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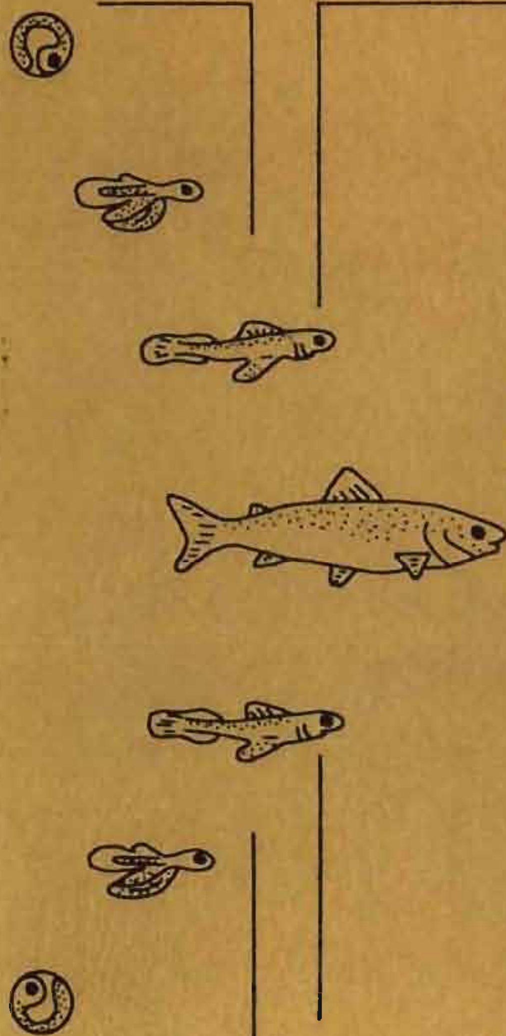

PROGRESS REPORT NO. 84

THE LIMNOLOGY, ECOLOGY AND SPORT FISHERY OF PADDYS POND: A HEAVILY FISHED LAKE NEAR METROPOLITAN ST. JOHN'S, NEWFOUNDLAND

BY

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The Limnology, Ecology and Sport Fishery of Paddys Pond: A Heavily Fished Lake near Metropolitan St. John's, Newfoundland.

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1972

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ACKNOWLEDGEMENTS

W.G. Whelan, Project Technician, deserves special recognition for his technical advice and assistance in the planning and implementing of field work and in the often-tedious calculations of field data.

The field assistance of W. Bruce, J. Jones, and B. Ebsary, summer students; and D. Riche, casual employee, is also appreciated.

Appreciation is extended to A. Jamieson, Technician, Laboratory Services Unit, who supervised much of the water quality analysis.

The author acknowledges the interest and guidance of R.E. Cutting, Chief Biologist, throughout the planning phase, field operations, data analysis, and preparation of the manuscript.

Lastly, I acknowledge the excellent cooperation of the hundreds of anglers from the St. John's area who made their vital contributions to this project. Without their assistance, this study would not have been possible.

I. INTRODUCTION

Undoubtedly, one of the most rapidly-growing outdoor recreational activities in Newfoundland generally, and on the Avalon Peninsula in particular, is freshwater sport fishing. The lakes, ponds, and rivers of insular Newfoundland provide one of the largest, relatively-unexploited sport fishery resources in eastern North America. The local sport fishery is based entirely on species of the Family Salmonidae. Most popular with anglers are resident and anadromous brook trout and Atlantic salmon, with both forms of brown trout, rainbow trout, and arctic char occupying less important positions in the fishery.

Following Confederation in 1949, a program of increased highway construction, together with the emergence of more affluence in society, has led to an increased sport fishing pressure on fish stocks, particularly in standing waters near major population growth centers. Construction of numerous highways and roads during the late-fifties to mid-sixties resulted in many previously-inaccessible lakes and ponds being made available to the sport fishing public. Completion of the building of the Trans-Canada Highway and its numerous access roads during the sixties opened up vast expanses of the Island that formerly were considered as "wilderness areas" by the sport fishing public.

Increased affluence and the availability of good roads gave rise to a marked increase in the use of the automobile in the pursuit of recreational activities. Then, beginning during the late-sixties, a tremendous increase in the use of automobile-related recreational vehicles such as house trailers, camper trailers, snowmobiles, all-terrain vehicles, pleasure boats, etc., led to further demands on the recreational resources of the Island.

With this increase in activity the demand on the sport fish resource has increased tremendously and many of the Island's fish stocks are now available for exploitation. With further increases predicted for human population growth, resource accessibility, affluence, and leisure time, the near-virgin state of the remainder of the stocks is now only temporary.

Approximately 200,000 of the Province's half-million people live on the Avalon Peninsula, with the vast majority in and around St. John's and along Conception Bay (the population of Metropolitan St. John's alone was estimated to be approximately 129,000 in 1971). If we assume 10 percent of the Newfoundland population are sport fishermen, of those approximately 50,000 resident anglers in the Province, nearly 13,000 reside in Metropolitan St. John's. McFadden (1969) estimated that 18 percent of North Americans will be anglers by the year 2000. Increases in the number of resident anglers, together with a larger share of tourists expected to emigrate in mass numbers annually from the Megalopolis of the eastern United States to the boreal regions of Canada, will place unprecedented demands on the Province's recreational resources and its fish stocks in particular.

This growth in recreational fishing activity will not be without its problems, particularly in the area of conflict in resource use. There is, and will be more so in the future, a growing competition between industrial development and sport fisheries. There will be increasing pressure to use sport fish habitat for purposes which will interfere with the ecology of such fishes. In addition, any over-exploitation that may result from the increased demand will be more severe because of the delicate nature of sport fish populations inhabiting our boreal areas.

As the number of sport fishermen grows, more and more pressure will be placed on fishery managers to improve present fish stocks and habitats. To be in a position to effectively manage the fishery resource for the present and future demands we must be in possession of an inventory of existing resources.

Already, sport fishermen harvesting fish populations of the lakes and ponds near the Metropolitan Area of St. John's, particularly along the Trans-Canada Highway and other major traffic arteries, have begun to complain frequently during recent years that these populations are "overfished", and the Department was requested to carry out a program to improve fishing in these waters.

Beginning in late 1967, the Lake Management Group of the Resource Development Branch launched a detailed long-term study to evaluate the status of the recreational fishery in heavily-fished lakes near the Metropolitan Area of St. John's. The objective of this study was to define for the first time annual production rate, harvest rate, and angling pressure for several representative Metro-area lakes. Information collected during the course of this investigation will form the basis of future management plans.

The first phase of that investigation involved the study of a sport fish population which had not been exploited by man for nearly 15 years (See The Limnology, and Ecology of Petty Harbour, Long Pond: an Unfished Reservoir, Progress Report 65, Resource Development Branch, St. John's). The second phase, beginning during 1968, consisted of a comparable study on a lake which is one of the most heavily-fished on the Island of Newfoundland (See The Limnology, Ecology, and Sport Fishery of Thomas Pond: a Multi-Use Reservoir, Progress Report 73, Resource Development Branch, St. John's).

The third and final phase of the investigation, begun in 1969, consisted of a study of the limnology, ecology, and recreational fishery of Paddys Pond, which together with Thomas Pond represents the most-fished lake waters in the Province.

Following five years of intensive data collection, we now feel the Department is in a position to make some effective management decisions regarding Newfoundland lakes, enabling us to maximize the benefits to be derived from inland sport fisheries and fishing.

II. THE LIMNOLOGY OF PADDYS POND

A. Location

Paddys Pond is situated at 47° 28' North Latitude and 52° 57' West Longitude. It lies approximately 8 miles south-west of the City of St. John's along the Trans-Canada Highway (Fig. 1). Paddys Pond has a full storage elevation of 430 feet.

B. Uses

1. Industrial

In 1931-32, Paddys Pond was dammed for use as a reservoir for the hydroelectric generating station at Topsail. Five standing waters were inundated to form the present lake. These waters were: (1) Paddys Pond, (2) Fannys Pond, (3) Duck Pond, (4) Juniper Pond, and (5) Gull Pond. During 1956, construction of a new diversion dam raised the lake water level an additional 6 feet. At full storage Paddys Pond occupies a surface area of 538 acres.

Paddys Pond originally emptied into Manuels River; however, upon completion of the rock-fill diversion dam (Fig. 2), the water was diverted by a controlled-flow spill gate (Fig. 3) and channeled into the Topsail River system via a number of downstream lakes. During high water the overflow from Paddys Pond spills into Manuels River (Fig. 4).

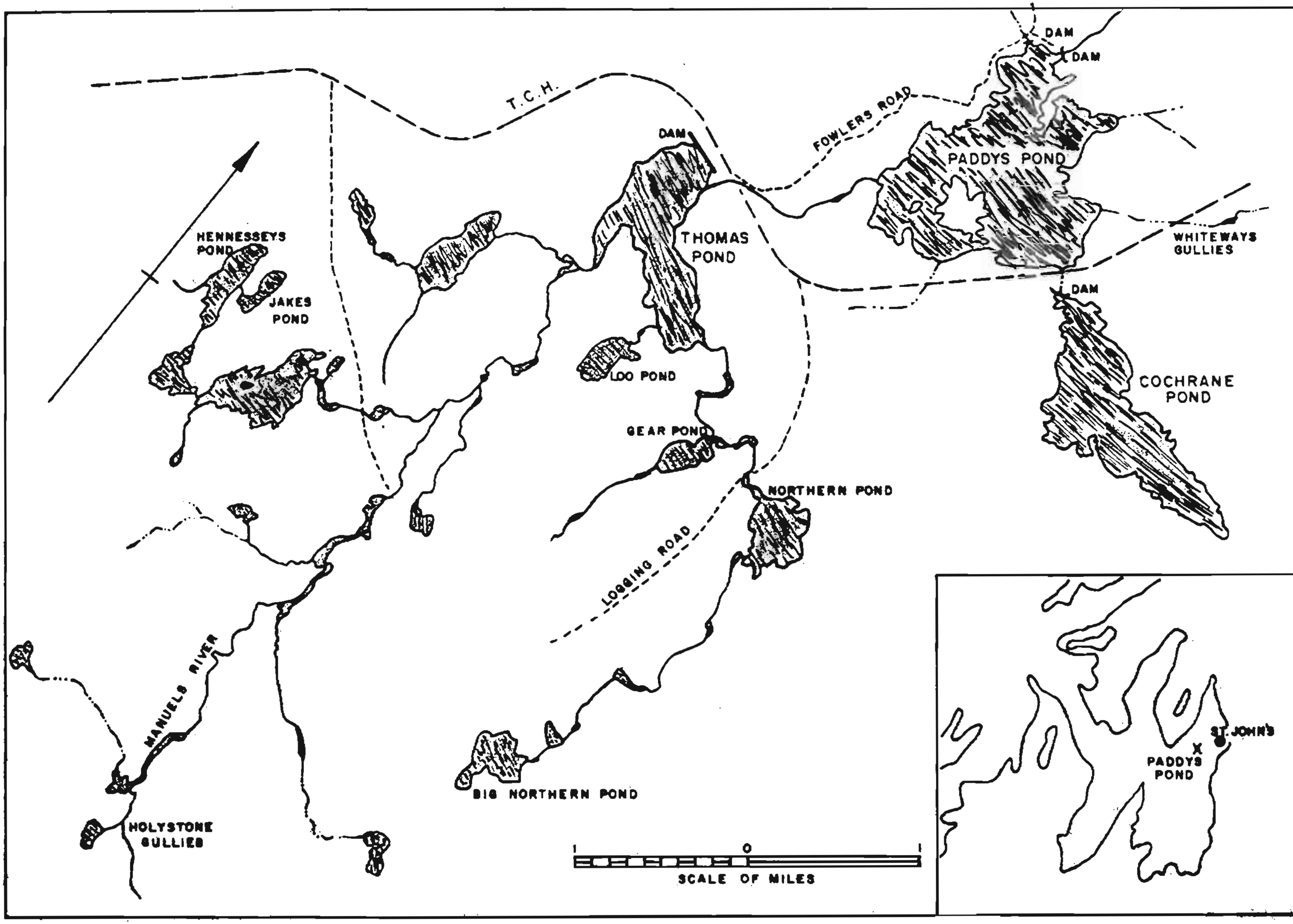

FIG. 1 PADDYS POND DRAINAGE SYSTEM

Figure 2. Paddys Pond dam and high-water spillway.

Figure 3. Controlled-flow spillgate and diversion channel at the outlet of Paddys Pond.

Prior to impoundment, Paddys Pond received the outflow from Cochrane Pond. However, Cochrane Pond was also impounded for hydro-electric development during the early 1930's; its water was diverted from Paddys Pond and channeled to the Petty Harbour power station via Cochrane Pond Brook. During high water, the overflow from Cochrane Pond still enters Paddys Pond, crossing the Trans-Canada Highway via an underground culvert (Fig. 5).

Figure 4. Paddys Pond spilling into Manuels River during spring run-off.

During 1956 the waters of the Upper Manuels River were impounded by a diversion dam at Thomas Pond and channeled into Paddys Pond (Fig. 6). Maximum annual fluctuation in water level at Paddys Pond is about 3 - 4 feet (Fig. 7). The pond usually experiences only a summer drawdown.

Figure 5. Overflow from Cochrane Pond entering Paddys Pond via a culvert.

2. Governmental

The Government of Newfoundland and Labrador Air Ambulance Service operates a sea-plane base and heliport on Paddys Pond. The facilities of the base are also used by several private interests. In addition, the Provincial Department of Mines, Agriculture and Resources maintains a Forest Fire Patrol Depot at Paddys Pond (Fig. 8).

Figure 6. Discharge from Thomas Pond entering Paddys Pond.

Figure 7. A portion of the shoreline of Paddys Pond showing the extent of summer drawdown.

3. Recreational

In addition to angling, other recreational uses include boating, swimming, picnicing, camping, and some waterfowl hunting. The proximity of the lake to Cochrane Pond Provincial Park increases its recreational use substantially. In addition there is a modest summer cabin development consisting of about six units (Fig. 9).

Figure 8. Provincial Government-operated sea-plane base, heliport, and forest fire patrol depot.

Figure 9. Summer cabins on Paddys Pond (near Fowlers Road).

C. <u>Characteristics of the Drainage Area</u>

The drainage area of Paddys Pond occupies 20.1 square miles. Included in this area are four drainage systems of varying magnitude. In addition to the major system, the Upper Manuels River, three minor systems contribute their drainage to Paddys Pond (Figs. 10-12).

Figure 10. Minor drainage system originating in bog and marshland west of Cochrane Pond.

Several ditches draining the Trans-Canada Highway contribute intermittently to Paddys Pond via culverts (Fig. 13). Of the total drainage area, 2.1 square miles are in standing water.

Figure 11. Minor drainage system originating at Whiteways Gullies.

Figure 12. Minor drainage system originating in bog and marshland north of Paddys Pond.

Figure 13. One of several drainage ditches carrying run-off from the Trans-Canada Highway.

Paddys Pond receives drainage from Thomas Pond, Western Pond, Cochrane Pond, Loo Pond, Gear Pond, Northern Pond, Big Northern Pond, Hennesseys Pond, Jakes Pond, Holystone Gullies, Whiteways Gullies and an additional number of unnamed lakes, ponds, and gullies.

The drainage area lies at an altitude ranging from 430 to 620 feet above sea level. The terrain ranges from heavily-wooded to marshy boglands.

The area lies in a region of Precambrian sedimentary and volcanic rocks. Most of the strata in the area are of sedimentary origin and have been classified as belonging to the Conception Group. The drainage basin contains Hadrynian siltstone, conglomerate, slate, greywacke, and minor volcanic rocks (Geological Survey of Canada, Map 1231 A, 1967).

Since the Paddys Pond drainage lies at a fairly high altitude, glacial scouring has left soils which are intermittent and shallow. Poorly-drained soils have resulted in numerous bogs and marshes.

Sundew Peat Moss Co. Ltd. operates a small peat moss industry which is partially within the drainage area. The Provincial Department of Mines, Agriculture and Resources maintains two Community Pasture Projects in the drainage area. The Foxtrap pasture (2,500 acres) lies totally within the area, while the Cochrane Pond pasture (10,000 acres) is partly within the drainage area. Some timber is removed from the forests of the drainage area by Newfoundland Fiberply Co. Ltd. who has cutting concessions within the drainage boundaries to supply the fiberply plant at Donovans, near St. John's.

D. Vegetative Cover

1. Terrestrial

The immediate area of Paddys Pond, as well as most of the drainage area, is covered by a climax coniferous forest of balsam fir (*Abies balsamea*), tamarack (*Larix laricina*), and black spruce (*Picea marina*), which in most cases extends to the water's edge (Fig. 14). In a few places there are small stands of white birch (*Betula papyrifera*). Along other areas of shoreline the forest gives way to shrubs and finally to semi-aquatic and aquatic vegetation (Fig. 15). Small stretches of the lake shoreline are also ringed with zones of submerged and emergent deadwood, as a result of flooding (Fig. 12).

Figure 14. Climax coniferous forest extending to the water's edge at Paddys Pond.

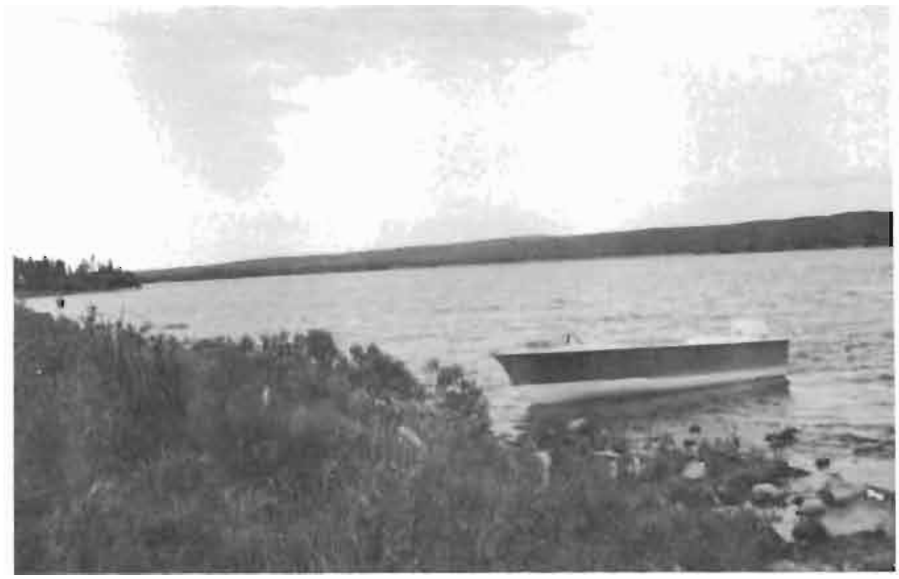

Figure 15. Shrubs and semi-aquatic vegetation - typical vegetative cover on portions of shoreline not covered by climax vegetation.

Marshes and bogs cover only small areas but they have had an important effect upon the lake through their contribution of organic matter.

2. Aquatic

The aquatic vegetation of Paddys Pond was identified by referring to Fassett (1940). Portions of shoreline having a soft, organic bottom composition are ringed with aquatic vegetation. The main components of this vegetation are the sedges (Cyperaceae), rushes (Juncaceae), and aquatic grasses (Gramineae). In sheltered bays and coves are small patches of yellow pond lily (*Nuphar variegatum*) and extensive areas of burreed

(*Sparganium spp.*). Also around the shore and extending out to a depth of 3 or 4 feet grows the water lobelia (*Lobelia dortmanna*) and the pipewort (*Eriocaulon septangulare*). Farther off-shore, and generally in association with 3-6 feet deep shoal areas, are small forests of pondweed (*Potamogeton americanus*, *Potamogeton natans*, and *Potamogeton sp.*). In addition to these emergent species, much of the bottom of Paddys Pond is covered by a mat of submerged species such as bladder-wort (*Utricularia sp.*), water millfoil (*Myriophyllium sp.*), and mosses (*Fontinalis sp.*). This variety of vegetation supports an extensive population of invertebrates, especially amphipods (Steele, 1967). It is estimated that the emergent vegetation occupies approximately 26 acres, or 5 percent of the total surface area of the lake.

E. Physical and Chemical Environment

1. Morphometry

A bathymetric map of Paddys Pond is presented in Figure 16, the morphometric parameters are given in Table I. Parameters are given in both the English and metric systems in accordance with international limnological practice.

Depth and volume information were obtained by using a Ferrograph "Offshore 500" depth recorder (Fig. 17) on an outrigger-type transducer arm attached to the gunwhale of a 16' 7" Boston Whaler boat (Fig. 18). Other parameters were determined by methods recommended by Welch (1948) and are calculated directly from topographical maps from the Canadian Mines and Technical Surveys series.

Table I. Morphometry of Paddys Pond.

Area, including islands	(acres)	538.0	Area, excluding islands	(acres)	526.0
	(ha.)	217.8		(ha.)	213.0
Maximum length	(mi.)	1.4	Maximum effective length	(mi.)	1.3
	(km.)	2.2		(km.)	2.1
Maximum width	(mi.)	1.0	Maximum effective width	(mi.)	1.0
	(km.)	1.6		(km.)	1.6
Mean width	(mi.)	0.6	Volume	(cu. ft.)	2.85×10^8
	(km.)	1.0		(cu. m.)	8.08×10^6
Maximum depth	(ft.)	48.0	Mean depth	(ft.)	10.4
	(m.)	14.6		(m.)	3.2
Mean depth - maximum depth ratio		0.22	Volume development		0.66
Perimeter, including islands	(mi.)	10.6	Perimeter, excluding islands	(mi.)	8.5
	(km.)	17.1		(km.)	13.7
Shore development, including islands		3.26	Shore development, excluding islands		2.65
Direction of Major Axes		S.W. - N.E.			

Depth (ft.)	Area (ft^2)	Area (acres)	%
0-5	3,445,596	79.1	15.0
5-10	4,552,020	104.5	19.9
10-15	6,603,696	151.6	28.8
15-20	6,046,128	138.8	26.4
20-25	1,860,012	42.7	8.1
25-30	257,004	5.9	1.1
30-35	74,052	1.7	0.3
35-40	39,204	0.9	0.2
40-45	26,136	0.6	0.1
over 45	8,712	0.2	Trace
TOTAL	22,912,560	526.0	

FIGURE 16 BATHYMETRIC MAP OF PADDYS POND

Figure 17. The recording and power units of the Ferrograph "Offshore 500" depth sounder.

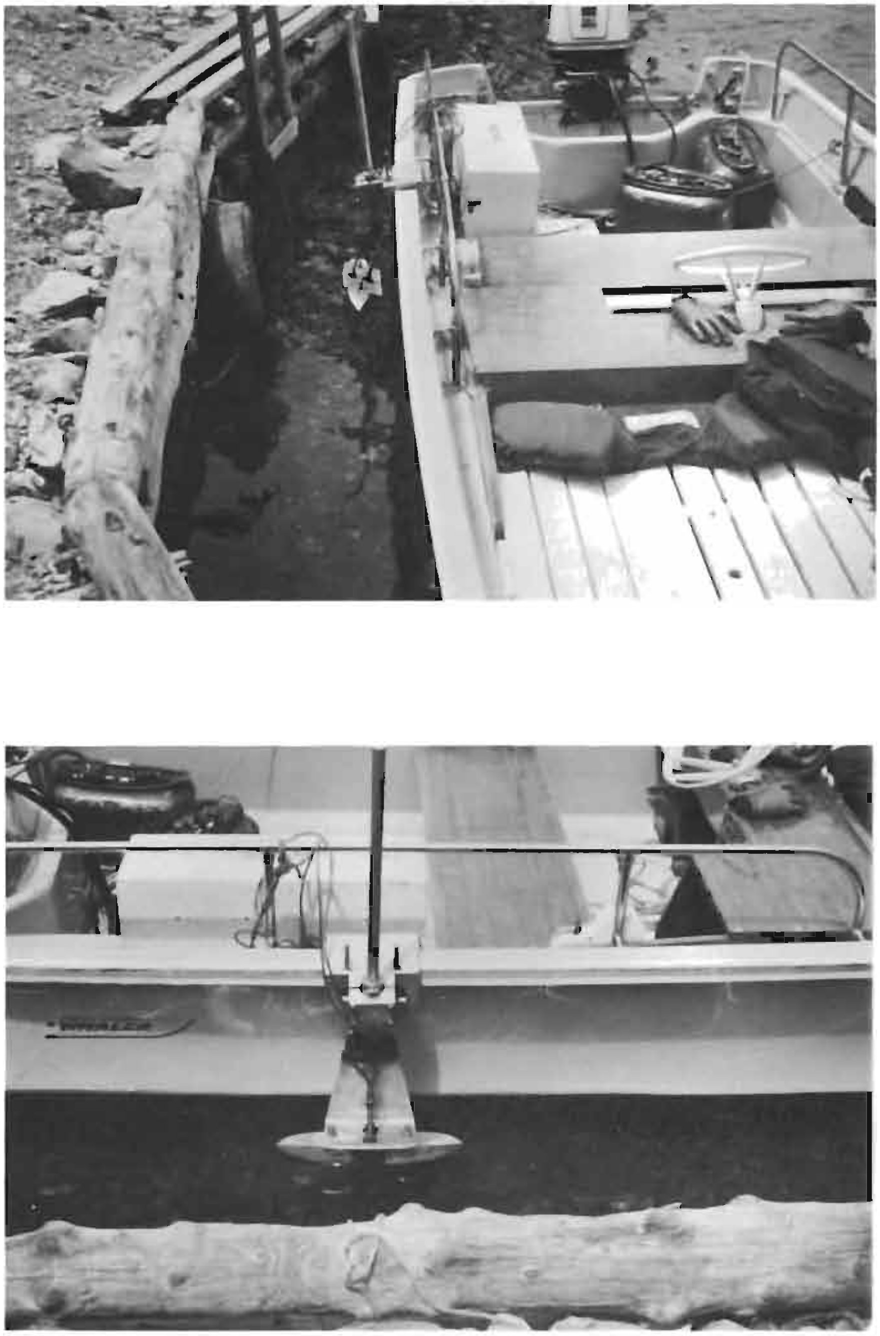

Figure 18. Outrigger-type transducer arm with transducer mounted on the gunwhale of a Boston Whaler.

Paddys Pond is fairly irregular in shape (shore development index = 3.26) and its shores are rather gently sloped. Approximately 90 percent of the lake area is included in the 0-20 feet range of depth. This range is generally accepted as having the most value for bottom fauna production. Paddys Pond would appear, then, to be a very productive lake in terms of its morphometry.

2. Bottom Conditions

The bottom-type composition of Paddys Pond is given in Table II. The littoral area of the lake (0-20 feet) is gently sloped and covered by both a recent organic sediment composed of vegetation in varying stages of decomposition (detritus, peat, and muck), as well as the original inorganic sediment. Most of the organic sediment is found in areas of the lake recently flooded. In the deeper, original areas of the lake, bottom materials are generally inorganic, grading into clay.

Table II. Bottom type composition of Paddys Pond.

	Bottom type	Percent composition
Inorganic	Boulders	5
	Coarse rubble	15
	Fine rubble	20
	Coarse gravel	15
	Fine gravel	5
	Sand	2
	Silt	3
	Clay	10
Organic	Detritus	5
	Peat	5
	Muck	15

3. Temperature of the Water

Surface water temperature data were obtained from a continuous - recording Ryan thermograph during the periods April - November, 1970 and 1971. The lowest recorded temperature for the period was 32.3°F and the highest was 72.5°F. Maximum summer water temperatures rarely exceed 70°F. During 1970 and 1970, there were 175 and 169 consecutive days, respectively, when the mean daily surface water temperatures exceed 7°C (44.6°F). A growing season of this duration greatly exceeds what is probably the minimum one for salmonid growth, i.e. 100 consecutive days (Power, 1958).

Vertical series of water temperatures were obtained weekly during the periods May - October, 1969, and January - February, 1970, at 2 - foot intervals in the deepest part of the lake using a Model 85 Delta Scientific combination oxygen meter-thermistor (Fig. 19).

Only very weak thermal stratification was recorded at Paddys Pond during the summer of 1969 (Fig. 20). It appears that there is seldom a thermocline in the lake's water column, attributable to the facts that the deeper waters of the lake (40-48 feet) occupy a very small percentage of the total lake area (0.1 percent) and this area receives the full impact of the prevailing winds.

The 1969 fall overturn occurred in Paddys Pond during the period from late September to early October. The lake was homothermous, for all intents and purposes, on October 1 (Fig. 20).

The lake generally freezes over in mid- to late December with some annual variation (as early as December 8 in 1971). Maximum ice thickness

Figure 19. Equipment used to obtain vertical series of water temperatures and dissolved oxygen concentrations beneath the ice at Paddys Pond.

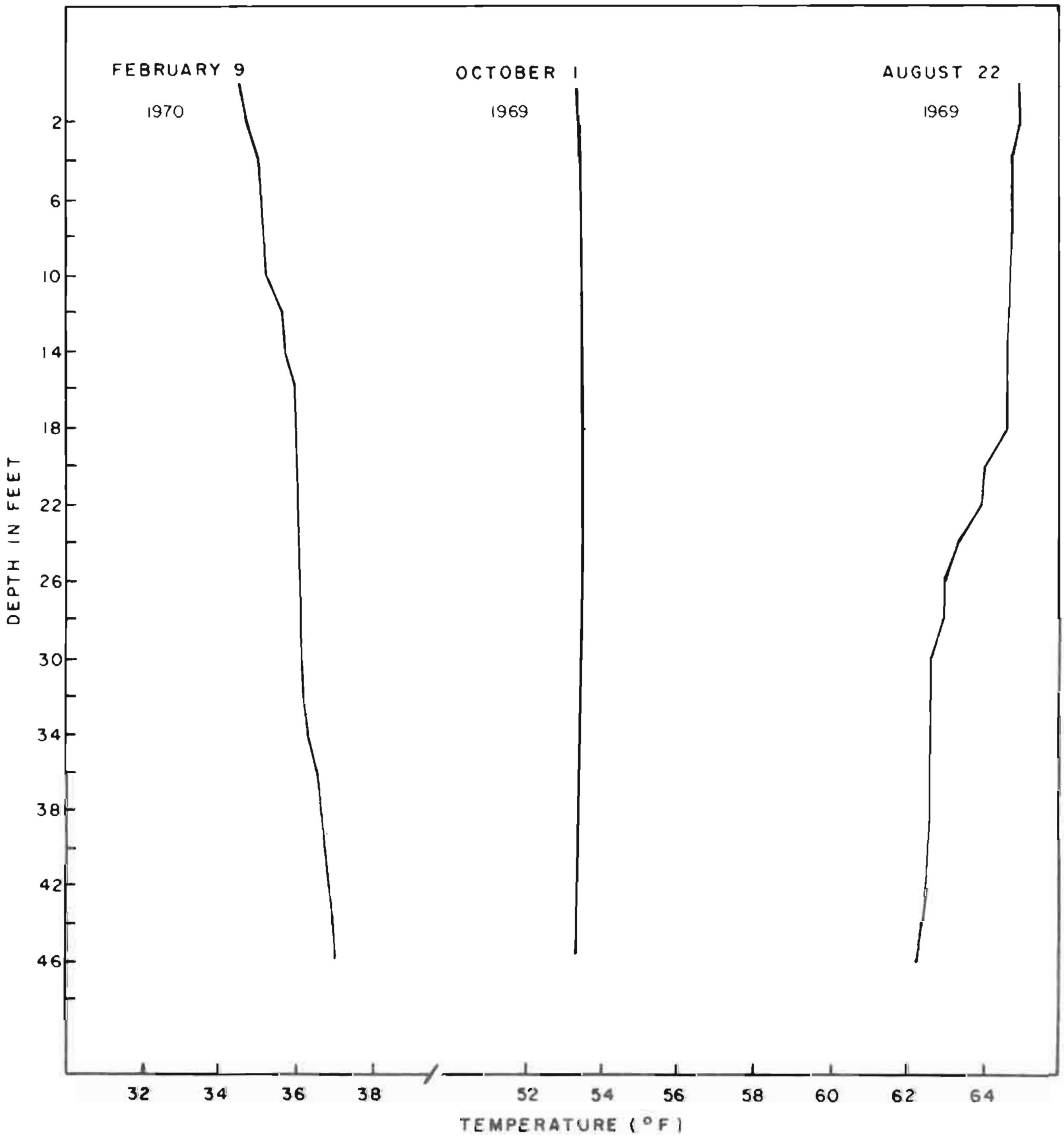

FIGURE 20 TEMPERATURE CURVES FOR PADDYS POND (SELECTED DATES DURING 1969 AND 1970).

during the winters of 1969-70, 1970-71, and 1971-72 was about 13 inches, with the average annual maximum about 10 inches. Ice-out normally occurs during early April, however, complete break-up had occurred by March 1 in 1970. Areas of open water, particularly near the major inlet stream and the spill gate, may persist for the duration of the winter or at least appear well in advance of general break-up.

4. Dissolved Oxygen

Vertical series of dissolved oxygen concentration readings were obtained weekly during the periods July - October, 1969, and January - February, 1970, using the combination oxygen meter - thermistor instrument. Oxygen curves for Paddys Pond are shown in Figure 21. There is some late summer reduction in the concentration of dissolved oxygen near the bottom of the lake which may be partly associated with the weak thermal stratification at this time but more likely due to bacterial decomposition of organic matter on the lake bottom. The reduction occurring during the winter months is undoubtedly caused by decomposition of organic matter and the reduced light penetration and mixing as a result of ice cover. Reduction in oxygen content is not severe (concentrations of less than 5 ppm are rare) and occurs in only a small percentage of the total volume of the lake. Upon break-up of thermal stratification or ice cover that may be present, dissolved oxygen content is more or less homogenous at all depths (Fig. 21).

5. Surface Water Chemistry

Water analysis was carried out by both the Inland Waters Branch, Department of the Environment, Moncton, N.B., and by the Laboratory Services

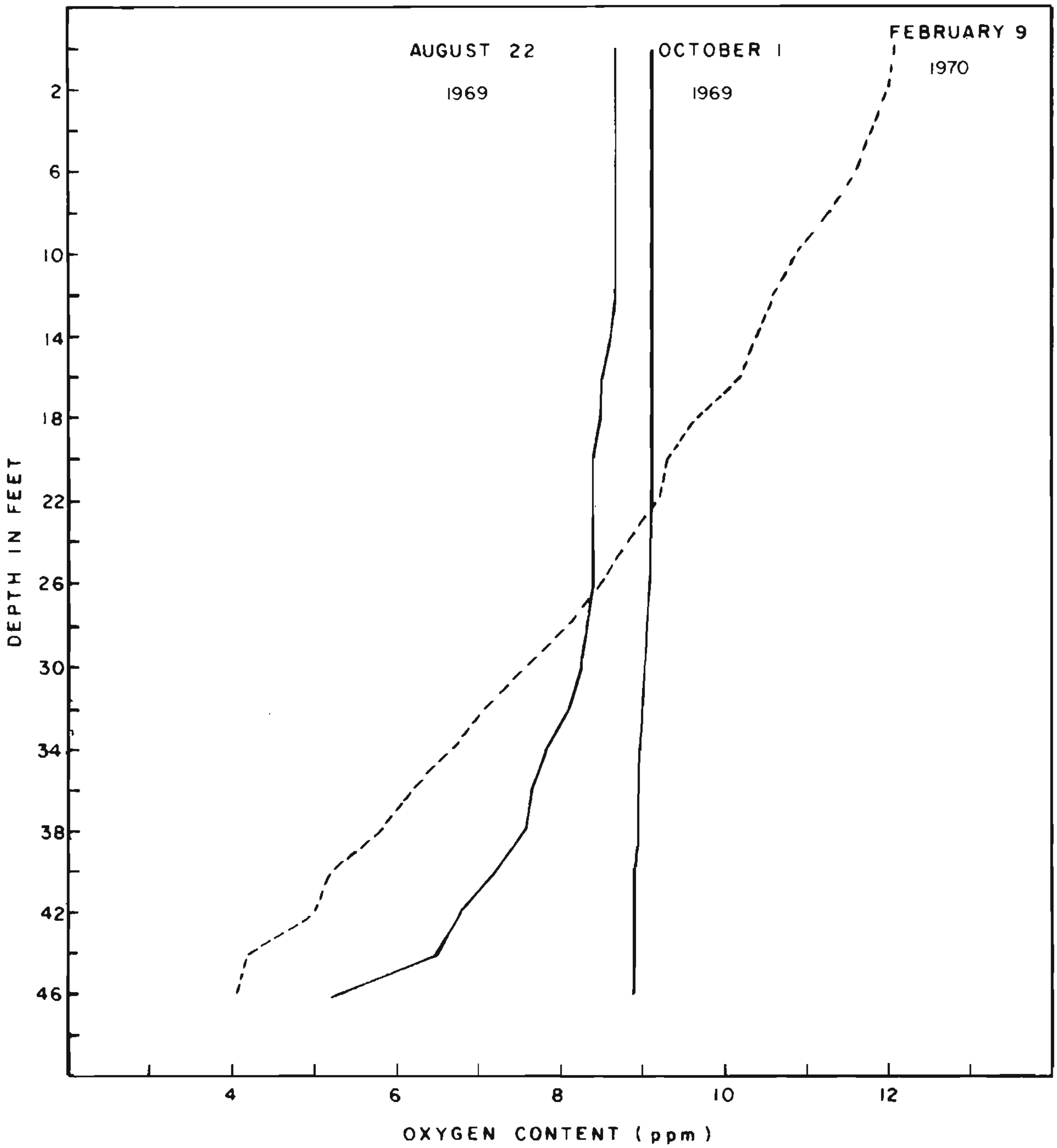

FIGURE 21 DISSOLVED OXYGEN CURVES FOR PADDYS POND (SELECTED DATES DURING 1969 AND 1970).

Unit of the Pollution Control Group, Resource Development Branch, St. John's. Alkalinity, total hardness, pH, and specific conductance were determined by both agencies and mean values were calculated. Analyses of surface waters appears in Table III.

Table III. Analysis of surface water of Paddys Pond (samples collected June and October, 1969, and May, 1970).

	Range	Mean
pH	5.6 - 6.0	5.8
Alkalinity as $CaCO_3$	2.0 - 3.8 ppm	3.0 ppm
Total hardness as $CaCO_3$	3.4 - 6.1 ppm	4.7 ppm
Sp. conductance, micromhos at 25°C	26.0 - 34.6	29.5
Total dissolved solids	25.8 - 31.9 ppm	28.2 ppm
Colour (Hazen units)	25 - 30	-
Turbidity (Units)	0.45 - 2.00	-
Oxygen consumed ($KMnO_4$)	5.7 - 6.3 ppm	6.0 ppm
Calcium (Ca)	0.9 - 1.1 ppm	1.0 ppm
Magnesium (Mg)	0.5 - 0.6 ppm	0.6 ppm
Sodium (Na)	4.1 - 4.6 ppm	4.4 ppm
Potassium (K)	0.4 - 0.5 ppm	0.4 ppm
Carbonate (CO_3)	-	0.0 ppm
Bicarbonate (HCO_3)	1.5 - 3.1 ppm	2.5 ppm
Sulphate (SO_4)	2.1 - 2.7 ppm	2.4 ppm
Chloride (Cl)	7.0 - 8.0 ppm	7.5 ppm

Table III. (Cont'd).

		Range	Mean
Phosphate (PO_4)	total	0.06 - 0.07 ppm	0.07 ppm
	dissolved	-	0.06 ppm
Nitrate (NO_3)		-	0.01 ppm
Silica (SiO_2)		1.2 - 1.4 ppm	1.3 ppm
Sum of constituents		17.4 - 19.6 ppm	18.9 ppm

a. Water Color. Color of water is an important environmental factor in lakes. Paddys Pond waters are moderately stained, with a color value ranging from 25 - 30 Hazen units. The brown stain of the water indicates the presence of organic substances in colloidal and dissolved forms, usually originating from incomplete decomposition of plant materials, usually occurring under acid and anaerobic conditions. Although some substances developed within the lake following flooding, the greater part of these materials are derived from the upper Manuels River which receives surface drainage from bogs, swamps, and acid soils. The waters of Thomas Pond, which empty directly into Paddys Pond are highly stained, with color values ranging from 40-45 units (Wiseman, 1971). The reduction in the color of Paddys Pond water would indicate the presence of substantial amounts of groundwater in the lake.

The most obvious effect of colored water is to reduce light penetration and photosynthesis. In addition, bacterial decomposition of organic material causing stained water results in a reduction in dissolved oxygen content.

b. Oxygen Consumed. The oxygen consumed values for Paddys Pond are moderately high, ranging from 5.7 - 6.3 ppm.

Oxygen consumed values are indices of the amount of organic matter in the waters and, as such, show a positive correlation with color values. The organic materials and acids (humic) entering the lake are largely carbonaceous rather than nitrogenous in nature.

It follows, therefore, that lower values for oxygen consumed in Paddys Pond as compared to a "brown-water" lake, such as Thomas Pond, indicate a lesser organic content in the former. However, these values cannot be thought of as an index of a correspondingly lesser fertility with respect to source of nitrogen.

c. Hydrogen - Ion Concentration. The pH values ranged from 5.6 - 6.0 depending on location of sampling station and season and indicate moderately soft waters. Low pH values are attributed to the surface drainage from bogs in the Upper Manuels River. The pH of the outflow from Thomas Pond has a range of 5.4 - 5.8, again indicating that Paddys Pond receives sufficient ground water of low acidity to substantially raise the pH of the lake water above that of the inflow received via surface drainage.

d. Alkalinity as $CaCO_3$. Alkalinity values ranged from 2.0 - 3.8 ppm depending on season and location of sampling station. Total alkalinity is generally considered to be one of the most important indices in estimating lake productivity. Alkalinity values of less than 40.0 ppm indicate soft waters (Moyle, 1946), therefore Paddys Pond, as well as most other lakes on the Avalon Peninsula where alkalinity values rarely exceed 10 ppm, must be considered as having extremely soft water. The most productive lake waters in the Province are undoubtedly on the west coast where alkalinity has been reported as high as 118 ppm (Dadswell, 1970).

e. Total Hardness. The values for total hardness ranged from 3.4 - 6.1 ppm. Thomas (1960) suggests that waters with less than 60.0 ppm total hardness as $CaCO_3$ are considered soft and gives the Newfoundland average as 16.0 ppm. Waters on the west coast of the Province are considerably harder, having values as high as 136 ppm (Dadswell, 1970).

f. Ionic Order of Dominance. The ionic order of dominance for cations was $Na > Ca > Mg > K$, while the anionic order was $Cl > HCO_3 > SO_4$. The general abundance of Na and Cl, as the dominant cation and anion respectively, reflect the proximity of this lake to the ocean (4 mi.) which contributes significant amounts of salt to coastal fresh waters of Newfoundland by sea breezes and gales.

g. Specific Conductance and Total Dissolved Solids. The values for specific conductance at 25°C ranged from 26.0 - 34.6 micromhos depending on season and station. Specific conductance values were converted to a more significant limnological parameter, total dissolved solids (T.D.S.), by the method of conversion given in an earlier report (Wiseman, 1970). T.D.S. values ranged from 25.8 to 31.9 with a mean value of 28.2 ppm. Thomas (1960) gives the average total mineral content for Newfoundland freshwater as 27.9 ppm. Dadswell (1970), however, reports values as high as 206 ppm. for lakes in the proposed Gros Morne National Park at Bonne Bay. However, elsewhere in North America, most lakes have a mineral content of 100-200 ppm. (Rawson, 1951). Numerous authors, a recent one being Ryder (1970), point out the importance in relation to productivity of the amount of dissolved nutrients (T.D.S.) present in lakes.

6. Morphoedaphic Index and Lake Productivity

Combining morphometric and edaphic data into a morphoedaphic index, Ryder (1965, 1970) devised a means of predicting potential fish production in north-temperate lakes. Morphoedaphic indices and corresponding fish production figures for Paddys Pond and 16 other Avalon Peninsula lakes are given in Table IV. Paddys Pond has an estimated annual fish production of 3.29 pounds per acre per year, or 1731 pounds per year. Of the Avalon Peninsula lakes investigated to date, potential annual production ranges from approximately 2 to 4 pounds per acre per year, with an average of about 3. Therefore, given reasonable estimates of the total biomass of fish produced in each of a number of lakes per year, it becomes possible to set annual creel limits in terms of weight, for either individual lakes or a number of lakes in a geographic area.

Table IV. Morphometric, edaphic, and potential fish production data for 17 Avalon Peninsula lakes.

	Mean depth (ft.)	T.D.S.	T.D.S./Mean depth	Potential production (lbs/acre/yr.)	Area (acres)	Potential production (lbs/yr)
Paddys Pond	10.4	28.2	2.71	3.29	526	1,731
Thomas Pond	13.3	27.0	2.03	2.85	255	727
Petty Harbour Long Pond	21.3	33.8	1.59	2.52	428	1,079
Big Triangle Pond	9.1	32.7	3.59	3.79	119	451
Southern Peak Pond	13.6	32.4	2.38	3.09	193	596
Ocean Pond	15.0	31.6	2.04	2.86	815	2,331
Dildo Pond	32.7	29.1	0.89	1.87	970	1,814
Hogans Pond	16.0	37.3	2.32	3.05	147	448
Southwest Pond	14.8	31.4	2.12	2.91	353	1,027
Snows Pond	9.9	27.5	2.78	3.33	1,251	4,166
Middle Gull Pond	33.8	25.2	0.75	1.73	757	1,310
Nine Island Pond South	11.1	29.1	2.62	3.24	203	658
Finnies Pond	12.5	23.7	1.90	2.76	384	1,060
Soldiers Pond	8.8	22.6	2.57	3.21	334	1,072
Gull Pond	14.0	44.1	3.15	3.55	140	498
Little Soldiers & Loon Pond	14.2	31.2	2.20	2.97	167	496
Harbour Main Pond	10.8	33.1	3.06	3.50	500	1,750
Mean		30.6		2.97		

F. Bottom Fauna

1. Materials and Methods

Collection of quantitative and qualitative data on bottom fauna was made at 48 stations located approximately equidistant around the perimeter of Paddys Pond. The sampling was generally carried out in water 20 feet deep or less, and consisted of 5 Petersen dredgings taken in close proximity. The sampling was carried out during July and August, 1969. Dredgings were washed through a set of three wire screens of varying mesh size and the organisms were removed, preserved, and returned to headquarters for final identification, enumeration, and dry weighing.

Organisms were classified by class, subclass order, suborder, or family. The quantitative analysis was undertaken by (1) the occurrence method, (2) the number method and (3) the weight method.

2. Qualitative Analysis

Table V gives the qualitative and quantitative analyses of bottom fauna collected at Paddys Pond. Only fourteen types of organism were found. It is generally conceded that relatively few benthic species are present in the fresh waters of insular Newfoundland (Valle, 1955; and Sharpe, 1968). In earlier investigations at two other Avalon Peninsula lakes, Petty Harbour Long Pond and Thomas Pond, only eleven and twelve types, respectively, were found (Wiseman, 1970 and 1971).

Table V. The bottom fauna of Paddys Pond expressed as percentages of frequency of occurrence, composition, and weight (based on samples taken at 48 stations during July and August, 1969).

Group	Freq.	Percent occurrence	Number	Percent	(mg.) Weight	Percent
Amphipoda	48	100.0	2,862	58.7	781.6	46.2
Chironomidae (Larvae)	48	100.0	1,018	20.9	124.5	7.4
Oligochaeta	39	81.3	383	7.9	184.8	10.9
Trichoptera (Larvae)	31	64.5	130	2.7	206.3	12.2
Ostracoda	35	72.9	106	2.2	32.1	1.9
Sphaeriidae	30	62.5	94	1.9	110.5	6.5
Hirudinea	33	68.8	72	1.5	124.8	7.4
Hydracarina	26	54.2	54	1.1	12.4	0.7
Chironomidae (Pupae)	19	39.6	43	0.9	3.5	0.2
Hemiptera	18	37.5	39	0.8	7.7	0.5
Amnicolidae	14	29.2	20	0.4	41.4	2.4
Emphemeroptera (Nymph)	12	25.0	18	0.4	24.4	1.4
Coleoptera (Larvae)	13	27.1	18	0.4	4.2	0.2
Anisoptera (Nymph)	6	12.5	7	0.1	22.4	1.3
Coleoptera (Adult)	5	10.4	5	0.1	9.9	0.6
Zygoptera (Nymph)	3	6.3	3	0.1	0.5	Trace
Total	48 stations		4,872		1,691.0	

3. <u>Quantitative Analysis</u>

Table V indicates that 1691.0 mg. (dry weight) of benthic organisms were collected at 48 stations. Each station sample consisted of

5 dredgings covering a total area of 500 square inches. The dredging of 48 stations covered an area of 166.6 square feet: the estimated biomass (dry weight) of benthos was 445.0 g./acre, or 1.10 kg./hectare. The total area of the substrate of Paddys Pond is 526 acres, therefore the total estimated biomass of benthos is calculated to be 234.1 kilograms. Assuming that the dry weight of benthos approximates 15 per cent of the live weight (Rawson, 1953), the biomass of living benthos in Paddys Pond would be 1561 kg. or 7.33 kg./hectare.

Earlier investigations at Thomas and Petty Harbour Long Ponds indicated the biomass (dry weight) of benthos to be 1.02 and 1.18 kg./hectare respectively (Wiseman, 1970 and 1971). The standing crop (dry weight) of benthos in several lakes in the Maritime Provinces is reported to range from 1.2 to 6.1 kg./ha. (Smith, 1952 and 1961). Hunter (1970) reports a value of 0.80 kg./ha. for a small Arctic lake. From the data collected to date, it would appear that the larger Avalon Peninsula lakes are intermediate between Arctic and Maritime Provinces lakes in benthic standing crop. However, relatively small lakes on the Avalon Peninsula may maintain somewhat higher standing crops than the larger lakes. Furthermore, Butlers Pond, a 20-acre pond near St. John's, has 2.42 kg. of benthos per hectare (Dominey, 1965).

G. Fish Species

Five fish species inhabit Paddys Pond and its drainage system. Three of the species are of recreational value and include the eastern brook trout, *Salvelinus fontinalis* (Mitchill) 1815; the landlocked Atlantic salmon or ouananiche, Salmo salar Linnaeus 1758; and the brown trout, Salmo trutta Linnaeus 1758. The brook trout and ouananiche are native species while the brown trout is an exotic species introduced into the Topsail River drainage beginning in 1886. It was not until 1932, at which time Paddys Pond was diverted from Manuels River into the Topsail River, that brown trout had access to Paddys Pond and attached waters. Sea-run and non-anadromous populations were well-established in the lower Manuels River prior to 1932, however, a complete obstruction to fish migration located about one mile from the mouth prevented access to Paddys Pond.

The American eel, Anguilla rostrata (Le Sueur) 1817, is also a resident of Paddys Pond. Many specimens of Anguilla were captured in the trap nets and it is felt that the standing crop of eels may be moderately high. A sample of 213 eels was taken from trap nets and measured. Range in total length was 23 cm. to 83 cm. with a mean of 54.6 cm. Since the eel grows to be one of the largest fish in the lake, is predatory, and is a dominant of the fish populations, the eel is a most serious competitor and predator for the three sport species.

The fifth fish species in the lake is the threespine stickleback, Gasterosteus aculeatus Linnaeus 1758. Although present in the extreme lower Topsail and Manuels Rivers, obstructions near both river mouths prevented the establishment of this species any significant distance above tidal influence. During 1971, approximately 22,500 individuals were planted in Paddys Pond as part of a forage fish introduction and evaluation program.

H. Summary of Limnological Conditions

Paddys Pond can be considered a multi-use reservoir where both recreational and hydroelectric interests are in competition for the use of the waters.

In Paddys Pond, the edaphic and morphometric factors, useful in estimating lake productivity, have somewhat conflicting influences. The morphometric factor is extremely favourable (shore development index = 3.26, and 90 percent of the lake has a depth of 20 feet or less). However, relatively unfavourable edaphic characteristics have resulted in a low level of overall production (by North American standards). The shallow, intermittent, and poorly-drained soils of the drainage area result in poorly-mineralized waters entering the lake. Poorly-mineralized water plus the entrance of incompletely-decomposed plant materials in the surface drainage have contributed to relatively poor water quality, low benthos production, and low fish production.

Paddys Pond also experiences a moderate summer drawdown which may have a deleterious effect on both benthos and fish production.

The interaction of these factors at Paddys Pond indicates that all levels of production (primary, benthic, and fish) appear at the lower end of the range for lake productivity as determined for North American waters. However, indications are that Paddys Pond is one of the more productive of the larger Avalon Peninsula lakes.

III. ECOLOGY OF THE SALMONIDAE OF PADDYS POND

A. Sampling

Information on the salmonid populations of Paddys Pond was collected by gill-netting, live-trapping, and conducting a creel census.

The collection of data on food, age, and growth occurred during May, 1969, by gill-netting. Two gangs of nylon gill nets, each composed of three nets with stretched-mesh size 1½", 2", and 3" were fished over-night. Each net measured 50 yards in length and was six feet deep. The gangs were invariably set with the 1½-inch net tied to the shore.

Information on population levels was obtained during June - July, 1969; September - October, 1969; May - June, 1970; September - October, 1970; May - June, 1971; and September - October, 1971, by live-trapping. Six to nine lake trap nets, tended from a 16'7" Boston Whaler boat, were used in the live-trapping operations.

A creel census during the periods May - September, 1970 and 1971, and January - February, 1970, supplied angling statistics. The census was partial, with a census being taken for each day of the week, once each month. In addition, most statutory holidays were creel census days. A little over one-quarter of the angling season consisted of creel census days. In addition, angling statistics on the 1971 winter fishery were collected by a Guardian of the Conservation and Protection Branch.

B. Food

1. Methods

The collection of fish specimens for the food study was made May 27 - 30, 1969. The entire stomach from the lower esophagus to the pyloric sphincter was removed and placed in 10 percent formalin. The contents were examined at a later date in the laboratory. Quantitative analysis was undertaken by (1) the occurrence method, (2) the number method, and (3) the weight method. The procedures used in the three methods were similar to those used for bottom fauna analysis.

2. The Food of Brook Trout

a. Qualitative Analysis. Food composition of brook trout captured during May 1969 is given in Table VI. Generally, the trout are insectivorous, feeding almost entirely on benthos. The only terrestrial organisms appearing in the diet were Isopoda which occurred in 2 stomachs. Planktonic cladocerans (*Daphnia sp.*) occurred in only 3 stomachs. An unidentified salmonid occurred in one stomach; however, during the course of live-trapping operations later that year, and in subsequent years, the occurrence of small salmonid fishes in the mouth and esophagus of the larger trout was not uncommon. It is felt, however, that the relatively high incidence of predation on small salmonid fish in the traps is an artificial situation caused by intense crowding.

b. Quantitative Analysis. Only one of the 89 trout stomachs collected during May 27 - 30, 1969, was empty. There was an average of 75.80 mg. (dry weight) of food per stomach.

A comparison of the bottom fauna composition with the composition of the food consumed indicates a little evidence of food selection by Paddys Pond brook trout. Ephemeropteran nymphs appear to be consumed disproportionately greater than their abundance in the bottom fauna composition. However, since the collection of bottom fauna was made during July and August, Ephemeropteran nymphs would not be expected to be high in numbers then since this group usually has late spring or early summer emergence dates.

Table VI. The food of Paddys Pond brook trout expressed as percentages of frequency of occurrence, composition, and weight (based on examination of fish 14.3 - 28.8 cm. fork length, collected during May, 1969).

Group	Freq.	Percent occur.	Number	Percent	Weight (mg.)	Percent
Amphipoda	63	70.8	5,176	43.0	1,397.5	20.7
Coleoptera (Larvae)	17	19.1	2,344	19.5	539.2	8.0
Chironomidae (Pupae)	5	5.6	2,100	17.4	168.0	2.5
Trichoptera (Larvae)	61	68.5	1,486	12.3	2,362.3	35.0
Ostracoda	10	11.2	331	2.8	99.2	1.5
Chironomidae (Larvae)	16	18.0	136	1.1	16.3	0.2
Sphaeriidae	30	33.7	121	1.0	143.1	2.1
Amnicolidae	26	29.2	118	1.0	280.3	4.2
Ephemeroptera (Nymph)	33	37.1	114	1.0	299.3	4.4
Hirudinea	26	29.2	49	0.4	119.0	1.8
Coleoptera (Adult)	20	22.5	27	0.2	457.2	6.8
Zygoptera (Nymph)	11	12.4	14	0.1	143.1	2.1
Anisoptera (Nymph)	10	11.2	10	0.1	235.3	3.5
Isopoda	2	2.3	6	0.1	115.8	1.7
Hydracarina	4	4.5	5	Trace	3.9	0.1
Daphnia sp.	3	3.4	-	-	206.4	3.1
Hemiptera	2	2.3	2	Trace	7.8	0.1
Salmonidae	1	1.1	1	Trace	153.2	2.3
Total	89 stomachs*		12,040		6,746.9	

* 1 empty stomach

3. The Food of Ouananiche

a. Qualitative Analysis. The food of ouananiche captured during May, 1969, is given in Table VII. Like the brook trout, the ouananiche of Paddys Pond are generally insectivorous. Only one terrestrial group (Isopoda) was included in the diet; however, mayflies (sub-imagos and adults) were consumed in large numbers. Planktonic cladocerans also occurred fairly frequently. Fish did not appear in the diet of ouananiche collected for food studies. During three years of live-trap operations and angling, there was no evidence of predation on any fish species.

b. Quantitative Analysis. Of the 55 ouananiche stomachs collected during May, 1969, 2 were empty. There was an average of 46.41 mg. of food per stomach, significantly less than the amount measured in the brook trout. Similarly, Thomas Pond brook trout contained substantially more food per stomach than did the ouananiche in the lake (Wiseman, 1971).

Although ouananiche and brook trout consume the same food organisms, the proportion of these organisms is somewhat different. Strictly bottom organisms, such as Amphipoda, Coleoptera larvae, Hydracarina, Ostracoda, Hirudinea, and Sphaeriidae are eaten much less frequently by ouananiche than by brook trout. The exception is Trichoptera larvae; this bottom organism is one of the main constituents in the diet of ouananiche and is probably selected because of its relatively large size. Generally, pelagic or semi-pelagic forms such as Daphnia sp. and Chironomidae larvae and pupae are taken more frequently by ouananiche. Ephemeroptera are taken frequently and in substantial numbers, most being either subimagos or adults which are captured either pelagically or at the surface. Leggett (1965) suggests that ouananiche feed heavily on pelagic and surface organisms during June and July, but depend on bottom forms in late summer and early fall. Havey and Warner (1970) suggest ouananiche feed pelagically for the most part.

Table VII. The food of Paddys Pond ouananiche expressed as percentages of frequency of occurrence, composition, and weight (based on examination of fish 15.7 - 26.6 cm. fork length, collected during May, 1969).

Group	Freq.	Percent occur.	Number	Percent	Weight (mg.)	Percent
Chironomidae (Pupae)	10	18.2	1,154	44.4	92.3	3.6
Trichoptera (Larvae)	38	69.1	727	28.0	1,156.5	45.3
Chironomidae (Larvae)	11	20.0	347	13.4	41.6	1.6
Daphnia sp.	11	20.0	-	-	229.9	9.0
Amphipoda	8	14.6	136	5.2	36.8	1.4
Amnicolidae	13	23.6	77	3.0	230.1	9.0
Ephemeroptera (Duns)	28	50.9	68	2.6	546.2	21.4
Coleoptera (Larvae)	7	12.7	70	2.7	16.1	0.6
Hirudinea	5	9.1	7	0.3	28.7	1.1
Sphaeriidae	2	3.6	5	0.2	2.9	0.1
Anisoptera (Nymph)	2	3.6	2	0.1	5.2	0.2
Coleoptera (Adult)	2	3.6	2	0.1	140.4	5.5
Zygoptera (Nymph)	2	3.6	2	0.1	12.4	0.5
Isopoda	1	1.8	1	Trace	13.5	0.5
Total	55 stomachs*		2,598		2,552.6	

* 2 empty stomachs

The lack of a forage fish species in the diet of Paddys Pond ouananiche may be significant since the oft-expressed opinion suggests that forage fish are essential for good salmon growth (Scott and Crossman, 1964; Leggett, 1965; and Havey and Warner, 1970). Beginning in the spring of 1971 threespine sticklebacks were introduced as forage fish and during the next few years it is planned to evaluate their contribution, not only to the diet and growth of ouananiche, but of the other two salmonid species as well.

4. The Food of Brown Trout

Since the brown trout occurred less frequently in gill net catches than did the other two species, a sufficient sample could not be obtained for food studies. However, during the course of mark-recapture studies, several thousand live specimens were examined. It was readily noticeable that browns were feeding on juvenile salmonids, mainly brook trout and ouananiche, in addition to the consumption of benthos. However, observation of several dozen angled adult brown trout indicated that all those had been feeding exclusively on benthos. It is concluded that crowding of fish in the live traps contributes to abnormally high predation on juvenile salmonids by both brown and brook trout. If, on the other hand, the brown trout is normally a predator of young salmonids, substantial numbers in Paddys Pond would have a significant effect on the other game species.

C. Age and Growth

1. Materials and Methods

Fish used for age-and-growth studies included all fish gill-netted during May 27 - 30, 1969, plus all large fish live-trapped or examined in anglers' creels during 1970-1971. Small scrapings of scales were taken from a key area on the left side just above the lateral line and at the level of the adipose fin.

A number of scales were cleaned by rubbing them between the fingers then mounted wet in a Petri dish. Then the scale image, using a Bausch and Lomb microprojector with a magnification of 43x, was projected onto a sheet of white paper. An outline of each scale with its focus and annuli was traced on the paper.

2. Maximum Ages and Sizes Attained.

The oldest and largest brook trout observed during the three years of study was VI^+ years of age with a fork length of 28.8 cm. In the Paddys Pond population, brook trout VI^+ years of age are indeed rare and very few even reach V^+ years of age. Carlander (1969) gives the maximum recorded age for brook trout as XV^+ years, with fish beyond IX^+ indeed rare. However, as Cooper (1967) and Saunders and Power (1970) point out, fish of these ages are rarely found in heavily-fished stocks but are not uncommon in unexploited stocks.

A ouananiche 29.9 cm. fork length and VII^+ years of age holds the known longevity and size record at Paddys Pond. Fish of this age are quite rare, although VI^+ fish are fairly common. Carlander (1969) gives the maximum recorded age for ouananiche as $XIII^+$ years.

The oldest and the longest brown trout captured at Paddys Pond was a fish 52.3 cm. in fork length and IX^+ years of age and a X^+ years old fish having a fork length of 52.0 cm. Brown trout IX^+ and X^+ years of age are not uncommon in Paddys Pond. The maximum known age as reported by Carlander (1969) is $XVIII^+$ years.

3. Back-calculation of Growth

a. Brook Trout. The use of scales for age determination in brook trout has been validated by numerous authors throughout North America, and the method has recently been validated (Wiseman, 1969) and used successfully by the author (Wiseman, 1970 and 1971) in Newfoundland.

The Monastyrsky method of back-calculation has been shown to be suitable for brook trout.

From paired observations of fish length and scale length, a log - log regression was calculated and is as follows:

$$\text{Log } L_f = 1.2959 \text{ Log } L_s - 0.8002$$

$$\text{or } L_f = 6.313\ L_s^{1.2959}$$

The average scale lengths for each year of life and the corresponding calculated fish lengths are given in Table VIII.

Table VIII. Actual scale length (X43) and calculated fork length at annulus formation of Paddys Pond brook trout.

Annulus	I	II	III	IV	V	VI
Scale length (X43)	0.77	1.38	1.97	2.45	2.83	3.20
Fork length (cm.)	4.5	9.6	15.2	20.2	24.3	28.5
Fork length (in.)	1.8	3.8	6.0	8.0	9.6	11.2

Table IX compares the growth rate of Paddys Pond brook trout with those of fish from thirteen other Avalon Peninsula lakes. Generally, the growth of Paddys Pond trout is slightly slower than the mean growth rate of fish from the fourteen areas.

Table IX. Back-calculated growth in form length (cm.) for brook trout in selected Avalon Peninsula lakes.

Annulus	I	II	III	IV	V	VI	VII	VIII
Paddys Pond	4.5	9.6	15.2	20.2	24.3	28.5	-	-
Thomas Pond	5.5	10.8	16.4	20.9	24.9	28.2	31.4	-
Petty Harbour Long Pond	5.1	9.9	15.5	21.3	25.8	30.8	33.1	35.5
Windsor Lake	5.8	11.3	16.6	20.5	24.3	-	-	-
Big Triangle Pond	5.1	11.3	17.2	23.2	28.5	-	-	-
Angle Pond	7.9	14.8	20.0	26.0	32.2	-	-	-
Harveys Pond	7.1	11.7	15.8	19.8	24.0	-	-	-
Donneys Pond	5.9	10.2	14.4	18.1	22.9	-	-	-
Petty Harbour Rocky Pond	6.0	10.3	14.7	18.7	23.9	-	-	-
Stephens Pond	5.0	10.5	15.6	22.5	26.5	-	-	-
Shag Pond	5.2	11.0	15.4	-	-	-	-	-
Snows Pond	4.5	9.1	14.1	19.3	25.1	30.8	35.3	-
Southwest Pond	4.7	8.3	13.1	17.3	22.1	28.2	-	-
Middle Gull Pond	6.2	11.3	15.3	19.7	23.4	28.3	33.6	38.0
Mean (cm.)	5.6	10.7	15.7	20.6	25.2	29.1	33.4	36.8
(in.)	2.2	4.2	6.2	8.1	9.9	11.5	13.1	14.5

b. Ouananiche. Age determinations were made for Paddys Pond ouananiche using the scale method validated for landlocked salmon by Havey (1959). The Lee Method of back-calculation which was shown to be suitable for ouananiche by Warner and Havey (1961) was used successfully for Paddys Pond fish.

From paired observations of fish length and scale length, a least squares regression was calculated, as follows:

$$L_f = 3.30L_s + 2.36$$

The average scale lengths for each year of life and th corresponding calculated fish lengths are given in Table X.

Table X. Actual scale length (X43) and calculated fork length at annulus formation of Paddys Pond ouananiche.

Annulus	I	II	III	IV	V	VI	VII
Scale length (X43)	0.95	2.02	3.70	5.04	6.27	7.13	7.80
Fork length (cm.)	5.7	9.0	14.6	19.0	23.1	25.9	28.1
Fork length (in.)	2.2	3.5	5.7	7.5	9.1	10.2	11.1

Table XI compares the growth rate of ouananiche in Paddys Pond with those of fish from thirteen other Avalon Peninsula lakes. Generally, the growth rate of ouananiche in Paddys Pond is better than the combined mean growth rate of fish from the fourteen areas.

Table XI. Back-calculated growth in fork length (cm.) for ouananiche in selected Avalon Peninsula lakes.

Annulus	I	II	III	IV	V	VI	VII	VIII	IX	X	XI
Paddys Pond	5.7	9.0	14.6	19.0	23.1	25.9	28.1	-	-	-	-
Thomas Pond	4.7	10.0	15.4	20.1	23.0	25.5	28.2	-	-	-	-
Bay Bulls Long Pond	5.6	9.1	15.1	19.4	24.3	28.1	29.9	-	-	-	-
Donneys Pond	6.2	10.2	14.5	17.7	20.3	22.4	-	-	-	-	-
Forest Pond	4.7	9.1	13.1	16.4	19.1	21.1	-	-	-	-	-
Topsail Pond	4.2	8.5	11.2	13.9	16.0	18.7	23.0	25.7	-	-	-
Harveys Pond	4.0	7.7	10.7	13.0	14.8	19.9	22.0	-	-	-	-
Ocean Pond	5.6	10.3	15.3	20.9	23.7	27.1	29.6	31.1	-	-	-
Big Triangle Pond	5.8	11.2	16.0	20.4	23.2	26.9	29.0	31.1	37.6	-	-
Southern Peak Pond	4.7	8.9	13.5	17.4	20.3	24.0	28.9	33.6	-	-	-
Middle Gull Pond	4.9	7.8	12.4	16.9	22.0	27.6	32.5	36.2	40.7	42.7	44.9
Snows Pond	3.9	7.2	11.5	15.7	19.6	23.2	30.5	38.5	44.1	-	-
Southwest Pond	5.8	9.3	14.0	17.4	21.4	-	-	-	-	-	-
Nine Island Pond South	5.5	8.0	11.6	14.7	17.1	20.0	22.8	24.1	-	-	-
Soldiers Pond	3.3	5.7	8.8	11.5	13.1	14.6	16.1	-	-	-	-
Loon Pond	4.2	7.1	10.7	13.3	15.0	-	-	-	-	-	-
Mean (cm.)	4.9	8.7	13.0	16.7	19.8	23.2	26.7	31.5	40.8	42.7	44.9
(in.)	1.9	3.4	5.1	6.6	7.8	9.1	10.5	12.4	16.1	16.8	17.7

c. Brown Trout. The ages of Paddys Pond brown trout were determined by scale examination. The scale method for age determination has been validated by Kipling (1962). The Lee Method of back-calculation, used successfully for brown trout by Liew (1969), was used with success for Paddys Pond fish.

A least squares regression was calculated from paired fish length and scale length observations. The regression is as follows:

$$L_f = 3.44\ L_s + 2.40$$

The average scale lengths for each year of life and the corresponding calculated fish lengths are given in Table XII.

Table XII. Actual scale length (X43) and calculated fork length at annulus formation of Paddys Pond brown trout.

Annulus	I	II	III	IV	V	VI	VII	VIII	IX	X
Scale length (X43)	1.10	2.47	4.11	5.73	6.99	8.01	9.07	10.43	12.50	14.40
Fork length (cm.)	6.2	10.9	16.5	22.1	26.5	30.0	33.6	38.3	45.4	52.0
Fork length (in.)	2.4	4.3	6.5	8.7	10.4	11.8	13.2	15.1	17.9	20.5

The growth rate of Paddys Pond brown trout is compared with those of fish from six other Avalon Peninsula lakes in Table XIII. Generally, the growth of Paddys Pond brown trout for the first five years of life is a little slower than the average growth rate of fish from the seven areas. Growth of older fish, however, is comparable to the average of fish from the other areas.

Table XIII. Back-calculated growth in fork length (cm.) for brown trout in selected Avalon Peninsula lakes.

Annulus	I	II	III	IV	V	VI	VII	VIII	IX	X
Paddys Pond	6.2	10.9	16.5	22.1	26.5	30.0	33.6	38.3	45.4	52.0
Thomas Pond	6.0	12.1	18.3	23.9	27.1	31.1	33.9	37.1	40.1	-
Windsor Lake	8.2	15.7	22.1	27.3	32.0	35.5	38.4	42.4	-	-
Long Pond	8.8	13.9	19.3	23.4	27.6	31.6	34.7	37.3	-	-
Western Island Pond	6.7	11.7	19.2	24.6	29.1	32.8	37.5	-	-	-
Topsail Pond	7.4	11.4	16.7	20.3	22.8	26.5	29.9	-	-	-
Bay Bulls Middle Pond	6.6	10.5	15.0	19.7	23.8	27.3	30.1	33.6	-	-
Mean (cm.)	7.1	12.3	18.2	23.0	27.0	30.7	34.0	37.7	42.8	52.0
(in.)	2.8	4.8	7.2	9.1	10.6	12.1	13.4	14.8	16.9	20.5

4. Factors Influencing the Growth of Paddys Pond Salmonidae

Of the three salmonid fishes present in Paddys Pond, brown trout exhibit the fastest growth rate, brook trout are intermediate, and ouananiche are slowest-growing. Comparisons of the combined mean growth rates for those species for Avalon Peninsula populations indicate that these ratings are the general rule.

Paddys Pond brook trout appear to be growing slightly slower than the combined mean growth rate for several other populations. Ouananiche appear to be growing a little faster, while brown trout exhibit a rate of growh somewhat similar to the combined mean rate.

Growth of the salmonids in Paddys Pond, and in Newfoundland generally, is slow by North American standards (Frost, 1940; Scott and

Crossman, 1964; Liew, 1969; and Wiseman, 1969).

Generally the factors influencing the growth rate of Paddys Pond salmonids are probably of two types: (1) environmental, and (2) genetic. Perhaps the most dominant influences concerned with the growth of Paddys Pond fish are environmental, both physico-chemical and biotic. The chief physico-chemical influences are temperature and water quality, while availability, quantity, and quality of food supply, and inter-specific and intra-specific relationships are the most important biotic influences. Genetic factors may also be important at Paddys Pond but these are probably masked by environmental factors.

a. Environmental Factors. The growth of fish during any one year is directly related to the number of days during that year which offered water temperatures conducive to growth. Power (1958) suggests ouananiche require a growing season with a minimum duration of 100 days, during which time, the mean daily water temperature remains above 7°C (44.6°F). Leggett (1965) suggests a growing season of approximately 150 days was quite suitable for Gambo Pond ouananiche. During 1970 and 1971, there were 175 and 169 consecutive days respectively, when the mean daily surface water temperatures exceeded 7°C. Assuming the growing season requirement of other salmonid species is similar to that of ouananiche, it would appear that water temperatures at Paddys Pond are above minimum requirements for growth in all three species.

This whole growing season is utilized only by immature fish since sexually-maturing individuals cease growing well in advance of termination of the growing season. Although the length of the growing season at Paddys Pond, and undoubtedly in all other Avalon Peninsula lakes, is well above the minimum duration required for salmonid growth, other circumstances do contribute to a slow growth rate, generally resulting in small sexually-mature fish which are not able to utilize the full growth potential of the growing season.

The growth rate of fishes is often related to the quality (dissolved nutrients) of the water. As we have already seen, the waters of Paddys Pond are relatively infertile. Low water quality affects fish growth rate indirectly by controlling food supply. Although primary and benthic production rates in Paddys Pond are low by North American standards, they are probably as high, or even higher than, average for Avalon Peninsula lakes. This fact is reflected in the early growth rate of Paddys Pond fishes which is generally as good, or better than, average for this area.

The quality and availability of the food supply in Paddys Pond is perhaps more important to fish growth than quantity. While the limited bottom fauna (generally small organisms) may be sufficient for substantial growth in young fish during the spring months, much of this benthos is unavailable during the summer period since adult forms have emerged leaving immature, and hence smaller, forms composing the benthic community. It is suggested that the situation regarding the food supply of larger fishes is even more severe. Most of the benthic fauna consumed, even in springtime, is perhaps unable to sustain a salmonid above 10-12 inches in length. In addition, the larger fishes (particularly ouananiche and brown trout) have a tendency to move farther offshore during the summer period taking them away from what limited bottom fauna there is in the littoral zones. The dependence of ouananiche, in particular, on pelagic food organisms is evident from review of their food habits. Of the types and amount of pelagic forms consumed, the vast majority can be considered as minute. For example, plankton and chironomid larvae and pupae occur, collectively, in approximately 58 percent of the fish examined, and represent the vast majority of organisms consumed in the terms of number.

Unlike ouananiche, brook trout depend to a greater extent on bottom-dwelling benthic forms. The dominant bottom organism in the diet of Paddys Pond brook trout is the amphipod. Two members of the Order Amphipoda are found in Paddys Pond. By far the most abundant is Hyallella azteca, a relatively minute (4 to 8 mm.) member of the family. The larger, less abundant species, is Crangonyx richmondensis. Also of great importance as trout food generally are Mollusca (Pennak, 1953). The representatives of this Class rarely exceed a length of 2 - 3 mm. in the waters of Paddys Pond and thus are of limited value as food of brook trout.

The nutritional value of a large organism, be it forage fish, gastropod, plankter etc., greatly outweighs that of a large number of minute life forms. The energy expended in capturing one large prey organism is far less than that required to capture a large number of smaller organisms, and, as a result, the total energy gained from eating a large food organism is proportionately greater than that gained from the consumption of a large number of small organisms.

The necessity of a forage fish in the diet of adult salmonids to produce a fast growth rate is well-documented (Ricker, 1932; Havey and Warner, 1970; and Frost and Smyly, 1952; for brook trout, ouananiche, and brown trout, respectively). Several investigators have commented on the relationship between the presence of forage fish species and fast-growing salmonids in certain lakes of insular Newfoundland (Scott and Crossman, 1964; Leggett, 1965; and Pippy, 1966).

During the course of the investigation at Paddys Pond it became evident that this lake contains better-than-average numbers of salmonids per surface acre, however the size of the fish (excluding brown trout) is relatively small. The growth rate of these fish for the first four or five years (8 - 10 inches) is, however, as good, or better than, that of most Avalon Peninsula populations.

During studies on a number of other lakes in connection with the sport fishery investigation, populations of brook trout and ouananiche were observed which contained many large fish. Without exception, these large fish were existing on a fish diet exclusively. However, the growth during the early years of life, in most cases, is no better and often slower than that of Paddys Pond fish. The fastest growth of these large fish occurs after they have reached a length of approximately 9 - 10 inches, at which time they begin to feed almost exclusively on sticklebacks and/or small salmonids.

This situation has particular significance for Paddys Pond fish in general and for ouananiche especially. Fall standing crops of ouananiche over 9 - 10 inches in length are significant, these fish are usually VI^+ years of age and sexually-mature. However, spring standing crops of VII^+ fish are almost negligible even though the winter sport fishery takes very few ouananiche. Natural over-winter mortality is obviously high for these fish. It is suggested that these fish are unable to find suitably large food organisms during the winter months, and thus do not recover from the rigors of spawning. The availability of large food items throughout the "recovery period" as well as the growing season is obviously of primary importance in determining longevity and growth rate.

With this in mind, beginning during the spring of 1971, a program of forage fish introduction and evaluation was initiated at Paddys Pond, using the threespine stickleback.

Since brown trout are the fastest-growing of the salmonids in Paddys Pond, they are capable of switching to a fish diet at a younger age than either brook trout or ouananiche. At a length of 9 - 10 inches (IV^+ and V^+ years old) they have the ability to take small forage species such as sticklebacks. However, brook trout and ouananiche of this size are relatively older (V^+ and VI^+ years) and scarcer. The success of a forage fish introduction program to increase growth rate of brook trout and ouananiche therefore may not be realized unless suitable benthic and/or pelagic organisms such as molluscs, mysid shrimp, or amphipods are also introduced to increase the growth rate of younger fish, thereby permitting them to take sticklebacks a year or two sooner. In this respect, a number of organisms are offered for consideration of their potential as food items for younger salmonids. To encourage faster growth rate among young brook trout the introduction of gastropods of the Family Lymnaeidae and Planorbidae might be considered. Both of these are native to insular Newfoundland and are relatively large (ca. 16 and 13 mm. respectively). The main limiting factor in their distribution is water hardness. Although, as a rule, these organisms require relatively hard water, some numbers of the Family have a relatively wide range of tolerance towards water hardness. A second organism which should be considered for future introduction is one of the larger members of the Order Amphipoda, Gammarus lacustris. This genus is found on the west coast of the Province. It is this species which is credited with being responsible for the phenomenal growth rate exhibited by rainbow trout stocked in "potholes" in central Canada for fish farming purposes (Johnson, Lawler, and Sunde; 1970). Indeed, Steele (1968) states ". . . the freshwater environment of Newfoundland is wide open for the introduction of exotic amphipod species, which might serve as forage for fish".

To enhance the growth rate of young ouananiche it is suggested consideration be given to the introduction of the opossum shrimp, Mysis relicta. This relatively large (ca. 30 mm. in length) plankter exhibits diurnal vertical migrations in coldwater lakes and, as such, would be an excellent source of food for pelagically-feeding ouananiche. It has been introduced successfully into several Canadian lakes including Kootenay Lake, British Columbia (Sparrow, Larkin, and Rutherglen; 1964) where growth of rainbow trout was increased to a point where fish over 3 pounds were common where previously fish rarely exceeded ½ pound.

Competition, both interspecific and intraspecific, for food and living space is also an important factor affecting growth rate. Because brook trout are cropped relatively more heavily by anglers than ouananiche or brown trout, intraspecific competition between catchable-size fish is probably somewhat less severe than for catchables of the other two species. Although brook trout, ouananiche and brown trout eat the same food organisms, they generally take them from different areas of the lake and in different composition. Thus interspecific competition between brook trout, ouananiche, and brown trout is somewhat reduced particularly during the summer months. However, we should not dismiss lightly the effects of either interspecific or intraspecific competition in view of the fact that the fall standing crop of salmonids in Paddys Pond often exceeds ¼-million individuals. Brown trout are becoming, and perhaps already are, the most successful of the three salmonid species in the lake. Their low catchability, good growth rate, and long life span make them the most serious competitor of both brook trout and ouananiche (Havey and Warner, 1970; and Wales, 1946). Since browns are present in relatively large numbers in Paddys Pond, the interspecific competition with brook trout and ouananiche may very well result in a depression in growth rates of those two species.

Competition from, and predation by, eels on salmonids is not well-documented. However, the relatively large size attained by eels would make them a dominant of the fish population in terms of interspecific competition.

b. Genetic Factors. It is well-known that growth rate of fishes can be increased by selective breeding. It has also been suggested that small, slowly-growing trout are derived from smaller eggs than those trout growing more rapidly, and that egg size varies with genetic strains and varies the size at hatching. In the natural environment, the presence of genetic variations in growth potential in population of the same species is usually modified by environmental factors, but the advantages may be lifelong.

Under intensive angling, fish with greater growth potential than others in the population would be harvested first (Cooper, 1952). If these fish with potential for fast growth and for production of larger eggs are selectively cropped, their contribution to the population gene pool is diminished. Subsequently, egg size and fry size, and consequently adult size, diminish in future populations.

Anglers have been complaining frequently in recent years that over-fishing of sport fish populations has resulted in significantly smaller fish in heavily-fished lakes, and Paddys Pond fishermen are no exception. It is difficult to dismiss simply as nostalgia or "fish stories", reports from competent anglers that the average size of fish creeled in recent years is significantly smaller than fish angled in past decades.

Older anglers are adamant in their suggestion that large fish (both brook trout and ouananiche) were angled from Paddys Pond prior to impoundment. Undoubtedly, some of the decrease in growth rate and numbers of large fish could have been due to impoundment during the early thirties and the subsequent deterioration in lake productivity. However, available information obtained from anglers indicates large fish were angled consistently right up to, and during, the period of highway construction and correspondingly higher fishing pressure. It may very well be then that the fish which attained those larger sizes in earlier days may have been those with genetic potential for faster than usual growth. With increased angling intensity they were cropped and subsequently this "growth gene" became diluted in the population gene pool. This would indicate that over-exploitation and not reservoir-formation is the cause of the alleged reduction in the average size of fish angled.

5. Length-Weight Relationship and Condition

The mathematical relationship between length and weight of fishes has been shown to be satisfactorily expressed by the relationship:

$$W = aL^{n}, \text{ or expressed logarithmically:}$$

$$\text{Log } W = n \log L + \log a$$

This relationship is used in this study to provide a method of calculating biomass when the length composition of the population is known.

Besides being used to express the degree of well-being, condition factors have been used as an addition to age and growth studies and are often used to indicate environmental suitability. Condition factors have also been used to compare condition of fishes from one area with a general average for an entire region.

Calculation of the coefficient of condition is based on the cube law, hence $W = KL^3$ or K (condition coefficient) = W/L^3. The condition factor used in this study follows Hile (1936), where:

$$K = \frac{W \times 10^2}{L^3}$$

a. <u>Brook Trout</u>. The length-weight relationship was calculated by arranging the fork length data into 2.0 cm. intervals and calculating the mean whole weight in grams for each class-interval. The log regression was calculated for the variables, fork length (class mark) and whole weight. The length-weight relationship for Paddys Pond brook trout is expressed by the equation:

$$W = .002339\ L^{2.7651}, \text{ or, expressed logarithmically:}$$

$$\text{Log } W = 2.7651 \log L - 1.6309$$

Table XIV gives the data on condition of Paddys Pond brook trout.

Table XIV. Condition factors of brook trout taken by gill net in Paddys Pond during May, 1969.

Mean condition value (K)	=	1.13
Standard deviation	=	0.0708
Standard error	=	0.0066
Range of values	=	0.76 - 1.70
Sample number	=	115

Condition factors for fishes may either increase or decrease with increase in length. Cooper and Benson (1951) suggest a general "rule of thumb" is that values of n (the exponent in the length-weight relationship) greater than 3 indicate an increase in condition with increase in length, while values less than 3 indicate a decrease in condition with increase in length. The length-weight relationship of Paddys Pond brook trout indicates that condition is decreasing with increase in length ($n = 2.7651$).

Rounsefell and Everhart (1953) suggest the normal situation is for older (larger) fish to increase proportionately more in weight than length, and this condition increases with age. When condition decreases with age or length, it is due to some deficiency or a limitation of some environmental factor. The most obvious factors in the case of Paddys Pond brook trout would be the low quality of the food supply, specifically the almost total absence of large forage organisms, and the relatively high level of competition, both intraspecific and interspecific.

The mean condition factor (K) for Paddys Pond brook trout is 1.13, and is significantly lower ($p < 0.01$) than the mean of other populations in insular Newfoundland (Wiseman, 1970). Paddys Pond trout are also significantly poorer-conditioned ($p < 0.01$) than those of Thomas Pond which is in the same drainage system (Wiseman, 1970). These comparisons substantiate the suggestion that competition at Paddys Pond reduces the condition of trout in the lake, for, as we shall see later, standing crops are almost double those in Thomas Pond.

b. Ouananiche. The length-weight relationship and condition factors were calculated as for brook trout. The length-weight relationship for Paddys Pond ouananiche is expressed by the equation:

$$W = .003860\ L^{2.5708}$$, or, expressed logarithmically:

$$\text{Log } W = 2.5708 \log L - 1.4134$$

Table XV gives the data on condition of Paddys Pond ouananiche.

Table XV. Condition factors of ouananiche taken by gill net in Paddys Pond during May, 1969.

Mean condition value (K)	=	1.05
Standard deviation	=	0.0913
Standard error	=	0.0123
Range of values	=	0.81 - 1.22
Sample number	=	55

A value of 2.5708 for the exponent n indicates the condition of Paddys Pond ouananiche decreases with increase in length. As for brook trout, it is suggested the lack of large forage organisms in the diet and intense competition is the cause of poorer-conditioned larger ouananiche in Paddys Pond. Paddys Pond ouananiche are also poorer-conditioned than their Thomas Pond counterparts ($p < 0.01$). A comparison of the condition of brook trout and ouananiche in Paddys Pond indicates that brook trout are heavier per given length than ouananiche ($p < 0.01$). The same situation occurs at Thomas Pond (Wiseman, 1971), and, indeed, Carlander (1969) suggests that the genus *Salvelinus* is generally better-conditioned than the genus *Salmo* whenever both occur in the same habitat.

c. Brown Trout. Unfortunately, the small catches of brown trout in the gill nets were insufficient for length-weight and condition studies. However, due to the necessity of being able to convert length data to weight data in population estimate studies, data on four Avalon Peninsula brown trout populations presented by Liew (1969) were combined to give a general expression of the length-weight relationship for brown trout. It is assumed that this general expression approximates that relationship for Paddys Pond fish as expressed by the equation:

$W = .001273\ L^{2.9614}$, or, expressed logarithmically

$\text{Log } W = 2.9614 \log L - 1.8954$

D. Population Estimate and Standing Crop

1. Methods

Population estimates for 1969, 1970, and 1971 were made using the mark-recapture procedure. Fish were live-trapped and were marked by fin-clipping and fin-punching. Table XVI lists the information on the various marks used during the course of the experiments.

Table XVI. Marks used during the course of mark-recapture experiments on brook trout, ouananiche, and brown trout conducted during the period 1969-1971 at Paddys Pond.

Date	Mark used
June 20 - July 11, 1969	Adipose fin, clipped
September 24 - October 10, 1969	Left pelvic fin, clipped
May 25 - June 16,1970	Right pelvic fin, clipped
September 24 - October 16, 1970	Lower caudal fin, punched
May 15 - June 4, 1971	Upper caudal fin, punched
September 22 - October 12, 1971	Adipose fin, clipped

The mark-recapture method requires that all marked fish be easily recognized upon recapture. For this reason, regeneration of clipped and punched fins should be at a minimum. Several authors (Shetter, 1951; Stuart, 1958; and Fry, 1961) report that clipped adipose fins show little or no regeneration in salmonids. Pelvic fins tend to regenerate to a fair degree, particularly if they are not clipped as closely to the body as possible (Stuart, 1958). Caudal fins which have a central hole punched in them tend to regenerate quite readily (Stuart, 1958). Since all our marking experiments were short-term (three to four weeks), recognition of marked individuals was not difficult even though some regeneration did occur, since the clipped and punched fins show a well-defined pattern of regeneration (Stuart, 1958).

One basic assumption in mark-recapture experiments is that marked and unmarked individuals in the population have the same mortality rate during the experiment. The Schnabel (1938) method of estimating population size was used throughout this study. The method consists of continuous marking and recapturing for a short period of time, and estimating the population from the proportion of recaptured marked fish in the catch, considering the number of unaccounted-for-marked fish at large when each catch is made. Rounsefell and Everhart (1953) suggest this method is most suitable for a small body of water in which the marked fish can quickly become distributed throughout the population.

All marked fish were measured to the nearest millimeter fork length, and released randomly along the shoreline of the pond. Marked individuals presumably became randomly distributed among unmarked individuals after release.

The length-frequency distribution of captured fish was determined for each species during the course of each mark-recapture experiment. Scale samples were taken, and age-length keys were determined for each species.

Data on the numbers of marked fish recaptured in relation to numbers marked and totals captured were accumulated on a daily basis for the Schnabel estimate. Estimates of the numbers of fish in the various age groups were calculated from the length-frequency distributions and age-length keys. The number of marked fish removed from the lake by anglers during the experiment was determined by creel census. This number was subtracted from the total number of fish marked and an adjusted number of marked fish present in the lake was used in the calculation of population size.

Estimates of population size for brook trout, ouananiche, and brown trout were made for July 11 and October 10, 1969; June 16 and October 16, 1970; and June 4 and October 12, 1971.

2. Brook Trout Population Estimates and Standing Crop

Table XVII shows the population estimates, by age-classes, of the brook trout population in Paddys Pond on selected dates during the period 1969 - 1971.

Generally, the estimates for the younger age-classes, specifically ages 0^+ - III^+ and sometimes IV^+, are minimal. These age-classes are, for the most part, lake-resident but they are not as vulnerable to the sampling gear as are the older individuals. Different behaviour and distribution are factors contributing to their reduced vulnerability to capture.

Saunders and Power (1970) in a similar study in Matamek Lake, Quebec, obtained remarkably similar results for the younger age-classes. They found the young trout were not present in the lake, but were inhabiting the tributaries of the lake during the summer.

Table XVII. Estimates of the brook trout population in Paddys Pond on selected dates during the period 1969 - 1971.

	Age-class							
Date	0^+	I^+	II^+	III^+	IV^+	V^+	VI^+	Total
11/7/69	-	130*	4041*	2084*	1365*	71	-	7691
10/10/69	-	881*	1159*	3898	1936	37	-	7911
16/6/70	-	1121*	8563*	3065*	3088	104	5	15946
16/10/70	-	569*	2136*	4596	1464	17	-	8782
4/6/71	-	601*	5356*	3921*	2263*	49	-	12190
12/10/71	-	593*	1359*	4273	2105	18	-	8348

* Minimum estimates for these age-classes

However, during three years of similar work in Thomas Pond (Wiseman, 1971) minimal estimates of the strength of younger age-classes was attributed to trapping gear selectivity since intensive seining of the main tributary stream yielded very few young brook trout. Indeed growth patterns on Thomas Pond trout scales did not indicate young fish were spending considerable periods of time in stream-residence.

Although no seining was conducted throughout the major tributary streams to Paddys Pond, it is felt that, as was the case in Thomas Pond, young trout produced in the streams leave during the summer of the year in which they were hatched. They become lake-resident, joining the progeny of shore-spawners inhabiting a narrow zone of shallow water around the margin of the shoreline and thus are not susceptible to capture by our sampling gear. This distribution is substantiated by the fact that the pattern on scales from adult brook trout showed no clear demarcation which would separate stream and lake growth histories, indicating that for most of their first year of life the young trout were lake-resident. For purposes of estimating fall standing crops it was assumed all brook trout under-yearlings in Paddys Pond are lake-resident by late autumn.

A consideration of the data on age-classes III^+ - VI^+ given in Table XVII indicates that, during the period of study, the numbers of older and larger fish have remained quite stable and have even shown small increases in spite of relatively-severe angling pressure. The annual reduction in the numbers of older fish from spring to fall is almost entirely the result of angling mortality. However, annual over-winter reductions have been the result of natural mortality almost exclusively, since the ice fishery, except in 1971 has been almost insignificant during the past three winters.

Although the numbers of older fish have generally remained constant during the past three years, the 1967 and 1968 year-classes of trout appear to be quite strong and have dominated the trap-net catches during the springs and falls of 1970 and 1971. In fact, as we shall see later, these two age-classes were probably the reason for the unprecedented high harvest during the 1971 open-water fishery. These natural fluctuations in year-class strength can have a marked effect on population structure, particularly when the population is heavily - exploited. The suspected causes of most year-class fluctuations in Paddys Pond are the degree of spawning success and of competition. It is interesting to note that the Thomas Pond trout population also produced strong year-classes during 1967 and 1968 (Wiseman, 1971). This fact suggests that a common environmental factor (s) effected strong year-classes in both lakes. This idea is substantiated by the fact that, in addition to brook trout, ouananiche and brown trout populations also produced strong year-classes during both those years in both lakes.

Suspected cause of year-class fluctuation in Thomas Pond populations was fluctuating water levels during spawning and egg incubation. However, as we have seen, Paddys Pond experiences a much less severe drawdown and fluctuation in water levels than does Thomas Pond. It is suggested then that strong year-classes in 1967 and 1968 were the result of high spawning escapements and/or high spawning success in conjunction with greatly-enhanced survival of young fish. Some physical environmental factor(s) appears to have been affecting optimum egg survival during the winters of 1966-67 and 1967-68 and, in conjunction with reduced intraspecific and interspecific competition during and following fry emergence, produced two strong year-classes. To accept this hypothesis we must assume that the standing crop of juvenile salmonids was below carrying capacity in both lakes for two successive years, and that both lakes have distinct populations.

By using the age structure data of the estimated populations present during the falls of 1969, 1970, and 1971 and by extrapolating downward the numbers in the younger age-classes with mortality coefficients calculated for a trout population at Petty Harbour Long Pond (Wiseman, 1970), we can make estimates of the population numbers and biomass of the trout stock during the fall of each of the three years (Table XVIII).

Standing crop estimates are 3359, 3775, and 3668 pounds, for the falls of 1969, 1970, and 1971 respectively. The standing crop of the intermediate age-classes is the greatest contributor to the total standing crop. A similar pattern existed for the other populations studied (Wiseman, 1970 and 1971) on the Avalon Peninsula, as well as the Matamek Lake, Quebec, population (Saunders and Power, 1970). The standing crops at Paddys Pond were 6.39, 7.16, and 6.97 pounds per acre for the three years. A study at Petty Harbour Long Pond indicated there were 5.42 pounds per acre in that one-species lake, and Thomas Pond, a multi-species lake, had 7.32 and 8.54 pounds per acre during two successive years (Wiseman, 1970 and 1971). Matamek Lake in Quebec (a multi-species lake) had only 2.8 pounds per acre (Saunders and Power, 1970). Paddys Pond is obviously a comparatively-productive environment for brook trout.

Table XVIII. Age-class distribution of the estimated populations and standing crops of brook trout in Paddys Pond on October 10, 1969; October 16, 1970; and October 12, 1971.

Age-class	1969		1970		1971	
	Estimated population	Standing crop (kg.)	Estimated population	Standing crop (kg.)	Estimated population	Standing crop (kg.)
O^{+}	84,131	126.2	99,193	148.8	92,226	138.3
I^{+}	30,161	446.4	35,561	526.3	33,063	489.3
II^{+}	10,852	487.3	12,795	574.5	11,896	534.1
III^{+}	3,898	269.7	4,596	318.0	4,273	295.7
IV^{+}	1,936	186.8	1,464	141.3	2,105	203.1
V^{+}	37	7.0	17	3.2	18	3.4
TOTAL	131,015	1523.4 (3358.5 lbs)	153,626	1712.1 (3774.5 lbs)	143,581	1663.9 (3668.2 lbs)

Generally, in the three study years an average of 46 percent of the population weight and 7.6 percent of the number was composed of trout exceeding six inches in length (Table XIX). The structure of the fall population at Petty Harbour Long Pond, an unfished lake, showed just a little over 77 percent by weight and 10 percent by number (Wiseman, 1970). Thomas Pond, a heavily-fished lake, had an average of 72 percent by weight and 10 percent by number (Wiseman, 1971). Paddys Pond had an average of 1.42 pounds of trout over 6 inches in length per acre of surface water, while Thomas Pond and Petty Harbour Long Pond had 5.72 and 4.19 pounds respectively. In addition to the proportion of catchable-size fish (over six inches) being less in Paddys Pond, it should be pointed out that the bulk of the "catchables" at Paddys Pond are barely more than six inches, while those of the other two lakes are distributed more evenly over a range of lengths greater than six inches.

Table XIX. Estimated standing crops (kg.) of brook trout over six inches in fork length in Paddys Pond during the falls of 1969, 1970, and 1971.

Year	Weight	Percent	Weight per acre	Number	Percent
1969	738.7 (1628.5 lbs)	48.49	1.40 (3.09 lbs)	10,519	8.03
1970	702.5 (1548.7 lbs)	41.03	1.34 (2.94 lbs)	10,623	6.91
1971	795.8 (1754.4 lbs)	47.83	1.51 (3.33 lbs)	11,409	7.95

3. Ouananiche Population Estimates and Standing Crop

Table XX shows the estimates, by age-class, of the ouananiche population in Paddys Pond on selected dates during the period 1969-1971. Population estimates for the younger age-classes, as for the brook trout, are minimal. Reduced vulnerability to capture because of the particular distribution and behaviour of the young ouananiche is indicated. It is suggested that a major segment of the younger age-classes is stream-resident.

During the Thomas Pond study, sampling of the major tributary stream indicated the presence of significant numbers of ouananiche ages 0^+

Table XX. Estimates of the ouananiche population in Paddys Pond on selected dates during the period 1969 - 1971.

	Age-class								
Date	0^+	I^+	II^+	III^+	IV^+	V^+	VI^+	VII^+	Total
11/7/69	-	53*	739*	1379*	1546	792	57	10	4576
10/7/69	-	64*	28*	245*	630*	651	12	6	1636
16/6/70	-	1099*	10,207*	2188*	3234	1979	178	64	18,949
16/10/70	-	74*	994*	4863*	1658	870	10	6	8475
4/6/71	-	87*	1,898*	7530*	6881	1372	72	8	17,848
12/10/71	-	43*	123*	1071*	2548	1549	3	2	5,339

* Minimum estimates for these age-classes.

- IV^+ years (Wiseman, 1971). Examination of scales patterns of adult fish in Paddys Pond indicated most had spent appreciable time in stream - residence; however, no sampling of the major streams entering Paddys Pond was carried out to verify the actual presence of parr in inlets.

Assuming that young ouananiche emigrate into Paddys Pond from the nursery streams at ages comparable to Thomas Pond fish, we can state that generally all ouananiche are lake-resident by the end of their third summer (II^+) and most are by the end of the second summer (I^+). Indeed, Havey and Warner (1970) state that 51 to 74 percent of parr salmon emigrate from the streams of Maine at age I or I^+. Available information indicates that the young ouananiche enter Paddys Pond during late May and early June.

The structure of the Paddys Pond ouananiche population during 1969 - 1971 is given in Table XX. A consideration of the data on age-classes IV^+ - VII^+ indicates that, during the period of study, the numbers of older and larger fish have increased somewhat. Much of this increase is attributed to those strong year-classes in 1967 and 1968.

As with brook trout, it is suggested that most spring-to-fall mortality is attributed to angling, while over-winter reductions are almost entirely the result of natural mortality. However, summer angling mortality for ouananiche is much less severe than for brook trout; the suggested reason is the lower catchability of ouananiche.

Using the age structure data on the estimated populations present during the falls of 1969, 1970, and 1971 and by extrapolating the numbers present in younger age-classes from rates of mortality (50 percent for ages 0^+ - I^+, I^+ - II^+, and II^+ - III^+, given by Havey and Warner, 1970) total

Table XXI. Age-class distribution of the estimated populations and standing crops of ouananiche in Paddys Pond on October 10, 1969; October 16, 1970; and October 12, 1971.

Age-class	1969 Estimated total population	1969 Total standing crop of age-class (kg.)	1969 Estimated lake population	1969 Total standing crop in the lake	1970 Estimated total population	1970 Total standing crop of age-class (kg.)	1970 Estimated lake population	1970 Total standing crop in the lake	1971 Estimated total population	1971 Total standing crop of age-class (kg.)	1971 Estimated lake population	1971 Total standing crop in the lake
0^+	20,832	37.5	7,256	13.1	38,904	70.0	13,550	24.4	40,768	73.4	14,199	25.6
I^+	10,416	99.0	7,184	68.2	19,452	184.8	13,416	127.5	20,384	193.6	14,059	133.6
II^+	5,208	171.3	4,956	163.1	9,726	320.0	9,256	304.5	10,192	335.3	9,700	319.1
III^+	2,604	164.8	2,604	164.8	4,863	307.8	4,863	307.8	5,096	322.6	5,096	322.6
IV^+	1,302	137.1	1,302	137.1	1,658	174.6	1,658	174.6	2,548	268.3	2,548	268.3
V^+	651	84.1	651	84.1	870	112.4	870	112.4	1,549	200.1	1,549	200.1
VI^+	12	2.1	12	2.1	10	1.8	10	1.8	3	0.5	3	0.5
VII^+	6	1.3	6	1.3	6	1.3	6	1.3	2	0.4	2	0.4
TOTAL	41,031	697.2	23,971	633.8	75,489	1172.7	43,629	1054.3	80,542	1394.2	47,156	1270.2
		(1537.0 lbs)		(1397.2 lbs)		(2585.3 lbs)		(2324.3 lbs)		(3073.6 lbs)		(2800.2 lbs)

estimates were made for the population number and biomass of the ouananiche stock during the fall of each of the three years (Table XXI). Using data calculated for the ouananiche population of Thomas Pond describing the percentage of young ouananiche which are lake-resident (Wiseman, 1971), it is possible to determine the proportion of the population of Paddys Pond which is lake-resident in the fall of the year and contributes to the lake's fish biomass.

Estimates of the ouananiche standing crop in Paddys Pond are 1397, 2324, and 2800 pounds for the falls of 1969, 1970, and 1971 respectively. The higher biomass during 1970 and 1971 is attributed to the strong year-classes of 1967 and 1968; however, there is some suspicion the 1969 estimate is a minimal one. As was the case with brook trout, the fish of intermediate age-classes are the greatest contributors to the total standing crop. A similar situation was found to occur with the Thomas Pond population (Wiseman, 1971). The fall standing crops of ouananiche in Paddys Pond were 2.64, 4.41 and 5.31 pounds per acre for the three-year period under consideration; the average was 4.12 pounds per acre. The fall standing crop of ouananiche per acre at Thomas Pond, basically a two-species lake, averaged 7.40 pounds over a two-year period.

Table XXII shows that, generally for the three years under consideration, an average of 57 percent of the population weight and 17 percent of the population number was composed of ouananiche over six inches in length. In terms of numbers there would be over twice as many catchable-size ouananiche than brook trout if both species had the same population number, again indicating the lower catchability rate, and therefore higher survival, of ouananiche in relation to brook trout. Comparable results were obtained for the two species in Thomas Pond (Wiseman, 1971).

Table XXII. Estimated standing crops (kg.) of ouananiche over six inches in fork length in Paddys Pond during the falls of 1969, 1970, and 1971.

Year	Weight	Percent	Weight per acre	Number	Percent
1969	371.2 (818.3 lbs)	58.7	0.71 (1.56 lbs)	4,288	17.89
1970	545.9 (1203.5 lbs)	51.78	1.04 (2.29 lbs)	6,585	15.09
1971	756.4 (1667.5 lbs)	59.55	1.44 (3.17 lbs)	8,637	18.32

4. Brown Trout Population Estimates and Standing Crop

Table XXIII shows the estimates, by age-class, of the brown trout population in Paddys Pond on selected dates during the period 1969-1971. Population estimates for the younger age-classes, as for the other two salmonid species, are minimal. Reduced vulnerability to capture because of the particular distribution and behaviour of young brown trout is suggested. Like ouananiche, a major segment of the brown trout younger age-classes is stream-resident. Although no sampling of the main tributary streams was carried out, scale pattern analysis indicated Paddys Pond brown trout spend a considerable portion of their early life in stream residence.

Table XXIII. Estimates of the brown trout population in Paddys Pond on selected dates during the period 1969-1971.

	Age-class											
Date	0^+	I^+	II^+	III^+	IV^+	V^+	VI^+	VII^+	$VIII^+$	IX^+	X^+	Total
11/7/69	-	23*	353*	83*	346*	357*	422*	92	11	-	-	1687
10/10/69	-	145*	14*	174*	661*	995*	884	77	12	-	-	2967
16/6/70	-	764	5384*	241*	417*	785*	576*	137	30	11	-	8345
16/10/70	-	44*	106*	1113*	850*	1040*	1449	57	5	9	-	4673
4/6/71	-	86*	583*	1006*	2150*	711*	652*	124	30	20	20	5382
12/10/71	-	325*	131*	445*	1921*	1996	1317	107	11	-	-	6253

* Minimum estimates for these age-classes.

Scale samples were taken from adult fish (ages IV^+ - IX^+) and scale patterns were examined for growth history. The growth pattern on brown trout scales, like those of most other salmonids, permits the examiner to distinguish growth during early life (stream-residence period) from adult growth (lake-residence period, or sea-residence in anadromous fish). From scale patterns it is possible to determine the number of years spent in the stream, and therefore the age at which the fish emigrate to the lake. This information for Paddys Pond brown trout is given in Table XXIV.

Generally, all brown trout are lake-resident by the end of their third summer (II^+) and almost half by the end of the second summer (I^+). Campbell (1957) suggests that the usual, early pattern of life of brown trout in northern Scotland is for the majority of the young fish to spend their first two years of

Table XXIV. Ages at which young brown trout migrate from stream to lake at Paddys Pond and the percent of the population which is lake-resident by the end of summer, as determined by scale reading (number of fish in parentheses).

	Age-class				
	0^+	I^+	II^+	III^+	IV^+
Percent of population which enters the lake at age-class	11.20 (14)	25.50 (32)	59.20 (74)	4.00 (5)	0.00 (0)
Cumulative percent of population in the lake at end of age (t)	11.20	36.80	96.00	100.00	100.00

life in the nursery stream before migrating to the lake. He also suggests that where lakes are large some fish may spend 3 or 4 years in the streams. Available information indicates that the young brown trout enter Paddys Pond during late May and early June.

The structure of the Paddys Pond brown trout population during 1969 - 1971 is given in Table XXIII. The increase in older and larger fish, which was so characteristic of the ouananiche population and somewhat less evident in the brook trout population, is most pronounced in the brown trout population. In fact, the oldest and largest brown trout encountered at Paddys Pond were present during 1971. As with the other two species, it is suggested that strong year-classes during 1967 and 1968 contributed to the relatively high numbers of larger fish during 1971. It is also suggested that significantly lower catch-ability of browns in relation to the other two species makes the increase all the more noticeable. Unlike the other two salmonids in Paddys Pond, most spring to fall and virtually all over-winter mortality, in the brown trout population is natural. Angling removes only a very small percentage of fish.

Using the age structure data on the estimated population present during the falls of 1969, 1970, and 1971 and extrapolating the numbers present in younger age-classes from rates of mortality (47 percent; average given by Liew, 1969, for four Avalon Peninsula populations), we made total estimates for the population number and biomass of the brown trout stock during the falls of each of the three years (Table XXV). Estimates of the brown trout standing crop in Paddys Pond are 5334, 8579, and 5884 pounds for the falls of 1969, 1970, and 1971 respectively. As was the case with the other two salmonid species, the fish of intermediate age-classes are the greatest contributors to the total population standing crop. The standing crops of brown trout at Paddys Pond were 10.14, 16.31, and 11.18 pounds per acre for the three years and, as such, are the dominant fish species in the lake in terms of biomass.

Table XXVI shows that generally, for the three years under consideration, an average of 84 percent of the population weight and 40 percent of the population number was composed of brown trout over six inches in length. In numbers, there would be over five times as many catchable-size brown trout than brook trout, and over twice as many brown trout catchables than ouananiche if all three species had the same population number, indicating the magnitude of differential catchability rate and, therefore, higher survival of brown trout in relation to ouananiche and brook trout.

The total biomass of salmonids in Paddys Pond during the three falls were 10,090, 14,677, and 12,353 pounds respectively, or 19.2, 27.9, and 23.5 pounds per acre respectively. Combining the data for the three years gives an average standing crop of 23.5 pounds per acre. There is some indication the estimate for 1969 may be minimal, in which case the average standing crop (average of 1970 and 1971) would be 25.7 pounds per acre.

Table XXV. Age-class distribution of the estimated populations and standing crops of brown trout in Paddys Pond on October 10, 1969; October 16, 1970; and October 12, 1971.

	1969				1970				1971			
Age-class	Estimated total population	Total standing crop of age-class (kg)	Estimated lake population	Total standing crop in the lake (kg.)	Estimated total population	Total standing crop of age-class (kg)	Estimated lake population	Total standing crop in the lake (kg)	Estimated total population	Total standing crop of age-class (kg)	Estimated lake population	Total standing crop in the lake (kg.)
0^+	56,576	62.2	6,337	7.0	92,736	102.0	10,386	11.4	63,872	70.3	7,154	7.9
I^+	28,288	198.0	10,410	72.9	46,368	324.6	17,063	119.4	31,936	223.6	11,750	82.3
II^+	14,144	495.0	13,578	475.2	23,184	811.4	22,257	779.0	15,968	558.9	12,058	422.0
III^+	7,072	603.9	7,072	603.9	11,592	990.0	11,592	990.0	7,984	681.8	7,984	681.8
IV^+	3,536	563.6	3,536	563.6	5,796	923.9	5,796	923.9	3,992	636.3	3,992	636.3
V^+	1,768	420.6	1,768	420.6	2,898	689.4	2,898	689.4	1,996	474.8	1,996	474.8
VI^+	884	228.1	854	228.1	1,449	330.5	1,449	330.5	1,317	300.4	1,317	300.4
VII^+	77	40.8	77	40.8	57	30.2	57	30.2	107	56.7	107	56.7
$VIII^+$	12	7.6	12	7.6	5	3.2	5	3.2	11	6.7	11	6.7
IX^+	-	-	-	-	9	14.3	9	14.3	-	-	-	-
TOTAL	112,357	2,619.8 (5775.6 lbs)	43,674	2419.7 (5334.4 lbs)	184,094	4219.5 (9302.2 lbs)	71,512	3891.3 (8578.7 lbs)	127,183	3009.5 (6634.7 lbs)	46,369	2668.9 (5883.8 lbs)

Table XXVI. Estimated standing crops (kg.) of brown trout over six inches in fork length in Paddys Pond during the falls of 1969, 1970, and 1971.

Year	Weight	Percent	Weight per acre	Number	Percent
1969	200.6 (4423.7 lbs.)	82.93	3.81 (8.41 lbs.)	17,406	39.85
1970	3214.3 (7086.2 lbs.)	82.60	6.11 (13.47 lbs.)	28,456	39.79
1971	2322.8 (5120.8 lbs.)	87.03	4.42 (9.74)	19,010	40.99

Carlander (1950) suggests trout lakes and ponds have a maximum standing crop of 40 to 50 pounds per acre, but most likely less than 10 pounds per acre; Paddys Pond therefore is a very good producer of salmonids. Carlander (1955) suggests that fish production will increase as the number of niches increases,unless the production of all species is limited by a single factor. He also suggests that although production probably increases with an increase in the number of niches, the maximum production of a particular species may be reached in a habitat with no other species, at least at the same food level, even though some of the niches may thereby be left vacant. Recall that the standing crop of brook trout in Petty Harbour Long Pond, a fairly unproductive one-species lake, was 5.42 pounds per acre, and in Thomas Pond, a more productive two species lake, there were 15.3 pounds of salmonids (brook trout and ouananiche) per acre.

Brook trout, ouananiche, and brown trout may be insectivorous or piscivorous in various lakes and, in fact, may thrive in habitats which would not be considered ideal or normal habitat elsewhere. Generally, in most small, shallow Newfoundland lakes, such as Paddys Pond, brook trout, ouananiche, and sometimes other salmonids are the only fish species besides the American eel. In this situation, the salmonid is generally insectivorous, taking mostly benthos but occasionally feeding on plankters. According to the well-known phenomenon referred to as the Eltonian pyramid of numbers (Carlander, 1955), this means that salmonid production in this type of lake may be more efficient than in a lake where other fish are also present. In such a lake, the food chain is shorter since one trophic level (forage fish) is completely eliminated and in the absence of competitors, all fish production is in the form of valuable salmonids. It appears that salmonid production in this type of lake is fairly high. It is probable that standing crops of salmonids in some of Newfoundland's shallow lakes (particularly on the west coast where water quality is much higher) are much higher than 23 pounds per acre.

E. Reproduction

Salmonid populations generally are quite resilient despite heavy exploitation by anglers and great reduction by natural causes. It is, therefore, of considerable importance to have information concerning the reproductive ability of such populations. In considering the reproductive ability of Paddys Pond Salmonidae, several aspects were of concern. These were (1) fecundity, (2) egg deposition, and (3) spawning.

1. Fecundity

Salmonid fecundity is defined as the number of ripe eggs present in the ovaries just prior to spawning (Vladykov, 1956).

a. Methods. None of the spawning stock of Paddys Pond Salmonidae were sacrificed for fecundity study because it was felt the data available on numerous other populations of Newfoundland fish would be generally representative of salmonid fecundity in Paddys Pond.

The data on brook trout fecundity, which were collected during an earlier study at Petty Harbour Long Pond and at several other Newfoundland lakes (Wiseman, 1969, 1970), were used and assumed to be representative for Paddys Pond brook trout. For details on sampling and enumeration procedures used see Wiseman (1970).

Information on ouananiche fecundity was obtained from a sample of 347 mature female ouananiche collected from several Avalon Peninsula lakes during studies in 1967 and 1968. In addition, data on 32 mature fish collected by Leggett (1965) were used to give a combined sample of 379 mature fish.

The fecundity of brown trout was determined by combining the data on three Avalon Peninsula brown trout populations given by Liew (1969). Although the total sample size was small (34 fish), it is felt the data are representative of brown trout fecundity generally.

b. Variation with Size of the Fish. The relationship between the number of eggs and fish length is curvilinear for salmonids (Ricker, 1932; Smith, 1944; Allen, 1951; Vladykov, 1956; Rounsefell, 1957; McFadden *et al*, 1965; and Wiseman, 1969). The relationship between egg number and fish length is exponential of the form, $F = aL^n$.

The mature female fish of each species were arranged into 2.0 cm. fork-length-classes and the mean number of mature eggs was calculated for each length-class. Scatter plots indicated curvilinear relationships. The empirical data were than fitted to a log regression of the form Log F = n log L + log a, the logarithm form of the exponential $F = aL^n$. The expressions calculated for brook trout, ouananiche, and brown trout are presented in Table XXVII.

Table XXVII. Calculated fecundity - fork length relationships for brook trout, ouananiche, and brown trout in Paddys Pond.

Species	Log Regression Form	Exponential Form
Brook trout	Log F = 3.1563 Log L - 1.5642	$F = .002728\ L^{3.1563}$
Ouananiche	Log F = 3.1981 Log L - 1.9223	$F = .001196L^{3.1981}$
Brown trout	Log F = 2.1845 Log L - 0.3998	$F = .03983L^{2.1845}$

2. Potential Egg Deposition

Having population estimates and knowing the number and size distribution of mature fish, it is a relatively simple procedure to estimate potential egg deposition.

a. Brook trout. Potential egg deposition estimates for the years 1969, 1970, and 1971 are given in Table XXVIII. A fairly large number of size-classes and age-groups contribute to egg production in Paddys Pond. Older, and consequently larger, trout produce many more eggs per individual than do smaller ones. Since these fish are proportionately less numerous in a heavily-exploited stock, they contribute a smaller share to total egg production than would fish of comparable ages in lightly-exploited stocks. Indeed, as McFadden (1961) points out, under heavy angling pressure a large proportion of the older fish are harvested, and the population may move towards dependence upon a single age-group for reproduction. As this change takes place, the dampening effect which a multiple age-group structure of spawning stock has on population fluctuations will diminish. The population would then become potentially less stable unless some other compensating mechanism takes over. During the spawning period in 1969, 1970, and 1971, the estimated potential deposition in Paddys Pond was 935,817; 813,319; and 996,746 eggs, respectively.

In salmonids an average 0.5 percent of egg production is lost through retention (Brown and Kamp, 1942; Hobbs, 1948; and Allen, 1951). Additional loss occurs during spawning when some eggs may not be deposited in the redd and suitably covered with gravel. Hobbs (1948) used a working estimate of 2 percent as the amount of eggs not correctly buried.

Losses from fish predation on recently-spawned trout eggs is considered insignificant (Greeley, 1932). The limited fish fauna makes this consideration even less important in Paddys Pond. Using a working estimate of 0.5 percent loss from egg retention and 2.0 percent unburied loss, we estimate 912,515, 793,067, and 971,927 eggs were deposited during the falls of 1969, 1970, and 1971 respectively.

McFadden (1961) suggests a 90 percent survival rate from egg to swimming fry. On this basis the expected number of fry emerging in 1970, 1971, and 1972 at Paddys Pond would be 821,264, 693,760, and 874,734 respectively.

Table XXVIII. Estimated potential egg deposition by brook trout in Paddys Pond during 1969, 1970, and 1971.

Fork length class-mark (cm.)	Percent mature females in the population by class interval	Calculated no. of eggs per female	1969		1970		1971	
			No. fish	No. eggs	No. fish	No. eggs	No. fish	No. eggs
14.55	6.32	128	394	50,432	469	60,032	391	50,048
16.55	19.67	192	1135	217,920	1357	260,054	1265	242,880
18.55	31.25	275	918	252,450	801	220,275	928	255,200
20.55	50.59	380	635	241,300	367	139,460	732	278,160
22.55	58.04	509	273	138,957	218	110,962	292	148,628
24.55	54.72	666	33	21,978	30	19,980	27	17,982
26.55	60.00	852	15	12,780	3	2,556	2	1,704
28.55	50.00	1072	-	-	-	-	2	2,144
TOTAL			3403	935,817	3245	813,319	3,639	996,746

McFadden (1961) also suggests the survival of young-of-the-year for the first 9 months following emergence averages 2.0 percent, but can vary from 0.1 to 11.4 percent. Cooper (1953) gives a survival rate of 2.7 percent for the first nine months of life. Smith (1944) suggests egg-to-fall fingerling survival can range from 3.6 to 42.4 percent and Brasch et al (1962) report survival of 1.0 to 2.0 percent. Using 2.0 to 4.0 percent as my working estimates, the expected number of fall fingerlings in 1970, 1971, and 1972 would be 16.425 - 32,875 - 27,750, and 17,495 - 34,990 respectively.

The calculated population of fall fingerlings during 1969, 1970, and 1971 was 84,131, 99,193, and 92,226 respectively. To produce this number of fall fingerlings from the known egg deposition, the fry survival rate would have to be about 10 - 12 percent. This figure is somewhat higher than normally quoted but well within expected limits. Indeed, it was estimated that the survival of young-of-the-year brook trout in Thomas Pond was about 12 percent (Wiseman, 1971).

Density-dependent factors, such as food, space, and cover, are considered by many to be the prime agents of population control. McFadden (1961) suggests the mortality rate from egg-to-fall fingerling is inversely related to the initial density of the young trout, primarily, and of the numbers of adults, secondly. The situation at Paddys Pond, where brook trout fry are almost the only fish inhabiting the shallow shoreline areas, probably reduces the intraspecific competition substantially and thus may be conducive to increased fry survival. McFadden suggests that beyond nine months, survival of brook trout does not appear to be density-dependent. Thus, strong year-classes may be produced from low egg deposition if fry survival is higher than usual.

b. Ouananiche. Potential egg deposition estimates for the years 1969, 1970, and 1971 are given in Table XXIX.

In contrast to the brook trout, relatively few size-classes and age-groups contribute to egg production; a similar situation exists for ouananiche spawning stocks in Thomas Pond (Wiseman, 1971). Because ouananiche populations are generally more stable than brook trout populations, this dependence upon few age-groups for reproduction is not really detrimental, assuming recruitment and mortality remain fairly constant. However, should intensive angling over-harvest the older fish, the situation would then be much more serious than one in which older brook trout were over-cropped. If older trout are removed from the population, the egg production by younger age-groups may still be sufficient. However, egg production by ouananiche of comparable younger ages is insignificant.

During the spawning period in 1969, 1970, and 1971, the estimated potential deposition was 157,990, 206,089, and 320,948 ouananiche eggs respectively. Using a working estimate of 0.5 percent loss through egg retention and 2.0 percent unburied loss, we estimate 127,972, 166,932, and 259,968 eggs were deposited during the falls of 1969, 1970, and 1971 respectively.

Warner (1963) suggests a 92 percent survival rate from egg to emerging fry. On this basis, the expected number of fry emerging in 1970, 1971, and 1972 at Paddys Pond would be 117,734, 153,577, and 237,170 respectively.

Table XXIX. Estimated potential egg deposition by ouananiche in Paddys Pond during 1969, 1970, and 1971.

Fork length class mark (cm)	Percent mature females in population	Calculated no. of eggs per female	1969		1970		1971	
			No. fish	No. eggs	No. fish	No. eggs	No. fish	No. eggs
16.55	1.92	95	20	1,900	45	4,275	33	3,135
18.55	3.50	136	35	4,760	86	11,696	79	10,744
20.55	9.60	189	75	14,175	47	8,883	183	34,587
22.55	24.19	254	94	23,876	112	28,448	422	107,188
24.55	42.98	334	177	59,118	210	70,140	366	122,244
26.55	56.49	428	100	42,800	171	73,188	93	39,804
28.55	42.86	541	21	11,361	15	8,115	6	3,246
30.55	50.00	672	-	-	2	1,344	-	-
TOTAL			522	157,990	688	206,089	1182	320,948

Havey and Warner (1970) suggest that survival from egg to fall fingerling averages 7.2 percent at Barrows Stream, Maine. Meister (1962) gives survival rates of 9.0 - 11.0 percent for fish at Cove Brook, Maine, and Elson (1957) reports survival in several New Brunswick streams to range from 6.0 - 8.0 percent. If we use 6.0 - 11.0 percent, numbers of fall fingerlings in 1970, 1971, and 1972 would range 9,479 - 17,379, 12,365 - 22,670, and 19,257 - 35,304 respectively.

The calculated population of fall fingerlings during 1969, 1970, and 1971 was 20,832; 38,904; and 40,768 respectively. To produce this number of fry from known egg deposition, the egg-to-fall fingerling survival rate would have to be considerably higher than 11 percent, which is the upper level of the range of survival rates reported in the literature. The estimated egg-to-fall fingerling survival rate at Thomas Pond was about 11 percent (Wiseman, 1971).

It is suggested that the estimate of the ouananiche population during the fall of 1969 is minimal, and hence egg deposition estimates are also minimal. However, the total number of estimated spawners present during the fall of 1970, at which time it is assumed population estimates were more accurate, is not much higher than the number estimated to have been present during 1969. Approximately twice as many spawners were present during the fall of 1971 and this occurrence is attributed to the strong 1967 and 1968 year-classes.

During the course of mark-recapture experiments conducted during the fall of 1971, it seemed that mature male ouananiche greatly out-numbered mature females in the trap-net catches. There was some suspicion that the females were not being caught in direct proportion to their population strength, and for this reason it was decided to continue mark-recapture experiments for an additional week. The proportion of ripe female fish did not increase and the percentage of marked-recaptures over the number of fish marked remained remarkably similar for both sexes. These results indicated that the mature female fish were taken by trap-nets in proportion to their numbers in the population, and that the number of female spawners was low. It must then be assumed that, either fry-to-fall fingerling survival rate is unusually high in Paddys Pond, or that estimates of the numbers of 0^+ fish are too high; this latter assumption would have very little basis in the author's opinion.

c. Brown trout. Potential egg deposition estimates for 1969, 1970, and 1971 are given in Table XXX.

Like the brook trout, a fairly substantial number of size-classes and age-groups contribute to egg production. The value of having a number of age-groups contribute to the total egg production of a stock has been discussed for brook trout and has a similar application for brown trout.

During 1969, 1970, and 1971, the estimated potential deposition was 1,077,110, 1,458,283, and 1,349,170 eggs respectively. Brown trout in Paddys Pond produce as many eggs as the brook trout and ouananiche combined.

Using similar estimates for loss through egg retention and unburied loss as were used for the other two species, we estimate 1,050,339, 1,421,972, and 1,315,576 eggs were deposited during the falls of 1969, 1970, and 1971 respectively.

Table XXX. Estimated potential egg deposition by brown trout in Paddys Pond during 1969, 1970, and 1971 (fecundity data from Liew, 1969).

Fork length class mark (cm.)	Percent mature females in the population	Calculated no. of eggs per female	1969		1970		1971	
			No. fish	No. eggs	No. fish	No. eggs	No. fish	No. eggs
22.55	5.71	360	74	26,640	101	36,360	78	28,080
24.55	14.63	433	233	100,889	97	42,001	592	256,336
26.55	23.38	514	657	337,698	362	186,068	539	277,046
28.55	42.03	603	302	182,106	514	309,942	268	161,604
30.55	46.94	699	211	147,489	802	560,598	475	332,025
32.55	36.17	803	207	166,221	291	233,673	176	141,328
34.55	53.33	914	89	81,346	46	42,044	100	91,400
36.55	50.00	1034	10	10,340	26	26,884	38	39,292
38.55	50.00	1161	21	24,381	8	9,288	19	22,059
52.55	50.00	2285	-	-	5	11,425	-	-
TOTAL			1084	1,077,110	2252	1,458,283	2285	1,349,170

Hobbs (1948) suggests a 90 percent survival rate from egg to emerging fry, and Le Cren (1961) gives a survival figure of 94 percent. On the basis of 90 percent survival, the expected number of brown trout fry emerging in 1970, 1971, and 1972 at Paddys Pond would be 945,302, 1,279,775, and 1,184,018 respectively.

Allen (1951) suggests that survival of emerging brown trout fry to the fall fingerling stage approximates 1.5 percent, while Le Cren (1961) gives a survival value of 2.7 percent. Using a working estimate of 2 percent, we expected the number of fry surviving to the falls of 1970, 1971, and 1972 would be 18,904, 25,596, and 23,680 fish respectively.

The calculated populations of fall fingerlings during 1969, 1970, and 1971 were 56,576, 92,736, and 63,872 respectively. To produce this number of fall fingerlings from the known egg deposition the fry survival rate would have to be about 6 percent. Although this estimate may be somewhat higher than literature values, it is substantially lower than apparent survival estimates for both brook trout and ouananiche in Paddys Pond.

Generally then, all three salmonid species are experiencing very favourable fry survival rates in Paddys Pond. Emerging fry-to-fall fingerling survival in both brook trout and ouananiche is about 11 - 12 percent, and approximately 6 percent of emerging brown trout fry reach the fall fingerling stage. The relatively high fry survival rates are attributed, for the most part, to density - dependent factors (reduced intraspecific and interspecific competition from other salmonid fry, and non-existent competition from any other species).

3. Spawning

a. Spawning Period. During the falls of 1969, 1970, and 1971, brook trout generally commenced spawning at Paddys Pond between the first and second weeks in October. The spawning peak was generally reached during the third week, and spawning activity is generally completed by October 31.

Ouananiche spawn in Paddys Pond at a somewhat later date than brook trout. Activity generally starts during the last week in October and reaches a peak during the first week in November. Spawning activity is considered to be over by mid-November.

Brown trout are the latest salmonid species to spawn in Paddys Pond. Browns generally begin spawning activity during the last week in October or the first week in November. The peak in activity usually occurs during mid-to-late November, and spawning may continue into the first week in December.

b. Spawning Areas. Two known major spawning areas for brook trout, ouananiche, and brown trout exist at Paddys Pond. In addition, two other areas are suspected to be used by one or more of the species (Table XXX).

The known areas are (1) the inlet stream from Thomas Pond via Western Pond, and (2) the inlet stream from Whiteways Gullies. The suspected areas are (1) the shoreline of Paddys Pond and (2) the small inlet stream draining an area north of Paddys Pond.

The inlet stream bringing the flow from Thomas Pond (Fig. 6) is without question a major spawning area for all three species and a major nursery area for both ouananiche and brown trout in particular. The river is

Table XXXI. Description of known and suspected spawning areas for brook trout, ouananiche, and brown trout in Paddys Pond.

Section		Outflow from Thomas Pond; from Western Pond	Whiteways Brook; from Whiteways Gullies	Shoreline of Paddys Pond	North inlet
Width (ft.)		14.5	3.2	-	3.0
Length (ft.)		1660	5220	-	2000
Depth (ft.)		1.3	0.4	-	0.3
Area (sq.ft.)		24,150	16,720	-	6000
Sq. ft. of suitable spawning area		9,419	6,521	Not determined	2,100
Quality of spawning area		Good	Good	Good in terms of substrate; extent of aeration unknown	Good
No. of redds observed		Numerous	Numerous	Nil	Nil-obstructed during survey
Bottom composition (Percent)	Bedrock	23	9	-	5
	Boulder	9	23	5	20
	Rubble	49	24	40	30
	Gravel	14	27	40	20
	Sand	3	5	15	10
	Mud & silt	2	12	-	5
Comments		Known major spawning area for all three species. Excellent rearing area, good tree cover.	Known major spawning area for all three species. There are two exceptionally good areas in this brook: (1) Pool near T.C.H. and (2) Section immediately above the pond. Excellent rearing area, heavy tree cover.	Shoreline of Paddys Pond is suspected as being a major spawning area for brook trout in particular, but possibly for the other two species as well	Fairly good spawning substrate. Fairly good rearing area, heavy tree cover. Stream was obstructed at the mouth by an abandoned beaver dam which was removed during the fall of 1971.

approximately one mile in length. Spawning is confined, for Paddys Pond fish, to the first 1700 feet of river (Paddys Pond to Western Pond). Above Western Pond, the river has been channeled from Thomas Pond and this section is deep (6 feet) and flows slowly. Western Pond sustains good populations of all three species, and the stocks from both ponds undoubtedly utilize much of the same spawning area. The substrate of the lower section of this river is rated good for spawning purposes and excellent for rearing. Because this river carries a released flow from Thomas Pond, fluctuation in flow occurs throughout the year. Although low flow may occur at time of spawning, it is never low enough to prevent upstream migration; however, the effects of extreme high flows during winter and early spring may very well result in dislodged eggs or alevins. Although the effects of these severe fluctuations in flow on egg and fry survival is not known, it may be postulated that fluctuation in year-class strength may very well be related to flow conditions during, and immediately after, incubation. The effect of reduced flows in late spring and summer may very well be the emigration of juvenile fish into the lake; however, this has not yet been documented.

The second known major spawning area for Paddys Pond fish stocks is the inlet stream draining Whiteways Gullies (Fig. 11). Whiteways Brook is approximately one mile in length and is a spawning area for all three species as well as a rearing area for browns and ouananiche. There are two excellent spawning areas in this brook. The first, 900 feet upstream from Paddys Pond, is composed of approximately 75 percent gravel and has dense brush and tree cover. A second good spawning area is a large, shallow pool located along the Trans-Canada Highway 2700 feet upstream from the lake (Fig. 22).

Figure 22. Pool on Whiteways Brook located along the side of the Trans-Canada Highway.

This pool is approximately 40 feet long and 12 feet wide with an average depth of 9 inches; 65 percent of the substrate is gravel.

Data given in Table XXXI indicate there are only approximately 16,000 square feet of known spawning area for Paddys Pond brook trout, ouananiche, and brown trout.

The inlet stream draining a marshy area to the north of Paddys Pond (Fig. 12) was found to have limited areas of good spawning material (2,000 sq. ft.), however, this stream was obstructed at its mouth by an abandoned beaver dam. No evidence of spawning was seen during a spawning survey conducted during 1971. It is expected that fish could enter this brook during periods of particularly high flow.

The only other drainage system of any size contributing to Paddys Pond is a small system originating in bog and marshland west of Cochrane Pond (Fig. 10). An examination of this brook indicated it was almost totally unsuitable for spawning purposes since its bottom-type composition was almost entirely organic.

Including the small, obstructed drainage system, the total area of suitable stream-spawning habitat for Paddys Pond fish is 18,000 square feet. Since this area seems rather small in comparison to the estimated spawning escapements, it is suspected that the fish shore-spawn to a great extent. The shore-spawning habits of brook trout are well-documented (Reimers, 1958; Needham, 1961; and McAfee, 1966), and areas of lake shoreline where upwelling seep water occurs are often preferred over streams. The shore-spawning habits of ouananiche and brown trout are not as well-documented. Leggett (1965) reports a suggestion by Fishery Officer Thomas Curran that ouananiche spawn on the shore of North Pond (near Gambo) where they share a spawning area with brook trout. Eddy and Surber (1960) found that brown trout spawned in Lake Superior on rocky reefs close to shore. Liew (1969) reports brown trout spawning on the shallow rocky shores of Windsor Lake, near St. John's. He concludes that brown trout are able to shore-spawn even where there is no suitable gravel available.

As was suggested earlier in a consideration of the water quality of Paddys Pond, considerable areas of upwelling ground water are suspected in the lake. These areas of upwelling occurring in conjunction with gravel or rubble bottom would provide excellent spawning beds, and it may be assumed that survival of eggs deposited under these conditions would be high.

c. Size and Sex Ratio of the Spawners. Data in Table XXXII indicate that in brook trout and ouananiche spawning stocks males are significantly smaller than females ($p < 0.01$). Mature male and female brown trout, on the other hand, show no difference in size ($p = 0.46$), although the sample was small. Generally, in spawning runs of non-anadromous salmonids, the mean size of the males is smaller because of their younger average spawning age.

The sex ratio of mature brook trout and brown trout captured during the spawning runs was approximately 1:1 for both species (Table XXXII). However mature male ouananiche outnumbered female fish by approximately 3:1.

Table XXXII. Comparison of the size (cm.) of mature male and female brook trout, ouananiche, and brown trout captured just prior to spawning during the fall of 1971 at Paddys Pond.

Species	Sex	Mean fork length (cm.)	Range	No.	S.D.	p value
Brook trout	Male	18.27	10.3 - 28.2	1272	2.46	<0.01
	Female	19.12	13.6 - 28.4	1269	2.05	
Ouananiche	Male	21.83	12.2 - 27.8	885	2.41	<0.01
	Female	22.92	17.2 - 27.2	304	2.06	
Brown trout	Male	29.29	20.3 - 36.9	46	3.40	0.46
	Female	28.77	23.2 - 37.7	46	3.46	

IV. THE SPORT FISHERY

A. Introduction

Angling is as much a part of the environment as the strictly "natural forces" to which fish populations are exposed. Angling is not only an important ecological factor affecting fish populations but is of great esthetic and economic importance to Man.

The sport of angling undoubtedly means very different things to different people. Because of this, sport fishing has been able to serve the recreational needs of a heterogeneous human population through periods of rapid social and economic change. But although the viability of the sport to date has been encouraging, what can we expect concerning its survival in the future? The present situation regarding sport fishing in North America is that the angler has refined and perfected his techniques to a point that his chief concern is to ensure that an exploitable resource remains at his disposal. To put it simply, the number of anglers is, at present, greater than ever and their fishing methods are more efficient. However, the amount of sportfish water is slowly but surely decreasing as more and more fresh waters are polluted or abstracted for industrial use. It is estimated that, by the year 2000, 18 percent of the population of North America will be sport fishermen, that they will fish an average of 20 times per year, and that 70 percent of this fishing activity will take place in fresh waters (McFadden, 1969). Management of sport fisheries, although not an uniquely modern idea, is now receiving more urgent attention than ever before.

Although it may be difficult to control most of the natural ecological factors affecting the abundance of a sport fish population, angling can be regulated to maximize the value of a sport fish resource. Therefore, it is imperative that, we as managers, devote a considerable effort to the study of sport fishing and fishermen and the analysis of catches in order to provide information for best management of sport fisheries.

Angling is essentially predation by Man upon a sport fish. It seems logical to assume that a somewhat predictable quantitative relationship exists between predator and prey although this predation is of a specialized nature.

The rate of exploitation is affected by numerous factors such as population density, fishing pressure, angler proficiency, temporal distribution of angling throughout the day and season, angling regulations, size and age of the fish, catchability of individual fish as well as the species, natural mortality concurrent with angling, physical differences in and location of the lake which influence the ease with which fishing may be carried out, weather, and numerous other factors.

B. Methods

Information on the salmonid sport fishery at Paddys Pond was obtained by conducting a creel census. Lack of human and monetary resources prevented conduct of a complete census and resulted in the choice of the partial census as recommended by Best and Boles (1956), which is stratified by calendar months. This census was used quite successfully during two years of study at Thomas Pond (Wiseman, 1971). Best and Boles suggest that when monetary, or other considerations, limit the number of census days to approximately 25 percent of the fishing days, the best overall coverage of the entire season will be obtained from a creel census involving stratification by calendar months.

In order to obtain an even distribution of sampling, Best and Boles stratified the fishing season into the number of calendar months comprising the season with the restriction that each day of the week was to be sampled only once each month (our census was modified somewhat in that most statutory holidays were also census days). A table of random numbers was employed in the selection of census days. The days of each month were numbered 1 to 30 (or 31) and each month was treated separately.

Creel censuses were conducted during the open-water seasons of 1970 and 1971, and a winter census of ice-fishermen was also conducted during 1970. In addition, information on the 1971 winter fishery was obtained from data supplied by Guardian M. King of the Conservation and Protection Branch, Fisheries Service. Both the 1970 and 1971 open-water censuses were conducted during the period May - September, while the 1970 winter census was conducted during January and February.

The existence of four major routes of access to the lake complicated the creel census somewhat; however, it is felt the census was 90 percent complete in its daily coverage. Creel census clerks interviewed anglers as they returned to their cars at the close of their day's fishing.

The following information was obtained from each angler fishing from shore or from a boat and recorded upon a creel census form: (a) hours of fishing to the nearest quarter-hour, whether any fish were taken or not,

(b) time of day fishing trip began and ended, (c) number and species of fish creeled, (d) number of creeled fish marked during mark-recapture experiments, (e) type of lure used, and (f) length of each fish to the nearest millimeter. Scale samples were taken from unusually large fish for age determination. Age composition of all other fish in the creel were determined from age-length keys compiled during the population studies. Average weight of creeled fish was calculated from the lengths of the fish using length-weight tables compiled during growth studies.

Successful fishing trips are defined as those during which at least one fish was caught and killed, although this definition is sometimes misleading since proficient anglers may choose to release all the fish they catch. During 1970 and 1971, there was no minimum size limit on brook trout; however, both ouananiche and brown trout had an 8-inch minimum size limit. The daily bag limit was 24 fish, or 10 pounds plus 1 fish, whichever is the lesser. The limit applies both to a single-species bag, as well as a mixed bag.

The angling season opened on January 15 and closed on September 30 during the two years of study. Angling was permitted twenty-four hours daily.

As was suggested above, the census was considered to be 90 percent complete on census days. Occasionally anglers avoided the checking area by entering the study area over a more difficult route or were overlooked during the evening "rush". Sometimes it was impossible to get all the desired information from each creel since some anglers had either lost some fish, given some away, or had eaten some of the catch.

C. Fishing Pressure

Paddys Pond, along with Thomas Pond (Wiseman, 1971) is undoubtedly one of the most heavily-fished lakes in insular Newfoundland. Like Thomas Pond, this distinction is attributed to (1) its proximity to the City of St. John's, (2) its location near the Trans-Canada Highway, (3) its past history of high angler-success and quality fishing, (4) its present status as a lake offering medium quality fishing, and (5) its moderately good accessibility to boat fishermen.

Prior to start in construction of the Trans-Canada Highway during 1958, Paddys Pond was fished only by the more ardent and adventurous of sport fishermen. Vehicle access was limited to Fowlers Road which joins the Conception Bay Highway at Chamberlains. Prior to inundation by the Newfoundland Light and Power Company Limited in 1931-32, the access via Fowlers Road was limited to all but work-type vehicles. With construction of the new diversion dam and expansion of the demand on the upper Manuels River drainage during 1956, the road was upgraded and has been maintained in a condition suitable for passenger vehicles ever since. With impoundment of Thomas Pond during 1956, the road was extended to this lake and as a result there is now vehicle access to Paddys Pond via the T.C.H. - Fowlers Road junction (Fig. 1). Access to Paddys Pond during the pre - T.C.H. period was possible from the Goulds - Kilbride area via the Heavy Tree Road to Cochrane Pond and from there by foot. In addition, a trail led from the Donovans area to Paddys Pond.

With improved access came increasing fishing pressure and large catches. The ease with which quality fish could be taken resulted in widespread publicity, and during the early to mid-sixties fishing pressure and harvest increased significantly. There is some indication that this pressure and harvest reached an all-time high during 1971, although the quality of fishing has perhaps declined substantially.

1. Fishing Sites

The most popular fishing site for shore fishermen, during the open-water season, is along the shoreline in the immediate area of the Trans-Canada Highway (Figs. 23 and 24).

Figure 23. The area of Paddys Pond shoreline most frequented by shore fishermen.

Figure 24. Fishermen fishing along Paddys Pond in the immediate area of the Trans-Canada Highway.

The second most popular shoreline site for fishermen is along the rock-fill diversion dam (Figure 4). Access to this popular site is via a short lane leading off Fowlers Road (Figure 25).

Another fairly popular shore fishing site is at the mouth of the main inlet entering Paddys Pond (Figure 6). Access to this point is via a short trail from Fowlers Road.

Two other popular fishing sites are the wharf of the sea-plane base (Figure 8) and a portion of shoreline just west of the Provincial Government Depot, accessible via a short trail from the Trans-Canada Highway.

Figure 25. The short lane leading from Fowlers Road to the diversion dam on Paddys Pond.

Generally, except during periods of extremely high water level, the entire shoreline of Paddys Pond is usable by shore fishermen.

Ice fishermen usually distribute themselves randomly along the perimeter of the lake, but there is some activity in the central portions of the lake. Some concentration of effort usually occurs near the major inlet stream and in the vicinity of the islands.

Boat fishermen distribute themselves rather randomly throughout the lake. Sites favoured by boat fishermen include the areas near inlet streams, quiet coves, and shoals in the immediate area of islands.

There are four access points available to fishermen with boats. The best and most-used boat access point is located directly off a paved rest-lane immediate to the Trans-Canada Highway (Figures 26 and 27). The popularity of this site is due to the nearby parking facilities.

The second most frequently-used boat access is a gravel, launching strip leading directly from the T.C.H. to the lake (Figure 28). This site is less popular because of the hazard involved in leaving and re-entering highway traffic, the immediate area of highway is a "no-parking" zone, and difficulty is experienced in manoeuvring car and trailer in the loosely-gravelled, sharply-inclined launch-way.

Figure 26. A gravel-surface launching site, the most popular boat access point at Paddys Pond.

Figure 27. Paved-surface rest lane, popular parking area for both boat and shore fishermen.

Figure 28. Gravel-surface launching strip leading directly from the Trans-Canada Highway to the lake.

A third site where fishermen may launch boats is in the immediate area of the diversion dam. Access is via Fowlers Road (Figure 25), and fishermen reach this area from both the Conception Bay Highway and the Trans-Canada Highway.

An infrequently-used access point is the wooden slip-way used by aircraft at the Provincial Government sea plane base. Although the area is off-limits to the public, occasional use of the facility is made by anglers, particularly during weekends and evenings.

Although there are four access points available to boat fishermen, each has some limitation. For this reason boating activity at Paddys Pond has remained somewhat depressed during the past several years while activity at nearby Thomas Pond (where launch areas are much more suitable) is much more intense. Deterioration of fishing at Thomas Pond during the late sixties resulted in a movement of boat fishermen to Paddys Pond. This trend is illustrated by the fact that the activity of boat fishermen in 1971 was double that of 1970.

2. Fishing Methods

Inquiry about the methods and lures used by anglers revealed a strong inclination toward variety. Most anglers on Paddys Pond reported using more than one method; these methods are identical to those used by Thomas Pond fishermen (Wiseman, 1971).

Shore fishermen engage in still fishing (worm-baited hook and bobber), fly fishing, spin-cast fishing (lures as well as fly and bait), and bait fishing. Using more than one method, anglers tend to incorporate a number of types of lures into several combination, or "rigs". Popular combinations or "rigs" are (1) artificial fly and tail-bait fished on fly rods and spin-cast rods, (2) hardware lures (spinners) and bait, again fished on both types of rod, and (3) spinner and fly fished on spin-case rods.

Boat fishermen use all these methods to some extent but the most popular method for these anglers is trolling. Artificial flies, bait, spinners, and combination "rigs" are trolled using both types of rod.

3. Indices of Fishing Pressure

a. Incidence of Visible Injuries to Fish Resulting from Anglers' Lures.

During the course of mark-recapture experiments in 1969, a number of fish were examined closely for signs of having been injured by being hooked by angler's lures and subsequently either escaping from, or being released by, the angler. This information can be considered an index of fishing pressure. The data on visible injuries resulting from anglers' lures are given in Table XXXIII. Of all brook trout examined, approximately 7 percent had visible injuries; 19 percent of ouananiche were injured, and 4 percent of brown trout showed injuries. Data collected at Thomas Pond, where stocks are more heavily fished, indicated 9 percent of brook trout and 22 percent of ouananiche showed injuries. No data were available on brown trout (Wiseman, 1971).

Injuries consisted of torn and missing maxillaries, split and torn mandibles, torn or missing gill arches, torn opercula, and assorted cuts and lacerations to the head and oral region, in particular. Shetter and Allison

Table XXXIII. Incidence of visible injury to brook trout, ouananiche, and brown trout in Paddys Pond during 1969, resulting from being hooked and subsequently either escaping from, or being released by, the anglers.

Fork length class mark (cm.)	Brook trout			Ouananiche			Brown trout		
	Number examined	Number injured	Percent injured	Number examined	Number injured	Percent injured	Number examined	Number injured	Percent injured
8.55	3	-	-	5	-	-	-	-	-
10.55	44	-	-	25	-	-	6	-	-
12.55	335	3	0.9	40	-	-	21	-	-
14.55	805	33	4.1	12	2	16.7	7	-	-
16.55	275	19	6.9	69	5	7.2	1	-	-
18.55	275	25	10.2	86	17	19.8	2	-	-
20.55	252	40	15.9	62	19	30.6	4	-	-
22.55	105	14	13.3	61	17	27.9	18	-	5.6
24.55	39	9	23.1	55	15	27.3	13	-	-
26.55	1	-	-	14	7	50.0	8	-	-
28.55	-	-	-	1	-	-	19	-	-
30.55	-	-	-	-	-	-	22	3	13.6
32.55	-	-	-	-	-	-	19	1	5.3
34.55	-	-	-	-	-	-	7	1	14.3
36.55	-	-	-	-	-	-	3	-	-
40.55	-	-	-	-	-	-	1	-	-
TOTAL	2104	143	6.8*	430	82	19.1**	151	6	4.0***

* 7.0 percent of catchable brook trout had visible injuries.
** 22.8 percent of catchable ouananiche had visible injuries.
*** 5.5 percent of catchable brown trout had visible injuries.

(1955) suggest an average of 30 percent of trout hooked on baited hooks and released subsequently die, while only three percent of fish hooked on fly die. In a later paper (1958), they suggest hardware lures (spinners) are no more destructive than flies. It is interesting to speculate on the mortality rate of fish which are hooked and subsequently escape or are released, as we should remember that we are only examining the "survivors" of encounters with anglers' lures. Most injuries were external and, except for injuries to the gill area, probably would not be lethal. However, the extent of serious internal injury due to hooking could not be determined and can only be considered significant in view of the extent of external injuries. External, visible injuries are undoubtedly the result of contact with flies and spinners and the higher incidence of injuries among ouananiche is attributed to their behaviour following hooking. Ouananiche are generally more spirited in their aerial displays following hooking than are brook trout or brown trout which tend to struggle deeper beneath the surface.

It is of interest that the incidence of hook injuries is much higher in juvenile brook trout than in either juvenile ouananiche or brown trout. This difference is attributed for the most part to the fact that a significant proportion of juvenile ouananiche and brown trout are stream-resident and not available to anglers' lures since fishing is very light in the nursery streams.

b. Time of Fishing. Most of the angling pressure occurs during spring and early summer (Table XXXIV). During the period May to September, 1970, 7,311 man-hours of fishing effort were exerted at Paddys Pond. During

Table XXXIV. Angling intensity at Paddys Pond during the open-water seasons of 1970 and 1971.

Month	1970				1971			
	Man-hours per day	Man-hours per acre per day	Total man-hours	Man-hours per acre per month	Man-hours per day	Man-hours per acre per day	Total man-hours	Man-hours per acre per month
May	90	0.17	2,798	5.32	229	0.44	7,104	13.51
June	63	0.12	1,881	3.58	96	0.18	2,880	5.48
July	50	0.10	1,542	2.93	97	0.18	2,995	5.69
August	29	0.06	892	1.70	37	0.07	1,147	2.18
September	7	0.01	198	0.38	8	0.02	239	0.45
TOTAL			7,311	13.91/acre/season			14,365	27.31/acre/season

the same period in 1971, the effort increased to 14,365 man-hours. The unprecedented angling pressure at the lake during 1971 is attributed to a combination of some deterioration in the Thomas Pond sport fish population and of the presence of a substantial number of harvestable-size sport fishes in Paddys Pond. The intensity of the 1971 fishery is best demonstrated by considering the effort expended during the month of May. A total of 7,104 man-hours of effort were expended during May, 1971, approximately the same as the total for five months during 1970. During the May 24th weekend, 1,481 man-hours of angling effort were exerted at Paddys Pond which is almost 20 percent of the total effort exerted during a five-month period in 1970. This effort was expended by 641 angler-trips made at the lake at some time during the three-day weekend. On Monday, May 24, 268 anglers fished at Paddys Pond. The number of man-hours per acre per season spent at Paddys Pond during the open-water seasons of 1970 and 1971 were 13.9 and 27.3 respectively. Carlander (1950) gives a range of 18-155 man-hours per acre per year for several temperate-zone lakes. The fishing effort per acre per season at Thomas Pond was 44.1 and 35.8 for 1968 and 1969 respectively (Wiseman, 1971). The fishing pressure per acre at Paddys Pond is at most moderate by North American standards.

Relatively little angling pressure is exerted by ice-fishermen. During the winter fishery of January - February, 1970, and January - March, 1971, the angling effort averaged only 38 and 55 man-hours per week respectively. The total man-hours fished for the two seasons was 174 and 428 respectively.

Tables XXXV and XXXVI show the mean daily man-hours of angling effort per day of the week for the open-water seasons of 1970 and 1971. The distribution pattern indicates that fishing pressure is highest on weekends. This situation is usual for sport fisheries near major population centers (Churchill and Snow, 1964, and Wiseman, 1971).

The mean daily man-hours of angling effort per day of the week for the 1970 and 1971 winter fishery is shown in Tables XXXVII and XXXVIII respectively. As was the case for the open-water fishery, the winter fishery is generally conducted on the weekends.

Diurnal distribution of fishing pressure (angler presence) for the open-water seasons of 1970 and 1971 is given in Table XXXIX and is presented graphically in Figures 29 and 30. The data were calculated by two-hour intervals which tends to conceal minor variations in fishing pressure. Also, all time spent on the lake was considered as fishing time, even though many anglers carried a lunch and took time out to eat. The diurnal distributions in Figures 29 and 30 are very much skewed to the right, indicating a predominately afternoon and evening fishery. The diurnal distribution of fishing pressure at Thomas Pond during 1968 and 1969 was almost identical (Wiseman, 1971). This distribution pattern is characteristic of a fishery near an urban area.

The distribution of length of angling trips during the 1970 and 1971 open-water seasons is given in Table XL and is illustrated in Figures 31 and 32. The distributions are skewed far to the left, indicating most anglers spend relatively little time at the lake. During 1970, the average length of fishing trip was 1.8 hours, while in 1971 it was 2.3 hours.

Table XXXV. Mean daily man-hours of angling effort per day of the week and resulting catch at Paddys Pond, May to September, 1970.

Day of week	S	M	T	W	T	F	S	Weekly total
Man-hours	66	60	34	54	34	17	81	346
Catch:								
Brook trout	18	26	16	26	15	5	29	135
Ouananiche	5	9	4	3	5	2	8	36
Brown trout	3	2	1	3	3	trace	2	14
Total catch (all species)	26	37	21	32	23	7	39	185

Table XXXVI. Mean daily man-hours of angling effort per day of the week and resulting catch at Paddys Pond, May to September, 1971.

Day of week	S	M	T	W	T	F	S	Weekly total
Man-hours	203	159	38	54	43	44	160	701
Catch:								
Brook trout	40	15	14	27	10	19	41	166
Ouananiche	27	21	8	18	14	20	30	138
Brown trout	16	5	3	4	4	5	10	47
Total catch (all species)	83	41	25	49	28	44	81	351

Table XXVII. Mean daily man-hours of angling effort per day of the week and resulting catch at Paddys Pond, January and February, 1970.

Day of week	S	M	T	W	T	F	S	Weekly total
Man-hours	12	1	6	9	4	1	5	38
Total catch (all species)	2	trace	1	1	1	trace	1	6

Table XXXVIII. Mean daily man-hours of angling effort per day of the week and resulting catch at Paddys Pond, January to March, 1971.

Day of week	S	M	T	W	T	F	S	Weekly total
Man-hours	14	5	4	8	5	10	9	55
Total catch (all species)	36	12	9	21	14	26	24	140

Table XXXIX. Daily time-frequency distribution (two hour intervals) of censused angling parties at Paddys Pond during May to September, 1970 and 1971.

	1970		1971	
Time of day	Number of parties	Percent	Number of parties	Percent
3:15 - 5:15 a.m.	1	0.10	2	0.12
5:15 - 7:15	3	0.31	10	0.60
7:15 - 9:15	15	1.55	33	1.99
9:15 - 11:15	50	5.15	77	4.65
11:15 - 1:15 p.m.	62	6.39	125	7.55
1:15 - 3:15	97	10.00	191	11.53
3:15 - 5:15	134	13.81	262	15.82
5:15 - 7:15	170	17.52	332	20.05
7:15 - 9:15	326	33.60	453	27.36
9:15 - 11:15	112	11.54	171	10.33
TOTAL	970		1,656	

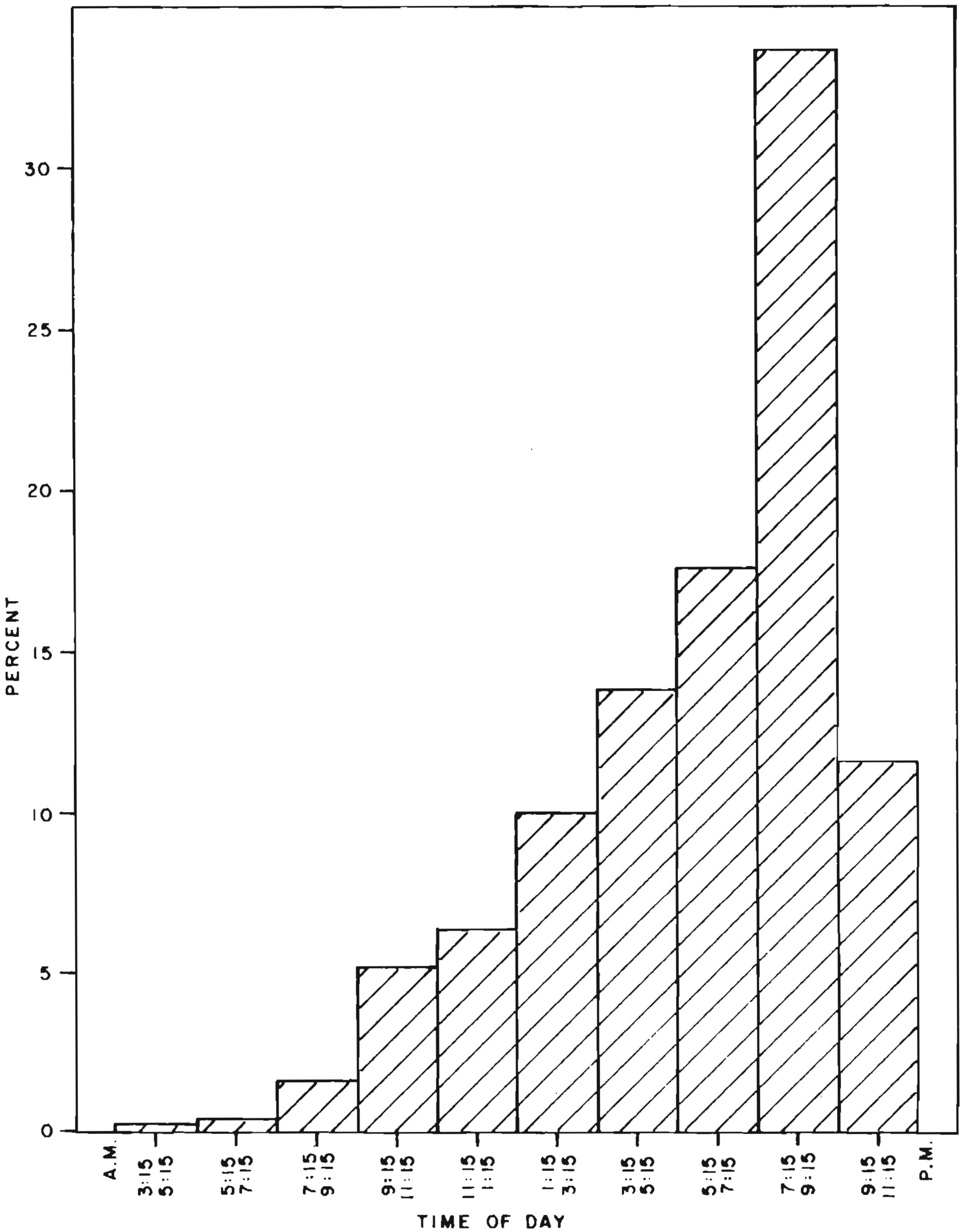

FIGURE 29 DAILY TIME FREQUENCY DISTRIBUTION OF ANGLING PARTIES AT PADDYS POND DURING MAY-SEPTEMBER, 1970.

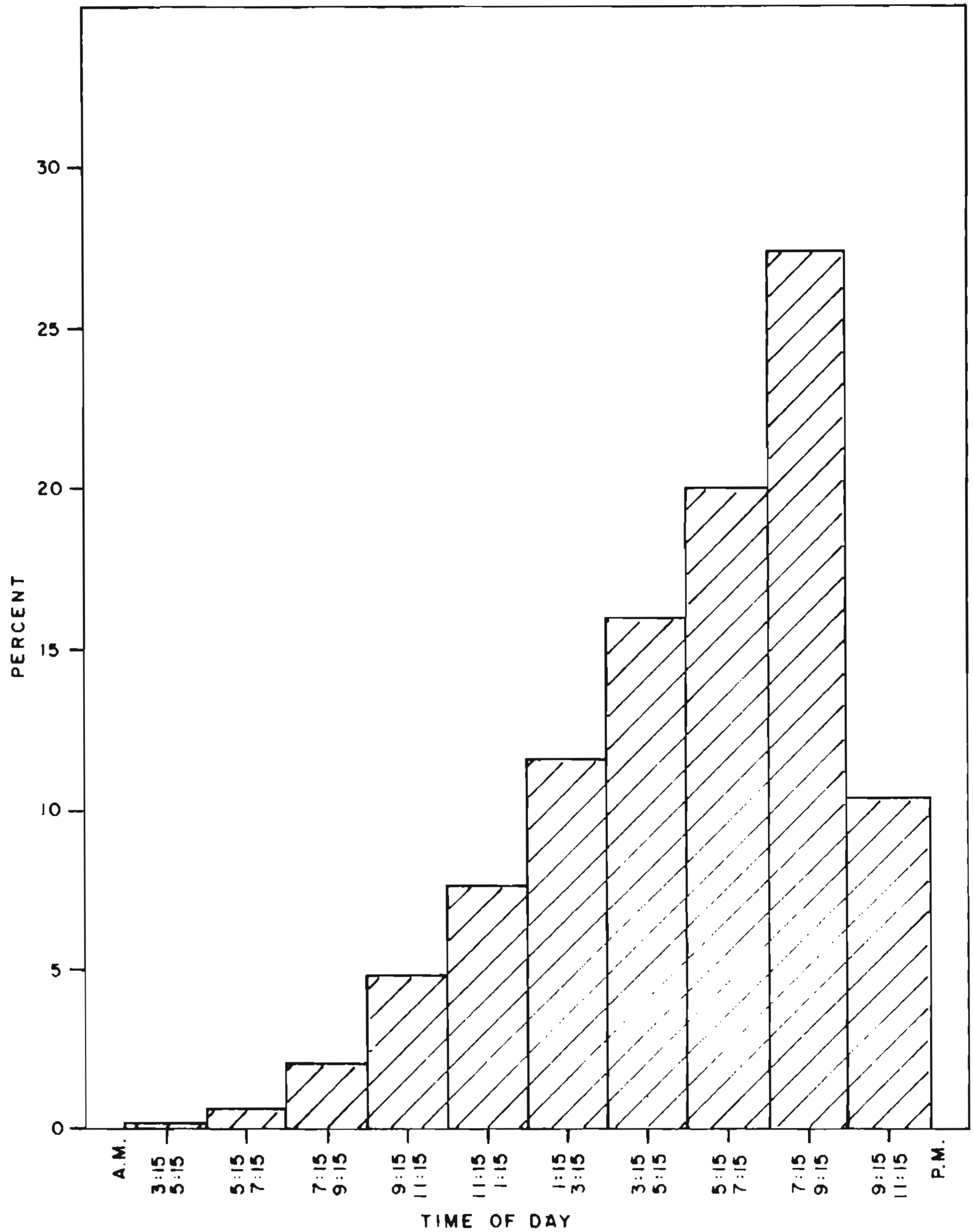

FIGURE 30 DAILY TIME FREQUENCY DISTRIBUTION OF ANGLING PARTIES AT PADDYS POND DURING MAY - SEPTEMBER, 1971.

Table XL. Distribution of time spent angling (hours) by fishing parties visiting Paddys Pond during May to September, 1970 and 1971.

Hours fished	1970		1971	
	Number of parties	Percent	Number of parties	Percent
½ - 1	184	34.9	469	26.6
1½ - 2	196	37.2	590	33.5
2½ - 3	86	16.3	369	20.9
3½ - 4	35	6.6	131	7.4
4½ - 5	11	2.1	75	4.3
5½ - 6	4	0.8	54	3.1
6½ - 7	6	1.1	27	1.5
7½ - 8	2	0.4	11	0.6
8½ - 9	2	0.4	8	0.5
9½ - 10	-	-	18	1.0
10½ - 11	-	-	1	0.1
11½ - 12	-	-	7	0.4
12½ - 13	1	0.2	-	-
13½ - 14	-	-	-	-
14½ - 15	-	-	3	0.2
Total	527		1,763	
Mean	1.8		2.3	

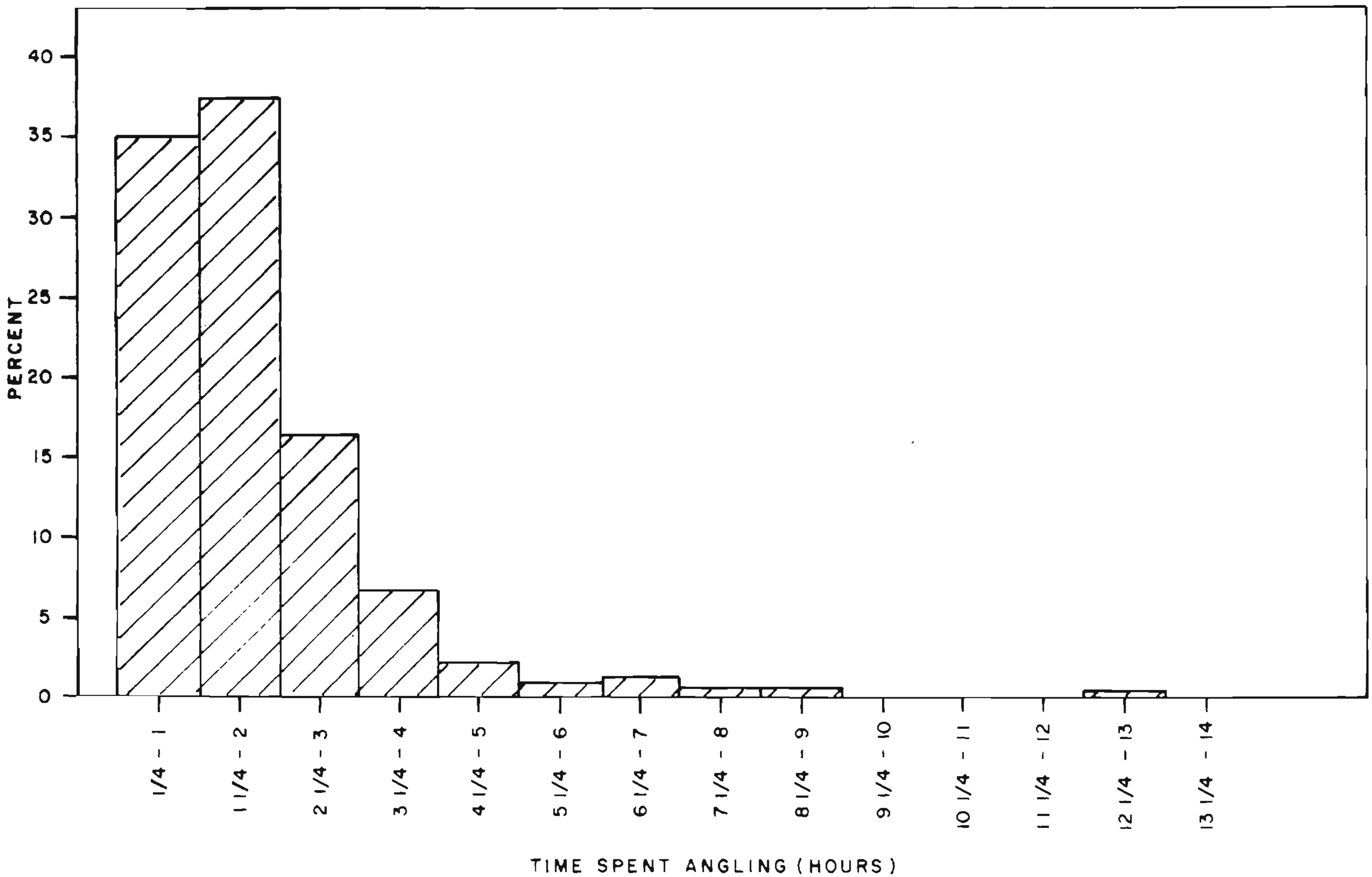

FIGURE 31 DISTRIBUTION OF TIME SPENT ANGLING (HOURS) BY FISHING PARTIES VISITING PADDYS POND DURING MAY — SEPTEMBER, 1970.

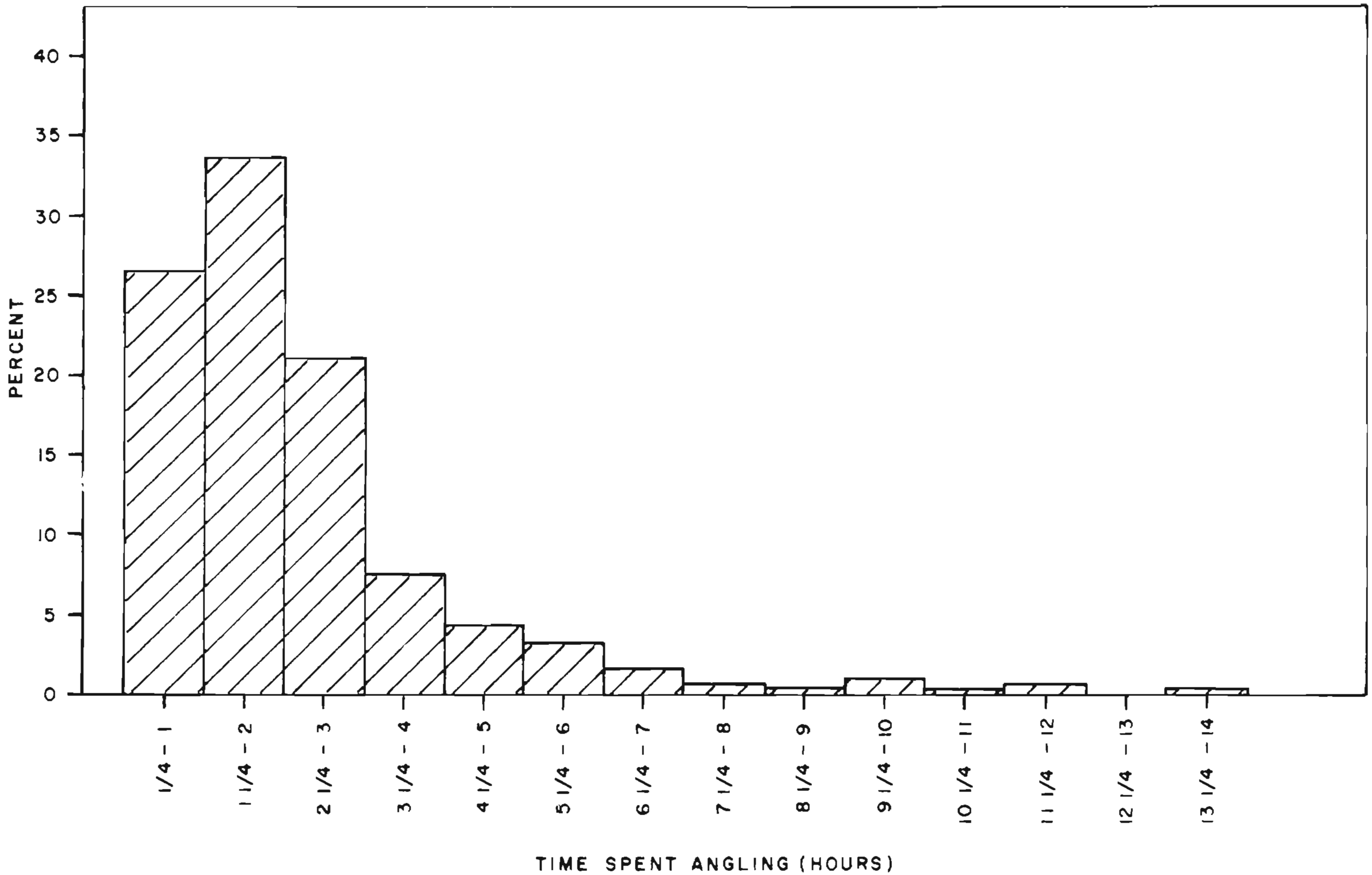

FIGURE 32 DISTRIBUTION OF TIME SPENT ANGLING (HOURS) BY FISHING PARTIES VISITING PADDYS POND DURING MAY-SEPTEMBER, 1971

Generally, the short duration of angling trips is attributed to the close proximity of the lake to the urban area. Anglers visiting more-remote lakes would be expected to spend a substantially-longer fishing period. Carlander (1950) gives a range of 2-6 hours per angling trip for numerous North American fishing spots. The reason for the significant increase in duration of fishing trips during 1971 and 1970 is not fully understood. Whether trip duration increased because the catch increased, or vice-versa, is not certain. In a reverse situation at Thomas Pond where the catch during 1969 was approximately one half that of 1968, the mean length of fishing trip decreased substantially in 1969. The increase or decrease in length of fishing trips may be purely psychological, in that the angler feels his luck, whether good or bad, is related to the amount of time he spends fishing on any given trip. It is interesting to note that although the total effort and total catch during 1971 were double that of 1970, and the mean length of fishing trips increased, there was in fact a slight decrease in the catch-per-effort.

Churchill and Snow (1964) suggest boat fishermen fish about twice as long as shore fishermen. They attribute this difference to the fact that the boat fisherman has invested more time and money in his trip than the shore angler and, therefore, is more reluctant to quit. Moreover, the boat angler can change his location more easily than the shore fisherman and is less likely to lose interest. This difference between boat and shore fisherman was also observed by Moyle and Franklin (1957). In addition, this present study, as well as the investigation at Thomas Pond, has shown that the boat fishermen is 2-3 times as successful as the shore fisherman per unit-effort. During the two open-water seasons under consideration, boat fishermen averaged 2.8 and 3.3 hours fishing per trip in comparison with 1.6 and 2.0 hours per trip for shore fishermen. During 1970, shore fishermen outnumbered boat fishermen by a little over four to one; during 1971 there were almost 6 times as many shore anglers as boat anglers.

D. The Catch

A condensation of the data from the creel censuses conducted at Paddys Pond during the period 1970 and 1971 (open-water seasons only) is presented in Table XLI. The yield of fish to the anglers at Paddys Pond was significant, particularly during 1971. However, it required considerable patience on the part of the angler since it took approximately 2 hours to catch a fish during 1970 and 1971. A similar study at Thomas Pond indicated it took 1 and 2 hours for an angler to catch a fish during 1968 and 1969, respectively (Wiseman, 1971).

During the 1970 open-water season 4,073 fish were caught during angling trips totalling 7,311 man-hours of effort. Under a fishing intensity of 13.9 man-hours per acre, Paddys Pond yielded 7.7 fish, or 1.6 pounds, per acre.

During the comparable period in 1971, 7,264 fish were creeled during angling trips totalling 14,365 man-hours of effort. Under a fishing intensity of 27.3 man-hours per acre, the lake yielded 13.8 fish, or 3.0 pounds, per acre.

Table XLI. Statistics for angling intensity and exploitation of the fish stocks of Paddys Pond, during the 1970 and 1971 open-water seasons.

Statistic	1970	1971
Total man-hours fished	7,311	14,365
Man-hours fished per acre	13.9	27.3
Number of fish creeled	4,073	7,264
Pounds of fish creeled	846.2	1600.3
Number of fish per acre	7.7	13.8
Pounds of fish per acre	1.61	3.04
Estimated production (lb./acre)	3.29	3.29
Post-season stock (lb./acre)	27.9	23.5
Number of fish per man-hour	0.56	0.51
Pounds of fish per man-hour	0.12	0.11
Number of fish per man-trip	1.0	1.1
Percent successful anglers	35.5	38.2
Percent anglers taking 50 percent of the total catch	6.1	6.8
Length of average fishing day (hours)	1.79	2.26
Average fork length of fish creeled (in.)	7.9	8.1
Average weight of fish creeled (lb.)	0.21	0.22

1. <u>Catch-per-unit-effort</u>

The unit-of-effort used in this study is the man-hour.

a. Total Yield of Fish to Anglers. During the 1970 open-water season the catch-per-effort was 0.56 fish per man-hour; the catch-per-effort during a comparable period in 1971 was only slightly less at 0.51 fish per man-hour. Although the catch-per-effort showed little variation between 1970 and 1971, the total effort rose sharply from 7,311 man-hours during 1970 to 14,365 man-hours during 1971. During an earlier study at Thomas Pond over a two-year period, although total effort remained fairly constant during both years, both total catch and catch-per-effort were almost halved during the second year following a harvest of over 3 times the maximum sustained yield during the first year. That is a textbook case of overfishing where a decreasing catch-per-effort occurs in conjunction with a constant or declining fishing effort. Such a fishery is usually operating above the maximum sustained yield, and in other words, overfishing is occurring and, if it is not alleviated, decrease in the stocks will result.

Because the maximum sustained yield was exceeded at Paddys Pond during 1971, it is suggested that if an equivalent number of man-hours is exerted during 1972, a decline in catch-per-effort will occur, and overfishing will have increased.

During four years of study of the "overfishing problems" it has become apparent that, during certain years, overharvesting of sport fish populations inhabiting heavily-fished lakes near metropolitan St. John's does occur. The long-term results of this overfishing have not yet been documented. However, experience gained at Thomas Pond indicates that the initial effect is reduced fishing pressure and harvest in subsequent years. The final long-term effects can only be speculated.

It would appear that, unless the pressure is reduced on these overfished lakes, periodic maintenance stocking of fry or fingerlings would have to be considered. On the other hand, should the pressure be reduced by encouraging the anglers to fish other less-exploited populations, the need for stocking may be eliminated.

As we shall see, boat fishermen are 2-3 times as successful as shore fishermen, and, although they may be outnumbered by 4 or 5 to one, they also tend to fish twice as long as shore fishermen. In fact then, although the numbers of boat fishermen may not be all that high, they contribute to the "overfishing problem" disproportionately to their numbers. On this basis, a program to provide additional fishing opportunity for boat fishermen on other lakes would not only lessen the pressure and harvest rate on these lakes already being "hit hard" but provide for increased utilization of stocks which are presently under-exploited.

During the winter cencus of ice-fishermen conducted from January 15 - February 15, 1970, only an estimated 28 fish (mainly brook trout) were caught during angling trips totalling 174 man-hours of effort. The catch-per-effort was a very low 0.12 per man-hour.

During the period January 15 - March 15, 1971, data collected by Guardian M. King of the Conservation and Protection Branch indicate approximately 1100 fish were caught during angling trips totalling 428 man-hours of effort. The catch-per-effort was moderately good at 2.6 per man-hour. The increase in harvest during the 1971 fishery is attributed to recruitment of the 1967 and 1968 year-classes to the fishery and to the longer duration of ice cover on the lake that winter. The upswing in the open-water harvest the following spring and summer was attributable, for the most part, to the entrance of 1967 and 1968 year-class fishes into the fishery.

Catch-per-effort figures of approximately 0.6 and 0.5 fish per man-hour, during the 1970 and 1971 open-water seasons are apparently moderately high for the Atlantic Provinces. Smith (1952) reports a range of 0.1 to 0.6 fish per man-hour for eight New Brunswick trout lakes, with data collected over a number of years from each lake. He also gives catch-per-effort figures for 4 Nova Scotia lakes. Catches-per-effort ranged from 0.2 to 0.8 fish per man-hour, again with data collected over several years from each lake. He further reports the catch-per-effort for a small (23 acres) artificial pond in Prince Edward Island to range from 1.4 to 2.5 fish per man-hour over a seven-year period. Smith concludes that these thirteen lakes represent the most and the least productive trout waters in the Maritime Provinces. The catch-per-effort was 0.94 and 0.46 at our Thomas Pond during 1968 and 1969, respectively (Wiseman, 1971).

Wales and German (1956) consider catch-per-effort figures of 0.8 to 2.1 brook trout per man-hour at Castle Lake, California, to represent "high quality" fishing. Havey and Warner (1970) report 0.051 ouananiche per man-hour is the average catch per effort in Maine Lakes. Carlander (1950) gives a range of 0.0 to 16.0 fish per man-hour for numerous North American trout lakes, with the majority of the lakes yielding less than 2 fish per man-hour.

The catch per effort in weight terms at Paddys Pond was 0.12 and 0.11 pounds of fish per man-hour during 1970 and 1971, respectively. Two years of data from Thomas Pond indicate a catch of 0.22 and 0.14 pounds of fish per man-hour (Wiseman, 1971). Rupp (1955) reports a range of 0.07 to 1.4 pounds per man-hour for several North American trout streams.

During 1970 the number of fish per man-trip at Paddys Pond averaged 1.0. In 1971, the average rose slightly, to 1.1 fish per man-trip. The catch per man-trips for two successive years at Thomas Pond was 1.9 and 1.0 fish, respectively (Wiseman, 1971).

b. Yield of Fish with Respect to Boat Versus Shore Fishing. Tables XLII and XLIII summarize the catch per man-hour during the open-water seasons of 1970 and 1971 for brook trout, ouananiche, and brown trout for boat and for shore fishermen.

Overall, the boat fishermen take a little over twice as many fish per effort as the shore fishermen. This relationship is undoubtedly the general rule in heavily-fished lakes and ponds on the Avalon Peninsula. At Thomas Pond, it was found that boat fishermen catch from 2 - 3 times as many fish per effort than anglers fishing from shore (Wiseman, 1971).

Generally, the catch per man-hour during both years, for boat and shore fishermen combined, increases from May to July, and then decreases. This trend is caused mainly by the shore fishermen's "luck", since the catch-per-hour for boat fishermen does not show a regular pattern of increase or decrease while shore fishermen generally have an increase in catch-per-effort from May to July and thence a decrease. Investigation at Thomas Pond indicated that generally catch-per-effort declined, or at best remained

Table XLII. Catch per man-hour at Paddys Pond, May to September, 1970, for both shore and boat fishermen angling for brook trout, ouananiche, and brown trout.

		Fishing site		
Month	Species	Boat	Shore	Total
May	Brook trout	0.69	0.11	0.26
	Ouananiche	0.34	0.06	0.13
	Brown trout	0.10	0.01	0.03
	Total	1.13	0.18	0.42
June	Brook trout	0.54	0.31	0.42
	Ouananiche	0.09	0.07	0.08
	Brown trout	0.06	0.02	0.04
	Total	0.69	0.40	0.54
July	Brook trout	0.79	0.59	0.66
	Ouananiche	0.09	0.08	0.08
	Brown trout	0.07	0.04	0.05
	Total	0.95	0.71	0.79
August	Brook trout	0.05	0.65	0.46
	Ouananiche	0.05	0.11	0.09
	Brown trout	0.03	0.07	0.06
	Total	0.13	0.83	0.62
September	Brook trout	-	0.62	0.39
	Ouananiche	0.06	0.24	0.17
	Brown trout	T	-	-
	Total	0.06	0.86	0.56
Open-water season summary	Brook trout	0.58	0.31	0.40
	Ouananiche	0.17	0.08	0.11
	Brown trout	0.07	0.02	0.04
	Total	0.82	0.41	0.55

Table XLIII. Catch per man-hour at Paddys Pond, May to September, 1971, for both shore and boat fishermen angling for brook trout, ouananiche, and brown trout.

		Fishing site		
Month	Species	Boat	Shore	Total
May	Brook trout	0.59	0.15	0.23
	Ouananiche	0.23	0.18	0.19
	Brown trout	0.20	0.03	0.06
	Total	1.03	0.36	0.48
June	Brook trout	0.22	0.27	0.25
	Ouananiche	0.17	0.20	0.19
	Brown trout	0.06	0.05	0.06
	Total	0.45	0.52	0.50
July	Brook trout	0.49	0.15	0.26
	Ouananiche	0.38	0.16	0.23
	Brown trout	0.23	0.05	0.11
	Total	1.10	0.36	0.60
August	Brook trout	0.42	0.10	0.17
	Ouananiche	0.40	0.07	0.14
	Brown trout	0.12	0.01	0.03
	Total	0.94	0.18	0.34
September	Brook trout	0.81	0.49	0.70
	Ouananiche	0.11	0.27	0.16
	Brown trout	0.11	0.05	0.09
	Total	1.03	0.81	0.95
Open-water season summary	Brook trout	0.46	0.16	0.24
	Ouananiche	0.26	0.17	0.07
	Brown trout	0.16	0.04	0.07
	Total	0.88	0.37	0.50

relatively constant, during the May to September period (Wiseman, 1971). It may only be concluded that a greater percentage of proficient anglers fish during the later angling season, and since Paddys Pond is a relatively-shallow, totally accessible lake, the catchability and hence availability of fish to proficient anglers does not decrease until the onset of sexual maturity occurs (August and September).

It is also interesting to note that brook trout, ouananiche, and brown trout rank 1-2-3, respectively, in terms of catchability and there is little appreciable difference in the proportions which the three species make up in the creel of either a boat or shore fishermen, although the latter is only one-half as successful per effort as the boater.

c. Yield of Fish with Respect to Type of Lure Used. No attempt was made in this study to compare the catch-per-effort for anglers using various types of lures. An investigation into this aspect of the yield was made at Thomas Pond (Wiseman, 1971) and the general conclusion was that, considering brook trout and ouananiche together, there is relatively little difference in the catch rates for bait, fly, spinner, or combination bait and fly. However, these four "rigs" are significantly more successful than either a combination of bait and spinner or fly and spinner. Brook trout were found to be more susceptible to fly and other lures used in conjunction with the fly than are ouananiche. Ouananiche, on the other hand, are more easily caught on natural bait and other lures used in combination with the bait. Thomas Pond anglers catch so few brown trout that relative effectiveness of the various lures used could not be evaluated. However, at Paddys Pond where brown trout are caught in larger numbers, the fly appears to be the most successful lure for this species. The Thomas Pond study indicated there was little evidence to show that certain lures are seasonally more successful than others. Spinners, however, were found to be most successful early in the season.

2. Total Landings

Table XLIV summarizes the data on total landings of sport fishes at Paddys Pond during the 1970 and 1971 open-water seasons. During the period May to September, 1970, 4,073 fish having a total weight of 846 pounds were harvested from Paddys Pond. During a comparable period in 1971, 7264 fish weighing a total of 1600 pounds were landed. The total landings increased approximately 80 percent from 1970 to 1971, while the effort increased approximately 95 percent. During the period May to September, 1970, the average weekly landings were 185 fish, while during the same period in 1971, the landings rose to 351 fish per week.

The landings of fish during the period May - September, 1970, approximates the total annual yield since the winter fishery was almost non-existent that year and very few fish were taken during open-water fishing during March and April.

During the winter of 1971, however, approximately 1100 fish weighing a total of 208 pounds were harvested. It is again assumed a minimum number of fish were angled during the early period of open-water fishing (mid-March to April).

Estimates of total annual yield for the two years are 852 and 1808 pounds respectively. The total weight of sport fishes harvested per acre of water surface at Paddys Pond was 1.62 pounds during 1970 and 3.44 pounds during 1971.

During two consecutive years, the total harvest per acre at Thomas Pond was 10.0 and 4.9 pounds respectively (Wiseman, 1971). Smith

Table XLIV. Total landings of sport fishes at Paddys Pond for comparable periods during 1970 and 1971.

	May - September, 1970	May - September, 1971
No. of brook trout	3016	3378
Pounds of brook trout	524.2	640.2
Pounds per acre	1.00	1.22
No. of ouananiche	757	2899
Pounds of ouananiche	178.5	556.3
Pounds per acre	0.34	1.06
No. of brown trout	300	967
Pounds of brown trout	143.5	403.8
Pounds per acre	0.27	0.77
Total no. fish landed	4073	7264
Total no. per acre	7.7	13.8
Total lb. fish landed	846.2	1600.3
Total lb. per acre	1.61	3.04

(1952) reports several New Brunswick lakes average 0.58 pounds per acre per year, with a range of 0.08 to 2.16 pounds per acre, while Nova Scotia lakes average 1.04 pounds per acre, with a range of 0.1 to 3.8 pounds per acre. A small, artificial lake in Prince Edward Island had an annual harvest of 22.4 to 44.0 pounds per acre, and Smith considered this pond one of the most productive in the Maritime Provinces. Carlander (1950) reports the yield per acre for North American trout lakes to range from 0.9 to 79 pounds.

The estimated annual production (maximum sustained yield) of sport fishes at Paddys Pond, using the method of Ryder (1965), is 3.29 pounds per acre. The angling harvest during 1971 exceeded that estimated production, indicating that over-harvesting occurred during that year. It is estimated that 1808 pounds of sport fish were harvested, thus the fishery was over-exploited by approximately 80 pounds, since the maximum sustained yield is estimated to be 1731 pounds. Although the stocks were not heavily over-harvested during 1971, that harvest may very well be the highest ever at Paddys Pond. Additional, or even equivalent, pressure exerted over the next several years would undoubtedly have an adverse effect on the stocks.

The total number of fish harvested per surface area of the lake during the open-water fishery during 1970 and 1971 was 7.7 and 13.8 respectively. The total annual harvest per acre of lake was 7.8 and 15.9 fish during 1970 and 1971 respectively.

During two successive years, the number of fish harvested per acre at Thomas Pond was 41.4 and 16.5 pounds, respectively (Wiseman, 1971). Shetter (1951) reports 9.5 trout per acre per year over a ten-year period for a Michigan lake.

3. Size and Age Composition of the Catch

Comparison of the mean size of brook trout, ouananiche, and brown trout angled at Paddys Pond during 1970 and 1971 is given in Table XLV. The average size of brook trout angled at Paddys Pond is about 7½ inches fork length, with fish ranging from 5 to 11 inches. The average

Table XLV. Comparison of the mean size (fork length, cm. and in.) of brook trout, ouananiche, and brown trout angled at Paddys Pond during the open-water seasons of 1970 and 1971.

		Month					
Year	Species	M	J	J	A	S	Annual mean size
1970	Brook trout	20.4	18.7	18.1	18.4	18.0	19.0
		8.0	7.4	7.1	7.3	7.1	7.5
	Ouananiche	22.8	22.9	14.3	19.6	20.3	21.8
		9.0	9.0	7.6	7.7	8.0	8.6
	Brown trout	27.6	26.6	26.6	26.6	*	26.9
		10.9	10.5	10.5	10.5	-	10.6
1971	Brook trout	19.4	19.2	20.0	17.9	19.0	19.4
		7.7	7.6	7.9	7.1	7.5	7.6
	Ouananiche	20.3	19.5	20.0	20.6	21.4	20.2
		8.0	7.7	7.9	8.1	8.4	7.8
	Brown trout	25.2	25.5	25.5	28.8	30.2	25.6
		9.9	10.0	10.0	11.3	11.9	10.1

* No brown trout observed during the creel census in September, 1970.

size of ouananiche in the creel is a little larger, about 8-8½ inches, with fish from 5 to 12 inches. Brown trout are the largest fish angled at Paddys Pond. Angled browns average 10-10½ inches fork length, with fish 8 to 15 inches generally.

Comparison of the mean size of fish angled each month during the open-water seasons of 1970 and 1971 indicates little difference in the size of fish caught during any particular month (Table XLV).

There was an interesting, apparent decrease in mean size of ouananiche and brown trout angled during 1971, while angled brook trout tended to be a little larger. Overall, however, the mean size of sport fishes landed during 1971 was a little greater than those landed in 1970 (Table XLV). This increase is attributed to the fact that the brook trout, dominant in the sport catch in numbers, were a little larger, and brown trout, the largest sport fish in the lake, comprised a greater proportion of the total catch in 1971 than during 1970.

There is presently no size limit for brook trout. At Paddys Pond approximately 14 percent of the brook trout harvested during 1970 were less than 6 inches long; during 1971 however, only 4 percent were less than 6 inches in length (Table XLVI). The preponderance of small trout in anglers' creels in 1970 was apparently due to the high numbers of II^+ and III^+ fish in the lake as a result of the 1967 and 1968 year-classes. These fish which averaged less than 6 inches in length during 1970 were larger during 1971. It would appear then, that the anglers at Paddys Pond and undoubtedly at other lakes, choose to keep the larger of available fish

Table XLVI. Length composition in percent for brook trout, ouananiche, and brown trout angled at Paddys Pond during the open-water seasons of 1970 and 1971.

Fork length class mark (cm.)	Brook trout 1970	Brook trout 1971	Ouananiche 1970	Ouananiche 1971	Brown trout 1970	Brown trout 1971
12.55	1.64	0.50	0.61	0.45	-	0.41
14.55	12.66	3.50	2.45	2.87	-	0.41
16.55	17.11	14.86	8.59	11.01	3.03	-
18.55	21.55	35.08	13.50	22.78	3.03	2.06
20.55	28.62	31.59	20.86	40.12	3.03	10.70
22.55	15.30	10.99	20.86	13.27	7.58	25.93
24.55	2.80	3.50	20.25	6.49	16.67	18.93
26.55	0.33	-	11.66	2.11	12.12	10.29
28.55	-	-	1.23	0.90	30.30	9.05
30.55	-	-	-	-	18.18	11.93
32.55	-	-	-	-	4.55	8.23
34.55	-	-	-	-	-	1.23
36.55	-	-	-	-	1.52	0.41
38.55	-	-	-	-	-	0.41

and this self-imposed size limit varies with the size of available fish. The numbers of brook trout less than 6 inches in length were negligible in the catch at Thomas Pond where trout are significantly larger (Wiseman, 1971). During the 1970 and 1971 fishery at Paddys Pond, the percentage of brook trout less than 8 inches in length taken by anglers was 53 and 54 respectively. Although raising the size limit on sport fishes is undoubtedly one of the most successful methods of reducing the catch, size limits must be related to growth rate of the species. For brook trout populations exhibiting slow growth rates similar to that of the Paddys Pond population, a size limit would be biologically unsound.

There is presently an 8-inch size limit on ouananiche. About 25 - 35 percent of the ouananiche creeled annually at Paddys Pond are sub-legal. At Thomas Pond, an average 15 percent of creeled ouananiche were sub-legal (Wiseman, 1971). A Province-wide size limit of 8 inches is not biologically sound, particulary for populations exhibiting relatively slow growth, as is the case for the Paddys and Thomas Pond populations. Since most ouananiche populations exhibit a growth rate similar to brook trout, it may be logical to drop the size limit on this species, particularly for populations exhibiting slow growth and early maturity, however the present size limit does have some merit as there is a need to protect anadromous salmon smolt and parr which are often found in lakes.

Brown trout also have an 8 - inch size limit. About 3 - 6 percent of fish creeled at Paddys were sub-legal (Table XLVI).

Generally then, there appears to be an inverse relationship between the percent of sub-legal fish creeled and the number of large fish of that species available to anglers. Thus the percent of sub-legal fish is lowest for that species attaining greatest sizes, and for lakes producing the largest fish. In other words, the legal size limit is generally being ignored, and the anglers regulate or condition themselves to harvest mainly the largest of existing individuals of a population.

The age composition of brook trout, ouananiche, and brown trout angled at Paddys Pond during 1970 and 1971 is given in Table XLVII. Generally, angled brook trout are younger than angled ouananiche, which in turn are younger than angled brown trout. A similar age-distribution by species was noted for Thomas Pond fish (Wiseman, 1971).

The vast majority of the brook trout angled at Paddys Pond are III^+ and IV^+ years old, with fish younger and older than those ages constituting about 10 percent of the catch. Almost no fish younger than II^+ years are taken by anglers (only one I^+ trout was observed in anglers' creels during 2 years of study), and the oldest fish known to be caught are V^+ years of age.

Ouananiche in the anglers' creels are mainly III^+, IV^+, and V^+ years old. Fish of II^+ years compose only 1-2 percent of the catch and I^+ fish are never retained by anglers. The oldest fish caught are VII^+ years of age.

The angler harvest of brown trout is composed primarily of fish aged IV^+, V^+, and VI^+ years. Very few fish as young as II^+ years are taken (1-2 percent), and the oldest observed age of angled brown trout is VII^+ years.

It is suspected that young fish of all these species contribute a larger share to the total catch as the season advances since such a situation was found to occur at nearby Thomas Pond (Wiseman, 1971). This is indicated by considering the percentage of age II^+ fish (all three species) in the 1970 catch. These fish of the 1968 year-class reached catchable size by late summer and contributed significantly to the late season harvest.

Table XLVII. Age composition of brook trout, ouananiche, and brown trout angled at Paddys Pond during the open-water seasons of 1970 and 1971 (percentages in parentheses).

Year	Species	Age							Annual mean (years plus)
		I+	II+	III+	IV+	V+	VI+	VII+	
1970	Brook trout	1	478	1174	1305	58	-	-	3.02
		(0.03)	(15.85)	(38.93)	(43.27)	(1.92)	-	-	
	Ouananiche	-	13	151	319	245	28	1	4.17
		-	(1.72)	(19.95)	(42.14)	(32.36)	(3.70)	(0.13)	
	Brown trout	-	5	21	77	123	70	4	4.81
		-	(1.67)	(7.00)	(25.67)	(41.00)	(23.33)	(1.33)	
1971	Brook trout	-	214	1602	1525	57	-	-	3.42
		-	(6.30)	(47.15)	(44.88)	(1.68)	-	-	
	Ouananiche	-	46	885	1536	390	39	3	3.83
		-	(1.59)	(30.53)	(52.98)	(13.45)	(1.35)	(0.10)	
	Brown trout	-	7	163	390	220	164	23	4.46
		-	(0.72)	(16.86)	(40.33)	(22.75)	(16.96)	(2.38)	

This same year-class continued to contribute substantially to the 1971 harvest as III^+ fish. Overall, the 1968 year-class, as II^+ fish, contributed nearly double the percentage of the total harvest as did the 1969 year-class as II^+ fish.

4. Distribution of the Catch among Anglers

Table XLVIII summarizes the data on the distribution of the sport fish catch among the anglers. During the 1970 and 1971 seasons the success ratio of Paddys Pond angler-trips was 35.5 and 38.2 percent respectively, i.e. 35.5 and 38.2 percent of the angler-trips were successful in harvesting at least one fish. The success ratio of Thomas Pond fishermen during two consecutive seasons was 53.7 and 32.0 percent.

During 1970, at Paddys Pond, 50 percent of the harvest was attributed to 6.1 percent of the anglers, while, in 1971, 6.8 percent of the anglers participated in 50 percent of the harvest. Many investigators have commented upon the fact that small percentages of anglers often take large percentages of the catch (Shetter, 1944; Rupp, 1955; Wales and German, 1956; McFadden, 1956; Hunt et al, 1962; Churchill and Snow, 1964; Hunt, 1970; and Wiseman, 1971).

The consistency with which certain anglers make good catches while as many as 60-65 percent of the other anglers may be unsuccessful testified to skill of the individual angler as the single most important factor in determining how many fish he will catch. Generally then, this observation indicates that a relatively few anglers of exceptional skill take a disproportionately large share of the sport fishes harvested from

Table XLVIII. Frequency of various catch sizes of sport fishes (per angler) from Paddys Pond during May to September, 1970 and 1971.

Catch per angler	1970			1971		
	Number of anglers	Percent	Group percent	Number of anglers	Percent	Group percent
0	628	64.5	96.0 (0–5)	1049	61.8	95.3 (0–5)
1	150	15.4		259	15.3	
2	75	7.7		152	9.0	
3	42	4.3		79	4.7	
4	26	2.7		53	3.1	
5	14	1.4		31	1.8	
6	5	0.5	2.7 (6–11)	20	1.2	3.2 (6–11)
7	9	0.9		9	0.5	
8	5	0.5		9	0.5	
9	6	0.6		1	0.1	
10	1	0.1		6	0.4	
11	-	-		8	0.5	
12	1	0.1	0.8 (12–17)	8	0.5	1.0 (12–17)
13	-	-		3	0.2	
14	2	0.2		1	0.1	
15	1	0.1		1	0.1	
16	2	0.2		-	-	
17	2	0.2		1	0.1	
18	-	-	0.2 (18–23)	-	-	0.3 (18–23)
19	1	0.1		-	-	
20	1	0.1		2	0.1	
21	-	-		-	-	
22	-	-		1	0.1	
23	-	-		1	0.1	
24	1	0.1	0.2 (24–25)	4	0.2	0.2 (24–25)
25	1	0.1		-	-	
Total	973			1698		

lakes near the Metropolitan Area. So-called "angler's luck" can be largely discounted as a factor influencing the harvest of sport fishes. Hence, as Hunt et al (1962) point out, the success of even the best management program might easily be underestimated by those anglers who fail to recognize the relationship between fishing ability and fish in the creel. It is suggested, therefore, that consideration be given to a management program which could benefit these 60 or 65 percent of the angler population which return home "empty-handed" and are quite vociferous in their suggestion that lakes near the urban area are "fished-out". A suggested objective might be to "place a fish in every creel". The vehicle required to reach such an objective may very well be a small lake(s) intensively managed on a put-and-take basis where large numbers of either wild or hatchery fish are confined in a relatively small area. Although the sporting aspect of such a venture would be of little importance, such a fishery would undoubtedly fill a real need for the less proficient and demanding of anglers. Such an intensive management program in conjunction with the objective of improving the quality of existing fisheries would effectively manage the recreational fishery resource and assure accrual of maximum benefits to both proficient and unskilled fishermen.

The present daily bag limit in the Province is the lesser of 24 fish or 10 pounds plus one fish. Table XLVIII indicates that only 0.2 percent of the anglers are known to have made or exceeded that limit during both 1970 and 1971. During two years of operating a creel census at Thomas Pond, only an average of 0.15 percent of the anglers are known to "limit-out" (Wiseman, 1971). One (1.0) percent of the anglers at Paddys Pond creeled a dozen or more fish per trip during 1970, and 1.3 percent took this many during 1971. The most frequent catch-sizes per trip for successful anglers is 1 or 2 fish. A similar catch distribution was noted for Thomas Pond anglers (Wiseman, 1971).

This particular pattern of catch-size frequency for sport fishes points out the need for a re-evaluation of the effectiveness and desirability of bag limits, particularly for species inhabiting heavily-exploited lakes near urban centers. Bag limits provide no protection to the resource until the limit is reached. In contrast to the size limit, the bag limit does not apply to every fish caught. Investigation at these two lakes has shown that most of the catch of sport fishes from urban-area lakes is accounted for by anglers creeling 1 or 2 fish per trip, therefore very restrictive bag limits would be needed to effect substantial reductions in the total harvest. For example, if angling effort remained the same, decreasing the bag limit from 24 fish to 12 fish at Paddys Pond would reduce the total catch a maximum of 14 - 28 percent and not 50 percent. The effect of a 12-fish bag limit at Thomas Pond would be to reduce the total catch by 15 - 20 percent (Wiseman, 1971).

It is generally concluded that lowering daily bag limits has no discernable effect in distributing the catch among anglers (Hunt _et al_, 1962, and Hunt, 1970). Bag limit reductions simply divert a small percent of the pre-season population away from the creels of the more proficient angler during a period when these fish are exposed to natural mortality. If we assume that the natural mortality rate of this fish "diverted from the creel" is the same as for the rest of the population, a somewhat smaller number of fish than were diverted from the proficient angler will be available to the less-skilled angler. It is doubtful whether such a small increase in available fish would significantly improve the "luck" of the unskilled anglers. In fact, it has been suggested (Hunt, 1970) that among the skilled anglers, the effect of a bag limit which they could reasonably expect to attain may be a stimulus to keep fishing until the limit is reached. Generally then, angling skill becomes an increasingly-important factor as fishing regulations are made more restrictive.

Although lower bag limits may not effectively reduce the harvest from heavily-fished lakes directly, the psychological reactions of anglers to various bag limits may influence angling effort and thus harvest. It is suggested that even though few anglers are able to catch a limit of, say 24 fish, the opportunity to catch only 12 rather than 24 per trip may cause a decline in fishing pressure. If this hypothesis is valid, application of bag limits that differ over the course of a season, or that differ regionally within the Province, may provide a means of regulating one of the more important factors determining the magnitude of the harvest, i.e. the number of anglers fishing a given lake or region of lakes.

V. SUMMARY AND CONCLUSIONS

Paddys Pond, like most lakes in Newfoundland, lies in an igneous rock formation, and waters in this type of area are characteristically soft. Poorly-drained soils have resulted in numerous bogs and marshes. The waters of Paddys Pond are, therefore, relatively highly-acidic and moderately-stained by humic extractives, and the lake is considered to be mildly dystrophic.

Although morphological indices such as mean depth and shore development are favourable, poor water quality masks the favourable factors to produce low primary and benthic production resulting in relatively low sport fish production. The interaction of all ecological factors at Paddys Pond indicates that all levels of production are low by North American standards, however the productivity of Paddys Pond is undoubtedly moderately high for the east coast of Newfoundland.

The low benthos production and lack of a forage fish species has contributed to a slow growth rate for the sport fishes in the lake. Available information suggests growth rate has declined during a period of heavy fishing pressure experienced in the last few years. To bolster the growth rate, introductions of sticklebacks were begun during 1971. However, the total success of this forage fish introduction program to increase the growth rate of Paddys Pond salmonids may not be realized unless suitable benthic and/or pelagic organisms such as molluscs, mysid shrimp, or amphipods are also introduced to increase the growth rate of younger fish, thereby permitting them to consume sticklebacks a year or two sooner. In this respect Gastropods of the Family Lymnaeidae and Planorbidae; the amphipod, Gammarus lacustris; and the opossum shrimp, Mysis relicta are offered for consideration of their potential as food items for younger salmonids in Paddys Pond as well as in other Newfoundland lakes.

The fall standing crop of sport fishes in Paddys Pond is approximately 24 pounds per acre and is undoubtedly above average for most Newfoundland lakes, particularly those on the Province's east coast. Paddys Pond is a good salmonid producer by even mainland North American standards. This production is undoubtedly attributed to the fact that, in the absence of competition from other fish species, sport fishes in insular Newfoundland waters are occupying niches normally filled by these other species.

Population levels of all thres species have apparently gone up somewhat during the period of study, and this increase is attributed, for the most part, to the production of a particularly strong year-class, in both 1967 and 1968.

The egg-to-fry survival is apparently extremely high for both brook trout and ouananiche (11 to 12 percent), and moderately high for brown trout (6 percent). The presence of limited stream-spawning opportunities for Paddys Pond fish suggests that shore spawning may be extensive, particularly for brook trout.

Paddys Pond was one of the most heavily-fished lakes in insular Newfoundland during 1971, with approximately 14,000 man-hours of effort being expended during the May to September period. During the May 24th weekend alone, some 1,500 man-hours of fishing pressure were exerted, and on May 24th, 268 anglers fished at the lake. Annual fishing pressure per acre of lake (14-27 man-hours), however, is only moderate by North American standards. The winter fishery is relatively light generally, with a high of 428 man-hours exerted during the winter of 1971. The open-water fishery is prosecuted by both shore and boat fishermen. Most activity is during the months of May and June, and the fishery is predominantly a weekend and evening one. Average fishing time spent by the angler is two hours, approximately. Boat fishermen tend to fish almost twice as long as do shore fishermen. Shore fishermen generally outnumber boat fishermen by 4 or 5 to 1.

The total landings of sport fishes increased from approximately 4,000 fish in 1970 to nearly 7,300 in 1971. This rise is attributed to both an increase in effort and in availability of fish during 1971. The effort increased nearly 100 percent in 1971 and fish of the strong 1967 and 1968 year-classes were recruited into the fishery. The total annual harvest during 1971 barely exceeded the maximum sustained yield; however, it is suggested that if an equivalent fishing pressure is exerted during 1972, a decline in catch per effort will result and overfishing will have increased. In this respect, it is recommended that consideration be given to a program to provide additional fishing opportunities for anglers presently fishing overfished lakes near the Metro-area. Because boat fishermen contribute to the "overfishing problem" disproportionately to their numbers, a program of boat access development on several lightly-exploited lakes near the Metropolitan Area would lessen the pressure and harvest rate on those lakes already being overfished as well as provide for increased utilization of stocks which are presently underexploited.

The catch-per-effort at Paddys Pond during the open-water season is approximately 0.5 fish per man-hour, and this is moderately high for fisheries in the Maritime Provinces. At present, legal size limits for sport fishes are not being observed, at least by Paddys Pond fishermen. It appears that anglers regulate themselves by taking the largest of existing fish in a given lake.

Small percentages of anglers take large percentages of the harvest each year at Paddys Pond. The success ratio was approximately 36 and 38 percent during the two years the harvest was monitored. The numbers of anglers catching their limit at Paddys Pond is almost negligible, only 1 percent of the fishermen creeled a dozen or more per trip. The most frequent catch-sizes per trip for successful anglers is 1 or 2 fish. The effectiveness or desirability of bag limits on lakes near the Metropolitan Area is questionable. It is suggested, therefore, that consideration be given to intensively managing a small lake on a put-and-take basis for the benefit of these less experienced and proficient anglers. These people are estimated to compose 60-65 percent of the urban-based angler population.

Boat fishermen average 2 - 3 times as many fish per effort as shore fishermen.

The average size of brook trout angled is 7½ inches, ouananiche average 8-8½ inches, and brown trout are the largest fish creeled, averaging 10-10½ inches in length. Anglers report a marked decrease in the size of fish angled since construction of the Trans-Canada Highway, with brook trout being particularly smaller now. Because of the relatively-slow growth rate, a minimum size limit for Paddys Pond brook trout and ouananiche is not biologically sound.

In summary, the growth rate of Paddys Pond sport fishes is likely the maximum that can be sustained in a lake with its particular limnological conditions unless some management technique is applied. The most suitable technique is undoubtedly the introduction of suitable benthic and/or pelagic invertebrates and forage fish.

Because the maximum sustained yield is exceeded during certain years in Metropolitan Area lakes, it is imperative to reduce the fishing pressure on these lakes rather than attempt to reduce the harvest by imposing lower bag or size limits. The most effective and efficient management technique is to redistribute the angling pressure by encouraging the more proficient (generally boat fishermen) anglers to distribute their fishing trips over a wide selection of lakes. Redistribution can be accomplished by the development of lake access roads which, in simple terms, "bring the fishermen to the fish". Such an approach is more sound economically and biologically, in this case, than fish hatcheries which "bring the fish to the fishermen".

It is also suggested there is a real need for recreational fishing opportunity for the less-proficient angler. Such segments of the population as the aged, the youth, the handicapped, etc., are entitled to a share of the sport fishing resource. It is suggested, therefore, that a lake(s) be managed annually on a put-and-take basis with a suggested objective being "to put a fish in the creel of every angler whether he be proficient or otherwise". Such a program could utilize either wild or hatchery stock.

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