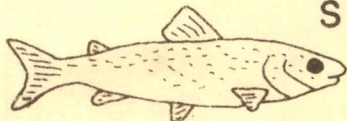


PROGRESS REPORT NO. 73  
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SPORT FISHERY OF THOMAS POND:  
A MULTI-USE RESERVOIR.

by

R. J. Wiseman.

ENVIRONMENT, CANADA  
FISHERIES SERVICE

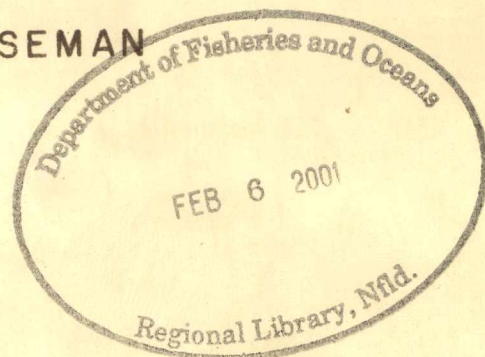


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R. J. WISEMAN



RESOURCE DEVELOPMENT BRANCH  
NEWFOUNDLAND REGION  
ST. JOHN'S  
1971

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THOMAS POND: A MULTI-USE RESERVOIR

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Resource Development Branch  
Department of Environment  
Fisheries Service,  
St. John's, Newfoundland

October, 1971

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## I. INTRODUCTION

The standing waters of Insular Newfoundland contain one of the largest, relatively unexploited sport fishery resources in eastern North America. The local sport fishery is based mainly on the eastern brook trout (Salvelinus fontinalis) and the landlocked salmon (Salmo salar) with the brown trout (Salmo trutta), rainbow trout (Salmo gairdneri), and Arctic char (Salvelinus alpinus) having somewhat lesser importance.

With increased highway construction across the Island many previously inaccessible lakes and ponds have been made available to the sport fisherman. The increased network of highways and roads has led to an increased sport fishing pressure on fish stocks, particularly in standing waters near densely populated areas.

Approximately 200,000 of the Province's half million people live on the Avalon Peninsula, with the majority in and around St. John's and along Conception Bay. It is logical then that the lakes, ponds, and streams around this relatively densely populated area bear the brunt of the Province's sport fishery.

Construction of the Trans Canada Highway and its numerous access roads during the sixties opened up vast areas of the Avalon Peninsula that formerly were available only to the more hardy and adventurous of sport fishermen. With this increased access, sport fishing pressure has increased and most of the Avalon Peninsula's fish stocks are now available for exploitation. With further increase in the human population and road access, the near-virgin state of the remainder of the stocks is now only a thing of the past.

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 complained 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 1967, the Lake Management Group of the Resource Development Branch launched a detailed investigation into the alleged overfishing in lakes and ponds near the Metropolitan area. The main objective of this investigation was to evaluate yield to the angler in relation to present standing crops and fishing pressure and to make recommendations which will enable the Department to maintain at present levels, or to increase, stocks of resident sport fishes.

The first phase of this investigation involved the study of an ecosystem where man, as a predator, was not a factor (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 in 1968, involved a comparable study on a lake whose fish populations were heavily exploited by Man. The lake chosen for study was Thomas Pond, a 255-acre hydroelectric reservoir. Thomas Pond is one of the heaviest fished lakes on the Island of Newfoundland. This distinction is undoubtedly caused by its proximity to the City of St. John's and its location immediately off the Trans Canada Highway. Adding to its popularity with anglers is the fact that it is one of very few lakes in the area where the public is able to launch boats without too much difficulty. The lake's past history of high angler-success and high quality fishing also enhances its popularity.

Prior to impoundment in 1956 and the start in construction of the Trans Canada Highway in 1958, Thomas Pond was only lightly fished. However, with impoundment and improved access came increased fishing pressure and large catches. The ease with which quality fish could be attained resulted in widespread publicity and, during the early to mid-sixties, fishing pressure and angler-success reached a peak, with both subsequently declining during the years between that period and the present.

## II. LIMNOLOGY OF THOMAS POND

### A. Location

Thomas Pond is situated at 47°27'30" North Latitude and 52°55'00" West Longitude. It lies approximately 9 miles southwest of the City of St. John's along the Trans Canada Highway (Fig. 1). Thomas Pond has a full storage elevation of 482 feet.

### B. Uses

#### 1. Industrial

In 1956, Thomas Pond was dammed for use as a reservoir for the hydroelectric generating station at Topsail. Prior to inundation, the total standing water was 73.5 acres (Fig. 2). The two standing waters flooded were Thomas Pond (44.8 acres) and the Grassy Gullies (28.7 acres). Flooding increased the acreage to 255 acres.

Thomas Pond originally emptied into Manuels River via the Grassy Gullies, however, upon completion of the earth-fill dam (Fig. 3), the water was diverted by a controlled-flow spillgate and channeled into the Topsail River system via a number of downstream lakes. During high water, the overflow from Thomas Pond still spills into Manuels River (Fig. 4-6).

Maximum annual fluctuation in water level at Thomas Pond is about 9 feet (Fig. 7 and 8). The pond usually experiences both a summer and winter drawdown.

#### 2. Recreational

In addition to angling, other recreational uses include boating, swimming, picnicing, camping and waterfowl hunting.

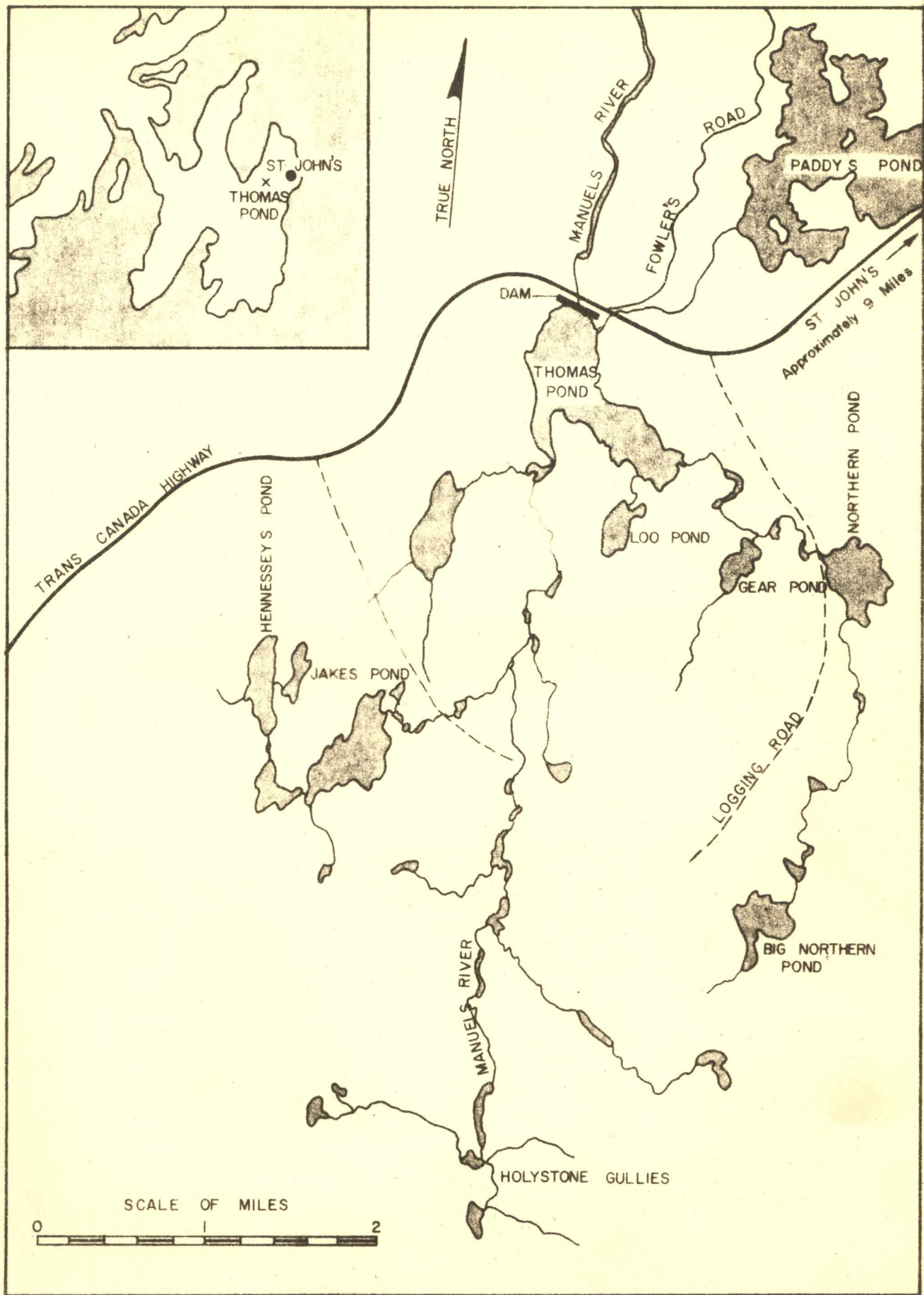


FIG. 1 THOMAS POND DRAINAGE SYSTEM

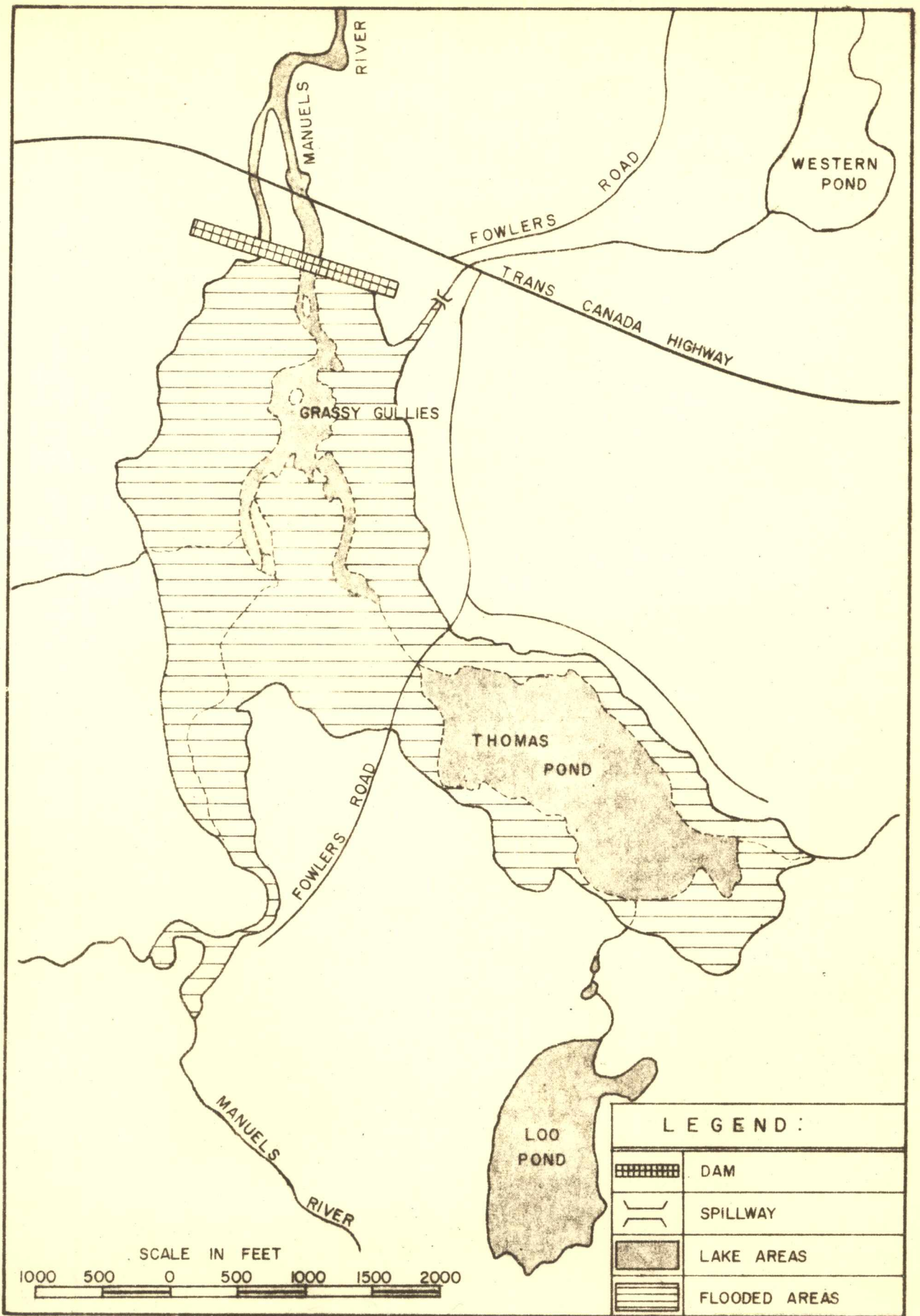


FIG. 2 THOMAS POND IMPOUNDMENT, SHOWING EXTENT OF FLOODING OF THE ORIGINAL POND



Fig. 3. Thomas Pond dam and high-water spillway.



Fig. 4. Controlled flow spillgate at the outlet of Thomas Pond.



Fig. 5. Diversion channel leading into the Topsail River system.



Fig. 6. Thomas Pond spilling into Manuels River during spring run-off.



Fig. 7. A portion of the eastern shoreline of Thomas Pond prior to summer drawdown.



Fig. 8. The eastern shoreline following summer drawdown.

C. Characteristics of the Drainage Area

The drainage area feeding Thomas Pond occupies 15.8 square miles. Included in this area are four minor drainage systems of varying magnitude. Of the total drainage area, there are 1.3 square miles of standing water.

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

The drainage area lies at a relatively high altitude, ranging from 482 to 620 feet above sea level. The terrain of the area 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 1231A, 1967).

Since the Thomas Pond drainage lies at a fairly high altitude, glacial scouring has removed much of the surface material leaving soils which are intermittent and shallow. Poorly-drained soils have resulted in numerous bogs.

The Provincial Department of Mines, Agriculture and Resources operates 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.

Newfoundland Fiberply has cutting concessions within the drainage boundaries which presently supply the fiberply plant at Donovan's, near St. John's.

D. Vegetative Cover

1. Terrestrial

The immediate area of Thomas Pond, as well as most of the drainage area, is covered mainly by a climax coniferous forest of black spruce (Picea marina), balsam fir (Abies balsamea), and tamarack (Larix laricina), which extends to the water's edge. The lake is ringed with an extensive zone of submerged and emergent deadwood, as a result of flooding (Fig. 9).



Fig. 9. Submerged and emergent deadwood, typical of the Thomas Pond shoreline.

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

## 2. Aquatic

The only aquatic vegetation in Thomas Pond is several small patches (1,000 sq. ft. total) of yellow pond lily (Nuphar variegatum).

## E. Physical and Chemical Environment

### 1. Morphometry

A bathymetric map of Thomas Pond is presented in Figure 10; 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 depth recorder on an outrigger-type transducer arm attached to the gunwale of a 14-foot aluminum boat. 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.

Thomas Pond is fairly irregular in shape (Shore Development Index - 2.14) and its shores are rather gentle. A depth range of 0 to 20 feet has been arbitrarily set by Reimers, Maciolek, and Pister (1955) as the area with potential for bottom fauna production. Combined with the fact that Thomas Pond has a fairly high shore development index (2.14), and approximately 91 percent of the lake area is included within the 20 foot production zone, it would appear to be a fairly productive lake in terms of its morphometry.

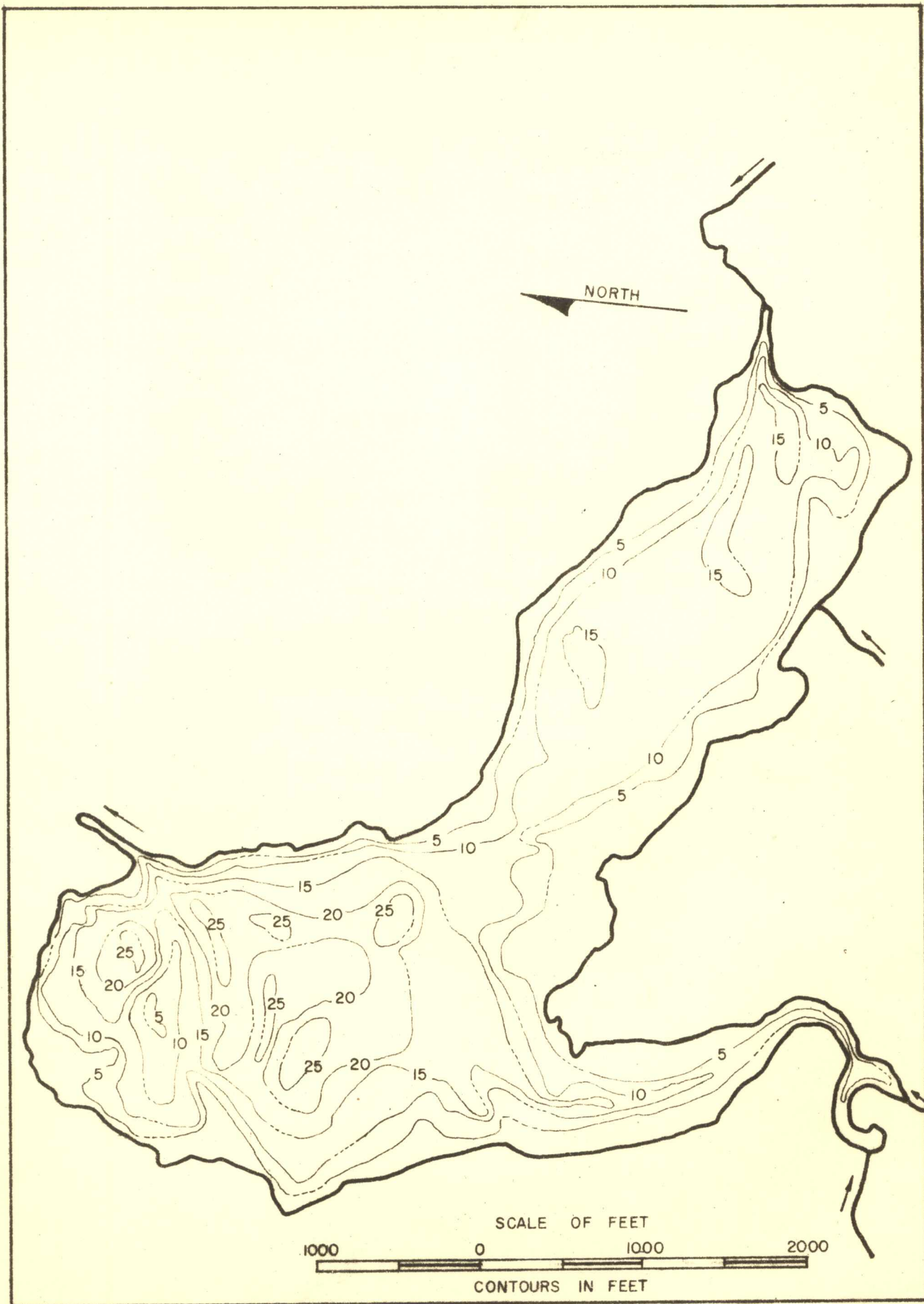


FIG. 10 BATHYMETRIC MAP OF THOMAS POND

Table I. Morphometry of Thomas Pond

Area (acres)	255	Maximum length (mi.)	1.2
(ha.)	103	(km.)	1.9
Maximum effective length (mi.)	1.2	Maximum width (mi.)	0.7
(km.)	1.9	(km.)	1.1
Maximum effective width (mi.)	0.7	Mean width (mi.)	0.3
(km.)	1.1	(km.)	0.5
Volume (cu. ft.)	$2.20 \times 10^8$	Maximum depth (ft.)	29.0
(cu. m. )	$6.23 \times 10^6$	( m. )	8.8
Mean depth (ft.)	13.3	Mean depth - maximum	
(m.)	4.1	Depth ratio	0.46
Volume Development	1.38	Perimeter (mi.)	6.9
		(km.)	11.1
Shore Development	2.14		
Direction of Major Axes S.E. - N.W.			

Depth (ft.)	Area (ft.) <sup>2</sup>	Area (acres)	%
0 - 5	2,742,000	63	24.6
5 - 10	1,889,000	43	17.0
10 - 15	3,480,000	80	31.3
15 - 20	1,980,000	45	17.8
20 - 25	1,736,000	17	6.6
Over 25	299,000	7	2.7
<b>TOTAL</b>	<b>12,126,000</b>	<b>255</b>	

## 2. Bottom Conditions

The bottom-type composition of Thomas Pond is given in Table II. The littoral area of the lake (0-20 feet) is gently-sloped

and covered by a sediment which is both recent and biogenic. This sediment is composed of vegetation in varying stages of decomposition (detritus, peat, and muck). Limited areas of rubble and gravel are also present. In the deeper, original areas of the lake, the bottom materials grade into clay. In areas of the lake only recently flooded, there is a greater amount of organic material.

Table II. Bottom type composition of Thomas Pond

	Bottom Type	% Composition
<u>Inorganic</u>	Boulders	1
	Coarse rubble	10
	Fine rubble	10
	Coarse gravel	5
	Fine gravel	2
	Sand	1
	Silt	5
	Clay	10
<u>Organic</u>	Detritus	40
	Peat	10
	Muck	5

### 3. Temperature of the Water

Surface water temperature data were obtained from a continuous-recording Ryan thermograph during the period April - November, 1970. The lowest recorded temperature for the period was 37.6°F and the highest was 73.4°F. Maximum summer water temperatures rarely exceeded 73°F.

Vertical series of water temperatures were obtained weekly during the periods January - February, and May - August, 1969, at 2-foot intervals in the deepest part of the lake using a simple electric thermistor (Fig. 11). A similar weekly series was obtained during the period August - October, 1969, using a Model 85 Delta Scientific combination oxygen meter-thermistor.

Strong thermal stratification was recorded at Thomas Pond on one occasion only, June 23 (Fig. 12). The thermocline began at 16 feet and ended at 22 feet, and the temperature decline was  $9.6^{\circ}\text{F}$ . A vertical temperature series taken on July 5 indicated that the thermocline had disappeared and the lake was then only very weakly stratified. The suggested explanation for such short-lived thermal stratification is a sudden rise and subsequent fall in air temperature. The monthly



Fig. 11. A simple electric thermistor used to obtain a vertical series of water temperatures beneath the ice at Thomas Pond.

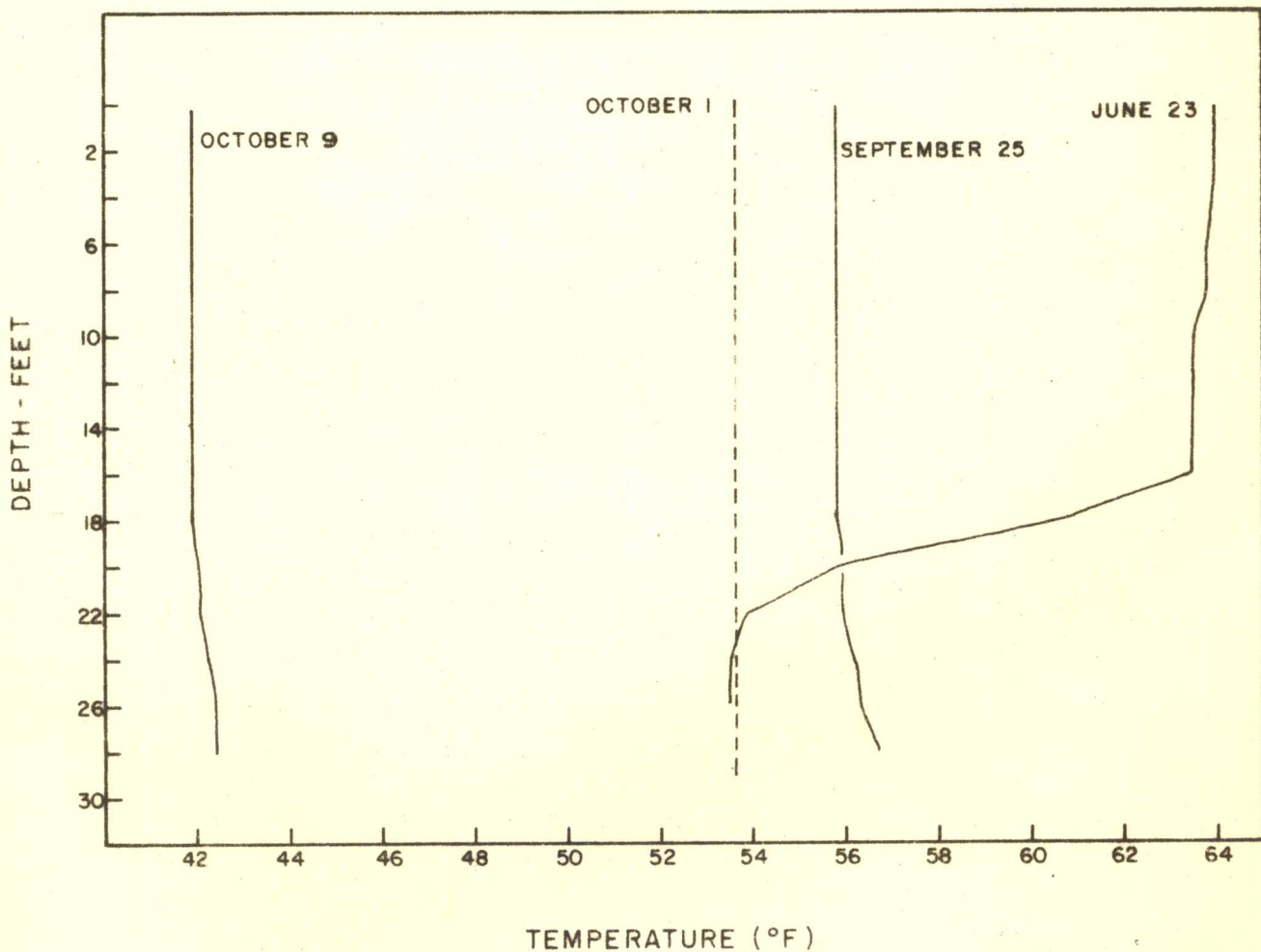


FIGURE 12 - TEMPERATURE CURVES FOR THOMAS POND  
(SELECTED DATES DURING 1969)

records of the Department of Transport Meteorology Branch for the months of June and July support this point. Mean daily June air temperatures were 4.7°F above normal, while July temperatures were 2.8°F below normal. During the period June 13 - 23, at which time the thermocline disappeared, the temperatures were 2.5°F below normal. Prolonged periods of stratification would not seem likely at Thomas Pond even during the warmest of summers because of the lake's small size, relative shallowness, and exposure to prevailing winds.

The 1969 fall overturn occurred in Thomas Pond during the period of mid-September to early October. The lake was homothermous on October 1.

The lake generally freezes over in mid to late December, with some annual variation. Maximum ice thickness during the winters of 1968-69, and 1969-70, was 13 inches, with the average about 8 inches. Ice-out normally occurs during early April; however, complete breakup had occurred by March 1 in the spring of 1970. Areas of open water, particularly near the major inlet streams and the spillgate, appear well in advance of general breakup.

#### 4. Dissolved Oxygen

Vertical series of dissolved oxygen readings were obtained weekly during the period January - February, 1969, using the Winkler Method on samples collected at selected depths with a Kemmerer sampler. All titrations were carried out in the field. Similar weekly readings were obtained during the period August - October using the combination oxygen meter-thermistor instrument. Oxygen curves for Thomas Pond are shown in Figure 13. There is some late summer reduction in the quantity

of dissolved oxygen near the bottom of the lake and this may partly be associated with weak thermal stratification (Fig. 14). Reduction in oxygen content is not severe and it occurs in only a small percentage of the total volume of the lake. Upon breakup of any thermal stratification that may be present, dissolved oxygen content is more or less homogenous at all depths.

#### 5. Surface Water Chemistry

Water analysis was carried out by both the Canada Department of Energy, Mines and Resources and by the Laboratory Services 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. Analysis of surface water appears in Table III.

a. Water Color. Color of water is an important environmental factor in lakes. Thomas Pond waters are deeply stained, with a color value ranging from 40 - 45. Although Thomas Pond is a "brown-water lake", it is not a true "bog lake" in the sense that it is peripherally in contact with a bog. 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 develop within the lake (autochthonous) following flooding, the greater part of these materials are derived from outside the lake (allochthonous) and are brought in by surface drainage from bogs, swamps, and acid soils.

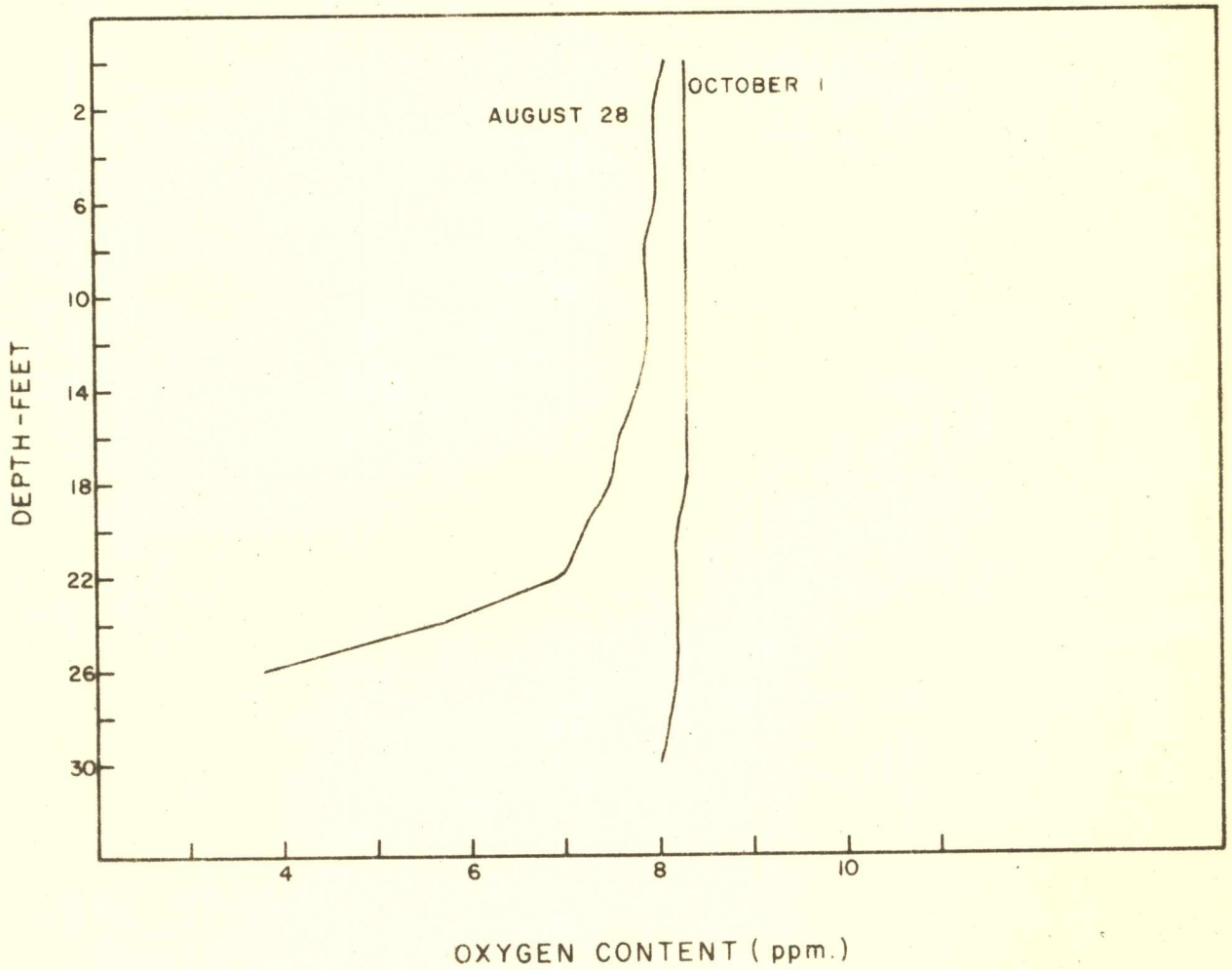


FIGURE 13 - DISSOLVED OXYGEN CURVES FOR THOMAS POND  
( SELECTED DATES DURING 1969 )

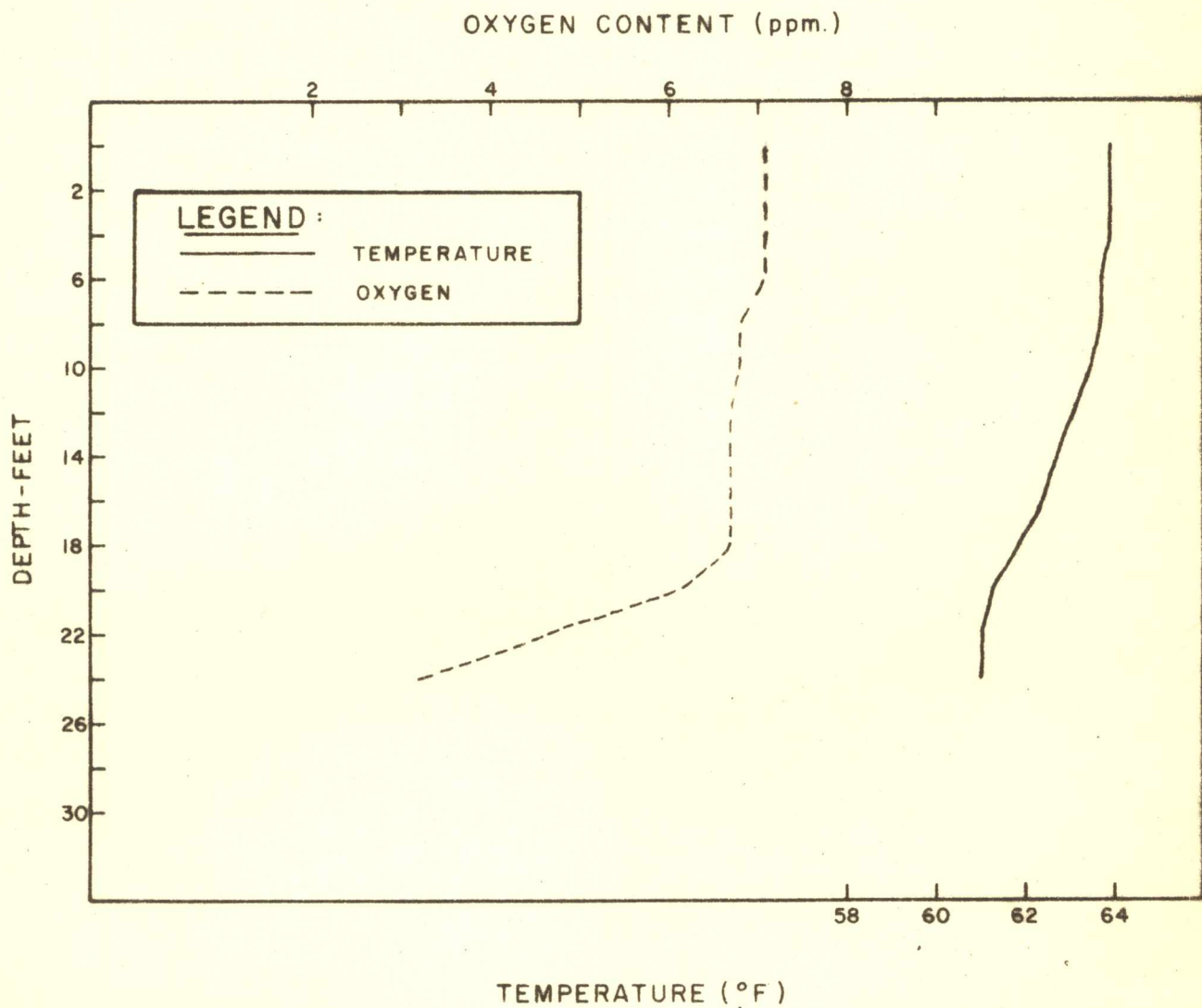


FIGURE 14- TEMPERATURE AND DISSOLVED OXYGEN CURVES FOR THOMAS POND, AUGUST 22, 1969

The most obvious effect of colored water is to reduce light penetration and photosynthesis. Birge and Juday (1932) found that only 20 percent of the total incident radiation reached a depth of one meter in lakes with color values ranging from 20 to 30. In clear lakes about 40 percent of the radiation penetrated to the same depth. Thus the zone for effective photosynthesis by phytoplankters is much reduced in colored waters.

Table III. Analysis of surface water of Thomas Pond (samples collected September, 1968; June, 1969; and May, 1970)

	Range	Mean
Alkalinity as CaCO <sub>3</sub>	1.7 - 6.0 ppm.	3.6 ppm.
Total hardness as CaCO <sub>3</sub>	4.2 - 7.3 ppm.	5.5 ppm.
pH	5.2 - 5.8	5.4
Color (Hazen units)	40 - 45	-
Oxygen consumed (KMNO <sub>4</sub> )	5.5 - 8.5 ppm.	6.8 ppm.
Turbidity (units)	0.65 - 2.00	-
Sp. conductance, mhos. at 25°C	20.8 - 33.6	27.7
Total dissolved solids	22.0 - 31.2	27.0
Calcium (Ca)	0.8 - 0.9	0.8
Magnesium (Mg)	0.5 - 0.6	0.5
Sodium (Na)	3.8 - 3.9	3.8
Potassium (K)	-	0.4
Carbonate (CO <sub>3</sub> )	-	0.0
Bicarbonate (HCO <sub>3</sub> )	2.2 - 2.8	2.5
Sulphate(SO <sub>4</sub> )	1.1 - 2.5	1.9
Chloride (Cl)	6.4 - 6.7	6.6
Phosphate (PO <sub>4</sub> )	Total Dissolved	0.08 - 0.11 -
		0.09 0.06
Nitrate (NO <sub>3</sub> )	0.01 - 0.03	0.02
Silica (SiO <sub>2</sub> )	1.1 - 1.4	1.3
Sum of Constituents	15.9 - 17.2	16.6

Acid brown-water lakes may, however, have a good bacterial flora (Smith, 1961). Hayes and Anthony (1959) found a positive correlation between bacterial counts and color for Nova Scotian lakes. Bacterial decomposition of the allochthonous organic matter results in a reduction in dissolved oxygen content, and in fact it is probably this factor and not thermal stratification which causes low dissolved oxygen levels near the bottom of Thomas Pond during the summer months.

b. Oxygen Consumed. The oxygen-consumed values for Thomas Pond are fairly high, ranging from 5.5 to 8.5 ppm.

Oxygen-consumed values are indices of the amount of organic matter in lake waters. Smith (1952) shows a positive correlation between the values for oxygen consumed and color. Juday and Birge (1933) state that allochthonous humic substances entering lakes as stains are largely carbonaceous rather than nitrogenous in nature. It follows therefore that higher values for oxygen consumed and color in Thomas Pond as compared to a clear lake, such as Petty Harbour Long Pond (Wiseman, 1970), indicate a greater organic content in the former. However, these values cannot be thought of as an index of a correspondingly greater fertility with respect to sources of nitrogen.

c. Hydrogen-Ion Concentration. The pH values ranged from 5.2 to 5.8 depending on location of sampling station and season and indicate extremely soft waters. Low pH values are attributed to the surface drainage from bogs.

d. Alkalinity as CaCO<sub>3</sub>. Alkalinity values ranged from 1.7 - 6.0 ppm. depending on season and location of sampling station. Total alkalinity is considered to be one of the most important indices in

estimating lake productivity (Ball, 1945; Moyle, 1946; Barrett, 1953; Geagan and Allen, 1960; Hayes and Anthony, 1964; and Mairs, 1966). Moyle (1946) suggests that alkalinity values of less than 40.0 ppm. indicate soft waters.

e. Total Hardness. The values for total hardness ranged from 4.2 - 7.3. Thomas (1960) suggests that waters with less than 60.0 ppm. total hardness as  $\text{CaCO}_3$  are considered soft, and gives the Newfoundland average as 16.0 ppm.

f. Ionic Order of Dominance. The ionic order of dominance for cations was  $\text{Na} > \text{Ca} > \text{Mg} > \text{K}$ , while the anionic order was  $\text{Cl} > \text{HCO}_3 > \text{SO}_4$ . The general abundance of Na and Cl as the dominant cation and anion respectively, reflect the proximity of this lake to the ocean (5 mi.). Gorham (1957), Smith (1961), Kerekes (1967), and Murray and Harmon (1969) have all noted the contribution of salt to the coastal fresh waters of the Atlantic provinces by sea breezes and gales.

g. Specific Conductance and Total Dissolved Solids. The values for specific conductance at 25°C ranged from 20.8 - 33.6 micromhos depending on season and station. Specific conductance values were converted to a more significant limnological parameter, total dissolved solids. The method of conversion is given in an earlier report (Wiseman, 1970). T.D.S. values ranged from 22.0 to 31.2 with a mean value of 27.0 ppm. Thomas (1960) gives the average total mineral content for Newfoundland freshwaters as 27.9 ppm. Elsewhere in North America, most lakes have a mineral content of 100 - 200 ppm. (Rawson, 1951). Rawson (1939), Northcote and Larkin (1956), and Ryder (1965) point out the importance of the amount of dissolved nutrients (T.D.S.) present in lakes in relation to productivity.

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 Thomas Pond and several other Avalon Peninsula lakes are given in Table IV. Thomas Pond has an estimated annual fish production of 2.85 pounds per acre per year, or 727 pounds per year. Of the Avalon Peninsula lakes investigated to date, potential annual production ranges from approximately 2 to 4 lbs. per acre per year, with 2.96 as an average. Therefore, given a reasonable estimate of the total biomass of fish produced in a lake per year, it may be possible to set annual creel limits in terms of weight, for either individual lakes or geographic areas.

Table IV. Morphometric, edaphic, and potential fish production data for 10 Avalon Peninsula lakes.

	Mean depth (ft.)	T.D.S.	T.D.S. Depth	Potential production (lbs/acre/yr)	Area (acres)	Potential production (lbs/yr)
Thomas Pond	13.3	27.0	2.03	2.85	255	727
Petty Harbour Long Pd.	21.3	33.8	1.59	2.52	428	1,079
Paddys Pond	10.4	28.2	2.71	3.29	528	1,737
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
MEAN		31.1		2.96		

## F. Bottom Fauna

### 1. Methods and Materials

The collection of quantitative and qualitative data on bottom fauna was made at 27 stations located approximately equidistant around the perimeter of Thomas Pond. The sampling at each station was carried out in water 20 feet deep, or less, and consisted of 5 dredgings taken at close proximity using a Petersen dredge. The sampling was carried out during August and September, 1968. The dredgings were washed through a set of three wire screens of varying mesh size, 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 analysis of bottom fauna collected at Thomas Pond. Only eleven organism types were found. Sharpe (1968), in an investigation of lakes in Terra Nova National Park, found only eleven types, while studies at Petty Harbour Long Pond (Wiseman, 1970) indicated only twelve organism types were present there. It has been suggested that comparatively few species inhabit the fresh waters of Newfoundland because of the cold climate (Valle, 1955).

### 3. Quantitative Analysis

Table V indicates that 888.7 mg. (dry weight) of bottom organisms were collected at 27 stations. Each station sample consisted of 5 dredgings covering a total area of 500 square inches. The dredging of 27

Table V. The bottom fauna of Thomas Pond expressed as percentages of occurrence, composition, and weight (based on samples taken at 27 stations during August and September, 1968)

Organism	Frequency	Percent		Weight(mg.)	Percent
		occurrence	Number		
AMPHIPODA	27	100.0	579	195.7	22.0
CHIRONOMIDAE (Larvae)	27	10.0	550	143.2	16.1
OLIGOCHAETA	25	92.6	219	130.9	14.7
HIRUDINEA	12	44.4	22	109.7	12.4
SPHAERIIDAE	14	51.9	86	104.3	11.7
TRICHOPTERA (Larvae)	11	40.7	28	88.0	9.9
HEMIPTERA	26	96.3	96	72.4	8.1
EPHEMEROPTERA (Nymph)	10	37.0	26	16.8	1.9
CHIRONOMIDAE (Pupae )	13	48.1	25	9.0	1.0
COLEOPTERA (Adult)	2	7.4	2	7.3	0.8
ANISOPTERA (Nymph)	3	11.1	4	4.9	0.6
HYDRACARINA	6	22.2	14	3.9	0.4
COLEOPTERA (Larvae)	1	3.7	1	2.4	0.3
TOTAL	27 stations		1,652	888.7	

stations covered an area of 93.8 square feet. The estimated biomass (dry weight) of benthos was 412.51 g./acre, or 1.02 kg./hectare. The total area of the substrate of Thomas Pond is 255 acres, therefore the total estimated biomass of benthos is calculated to be 105.2 kilograms.

During an investigation of another Avalon Peninsula lake, Petty Harbour Long Pond, the standing crop of benthos was calculated to be 1.18 kg./ha. (Wiseman, 1970). Smith (1952) suggests a range of 1.9 to 6.1 kg./ha. for several New Brunswick lakes, and considers these standing crops as being poor. Smith (1961), in an investigation of a Nova Scotia "brown-water lake", reports the benthic biomass to be 1.2 kg./ha. and considers this to be "quantitatively poor".

Assuming that the dry weight of benthos approximates 15 percent of the live wet weight (Rawson, 1953), the biomass for Thomas Pond would be 701 kg., or 6.74 kg./hectare. Dominy (1965) gives a value of 13.7 kg./ha. for Butlers Pond, near St. John's. Nearby Murrays Pond (fertilized) has 46.0 kg./hectare.

#### G. Fish Species

Four fish species inhabit Thomas Pond and its drainage system. Three of the species are of sport value and include the eastern brook trout, Salvelinus fontinalis (Mitchill) 1815; the landlocked salmon or ouananiche, Salmo salar (Linnaeus) 1758; and the brown trout, Salmo trutta (Linnaeus) 1758. The brook trout and landlocked salmon are native species, while the brown trout is an exotic species introduced into the Topsail River drainage beginning in 1886. It was not until 1956, at which time Thomas Pond was diverted from Manuels River into this drainage, that brown trout had access to Thomas Pond and the waters beyond. Sea-run and non-anadromous populations were well-established in the lower Manuels River prior to 1956, however a complete obstruction located about one mile from the mouth prevented access to Thomas Pond.

The American eel, Anguilla rostrata (Le Sueur) 1817, is also a resident of Thomas 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 465 eels was taken from trap nets and measured. Range in total length was 23 cm. to 88 cm., with a mean of 52.8 cm. Since the eel grows to be 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.

#### H. Summary of Limnological Conditions

Thomas Pond may be considered a multi-use reservoir where both recreational and industrial interests are in competition for the use of the waters.

Two major factors useful in estimating lake productivity are edaphic and morphometric. The edaphic factor depends on the characters of the drainage area, while the morphometric aspect is dependent on the physical features of the lake. The fertility of lake waters is directly influenced by the fertility of soils in the drainage area, and then factors in the lake will determine the efficiency of utilization of these soil nutrients to establish a level of production.

In Thomas Pond, the edaphic and morphometric factors have conflicting influences. The morphometric factor is very favourable (shore development index = 2.14 and 91 percent of the lake has a depth of 20 feet or less), however, very unfavourable edaphic characteristics have resulted in a low level of overall production.

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 via the surface drainage and the presence of autochthonous materials already in the lake as a result of flooding, have contributed to poor water quality, low benthos production, and low fish production.

Thomas Pond also experiences summer and winter drawdowns which have a deleterious effect on both benthos and fish production.

The interaction of these factors at Thomas Pond indicates that all levels of production (primary, benthic, and fish) appear at the lower end of the range for lake productivity.

### III. ECOLOGY OF THE SALMONIDAE OF THOMAS POND

#### A. Sampling

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

The collection of data on food, age, and growth occurred during June, 1968, by gill-netting. Two gangs of nylon gill nets, each composed of three nets with stretched-mesh size 1 1/2", 2", and 3" were fished overnight. Each net measured 50 yards in length and was six feet deep. The gangs were invariably set with the 1 1/2-inch net tied to the shore.

Information on population levels was obtained during June-August, 1968; June, 1969; September, 1969; April-May, 1970; and September, 1970, by live-trapping. Four stream fyke nets, modified for use in standing waters by the addition of a center leader and a collection bag, were used during the 1968 operations. Six lake trap nets were used in live-trapping operations during 1969 and 1970 (Figs. 15 & 16). The use of these trap nets in conjunction with a 16'7" "Boston Whaler" boat having a built-in work platform facilitated the operations during 1969 and 1970 (Fig. 17).



Figure 15. Lake trap net used in population studies



Figure 16. The lake trap net operating in Thomas Pond.



Figure 17. "Boston Whaler" with work platform.

A creel census during the periods June - September, 1968; January - February, 1969; and May - September, 1969, supplied vital 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.

B. Food

1. Methods

The collection of fish specimens for analysis of stomach contents was made June 6 - 7, 1968. 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. The food composition of brook trout captured during June 1968 is given in Table VI. Generally, the trout are insectivorous, feeding almost entirely on benthos. No terrestrial insects were included in the diet. Planktonic cladocerans (Daphnia sp.) occurred in only two stomachs and were probably taken incidently. During another study in June 1965 (Wiseman, 1969) several terrestrial forms were noted in the diet, as well as unidentified fish remains. Although fish did not appear in the diet of trout collected during June 1968 in Thomas Pond, during the course of live-trapping operations later that year, as well as in subsequent years, the occurrence of small salmonid fishes in the mouth and esophagus of the larger trout was not uncommon.

b. Quantitative Analysis. None of the 100 trout stomachs collected during June 6 - 7, 1968, were empty. During an earlier study at Thomas Pond (Wiseman, 1969), there were 5 empty stomachs out of 105 examined.

During June 6 - 7, 1968, there was an average of 133.24 mg. (dry weight) of food per stomach. During the June 1965 study, trout averaged 144.73 mg. of food.

A comparison of the bottom fauna composition with the composition of the food consumed indicates occurrence of selection of a number of organisms including Sphaeriidae, Amnicolidae, Ephemeroptera

Table VI. The food of Thomas Pond brook trout expressed as percentages of occurrence, composition, and weight (based on examination of fish from 14.0 - 27.0 cm. fork length, collected during June, 1968).

Group	Percent		Weight			
	Frequency	Occurrence	Number	Percent	(mg.)	Percent
AMPHIPODA	78	78.0	7357	74.8	2501.5	18.8
SPHAERIIDAE	29	29.0	657	6.7	794.6	6.0
EPHEMEROPTERA (NYMPH)	71	71.0	609	6.2	2389.8	17.9
TRICHOPTERA (LARVAE)	60	60.0	366	3.7	3669.9	27.5
CHIRONOMIDAE (LARVAE)	24	24.0	323	3.3	84.0	0.6
AMNICOLIDAE	19	19.0	234	2.4	510.9	3.8
HEMIPTERA	36	36.0	107	1.1	512.7	3.8
COLEOPTERA (LARVAE)	9	9.0	62	0.6	57.7	0.4
COLEOPTERA (ADULT)	30	30.0	49	0.5	1355.0	10.2
HIRUDINEA	19	19.0	29	0.3	374.3	2.8
CHIRONOMIDAE (PUPAE)	7	7.0	23	0.2	25.8	0.2
ANISOPTERA (NYMPH)	10	10.0	13	0.1	795.1	6.0
HYDRACARINA	5	5.0	5	0.05	1.4	Trace
OLIGOCHAETA	3	3.0	5	0.05	160.6	1.2
<u>Daphnia sp.</u>	2	2.0	-	-	91.1	0.7
TOTAL	100 STOMACHS*		9,839	13,324.4		

\* No empty stomachs.

nymphs, and Trichoptera larvae. Because the collection of bottom fauna was made during August and September, Ephemeroptera nymphs and Trichoptera larvae would not be expected to be high in numbers since these groups usually have late spring and early summer emergence dates. No Amnicolidae were collected in bottom samples.

Although Frost (1940) and Scott and Crossman (1964) suggest there appears to be no food selection by brook trout in Newfoundland waters, Thomas Pond trout appear to exhibit definite selection of Sphaeriidae and Amnicolidae. Although very small, these clams and snails supply most of the calcium in the trout's diet.

### 3. The Food of Ouananiche

a. Qualitative Analysis. The food of ouananiche captured during June 1968 is given in Table VII. Like the trout, the ouananiche of Thomas Pond are generally insectivorous. Only one terrestrial group was included in the diet, however, mayflies (subimagos 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, there was no evidence of predation on any fish species.

b. Quantitative Analysis. Of the 100 ouananiche stomachs collected during June 6 - 7, 1968, five were empty. There was an average of 59.32 mg. of food per stomach, less than one half the amount measured in the brook trout.

Although ouananiche and brook trout consume the same food organisms, the proportion of these organisms is very different. Strictly bottom organisms, such as Amnicolidae, Sphaeriidae, Hirudinea, Trichoptera larvae, and amphipods are eaten much less frequently by ouananiche than by brook trout. However, pelagic or semi-pelagic forms such as chironomid larvae, Hemiptera, Daphnia sp., and adult Coleoptera are taken more

Table VII. The food of Thomas Pond ouananiche expressed as percentages of occurrence, composition, and weight (based on examination of fish from 14.5 - 25.2 cm. fork length collected during June, 1968).

Group	Percent			Weight		
	Frequency	Occurrence	Number	Percent	(mg.)	Percent
CHIRONOMIDAE(LARVAE)	32	32.0	929	41.5	241.6	4.1
EPHEMEROPTERA(DUNGS)	75	75.0	814	36.3	3149.0	53.1
AMPHIPODA	21	21.0	259	11.6	87.9	1.5
TRICHOPTERA(LARVAE)	40	40.0	73	3.3	454.8	7.7
CHIRONOMIDAE(PUPAE)	15	15.0	72	3.2	60.5	1.0
ANISOPTERA(NYMPH)	21	21.0	29	1.3	1311.2	22.1
HEMIPTERA	15	15.0	21	0.9	59.3	1.0
COLEOPTERA(ADULT)	13	13.0	15	0.7	71.5	1.2
HIRUDINEA	9	9.0	13	0.6	84.7	1.4
SPHAERIIDAE	4	4.0	7	0.3	3.1	Trace
AMNICOLIDAE	4	4.0	4	0.2	7.4	0.1
COLEOPTERA(LARVAE)	1	1.0	3	0.1	0.9	Trace
DIPTERA(ADULT)	1	1.0	1	Trace	1.7	Trace
<u>Daphnia</u> sp.	10	10.0	-	-	398.7	6.7
TOTAL	100 STOMACHS*		2,240		5932.3	

\* 5 empty stomachs

frequently by ouananiche. Ephemeroptera are taken frequently and in large numbers, most being either subimagos or adults which are captured either pelagically or from 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.

The only bottom organism consumed more often by ouananiche than brook trout are Anisoptera nymphs. Selection exists for this organism, undoubtedly because of its large size.

The lack of a forage fish species in the diet of Thomas Pond ouananiche may be significant since oft-expressed opinion suggests that forage fish are essential for good salmon growth (Scott and Crossman, 1964; Leggett, 1965; and Havey and Warner, 1970).

#### 4. The Food of Brown Trout

Since the brown trout occurs infrequently in Thomas Pond, a sample could not be obtained for food studies. However, during the course of mark-recapture studies, two or three dozen live specimens were examined. It was readily noticeable that browns were feeding on juvenile salmonids, mainly brook trout, in addition to the consumption of benthos. The brown trout is a predator of young salmonids, in addition to the eel; however its small numbers in the lake preclude any significant effect on the other game species.

### C. Age and Growth

#### 1. Methods and Materials

Fish used for age and growth studies included all fish gill-netted during June 6 - 7, 1968, plus all large fish live-trapped or examined in angler's creels during 1968-1970. 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 between the fingers then mounted wet in a petri dish. Then the scale image, using a Baush 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 a fish VII<sup>+</sup> years of age with a fork length of 33.8 cm. In the Thomas Pond population, brook trout VII<sup>+</sup> years of age are indeed rare, very few reach VI<sup>+</sup> years, and only a few reach V<sup>+</sup> years old. Carlander (1969) gives the maximum recorded age for brook trout as XV<sup>+</sup> years, with fish beyond IX<sup>+</sup> indeed rare. During a study of Petty Harbour Long Pond, an unfished reservoir, one specimen VIII<sup>+</sup> years of age was obtained, several fish VII<sup>+</sup> years were captured, and VI<sup>+</sup> fish were not uncommon. 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 lightly-fished or unexploited stocks.

A ouananiche 29.7 cm. fork length and VII<sup>+</sup> years of age holds the known longevity and size record at Thomas Pond. Fish of this age are quite rare, however VI<sup>+</sup> fish are fairly common. Carlander (1969) gives the maximum recorded age for ouananiche as XIII<sup>+</sup> years.

The oldest and largest brown trout captured at Thomas Pond was VII<sup>+</sup> years of age and had a fork length of 34.4 cm. Brown trout of this age are not uncommon in Thomas Pond. The maximum known age as reported by Carlander (1969) is XVIII<sup>+</sup> 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 and used successfully by the author (Wiseman, 1969 and 1970) for the species 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:

$$\begin{aligned} \text{Log } L_f &= 1.0222 \text{ Log } L_s - 0.8814 \\ \text{or } L_f &= 7.610 L_s^{1.0222} \end{aligned}$$

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 fish length at annulus formation of Thomas Pond brook trout.

Annulus	I	II	III	IV	V	VI	VII
Scale length (X43)	0.72	1.41	2.12	2.68	3.19	3.60	4.00
Fish fork length (cm.)	5.5	10.8	16.4	20.9	24.9	28.2	31.4
Fish fork length (in.)	2.2	4.3	6.5	8.2	9.8	11.1	12.4

Table IX compares the growth rate of Thomas Pond brook trout with those of fish from ten other Avalon Peninsula lakes. Generally, the growth of Thomas Pond trout is similar to the mean growth rate of fish from all eleven areas.

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

Annulus	I	II	III	IV	V	VI	VII	VIII
Thomas Pond	5.5	10.8	16.4	20.9	24.9	28.2	31.4	-
Petty Harbour Long Pd.	5.1	9.9	15.5	21.3	25.8	30.8	33.1	35.5
Paddys Pond	4.5	9.6	15.2	20.2	24.3	28.5	-	-
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 Rockey 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	-	-	-	-	-
MEAN (cm.)	5.7	11.0	16.1	21.1	25.7	29.2	32.3	35.5
(in.)	2.2	4.3	6.3	8.3	10.1	11.5	12.7	14.0

b. Ouananiche. Age determinations were made for Thomas Pond ouananiche using the scale method validated for freshwater 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 Thomas Pond fish.

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

$$L_f = 3.05 L_s + 1.63$$

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

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

Annulus	I	II	III	IV	V	VI	VII
Scale length (X43)	1.02	2.74	4.52	6.05	7.00	7.84	8.71
Fish fork length (cm.)	4.7	10.0	15.4	20.1	23.0	25.5	28.2
Fish fork length (in.)	1.9	3.9	6.1	7.9	9.1	10.0	11.1

Table XI compares the growth rate of ouananiche in Thomas Pond with that of fish from eleven other Avalon Peninsula lakes. Generally, the growth rate of ouananiche in Thomas Pond is a little better than the combined mean growth rate of fish from all twelve 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
Thomas Pond	4.7	10.0	15.4	20.1	23.0	25.5	28.2	-	-	-	-
Paddys Pond	5.7	9.0	14.6	19.0	23.1	25.9	28.1	-	-	-	-
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	-	-	-
Bay Bulls Long Pd.	5.6	9.1	15.1	19.4	24.3	28.1	29.9	-	-	-	-
Snows Pond	3.9	7.2	11.5	15.7	19.6	23.2	30.5	38.5	44.1	-	-
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
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	-	-	-	-	-
Ocean Pond	5.6	10.3	15.3	20.9	23.7	27.1	29.6	31.1	-	-	-
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	-	-	-	-	-
MEAN (cm.)	5.0	9.1	13.6	17.6	20.8	24.3	28.9	32.7	40.8	42.7	44.9
(in.)	2.0	3.6	5.4	6.9	8.2	9.6	11.4	12.9	16.1	16.8	17.7

c. Brown Trout. The ages of Thomas Pond brown trout were determined by scale examination. The scale method for age determination has been validated by Dahl (1910), Lake (1957), and Kipling (1962).

The Lee method of back-calculation, used successfully for brown trout by Whitney and Carlander (1957) and Liew (1969), was used with success for Thomas Pond fish.

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

$$L_f = 3.42 L_s + 2.22$$

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 fish length at annulus formation of Thomas Pond brown trout.

Annulus	I	II	III	IV	V	VI	VII
Scale length (X43)	1.11	2.89	4.70	6.34	7.27	8.44	9.25
Fish fork length (cm.)	6.0	12.1	18.3	23.9	27.1	31.1	33.9
Fish fork length (in.)	2.4	4.8	7.2	9.4	10.7	12.2	13.3

The growth rate of Thomas Pond brown trout is compared with that of fish from six other Avalon Peninsula lakes in Table XIII. Generally the growth of Thomas Pond brown trout is similar to the average growth rate of fish from all seven 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
Thomas Pond	6.0	12.1	18.3	23.9	27.1	31.1	33.9	-	-
Paddys Pond	6.2	10.9	16.5	22.1	26.5	30.0	33.6	38.3	45.4
Windsor Lake	8.2	15.7	22.1	27.3	32.0	35.5	38.4	42.4	-
Topsail Pond	7.4	11.4	16.7	20.3	22.8	26.5	29.9	-	-
Bay Bulls Middle Pd.	6.6	10.5	15.0	19.7	23.8	27.3	30.1	33.6	-
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	-	-
MEAN (cm.)	7.1	12.3	18.2	23.0	27.0	30.7	34.0	37.9	45.4
(in.)	2.8	4.8	7.2	9.1	10.6	12.1	13.4	14.9	17.9

#### 4. Factors Influencing the Growth of Thomas Pond Salmonidae

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

Thomas 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 growth remarkably similar to the combined mean rate.

Growth of brook trout, ouananiche, and brown trout in Thomas 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 fishes are of three types: (1) genetic, (2) physiological, and (3) environmental.

Perhaps the most dominant factors concerned with the growth of Thomas Pond fish are environmental, both physico-chemical and biotic. The chief physico-chemical factors are temperature and water quality, while availability, quantity, and quality of food supply, and interspecific and intraspecific piscine relationships are the most important biotic factors.

Genetic factors may also be important but are usually masked by environmental factors.

a. Environmental Factors. Ample evidence exists in the literature of the importance of temperature on the growth of salmonid fishes. The growth exhibited by a fish during any one year is directly related to the number of days during that year which offered water temperature conducive to growth. Leggett (1965) suggests that 7°C is the critical temperature for ouananiche growth, with cessation of growth occurring at lower temperatures. Power (1958) suggests ouananiche require a growing season with a minimum duration of 100 days. During 1970, which was slightly warmer than average, the average daily surface water temperature of Thomas Pond exceeded 7°C on 177 consecutive days. Leggett suggests a growing season of approximately 150 days was quite suitable for Gambo Pond ouananiche; it is therefore concluded that the growing season for Thomas Pond ouananiche is also quite suitable. However, assuming both brook trout and brown trout require the same length of growing season as ouananiche, it appears that water temperatures at Thomas Pond are quite suitable for optimum growth in all three species, and are not a contributing factor to the generally slow

growth rates exhibited in this lake.

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 Thomas Pond is quite suitable for good growth, other circumstances do contribute to a slow growth rate, resulting in small sexually-mature fish which are not able to utilize the full growth potential of the growing season.

Numerous investigators have related the growth of fish to the quality of the water (Southern, 1932; Went and Frost, 1942; McFadden, 1961; and Scherer, 1963). As we have already seen, waters of Thomas Pond are quite infertile. Water quality undoubtedly affects fish growth rate indirectly by controlling food supply. For example, lack of suitable amounts of calcium carbonate in the water restricts the growth of molluscs, an excellent form of benthic food. Although the bottom fauna of Thomas Pond is sparse, both qualitatively and quantitatively, by North American standards, it is probably average for the Avalon Peninsula. This fact is reflected in the early growth rate of Thomas Pond fishes which is generally as good, or better than, average for this area.

The quality and availability of the food supply is perhaps more important to growth than quantity. While the limited bottom fauna (generally confined to a narrow zone along the lake perimeter) may be sufficient during the spring months for the three salmonid species concerned, much of this benthos is unavailable during the summer period, particularly to ouananiche and brown trout which move offshore to seek cooler water. The lack of a forage fish species, smelt or stickleback for example, in Thomas Pond has particular significance at this time of year.

It can be readily seen that the nutritional value of a large organism, such as a forage fish, greatly outweighs that of a large number of small insects. The energy expended in capturing one fish is far less than that required to capture a large number of insects, and, as a result, the total energy gained from eating one fish is much greater than that gained from the consumption of a large number of small insects.

The necessity of a forage fish in the diet of 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).

Due to past glaciation, the fish fauna of the Island is sparse, and only two species are considered to be of significant forage value. These are the landlocked smelt, Osmerus mordax, and the sticklebacks (generally the three-spine, Gasterosteus aculeatus). It is not coincidence that the largest brook trout, arctic char, and ouananiche occur in waters having these forage species.

Several investigators have commented on the relationship between the presence of forage fish species and fast growing salmonids in certain lakes on the Island.

Scott and Crossman (1964) suggest fastest growing brook trout and ouananiche in insular Newfoundland are those inhabiting lakes with a suitable forage species.

Leggett (1965) attributes the slow growth rate and small size attained by Flatwater Pond (Baie Verte) ouananiche to a lack of forage fish in the diet, while fish at Gambo Pond were attaining very large sizes, relatively quickly, on a diet of smelt and stickleback.

Pippy (1966) reports that sticklebacks make up the bulk of the diet of Victoria Lake ouananiche of approximately 10 inches and greater, and suggests forage fish are required if ouananiche are to attain large sizes.

During the course of the investigation at Thomas Pond it became evident that this lake contains better than average numbers of salmonids per surface acre, however the size of the fish is relatively small. The growth rate of these fish for the first 4 or 5 years (9-10 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, was no better and often slower than that of Thomas 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 feed almost exclusively on sticklebacks and/or small salmonids.

This situation has particular significance for Thomas Pond fish, and for ouananiche especially. Fall standing crops of ouananiche over 9-10 inches in length are significant; these fish are usually 6<sup>+</sup> years of age. However, spring standing crops of 7<sup>+</sup> 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.

Since brown trout appear to be the fastest-growing of the salmonids in Thomas Pond, they are capable of switching to a fish diet at a younger age than either brook trout or ouananiche. At a length of about 11 - 12 inches they begin to take juvenile salmonids. However, brook trout and ouananiche of this size are relatively old and scarce. The total success of a forage fish introduction program to increase growth rate of brook trout and ouananiche therefore may not be realized unless suitable smaller benthic and/or pelagic organisms such as molluscs, mysid shrimps, or amphipods are also introduced to increase the growth rate of younger fish, thereby permitting them to take forage fish a year or two sooner.

Competition, both interspecific and intraspecific, for food and living space is also an important factor affecting growth rate. Since brook trout are harvested heavily by anglers, intraspecific competition is probably very light. Ouananiche, which are not cropped as heavily, probably experience heavier competition between themselves. Although brook trout and ouananiche 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 and ouananiche is probably minimal, particularly during the summer months. The most serious competitor of both species is usually the brown trout (Kendall and Warner, 1970; and Wales, 1946).

Since browns are present in such small numbers, the interspecific competition with brook trout and ouananiche is considered to be negligible at present. Competition from, and predation by, eels on salmonids is not well-documented. Generally speaking then, competition does not appear to be a significant factor in the relatively slow growth rates of the salmonid fish populations in Thomas Pond.

b. Genetic Factors. Numerous authors have shown that the growth rate of fishes can be increased by selective breeding. Dahl (1918) suggests that small, slowly-growing trout are derived from smaller eggs than those growing more rapidly, and that egg size varies with genetic strains, and with it varies the initial size at hatching. In nature, the presence of genetic variations in growth potential in populations of the same species is usually masked by environmental factors, but, as Brown (1946) points out, the advantages may be lifelong.

Fish with greater growth potential than others in the population would be harvested first under intensive angling (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, fry size, and consequently adult size diminishes in future populations. This result could partially explain the sudden decline in the quality of brook trout angled at Thomas Pond. Prior to, and for several years following impoundment, high quality brook trout of 1 - 2 pounds were caught and there were occasional reports of 3 - 4 pound fish being angled. Undoubtedly much of the decrease in growth rate and numbers of large trout was due to impoundment and the subsequent deterioration

in water quality and bottom fauna production. The fish which attained those larger sizes 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. It is also interesting to note that the present growth rate of brook trout is substantially slower than it was during 1965 (Wiseman, 1969).

Anglers report that although large brook trout were taken 10 - 15 years ago, ouananiche were seldom larger than those in present day catches. This report suggests that brook trout are genetically able to reach a substantially larger size on an insect diet than ouananiche do.

#### 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:

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

$\log W = n \log L + \log a$ , where  $\underline{a}$  and  $\underline{n}$  are empirical constants determined by computation, following Rounsefell and Everhart (1953). This relationship provides a means of calculating weight from length and is of particular value in this study for providing a method of calculating biomass when the length composition of the population is known.

Condition is defined as the degree of well-being, relative robustness, plumpness, or fatness. It is analyzed by means of a condition factor, coefficient of condition, ponderal index etcetera, with the objective of expressing the condition of the fish in numerical terms.

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 the 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:

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

where  $\underline{W}$  is the whole weight in grams,  $\underline{L}$  is the fork length in centimeters, and  $10^2$  is a constant which allows  $K$  to assume a value near unity.

a. Brook Trout. 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 empirical and calculated length-weight data are shown in Table XIV. The length-weight relationship for Thomas Pond brook trout is expressed by the relationship:

$$W = .000976L^{3.0824}, \text{ or, expressed logarithmically:}$$

$$\text{Log } W = 3.0824 \text{ Log } L - 2.0106$$

Table XIV gives the mean condition factor for brook trout in each length-class. Condition factors for brook trout may either increase or decrease with increase in length (Wiseman, 1969).

Cooper and Benson (1951) suggest a general "rule of thumb" is that values of  $\underline{n}$  (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.

Table XIV. Length-weight relationship and condition factors for brook trout taken by gill net in Thomas Pond during June, 1968.

Fork length (cm.) class mark	Actual weight (gm.)	Calculated weight	Condition coefficient K	Condition coefficient K <sub>c</sub>
14.55	34.3 (9)	37.5	1.10	1.20
16.55	55.3 (4)	55.8	1.21	1.22
18.55	90.0 (2)	79.3	1.40	1.23
20.55	117.6 (37)	108.7	1.35	1.24
22.55	140.7 (61)	144.7	1.22	1.25
24.55	178.4 (17)	188.0	1.20	1.26
26.55	232.8 ( 9)	239.2	1.24	1.27
28.55	-	299.3	-	1.29
30.55	-	368.8	-	1.31
32.55	-	448.5	-	1.31
34.55	-	539.2	-	1.31

Mean K Value = 1.25; S.D. = 0.0870; S.E. = .0075; range = 1.00-1.53; n = 134

To determine the direction and degree of change in condition with increase in length, a condition factor based on the exponential relationship rather than the cube law, was used in this study. This condition factor, which is designated  $K_c$  (based on calculated data), is very useful in smoothing fluctuating data to indicate a trend. Table XIV shows that for Thomas Pond brook trout  $K_c$  values increase with increase in length.

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.

The mean condition factor (K) for Thomas Pond brook trout is 1.25, and is significantly higher ( $p < 0.01$ ) than the mean of other populations in insular Newfoundland (Wiseman, 1970).

During an earlier study in 1965,  $K_c$  values for Thomas Pond brook trout increased with increase in length at that time also, and the mean K value was 1.26. Although growth rate has declined since 1965 it would appear that Thomas Pond is still a relatively good habitat for brook trout, at least for fish within the existing limited range of lengths.

b. Ouananiche. The length-weight relationship and condition factors were calculated as for brook trout and the data appear in Table XV. The length-weight relationship for Thomas Pond ouananiche is expressed by the relationship:

$$W = .003849L^{2.6193}, \text{ or, expressed logarithmically:}$$

$$\text{Log } W = 2.6193 \text{ Log } L - 1.4147$$

A value of 2.6193 for the exponent  $\underline{n}$  indicates the condition of Thomas Pond ouananiche decreases with increase in length, and the  $K_c$  values verify this. When condition decreases with age or length, it is due to some deficiency or a limitation of some environmental factor. The most obvious factor in the case of ouananiche would be low quality of the food supply, specifically the absence of a forage fish species. Carlander (1969) however, suggests that the genus Salmo generally has  $\underline{n}$  values less than 3, while Salvelinus has values greater than 3.

Table XV. Length-weight relationship and condition factors for ouananiche taken by gill nets in Thomas Pond during June, 1968.

Fork length (cm.) class mark	Actual weight (gm.)	Calculated weight	Condition coefficient K	Condition coefficient $K_c$
14.55	44.7(15)	42.8	1.44	1.38
16.55	57.0(35)	59.9	1.25	1.31
18.55	75.5(17)	80.8	1.17	1.26
20.55	113.9(78)	105.7	1.30	1.21
22.55	138.7(77)	134.8	1.20	1.17
24.55	163.7(32)	168.5	1.10	1.13
26.55	-	206.6	-	1.11
28.55	-	250.0	-	1.08
30.55	-	298.5	-	1.05

Mean K value = 1.23; S.D.= 0.0407; S.E.=0.0026; range = 0.94-1.49; n = 254

The mean condition factor (K) for Thomas Pond ouananiche is 1.23, and is not significantly different ( $P = 0.09$ ) than the mean for Thomas Pond brook trout.

c. Brown Trout. Unfortunately, because of small populations of brown trout in Thomas Pond, a sample was not obtained for length-weight and condition studies.

D. Population Estimate and Standing Crop

1. Methods

Population estimates for 1968, 1969 and 1970 were made using the mark-recapture procedure. Trout 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 and ouananiche conducted during the period 1968-1970 at Thomas Pond.

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Date	Mark Used
June 28 - July 30, 1968 July 31 - August 29, 1968	Adipose fin and left pelvic fin clipped.
June 4 - 20, 1969	Right pelvic fin; clipped.
September 9 - 22, 1969	Lower caudal fin; punched.
April 28 - May 22, 1970	Upper caudal fin; punched.
September 9 - 23, 1970	Left pelvic fin; clipped.

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The mark-recapture method requires that all marked fish be easily recognized upon recapture. For this reason, regeneration of clipped or 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 are short-term (less than one month), recognition of marked individuals is not difficult even though some regeneration may occur, since the clipped and punched fins show a well-defined pattern of mutilation (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 literature offers inconsistent results regarding differential mortality between marked and unmarked individuals, so no definite generalizations can be made. It is probable, though, that mortality from fin-clipping is apt to increase as the environment becomes more rigorous (Chadwick, 1966).

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 following 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 as well.

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 operation of a creel census. This number was subtracted from the total number of fish marked and the adjusted number of marked fish present in the lake was used in the calculation of population size.

Estimates of population size for both brook trout and ouananiche were made for July 30 and August 29, 1968; June 20 and September 22, 1969; and May 22 and September 23, 1970.

2. Brook Trout Population Estimates and Standing Crop

Table XVII shows the population estimates, by age-classes, of the brook trout population in Thomas Pond on selected dates during the period 1968-1970.

Table XVII. Estimates of the brook trout population in Thomas Pond on selected dates during the period 1968 - 1970.

Date	Age - Class							Total	
	0 <sup>+</sup>	I <sup>+</sup>	II <sup>+</sup>	III <sup>+</sup>	IV <sup>+</sup>	V <sup>+</sup>	VI <sup>+</sup>		VII <sup>+</sup>
30/7/68	-	33*	1404*	2436	1372	159	77	21	5502
29/3/68	-	29*	1234*	2135	1207	147	65	18	4835
20/6/69	-	89*	1202	1032*	1172	254	13	4	3766
22/9/69	102*	903*	2398*	2017	323	84	5	2	5834
22/5/70	-	483*	1962*	1798*	1539	208	12	5	6007
23/9/70	43*	336*	3986*	2537	249	35	5	2	7193

\* Minimal estimates for these age-classes.

Generally, the estimates for the younger age-classes, specifically ages  $0^+$  -  $II^+$  and sometimes  $III^+$ , are minimal. These age-classes are, for the most part, lake-resident but are not as vulnerable to the sampling gear as are the older individuals. It is felt that different behaviour and distribution are the contributing factors 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.

During August, 1969, qualitative sampling by beach seine in the main inlet stream at Thomas Pond, namely Upper Manuels River (Holystone Brook), yielded some interesting information on young brook trout (Table XVIII).

Table XVIII. Age-length distribution of brook trout taken by seine in Holystone Brook during August, 1969.

Fork length (cm.)	Age - Class		Total
	$0^+$	$1^+$	
1.55 - 3.55	8	-	8
3.55 - 5.55	63	-	63
5.75 - 7.55	1	-	1
7.55 - 9.55	-	-	-
9.55 - 11.55	-	1	1
TOTAL	72	1	73

At the time of seining, water levels were very low. Only 73 brook trout were captured during several days of careful seining, and 72 of these were young-of-the-year. Sampling in the mainstream of the river yielded no

brook trout; all specimens were collected from either undercut river banks or around fallen beaver dams.

The pattern on scales collected 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. This information supports the suggestion that young trout produced in the streams leave during the summer of the year in which they were hatched and become lake-resident, joining the progeny of shore-spawners in inhabiting a narrow zone of shallow water around the margin of the shoreline and thus are not susceptible to capture by our sampling gear.

Changes in the structure of the Thomas Pond brook trout population are best studied by considering the data on age classes IV<sup>+</sup> - VII<sup>+</sup> given in Table XVII. Generally, the numbers of older and larger fish has declined during the period of study, and this is attributed, for the most part, to high angling mortality. 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 has been almost a complete failure the past three winters.

Although the numbers of older fish have generally declined during the past three years, the 1967 and 1968 year-classes of trout appear to be quite strong and dominated the trap-net catches during the spring and fall of 1970. 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 Thomas Pond are the degree of spawning success and of competition. Following

particularly dry summers, the lake level may be drawn down as much as nine feet by September. If the inlet streams also experience low water levels, the trout may be forced to shore-spawn to a greater extent than usual. In a normal fall and winter the lake is usually filled to maximum storage capacity; in such a situation the redds would be covered by at least nine feet of water. Another adverse situation occurs if trout shore-spawn during high water conditions and a dry winter follows. The lake is drawn down by as much as six feet and redds along the shore are exposed. It is suggested that strong year-classes in 1967 and 1968 were the result of high spawning success in conjunction with greatly-enhanced survival of young fish because of the heavy decrease in the older age groups and subsequent reduction in intraspecific competition.

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

Standing crop estimates are 1870 and 2180 pounds, for the falls of 1969 and 1970 respectively. The higher biomass during 1970 is attributed to strong year-classes of younger fish. The standing crop of the intermediate age-classes is, nevertheless, the greatest contributor to the total standing crop. A similar pattern existed for the Petty Harbour Long Pond population (Wiseman, 1970) and the Matamek Lake, Quebec, population (Saunders and Power, 1970). The standing crop per acre at Thomas Pond was 7.32 and 8.54 pounds for the two years. Investigation at Petty Harbour

Long Pond indicated there were 5.42 pounds per acre in that one-species lake, and Matamek Lake had only 2.8 pounds per acre and is a multi-species lake (Saunders and Power, 1970). Thomas Pond is obviously a comparatively productive environment for brook trout.

Table XIX. Age-class distribution of the estimated populations and standing crops of brook trout in Thomas Pond on September 22, 1969, and September 23, 1970.

Age-class	1969		1970	
	Estimated population	Standing crop (kg.)	Estimated population	Standing crop (kg.)
0 <sup>+</sup>	43,474	60.4	54,832	76.2
1 <sup>+</sup>	15,607	134.7	19,630	169.4
11 <sup>+</sup>	5,617	358.7	7,065	451.2
111 <sup>+</sup>	2,017	210.3	2,537	234.8
IV <sup>+</sup>	323	57.9	249	44.9
V <sup>+</sup>	84	22.4	35	8.7
VI <sup>+</sup>	5	1.6	5	1.8
VII <sup>+</sup>	2	1.1	2	0.9
TOTAL	67,129	847.1 (1867.9 lbs.)	84,355	987.9 (2178.3 lbs.)

Generally, in the two study years an average of 72 percent of the population weight and 10 percent of the number was composed of trout exceeding six inches in fork length (Table XX). 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. Long Pond had 4.19 pounds of trout over six inches in length per acre of surface water, while Thomas Pond had 5.29 and 6.15 pounds, for 1969 and 1970 respectively. Although the

proportion of catchable-size fish (over six inches) is similar in both lakes, it should be pointed out that the bulk of the "catchables" at Thomas Pond are barely more than six inches, while those at Long Pond are distributed more evenly over a range of lengths greater than six inches.

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

Year	Weight	Percent	Weight/acre	Number	Percent
1969	613.0 (1351.7 lbs.)	72.36	2.40 (5.29 lbs.)	7205	10.73
1970	712.0 (1570.0 lbs.)	72.07	2.79 (6.15 lbs.)	8833	10.47

### 3. Ouananiche Population Estimates and Standing Crop

Table XXI shows the estimates, by age-classes, of the ouananiche population in Thomas Pond on selected dates during the period 1968-1970. Population estimates for the younger age-groups, as for the brook trout, are minimal. A major segment of the younger age-classes is stream-resident.

Table XXI. Estimates of the ouananiche population in Thomas Pond on selected dates during the period 1968 - 1970.

Date	0 <sup>+</sup>	I <sup>+</sup>	II <sup>+</sup>	III <sup>+</sup>	IV <sup>+</sup>	V <sup>+</sup>	VI <sup>+</sup>	VII <sup>+</sup>	Total
30/7/68	-	15*	399*	903*	1317	236	44	-	2914
29/8/68	-	16*	370*	847*	1235	224	48	-	2740
20/6/69	-	157*	103*	616*	1259	987	97	-	3219
22/9/69	-	65*	589*	756*	1209	496	41	-	3156
22/5/70	-	207*	417*	1455*	1265	988	134	7	4473
23/9/70	-	362*	6536	2933	1219	309	18	-	11377

\* Minimal estimates for these age-classes.

Qualitative sampling by beach seine of the major inlet stream (Holystone Brook) during August, 1969, resulted in the information given in Table XXII. Though water levels were extremely low at that time, 367 ouananiche comprising five year-classes were captured. Although the sample was non-quantitative, it does indicate a fairly extensive stream-resident population, particularly of year-classes 0<sup>+</sup> and 1<sup>+</sup>. The low number of fish older than 1<sup>+</sup> years indicates that most young ouananiche leave the nursery area before their third summer of life.

Table XXII. Age-length distribution of ouananiche seined in Holystone Brook during August, 1969.

Fork Length (cm.)	Age-Class					Total
	0 <sup>+</sup>	1 <sup>+</sup>	II <sup>+</sup>	III <sup>+</sup>	IV <sup>+</sup>	
1.55 - 3.55	69	-	-	-	-	69
3.55 - 5.55	164	-	-	-	-	164
5.55 - 7.55	-	19	-	-	-	19
7.55 - 9.55	-	83	-	-	-	83
9.55 - 11.55	-	17	1	-	-	18
11.55 - 13.55	-	-	4	-	-	4
13.55 - 15.55	-	-	5	3	-	8
15.55 - 17.55	-	-	-	-	-	-
17.55 - 19.55	-	-	-	-	2	2
Total	233	119	10	3	2	367

To assess this hypothesis, a number of adult fish (ages IV<sup>+</sup> - VI<sup>+</sup>) scale patterns were examined for growth history. The pattern of growth of

ouananiche scales, like those of sea-run Atlantic salmon, permits the examiner to distinguish growth during early life (stream-residence period) from adult growth (lake-residence in ouananiche and 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 migrate to the lake. This information for Thomas Pond fish is given in Table XXIII.

Table XXIII. Ages at which young ouananiche migrate from stream to lake at Thomas 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 <sup>+</sup>	1 <sup>+</sup>	II <sup>+</sup>	III <sup>+</sup>	IV <sup>+</sup>
Percent of population which enters the lake at age class	34.83 (101)	34.14 (99)	26.20 (76)	4.83 (14)	0.00 (0)
Cumulative percent of population in the lake at end of age (t)	34.83	68.97	95.17	100.00	100.00

Generally, all ouananiche are lake-resident by the end of their third summer (II<sup>+</sup>) and most are by the end of the second summer (I<sup>+</sup>). Leggett (1965) suggests that young ouananiche enter Gambo Pond at age II - II<sup>+</sup>, however his data indicate only that the bulk of the fish have left the stream by the end of their third summer (II<sup>+</sup>). Indeed, Havey and Warner (1970) state that 51 to 74 percent of darr salmon emigrate from the streams of Maine at age 1 or 1<sup>+</sup>. Available information indicates that the young ouananiche enter Thomas Pond during late May and early June.

The structure of the Thomas Pond ouananiche population during 1968 - 1970 is given in Table XXI. The decrease in older and larger fish, which was so characteristic of the brook trout population, did not occur in the ouananiche population. In fact, the oldest and largest ouananiche encountered at Thomas Pond were present during 1970. As with brook trout, it is suggested that most spring to fall mortality is attributed to angling, while overwinter reductions are 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.

The 1967 and 1968 year-classes of ouananiche, as with brook trout, appear to be quite strong, and this strength is attributed to environmental conditions which were conducive to good spawning success, and subsequent high survival of the young. Ideal water levels and flows during spawning and incubation, plus reduced competition from larger fish (particularly brook trout) are suspected as the contributing factors to good year-class strength during 1967 and 1968. Using the age structure data on the estimated population present during the falls of 1969 and 1970 and by extrapolating the numbers present in younger age groups from rates of mortality (50 percent for ages  $0^+ - 1$ ,  $- 11^+$  and  $11^+ - 111^+$ , given by Havey and Warner, 1970) total estimates were made for the population number and biomass of the ouananiche stock during the fall of each of the two years (Table XXIV).

Using data in Table XXIII which indicate the percentage of young ouananiche which are lake resident, it is possible to determine the proportion of the ouananiche, resident in Thomas Pond, which contributes to the lake's fish biomass.

Table XXIV. Age-class distribution of the estimated population and standing crop of ouananiche in Thomas Pond on September 22, 1969, and September 23, 1970.

Age-Class	Estimated Total Population	Total Standing Crop (kg.)	Estimated Lake Population	Total Standing Crop in the Lake (kg.)	Estimated Total Population	Total Standing Crop (kg.)	Estimated Lake Population	Total Standing Crop in the Lake (kg.)
0 <sup>+</sup>	23,272	27.7	8,106	9.6	26,144	31.1	9,106	10.8
1 <sup>+</sup>	11,636	141.4	8,025	97.5	13,072	158.8	9,016	109.5
11 <sup>+</sup>	5,818	242.3	5,537	230.6	6,536	272.2	6,220	259.0
111 <sup>+</sup>	2,909	253.7	2,909	253.7	2,933	255.8	2,933	255.8
IV <sup>+</sup>	1,209	152.7	1,209	152.7	1,219	154.0	1,219	154.0
V <sup>+</sup>	496	83.1	496	83.1	309	51.8	309	51.8
VI <sup>+</sup>	41	8.2	41	8.2	18	36.1	18	36.1
Total	45,381	909.1 (2004.6 lbs.)	26,323	835.4 (1842.0 lbs.)	50,231	959.8 (2116.0 lbs.)	28,821	877.0 (1934.0 lbs.)

Estimates of the ouananiche standing crop in Thomas Pond are 1842 and 1934 pounds for the falls of 1969 and 1970 respectively. The higher biomass during 1970 is attributed to the strong year-classes of younger fish. As was the case with brook trout, the fish of intermediate age-groups are the greatest contributors to the total standing crop. The standing crop of ouananiche per acre at Thomas Pond was 7.2 and 7.6 pounds for these two years.

The total biomass of salmonids in Thomas Pond during the two falls were 3710 pounds and 4112 pounds, or 14.5 pounds per acre and 16.1 pounds per acre, respectively. Carlander (1950) suggests trout lakes and ponds have a maximum of 40 to 50 pounds per acre, but most likely less than 10 pounds per acre; Thomas Pond therefore is a fairly 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, while in Thomas Pond, a more productive environment, there were 7.32 and 8.54 pounds per acre.

Brook trout and ouananiche 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 Thomas Pond, brook trout and ouananiche 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 lakes (particularly on the West Coast where water quality is much higher) are much higher than 14 - 16 pounds per acre.

Table XXV shows that generally, for the two years under consideration, an average of 64 percent of the population weight and 22 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.

Table XXV. Estimated standing crop (kg.) of ouananiche over six inches in length, in Thomas Pond during the falls of 1969 and 1970.

Year	Weight (kg.)	Percent	Weight/Acre	Number	Percent
1969	551.4 (1215.8 lb.)	65.25	2.16 (4.76 lb.)	5,943	22.58
1970	558.0 (1230.4 lb.)	63.62	2.19 (4.83 lb.)	5,926	22.51

## E. Reproduction

Salmonid populations generally are quite resilient despite heavy exploitation by anglers and great reduction by other causes. It is, therefore, of considerable importance to have information concerning the reproductive ability of such populations. Several authors (Rounsefell and Kelez, 1938; and Rounsefell, 1949) point out there is a relationship between the reproductive potential of the spawning stocks and the number of surviving young. In a consideration of the reproductive ability of Thomas Pond brook trout and ouananiche, several aspects were of concern. These were: (1) Fecundity (2) Egg deposition, and (3) Spawning.

### 1. Fecundity

Fecundity is defined as the number of ripe eggs present in the ovaries just prior to spawning. This definition was proposed by Vladykov (1956) and has since been accepted by McFadden (1961) and Wydoski and Cooper (1966).

a. Methods. Because atresia has been shown to be of such importance in determining egg numbers (Vladykov, 1956), fish used for our fecundity studies were collected as close to spawning time as possible. Three hundred and forty seven mature female ouananiche were collected from several Avalon Peninsula lakes during the falls of 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. None of the Thomas Pond spawning stock were sacrificed for fecundity because it was felt that the combined samples from several localities would be representative of ouananiche fecundity generally.

The majority of fish used were at the stage of maturity designated as stage 4 by Vladykov (1956). Ovaries were removed from the fish in the field and placed in 10 percent formalin.

Enumerations were made by direct count where only several hundred eggs were involved. Larger numbers of eggs necessitated the use of the volumetric method as used by Raitt (1933). The total number of ripe eggs present in both ovaries was counted.

Brook trout fecundity data which were collected during an earlier study at Long Pond and at several other Newfoundland lakes (Wiseman, 1969; 1970) were used and assumed to be representative for Thomas Pond brook trout. Methods and procedures used in collection and enumeration were identical to those used for ouananiche.

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; Allan, 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 379 mature female ouananiche were arranged into 2.0 cm. length classes and the mean number of mature eggs was calculated for each length-class. A scatter plot indicated a curvilinear relationship. The empirical data were then fitted to a log regression of the form,  $\text{Log } F = n \log L + \log a$ , which is the logarithm form of the exponential  $F = aL^n$ . The expression calculated for ouananiche is as follows:

$$\text{Log } F = 3.1981 \log L - 1.9223$$

or, expressed exponentially:

$$F = .001196 L^{3.1981}$$

Generally then, the number of mature eggs in ouananiche is approximately proportional to the cube of the length, or  $F = aL^3$ . The calculated egg number for each length-class is given in Table XXVI.

The data on 150 mature female brook trout were treated similarly and the logarithmic expression calculated for this species is as follows:

$$\text{Log } F = 3.1563 \text{ log } L - 1.5642$$

or, expressed exponentially:

$$F = .002728 L^{3.1563}$$

Table XXVI. Empirical and calculated data of the number of mature eggs by fork length size-class for 379 mature female ouananiche.

Size-class fork length (cm.)	Sample size	No. of mature eggs	*Calculated No. of mature eggs
16.55	12	147	95
18.55	23	164	136
20.55	39	217	189
22.55	57	285	254
24.55	102	321	334
26.55	61	432	428
28.55	48	562	541
30.55	20	659	671
32.55	9	801	822
34.55	5	890	995
36.55	3	1211	1191

\* Calculated from  $\text{Log } F = 3.1981 \text{ Log } L - 1.9223$

## 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 and 1970 are given in Table XXVII. A fairly large number of size-classes and age-groups contribute to egg production in Thomas 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 and 1970, the estimated potential deposition in Thomas Pond was 478,226 and 429,841 eggs, respectively.

In salmonids an average of 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 2.0 percent as the amount of eggs not correctly buried.

Table XXVII. Estimated potential egg deposition by brook trout in Thomas Pond during the spawning seasons of 1969 and 1970.

Fork length (cm.) class mark	Percent mature females in the population	Calculated no. of eggs per female	1969		1970	
			No. fish	No. eggs	No. fish	No eggs
16.55	8.18	192	157	30,144	197	37,824
18.55	14.06	275	333	91,575	419	115,225
20.55	18.63	380	157	59,660	196	74,480
22.55	64.60	509	298	151,682	194	98,746
24.55	54.67	666	131	87,246	106	70,596
26.55	68.75	852	40	34,080	28	23,856
28.55	50.00	1072	21	22,512	3	3,216
30.55	50.00	1327	1	1,327	2	2,654
32.55	50.00	1622	-	-	2	3,244
Total			1138	478,226	1147	429,841

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 Thomas Pond.

Using a working estimate of 0.5 percent loss from egg retention and 2.0 percent unburied loss, we estimate 466,318 and 419,138 eggs were deposited during the falls of 1969 and 1970, 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 and 1971 at Thomas Pond would be 419,686 and 377,224, respectively.

McFadden (1961) suggests the survival of young-of-the-year for the first nine 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.

If we use 2.0 to 4.0 percent as working estimates, the expected number of fall fingerlings in 1970 and 1971 would be 8,394 - 16,798 and 7,544 - 15,088, respectively.

The calculated population of fall fingerlings during 1969 and 1970 was 43,474 and 54,832, respectively. To produce this number of fall fingerlings from the known egg deposition, the fry survival rate would have to be about 12 percent. This figure is somewhat higher than normally quoted but well within expected limits.

Density - dependent factors, such as food, space, and cover, are considered by many ecologists 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 number of adults secondly. The situation at Thomas Pond, where there is reduced numbers of both adults and fry, would thus be conducive to increased fry survival. In fact, if this compensatory mechanism did not occur, reduction or even depletion of the stock would occur because of insufficient annual recruitment.

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 providing fry survival is higher than usual.

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

In contrast to the brook trout, relatively few size-classes and age-groups contribute to egg production. 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 ages is insignificant.

During the spawning period in 1969 and 1970, the estimated potential deposition was 301,920 and 213,973 ouananiche eggs, respectively. Using a working estimate of 0.5 percent loss through egg retention and 2.0

Table XXVIII. Estimated potential egg deposition by ouananiche in Thomas Pond during the spawning seasons of 1969 and 1970.

Fork length (cm.) class mark	Percent mature females in the population	Calculated no. of eggs per female	1969		1970	
			No. fish	No. eggs	No. fish	No. eggs
18.55	1.52	136	15	2,040	15	2,040
20.55	5.50	189	59	11,151	59	11,151
22.55	17.32	254	185	46,990	182	46,228
24.55	42.88	334	370	123,580	265	88,510
26.55	49.50	428	247	105,716	148	63,344
28.55	42.86	541	23	12,443	5	2,700
Total			899	301,920	674	213,973

percent unburied loss, we estimate 294,402 and 208,645 eggs were deposited during the falls of 1969 and 1970.

Warner (1963) suggests a 92 percent survival rate from egg to emerging fry. On this basis, the expected number of fry emerging in 1970 and 1971 at Thomas Pond would be 270,850 and 191,953, respectively.

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 to 8.0 percent. If we use 6.0 to 11.0 percent as working estimates, the expected number of fry surviving to the falls of 1970 and 1971 would be 17,664 - 32,384 and 12,519 - 22,951, respectively.

The calculated population of fall fingerlings during 1969 and 1970 was 23,272 and 26,144 respectively. To produce this number of fry from the known egg deposition, the egg-to-fall fingerling survival rate would have to be about 11 percent, which is at the upper level of the range of survival rates reported in the literature.

Generally then, both brook trout and ouananiche at Thomas Pond are experiencing high fry survival rates of about 11 - 12 percent, and this is attributed, for the most part, to density-dependent factors.

### 3. Spawning

a. Spawning Period. Brook trout spawn from August to January, depending on latitude and water temperature (McAfee, 1966). Spawning is mainly at mean daily water temperatures between 40 and 50°F.

During the fall of 1968, brook trout commenced spawning at Thomas Pond between October 11 and October 16 at a stream surface water temperature of 44°F. The spawning peak was reached around October 24, when the surface water temperature was 38°F., and spawning activity was considered to be over by October 31.

Ouananiche generally spawn in October and November (Havey and Warner, 1970).

Spawning at Thomas Pond, during 1968, began around October 16, peaked between October 24 and 31; and was ended, for all intents and purposes, by November 12. (Table XXIX).

b. Spawning Areas. There are two known major spawning areas for brook trout and ouananiche at Thomas Pond. In addition, there are two suspected areas for brook trout (Table XXX).

The known areas are (1) the inlet stream from the Holystone Gullies (Holystone Brook) and (2) the inlet stream from Gear and Northern Ponds (Figures 18 and 19). The suspected areas are (1) the shoreline of the lake itself, and (2) the inlet stream from Loo Pond (Figure 20.).

The Holystone Brook is without question the main spawning area for both brook trout and ouananiche and the major nursery area for ouananiche. The main brook is approximately 6 miles in length, with an additional 6 miles of tributary streams. Spawning is confined, for Thomas Pond fish, to the first 3/4-mile of river. Numerous small bodies of standing water above this stretch also sustain good populations of brook trout and ouananiche, and these stocks utilize the upper sections of the river for spawning. The substrate of this river is excellent for spawning purposes. Under normal

Table XXIX. Pre-spawning, spawning, and post-spawning events for the spawning of brook trout and ouananiche in Holystone Brook, an inlet to Thomas Pond, during October - November, 1968.

Date	Pond Temp. (Surface )	Stream Temp.	Remarks
Oct. 4	52.5°F	61.0°F	Water levels extremely low - no fish in the river.
Oct. 8	50.0°F	50.0°F	River in flood following heavy rain - no fish observed in the river - set a fyke net at the mouth of the river.
Oct. 10	48.0°F	44°F	Only 15 fish in the fyke net (11 ouananiche, 4 brook trout)
Oct. 11	47.0°F	44°F	River still in flood - only 11 fish in the fyke net.
Oct. 16	46.0°F	44°F	Approximately 240 fish in the fyke net (200 ouananiche, 40 brook trout) - spawning started for both species - water level falling.
Oct. 24	42.0°F	38.0°F	Several hundred fish in the fyke net - water level down - hundreds of fish in the river and spawning - spawning peak reached.
Oct. 31	41.0°F	36.0°F	Many of the brook trout spent and moving downstream, some ouananiche still entering the stream.
Nov. 12	39.0°F	35.5°F	Only a few fish in the stream most spent, spawning considered to be complete.

Table XXX. Description of known and suspected spawning areas for brook trout and ouananiche in Thomas Pond.

Section	Holystone Brook to First Beaver Pond	Gear Pond Brook to Crooked Gully	Loo Pond Brook	Shoreline of Thomas Pond
Width (ft.)	35.0	15.0	4.0	-
Length (ft.)	3960.0	2110.0	1584	-
Depth (ft.)	0.8	1.0	0.5	-
Area (sq. ft.)	138,600	31,650	6,336	-
Sq. ft. of suitable spawning areas	103,950	4,748	950	Not Determined
Quality of spawning area	Excellent	Fair	Fair	Fair in terms of substrate but very poor in terms of aeration.
No. of redds observed	Numerous	Nil-high water levels during survey	Nil	Nil
Bottom	Bedrock	-	5	-
Composition, percent	Boulder	5	30	5
	C.Rubble	20	50	40
	F.Rubble	40	10	40
	C. Gravel	25	5	10
	F. Gravel	10	-	5
Comments:	Known major spawning area for ouananiche and brook trout. Good tree cover (fir, tamarack, birch & spruce). Fair rearing area.	Very few spawners entered this brook during 1968. Excellent rearing area. Excellent tree cover.	Doubtful if used for spawning-water level usually low. Much aquatic vegetation in and around this brook. Good rearing area.	Shoreline of Thomas Pond is suspected as being major spawning area for brook trout, particularly when water levels are low in inlet streams.



Figure 18. Inlet stream from the Holystone Gullies (Holystone Brook).



Figure 19. Inlet stream from Gear Pond and Northern Pond.



Figure 20. Inlet stream from Loo Pond.

run-off conditions, the spawning area is completely accessible; however, during abnormally low run-off there may not be sufficient flow to accommodate the spawners. Such a situation occurred in 1968 when no fish were able to enter the river prior to a heavy rainfall about October 8. Following this rainfall, the normal spawning run of ouananiche occurred; however, very few brook trout entered the river. During 1969 and 1970, normal fall run-off occurred after early September. During early and mid-September, many mature brook trout were observed moving up the river in preparation for spawning. This early fall upstream migration could not occur during September, 1968, and the fish probably reverted to shore-spawning on that occasion.

During the spawning survey of 1968, a fyke net was operated at the mouth of Gear Pond Brook from October 8 to October 31; however, catches indicated relatively few fish enter this stream, relative to Holystone Brook. The spawning material quality in this stream can only be considered fair.

No fish were observed entering Loo Pond Brook during the fall of 1968; however, brook trout could conceivably utilize this stream to some extent although the quality of spawning material is only fair.

Since very few brook trout entered the inlet streams during October, 1968, when flows were normal, and since they could not enter during September because of abnormally low run-off, it is suspected that the trout shore-spawn to a great extent if low run-off conditions exist in the streams at time of spawning migration. 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. However, since Thomas Pond has been inundated, it is doubtful that the present shoreline has any shallow areas which are spring-fed; in fact, there are very few areas of gravel or rubble along the present shoreline. It can be assumed from this information that survival of eggs deposited under these conditions must be minimal.

c. Size and Sex Ratio of the Spawners. Data in Table XXXI indicate that, in both brook trout and ouananiche spawning stocks, males are significantly smaller than females ( $p < 0.01$ ). This situation is general in spawning runs of non-anadromous salmonids, the mean size of the males being smaller because of their younger average spawning age.

The sex ratio of mature fish captured during the spawning runs was approximately 2:1 in favour of males for both species (Table XXXI).

Table XXXI. Comparison of the size (cm.) of mature male and female brook trout and ouananiche captured just prior to spawning during 1969 and 1970, Thomas Pond.

Species	Year	Sex	Mean Fork Length (cm.)	Range	No.	S.D.	p. Value
Brook Trout	1969	Male	18.74	13.5 - 28.7	212	3.660	< 0.01
		Female	20.76	15.8 - 31.0	119	3.902	
	1970	Male	18.31	13.4 - 30.1	311	3.400	< 0.01
		Female	20.05	15.6 - 32.5	163	3.776	
Ouananiche	1969	Male	22.25	13.5 - 28.7	417	3.218	< 0.01
		Female	24.43	17.6 - 28.5	181	3.510	
	1970	Male	22.06	14.0 - 28.6	351	3.310	< 0.01
		Female	24.00	17.8 - 29.0	142	3.914	

#### IV. THE SPORT FISHERY

##### A. Introduction

Angling is as much a part of the environment as the strictly "natural" forces to which salmonids are exposed. Angling is not only of ecological importance to the fish populations but is of great esthetic and economic importance to Man. Although it may be difficult to control most other ecological factors affecting the abundance of a fish population, angling can be regulated to maximize the value of a fish resource. Therefore, it becomes imperative to devote a considerable amount of work 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. Although this predation is of a specialized nature, it seems logical to assume that a predictable quantitative relationship exists between predator and prey.

The rate of exploitation is affected by population density, fishing pressure, angler ability, the 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 influences the ease with which fishing may be carried out, weather, and numerous other factors.

##### B. Methods

Information on the salmonid sport fishery at Thomas Pond was obtained by conducting a creel census. Lack of sufficient human and monetary resources to conduct a complete census resulted in the choice

of the partial census recommended by Best and Boles (1956), which is stratified by calendar months. 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 1968 and 1969, and a winter census of ice-fishermen was also conducted during 1969. The 1968 open-water census was conducted during the period June - September, while the 1969 summer-season census was conducted from May to September. A winter census was conducted during January and February, 1969.

The existence of only two major routes of access to the lake facilitated the creel census. 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 1968 and 1969, 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.

It is estimated that the census was over 90 percent complete. 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

Thomas Pond is undoubtedly one of the heaviest-fished lakes on the island of Newfoundland. This distinction is attributed to (1) its proximity to the City of St. John's, (2) its location along the main surface transportation artery (Trans Canada Highway), (3) it is one of very few lakes near the Metropolitan area into which the public is able to launch boats without too much difficulty, (4) its past history of high angler-success and quality fishing, and (5) its present status as a lake offering medium quality fishing.

Prior to inundation by the Newfoundland Light and Power Company Limited in 1956 and the start in construction of the Trans Canada Highway during 1958, Thomas Pond was only fished by the more hardy and adventurous of sport fishermen. Access for Conception Bay South residents was via Fowler's Road to Paddys Pond and from there on foot. Access from the Goulds-Kilbride area was via the Heavy Tree Road to Cochrane Pond and from there by foot. In addition, a trail led from the Donovans area to Thomas Pond.

With improved access came increased 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 success reached a peak. Both have subsequently diminished.

#### 1. Fishing Sites

The most popular fishing site for shore fishermen, during the open-water season, is along the earth-fill dam (Figure 21). Another popular site is along the shoreline in the immediate area where Fowler's Road meets Thomas Pond at a point near the junction of the Grassy Gullies and pre-impounded Thomas Pond (Figure 2).

Ice fishermen usually distribute themselves randomly along the perimeter of the lake, staying relatively close to the shore. There is usually some concentration of effort near Holystone Brook.

Sites favored by boat fishermen include the areas near the inlet streams and portions of shoreline having an abundance of deadwood. Relatively little fishing is done in the central portions of the lake.

There are three access points available to fishermen with boats. The best boat access point is the short road from the Trans Canada Highway to the controlled-flow spillgate (Figure 22). The second most frequently-used boat access is at a point approximately 200 yards southeast of the controlled-flow spillgate (Figure 22). Boat fishermen reach this launching area from the Trans Canada Highway via a large gravel pit (Figure 23).



Figure 21. Shore fishermen fishing along the dam at Thomas Pond.



Figure 22. Two major boat launching sites at Thomas Pond.



Figure 23. Gravel pit bordering on the Trans Canada Highway, through which boat fishermen have access to Thomas Pond.

An infrequently-used access point is at the end of Fowler's Road, the same location mentioned earlier as a popular location for shore fishing.

Thomas Pond is rather unique in that only about ten percent of its perimeter is usable by shore fishermen during spring and early summer. At this time the lake is near full storage capacity and is difficult to fish from shore. Following drawdown, in late summer and early fall, much of the shoreline is exposed but is then utilized little by shore fishermen because of the lateness of the angling season.

## 2. Fishing Methods

Inquiry about the methods and lures used by anglers revealed a strong inclination toward variety. Most anglers on Thomas Pond reported using more than one method.

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 combinations, 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-cast 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 Angler's Lures. During the course of mark-recapture experiments in 1968, 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 angler's lures are given in Table XXXII. Of all brook trout examined, approximately nine percent had visible injuries and 22 percent of the ouananiche were injured. (Too few brown trout were examined to give a significant figure for this species). The 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 (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. 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

Table XXXII. The incidence of visible injury to brook trout and ouananiche in Thomas Pond during 1968, resulting from being hooked and subsequently either escaping from, or being released by, the anglers.

Fork Length-Class (cm.)	Brook Trout			Ouananiche		
	No. Examined	No. Injured	% Injured	No. Examined	No. Injured	% Injured
10.55	3	-	-	10	-	-
12.55	23	-	-	22	1	4.5
14.55	71	-	-	12	1	8.3
16.55	209	4	1.9	39	3	7.7
18.55	152	10	6.6	48	7	14.6
20.55	72	14	19.4	56	14	25.0
22.55	114	20	17.5	87	30	34.4
24.55	61	12	19.6	43	14	32.5
26.55	25	5	20.0	13	3	23.0
28.55	6	-	-	1	1	100.0
30.55	1	1	100.0	-	-	-
Total	737	66	9.0*	331	74	22.4**

\* 10.3% of catchable trout had visible injuries.

\*\* 23.1% of catchable ouananiche had visible injuries.

aerial displays following hooking than are brook trout which tend to struggle deeper beneath the surface.

The significance of the incidence of visible injury to Thomas Pond fish will only be determined when other fish populations can be examined in a similar manner.

b. Time of Fishing. Most of the angling pressure occurs during spring and early summer (Table XXXIII). During the period May to September, 1968, 11,239 man-hours of fishing effort were exerted at Thomas Pond. During the same period in 1969, the effort dropped to 9,115 man-hours. The number of man-hours per acre per year spent at Thomas Pond during the open-water seasons of 1968 and 1969 were 44.1 and 35.8 respectively. Fishing pressure on four well-known American trout streams range from approximately 100 - 500 man-hours of angling per acre per year (Shetter, 1944; Cooper, 1952; and Rupp, 1955). However, Carlander (1950) gives a range of 18 - 155 man-hours per acre per year for several temperate-zone lakes. This would indicate that fishing pressure at Thomas Pond is moderately heavy by North American standards.

Very little angling pressure is exerted by ice-fishermen. During the winter fishery of January and February, 1969, the angling effort averaged only 24 man-hours per day. The total number of man-hours fished for the period was 1080.

Tables XXXIV and XXXV show the mean daily man-hours of angling effort per day of the week for the open-water seasons of 1968 and 1969. The distribution pattern indicates that fishing pressure is highest on weekends. This is the usual situation for sport fisheries near major

population centers (Churchill and Snow, 1964).

The mean daily man-hours of angling effort per day of the week for the 1969 winter fishery is shown in Table XXXVI. 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 1968 and 1969 open-water seasons is given in Table XXXVII and is presented graphically in Figure 24. 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 it. The diurnal distribution in Figure 24 is very much skewed to the right, indicating a predominantly afternoon and evening fishery. This distribution is characteristic of a fishery near an urban area.

The distribution of time spent fishing during the 1968 and 1969 open-water seasons is given in Table XXXVIII and is illustrated in Figures 25 and 26. The distributions are skewed far to the left, indicating most anglers spend relatively little time at the lake. During 1968 the average length of a fishing trip was 2.3 hours, while in 1969, it was only 2.1 hours. 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.

Table XXXIII. Angling intensity at Thomas Pond during the open-water seasons of 1968 and 1969.

Month	1968				1969			
	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	110	0.43	3,410	13.4	105	0.41	3,255	12.8
June	89	0.35	2,670	10.5	85	0.33	2,550	10.0
July	94	0.37	2,914	11.4	55	0.22	1,705	6.7
August	55	0.22	1,705	6.7	45	0.18	1,395	5.5
Sept.	18	0.07	540	2.1	7	0.03	210	0.8
Total			11,239	44.1/acre/season			9,115	35.8/acre/season

Table XXXIV. Mean daily man-hours of angling effort per day of the week and resulting catch at Thomas Pond, June to September, 1968.

Day of week	S	M	T	W	T	F	S	Weekly total
Man-hours	80	87	63	36	42	36	103	447
Catch								
Brook trout	27	25	17	9	9	12	40	139
Ouananiche	36	34	20	14	17	16	41	178
Brown trout	Trace	T	T	T	T	T	T	1
Total	63	60	37	23	26	28	81	318

Table XXXV. Mean daily man-hours of angling effort per day of the week and resulting catch at Thomas Pond, May to September, 1969.

Day of week	S	M	T	W	T	F	S	Weekly total
Man-hours	128	62	49	35	25	31	91	421
Catch								
Brook trout	40	20	10	9	8	6	16	109
Ouananiche	30	14	12	15	7	2	10	90
Brown trout	Trace	T	T	T	T	T	T	1
Total	70	34	22	24	15	8	26	200

Table XXXVI. Mean daily man-hours of angling effort per day of the week and resulting catch at Thomas Pond, January and February, 1969.

Day of week	S	M	T	W	T	F	S	Weekly total
Man-hours	37	20	11	10	9	8	72	167
Total catch (all species)	2	1	T*	T	T	T	3	7

\* Trace

Table XXXVII. Daily time frequency distribution (two-hour intervals) of censused angling parties at Thomas Pond during June - September, 1968, and May - September, 1969.

Time of day	1968		1969	
	No. of parties	Percent	No. of parties	Percent
3:15 - 5:15 AM	3	0.3	4	0.4
5:15 - 7:15	5	0.6	8	0.7
7:15 - 9:15	26	2.9	18	1.6
9:15 - 11:15	62	6.9	73	6.7
11:15 - 1:15 PM	82	9.1	99	9.1
1:15 - 3:15	135	14.9	159	14.6
3:15 - 5:15	154	17.1	189	17.3
5:15 - 7:15	193	21.4	222	20.3
7:15 - 9:15	186	20.6	236	21.6
9:15 - 11:15	55	6.1	84	7.7
Total	901		1,091	

Table XXXVIII. Distribution of time spent angling (hours) by fishing parties visiting Thomas Pond during June - September, 1968, and May - September, 1969.

Hours fished	1968		1969	
	No. of parties	Percent	No. of parties	Percent
1/4 - 1	121	30.3	190	37.9
1 1/4 - 2	108	20.1	151	30.1
2 1/4 - 3	65	16.3	72	14.4
3 1/4 - 4	33	8.3	35	7.0
4 1/4 - 5	26	6.5	12	2.4
5 1/4 - 6	29	7.3	11	2.2
6 1/4 - 7	7	1.8	8	1.6
7 1/4 - 8	4	1.0	4	0.8
8 1/4 - 9	4	1.0	4	0.8
9 1/4 - 10	2	0.5	5	1.0
10 1/4 - 11	2	-	3	0.6
11 1/4 - 12	-	-	2	0.4
12 1/4 - 13	-	-	2	0.4
13 1/4 - 14	-	-	1	0.2
14	-	-	1	0.2
Total	399		501	
Mean	2.3 hr.		2.1 hr.	

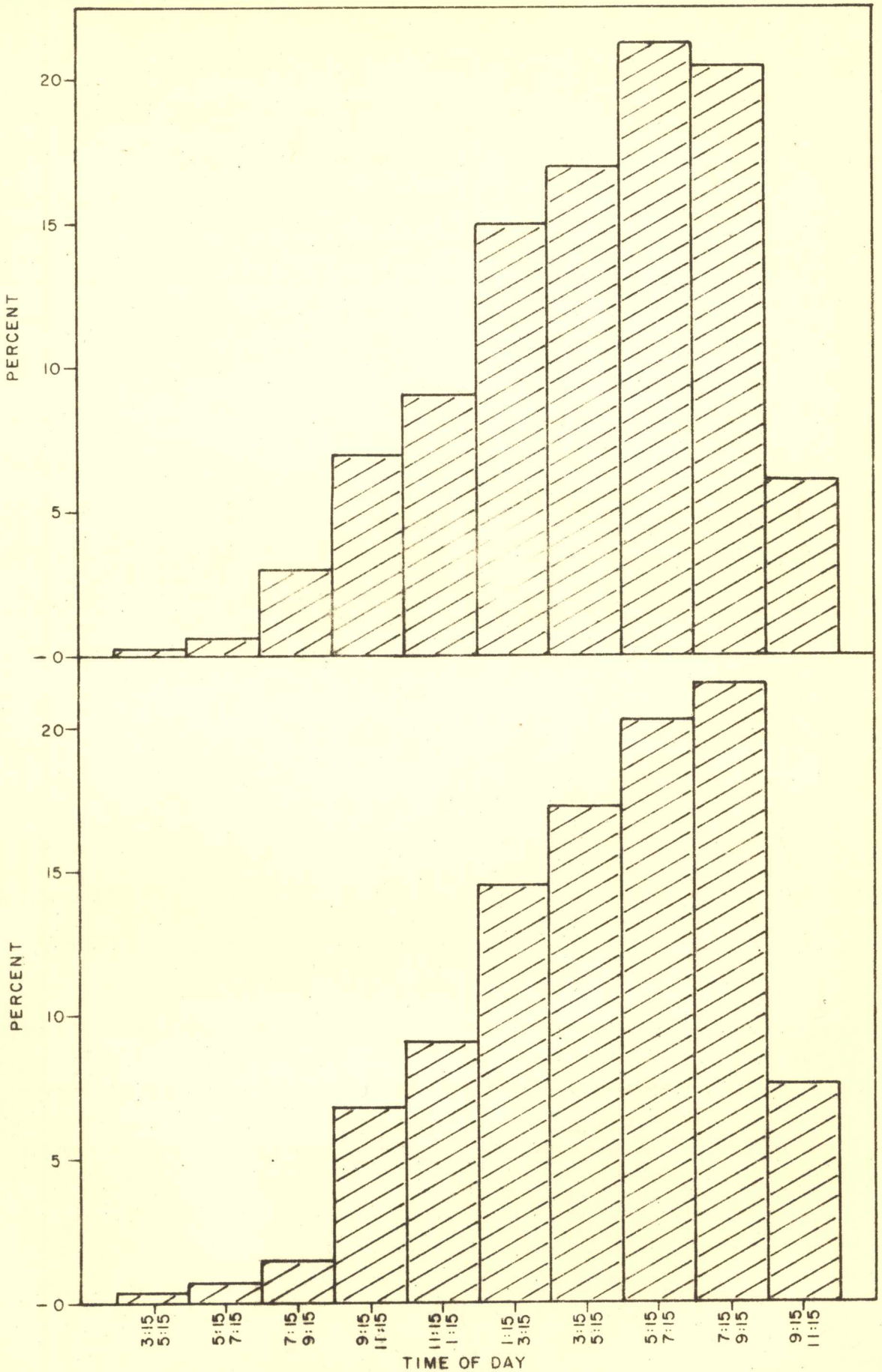


FIGURE 24. DAILY TIME FREQUENCY DISTRIBUTION OF ANGLING PARTIES AT THOMAS POND DURING JUNE-SEPTEMBER, 1968, AND MAY - SEPTEMBER, 1969.

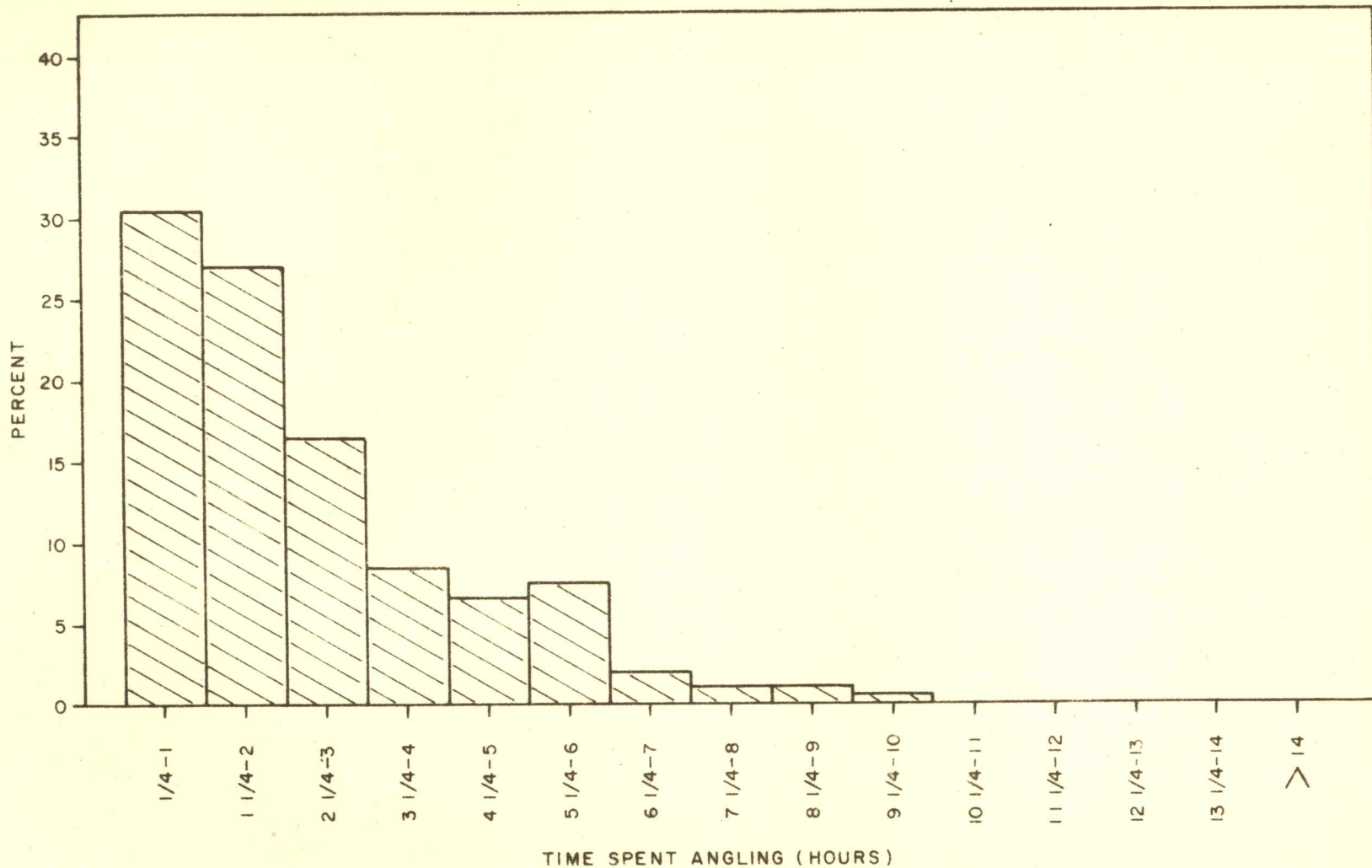


FIGURE 25 . DISTRIBUTION OF TIME SPENT ANGLING (HOURS) BY FISHING PARTIES VISITING THOMAS POND DURING JUNE - SEPTEMBER, 1968 .

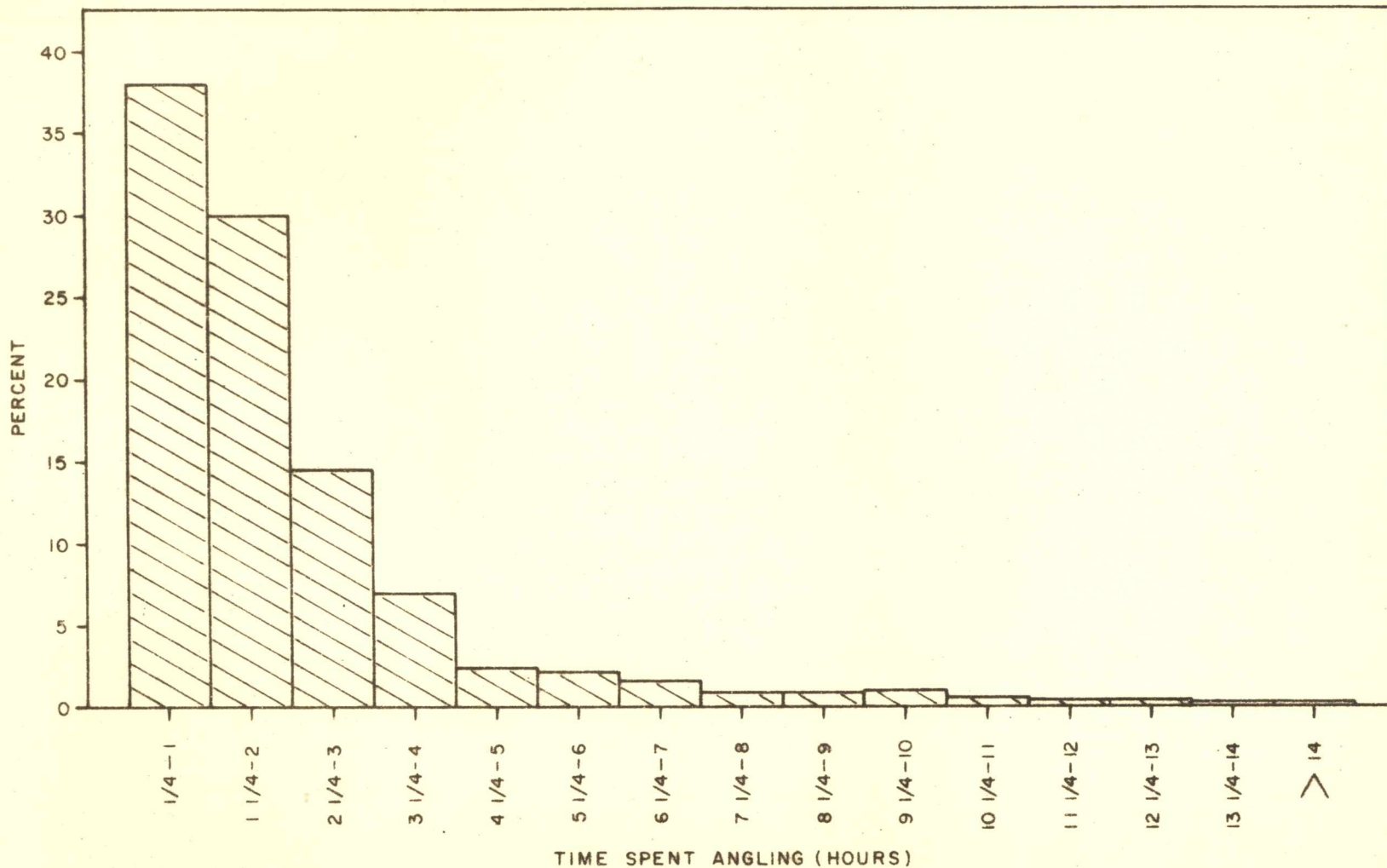


FIGURE 26 - DISTRIBUTION OF TIME SPENT ANGLING (HOURS) BY FISHING PARTIES VISITING THOMAS POND DURING MAY - SEPTEMBER, 1969 .

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, may be more reluctant to quit. Moreover, the boat angler can change his location more easily than the shore angler and is less likely to lose interest. This difference between boat and shore fishermen was also observed by Moyle and Franklin (1957). Although no distinction was made between the two types in this present study, observations indicate boat fishermen angle about 3 - 4 times as long per trip as the shore fishermen.

D. The Catch

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

During the 1968 open-water season 10,554 fish were caught during angling trips totalling 11,239 man-hours of effort. Under a fishing intensity of 44.1 man-hours per acre, Thomas Pond yielded 41.4 fish, or 10.0 pounds, per acre.

During a comparable period in 1969, only 4,208 fish were creeled during angling trips totalling 9,115 man-hours of effort. Under a fishing intensity of 35.8 man-hours per acre, the lake yielded only 16.5 fish, or 4.9 pounds, per acre.

Table XXIX. Statistics for angling intensity and exploitation of the fish stocks of Thomas Pond, during the 1968 and 1969 open-water season.

Statistic	1968	1969
Total man-hours fished	11,239	9,115
Man-hours fished per acre	44.1	35.8
Number of fish creeled	10,554	4,208
Pounds of fish creeled	2,555.5	1,248.0
Number of fish per acre	41.4	16.5
Pounds of fish per acre	10.0	4.9
Estimated production (lb. per acre)	2.85	2.85
Post-season stock (lb. per acre)	14.54	16.13
Number of fish per man-hour	0.94	0.46
Pounds of fish per man-hour	0.22	0.14
Number of fish per man-trip	1.9	1.0
Percent successful anglers	53.7	32.0
Percent anglers taking 50 percent of the catch	10.5	5.4
Length of average fishing day (hours)	2.28	2.14
Average fork length of fish creeled (in.)	8.6	8.6
Average weight of fish creeled (lb.)	0.25	0.29

1. Catch-Per-Unit-Effort

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

a. Total Yield of Fish to Anglers. During the 1968 open-water season the catch-per-effort was 0.94 fish per man-hour, the catch-per-effort during a comparable period in 1969 was only 0.46 fish per man-hour, a decrease of a little over 50 percent. The total effort meanwhile also declined slightly, from 11,239 man-hours during 1968 to 9,115 man-hours during 1969. If we assume angler proficiency was the same during the two years and that environmental conditions were relatively constant, a fishery which shows a decreasing catch-per-effort in conjunction with a constant or declining fishing effort is usually operating above the maximum sustained yield. In other words, overfishing is occurring and, if it is not alleviated, decrease in the stocks will result.

Although a creel census was not in operation during the 1970 open-water season, the field team was often in the area and spoke to anglers concerning the success of that particular year's fishery. Without exception, the anglers reported fewer fish per effort and less total effort than during the previous year.

During the winter census of ice-fishermen conducted from January 15 to February 28, 1969, only an estimated 44 fish were caught during angling trips totalling 1,080 man-hours of effort. The catch-per-effort was a very low 0.04 fish per man-hour.

During comparable periods in 1970 and 1971, field team members, as well as a Guardian from the Conservation and Protection Branch, visited the lake periodically, and indications are that fewer than 100 fish were

taken during each of those two winter fisheries. The same Guardian reports (pers. comm.) 3 - 4 hundred dozen fish were taken by ice-fishermen at Thomas Pond during the 1960 season.

A catch-per-effort of 0.94 fish per man-hour, during the 1968 open-water season is apparently a moderately high one 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. Catch-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.

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. Data for trout streams show a range of 0.0 to 14.0 fish per man-hour, again with the majority of streams yielding less than 2 fish per man-hour (Carlander, 1950).

The catch-per-effort in weight terms at Thomas Pond was 0.22 and 0.14 pounds of fish per man-hour during 1968 and 1969, respectively.

Rupp (1955) reports a range of 0.067 to 1.9 pounds per man-hour for several North American trout streams.

During 1968 the number of fish per man-trip at Thomas Pond averaged 1.9. In 1969, however, the average dropped to 1.0 fish per man-trip, a decrease of approximately 50 percent.

b. Yield of Fish with respect to Boat Versus Shore Fishing.

Tables XL and XLI summarize the catch per man-hour during the open-water seasons of 1968 and 1969 for trout and ouananiche for both boat and shore fishermen. During 1968, generally the catch per man-hour decreased as summer progressed with the shore fishermen having a more marked decrease in "luck" than the boat fishermen. Although the catch per man-hour during 1969 did not show a decrease as summer progressed, the shore fishermen again became progressively less successful during the time interval. The decrease in the shore fisherman's "luck" as summer progressed is attributed mainly to his inability to catch the ouananiche, which move offshore to seek cooler water. A marked decrease in the shore fishermen's ability to catch brook trout as the summer progresses is not indicated during either year. Because the harvest of ouananiche during 1968 was much greater than in 1969 and since ouananiche show a seasonal decline in catchability throughout the summer months, it is felt that this species is the major contributor to decreasing catch-per-effort figures as the summer of 1968 progressed. The relatively constant catch-per-effort during the summer of 1969 is therefore attributed to a smaller proportion of ouananiche in that year's harvest.

Table XL. Catch per man-hour at Thomas Pond, June to September, 1968, for both shore and boat fishermen angling for brook trout, ouananiche, and brown trout.

Month	Species	Fishing Site		Total
		Boat	Shore	
June	Brook trout	0.45	0.18	0.31
	Ouananiche	0.72	0.27	0.49
	Brown trout	Trace	Trace	Trace
	Total	1.17	0.46	0.81
July	Brook trout	0.34	0.19	0.29
	Ouananiche	0.54	0.09	0.40
	Brown trout	-	Trace	Trace
	Total	0.88	0.29	0.70
August	Brook trout	0.48	0.11	0.36
	Ouananiche	0.46	0.05	0.32
	Brown trout	-	-	-
	Total	0.94	0.16	0.68
September	Brook trout	0.24	0.20	0.23
	Ouananiche	0.56	-	0.43
	Brown trout	-	-	-
	Total	0.80	0.20	0.68
June - September	Brook trout	0.40	0.17	0.31
	Ouananiche	0.56	0.16	0.41
	Brown trout	Trace	Trace	Trace
	Total	0.96	0.33	0.73

Table XLI. Catch per man-hour at Thomas Pond, May to September, 1969, for both shore and boat fishermen angling for brook trout, ouananiche, and brown trout.

Month	Species	Fishing site		Total
		Boat	Shore	
May	Brook trout	0.39	0.06	0.19
	Ouananiche	0.36	0.20	0.26
	Brown trout	Trace	Trace	Trace
	Total	0.75	0.26	0.45
June	Brook trout	0.41	0.16	0.28
	Ouananiche	0.25	0.16	0.20
	Brown trout	-	Trace	Trace
	Total	0.66	0.32	0.48
July	Brook trout	0.40	0.07	0.32
	Ouananiche	0.21	0.01	0.16
	Brown trout	-	-	-
	Total	0.61	0.08	0.48
August	Brook trout	0.33	0.09	0.28
	Ouananiche	0.14	0.03	0.12
	Brown trout	0.01	0.01	0.01
	Total	0.48	0.13	0.41
September	Brook trout	0.30	0.54	0.39
	Ouananiche	0.51	-	0.32
	Brown trout	-	-	-
	Total	0.81	0.54	0.71
May - September	Brook trout	0.38	0.10	0.25
	Ouananiche	0.25	0.16	0.21
	Brown trout	Trace	Trace	Trace
	Total	0.63	0.26	0.46

Overall, boat fishermen took 2 - 3 times as many fish per effort as the shore fishermen. During July to September the boat fishermen may be up to 20 times as successful (particularly for ouananiche) as the shore fishermen.

c. Yield of Fish with Respect to Type of Lure Used. Table XLII summarizes the catch per man-hour during the open-water season of 1968 for trout and ouananiche for the various types of lures used. Generally, considering all three species together, there is relatively little difference in the catch rates for bait, fly, spinner, or combination bait and fly. However, those four "rigs" are significantly more successful lures than either a combination of bait and spinner or fly and spinner. If we consider the two major species separately, ouananiche are more susceptible to bait, and other lures used in combination with bait, than are brook trout. Brook trout, on the other hand, are more easily caught on fly and other lures used in combination with the fly. Rupp (1955) reports fly fishermen are significantly more successful than bait fishermen in catching brook trout. There is little evidence indicating certain lures are seasonally more successful than others. Spinners, however were most successful early in the season.

No attempt was made to compare the effectiveness of these various lures fished actively or passively since all are fished actively for the most part, with the exception of bait which may be fished either way.

## 2. Total Landings

Table XLIII summarizes the data on total landings of sport fishes at Thomas Pond during the 1968 and 1969 open-water seasons.

Table XLIII. Catch per man-hour at Thomas Pond, June to September, 1968, for the various types of fishing lures used.

Month	Species	Type of lure					
		Bait	Fly	Spinner	Bait & Fly	Bait & spinner	Fly & Spinner
June	Brook trout	0.16	0.44	0.40	0.34	0.10	0.17
	Ouananiche	0.63	0.34	0.64	0.51	0.22	0.34
	Brown trout	Trace	Trace	0.03	Trace	-	-
	Total	0.80	0.79	1.07	0.85	0.32	0.51
July	Brook trout	0.20	0.31	0.34	0.32	0.12	0.31
	Ouananiche	0.18	0.49	0.24	0.45	0.39	0.15
	Brown trout	-	Trace	-	-	-	-
	Total	0.38	0.81	0.58	0.77	0.51	0.46
August	Brook trout	0.30	0.53	0.09	0.39	0.02	0.18
	Ouananiche	0.63	0.28	0.13	0.35	0.34	0.24
	Brown trout	-	-	-	-	-	-
	Total	0.93	0.81	0.22	0.74	0.36	0.42
Sept.	Brook trout	0.08	0.51	-	0.17	-	-
	Ouananiche	0.58	0.17	-	0.30	0.07	-
	Brown trout	-	-	-	-	-	-
	Total	0.66	0.68	-	0.47	0.07	-
June - Sept.	Brook trout	0.17	0.41	0.30	0.34	0.07	0.24
	Ouananiche	0.55	0.38	0.41	0.45	0.30	0.21
	Brown trout	Trace	Trace	0.02	Trace	-	-
	Total	0.72	0.79	0.73	0.79	0.37	0.45

Table XLIII. Total landings of sport fishes at Thomas Pond for comparable periods during 1968 and 1969.

Year	Period	No. of Brook trout	Pounds of Brook trout	Pounds per acre	No. of ouananiche	Pounds of ouananiche	Pounds per acre	Total no. fish landed	Total no. per acre	Total pounds fish landed	Total pounds per acre
1968	June - Sept.	2418	707.7	2.78	3290	961.5	3.77	5708	22.4	1669.2	6.55
1969	June - Sept.	1729	441.2	1.73	1029	293.5	1.15	2758	10.8	734.7	2.88
1968	May* - Sept.	3122	915.8	3.59	7432	1634.7	6.43	10,554	41.4	2555.5	10.02
1969	May - Sept.	2330	677.5	2.66	1878	570.5	2.24	4,208	16.5	1248.0	4.89

\* Figures for May, 1968 extrapolated using the proportion of the 1969 total catch taken during May, 1969.

During the period May to September, 1968, a total of 10,544 fish having a total weight of 2556 pounds were harvested from Thomas Pond. During a comparable period in 1969 only 4,208 fish, a total of 1,248 pounds were landed. The total landings dropped approximately 50 percent from 1968 to 1969, while the effort declined about 20 percent. During the period June to September, 1968, the average weekly landings were 318 fish; however, during the same period in 1969 the landings fell to 167 fish per week.

The total weight of sport fishes harvested per acre of water surface at Thomas Pond was 10.0 pounds during 1968 and 4.9 pounds during 1969. Smith (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 of sport fishes at Thomas Pond, using the method of Ryder (1965), is 2.85 pounds per acre. The angling harvests during 1968 and 1969 vastly exceeded that estimated production, indicating that over-harvesting occurred in both years. Conversations with anglers during 1970 indicate a reduced harvest from 1969, and conceivably the harvest may be moving back down towards an equilibrium with

production, i.e., a maximum sustained yield of 2.85 pounds of fish per acre per year or a total of 727 pounds.

The total number of fish harvested per surface area of the lake was 41.4 during 1968 and 16.5 during 1969. Shetter (1951) reports 9.5 trout per acre per year for a Michigan lake over a ten-year period.

### 3. Size and age composition of the catch

The comparison of the mean size of brook trout, ouananiche, and brown trout angled at Thomas Pond during 1968 and 1969 is given in Table XLIV.

The average size of brook trout angled at Thomas Pond is about 8 to 8 1/2 inches fork length, with fish ranging from 5 to 14 inches. The average size of ouananiche in the creel is a little larger. The average length is about 8 1/2 or 9 inches, with fish from 6 to 12 inches. Brown trout are the largest fish angled at Thomas Pond. Angled browns average 10 - 11 inches fork length, with fish of 8 to 14 inches generally.

Comparison of the mean size of fish angled each month during the open-water seasons of 1968 and 1969 indicates little difference in the size of fish caught during any particular month (Table XLIV). It is also interesting to note that, although the number of fish caught during the 1969 season was much fewer than caught during 1968, there was no apparent decrease in mean size; in fact during 1968 the average weight of an angled fish was 0.25 pounds, while in 1969 the average weight was 0.29 pounds. The mean length of angled fish remained constant, 8.6 inches. This apparent incongruity is attributed to the fact that the 1969 catch consisted of a greater proportion of brook trout

Table XLIV. Comparison of the mean size (fork length, cm. and in.) of brook trout, brown trout, and ouananiche angled at Thomas Pond during the summers of 1968 and 1969.

Year	Species	Month					Annual Mean
		May	June	July	August	September	
1968	Brook trout	-	22.0	21.4	21.6	21.3	21.7 cm.
			8.7	8.4	8.5	8.4	8.5 in.
	Ouananiche	-	21.3	22.2	22.9	23.5	22.2 cm.
			8.4	8.7	9.0	9.3	8.7 in.
	Brown trout	-	-	-	-	-	25.7 cm.
			-	-	-	-	10.1 in.
1969	Brook trout	22.1	21.0	20.8	21.4	19.7	21.4 cm.
		8.7	8.3	8.2	8.4	7.7	8.4 in.
	Ouananiche	22.7	21.9	22.3	22.7	23.0	22.5 cm.
		8.9	8.6	8.8	8.9	9.0	8.8 in.
	Brown trout	-	-	-	-	-	27.4 cm.
			-	-	-	-	10.8 in.

than did the 1968 catch. Since brook trout are heavier per given length than ouananiche, the mean weight was slightly greater in 1969 although the mean length remained the same.

There is presently no size limit for brook trout. At Thomas Pond, very few brook trout less than 6 inches were caught and killed during either 1968 or 1969. Apparently, as Hunt (1970) suggests, few anglers choose to keep brook trout less than 6 inches long, and a six-inch limit is only slightly better than no limit at all. Only a little more than 20 percent of the catch was less than 8 inches in length. Although, as Hunt et al.(1962) and Hunt (1970) point out, raising the size limit is perhaps

the most successful method of reducing the catch, size limit must be related to growth rate of the species. For brook trout populations exhibiting slow growth rates similar to that of the Thomas Pond population, a size limit would not be biologically sound.

There is presently an 8-inch size limit on ouananiche. About 15 percent of ouananiche creelred annually at Thomas Pond are sub-legal. A Province-wide size limit of 8 inches is not biologically sound, particularly for populations exhibiting relatively slow growth, as is the case for the Thomas Pond population. 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.

It would appear that anglers generally regulate or condition themselves to harvest mainly the largest of existing individuals of a population.

The comparison of the mean age of brook trout and ouananiche angled at Thomas Pond during 1968 and 1969 is given in Table XLV.

Table XLV. Comparison of the mean age (years plus) of brook trout and ouananiche angled at Thomas Pond during the summers of 1968 and 1969.

Year	Species	Month					Annual Mean
		May	June	July	August	September	
1968	Brook trout	-	3.61	3.48	3.17	2.70	3.43
	Ouananiche	-	4.09	4.23	3.75	3.92	4.07
1969	Brook trout	3.89	3.51	3.38	3.20	2.39	3.49
	Ouananiche	4.47	4.07	3.94	3.71	3.67	4.20

Generally, angled brook trout are younger than angled ouananiche. The majority of the brook trout angled at Thomas Pond are III<sup>+</sup> and IV<sup>+</sup> years old, with fish younger and older than these ages constituting about 25 percent of the catch. No fish younger than II<sup>+</sup> years are taken by anglers, and the oldest fish caught are VII<sup>+</sup> years of age.

Ouananiche in the angler's creel are mainly IV<sup>+</sup> and V<sup>+</sup> years old. Fish of II<sup>+</sup> years are rarely taken, and the oldest fish caught are VI<sup>+</sup> years of age.

Generally, young fish of both species contribute a larger share to the total catch as the season advances (Table XLV). This trend is attributed to the fact that as the season advances these younger fish reach a size acceptable to the angler. Earlier in the season, these fish would be significantly smaller, and on being captured by the angler would undoubtedly be released. Also contributing to this situation is the fact that most of the older, harvestable fish are taken earlier in the season.

#### 4. Distribution of the catch among anglers

Table XLVI summarizes the data on the distribution of the sport fish catch among the anglers. During 1968 the success ratio of Thomas Pond anglers was 53.7 percent, i.e. 53.7 percent of anglers visiting the lake were successful in harvesting at least one fish. During 1969, however, the success ratio declined to only 32.0 percent.

During 1968, 50 percent of the harvest was attributed to 10.5 percent of the anglers, while in 1969 only 5.4 percent of the anglers participated in 50 percent of the harvest. Many workers have commented

Table XLVI. Frequency of various catch sizes of sport fishes (per angler) from Thomas Pond during June - September, 1968, and May - September, 1969.

Catch per angler	1968		1969	
	Number of anglers	Percent	Number of anglers	Percent
0	342	46.3	667	68.0
1	142	19.2	135	13.8
2	85	11.5	59	6.0
3	44	6.0	29	3.0
4	32	4.3	28	2.9
5	14	1.9	17	1.7
6	17	2.3	5	0.5
7	15	2.0	8	0.8
8	5	0.7	13	1.3
9	12	1.6	6	0.6
10	4	0.5	3	0.3
11	6	0.8	-	-
12	6	0.8	1	0.1
13	3	0.4	1	0.1
14	1	0.1	2	0.2
15	5	0.7	2	0.2
16	2	0.3	2	0.2
17	1	0.1	-	-
19	2	0.3	-	-
25	-	-	2	0.2
28	-	-	1	0.1
<b>Total</b>	<b>738</b>		<b>981</b>	

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; and Hunt, 1970).

The consistency with which certain anglers make good catches while as many as 50 - 70 percent of the other anglers may be unsuccessful testifies to skill of the individual angler as the single most important factor in determining how many fish he will catch. Generally then, this observation would indicate that a relatively few anglers of exceptional skill take a disproportionately large share of the sport fishes harvested from 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) points 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.

The present daily bag limit in the Province is the lesser of 24 fish or 10 pounds plus one fish. Table XLVI indicates that only 0.3 percent of the anglers are known to have made or exceeded the limit during 1969, and no anglers were known to "limit-out" during 1968. Two point four (2.4) percent of the anglers creeled a dozen or more fish per trip during 1968, while only 0.8 percent took this many during 1969. The most frequent catch-sizes per trip for successful anglers is 1 or 2 fish.

This particular pattern of catch-size frequency for sport fishes leads to the much-disputed question of the effectiveness and desirability of bag limits. Bag limits provide no protection until the limit is reached.

In contrast to the size limit, the bag limit does not apply to every fish caught. Since most of the catch of sport fishes from urban-area lakes is probably accounted for by anglers creeling 1 or 2 fish per trip, very restrictive bag limits would be needed to effect substantial reductions in the catch, and especially where bag limits are applied to broad geographical areas (Province-wide). For example, if angling effort remained unchanged, decreasing the bag limit from 24 fish to 12 would reduce the total catch in the present examples a maximum of 15 - 20 percent and not 50 percent.

Many workers suggest lowering daily bag limits has no discernible effect in apportioning the catch among anglers (Hunt et al. 1962; and Hunt, 1970). Such bag limit reductions divert a small percent of the pre-season population away from the more-proficient angler's creels, during a period when these fish are exposed to natural mortality. Assuming that natural mortality losses occur at the same rate for this "surplus from the creel" as for the rest of the population, a somewhat smaller number of fish than were diverted from the successful angler will be available to the less-skilled angler. It is doubtful whether such a small increase in available fish would improve the success of the unskilled anglers. In fact, as Hunt (1970) reports, among the skillful anglers, the effect of a bag limit which they could reasonably attain may have been a stimulus to keep fishing until the limit was reached. He suggests more limit catches are made by these people than catches of 1 or 2 fish less than the allowable limit. Generally, angling skill became an increasingly-important factor as the fishing regulations were made more restrictive.

Hunt (1970) suggests that, although lower bag limits may not effectively reduce the harvest directly, the psychological reactions of anglers to various bag limits may influence angling effort and thus the harvest. He suggests 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 control of one of the most important factors determining the size of the harvest, i.e. the number of anglers fishing a given lake or region of lakes.

#### V. SUMMARY AND CONCLUSIONS

Many lakes in the Atlantic Provinces lie in igneous rock formations, and waters in these areas are characteristically soft. Frequently the waters are stained in varying degree by humic extractions, derived from marginal bogs or from drainage of bogs and marshes in the watersheds. Thomas Pond is among those lakes in which high acidity and dark water colour are most extreme for the region, and it can be considered to be a dystrophic lake.

In addition to dystrophy resulting from the geology and geography of the drainage area, reservoir formation has also contributed to waters low in essential nutrients. The usual sequence of events following impoundment of fresh waters is well-documented. Initially, there is a brief period of high production at all trophic levels. This period is followed by a steady decline to a very low level of production. The initial stage of false entrophy, or mesotrophy, is attributable to the nutrient material leached from the organic debris, chiefly trees, shrubs, and grass, left on the floor of the basin before flooding. Immediately following inundation the production at all trophic levels of the ecosystem, particularly around the margin of the reservoir, is intensified. The supply of leachable materials in the submerged detritus is gradually exhausted and nitrogen and phosphate levels fall (both are essential for plant and animal growth). Declining fish populations are a result. In addition, reservoir formation results in annual summer and winter drawdowns which have a deleterious effect on both benthos and fish production.

Although morphological indices such as mean depth and shore development are favourable, poor water quality masks the favourable morphological factors to produce low plankton and benthos production, resulting in relatively low sport fish production. The interaction of all ecological factors at Thomas Pond indicates that all levels of production appear at the lower end of the range for lake productivity.

The low benthos production and lack of a forage fish species has resulted in a slow growth rate for the sport fishes in the lake. Information suggests growth rate has declined since impoundment.

The standing crop of sport fishes in Thomas Pond is approximately 15 pounds per acre and is, perhaps, moderately high for Newfoundland lakes. This standing crop is attributed to the fact that in the absence of competition from other fish species, sport fishes are occupying niches normally filled by these other species.

The brook trout population has apparently declined somewhat during the period of study, and this decline is attributed to both overharvesting and low reproductive success in certain years. The ouananiche population, on the other hand, has shown no such decline, but rather a slight increase. This stability is attributed to increased survival resulting from reduced interspecific competition with brook trout.

The egg-to-fry survival is apparently extremely high for both major species. Shore-spawning habits are not unusual, particularly for brook trout, during those years in which low inlet run-off is coincident with time of spawning. Low egg-to-fry survival usually results. However, when tributary flows are suitable, both species apparently prefer stream-spawning.

Thomas Pond is the heaviest-fished lake in insular Newfoundland. Approximately 10,000 man-hours of effort are expended during the May to September period. The winter fishery is relatively light, with only about 1,000 man-hours of effort yearly. 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 or evening one. The average fishing time spent by the angler is two hours, approximately. Boat fishermen tend to fish longer than shore fishermen.

The total landings of sport fishes dropped from approximately 10,000 fish in 1968 to only 4,000 in 1969. The effort declined approximately 20 percent, with catch-per-effort also showing a decline. During both years the fishery was operating at a level significantly higher than the maximum sustained yield.

The winter catch during both years was negligible. Indications are that present day winter landings are less than those experienced during the first few years of impoundment.

Small percentages of anglers take large percentages of the harvest each year at Thomas Pond. The success ratio was 50 and 30 percent during the two years the harvest was monitored. The numbers of anglers catching their limit at Thomas Pond is almost negligible; only 1 or 2 percent of the fishermen creeled a dozen fish 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 major urban areas is questionable.

Boat fishermen average 2 - 3 times as many fish per effort as shore fishermen and, during the late summer and early fall, the difference in catch-per-effort between the two types of fishing is even more pronounced.

There is relatively little difference in the effectiveness of the various fishing lures used.

The average size of brook trout angled is 8 - 8 1/2 inches, ouananiche average 8 1/2 - 9 inches, and brown trout are the largest fish creeled, averaging 10 - 11 inches in length. Anglers report a marked decrease in the size of fish angled during the past 10 or 15 years, with the present size of brook trout being particularly smaller. Because of the relatively-slow growth rate, a minimum size limit for Thomas Pond brook trout and ouananiche is not biologically sound.

It may be more than coincidental that Thomas Pond, which offered excellent sport fishing 10 - 15 years ago and is now considered by some to be "fished out" because of its proximity to the Trans Canada Highway, had its peak of angler success during the first few years following impoundment for hydroelectric development.

The growth rate of Thomas Pond sport fish is likely the maximum that can be sustained in a lake with its particular limnological history unless some management technique is applied. The most suitable technique is undoubtedly the introduction of a forage fish.

Because the maximum sustainable yield has been exceeded during the last few years, it is logical to assume that population levels will increase with a decrease in fishing pressure, assuming present standing crops are below the carrying capacity of the lake.

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