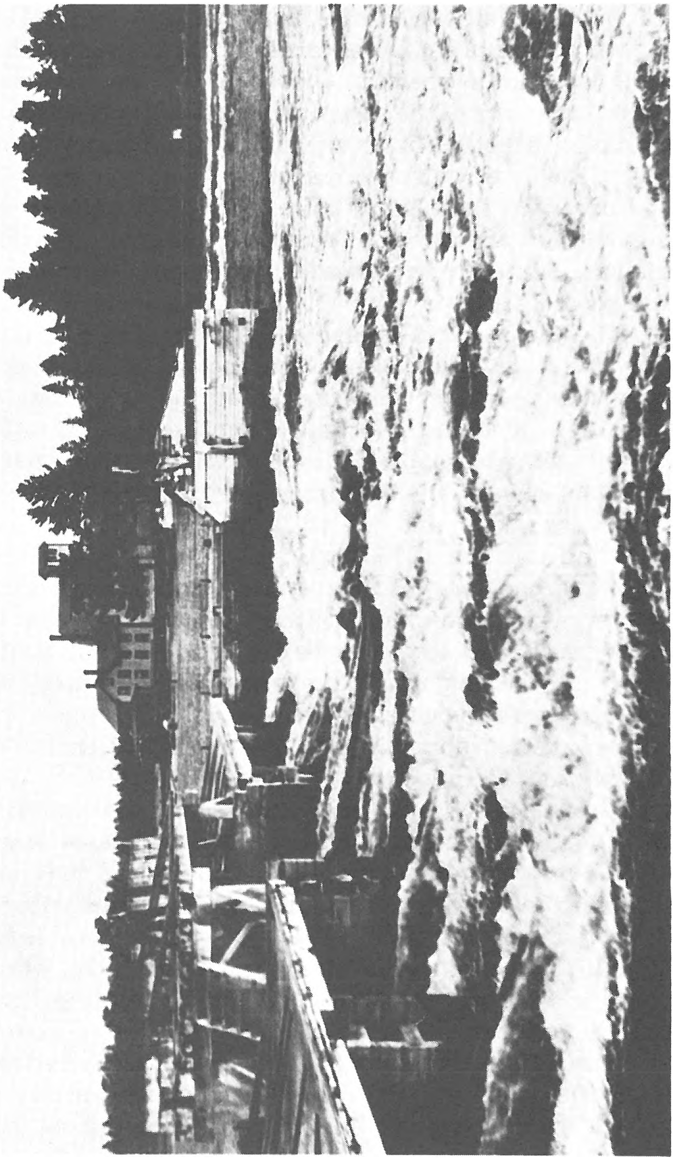
	Salmon			Lake trout			Brook trout		
	Number with food	Number with smelts	Percentage	Number with food	Number with smelts	Percentage	Number with food	Number with smelts	Percentage
1975	12	5	42	23	22	96	23	3	13
1976	13	1	8	20	14	70	16	4	25
1977	44	24	55	36	35	97	3	1	33
1978	17	8	47	25	24	96	23	2	7
1979	24	18	75	50	47	94	24	3	13
1980	16	11	69	40	38	95	7	3	43
1981	13	10	77	62	60	97	7	5	71
Totals	139	77	55	256	240	94	103	21	20

dence on smelts makes salmon management precarious because of the often-cyclic nature of smelt populations, and that there is a dire need for an alternate or buffer forage species acceptable to salmon and lake trout in our waters.

After we determined the Moosehead Lake smelt population was unusually low (during the 1960's), we made an effort to determine the extent of smelt spawning runs in the tributaries. Upon questioning wardens, guides, and older residents, we learned that there were very few known smelt runs, and no one knew or heard of smelts spawning in any of the several tributaries crossing the major access roads along the southwestern and the southeastern part of the lake. Rupp (1968) tagged spawning smelts in a tributary to Branch Lake and observed the tagged fish spawning in another tributary one mile distant, and at a shore spawning site four miles distant on subsequent nights. Rupp concluded that homing of smelts to a particular spawning site was probably not well developed. Because Rupp's studies were conducted on a relatively small lake (1,700 acres), I considered the differences in size and the several deep, almost isolated, basins present in Moosehead Lake. Perhaps the original Moosehead smelt introduction was made in only 1 or 2 streams tributary to the large, deep Moose River basin, and had not become abundant enough to establish spawning runs in the southern portion of the lake.

During the late 1960's and early 1970's, we transferred smelt eggs, and on some years live smelts, to 4 easily accessible brooks entering the southern one-third of Moosehead Lake. Beginning in 1973, smelt spawning runs began to occur in all 4 of these tributaries and, later on, in 2 additional tributaries nearby, where we had not introducted smelt eggs or live smelts. The smelt spawning runs have continued annually, and the additional smelts are certainly contributing to the recently improved growth and condition of the salmonids. These results do not necessarily invalidate the theory of non-homing in smelts, but they indicate that, in large lakes with more than one deep basin, smelt populations may be isolated or restricted to certain basins with their associated tributary streams.

Another measure we undertook to increase suitable forage, especially for the young salmonids in Moosehead Lake, was to introduce oppossum shrimp (*Mysis relicta*). In many deep Canadian lakes these invertebrates are practically the sole food source for young lake trout, and the stomachs of many adult lake trout are often filled with mysids. In 1975 we transferred an estimated 50,000 mysids from Lake Memphremagog, situated on the Vermont-Canada boundary, to Moosehead Lake. The mysids were released at the surface of a deep-water area which we determined should be ideally suited for these organisms. Since 1975 we have examined many salmonid stomachs during every fishing season and have found no indication that the introduction was successful. Some Mysis relicta introductions, however, did not show evidence of success until as many as 10 years later when they appeared in large numbers (Sparrow et al. 1964).



Old log-cribbed dam at East Outlet.

WATER USAGE

A large concrete dam on the principal outlet (East Outlet) of Moosehead Lake is operated by the Kennebec Water Power Co. to regulate the flow of water down the Kennebec River. The water is utilized for hydroelectric power generation at the 86,000 kilowatt station at Harris Dam, situated 13 miles below Moosehead Lake at the outlet of Indian Pond. The next generating facility (Wyman Dam) situated 29 miles below Harris Dam has a capacity of 80,000 kilowatts. Wyman and several other hydroelectric power facilities downstream utilize Moosehead Lake water plus water from storage impoundments on major tributary streams.

Moosehead Lake flowage rights acquired prior to 1840 primarily for log driving purposes, allowed the natural elevation of Moosehead Lake to be raised approximately 7.5 feet resulting in a usable storage capacity of 23.735 billion ft^3. With the 2 dams on tributaries to Moosehead Lake holding 9.5 billion ft^3, the total usable storage in the Moosehead Lake drainage is approximately 33.233 billion ft^3. While potential drawdown on Moosehead Lake is 7.5 ft., the lake is not drawn down to the lowest possible level in most years. Lake gage height records from annual reports of the U.S. Geological Survey for the years 1896-1971 were utilized to compare lake drawdowns during 3 time periods conforming to changes in water usage. These are summarized in the table below:

	1896-1929		1930-1953		1954-1971	
Gage (ft)[a]	Years lower	%	Years lower	%	Years lower	%
11.0	9	26	3	13	2	11
12.0	20	59	10	42	5	28
13.0	24	71	18	75	11	61
14.0	27	79	21	88	13	72
Mean low for period	11.92		11.92		12.83	

[a] Gage readings are feet above sill (10.0 ft.).

During the early period (1896-1929) there were no large hydroelectric generating plants in the upper portion of the Kennebec River drainage. Moosehead Lake water was used primarily for log driving purposes and many of the tributaries also had timber dams to drive logs to Moosehead Lake or to the river below. There were many industries with their own small generating facilities, and some public utilities beginning at a point approximately 70 miles below the Moosehead Lake dam. The gates of the old timber dam on

Moosehead Lake were probably closed to catch the spring melt water, and, except for leakage which usually provided a minimal flow down the outlet, the gates were probably not opened until the log drives began some time after ice-out (mid-May or June). The log driving operations usually continued through most of the summer, and the large volume of water required for the drives resulted in a gradual decline of the lake level. In late fall, the gates of most timber dams were usually opened, and the remaining storage was allowed to run out of the system.

In 1930 Wyman Dam, with a usuable storage reservoir of 2.6 billion ft^3, and 80,000 kilowatts generating capacity became operational. Annual log drives to supply pulpwood to paper mills more than 70 miles below Moosehead Lake continued. From water records of the period 1930-1953, it appears that Moosehead Lake water was regulated more closely, and the lake level was held high later in the fall even though the mean low for this period was identical to that of the early period. Holding water later in the fall and then releasing it some time after lake trout spawned may have resulted in egg mortalities in some years.

In 1954, Harris Dam and its 86,000 kilowatt generating plant was completed. The new dam built in a deep gorge 13 miles below Moosehead Lake flowed 2 small contiguous trout ponds to a distance of 3 miles below Moosehead Lake. Because a nearly full pond is required to operate the power plant at maximum, efficiency, the level of this impoundment, with depths greater than 100 feet, is fluctuated very little. To complement this system of generating facilities, in 1950 a dam was complete on the Dead River, a major tributary, emptying into the Kennebec River above Wyman Dam. The dam created a large flowage (Flagstaff Lake) with a storage capacity of approximately 12 billion ft^3. The additional storage capacity with the 2.6 billion ft^3 at Wyman Lake, which can be used as a buffer while generating at that station along with the small (830 million ft^3) buffer at Harris Dam, makes it possible to meter out the storage from Flagstaff Lake and Moosehead Lake in a highly efficient manner.

Beginning in 1955 both power stations (Wyman and Harris) were operational, and with the highly controlled storage available, winter drawdowns on Moosehead Lake increased greatly to the detriment of lake trout. The following table summarizes the frequency of Moosehead Lake drawdowns of 2 feet and 3 feet occurring between October 5 and April 1 for the 3 periods when water usage changed appreciably as a result of added impoundments and generating plants.

Period	Years	(%) 2 feet or more[a]	Years	(%) 3 feet or more
1896-1929 (34 years) Before Wyman & Harris dams	8	(23.5)	5	(14.7)
1930-1953 (24 years) After Wyman, before Harris	11	(45.8)	8	(33.3)
1954-1971 (17 years) Both plants operational	13	(76.5)	8	(47.1)

[a] The 2-foot drawdowns include the 3-foot drawdowns.

Because the Moosehead Lake study was undertaken primarily to determine the causes of a continuing decline in the lake trout fishery, I examined, in detail, Moosehead Lake water level records available from 1896 to the present. The study disclosed the increased frequency of winter drawdowns could have resulted in heavy mortalities of lake trout eggs, fry, or both on 40% of the years between 1954 and 1971.

In 1971 the Chief of the Fishery Division and I met with Mr. Otis Bacon, hydraulic engineer, and other representatives of the Kennebec Water Power Co. to discuss possible changes in the pattern of Moosehead Lake drawdowns. The Company officials were very cooperative, and they agreed to begin drawing the water in late summer if we agreed to handle complaints from shore property owners who like to have the lake maintained at nearly full level all summer. We agreed to do this. The agreement was as follows: Beginning in late July or August, Moosehead Lake water would be drawn gradually until October 10. After that date the water level would not be decreased below the October 10 level until April 1. If the lake level increased, as it often does following fall rains or winter thaws, however, the added water could be drawn down to the October 10 level if desired. Moosehead lake trout spawn between October 10 and October 20. In certain years, because of unusually high summer rainfall, it may not be practicable to lower the lake level appreciably by October 10. On those years some additional drawdown may be required during the winter to prepare the reservoir for the spring runoff; otherwise, flooding in the lower portion of the drainage may result. After 1971 we acquired more data on lake trout spawning and concluded that the lake level could be safely reduced approximately 2 feet between spawning time and emergence of fry from the bottom rubble. The lake level should not be decreased below a gage reading of 13.0 feet at the outlet dams, however.

Since the 1971 agreement with the Kennebec Water Power Co., the water level fluctuation downward between October 10 and April 1 has been limited to 2 feet or less, and on 5 of those 10 years the drawdown was less than 1 foot. Lake level data are presented below:

Year	October 10 level	Low to April 1	Change (ft)
1971-1972	12.5	12.1	0.4 down
1972-1973	14.2	15.3	1.1 up
1973-1974	16.9	16.1	0.8 down
1974-1975	13.5	13.8	0.3 up
1975-1976	11.9	14.7	2.8 up
1976-1977	16.5[a]	14.5[a]	2.0 down
1977-1978	16.8	14.9	1.9 down
1978-1979	14.2	12.8	1.4 down
1979-1980	14.9	13.7	1.2 down
1980-1981	16.9	15.3	1.6 down

[a] Estimated.

Brook trout and salmon spawning may also be improved by lowering the lake level as much as possible in early October. Some brook trout traditionally spawn in shallow areas of spring influence near the shore where high egg or fry mortalities may occur as a result of lowered water levels between spawning and fry emergence. At high water levels, many tributary streams are inundated for substantial distances rendering these lower sections undesirable as salmon spawning areas. In many instances these lower stream sections contain the better spawning substrates, and the increased velocity resulting from the lowered lake level is sufficient to induce salmon to spawn there. Camp owners whose docks need repairing, or whose docks could be damaged by heavy ice formed at high water levels, may incidentally benefit from early fall drawdowns.

SUMMARY AND DISCUSSION

If we could go back to the time when we were one of the first Europeans to see this area, and spend a year or more becoming familiar with the Moosehead Lake Drainage, perhaps our first impression, within our limited field of view would be one of complete awe at the sight of endless forests, mostly spruce and fir, with giant pines protruding above the forest canopy and large beech, birch, and maples on the hillsides. The surrounding mountains would be a challenge, and we would probably proceed to the top of the highest one to get a better view.

From the top of Squaw Mountain our field of view would be greatly expanded, and we would gaze in wonder at this beautiful, immense lake with its extremely irregular shoreline. Several other lakes would be visible, but the rivers and streams connecting them would remain unknown to us until, like the native American Indian, we could take a birch bark canoe with our dunnage and spend the entire summer and fall seasons paddling, poling, dragging, and portaging in an effort to determine how far this inter-connected system of lakes extends. Moose, caribou, bear, beaver, otter, mink, waterfowl, eagles, ospreys, and grouse abounded. A try with a fishing line and hook tied to a sapling for a fishing pole, and practically anything for bait would bring immediate results from unlimited numbers of brightly colored brook trout residing in every brook, stream, and river connecting the 166 square miles (106,000 acres) of water area in the 126 lakes and ponds.

The largest of these waters (Moosehead Lake) with its 75,000 acres of water and 190 miles of shoreline plus many smaller tributaries could take another summer to explore. With a few staples we could subsist on brook trout weighing up to 5 pounds, whitefish, and by fishing deeper water we would soon discover the presence of the larger lake trout weighing over 20 pounds. The native Americans (Indians) knew all these things and much more. They were a part of this vast wilderness, and obtained everything they needed from it without changing it appreciably. The new arrivals were not satisfied with living like the natives and soon initiated a series of changes, some of them having unquestionably adverse effects upon the entire Moosehead Lake Drainage and its inhabitants (fish and wildlife). Some of the changes can be reversed and some are likely permanent.

Perhaps the first detrimental change, called improvement then, was the construction of dams on practically every lake, pond and flowing stream, for water storage in order to float the large pine and spruce logs down the Kennebec River to sawmills and later to paper mills. The dams prevented trout and other fish from returning to their ancestral spawning areas in many instances, and the dams became convenient places to trap and kill excessive quantities of trout before they were allowed to reproduce. Most of the old timber dams are gone but a few were replaced by concrete structures for water storage associated with hydro-electric power generation. Fishways were almost unheard of, and when the first ones were finally built they were in their infancy, and either were not located properly or were soon abandoned. The result of these temporary and permanent barriers was the probable loss of important variability in trout stocks evolved over a period of several thousands of years. When I came to this area 25 years ago, local residents remembered when there was no dam on Moose River at the outlet of Brassua Lake, the next largest lake upstream on Moosehead Lake's largest tributary. These old residents spoke of annual runs of large lake trout up this river and of the excellent fishery for large brook trout. The concrete structure on the outlet of Moosehead Lake had no fishway until 1957. Some old guides remembered poling their canoes down the East Outlet River with their "sports" to Indian Pond for the excellent trout fishing enjoyed there. They did this daily, at times, returning by poling their canoes up the West Outlet, a smaller stream, to Moosehead Lake.

The introduction of landlocked salmon and smelts to Moosehead and other waters in the drainage, and stocking millions of salmon, lake trout, and brook trout, beginning in the late 1800's, were certainly important changes, though less visible, in the biology of the entire drainage. Increased water use resulting in lake drawdowns of several feet during the winter coupled with changes in and siltation of ancestral lake trout spawning areas probably resulted in a decline in lake trout numbers.

Some changes (concrete dams, introductions) are for practical purposes, permanent, but historical research made during this study has shed some light on these events and has shown us how some of the harm do to indigenous populations of lake trout and brook trout may be reversed. Landlocked salmon, an excellent sport and food species, added variety to the sport fisheries of the drainage during the early 1900's. Because of high mortality among hatchery reared salmon stocked as fry and fall fingerlings, these early stockings were highly self-limiting. The first stockings probably gradually established wild or self-sustaining populations throughout the drainage, and the continual stocking of small fish during the early years probably served more as a food source than additions to the fishery. However, as fish cultural techniques improved, greater numbers of stocked salmon survived until, early in this study, the annual harvest of salmon (numbers and weight) exceeded the combined harvests of native lake trout and brook trout. The salmon decreased in average size, and complaints of catching 25-50 short salmon to every legal sized one began to be heard. By this time the psychological effect of stocking hatchery fish was well established among sporting camp owners and other local business interests, who applied pressure to stock more lake trout and brook trout thereby aggravating an already serious shortage of forage fish. The Cooper and Fuller (1945) survey, an excellent contribution, and much employed reference for this study, caused some problems as a result of their unqualified stocking recommendation for 500,000 salmonids of larger sizes annually. Most sporting camps and other local persons have copies of the survey report and have used these recommendations to ask for more salmon, lake trout, and brook trout for Moosehead Lake. Cooper and Fuller did not know how many wild salmonids the lake could and did produce, nor did biologists know how sterile these deep cold-water lakes can be, nor how few large lake trout per acre may be harvested without endangering the spawning populations. Furthermore, Cooper and Fuller did not foresee the increase in size and survival of hatchery-reared salmon that would be produced in subsequent years.

Our study came at an opportune time when results of recent studies of lake trout and other populations inhabiting cold-water lakes in Canada became available to us from the literature, and from personal contacts with some of the biologists doing the research. With these results and results of some ongoing Maine studies in mind, the first step we took was to eliminate brook trout stocking, except for 2 marked lots, the result of which would help to convince local people that stocking brook trout in most large lakes is not practical. We set salmon rates at 50,000 marked yearlings and soon learned how important the wild salmon contribution was and reduced the salmon stocking rate to 25,000 marked spring yearlings annually (⅓ yearling per acre). We know now that natural reproduction will continue to provide equal numbers of wild salmon to the fishery. Salmon growth has, in 3 or 4 years, improved dramatically. We learned that winter lake level drawdowns probably resulted in increased mortality of lake trout eggs and promptly reached an agreement with the power interests to draw as much water as feasible prior to October 15 (lake trout spawning time) and limit subsequent drawdowns. We stocked marked yearling hatchery-reared lake trout for several years of the study to determine their contribution to the fishery. While their contribution was substantial, in some years only 5% of the numbers stocked were found in the angler harvest, so we eliminated the stockings completely to allow natural reproduction to restock the lake. This is a long process because we learned that lake trout females are 21 inches long and 7 or 8 years old before they were actually on the spawning areas. We increased the legal length limit for lake trout to 18 inches from the previous 14 inches. Much to our surprise this measure was very well accepted by anglers who proceeded to harvest more lake trout than we estimated the population could safely tolerate and recover from the previous lows. We asked for a reduction in bag limits to 2 salmon, 2 lake trout and 2 brook trout (aggregate of 5 salmonids), and this was accepted and took effect in 1977. This regulation was also accepted by my associates for a statewide regulation except for higher limits for brook trout on most waters.

The number of salmon harvested has decreased as we planned, but their average length and weight has increased to 17.7 inches and 30.4 ounces, with some 4 and 5 pound fish in the catch. The lake trout harvests have also improved. Since the 18-inch limit was imposed in 1972, winter lake trout harvests have increased from less than 1,000 to over 2,000 fish with an average weight of 39 ounces and a winter total weight harvest of more than 5,000 pounds. Total annual harvest of approximately 5,000 fish weighing more than 10,000 pounds through 1979. We have no annual harvest data beyond 1979, but we are continuing the winter census of anglers which gave us the above tentative winter estimates for 1980 and 1981. This is still below our goal of 8,000 lake trout weighing 20,000 pounds. The average harvest of brook trout has increased but it is erratic. The removal of the 300-foot winter shoreline restriction on Moosehead Lake has resulted in much higher winter brook trout harvests, but the 2-trout limit should offer adequate protection. The greater harvest of small trout in shallow water has also decreased the average size of trout harvested, but they are much more abundant than the larger fish and may tolerate the greater harvest.

A recent illegal introduction of smallmouth bass to Moosehead Lake may, several years hence, decrease the brook trout production if the bass become abundant enough to dominate the rocky shoal areas now occupied by brook trout.

As mentioned previously the reduction in salmon stocking to 25,000 has resulted in the desired reduction in harvest to approximately 12,000, but the average weight has increased dramatically. Further progress toward the lake trout goal occurred during 1980. The average lake trout weight for the winter of 1981 was 44 ounces and the number of lake trout per angler-day increased from 0.1 to 0.2 for winters 1980 and 1981. Winter catches of brook trout have gone from less than .01 to .14 and then back to 0.06 for the winter of 1981. It appears the winter brook trout catch may be influenced by the quality of lake trout and salmon fishing. If lake trout are active, anglers may not fish in very shallow water for brook trout. This recently acquired information may account for part of the erratic nature of the recent winter brook trout harvests. With present low bag limits it is possible anglers prefer to try to catch a large lake trout than 2 smaller brook trout, but some anglers try for both by stringing a line of tip-ups from inshore out to 30 or 40 foot water where chances for lake trout or salmon are better.

We have established the following goals for harvests of salmonids. The 1978 and 1979 harvests are included to indicate our progress toward these goals.

Estimated potential harvests[a] for Moosehead Lake.

Species	Number	Average weight (oz.)	Pounds
Salmon	12,000[a]	20	15,000[a]
1978	10,859	24.6	16,682
1979	12,447	26.8	20,818
Lake trout	8,000[a]	40	20,000[a]
1978	6,454	34.9	14,082
1979	4,540	39.3	11,154
Brook trout	5,000[a]	16	5,000[a]
1978	4,085	8.6	2,183
1979	3,778	11.4	2,690
Totals	25,000[a]		40,000[a]
			(1978 - 32,950)
			(1979 - 34,664)

RECOMMENDATIONS

1. Conduct annual winter surveys of anglers to determine catch composition, catch per unit of effort, and age and growth data. A mean value of 10,000 winter anglers may be employed for a tentative estimate of total winter harvest.
2. Approximately every 5 years, conduct a detailed survey of the fishery including counts by aircraft summer and winter to estimate total angler use and total harvests as was done during the project years.
3. Manage the wild salmon for maximum production, and adjust salmon stocking rates up to an 0.5 yearling per surface acre per year to maintain an annual yield of approximately 15,000 pounds.
4. Manage lake trout populations and harvest to attain annual yields of approximately 20,000 pounds. Hatchery-reared lake trout may be stocked, if necessary, at a rate not to exceed one yearling per surface acre per year.
5. Manage wild brook trout populations to attain an annual yield of approximately 5,000 pounds. The minimum legal length limit may have to be increased to 10 or 12 inches in the near future to attain this goal.
6. Attempt to increase the production of wild salmon in the East Outlet by stocking marked hatchery-reared yearlings, and trap the fishway to assess results.
7. Maintain lake level agreements to favor natural reproduction of lake trout.
8. Opening the Brassua Lake fishway should be accompanied by trapping all migrants to remove smallmouth bass.
9. Determine the effects of the extended September fishing season for salmon in the Roach River, Moose River and the East Outlet.

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Appendices I - XVI

Appendix I. Moosehead Lake physical chemical data.

Location - Piscataquis and Somerset Counties, Maine	
Latitude	45°40'
Longitude	69°42'
Precipitation (mean annual)	43.3 inches
Elevation (above m.s.l.)	1028.98
Drainage area	1,266 sq. mi.
Lake area	117.02 sq. mi.
Maximum depth	246 ft.
Mean depth	54.5 ft.
Volume	4,081,505 acre ft.
Perimeter	170 miles
Inflow (mean)	1,868.4 c.f.s.
Outflow (mean)	1,868.3 c.f.s.
Drainage area/lake area	10.8
Drainage area/lake volume	0.65
Hydraulic retention time (mean)	3 years
Transparency (secchi, summer)	15-32 ft.
Conductivity (50°F)	25 mho's
Ice cover (mean)	150 days
Stratification	July, Aug. part Sept.
Fall turnover	Late Sept.
Shoreline development	4.96
Trophic State	Oligotrophic
Storage (10.0-17.5 ft. gage ht.)	$23{,}735 \times 10^6$ ft^3
Outflow	2.48 × storage

Dam on outlets since 1834, concrete dam completed 1956 with Fishway. 7.5 ft. head.

Appendix II. Moosehead Lake water chemistry and nutrients.

Phenolphthalein alkalinity	0.0 ppm
Total	6.0 ppm
Total hardness (as $CaCo_3$)	13.0 ppm
Calcium	3.6 ppm
Magnesium	0.97 ppm
Total iron	0.085 ppm
Copper	0.08 ppm
Orthophosphate	<0.01 ppm
Sulphate	3.8 ppm
Ammonia nitrogen	0.175 ppm
Nitrate nitrogen	0.40 ppm
Nitrite nitrogen	0.0 ppm
Clorides	1.0 ppm
pH (surface)	6.6-7.0
Nutrient loading P/annum (Input)	54,270 lbs.
Nutrient loading N/annum (Input)	2,694,870 lbs.
Nutrient loading P/annum (Output)	29,420 lbs.
Nutrient loading N/annum (Output)	2,021,020 lbs.
Total P	0.7 lbs/acre/year
Accumulated P	0.3 lbs/acre/year
Total N	36 lbs/acre/year
Accumulated N	9 lbs/acre/year

Vollenweider rates gm/m^2/yr	Phosphorus
Permissible 0.23	Oligotrophic
Dangerous 0.46	Eutrophic rate

Phosphorus limited to .016 mg/1 then nitrogen limited.

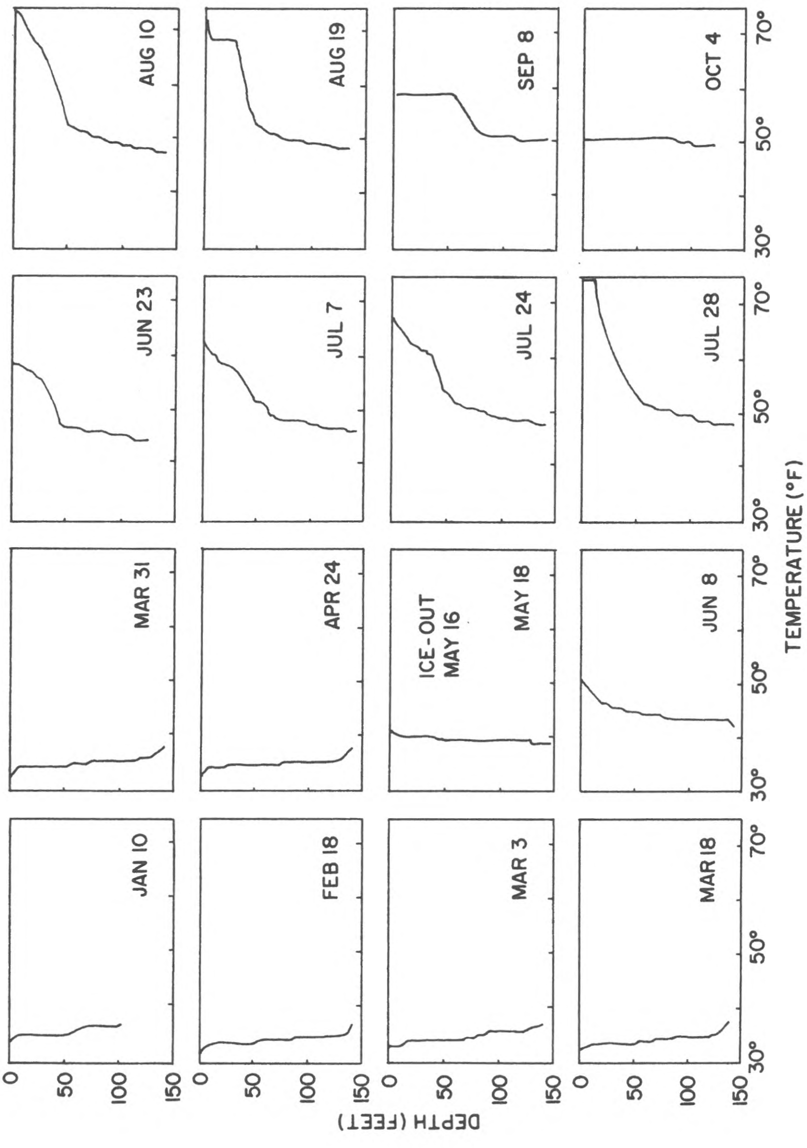
Appendix III. Temperature profiles of Moosehead Lake.

Depth (feet)	Temperature °F	Oxygen p.p.m.	pH	Total Alkalinity
0	69.5	9.0	6.9	8.0
5	69.5			
10	69.0			
15	68.0			
20	67.5			
25	67.5			
30	62.5			
35	56.0	9.0	6.5	7.0
40	51.0			
45	49.0			
50	48.0			
55	48.0			
60	47.5			
65	47.0			
70	47.0			
75	47.0			
80	47.0			
85	47.0			
90	47.0			
95	47.0			
100	46.5			
105	46.5			
110	46.5			
115	46.5			
120	46.0			
125	46.0	11.0	6.4	8.0

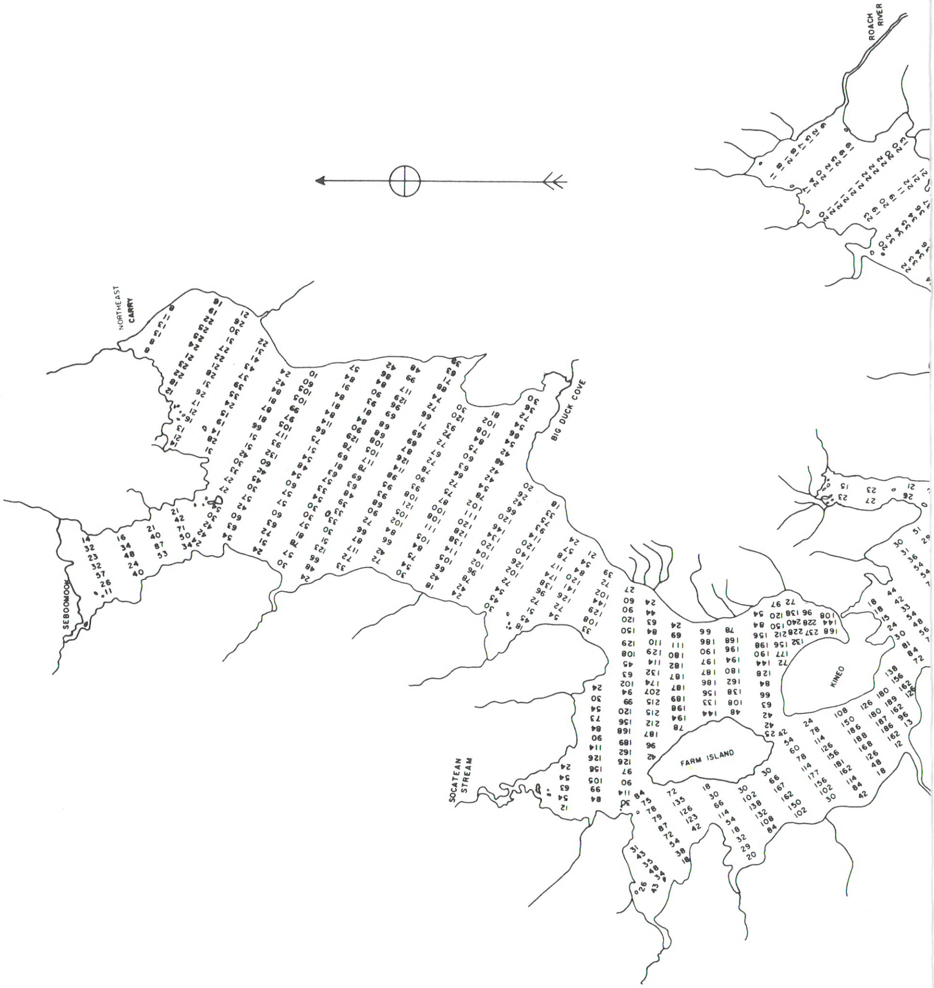
The complete series were made at the end of August following several temperature series made earlier.

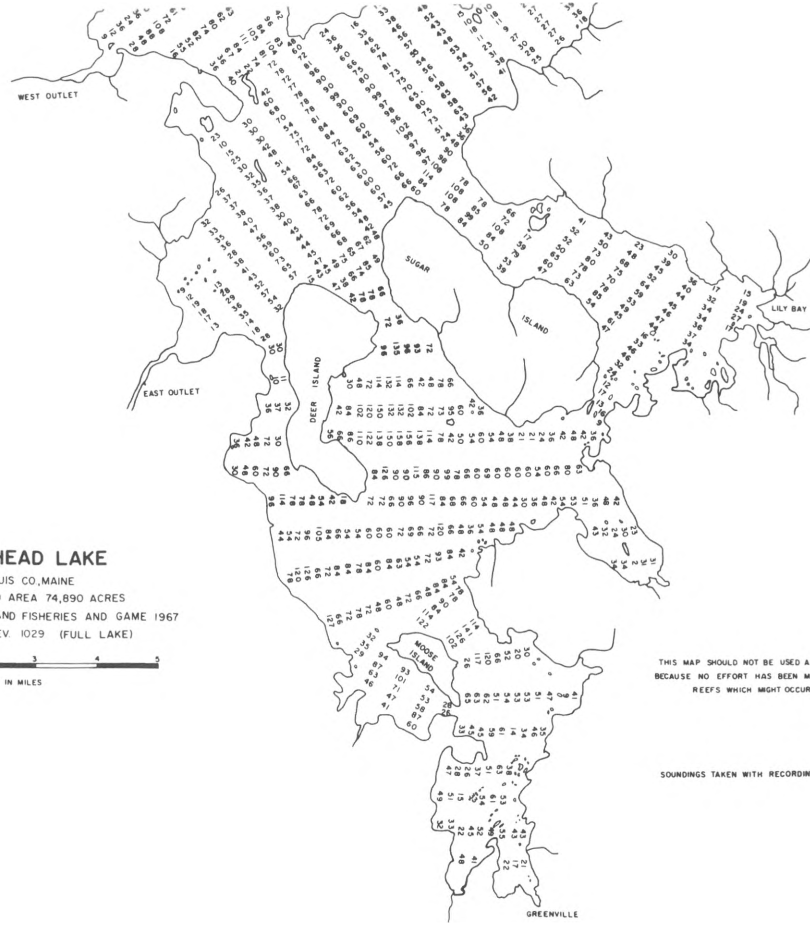
Sixteen temperature series are presented graphically to describe the effect of temperature changes on Moosehead Lake through the year. During the past ten years winter ice cover was complete between December 13 and December 29. The earliest freezeup on record occurred on November 23 in 1933, and 14 November freezeups are recorded since 1848. Ice-out usually occurs between April 25 and May 17. However, April ice-out dates are rare, having occurred only 18 times since 1848. An unusually high surface temperature of 76°F was recorded in July, 1970, but probably lasted only a few days before wind action mixed the upper layer and reduced the surface temperature to the 60's. Temperatures under the ice cover range from 32°F to 38°F from surface to a depth of 140 feet. Stratification was not pronounced in any of the several years of summer temperature series taken. In the accompanying figures for the 1970 series, stratification began in late June, but it was upset by wind action several times. Stratification was most pronounced in mid-August. In early September surface temperatures dropped several degrees, and stratification disappeared entirely by early October.

Appendix IV. Temperature profiles (1970).



Appendix V


ROACH RIVER
NORTHEAST CARRY
BIG DUCK COVE
SEBOOMOOK
SOCATEAN STREAM
FARM ISLAND
KINEO



MOOSEHEAD LAKE

PISCATAQUIS CO., MAINE

ELEVATION 1029 AREA 74,890 ACRES

MAINE DEPARTMENT OF INLAND FISHERIES AND GAME 1967

SOUNDED AT ELEV. 1029 (FULL LAKE)

0 1 2 3 4 5

SCALE IN MILES

THIS MAP SHOULD NOT BE USED AS A GUIDE IN NAVIGATION, BECAUSE NO EFFORT HAS BEEN MADE TO SHOW VARIOUS REEFS WHICH MIGHT OCCUR BETWEEN SOUNDINGS.

SOUNDINGS TAKEN WITH RECORDING FATHOMETER.

Appendix VI. Total potential yield (Moosehead Lake).

$Y = 2\sqrt{X}$

where X (morphoedapic index)

$$X = \frac{\text{Total Dissolved solids}}{\text{mean depth (ft)}}$$

For Moosehead TDS approx. 16-20 mg. 1.

mean depth 55 ft.

TDS = 20 mg. 1. $Y = 2\sqrt{.3636}$

$= 2 \text{ X } .603$

$= 1.2$ lbs/acre/yr

TDS = 16 mg. 1 $Y = 2\sqrt{.2909}$

$= 2 \text{ X } .5394$

$= 1.079$ lbs/acre/yr

(metric)

$$\text{MEI} = \frac{20 \text{ mg. 1.}}{16.76 \text{ m.}} = 1.193$$

$Y = 0.966\sqrt{X}$

$= 1.055$ K/ha.

Appendix VII. Angler counts and estimated harvest (Winter, 1975).

MOOSEHEAD LAKE AIRCRAFT COUNT OF FISH HOUSES AND ANGLERS

Day Saturday

Date February 15, 1975

Time 11:00

Weather Clear-moderate N.W. wind

Temperature 25°

Area	Houses[a]	Occupied houses	Anglers with no houses	Total anglers	Estimate
1		1	7		11.04
2		0	1		1.10
3		1	12		16.54
4		2	9		16.59
5		closed	closed		closed
6		22	7		81.29
7		1	5		8.84
8		0	16		17.60
Totals		27	57		152.96

Mean Party size — weekend days 3.04[b]

Correction for hour of day .90925[b]

[a] Total number of houses was also counted but was not used in determination of angler estimate.

[b] Determined from ground census.

Appendix VII (cont'd) Expanded angler counts — Winter, 1975.

Date	Estimated anglers	Estimated Anglers by area[a] 1	2	3	4	5	6	7	8	9
Sat. 2/1	223.84	11.64	16.27	39.55	27.91	Closed	95.93	14.00	18.54	Closed
Mon. 2/3	24.44	5.15	0	2.83	0	"	11.31	0	5.15	"
Wed. 2/5	39.88	1.27	0	2.54	5.08	"	27.89	3.10	0	"
Fri. 2/7	55.92	1.10	2.20	2.20	5.37	"	37.97	2.68	4.40	"
Sun. 2/9	113.40	6.95	7.00	15.16	12.84	"	63.29	3.52	4.64	"
Thurs. 2/13	23.52	1.16	0	5.80	2.32	"	11.31	2.83	0	"
Sat. 2/15	152.96	11.04	1.10	16.54	16.59	"	81.25	8.84	17.60	"
Mon. 2/17	87.75	4.37	3.81	14.38	6.35	"	46.24	0	12.70	"
Wed. 2/19	61.40	3.42	1.14	7.34	0	"	31.39	2.78	15.33	"
Sun. 2/23	136.13	11.62	16.82	11.62	9.52	"	52.90	9.44	24.21	"
Wed. 2/26	23.18	2.68	0	0	1.10	"	16.10	0	3.30	"
Thurs. 2/27	23.80	2.68	0	0	5.37	"	15.75	0	0	"
Fri. 2/28	41.15	10.13	0	5.70	2.28	"	17.47	5.57	0	"
Sun. 3/2	74.27	3.34	14.30	9.99	2.20	"	37.75	6.69	0	"
Mon. 3/3	10.36	0	0	5.70	0	"	2.10	0	2.56	"
Wed. 3/5	21.85	0	0	5.64	2.54	"	10.57	3.10	0	"
Fri. 3/7	27.34	0	0	8.74	0	"	12.40	6.20	0	"
Sun. 3/9	33.93	2.32	3.52	3.52	4.68	"	19.89	0	0	"
Tues. 3/11	19.61	3.92	0	5.06	0	"	10.63	0	0	"
Thurs. 3/13	34.07	2.56	0	2.56	0	"	24.76	0	4.19	"
Sun. 3/16	137.24	5.54	8.84	13.24	9.94	"	64.40	17.68	17.60	"
Mon. 3/17	23.93	0	0	7.08	1.10	"	12.45	0	3.30	"
Wed. 3/19	48.07	3.10	1.27	4.37	0	"	19.31	20.02	0	"
Sun. 3/23	109.66	7.00	11.64	5.80	11.64	"	51.51	5.84	16.23	"
Sat. 3/29	114.95	6.60	6.64	14.34	20.94	"	52.00	14.43	0	"
% by Area		6.47%	5.69%	12.61%	8.89%	—	49.7%	7.62%	9.01%	—

[a] Areas 5 and 9 closed to winter fishing.

Appendix VII (cont'd) Estimate of Anglers, Winter, 1975.

Mean weekday count	35.39
Mean weekend day and holiday count	121.82
Number of week days in season	41
Number of weekend days and holidays in season	18

Week days	41 × 35.39 =	1,450.99
Weekend days and holidays	18 × 121.82 =	2,192.76
		3,643.75

Weighted mean anglers per day 61.76±6.63 (10.74%)

Estimate of total anglers 3,644 (±10.74%)

Appendix VII (cont'd) Estimate of harvest, Winter, 1975.

Area	Percent of anglers	Number anglers	Hours per angler	Total hours	Salmon[a]	Lake trout	Brook trout
1	6.47	236	6.588	1,555	0	118	6
2	5.69	207	5.000	1,035	0	0	0
3	12.61	460	6.163	2,835	11	159	20
4	8.89	324	6.747	2,186	44	133	9
5	closed	closed	closed	closed	closed	closed	closed
6	49.71	1,811	7.209	13,055	313	261	170
7	7.62	278	7.606	2,114	34	42	8
8	9.01	328	5.929	1,945	70	140	0
9	closed	closed	closed	closed	closed	closed	closed
Totals		3,644		24,725	472[b]	853	213

[a] Catch computed using species per angler hour by area.

[b] Total catch is broken down into age structure based on fish samples collected during creel census.

Appendix VII (cont'd) Sample data from creel census[a], Winter, 1975.

All anglers	1,697		
Successful anglers	537		
Salmon	257		
Lake trout	307		
Brook trout	138		
Total salmonids	702		
All angler hours	12,073		
Ave. length salmon	15.79 in.	S.E.	.10
Ave. weight salmon	19.04 oz.	S.E.	.41
Ave. length lake trout	19.43 in.	S.E.	.11
Ave. weight lake trout	35.36 oz.	S.E.	.79
Ave. length brook trout	12.21 in.	S.E.	.21
Ave. weight brook trout	11.54 oz.	S.E.	.50
Estimate of total anglers	3,644		
Percent sample	46.57%		
Percent successful	31.64%		

[a] Complete sample totals are shown. For computation of estimate of anglers sample is broken down by areas of the lake.

Appendix VIII. Moosehead Lake harvest data, Winter 1967-1979.

	Year												
	1967	1968	1969	1970	1971	1972[a]	1973	1974	1975	1976	1977[b]	1978	1979
Anglers (no.)	4,623	4,274	3,542	3,560	2,561	2,071	2,674	3,072	3,644	5,092	5,948	10,228	7,914
Hours	30,220	30,514	25,149	25,247	19,181	13,308	18,042	20,723	24,725	32,937	38,991	71,827	52,423
Hours/acre	.4029	.4069	.3353	.3366	.2557	.1774	.2406	.2763	.3297	.4392	.5199	.9577	.6990
Hours/angl.	6.5369	7.1394	7.1002	7.0919	7.4897	6.4259	6.7472	6.7458	6.7851	6.4684	6.5553	7.0226	6.6241
% success	47.25	48.55	38.73	32.07	42.66	32.75	44.32	31.24	31.64	43.27	53.66	43.19	39.96
Prop. salmon	.0363	.1132	.0951	.0961	.1255	.6123	.5517	.3352	.3069	.4816	.5823	.4256	.4617
Salmon (no.)	113	337	158	151	212	496	971	351	472	1,612	2,593	2,421	1,836
Pounds	154	437	180	164	203	640	984	445	562	1,629	3,013	3,358	2,821
Ave. wt. (oz.)	21.78	20.73	18.19	17.42	15.34	20.64	16.21	20.30	19.04	16.17	18.59	22.19	24.58
Lbs/acre	.0021	.0058	.0024	.0022	.0027	.0085	.0131	.0059	.0075	.0217	.0402	.0448	.0376
Sal/ang.	.0244	.0788	.0446	.0424	.0828	.2395	.3631	.1143	.1295	.3166	.4359	.2367	.2320
Lbs/ang.	.0333	.1022	.0508	.0461	.0793	.3090	.3680	.1449	.1542	.3199	.5066	.3283	.3565
Prop. togue	.9364	.8647	.8592	.8505	.8626	.3420	.4034	.5702	.5546	.4252	.3802	.4525	.3488
Togue (no.)	2,914	2,575	1,428	1,337	1,457	277	710	597	853	1,423	1,693	2,574	1,387
Pounds	4,832	4,225	2,182	1,981	2,043	757	1,554	1,322	1,885	3,271	3,999	5,417	3,197
Ave. wt. (oz.)	26.53	26.25	24.45	23.71	22.43	43.74	35.03	35.43	35.36	36.78	37.79	33.67	36.88
Lbs/acre	.0644	.0563	.0291	.0264	.0272	.0101	.0207	.0176	.0251	.0436	.0533	.0722	.0426
Togue/angl.	.6303	.6025	.4032	.3756	.5689	.1338	.2655	.1943	.2341	.2795	.2846	.2517	.1753
Lbs/ang.	1.0452	.9885	.6160	.5565	.7977	.3655	.5812	.4303	.5173	.6424	.6723	.5296	.4040
Prop. trout	.0273	.0221	.0457	.0534	.0119	.0457	.0449	.0946	.1385	.0932	.0375	.1218	.1894
Trout (no.)	85	66	76	84	20	37	79	99	213	312	167	693	753
Pounds	64	50	67	83	20	60	72	90	154	233	173	415	518
Ave. wt. (oz.)	12.00	12.00	14.14	15.91	16.18	25.99	14.59	14.57	11.54	11.96	16.54	9.58	12.51
Lbs/acre	.0009	.0007	.0009	.0011	.0003	.0008	.0010	.0012	.0021	.0031	.0023	.0055	.0069
Trout/ang.	.0184	.0154	.0215	.0236	.0078	.0179	.0295	.0322	.0585	.0613	.0281	.0678	.0951
Lbs/ang.	.0138	.0117	.0189	.0233	.0078	.0290	.0269	.0293	.0423	.0456	.0291	.0406	.0655
All species	3,112	2,978	1,662	1,572	1,689	810	1,760	1,047	1,538	3,347	4,453	5,688	3,976
Pounds	5,050	4,712	2,429	2,228	2,266	1,457	2,610	1,857	2,601	5,133	7,185	9,190	6,536
Lbs/acre	.0673	.0628	.0324	.0297	.0302	.0194	.0348	.0248	.0347	.0684	.0958	.1225	.0871
Fish/ang.	.6132	.6968	.4692	.4416	.6595	.3911	.6582	.3408	.4221	.6573	.7487	.5561	.5024
Lbs/ang.	1.0924	1.1025	.6858	.6258	.8848	.7035	.9761	.6045	.7138	1.0081	1.2080	.8985	.8259

[a] 18" length limit on lake trout   [b] reduction in bag limit

Appendix IX. Moosehead Lake harvest data, Summer, 1967-1979.

	Year												
	1967	1968	1969	1970	1971	1972[a]	1973	1974	1975	1976	1977[b]	1978	1979
Anglers (no.)	31,023	29,766	27,320	25,647	27,838	35,244	33,881	32,717	33,478	34,782	45,739	51,436	35,148
Hours	193,397	204,429	120,558	121,976	185,515	148,108	155,022	147,465	137,374	133,975	204,976	235,536	168,604
Hours/acre	2.5786	2.7257	1.6074	1.6263	2.4735	1.9748	2.0670	1.9662	1.8317	1.7863	2.7330	3.1405	2.2481
Hours/angl.	6.2340	6.8679	4.4128	4.7560	6.6641	4.2024	4.5755	4.5073	4.1034	3.8518	4.4814	4.5792	4.7970
% success	52.14	70.13	29.32	33.40	49.89	31.18	43.44	28.87	23.75	34.29	42.03	26.09	35.39
Prop. salmon	.4547	.4940	.5508	.5403	.5946	.7297	.7157	.6253	.6296	.7086	.6679	.5371	.6320
Salmon (no.)	12,142	21,123	8,340	7,262	13,750	15,521	15,400	9,095	6,184	11,257	17,357	8,438	10,611
Pounds	20,679	26,404	9,899	9,486	17,136	19,062	16,363	10,306	7,243	12,671	19,776	13,327	17,999
Ave. wt. (oz.)	27.25	20.00	18.99	20.90	19.94	19.65	17.00	18.13	18.74	18.01	18.23	25.27	27.14
Lbs/acre	.2757	.3521	.1320	.1265	.2285	.2542	.2182	.1374	.0966	.1689	.2637	.1777	.2400
Sal/ang.	.3914	.7096	.3058	.2832	.4939	.4404	.4545	.2780	.1847	.3236	.3795	.1640	.3019
Lbs/ang.	.6666	.8871	.3623	.3699	.6156	.5409	.4830	.3150	.2164	.3643	.4324	.2591	.5121
Prop. togue	.3097	.2942	.2610	.3277	.2934	.1028	.1279	.1755	.1732	.1844	.1409	.2470	.1878
Togue (no.)	8,272	12,580	3,953	4,337	6,786	2,186	2,752	2,553	1,701	2,929	3,661	3,380	3,153
Pounds	26,884	21,645	8,340	7,294	13,937	5,596	7,172	6,555	3,677	7,824	8,905	8,665	7,957
Ave. wt. (oz.)	52.00	27.53	33.76	26.91	32.86	40.96	41.70	41.08	34.59	42.74	38.92	35.73	40.38
Lbs/acre	.3585	.2886	.1112	.0973	.1858	.0746	.0956	.0874	.0490	.1043	.1187	.1155	.1061
Togue/angl.	.2666	.4226	.1447	.1691	.2438	.0620	.0812	.0780	.0508	.0842	.0800	.0754	.0897
Lbs/ang.	.8666	.7272	.3053	.2844	.5006	.1588	.2117	.2004	.1098	.2249	.1947	.1685	.2264
Prop. trout	.2356	.2118	.1882	.1370	.1120	.1675	.1564	.1992	.1972	.1070	.1912	.2159	.1802
Trout (no.)	6,292	9,059	2,850	1,841	2,591	3,563	3,365	2,897	1,937	1,701	4,969	3,392	3,025
Pounds	4,837	6,794	2,439	1,572	2,504	1,488	1,964	1,972	1,397	1,688	6,367	1,768	2,172
Ave. wt. (oz.)	12.30	12.00	13.69	13.66	15.46	6.68	9.34	10.89	11.54	15.88	20.50	8.34	11.49
Lbs/acre	.0645	.0906	.0325	.0210	.0334	.0198	.0262	.0263	.0186	.0225	.0849	.0236	.0290
Trout/ang.	.2028	.3043	.1043	.0718	.0931	.1011	.0993	.0885	.0579	.0489	.1086	.0659	.0861
Lbs/ang.	.1559	.2282	.0893	.0613	.0899	.0422	.0580	.0603	.0417	.0485	.1392	.0344	.0618
All species (no.)	26,706	42,762	15,143	13,440	23,127	21,270	21,517	14,545	9,822	15,887	25,987	15,710	16,789
Pounds	52,400	54,843	20,678	18,352	33,577	26,146	25,499	18,833	12,317	22,183	35,048	23,760	28,128
Lbs/acre	.6987	.7312	.2757	.2447	.4477	.3486	.3400	.2511	.1642	.2958	.4673	.3168	.3750
Fish/ang.	.8608	1.4366	.5543	.5241	.8308	.6035	.6351	.4446	.2934	.4568	.5682	.3054	.4777
Lbs/ang.	1.6891	1.8425	.7569	.7156	1.2062	.7419	.7526	.5756	.3679	.6378	.7663	.4619	.8003

[a] 18" length limit on lake trout [b] reduction of bag limit

Appendix X. Moosehead Lake harvest data — Summer and Winter, 1967-1979.

	Year												
	1967	1968	1969	1970	1971	1972[a]	1973	1974	1975	1976	1977[b]	1978	1979
Anglers (no.)	35,646	34,040	30,862	29,207	30,399	37,315	36,555	35,789	37,122	39,874	51,687	61,664	43,062
Hours	223,617	234,943	145,707	147,223	204,696	161,416	173,064	168,188	162,099	166,912	243,967	307,363	221,027
Hours/acre	2.9816	3.1326	1.9428	1.9630	2.7293	2.1522	2.3075	2.2425	2.1613	2.2255	3.2529	4.0982	2.9470
Hours/angl.	6.2733	6.9020	4.7212	5.0407	6.7336	4.3258	4.7343	4.6994	4.3667	4.1860	4.7201	4.9845	5.1328
Prop. salmon	.4110	.4692	.5057	.4938	.5626	.7254	.7033	.6058	.5859	.6691	.6554	.5075	.5994
Salmon (no.)	12,255	21,460	8,498	7,413	13,962	16,017	16,371	9,446	6,656	12,869	19,950	10,859	12,447
Pounds	20,833	26,841	10,079	9,650	17,339	19,702	17,347	10,751	7,804	14,300	22,789	16,685	20,820
Ave. wt. (oz.)	27.20	20.01	18.98	20.83	19.87	19.68	16.95	18.21	18.76	17.09	18.28	24.58	26.76
Lbs/acre	.6778	.3579	.1344	.1287	.2312	.2627	.2313	.1433	.1041	.1907	.3039	.2225	.2776
Sal/ang.	.3438	.6304	.2754	.2538	.4593	.4292	.4478	.2639	.1793	.3227	.3860	.1761	.2890
Lbs/ang.	.5844	.7885	.3266	.3304	.5704	.5280	.4745	.3004	.2103	.3586	.4409	.2706	.4835
Prop. togue	.3751	.3313	.3202	.3780	.3322	.1116	.1487	.2020	.2248	.2263	.1759	.3016	.2186
Togue (no.)	11,186	15,155	5,381	5,674	8,243	2,463	3,462	3,150	2,554	4,352	5,354	6,454	4,540
Pounds	31,716	25,870	10,522	9,275	15,980	6,353	8,726	7,878	5,562	11,095	12,904	14,082	11,154
Ave. wt. (oz.)	45.37	27.52	31.29	26.16	31.02	41.27	40.16	40.06	34.86	39.63	38.56	34.91	39.31
Lbs/acre	.4229	.3449	.1403	.1237	.2131	.0847	.1163	.1050	.0742	.1479	.1721	.1878	.1487
Togue/angl.	.3138	.4452	.1744	.1943	.2712	.0660	.0947	.0880	.0688	.1091	.1036	.1047	.1054
Lbs/ang.	.8897	.7600	.3409	.3176	.5257	.1703	.2387	.2201	.1498	.2783	.2497	.2284	.2590
Prop. trout	.2139	.1995	.1741	.1282	.1052	.1630	.1480	.1922	.1893	.1046	.1687	.1909	.1820
Trout (no.)	6,377	9,125	2,926	1,925	2,611	3,600	3,444	2,996	2,150	2,013	5,136	4,085	3,778
Pounds	4,901	6,844	2,506	1,655	2,524	1,548	2,036	2,062	1,551	1,921	6,540	2,183	2,690
Ave. wt. (oz.)	12.30	12.00	13.70	13.76	15.47	6.88	9.48	11.00	11.54	13.89	20.37	8.55	11.39
Lbs/acre	.0653	.0913	.0334	.0221	.0337	.0206	.0271	.0275	.0207	.0257	.0872	.0291	.0359
Trout/ang.	.1789	.2681	.0948	.0659	.0859	.0965	.0942	.0837	.0579	.0505	.0994	.0662	.0877
Lbs/ang.	.1375	.2011	.0812	.0567	.0830	.0415	.0557	.0576	.0418	.0482	.1196	.0354	.0625
All species (no.)	29,818	45,740	16,805	15,012	24,816	22,080	23,277	15,592	11,360	19,234	30,440	21,398	20,765
Pounds	57,450	59,555	23,107	20,580	35,843	27,603	28,109	20,690	14,918	27,316	42,233	32,950	34,664
Lbs/acre	.7660	.7941	.3081	.2744	.4779	.3681	.3748	.2759	.1989	.3642	.5631	.4393	.4622
Fish/ang.	.8365	1.3437	.5445	.5140	.8163	.5917	.6368	.4357	.3060	.4824	.5889	.3470	.4822
Lbs/ang.	1.6117	1.7496	.7487	.7046	1.1791	.7397	.7690	.5781	.4019	.6851	.8171	.5343	.8050

[a] 18" length limit on lake trout [b] reduction of bag limit

Appendix XI. Some large lake trout from Moosehead Lake.

Year	Month	Pounds	Ounces	Length (inches)	Notes
1896	—	29	—	40	Largest in 25 yrs. Harpers
1897	—	17	12		
1937	—	32	—		Mrs. Charles Judkins - Kineo Hotel Mgr. - Gene Letourneau
1944	—	14	8		Cooper Survey
1958	May	21	2	38.8	F & W. Dept.
1958	—	20	8	27	F & W
1958	—	18	13	35.5	F & W
1959	—	17	10	36	F & W
1960	Feb.) Mar.)	18	—	—	Hamilton - F & W
1960	Mar.	20	—	—	,,
1960	Mar.	22	—	—	,,
1960	Mar.	24	—	—	,,
1960	Mar.	24	—	—	,,
1960	—	19	—	38	F & W
1960	—	16	3	34	F & W
1961	Mar.	28	—	39	Jackson - Pittsfield
1961	June	28	12	41	F & W
1961	July	21	4	36.3	F & W
1961	June	19	4	36.3	—
1961	Sept.	28	—	39.3	F & W
1962	May	17	—	36	F & W
1962	—	19	8	38	F & W
1963	June	28	—	—	Caron - Lewiston
1963	Sept.	27	4	42	—
1963	—	23	—	38	F & W

1964	Feb.	15	12	35	—
1964	May	26	—	39	—
1964	—	27	—	41	F & W
1964	—	18	8	—	F & W
1965	Mar.	14	—	33.8	F & W
1965	—	18	—	36	F & W
1966	Feb.	15	5	37	F & W
1966	—	27	—	—	F & W
1967	—	19	—	36	Jenkins, Winthrop F & W
1967	—	23	12	40.4	F & W
1967	—	23	8	38.5	F & W
1967	—	20	—	36	F & W
1968	—	17	10	35	F & W
1969	—	16	—	36	F & W
1969	—	15	3	35	F & W
1970	—	17	—	37	F & W
1970	—	16	13	36.3	F & W
1970	—	16	8	36	F & W
1971	—	23	—	39	F & W
1972	—	18	4	38	F & W
1972	—	17	—	35	F & W
1973	—	28	—	42	F & W
1974	—	—	—	—	—
1974	—	—	—	—	—
1975	—	18	12	38	F & W
1976	Feb.	14	—	36	—
1976	July	20	8	37.6	F & W
1977	Feb.	17	—	38	Bangor Daily
1977	Feb.	14	—	36	—
1978	Mar.	18	—	40.6	Omar McIvar F & W
1979	Mar.	13	8	—	(L.V. stocked 1966 - 14 yrs. old) Bill Cantara

Appendix XII. Moosehead Lake lake trout stocking record.

Year	Fry	Fingerlings	Yearlings	Notes
1926	25,000			Michigan eggs
1927	62,000			
1929	59,800			
1932	60,000			
1934	39,500			
1935	—	10,000		
1936	69,000	7,000		
1937	30,320	38,000		
1938	20,000	20,000		
1939	20,000	20,000		
1940	31,000	50,000		
1941	5,000	35,000		
1942	23,000	60,000		
1943	70,000			
1945	30,000			
1946	55,000			
1947	41,000			
1950	30,000			
1952	37,800			
1959	—	—	5,000	RV mark
1961	—	—	10,000	RV mark
1964			7,000	
1965			10,164	
1966			76,990	5,000 RV mark 13,000 LV mark
1968			50,000	BV mark
1970			30,000	LP mark
1972			50,000	LVD mark
1973			50,000	BV mark
1974			50,000	LP mark
1975			50,000	RV mark

Appendix XIII. Winter fishery Moosehead Lake, 1935-1944 (Cooper, 1944)

Year	Anglers	Hours	Togue	Trout	Salmon	Total fish	Fish/ Hr.	Fish/ ang.	Togue/ ang.	Trout/ ang.	Salmon/ ang.
1935-1944	3,262	22,508	2,620	547	74	3,241	.144	.994	.803	.168	.023
Mean	326.2	2,250.8	262	54.7	7.4	324.1	.144	.994	.803	.168	.023

Winter fishery Moosehead Lake, 1953-1958.

Year	Anglers	Hours[a]	Togue	Trout	Salmon	Total fish	Fish/ Hr.	Fish/ ang.	Togue/ ang.	Trout/ ang.	Salmon/ ang.
1953	409	2,822	228	23	3	254	.090	.621	.558	.056	.007
1954	719	4,961	710	68	9	787	.159	1.095	.988	.095	.013
1955	600	4,140	597	48	1	646	.156	1.077	.994	.080	.002
1956	551	3,802	260	52	—	312	.082	.566	.472	.094	0.0
1957	738	5,092	285	216	13	514	.101	.697	.386	.293	.018
1958	505	3,485	178	69	8	254	.073	.503	.353	.137	.014
Total	3,522	24,302	2,258	476	33	2,767	.114	.786	.641	.135	.009
Mean	587	4,050	376	79	5.5	461.2	.114	.786	.641	.135	.009

[a] Expanded to 6.9 hours per angler day.

Winter fishery Moosehead Lake, 1959-1966.

Year	Anglers	Hours[a]	Togue	Trout	Salmon	Total fish	Fish/ Hr.	Fish/ ang.	Togue/ ang.	Trout/ ang.	Salmon/ ang.
1959	1,042	7,190	444	53	6	503	.070	.483	.426	.051	.006
1960	707	4,878	511	22	7	540	.111	.764	.723	.031	.010
1961	597	4,119	386	57	14	457	.111	.766	.647	.096	.024
1962	1,092	7,535	901	95	21	1,017	.135	.931	.825	.087	.019
1963	686	4,733	660	28	13	701	.148	1.022	.962	.041	.019
1964	511	3,526	384	12	6	402	.114	.787	.752	.024	.012
1965	680	4,692	588	54	24	666	.142	.979	.865	.079	.035
1966	618	4,264	643	4	27	674	.158	1.091	1.041	.007	.044
Total	5,933	40,937	4,517	325	118	4,960	.121	.836	.761	.055	.020
Mean	741.6	5117.1	564.6	40.6	14.8	620	.121	.836	.761	.055	.020

[a] Expanded to 6.9 hours per angler day.

Appendix XIII. (cont'd.)

Winter fishery Moosehead Lake 1967-1971 project years.

Year	Anglers	Hours	Togue	Trout	Salmon	Total fish	Fish/ Hr.	Fish/ ang.	Togue/ ang.	Trout/ ang.	Salmon/ ang.
1967	599	3,950	379	6	16	401	.102	.669	.632	.010	027
1968	1,001	7,222	650	13	92	755	.105	.754	.649	.013	.092
1969	790	5,716	305	20	34	359	.063	.454	.386	.025	.043
1970	873	6,257	327	22	37	386	.062	.442	.375	.025	.042
1971	1,158	8,568	623	16	82	721	.084	.623	.538	.014	.071
Total	4,421	31,713	2,284	77	261	2,622	.083	.593	.517	.017	.059
Mean	884.2	6342.6	456.8	15.4	52.2	524.4	.083	.593	.517	.017	.059

Winter fishery Moosehead Lake, 1972[a]-1979 project years.

Year	Anglers	Hours	Togue	Trout	Salmon	Total fish	Fish/ Hr.	Fish/ ang.	Togue/ ang.	Trout/ ang.	Salmon/ ang.
1972	397	2,623	57	7	99	163	.062	.411	.144	.018	.249
1973	774	5,184	182	18	269	469	.091	.606	.235	.023	.348
1974	941	6,644	189	31	129	349	.053	.371	.201	.033	.137
1975	1,697	12,073	307	138	257	702	.058	.414	.181	.081	.151
1976	839	5,723	192	57	275	524	.092	.625	.229	.068	.328
1977	943	6,267	225	34	455	714	.114	.757	.239	.035	.483
1978	1,403	9,824	310	77	345	732	.075	.522	.221	.055	.246
1979	911	6,100	155	92	211	458	.075	.503	.170	.101	.232
Totals	7,905	54,438	1,617	454	2,040	4,111	.076	.520	.205	.057	.258
Mean	988.1	6804.8	202.1	56.8	255	513.9	.076	.520	.205	.057	.258

[a] Length limit on togue increased from 14" to 18".

Appendix XIV. Salmon stocking records — Moosehead Lake and tributaries.

Year	fry	f.f.	s.y.	f.y.	Total	Remarks
1896	unk.				unk.	
1902	60,000*				60,000	*size not given — probably all fry
1906	6,400*				6,400	
1908	43,000*				43,000	
1910	12,000	40,000			52,000	
1912		83,000			83,000	
1913		5,000			5,000	
1914		96,500			96,500	
1915		108,800			108,800	
1916		83,000			83,000	
1920		9,500**			9,500	**size not given — probably all f.f.
1921		123,700			123,700	
1922		125,200		9,200	134,400	
1923		127,200		10,000	137,200	
1924		118,400		10,000	128,400	
1925		123,000		10,000	133,000	
1926		69,000		10,000	79,000	
1927		53,000		38,000	91,000	
1928		41,174***		7,500	48,674	***sea-run salmon 10,000 + 31,174 escape
1929		30,000		65,000	95,000	
1932	unk.	unk.	unk.	unk.	450,423	
1933			10,000		10,000	
1934	108,700	4,000			112,700	
1935	15,000				15,000	
1936	96,400	65,000			161,400	
1937		135,000			135,000	
1939	45,000	379,000	12,000		436,000	
1940	20,000	213,000			233,000	
1941		233,900			233,900	

1942	70,000	166,000			236,000	
1943		53,000			53,000	
1944		141,000			141,000	
1945		15,000			15,000	
1946		30,000			30,000	
1948	15,000				15,000	
1949		20,000			20,000	
1950		17,000			17,000	
1951		15,000			15,000	
1952		11,000			11,000	
1953	15,000				15,000	
1954		25,000			25,000	
1955		79,000			79,000	
1956		65,000			65,000	
1958		20,500			20,500	
1959			33,200		33,200	
1961		55,000	41,200		96,200	
1963			89,530		89,530	
1964		25,000			25,000	
1965		113,000	30,005		143,005	
1966			22,000		22,000	
1967			50,000		50,000	
1969			50,000		50,000	
1971			50,000		50,000	
1972			50,000		50,000	
1973		10,000	50,000		60,000	
1974			50,000		50,000	
1975			50,000		50,000	
1976			25,000		25,000	
1977			25,000		25,000	
1978			25,000		25,000	
1979			25,000		25,000	
1980			25,000		25,000	
Totals	506,500	3,085,700	712,935	159,700	4,956,432	Unknown 450,423 F.F. sea-run 41,174

Appendix XV. Hatchery salmon stocked in Moosehead and adjoining lakes, 1967-1979.

Year stocked	Number stocked	Mark	Source	No/lb.	Ave. Lgth.	Age at capture II	III	IV	V	VI	Total (%)	Ave. lgth. (mm) of Yr. class
1967	50,000	LV	Casco	32.7	4.5"	**No.** 746	3,912	1,582	66	0	6,305	391.69
						Av.lgt. 360.68	388.26	413.70	417.79	—	(13%)	
1969	50,000	RP	Enfield	27.0	4.8"	**No.** 144	7,684	5,355	153	37	13,373	403.20
						Av.lgt. 356.00	389.35	421.95	461.99	506.05	(27%)	
1970	18,000 (Brassua)	LP-D	Casco	27.7	4.8")							
	2,000 (Spencer)	LP-D	Enfield	31.7	4.6)	**No.** 62	1,279	349	174	3	1,867	378.56
	400 (Prong)	LP-D	Enfield	25.0	5.0")	**Av.lgt.** 356.00	394.95	440.64	437.00		(9%)	
1971	50,000	RP-D	Enfield	18.5	5.5"	**No.** 380	12,252	3,007	180	68	15,887	392.45
						Av.lgt. 362.50	383.87	422.65	486.81	521.00	(32%)	
1972	50,000	RP-A	Casco	19.1	5.4"	**No.** 0	2,521	2,117	261	18	4,917	390.62
						Av.lgt. —	372.44	405.18	444.85	438.00	(10%)	

1973	50,000	BV	Casco	39.1	4.3")	No. 0	664	760	26	0	1,450	400.35
						Av.lgt. —	372.61	422.71	455.33	—	(3%)	
	1,400	BV	Casco	23.0	5.1")							
	10,000 (f.f.)	Ad	Enfield	56.5	5.3"	No. 0	0	0	0	0	0	
											(0%)	
1974	50,000	LP	Enfield	20.4	5.3"	No. 275	7,240	2,962	293	118	10,888	406.23
						Av.lgt. 363.50	391.06	438.98	471.49	452.36	(22%)	
1975	50,000	RV	Enfield	17.6	5.6"	No. 0	11,440	2,653	592	(15)	14,685	410.22
						Av. lgt. —	**396.59**	**450.86**	491.52	(438.00)	(29%)	thru V
1976	25,000	RP	Enfield	20.7	5.3"	No.377	1,937	1,019	(60)		3,333	411.42
						Av.lgt.365.50	400.39	449.37	(521.25)		(13%)	thru IV
1977	25,000	Ad	Enfield	17.2	5.6"	No.133	4,094	(391)			4,227	424.91
						Av.lgt.368.33	426.75	(482.19)			(17%)	thru III
1978	25,000	LV	Enfield	8.8	7.1"	No.247	(541)				247	
						Av.lgt.365.29	(415.75)				(1%)	
1979	25,000	Ad	Casco	8.8	7.1"							

Based on groups of 50,000 Spring Yearlings,
returns from Enfield averaged 27.5% through age VI, and
returns from Casco averaged 8.5% through age VI.

Appendix XVI. Brook trout stocking records in Moosehead Lake or tributaries.

Year	fry	ff	sy	"Adult>6"	Total	Remarks
01895	unk				unk	
1897	unk				unk	
1902	282,000*				282,000*	No size given — probably all fry
1906	52,000				52,000	
1910	80,000			500	80,500	
1912	20,500				20,500	
1913	200,000				200,000	
1914	195,000				195,000	
1915	138,100				138,100	
1916	41,515				41,515	
1921	130,000				130,000	
1922	80,000				80,000	
1923	132,000				132,000	
1924	138,000				138,000	
1925	137,000				137,000	
1926	155,000				155,000	
1927	240,000				240,000	
1928	219,000				219,000	
1929	122,000				122,000	
1932	93,984*				93,984*	No size given — probably all fry
1933	50,000				50,000	
1934	185,000		41,800		226,800	
1935	145,000		41,800	10,000	196,800	
1936	20,000		4,000		24,000	
1937	291,826		6,248		298,074	

1938	20,000	40,000		18,900	78,900
1939	195,000		23,000		218,000
1940	152,000		12,000	5,000	169,000
1941	47,500	335,198	4,500		387,198
1942		124,000	2,000		126,000
1943		17,300			17,300
1944		3,000		4,300	7,300
1945	172,500	16,000	500		189,000
1946	63,000	4,870	1,500		69,370
1948			2,500		2,500
1953		46,000			46,000
1954		50,000		2,000	52,000
1955	71,000	60,000			131,000
1956		85,000			85,000
1957		20,000	13,500		33,500
1958	40,000	136,590			176,590
1959		159,550	34,000		193,550
1960		20,000	15,000		35,000
1961	30,000	20,000	20,000	30,000	100,000
1962		30,000	10,000		40,000
1963		113,700	10,000		123,700
1964	12,900	200,000	21,970	2,760	235,970
1965		71,433	19,400	500	91,333
1966		132,500	12,000		144,500
1971		50,000			50,000
1973		75,000			75,000

Totals (1973)

fry	3,951,825
f.f.	1,810,141
s.y.	295,718
">6"	73,960
Total	6,131,644