THE RAINY LAKE FISHERIES MANAGEMENT PLAN: AN INITIAL DATA ASSESSMENT THROUGH SPOF GUIDELINES

By

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A Practicum Submitted in Partial Fulfillment
of the Requirements for the Degree of Master
of Natural Resources Management

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EXECUTIVE SUMMARY

The Rainy Lake, Ontario, fish stocks are perceived to be in a state of decline as evident through decreasing commercial production and recreational angling success. Reasons for the decline hypothesized as overexploitation, water quality degradation and fluctuating spring water levels were investigated to provide management strategies.

Potential yield of individual species available for harvest from each basin were estimated by the morphoedaphic index and community biomass composition. The North Arm was found to be most productive with a potential yield of 116,366 kg/year followed by the South Arm at 80,239 kg/year and 25,468 kg/year from Redgut Bay. Community structure was unique to each basin. Comparing potential yield to actual harvest by the three user groups of commercial, recreational and domestic fisheries demonstrated competition that has led to overexploitation of some species from all three basins.

Competition between commercial and recreational fisheries in the North Arm has resulted in overexploitation of the top predators, walleye and northern pike. In addition, the commercial fishery appears to be overharvesting all lower trophic level species. The South Arm harvest is presently within the allowable yield, but should any user group increase their respective harvest, competition for scarce fish stocks would follow. Redgut Bay competition is pri-

marily for the walleye by the recreational fishery.

Allocation of the available harvest among the user groups followed guidelines established by the Strategic Planning for Ontario Fisheries (SPOF). The resulting allocation reduced the available harvest to the commercial fishery and the non-resident non-contributing sector of the recreational fishery. A critique of the allocation was performed to identify the incremental economic changes that should be examined when comparing the economic worth of commercial and recreational fisheries during allocation deliberations.

Recommendations regarding management of the Rainy Lake fisheries resources have been divided into four areas as a result of this study. First, overall management strategies are suggested.

(1) Each basin composing Rainy Lake has unique productivity characteristics and fish community composition. In addition, three sub-populations of walleye and whitefish are restricted to the defined basins with little or no intermixing. This suggests the possibility of individual basin management, delineated into the North Arm, South Arm and Redgut Bay.

(2) The non-resident non-contributing sector of the recreational fishery presently removes approximately 50 percent of the angler harvest from the North Arm and Redgut Bay. These anglers make no contributions to the Ontario economy, other than purchasing a license. For this reason, restrict-

ing the top predator harvest by this sector of the recreational fishery from the North Arm and Redgut Bay is recommended.

(3) Angler harvest levels from each basin require additional monitoring to allow for estimates of harvested biomass by the recreational fishery.

(4) A walleye sanctuary is needed in the North Arm to allow escape of mature individuals from the angler creel. In this regard, restricted harvest from Stanjikoming Bay to all user groups except domestic harvest is suggested.

(5) Virtually all fish species in the North Arm community are overexploited, suggesting the need to reorganize the commercial fishery in this area.

Allocation of the available supply of fish stocks between alternative uses relies on economic evaluation. The second series of recommendations deals with the requirements for rational allocation.

(6) A measure of the primary benefits generated by all sectors of the recreational fishery is needed to establish a value for the opportunity to fish. The user pays principle is recommended for all recreational angling.

(7) Allocation decisions between commercial and recreational fisheries has traditionally relied on aggregate data. It is recommended that future allocation of the Rainy Lake fisheries resources consider marginal cost and revenue data for the respective industries to avoid misallocation.

The third area of concern identifies biological data gaps. Acquiring this type of background information is the initial step in establishing a bench-mark for future management programs.

(8) Species composition of the fish communities in each basin is required for estimating the potential yield. Definition of the epi-hypolimnion communities, particularly for smallmouth bass, crappie and whitefish, are required for establishing total available harvest.

(9) Walleye are presently overharvested by approximately 5,000 kg annually from the North Arm and more than 6,000 kg annually from Redgut Bay. It is recommended that harvest be reduced by these amounts in each basin to allow for a maintenance allocation.

(10) Northern pike harvest from the North Arm should be reduced by approximately 2,000 kg annually to provide for a maintenance allocation.

(11) Whitefish harvest has reached historic low production from the North Arm and is presently above the historic sustained yield from the South Arm and Redgut Bay. All three populations should be investigated as to age and size frequency of the population structures to determine if overexploitation is prevalent.

Finally, monitoring changes in the aquatic environment may be useful to anticipate future management requirements.

(12) Water quality does not appear to have changed over

the period between 1969-80. However, it is recommended that water quality assessment stations be established and maintained in all three geographic areas.

(13) Low spring water levels limit the available spawning substrate for walleye and northern pike. However, the average spring water levels over the last 20 years, when walleye populations appear to have declined, has increased in comparison to water levels during the years when walleye were abundant. Additional work is needed on the lake to establish the available spawning shoals for walleye and bays used by northern pike to assess the future impact of spring water level fluctuations.

(14) The final recommendation is to maintain continuous assessment of the findings in this study, adjusting the various estimates as more reliable data become available.

ACKNOWLEDGEMENTS

This study has contributed most to the learning experience through the people who offered their time, guidance and expertise in a manner that shall not be forgotten.

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CHAPTER I

INTRODUCTION

1.1 Preamble

Rainy Lake, located at 48°42'N latitude and 93°10'W longitude is transversed by the Canadian-American International boundary between Ontario and Minnesota (Fig. 1.1). About 75 percent of the total lake area and 70 percent of the watershed are within Ontario jurisdiction.

The lake is primarily underlain by Precambrian rock formations. Keewatin volcanic rocks, Couchiching sedimentary rocks, Windigokan sediments, Algoma granite, Animikie sediments and Keeweenawa diabase are frequently exposed on the 1,068 km of island shoreline and 1,495 km of basin shoreline. Deposits of calcareous and non-calcareous till, bluish-grey calcareous clays and associated fluvioglacial sands and gravels were left in the area by the Pleistocene glaciers. The southwest shore of Rainy Lake was probably the eastern boundary of postglacial Lake Agassiz, as this is the point where the Laurentian Shield ends and the characteristic lowlands of Lake Agassiz begin (Chevalier 1977).

Lake productivity is low (Table 1.1), and is classified as mesotrophic by Ryder's (1965) morphoedaphic index (MEI = 5.74 metric units) (Chevalier 1977). Urban development near the lake includes two towns with a total population of approximately 20,000 people, 2,000 lake front cottages and 38 tourist lodge establishments. Rainy Lake is

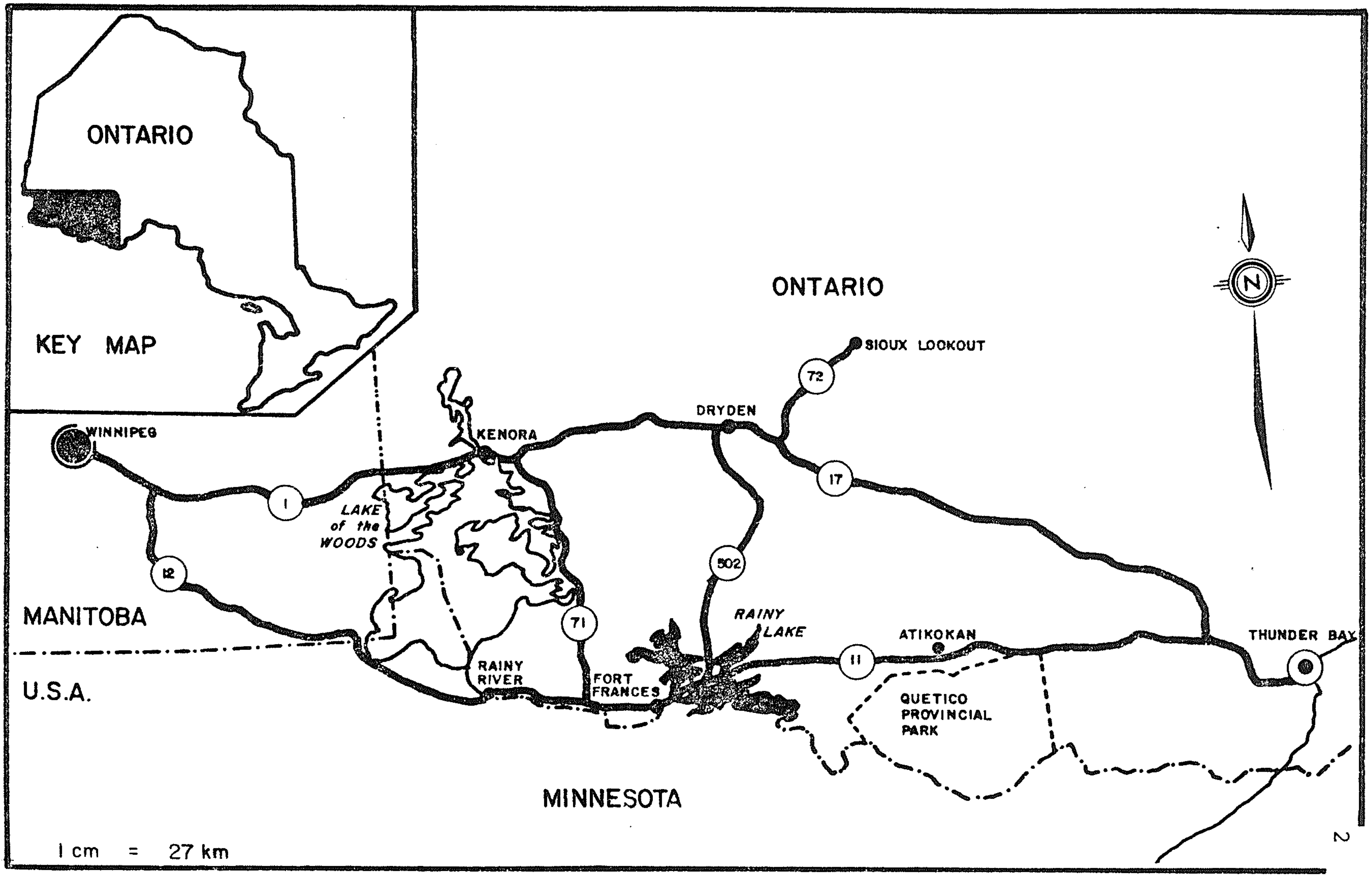


Fig. 1.1. General location of Rainy Lake in northwestern Ontario.

part of a reservoir system for a hydroelectric dam on the outlet of the lake, Rainy River, with lake water level regulations established by the International Joint Commission.

Table 1.1. Physical and chemical (ppm except as indicated) characteristics of Rainy Lake.

Physical		Chemical	
Area (km^2)		Total alkalinity	25
Lake	858.0	Total dissolved solids	57
Watershed	37,552	Conductivity (mhos)	44
Depth (m)		pH	6.8-7.8
Mean	9.94	Dissolved oxygen	3
Maximum	49.07	(late summer hypolimnion)	
Volume (10^9 m^3)	8.53	Morphoedaphic index (metric)	5.74
Flushing rate (days)	359	Sulphate ion	8.0
Shoreline (km)		Total phosphorus	0.027
Basin	1,495	Chlorides	5.65
Island	1,068	Nitrogen	
Shoreline Dev. Factor	14.4	Ammonia	0.03
Littoral zone (%≤6.1 m)	42	Nitrite	0.006
Transparency (m)	2.04	Nitrate	0.002
		Total Kjeldahl	0.40

From Chevalier (1977).

The commercial fishing industry developed around 1885 and was initially supported by a pound-net lake sturgeon (*Acipenser fulvescens*) fishery. Gill nets were introduced in 1904, but were not widely used until the late 1920's (Bonde et al. 1961). Presently, gill nets are used exclusively for fish harvesting except for the black crappie (*Pomoxis nigromaculatus*) which are taken by use of trap nets. The commercially important fish species include walleye (*Stizostedion vitreum vitreum*), northern pike (*Esox* lucius), whitefish (Coregonus clupeaformis), cisco (Coregonus artedii), ling (Lota lota), white sucker (Catostomus commersonii) and black crappie. Incidental catches of sauger (Stizostedion canadense), rock bass (Ambloplites repustris) and yellow perch (Perca flavescens) also occur.

Recreational fishing has increased in importance over the last 50 years. Anglers fish primarily for walleye, but harvest northern pike, smallmouth bass (Micropterus dolomieui), muskellunge (Esox masquinongy), sauger, black crappie, yellow perch and mooneye (Hiodon tergisus). In addition, a domestic fishery exists on the lake that harvests mainly walleye adjacent to the reservations bordering the lake.

1.2 Problem Statement

The Rainy Lake fisheries make important contributions to the local Fort Frances economy and incremental contributions to the economies of Ontario and Canada. These contributions are primarily the result of the economic activities generated by the recreational and commercial fishing industries. These fisheries are also of importance as a source of food for local residents and to native communities surrounding the lake.

Fisheries managers of the Ontario Ministry of Natural Resources have expressed concern that the Rainy Lake fish stocks are in a state of decline. This decline is evident by a reduction in the volume of commercial production from a ten year average of 392,000 kg for the period 1960-69 to a five year average of 172,000 kg for the period 1975-79. This respresents a decline in commercial production of 56 percent. In addition, the composition of the harvest is shifting towards a larger percentage of rough fish than observed from historic catch records. At the same time, angling success appears to be decreasing for the species shared with commercial fishing interests. A continuation of this trend in production will result in a loss in the contribution of these fisheries resources to the economy of Ontario. It will also create enormous problems in allocating available fish stocks among commercial, recreational and subsistence needs.

1.3 Objectives

The reasons for the decline in production are not fully understood. However, it is hypothesized that excess fishing effort, changes in water levels during crucial spawning periods and changes in water quality have contributed to the decline. These factors deserve scrutiny. In this regard, the objectives of this study are to evaluate the factors considered to be responsible for the decline in fish populations. In addition, it is proposed to quantify the production potential of the Rainy Lake fisheries and the balance between that production potential and existing levels of harvest by:

- estimating the biological production potential using the morphoedaphic index (MEI) and species composition of each community;

- quantifying historic and present commercial fisheries production;

- quantifying historic and present recreational fisheries harvest;

- estimating domestic harvest;

- identifying shortfalls or surpluses between potential and current production.

To the extent that a surplus or a shortfall exists between the productive potential of the Rainy Lake fish stocks and current use patterns, there is a requirement to develop consistent criteria on which to base allocation decisions. In this regard, allocation based on the criteria suggested by the Federal-Provincial committee for Strategic Planning for Ontario Fisheries (SPOF) will form the final component of this study.

1.4 Data Collection

This study is primarily concerned with the collation and assessment of available data from the Ontario Ministry of Natural Resources district office in Fort Frances and relevant published and unpublished manuscripts. Primary research conducted was a questionnaire survey of the 17 tourist lodge establishments to provide some indication as to the economic activity of this industry and their dependency on the Rainy Lake fish stocks. An important outcome of this study is identifying information gaps necessary for continuous fisheries management for the type of analysis employed in the following text.

1.5 Limitations

The trend through time data for commercial production must be approached with caution. The number of fishermen active on the lake has changed over the period of analysis along with changes in minimum mesh size regulations, which may limit the comparability of these data. Angler harvest data are also incomplete. Due to the irregularity of the lake, its large size and uncontrolled access, recreational harvest data at best, can only be considered approximations. Along the same line of reasoning, domestic harvest is only an estimate as the fishery is largely uncontrolled.

The economic analysis of both the commercial and tourist lodge industries are for illustrative purposes only. Historic economic data are absent, so comparisons with past performance was not possible. However, to the extent that they reflect reality, the type of analysis employed could be used in future rational allocation deliberations. In all cases, the estimates used throughout the text are considered the best available with regard to the present data base.

1.6 Report Format

In formulating this report, the second section provides a brief literature review of biological management concepts.

In addition, an economic perspective of the "tragedy of the commons" as the concept applies to fisheries and the economic data requirements to allocate fisheries resources is presented. Finally, management initiatives developed by the Strategic Planning for Ontario Fisheries (SPOF) committee are examined. The third section evaluates the productive potential of the Rainy Lake fisheries resources using standards such as the morphoedaphic index (MEI), historic commercial production and species composition. Section four presents current use patterns of the commercial, recreational and domestic fisheries and provides some sensitivity to the relative values of these alternative uses. Section five considers the allocation of the available fisheries resources among these alternative uses in accordance with the criteria specified in the SPOF documents. In addition, a critique of the resultant allocation decisions is provided.

CHAPTER II

LITERATURE REVIEW

During the early 1930's when fisheries management in Ontario was in an early phase of development, emphasis was placed on monitoring commercial harvests and estimating yield. Regulations were based primarily on the conservation of fish stocks from a biological perspective. This resulted in strong support of the maximum sustained yield concept that dominated regulation philosophy as a response to the depletion of some commercially important fisheries. Fisheries management has evolved since its early phase of development, and today the natural science of biology is complimented by the social science of economics.

The following review of fisheries resource management will begin with the biological conservation approach of maximum sustained yield (MSY) and proceed to the optimum sustained yield (OSY) concept. Optimum yield expands into economic considerations for determination of acceptable yield levels. Economic factors present universal concepts applicable to both marine and inland fisheries. The contributions from economics to management strategies in this report will include the concepts of rent, controlled entry and optimum harvest levels.

Allocation between competing users for fisheries resources are usually based on comparative valuation criteria. A review of common valuation techniques used in comparative analysis will therefore be provided. Finally, an overview of fisheries management strategies developed by the Federal-Provincial committee for Strategic Planning for Ontario Fisheries (SPOF) will delineate the goals of management within Ontario.

2.1 Maximum Sustained Yield

Maximum sustained yield (MSY) can be defined as the maximum yield (in numbers or weight) of a fish stock that can be maintained for an indefinite length of time. If less is taken, the potential of the resource is not realized; if more is taken, recruitment to the stock may be impaired. The philosophy was that any species produces a biological surplus available for harvest without endangering reproductive capabilities (Roedel 1975). The concept was based on years of biological monitoring of commercial fish harvests and natural sciences that supported scientific management. Regulations introduced to control harvest levels after World War II were dominated by the biological approach of maximizing catch and minimizing dangers of overexploitation (Larkin 1977).

The concept of MSY prevailed until the 1970's and its importance in management decisions for more than 25 years should not be shadowed by the brief treatment here. Ricker (1975) incorporated MSY into his equilibrium yield calculations as determined by recruitment curves for different species and stocks. It still has application in management decisions today, but only as far as quantifying the harvestable portion of the resource.

Ricker's (1975) stock-recruitment model for estimating MSY assumes density dependant mortality increases as the number of adults increases. This compensatory mortality results in a point of intersection where the number (or weight) of progeny surviving compensate for the number (or weight) of adults dying. In an unexploited population, this represents the equilibrium condition (point A; Fig. 2.1) (Royce 1972). Moving to the left of point A decreases progeny mortality as the adult population is depressed. Maximum survival of progent (Zmax.) occurs at the Mmax. number of adults, and the biological surplus produced (harvestable biomass) is the amount between the 45° replacement line and the apex of the curve (BC). Maximum biological production, or MSY, occurs when parental stocks are harvested below the Mmax. position (DE). At this remaining level of adult spawners (Meq.) the population will produce the maximum yield of progeny while maintaining the stock at the Meq. equilibrium level (Fig. 2.1) (Ricker 1975).

Maximum sustained yield can also be determined through analysis of total yield and effort data. Effort is defined as the number of boats in the fishery, or the amount of net set within a specified time period. Yield is the summation of individual catches, over the same time span, for individual fishing units using the same fish stocks. The yield curve (Fig. 2.2) assumes a parabolic shape. At low levels of

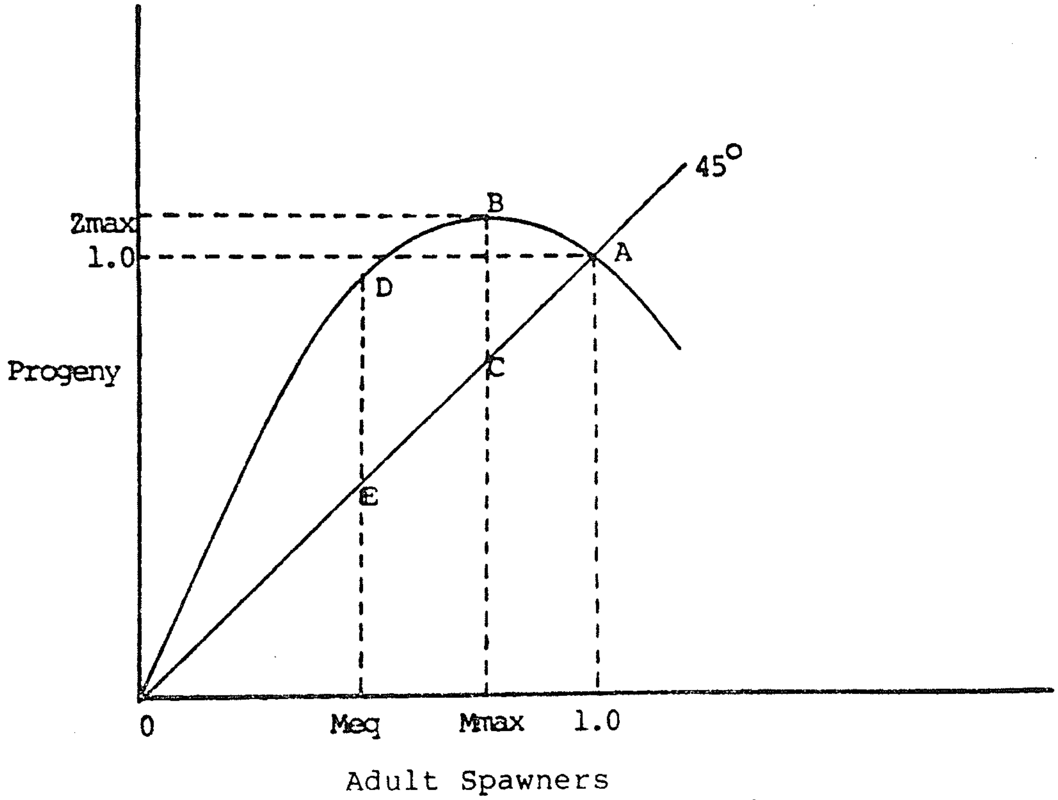


Fig. 2.1 Stock-recruitment model of a fishery. Reproductive curve shows the unexploited equilibrium of adults and progeny at point A. The maximum progeny survival of Zmax. occurs when adult spawners are at the depressed Mmax. level. MSY occurs at the Meq. level of adult spawners. Harvestable biological surplus is the area above the 45° replacement line and is maximized at DE (DE>BC) Modified from Ricker (1975)

effort, the aggregate catch will be low, but increases as effort is increased. The rate of increase in the catch is not proportional to the rate of increase in effort, so at some point any additional effort experiences no additional catch (point Z; Fig. 2.2) which is the MSY level. Any effort beyond this point will result in a smaller catch. The MSY level of harvest (ZY) can therefore show the minimum amount of effort required to achieve the maximum harvest (OY; Fig. 2.2) (Copes 1980).

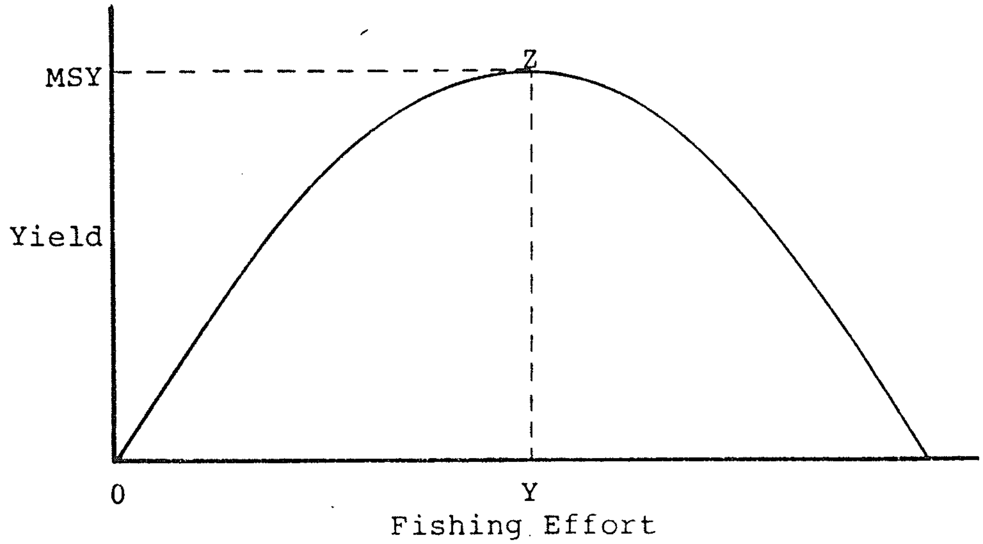


Fig. 2.2. Relationship between yield and effort for a commercial fishery. Parabolic shape of the yield curve is due to the declining rate of increase in catch as effort is expanded. Curve apex (Z) is the level of effort where MSY (ZY) is attained. Modified from Royce (1972).

Proponents of MSY were eventually criticized by members of the same discipline that developed it. Opposition by biologists identified limitations in applying a level of MSY to any particular fishery. Larkin (1977) reviewed the major problems that limited the success of effective management by establishing MSY levels. They are summarized as: 1) fish populations, at best, can only be estimated; 2) variation in recruitment between species and stocks; 3) migratory behaviour; 4) limited knowledge of interspecific interactions within ecosystems; 5) changes in species composition at different harvest levels; 6) unexplainable fluctuations in commercial production.

The major problem with the MSY model is that it is a static equilibrium model, allowing for no environmental or ecosystem changes that may alter the level of maximization over the short or long term (Clark 1977a). Directing harvest towards an individual species within an ecosystem can disrupt species composition and require a new level of MSY (Christie 1978). Introducing fishing mortality to an unexploited fishery will give an exaggerated MSY level until the stock reaches an exploited equilibrium density. Once this level is established, the MSY will require an adjustment downward (Ricker 1973). If there is a time delay in recognizing or controlling the excess harvest, the population will be exploited beyond the MSY level and recruitment will be impaired (Kendall et al. 1977). Finally, recruitment is assumed constant, which provides for no environmental constraints that may adversely effect egg survival (Larkin 1977). Water levels during spring spawning periods in inland lakes can have significant impact on recruitment rates (Johnson et al. 1966; Chevalier 1977). None of the preceding arguments suggest sustained yield over an extended period of time, rather, maximum yields should be expected to fluctuate regularly.

Another difficulty was in establishing a stock of fish that the MSY level can be applied to. Dickie (1979) considers the stock concept as "...an abstract term applied to provide a rationale for a certain kind of aggregation of catch data. This is not to say that there may not be such a thing as a discreet group of fish that may constitute an effective breeding group or stock, but in many cases there is significant uncertainty about the identifiable physical entity."

Ryder (1965) developed the morphoedaphic index as a potential fish yield estimator for north-temperate lakes. Water quality (total dissolved solids) and lake morphometry (mean depth) were combined to give an estimation of the production level individual lakes could annually sustain, and is analygous to the MSY concept. Total biomass produced from aquatic ecosystems is relatively constant, but the composition of species is not static over time (Larkin 1977). Selected exploitation of top predators in a lake will allow expansion of lower trophic level species so that total biomass produced remains constant even though composition is altered (Krebs 1978). Use of the morphoedaphic index to quantify production should be accompanied by composition knowledge to estimate maximum yield of individual species. Sustained yield may be difficult to achieve because not all fish species are equally susceptible to commercial fishing gear.

Biologists and mathematicians responded to the inadequate static model by developing dynamic models that indicate ranges for maximization. The use of calculus, differential equations, programming and control theory have been used extensively to reflect natural environments. Dynamic modelling allowed the fishery to be examined in a state of disequilibrium and explore the stabilizing effects of different input-output combinations. Quirk and Smith (1969) contributed to the theoretical advancement by attempting to integrate species interactions into an economic model of a fishery. Dynamic theory advances have been summarized by Bultin (1975) as follows:

(1) The use of certain formal techniques of dynamic analysis has made it possible to examine the fishery in disequilibrium states.

(2) There has been a more precise definition of the conditions under which inefficient competitive exploitation can be remedied.

(3) Explicit stock growth functions have been incorporated into the models.

(4) Dynamic modelling reduces the problems of modifying theoretical models to approach real world situations.

(5) Attempts have been made to incorporate into the problem of optimal rates of exploitation of a particular stock; the fact that fish comprising any particular stock are of different vintages.

The inherent risk of the MSY level was avoided by establishing harvest levels below that of maximum production. Alternative criteria began to have varying inputs into determining harvest levels other than biological considerations. Economics contributed to the decision-making process under the concept of optimum sustained yield.

2.2 Optimum Sustained Yield

Fisheries resources are managed for their benefits to people, not fish, which permits the substitution of people management concepts in place of fisheries management. Optimum sustained yield (OSY) levels are an attempt to incorporate social considerations into acceptable harvest levels of fish stocks. Rather than maximizing biological production, with its inherent risk of overexploitation, the objective today is to maximize social benefits. Measuring these benefits and associated costs to society depends heavily on economic evaluation. For many reasons, optimum sustained yield will have different interpretations depending on geographic location and social conditions.

Optimum yield cannot be expected to be sustained as people's desires change over time (Royce 1975). In fact, an acceptable yield level considered optimal has proven difficult to define. What one user group defines as optimal is not likely to be the same as an alternative user group's concept. Quantity versus quality is a common argument between commercial and sports fisheries. As such, optimum yield is considered to be an abstract term with several limitations when formulating policies (Larkin 1977). The application of OSY concepts to some of the world's fisheries may range between theoretical yields of almost zero to near extinction of commercially important species (Roedel 1975).

The recent introduction of optimum yield does, however, acknowledge the diverse social forces that must be considered before optimal resource allocation is achieved. In the commercial fishery, maximum biological yield (MSY) did little more than determine what could be removed. Now the OSY provides some indication as to the most efficient level of effort required for the removal to maximize social benefits. In addition, the conflicts of commercial and recreational fisheries competing for the same fish stocks and the social optimum of commercial input factors fall within the boundaries of optimum yield (Roedel 1975). The use of economic principles to determine optimum allocation and measure the social benefits available from fisheries resources have made the most contributions to date.

2.3 Economic Perspectives

Economics is concerned with the efficient allocation of resources among alternative uses to serve the welfare of society (Crutchfield 1975). The application of economics to fisheries management in Canada dates back to such early authors as Gordon (1954) who suggested that the socially optimum level of fisheries exploitation is that level which maximizes the "resource rent"; a surplus return to the resource after all factors of production (labour and capital) are paid.

The analysis by Gordon (1954) compared the fisheries between two fishing grounds of different quality. The superior ground will yield a greater average product at every level of fishing intensity when compared to the inferior ground, which will yield nothing more than costs of inputs plus opportunity income. This will result in the exploitation of the better area to the point where the average yield of both grounds are equal. In this regard, "the superior ground will be exploited to the same point as the inferior ground (where average product equals average costs) and the rent that should reflect the ground's superior capabilities would be reduced to zero" (Gordon 1954).

The concept of an economic rent is illustrated in Figure 2.3. In this regard, the yield curve (Fig. 2.2) has been transformed into a total revenue curve by replacing physical yield with the value of that yield. For illustrative purposes, a linear total cost function (OA), reflecting constant costs per unit of effort, has been superimposed on the total revenue function. The cost curve represents the payment to labour and capital (including normal profits) to harvest the resource. In referring to Figure 2.3, it will be noted that as fishing effort expands from 0, total revenues exceed total costs. There is a surplus profit, a rent, which reflects the value of the resource. Under conditions of open access, fishing effort will expand as new vessels are added to the fleet. If the resource does not receive a return by extracting the rent, expansion will continue as long as total revenues exceed total costs until the rents are dissipated (OB). Further, if the fishing industry is subsidized, it is possible that fishing effort will expand until total costs exceed total revenue and net revenues are negative (OK).

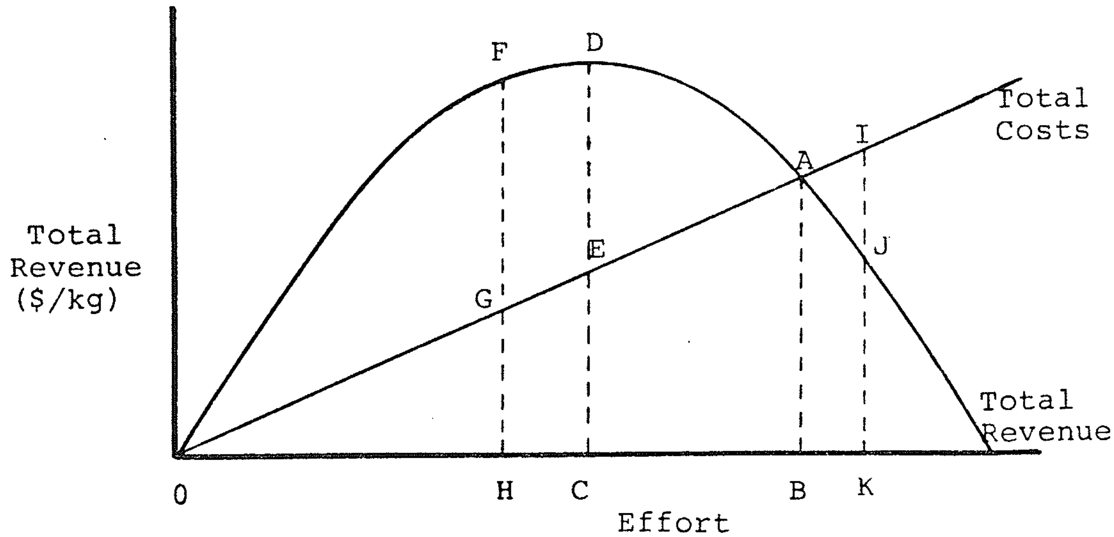


Fig. 2.3. Relationship between total revenue and effort for a commercial fishery. Parabolic shape of the total revenue curve shows where revenue is maximized at effort OC, but rent is maximized at effort OH (FG>DE). Effort OB generates no rent and is the bionomic equilibrium position when entry is uncontrolled (common property). Effort OK requires subsidization of IJ and further depletes stocks. Modified from Copes (1980).

The phenomena of expanding fishing effort until rents are reduced to zero has been attributed to the "common property" nature of fisheries resources and the failure or inability of government to control the expansion of fishing effort. In this regard, the tragedy of the commons (Hardin 1968), as the concept applies to fisheries, has been termed the tragedy of the fishery (Cauvin 1979). Uncontrolled access to harvest fisheries resources, coupled with the rule of capture, forces fishermen to compete for the available harvest. As a result of this competition, there is little incentive on the part of one fisherman to restrict fishing effort in the interest of conserving fish stocks because any fish that one individual leaves may be captured by another. The generally depressed economic condition of many of the world's fisheries has been attributed to this phenomena.

Under uncontrolled access, therefore, fishing effort will reach an equilibrium position (OB) which exceeds the point of maximum physical sustained yield (OC). At this point, fish stocks will be depleted, serving neither the economic objective of maximizing the rent or the biological objective of maintaining fish stocks. Scott (1955) addressed the problem in much the same manner as Gordon (1954). The problems of overfishing could be corrected and the rent maximized (FG) at effort OH, where the incremental cost of an additional unit of fishing effort equals the incremental revenue associated with that fishing effort. Rent maximization (FG) occurs at a level of fishing effort below that of maximum sustained yield (OC). At this point, the difference between the cost and value of production, the rent, is maximized.

Regulations aimed towards maximizing the difference between total revenue and total cost will depend on the pre-regulation equilibrium position (Turvey 1970). If this position is to the left of MSY, regulations attempting to reduce effort would decrease both costs and revenue (catch). Equilibrium positions to the right of MSY would respond to effort reducing regulations with lowered costs and increased revenues (catch).

The question of who should be the beneficiary of the rent has proven difficult when methods of extracting it are considered. The success of entry limitation in the Pacific salmon fishery (Munro 1977; Crutchfield and Pontecorvo 1969) has demonstrated that long term goals of reducing effort is not sufficient in itself. If rents are allowed to return to the fishermen, the additional revenue will be capitalized back into the fishing gear, increasing the efficiency of the restricted number of boats. The number of participants may have been reduced, but effort will remain unchanged (Clark 1977a). This suggests the need for a licence fee or a tax on landings, such as a royalty on landed value, reflecting the value of the resource (rent) that can be collected by government as steward of the resource (Cauvin 1979). The level of taxation on the catch can be considered a cost to fishermen, pushing the cost curve (OA) of Figure 2.3 to a tangential position along the revenue curve. This point will be the economic optimum as rent is maximized (FG) (Copes 1980). Economic overfishing occurs at all levels of fishing effort to the right of OH.

The steady state represented by the model of Figure 2.3 reflects the same difficulties as the maximum sustained biological yield model. "The maximum sustainable yield curve is an equilibrium relationship and when incorporated into models of fisheries, gives only long run equilibrium solutions" (Bultin 1975). A new fishery, or one that has not yet reached equilibrium production, may produce revenues that attract excessive effort. This has traditionally been called the fishing up period (Ricker 1975). When equilibrium production is finally established, the level of effort may be in excess of the bionomic equilibrium, resulting in the cost of fishing activity exceeding the revenue generated (point OK; Fig. 2.3). Under open access conditions, there are no offsetting influences during periods of declining success to reduce fishing effort, and the usual response is increased effort to increase revenue. The immobility of fishermen and their capital investments perpetuate this situation, as they are not readily transferable to alternative production processes (Kendall et al. 1977). This situation is compounded by government subsidy programs (vessel subsidies, price support, freight subsidies) that discourage natural adjustments. In order to maintain the level of employment, government feels compelled to subsidize the amount IJ (Fig. 2.3) in an attempt to cover the difference between costs and revenues. Larkin (1977) has suggested that future management should rely on natural market forces, and subsidies for uneconomic fisheries should not be considered.

Fishing regulations have been the only control method available to managers. Gear restrictions, area and season closures and quotas have been introduced to reduce fishing pressure and protect the stocks, but they also reduce the efficiency of the fishing fleet from an economic perspective.

Gear restrictions generally remove the most efficient catching techniques resulting in additional labour and capital employed in fishing and increasing costs. Closed areas and quotas are adopted to reduce excessive pressure on threatened stocks. Short run benefits may be realized by discouraging fishing, but long run modifications may adjust to the controls and leave short run gains dissipated as before. Shorter seasons encourage individuals to increase their fishing power, speed and storage facilities, causing excessive capital investment and labour (Clark 1977b). These modifications will increase the costs of operation and further reduce the incomes to fishermen. Further, the large volume of fish produced over a short time span may cause prices to fall and a less than optimal product on the market. Short run conservation of fisheries resources may be met by regulation, but over the long run, economic benefits will be dissipated, making no one better off (Copes 1980).

Economic efficiency is not only an element worth pursuing, but is an essential part of fisheries management. This is particularly so in establishing allocation criteria between conflicting resource use which is based on comparative evaluation of individual activities. The following section deals with some common valuation techniques for fisheries management.

2.4 Valuation Techniques

The valuation of fisheries resources for recreational use is complicated because a market system does not exist. The opportunity to fish recreationally is provided free or at a price which may not reflect consumer preferences. No price signals exist as is the case for bread, automobiles or houses. As a result, fisheries managers are placed in a very difficult position in planning investments in fisheries management and in making allocation decisions between competing recreational and commercial uses of fisheries resources. Such decisions require consistent valuation criteria to make allocation decisions. Unfortunately, however, where the management of public fisheries resources are concerned, consistent and totally acceptable valuation criteria are not available. As a result, it has been necessary to estimate proxy values, which are not unanimously agreed upon.

As a general observation, the valuation of the recreational and commercial use of fisheries resources are inconsistent, incomplete and incorrect (Cauvin 1981). These allegations deserve scrutiny. In this regard, some familiar valuation techniques will be reviewed.

2.4.1 Expenditure Method

Gross expenditures made in pursuit of angling experiences, including food, clothing, accommodation, boats, rods and reels etc., are often used as a proxy value for recreational fisheries resources. Unfortunately, these expenditures do not value the resource per se, but attempt to measure activity made in pursuit of angling or gross values generated by different industry groups serving anglers. In this regard, should expenditures on liquor spent in pursuit of angling be considered as part of the value of the recreational use of fisheries resources? Is there a danger of double counting by attributing such sales to recreation as opposed to the beverage industry (Cauvin 1980)? Further, should expenditures on gasoline in pursuit of recreational fishing be considered as part of the value of recreational fisheries resources? Given the scarce nature of petroleum resources, it cannot be argued that such gasoline would not otherwise be used (Cauvin 1980). From this perspective, gross expenditures are not considered to measure the value of recreational fisheries resources. This is largely substantiated by Pearse and Bowden (1969) who suggest that this technique might be appropriate for measuring the economic performance of the tourist industry or commercial fisheries, but it is questionable whether the values generated are representative of the specific activity of recreational fishing.

Required is a valuation measurement of the utility that anglers receive from the opportunity to fish, or the fishing experience. This may be construed as the primary benefit from the recreational use of fisheries resources. In a market economy the value of this experience is generally measured by the willingness to pay. Net primary benefits are calculated by deducting the cost of supplying fisheries resources for recreational use. Because license fees are not charged for the opportunity to fish for residents of Ontario, net revenues to the public sector activity of culturing fish are likely negative. In this case the value of the resource, the rent, is captured totally by the angler and perhaps the tourist camp operations.

Secondary or indirect benefits of recreational fishing are those which are induced by a program or allocation decision (Hirshleifer et al. 1970). Fishing lodges and charter vessels would appear to fit into this category. Once again, it is important to calculate net benefits by substracting costs of goods and services which are incurred in generating secondary benefits. Otherwise there is a danger of double counting the value of the output of industries serving tourist lodges and in inflating the magnitude of secondary benefits.

2.4.2 Willingness to Pay Method

As indicated previously, estimating the value of the recreational use of fisheries resources is made difficult by the absence of a market system to measure consumer preferences. In the absence of a market, therefore, techniques have been developed to measure value by constructing demand schedules. One such technique is to survey anglers to determine what they would be prepared to pay for the opportunity to fish rather than forego the experience. The resultant demand schedule is intended to provide a perspective of the quantity of recreational experiences desired at different price levels. The area under this schedule and above the price actually paid for the opportunity to fish is known as consumer's surplus, the value of the experience in excess of the price paid.

A second technique to measure demand is the travel cost method that also reflects consumer's surplus (Wilkins n.d). The "Travel Cost Method" was first developed by Hotelling (1949; in Topolniski 1980) and applied by Clawson (1959), and is based on observed behaviour rather than hypothetical questions. The distance travelled to a recreational site is proportional to the travelling costs, enabling the construction of a demand schedule (Laub n.d.). Problems with demand estimations derived by this method are treated in detail by Topolniski (1980), Crutchfield (1962) and Laub (n.d.).

A major problem with these valuation techniques occur when a value is finally estimated and used in comparative analysis for allocation decisions. Valuation is based on the consumer's surplus concept which is not equally applied to alternative choices." A comparison is thus being made between the value of one product including consumer's surplus and the value of other products excluding consumer's surplus" (Sirkin 1968). The problems of identifying and measuring the value of consumer's surplus in alternative production processes is impractical, which puts limitations on the comparative analysis. In addition, the validity of the consumer's surplus concept as a useful tool has not achieved full acceptance in economic theory (Sirkin 1968; Samuelson 1947). Regardless, the use of these valuation techniques could create bias in the allocation of resources.

2.4.3 Pricing Recreational Resources

One possible explanation for the failure to price the opportunity to fish for recreation appears to center on the concept of public and private goods. Market conditions generally used to distinguish public goods from private goods arise in situations where the "exclusion principle" exists and/or where consumption is non-rival (Musgrave and Musgrave 1976). Looking at the management of fisheries resources, it can be argued that the provision of recreational benefits is not a public good. First, the ability of government to regulate and enforce control measures is evidence that the exclusion principle is possible. Second, competition among anglers and between commercial fishermen for "scarce" stocks of fish is evidence that consumption is rival. That is, crowding and stock depletion resulting from excess fishing effort reduces the enjoyment and harvest of individual fishermen. These factors suggest that fisheries resources have the esential characteristics of private goods (Cauvin 1981). Under such realities, it would appear that a market mechanism could be established to measure the value of recreational fisheries on the basis of consumer sovereignty. Estimating the demand for recreational services through a pricing policy would facilitate efficient resource allocation and direct inputs towards the commodities that maximize benefits (Topolniski 1980). Pearse and Bowden (1969) have admitted that "certainly pricing offers an obvious and easy way of solving many of the problems of recreational resource management; that of rationing use; raising revenues; ensuring that those who benefit bear the cost; as well as establishing values." However, they continue, "For evaluation of planning purposes is quite a separate issue from the policy question of whether users should actually pay." The concerns presented will be addressed in more detail in Chapter V.

2.4.4 Commercial Fishery Valuation

For commercial fisheries production, gross landed value and/or gross market values are often used as a measure of value. It would appear that these measurements are not only incorrect, but inconsistent and incomplete. It appears incorrect because it does not value the resource per se, but rather attempts to measure gross values generated in the industry. It is inconsistent with recreational valuation to the extent that it measures the gross value of production, whereas traditional recreational valuation has been based on gross expenditures or willingness to pay. With respect to the willingness to pay, it is of interest to note that commercial fishermen are generally required to pay only a nominal license fee for the opportunity to fish. It is incomplete because a major component of the economic process of organizing resources to produce goods and services for distribution over time is absent. That is, the public sector supply function does not enter into the accounts (Cauvin 1981).

The net value of commercial fisheries production, estimated by deducting the cost of fisheries operations from the gross value of production, provides a measure of the contribution of the commercial fishing industry to the economy. However, it also suffers from the weakness suggested above. It also serves to illustrate the problems discussed in Section 2.3. Under open access conditions, fishing effort will expand until total revenues equal total costs and the net value of production will become zero. Furthermore, as indicated previously, if government subsidies are included in the calculations of cost, the net value of production will likely be negative.

It is readily apparent that the absence of a market system in the provision of fisheries resources has created some enormous problems in the valuation and allocation of fisheries resources.

2.5 Strategic Planning for Ontario Fisheries

Declining fish stocks in many of Ontario's exploited lakes initiated the Federal-Provincial committee for Strategic Planning for Ontario Fisheries (SPOF). Initially, the committee realized the diversity of social benefits attainable from the fisheries resource and "...that the principal goal of fisheries management must be to learn to live in harmony with fish" (SPOF 1974). Six main areas of concern were identified for consistent fisheries management within Ontario, and are summarized as (SPOF 1976):

(1) Conservation and augmentation of Ontario's fishery resources

(2) Maintenance of commercial fishing incomes

(3) Maintenance of fisheries related employment opportunities

(4) Minimization of social and economic disruptions

(5) The creation of public awareness about the importance of maintaining healthy fish communities and ecosystems

(6) The attainment of economic efficiency in fish harvesting

Sinclair (1977) reviewed these goals and identified potential problems with such idealism, particularly with (3) and (4). It was considered inconsistent to try to rationalize the commercial fishery in an efficient manner and maintain fisheries related jobs, while minimizing social disruptions. The overemployment and overcapitalization characteristic of the industry does not lend itself to maintaining employment when economic efficiency is attempted. Since then, several working groups were established to address the problems and develop guidelines towards rational fisheries management across the province.

The first step in provincial management is to group certain types of lakes into assessment units that could serve as models for similar lakes within the province. Based on fish communities, these assessment units were chosen to provide a representative cross-section of stress (exploitation, eutrophication, acidification, water levels, physical alterations and introductions) and inherent properties (area, mean depth, oxygen/temperature and dissolved solids) for each fish community. The basic roles of the units are to monitor and assess the response of fish communities to types and levels of stress. Trend through time data obtained from the lakes may then be applied to similar lakes elsewhere in the province (SPOF 1978a).

Public participation is considered essential if new fisheries initiatives are to succeed. A second working group was established to evaluate the best techniques for acquiring public input and presenting management strategies. The possibilities of citizen fishery advisory committees were considered useful in resolving specific or controversial issues, but a Provincial fisheries advisory "Council" was not recommended (SPOF 1978b). "If the (SPOF) goals for society are to become the goals of society, there would appear to be a need for government leadership (1) in initiating an articulation of these perceived goals and (2) in developing mechanisms to allow input by the public" (SPOF 1974).

The third approach is to develop a broader knowledge base essential to manage the resource efficiently. This is proposed by adopting experimental management in the recognition that many fish stocks and communities are depressed and that the level of understanding ecological systems in insufficient for rehabilitation programs. Designed to yield knowledge, these experimental lakes will provide a basis for developing long term management strategies. The broad term "experimental" is used to indicate that management will be used not only to find optimal ways of regulating the particular processes under study, but also to advance fishery science in general (SPOF 1978c).

The fourth requirement is to establish lake productivity. The yield estimations objectively set harvest levels that a) are appropriate to maintain steady state fish communities; b) recognize the need in many lakes to rehabilitate stocks; and c) incorporate the effects of social and economic constraints on fish harvests. Productivity is based on historic harvest levels and the morphoedaphic index to predict acceptable yield levels. Three yield measurements have been proposed. Potential yield, first, is a theoretically derived estimate representing sustainable fish harvest. Derived by the morphoedaphic index and historic species composition, it may be viewed as the rehabilitative goal of management. Second, anticipated yield is a realistic expectation of fish yields over the short term (5 years) and assuming no changes in present management strategies. This level of harvest is based on historic yield levels and does not deviate from present conditions. Third, and final, allowable yield is the recommended harvest incorporating management strategies of stock rehabiliation and/or maintenance. This level is based on adjustments of the anticipated yield according to stock requirements (SPOF 1978d). Differences between the three estimates will depend on the degree of exploitation and condition of fish stocks. It is possible for a lake experiencing limited pressure to have all three yield levels equal, whereas a heavily exploited lake requiring stock rehabilitation may demonstrate three separate values. Individual lakes must be treated separately.

After production has been established, the fifth requirement is to allocate the harvest among competing users. The need for stated allocation rationale and mechanisms was identified in the Fourth Report, Federal-Provincial Strategic Planning for Ontario Fisheries (SPOF 1976) as:

> "Allocate By Value Priorities"
>
> "Ensure that allocation of allowable yields among competing users is based on ongoing appraisal of society's values regarding use of the fisheries resource; develop adequate criteria based on publicly accepted biological, economic and social values regarding alternative use."

The working group assembled to priorize the values for allocation generated the following list (SPOF 1978e):

Priority Ranking	Allocate to:
1	All residents (Maintenance and/or rehabilitation of the resource)
2	Native people with Treaty fishing rights
3	People with subsistence and/or traditional needs
4	Resident sport fishermen
5	Business enterprises - priority between commercial fish or sport fishing industries, to be decided on the basis of optimum benefits to the residents of Ontario.

Without a resource, allocation is not necessary, so maintenance of the fish stocks receives the highest priority. Although the order of consideration is specified, the percentage of allowable harvest allocated to each group is at the discretion of local managers. A detailed application of the allocation criteria for Rainy Lake will be presented in Chapter V. The expenditure method will be used to establish a value for the recreational fishery while the value of production will be applied to the commercial fishery.

The sixth area of concern identifies the commercial fishery. Industry rationalization is supported because of the large disparity between the ideal and what presently exists. Largely uncontrolled in its commitment to catch fish, benefits that should be returned to society are dissipated among industry participants. The benefits and costs of the commercial fishing industry to Ontario residents have been identified by the sixth working group as follows (SPOF 1978f):

Benefits	Costs
1. Economic	1. Costs to Government
2. Employment	2. Disruption of fish community stability
3. Food	3. Conflicting uses of the resource (sport v.s. commercial)
4. Cultural and traditional values	4. Disruption of rehabilitation efforts
5. Fish community management	
6. Biological information	

The recreational fishery has increased in importance over the years and their impact on the resource is considered significant. The magnitude of participation is only speculative as Ontario residents do not require an angling licence. Maintaining the supply of fishing opportunities is costly to government agencies, suggesting the need for the user pays principle. Institution of a resident sport fishing licence would contribute to the information base required to manage the resource as well as generate revenue. A seventh working group report identifies the need for a resident sport fishing licence (SPOF 1978g).

Additional areas of concern have recently been assigned to various working groups in an attempt to provide uniform guidelines for management decisions. As a strategy for fisheries management by the Province of Ontario, all aspects of social, economic and biological concerns have been considered. Final fisheries management plans will be influenced by the diverse inputs that share in the benefits from a healthy fisheries resource.

CHAPTER III

PHYSICAL CHARACTERISTICS AND PRODUCTION POTENTIAL OF RAINY LAKE

3.1 Individual Basin Management

Although frequently alluded to in past ivestigational reports (Bonde et al. 1961; Johnson et al. 1966), the multi-basin characteristic of the Rainy Lake morphometry has not been firmly established. Increased sports and commercial fishing pressures on fish stocks initiated a tagging program in 1957 to document fish movements between basins (Caldwell n.d.). Since that time, morphometric data have been collected along with edaphic information that suggests management by individual basins. A review of physical and biological parameters supporting such a management strategy is presented.

3.1.1 Physical Parameters

Rainy Lake has been delineated into three geographical regions consisting of the North Arm, South Arm and Redgut Bay (Fig. 3.1). The North Arm is the northwest portion of the lake distinguished from the South Arm by the Canadian National Railway Bridge at Sand Bay and from Redgut Bay by Frog Portage. The South Arm is the portion of the lake extending from Fort Frances - International Falls on the west to Kettle Falls on the east. It is differentiated from the North Arm by the C.N.R. Bridge at Sand Bay and from Redgut Bay by the C.N.R. Bridge at Bear Passage. Redgut Bay is the northeast portion of the lake demarked from the rest of the

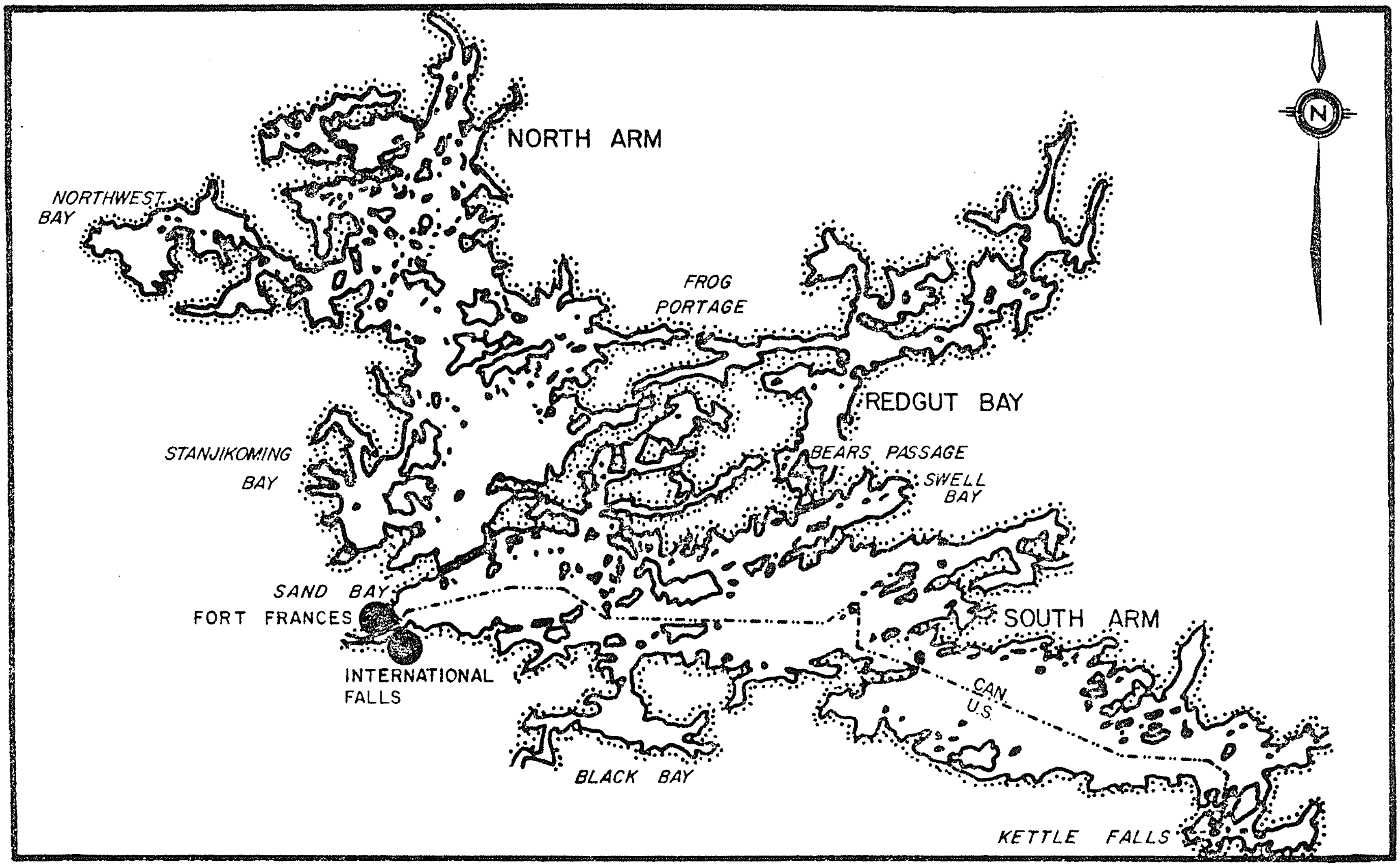


Fig. 3.1. Three basins composing Rainy Lake.

lake by Frog Portage and Bear Passage (Fig. 3.1).

The morphometry of each geographical region is different. The mean depth of the South Arm exceeds the mean depth of Redgut Bay by 4.57 m. The area of Redgut Bay is only 24 percent that of the North Arm (Table 3.1). These two characteristics have substantial effect on the potential productivity of each basin, and will be demonstrated later in this chapter.

Table 3.1. Physical, chemical and productivity characteristics for individual basins composing Rainy Lake.

	North Arm	South Arm[a]	Redgut Bay
Mean depth (m)	7.96	11.46	6.89
Area (ha)	34,588	27,270	8,323
TDS (mg/l)	54.73	42.59	34.85
MEI	6.88	3.72	5.06
Productivity (kg/ha/yr)	3.27	2.5	2.85
Potential production (kg/yr)	113,032	68,174	23,714

[a] Ontario portion only

Total dissolved solids (TDS) values for each basin were averaged from 35 sample sites throughout the lake. Each basin demonstrates discreet values with an area of overlap in Swell Bay, where Redgut Bay empties into the South Arm.[1] All other values can be grouped according to sampling site location.[2] The mean TDS value for the North Arm is 54.73; 42.59 for the South Arm; and 34.85 for Redgut Bay (Table 3.1).

1. See Appendix A, stations 2, 3, 31, Fig. A1.
2. See Appendix A, Table A1.

3.1.2 Productivity

Potential fish production of aquatic ecosystems is estimated by the morphoedaphic index (MEI) developed by Ryder (1965). Productivity is assumed to be a function of an edaphic variable (TDS) and a morphological variable (mean depth) that incorporates the diverse effects of climate, basin geology and lake morphometry. The influence of climate was held constant by considering only those lakes within a specific geographic region. In the case of Ryder's (1965) original work, the group of lakes used in his yield analysis were all from the north-temperate region of North America. The morphoedaphic index is determined by dividing the value of TDS by the mean depth of the lake.

As an indicator of edaphic conditions, the generalized value of TDS is more useful than measuring its component ions. Rawson (1951) has described TDS to be "a rough indicator of edaphic conditions which must in some measure affect the productivity of lakes." Alkalinity has been used by Hayes and Anthony (1964) to explain variation in their productivity index and Northcote and Larkin (1956) suggested that dissolved nutrients are important in determining productivity levels in British Columbia lakes. An instantaneous change in a growth limiting ion, such as orthophosphate (PO_4) due to rapid assimilation by algae, would have negligible effects on TDS values (Ryder et al. 1974). Any factors contributing to a continually depressed ion concentration would ultimately be reflected in a decreased TDS value.

Due to the multitude of effects incorporated by the morphological variable of mean depth as an estimator of fish yield, its influence is somewhat varied (Ryder et al. 1974). Mean depth is an indicator of the extent of the littoral zone to the area of a lake. This euphotic-littoral zone is proportional to the potential fish production so that large deep lakes have proportionally less productive littoral area when compared with smaller shallow lakes (Rawson 1952). The mean depth also influences seasonal temperature profiles and determines the depth of the epilimnion. Lake productivity increases with an increase in the annual heat budget. As the extent of the epilimnion increases, the depth of continual circulation determines nutrient availability for primary productivity (Cole 1975). The effects of mean depth on productivity may be illustrated by a comparison between Lake Ontario and Lake Erie. Both Laurentian Great Lakes have approximately equal TDS values, but the mean depth of Lake Ontario is five times that of Lake Erie. However, Lake Erie fish production is ten times greater than Lake Ontario (Ryder et al. 1974).

The morphoedaphic index (MEI) for each of the separate basins composing Rainy Lake have been established (Table 3.1). The potential yield (MSY) has been estimated by Ryder's (1965) yield equation of $Y=1.383\ x^{.44579}$ where Y is the potential production in kilograms per hectare per year, and x is the morphoedaphic index. The productive potential of individual basins demonstrates that the North Arm is the most productive basin in the lake (3.27 kg/ha/yr) and the South Arm as the least productive (2.5 kg/ha/yr). Redgut Bay productivity is intermediate in value (2.85 kg/ha/yr) (Table 3.1). Total potential production of each basin is a function of the surface area multiplied by the productivity value. From this estimation of potential fish yield, the annual production from Redgut Bay (23,714 kg/yr) is only 21 percent of the potential production from the North Arm (113,032 kg/yr) (Table 3.1).

The MEI has been expressed as a conservative estimator of fish yield by some authors (SPOF 1978d). As a result of the West Patricia Land Use Plan, a region of approximately 40,000 lakes in northwestern Ontario, several parameters were investigated as to their application towards predicting fish yield. Rainy Lake was included in the analysis of the relationship between yield and indices of plankton abundance. Spring phosphorus concentrations and secchi disc data were then used as indicies of fish yield. The average Rainy Lake productivity by these parameters is 3.9 kg/ha/yr weighted by basin area (Ryan 1980). An average MEI value for Rainy Lake productivity is 3.01 kg/ha/yr, or 0.89 kg/ha/yr lower than the value from Ryan (1980).

Several factors regarding the Rainy Lake data on fish yield would support the use of the conservative MEI estimate. First, complete community structure of individual basins is not well established, with only the commercial harvest of economic species known with any reliability. Several species, such as the smallmouth bass, yellow perch, muskellunge and others are not represented in the commercial, test net or to some degree, angler harvest. Lake productivity of individual species is dependent on the percentage composition in the community, and would be overestimated in favour of the fishes more commonly caught. Second, each basin has demonstrated inherent differences including a range of highest productivity experienced in the North Arm to the least productive South Arm. Applying an average value to the three basins would overestimate South Arm productivity and underestimate the productivity in the North Arm. Finally, in the interest of consistency across the province, the MEI estimator has been suggested as an initial starting point for developing yield estimates (SPOF 1978d). This is not to say that other fish yield estimators should be disregarded, but as more reliable and complete data accumulates over time, incorporating it into management strategies will be a necessity. However, as a first approximation, the arguments presented above would favour the use of MEI predictions. Once the initial starting point has been established, evaluation of more detailed modifications can proceed on a comparative basis.

3.1.3 Biological Parameters

The biological parameters used to advocate individual basin management will include the six year tagging program between 1957-63 and species composition of each basin. The tagging program was initiated to study walleye and whitefish populations in an attempt to determine if sub-populations exist, and if so, to delineate them. Study methods have been outlined in detail by Caldwell (n.d.) and Bonde et al. (1961) with the following discussion based on the results as presented in Bonde et al. (1965).

3.1.3.1 Tagging Progam

A total of 4,167 spawning walleye were tagged between 1957 and 1963 with a combined return of angler and commercial catch of 722 individuals, or 17 percent. Only seven of these recaptures, representing less than one percent, were caught in basins other than where they had been tagged. Although individual fish dispersed widely within the basins following tagging, free intermixing between the basins did not occur (Bonde et al. 1965).

Whitefish tagging was limited to a three year program involving the North and South Arms. Tagging operations were conducted during the fall spawning period with 1,300 white-fish being marked. The three following summers of commercial harvest recaptured 12 percent of the total. No fish were caught in basins other than where they were tagged, indicating no movement between basins. Distribution was again dispersed throughout the entire basins, but the shallow waters separating each basin has been attributed to restricting movement (Caldwell n.d.).

The six years of tagging data demonstrates that the Rainy Lake walleye and whitefish populations can be divided into a minimum of three sub-populations and that they are distinct from one another with little or no intermixing.

3.1.3.2 Species Composition

Species composition of fish communities within individual basins has changed over time (Fig 3.2). Recent test netting operations performed by the Ministry of Natural Resources over the last ten years and the five year average commercial harvest from 1976-80 indicate harvest composition changes of all fish trophic levels when compared with the five year average commercial harvest from 1948-53 (Fig 3.2). Test nets were set primarily for specific species and not for establishing community structure. The program made no attempt to sample the hypolimnion, so the results should only be used as estimates of the epi and metalimnion communities. In addition, gill net selectivity will underestimate the abundance of some species (smallmouth bass, crappie) while overestimating others (walleye).

Commercial catch data are also subject to limitations. The 108 mm (4.25 in.) gill net mesh size will select for larger individuals and nets set for specific species will misrepresent community structure. In addition, the selectivity of the commercial nets between the 1948-53 period (cotton) and the 1976-80 period (nylon) may not be totally

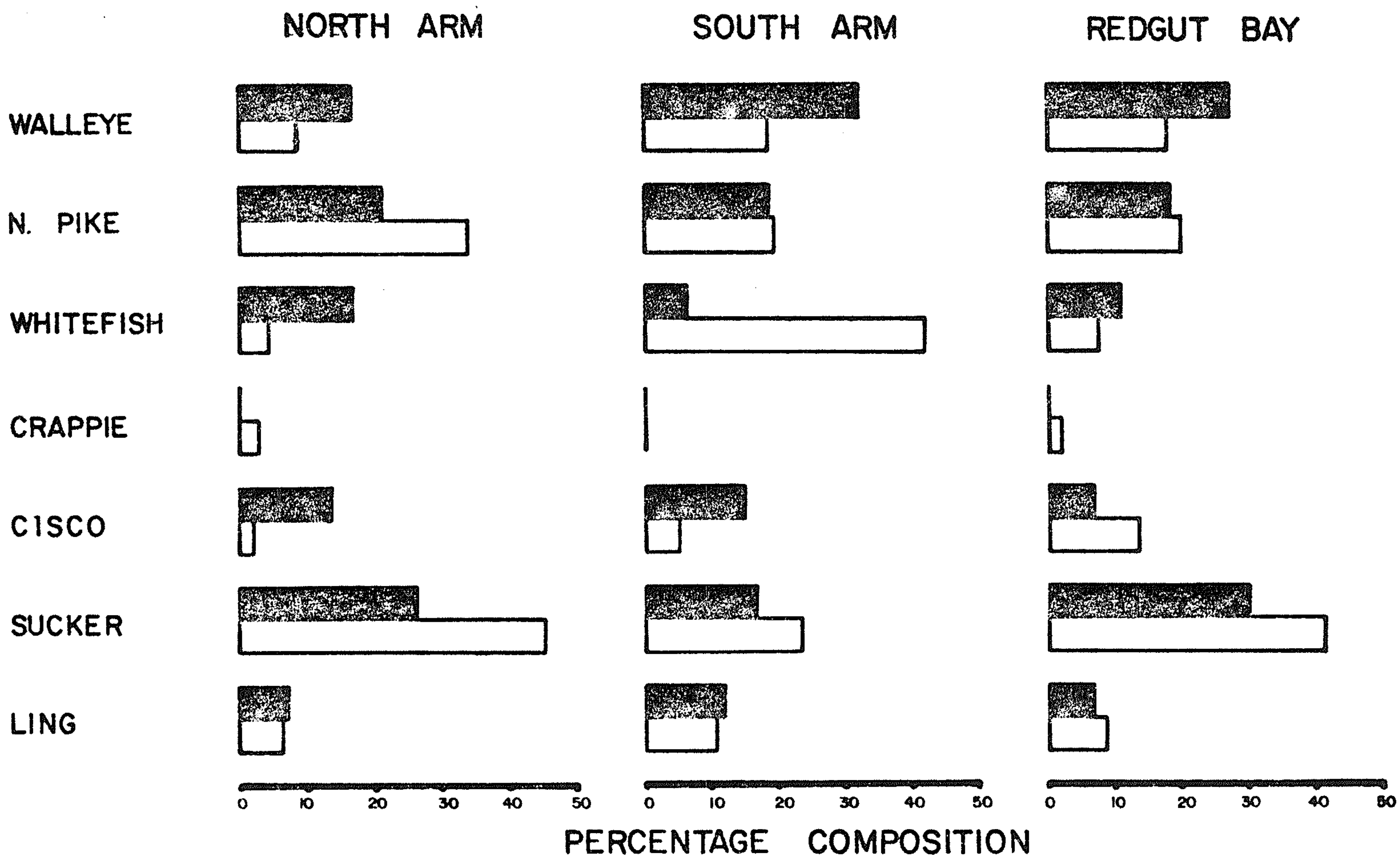


Fig. 3.2. Changes in fish community structure. Solid bars are historic commercial returns between 1948-1953, light bars are the mean commercial returns between 1976-1980 and O.M.N.R. test net surveys between 1970-1980.

comparable. Because of these limitations, the 1980 fish species biomass composition has been estimated by using the mean values of test netting results and the five year average commercial catch from 1976-80 (1966-70 for Redgut Bay) (Fig 3.2).

The walleye harvest from the North Arm has decreased 50 percent since the early 1950's and presently constitutes 8.15 percent of the community biomass. The reduction has been compensated to some degree by a 64 percent increase in the northern pike population. Whitefish, a cold water species of the hypolimnion, have decreased 73 percent from 16.6 percent in 1948-53 to 4.4 percent in the 1980 estimate. Cisco have also decreased in abundance from 13.6 percent in 1948-53 to 2.8 in 1980. This represents a 79 percent reduction. Rough fish such as sucker have increased 76 percent from 24.4 to 44.6 percent of community biomass by 1980. Ling have remained relatively constant at 6.5 percent (Fig 3.2).

The South Arm has a different composition of species within the community, but has demonstrated the general decline and expansion of the same fish species as in the North Arm. The main difference is the commercial catch of whitefish, which has increased considerably since the 1948-53 average of 6.3 percent of total landings to 41.4 percent from 1976-80. This may be due to the increased effort for whitefish after the mercury ban on walleye and northern pike prevented fishing for the two years of 1972-73. The walleye population has decreased 42 percent from a 1948-53 average of 31.2 percent to 18.0 in 1980. Northern pike, crappie and ling have remained relatively stable at 18.9, 0.1 and 10.6 percent respectively. Cisco have decreased 64 percent from 14.8 to 5.4 percent by 1980. Suckers have increased 41 percent to compose 23.3 percent of the community biomass in 1980 (Fig 3.2).

Redgut Bay has also experienced changes in species composition since the early 1950's. The major decrease is in the walleye population from 26.4 to 17.7 percent by 1980. This is a 33 percent reduction over the last 27 years. Commercial fishing stopped after 1970, so the last five years of 1966-70 have been used to compute the average composition of species biomass. These values are averaged with the test netting results taken annually since 1975. The whitefish population is the only other species to demonstrate a decline from 10.8 to 7.2 percent, but this may be a result of a decrease in fishing effort. Northern pike and ling populations appear to have remained stable at 19.1 and 7.6 percent respectively. Fish species showing biomass increases include crappie, cisco and sucker (Fig 3.2).

Each basin has experienced a change in species biomass composition over time. In all areas, walleye populations have been depressed between 50 (North Arm) and 33 (Redgut Bay) percent. This has not been compensated by an equal increase in the other endemic top predator, northern pike.

An analysis of the trophic levels within the communities may assist in interpreting the changes.

Aquatic ecosystems may be divided into five trophic levels. Producers are the first level and are composed of the macrophytes and planktonic primary producers. The second trophic level is composed of zooplankton and other invertebrates. The primary carnivore level, thirdly, is made up of the sucker, cisco and whitefish. These species consume invertebrates and represent forage for the higher piscivorous trophic levels. Fourth, the secondary carnivore trophic level consist of the crappie and smallmouth bass populations. These fishes consume the lower trophic level juveniles, along with some invertebrates, and are consumed by the top predators. Fifth, the tertiary carnivore trophic level is the top predators, walleye and northern pike which feed on the young of all lower trophic level species. Except for fingerling stages, these fish have no natural predators in an unexploited ecosystem. However, these top predators are commonly the selected species of both angler and commercial fisheries. Exploitation pressure selects these species removing the natural population control of lower trophic levels which allows changes in the community structure.

The North Arm demonstrates a typical expansion of the primary carnivore trophic level. Sucker abundance has increased in absence of secondary and tertiary trophic predation. The northern pike and crappie have increased to fill the niche vacated by walleye removal, but full replacement does not seem to have occurred because suckers have expanded. Crappie biomass has increased and may be attributed to less competition from other depressed fish populations, such as cisco and decreased predator pressures.

The South Arm is slightly different. Sucker expansion has not attained the same magnitude as in the North Arm, although northern pike have not increased in abundance as walleye have been depressed. Crappie have also remained constant. This situation questions the importance of small mouth bass populations in replacing the role of the disappearing walleye. Unfortunately, adequate data pertaining to dynamic changes in this population are not available. Future efforts should therefore include information on community structure in all habitats.

3.2 Water Quality

Water quality records have not been maintained over time. The first complete records were obtained in 1969-70 followed by irregular sampling throughout the summer months in subsequent years. The 1980 data were collected between May 19-29, limiting comparisons with historic data to those collected in May of 1969-70 (Table 3.2). Sampling techniques for the 1980 survey have been described in detail by Ryan (1980).

Limited comparisons between the variables of pH, dissolved oxygen (O_2) and secchi disc transparencies super-

Table 3.2. Water chemistry data for Rainy Lake. Sampling dates were between May 19–29 for all stations. See Fig. A.1 Appendix A for station locations.

	North Arm					South Arm						Redgut Bay					
	Station 33					Station 26						Station 1					
	1969		1970	1980		1969		1973		1980		1969		1979		1980	
Depth (m)	0	8	0	2	8	0	25	0	30	2	30	0	14	0	20	2	22
Temp. (°C)	11.6	11	8	18	10.9	9	4	11	5	14	5	5.5	5	4.4	4.4	12	6
O_2 (mg/l)	10	10	11	9.9	8.6	11	11	11	10	11.5	11.2	10	10	11	11	12.6	10.3
pH	7.2	7.2	7.3	7.2	6.4	7.2	7.0	7.2	7.1	7.0	6.2	6.2	6.2	6.8	6.8	7.1	5.6
Secchi (m)	1.5		2.0	3.9		1.8				3.4		1.8		1.5		1.95	

	Station 10						Station 30					
	1969		1970		1980		1969		1970		1980	
Depth (m)	0	8	0	14	2	6	0	10	0	10	2	10
Temp (°C)	14	12	9	9	14	10	13	9	7	7	14	10
O_2 (mg/l)	9	9	10	9	10	7.5	12	11	10	9	11.3	10.5
pH	7.5	7.0	7.3	7.2	7.0	6.5	7.2	7.2	7.2	7.2	7.1	6.5
Secchi (m)	1.5		2.0		2.8		1.4		1.7		3.0	

	Station 32				
	1969		1970		1980
Depth (m)	0	4	0	4	1
Temp (°C)	16	14	10	10	21
O_2 (mg/l)	9	9	9	9	8
pH	7.3	7.4	7.2	7.2	7.0
Secchi (m)	1.1		1.2		1.2

ficially indicate little change in the aquatic environment (Table 3.2). A slight decrease in pH values has occurred at all similar sites sampled during the two survey periods (see Appendix A for 1980 sample locations), and can probably be attributed to variations in sampling technique. The possibility of acidification from atmospheric SO_2 and NH_x compounds should be noted because the greatest decrease in pH has occurred in the subsurface depths of the two basins with the lowest total inflection point (TIP) alkalinity values. Redgut Bay and the South Arm have mean TIP alkalinity values of 9.34 and 13.95 mg/l respectively, and would therefore have less buffering capacity compared with the value of 25.59 mg/l for the North Arm (Appendix A). Secchi disc transparencies have also increased at all stations, however, the "point in time" observations of 1980 may not be comparable to the previous surveys as the time of day, year and weather conditions influence these values.

The available water quality records are not sufficient to draw a relationship between degrading water quality and declining commercial fish production. There is some indication that any change has been minimal from the comparison presented in Table 3.2. Accurate and consistent data will be required for future analysis to substantiate the claim of unchanged water quality.

3.3 Water Levels

The decline in walleye populations common to all basins after 1962 prompted investigations into factors that may affect the entire lake equally. One factor with lakewide effect that could influence walleye recruitment is spring water elevations. Rainy Lake is part of a reservior system which is used to generate power at a hydroelectric dam constructed on the outlet, Rainy River. General regulation of water levels has been established by the International Joint Commission. Under normal conditions, water fluctuations in Rainy Lake are a gradual fall and winter drawdown followed by a spring and summer buildup. In 1969, the IJC revised the regulations to allow for a zone of accepted water levels on specific dates. A minimum of 336.93 m and a maximum of 337.36 m have been established for the first two weeks of May, which is usually the spring spawning period (Chevalier 1977). Only the upper levels of this range are considered satisfactory for providing sufficient walleye spawning grounds (Johnson et al. 1966).

The relationship between spring water elevations and success of walleye spawning was examined by comparing the water level elevations during the spawning period with the three year running average of commercial catch per unit effort (CUE) four, five and six years later (Fig. 3.3). These age groups represented the bulk of commercially caught walleye between 1948-63. Regression analysis on the two variables demonstrated that spring water levels accounted for 50 percent of the variation in the commercial CUE (Chevalier 1977).

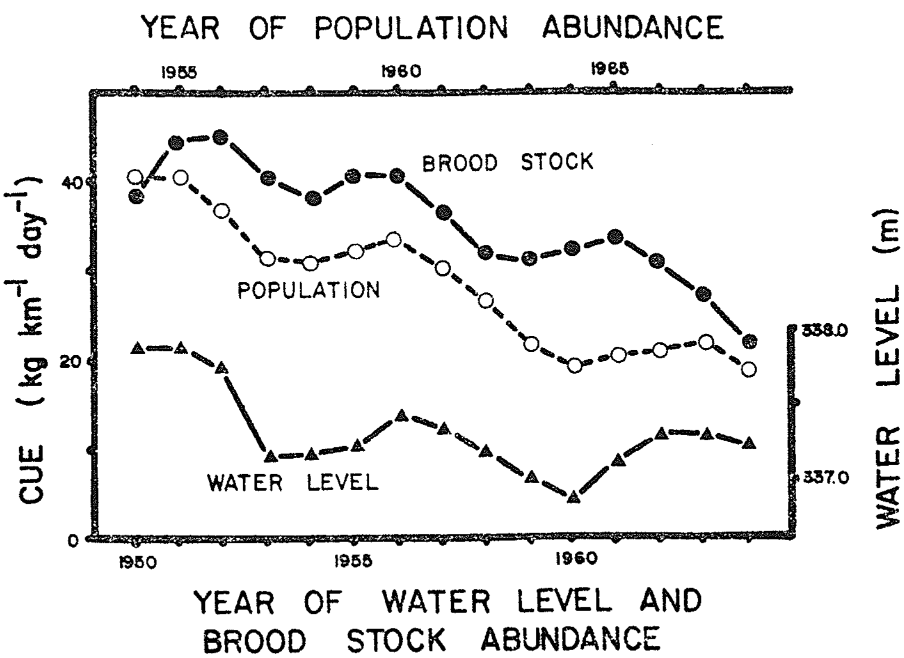


Fig.3.3. Trend of walleye population abundance in Rainy Lake, 1954-68, in relation to spring water levels and brood stock abundance 5 yr before (3 yr running averages). Abundance indexes were commercial 102 mm mesh gill net catches per unit of effort (CUE). Redrawn from Chevalier (1977).

Wave action during normal summer water levels establishes clean gravel-rubble rock beaches which are flooded in spring. During low spring water levels, these beaches may not be available to walleye (Johnson et al. 1966). Johnson (1961) demonstrated the importance of spawning substrate on walleye egg survival. Water levels below normal causes spawning on silt, sand or loam bottoms where egg survivial decreases.

The remaining 50 percent of the variation in Chevalier's (1977) analysis was related to the abundance of brood stock available for spring spawning. It was postulated that heavy exploitation pressures removed a substantial portion of the mature population which restricted the number of eggs laid and the subsequent recruitment to the population. The influence of spring water levels would, therefore, be more pronounced because of the need to maximize recruitment. The management strategy suggested for increasing the Rainy Lake walleye population was to optimize spring water levels and maintain the present rate of exploitation. If this option failed to demonstrate an increase in abundance, then a better understanding of the role played by exploitation would be acquired (Chevalier 1977).

Water levels for the first two weeks of May were divided into two periods from 1948-60 and 1961-76. The arithmetic mean water elevation for the period 1948-60 was 337.09 m and for the 1961-76 period it was 337.26 m. Testing the difference between these two means demonstrates that the mean spring water level for the period 1961-76 is significantly higher than the mean value for the first period at a 95 percent confidence level. Despite the increase in water levels, the commercial walleye CUE four years later, assumed to represent brood stock abundance, demonstrates a significant decline between these two periods. Although this simplistic analysis ignores changes between these two periods, such as the mesh size increase and shifts in age composition, it appears that increased spring water levels had little effect on increasing the walleye populations. In addition, the analysis suggests that spring water levels are not the major cause for the demise of the Rainy Lake walleye populations. Additional information regarding water levels and spawning success should be included in future management strategies, however, efforts should not be confined to analysis of commercial CUE data. The availability of spawning substrate at different water levels and the percentage of the total population using these areas may be beneficial in determining the future impact of fluctuating spring water levels.

3.4 Production Potential

The production potential for individual species within each basin has been separated into two estimates (Table 3.3). The historic production levels is based on the total MEI potential production of each basin as determined in Section 3.1 and multiplied by the species biomass composition from the five year average commercial catch from 1948-53. The effect of introduced eggs on species composition was investigated because artificial stocking of eyed walleye eggs had been performed annually between 1933-58.

Table 3.3. Potential yield of individual species by basin in Rainy Lake. Historic production is based on the 1948-53 species composition in the commercial catch. the 1981 prediction is based on the 1980 species biomass composition. All values are in kilograms.

	North Arm		South Arm[a]		Redgut Bay	
	Historic	1981	Historic	1981	Historic	1981
Walleye	18,424	9,212	21,270	12,270	6,260	4,197
Northern Pike	23,285	38,092	12,612	12,885	4,269	4,529
Whitefish	18,763	4,973	4,295	28,224	2,561	1,707
Crappie	396	3,165	68	68	71	356
Cisco	15,372	3,165	10,090	3,681	1,636	3,178
Suckers	28,710	50,412	11,249	15,885	7,114	9,699
Ling	7,799	7,347	7,567	7,226	1,589	1,802
	112,739	116,366	67,151	80,239	23,500	25,468

a Ontario portion only

Annual stocking rates from 1944-58 were compared with the three year running average of commercial walleye CUE from 102 mm gill nets four, five and six years later. The CUE was calculated as the weighted average of CUEs from each of the three basins forming the lake. The four, five and six year differentials were used because age groups IV - VI constituted the majority of commercial catch over the time period (Chevalier 1977). The regression equation of the three year average CUEs on stocking rates was Y=36.2 + 0.027X and the coefficient of determination (r^2=0.002) indicated that there was no significant increase in commercial CUE four to six years following stocking. In fact, the slope of the regression model (0.027) did not significantly differ from zero (t = 0.05) suggesting that stocking eggs had no relationship to catch (Fig. 3.4). From this analysis, it may be postulated that the higher percentage of walleye in the community during the 1948-53 period was not due to the stocking program.

The 1981 potential production (Table 3.3) has been estimated by using the 1980 biomass composition and multiplying it by the total basin MEI production potential. For all three basins, the summation of species is more than the theoretical MEI production. This may be due to averaging commercial and test netting results that overestimate the composition of some species (South Arm whitefish). In addition, the species listed in Table 3.3 are of commercial and/or recreational importance only, making no allowances for species such as sauger, smallmouth bass, perch, bullhead, rock bass or mooneye which are not represented in the commercial or test netting results. For this reason, it is reasonable to conclude that the estimates are maximum values and represent initial estimates only. Basin community structure should be established with additional accuracy over the entire community before estimates may be considered

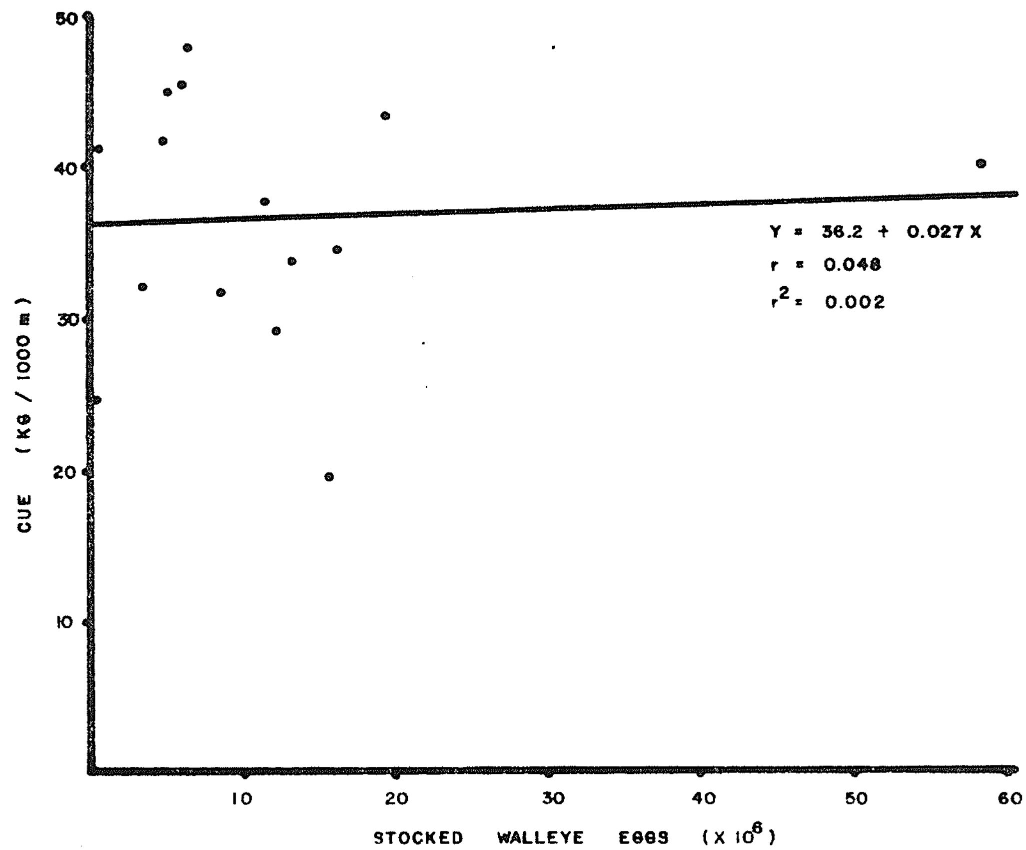


Fig. 3.4. Three year running average commercial walleye CUE (kg/1,000 m net) 4,5 and 6 years following eyed walleye egg stocking in Rainy Lake.

reliable. As a first approximation, and for short term management, these values will suffice until comprehensive data are available to refine the estimates (Table 3.3).

CHAPTER IV

CURRENT USE PATTERNS

4.1 Commercial Fishery

Rainy Lake has been an important source of fish for centuries. Accounts of exploration in this area during the late 1700's frequently document an extensive subsistence harvest by native Indians. Lake sturgeon were taken regularly with nets at Kettle Falls in the South Arm by the year 1800 (IJC 1917). The organized commercial fishery began in 1885 based on a pound-net lake sturgeon fishery. Gill nets had been introduced by 1904 for whitefish, while pound-nets remained popular for the warm water species of northern pike, walleye and rock bass. Trap nets set in shallow water were used initially for cisco, but after 1920 deeper sets were used for walleye (Bonde et al. 1961). Total commercial harvest of all species in 1908 has been estimated to be 72,575 kg (160,000 lb). Harvest has exceeded this estimate ever since. In 1916, Ontario had 62 licenced commercial fishermen operating in 25 designated fishing areas (Fig. 4.1) with a landed value of $25,133.19 (IJC 1917). The organized fishing grounds remained until the mid 1960's, with a gradual reduction in licences to 25. Since then, attrition has reduced the number of licenced fishermen to eight, operating in the ten remaining fishing areas (Fig. 4.2).

From the 1920's to the present time, the warm water top predators of northern pike and walleye, and the cold water

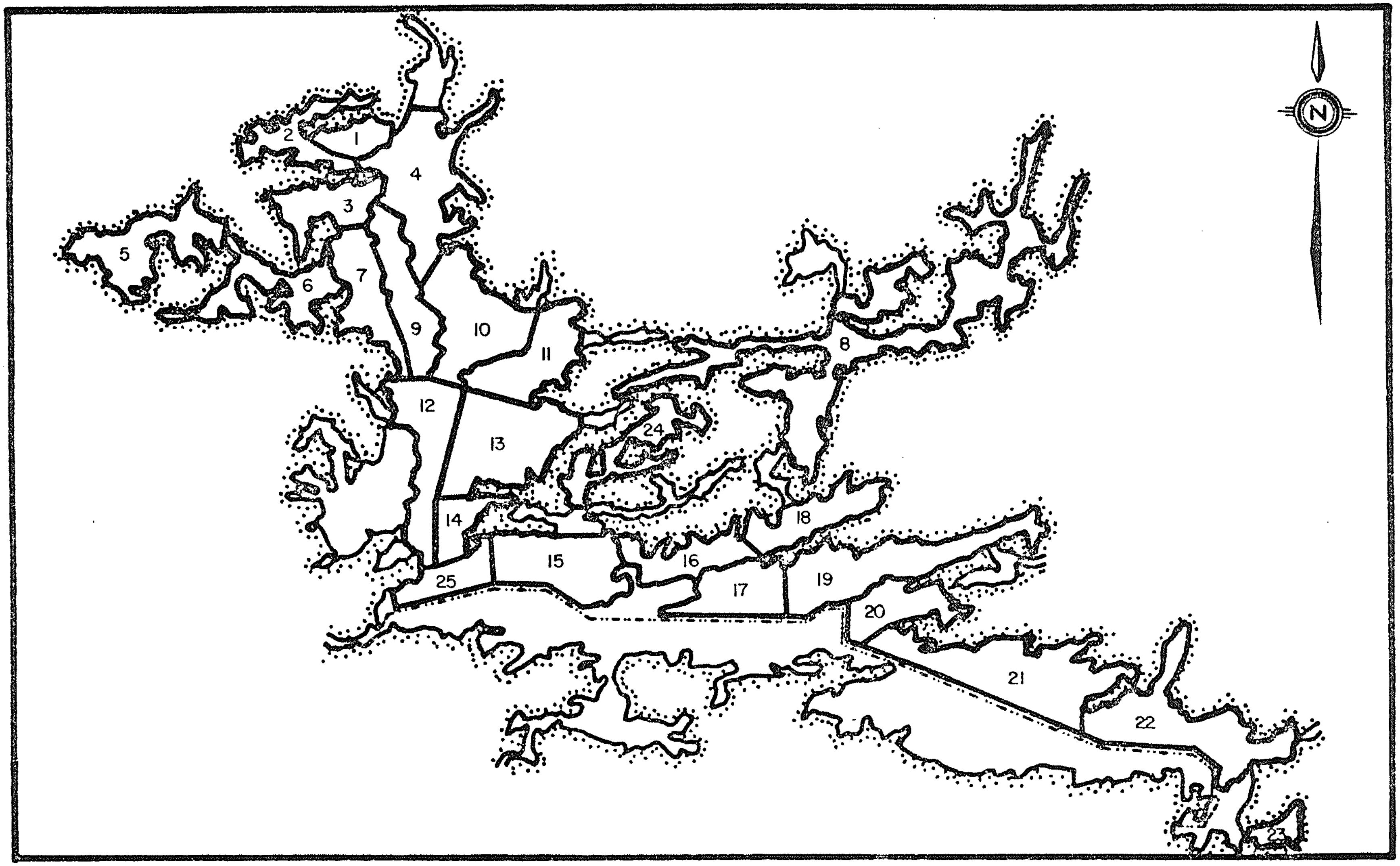


Fig. 4.1. Organized fishing grounds on Rainy Lake in existence between 1908 and the mid 1960's.

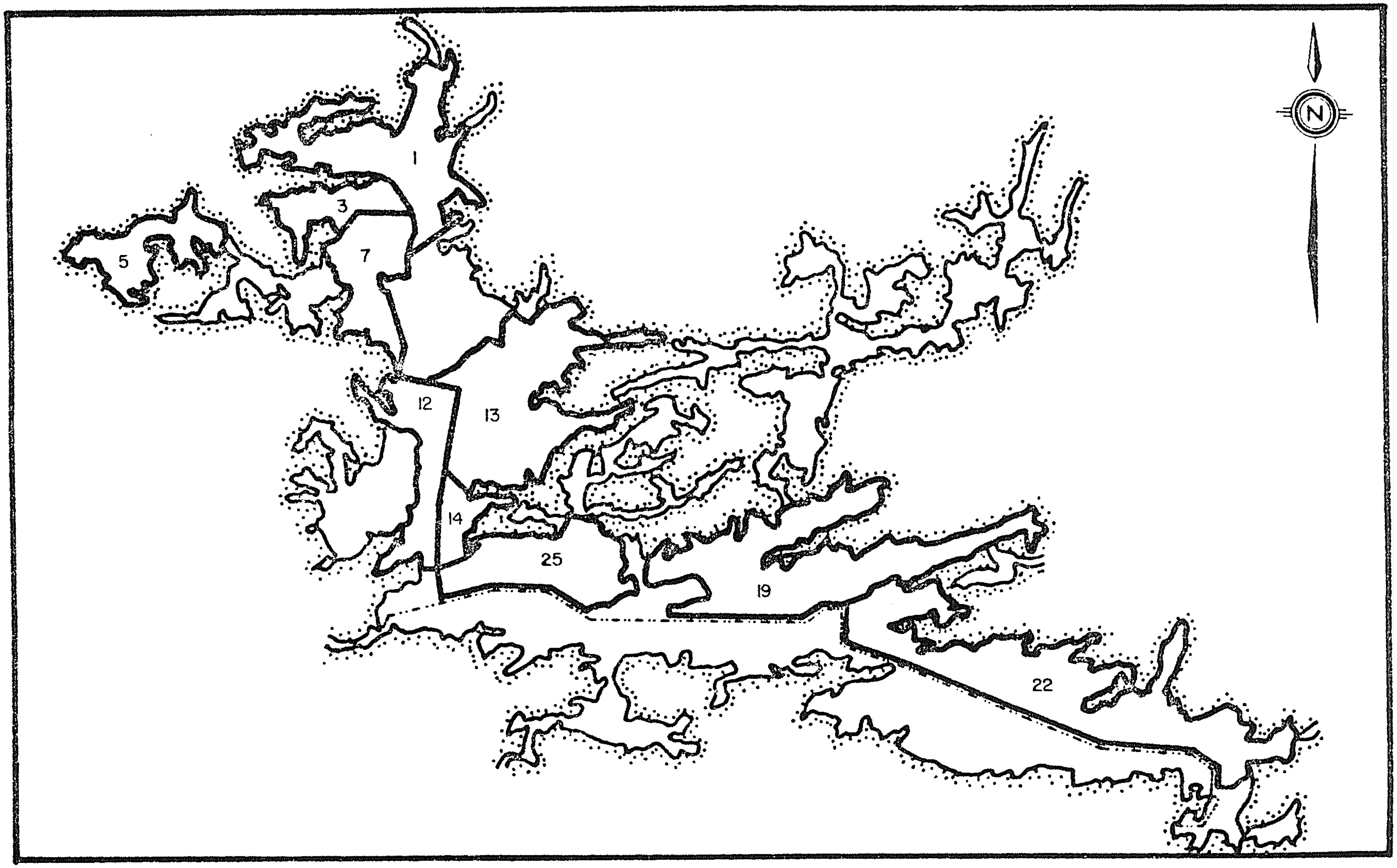


Fig. 4.2. Organized fishing grounds on Rainy Lake, 1980.

whitefish have formed the most important endemic component of the commercial fishery. The initial lake sturgeon fishery was quickly exhausted, contributing little to the modern harvest through occasional permits in the South Arm. Black crappie were introduced to the lake sometime before 1921 and now contribute significantly to the commercial catch. This fish is taken exclusively by trap nets, while all other species are harvested by gill nets. Incidental catches of suckers, ling, sauger and yellow perch frequently occur.

The present commercial fishery is managed by regulations concerning the amount of gear, net mesh size, fish size and fishing areas. Licences limit the amount of net set in any one day to 3,658 m (4,000 yds) with a minimum mesh size of 108 mm(4.25 in). In 1970, the minimum mesh size was raised from 102 mm (4.0 in) to the present 108 mm to reduce the harvest of immature fish. In addition, the minimum size of walleye allowed for sale is 38 cm (15 in). Walleye quotas for all fishing areas and four area quotas for northern pike have been established to limit the total annual harvest of these species. The walleye quotas in the North Arm were instituted in 1971-72 and in the South Arm in 1978. Licences, and the associated quotas, are issued annually to individual fishermen who fish in specified areas, so in practice the quotas are area quotas (Fig. 4.2). The Redgut Bay commercial harvest stopped in 1971 because of a combination of the gill net mesh size change and mercury levels above federal standards. The South Arm harvest of northern pike and walleye was restricted because of mercury for the two years of 1972-73 before a "blending" process reduced mercury levels in fish products to an acceptable level. The fishery was reopened in 1974 and all products were sold to the Freshwater Fish Marketing Corporation in Winnipeg, Manitoba. The past few years have witnessed sales of South Arm production directly to the United States market once again. The present fishing areas demonstrate the heaviest commercial pressures occurring in the North Arm with seven active areas. The South Arm has three active fishing grounds and Redgut Bay has a limited crappie and whitefish harvest that was initially allowed by permit in 1976. In 1979, the Redgut Bay crappie permit was changed to be incorporated into the allowable harvest for fishing area RL-13, while the whitefish harvest has remained under permit (Fig. 4.2).

Harvest data for the period between 1948-80 will form the basis for documenting commercial utilization of the fisheries resources as catch records predating this period are considered unreliable (Bonde et al. 1961). The North Arm has consistently produced the majority of the Rainy Lake fish yield over this period, but has shown a steady decline since the early 1950's. A maximum yield of 322,861 kg was produced from this area in 1953 declining to the 1980 low of 94,258 kg, a 71 percent reduction (Fig. 4.3). This may be a

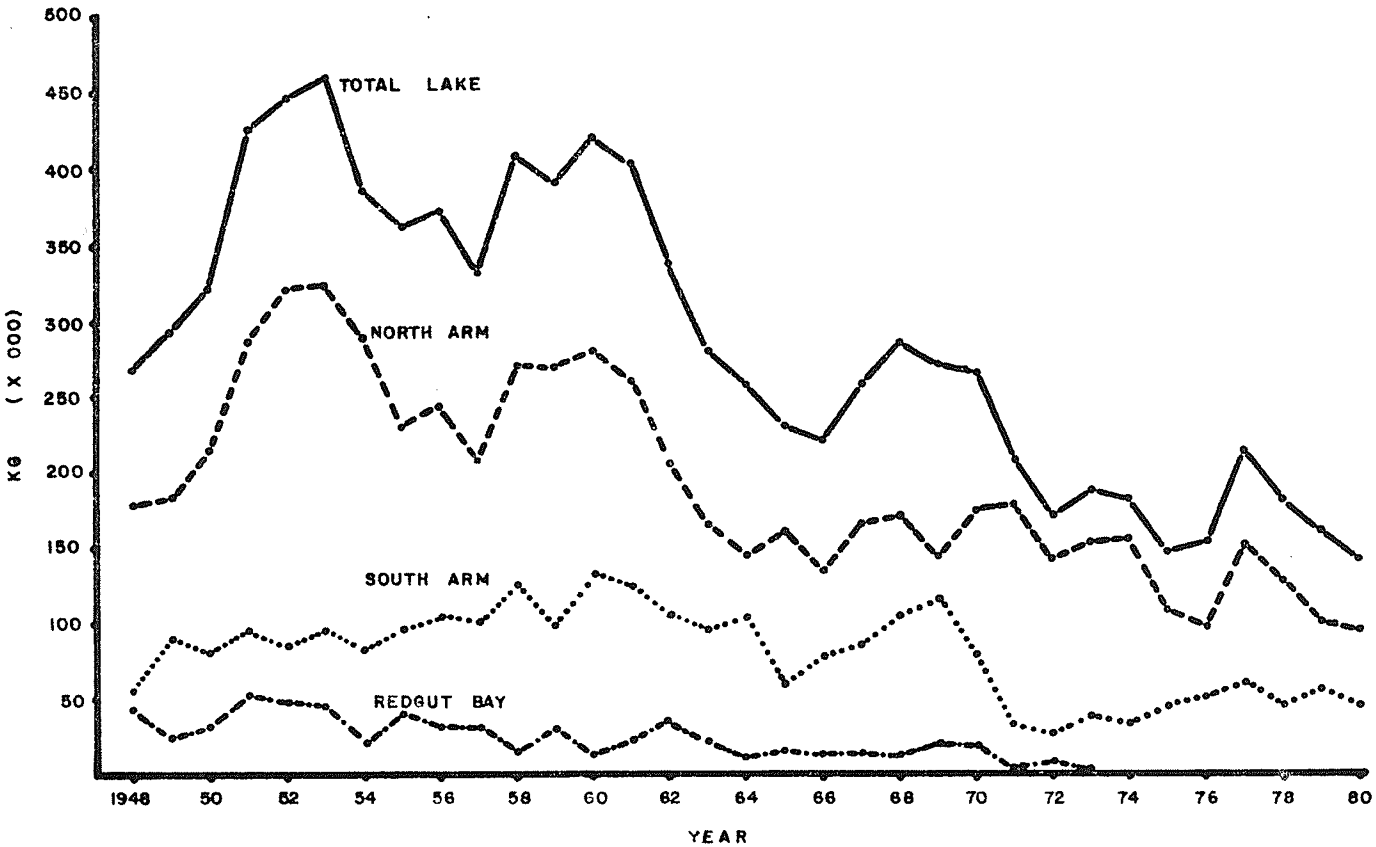


Fig. 4.3. Commercial yield of all species by basins composing Rainy Lake, 1948-1980.

result of a reduction in total commercial fishing effort and an increase in the angler harvest. Changes in production levels and species composition in the commercial harvest will be presented by individual species.

4.1.1 Walleye

Extensive management efforts have been directed towards the walleye populations because this species represents the best economic return and, therefore, attracts the most commercial effort. The first investigation into declining commercial walleye production was completed by Bonde et al. (1961). They documented the decline in commercial CUE (kg walleye/1,000 m net) that was necessary to maintain the stable production between 1950-62. Increased effort was required to produce the same volume of walleye until 1961 when total production began to decline (Fig. 4.4) with a continuing decline in CUE (Fig. 4.5). Overharvest was not identified as a threat to fish stocks and small walleye size caused the initial concern.

A second Rainy Lake report by Bonde et al. (1965) documented an age composition change from earlier years. The modal age group in 1955 and 1957 were groups VI and VII, but by 1963 the modal age group had decreased to age IV. Size composition appeared constant throughout this time span, suggesting an elevated growth rate accompanying the decrease in age. Chevalier (1977) used regression analysis to demonstrate a significant increase in growth rates that

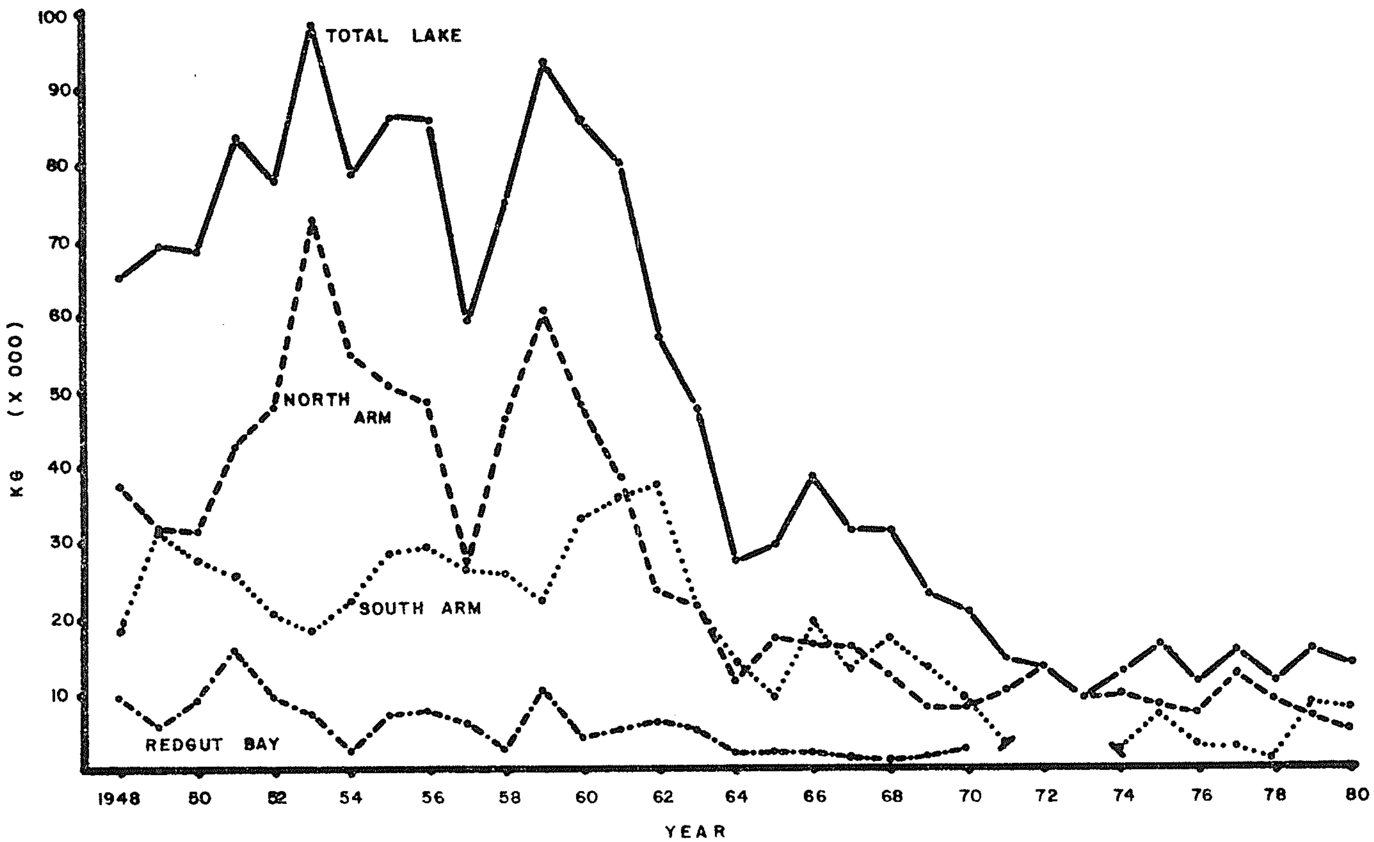


Fig. 4.4. Commercial walleye yield by basins composing Rainy Lake, 1948-1980.

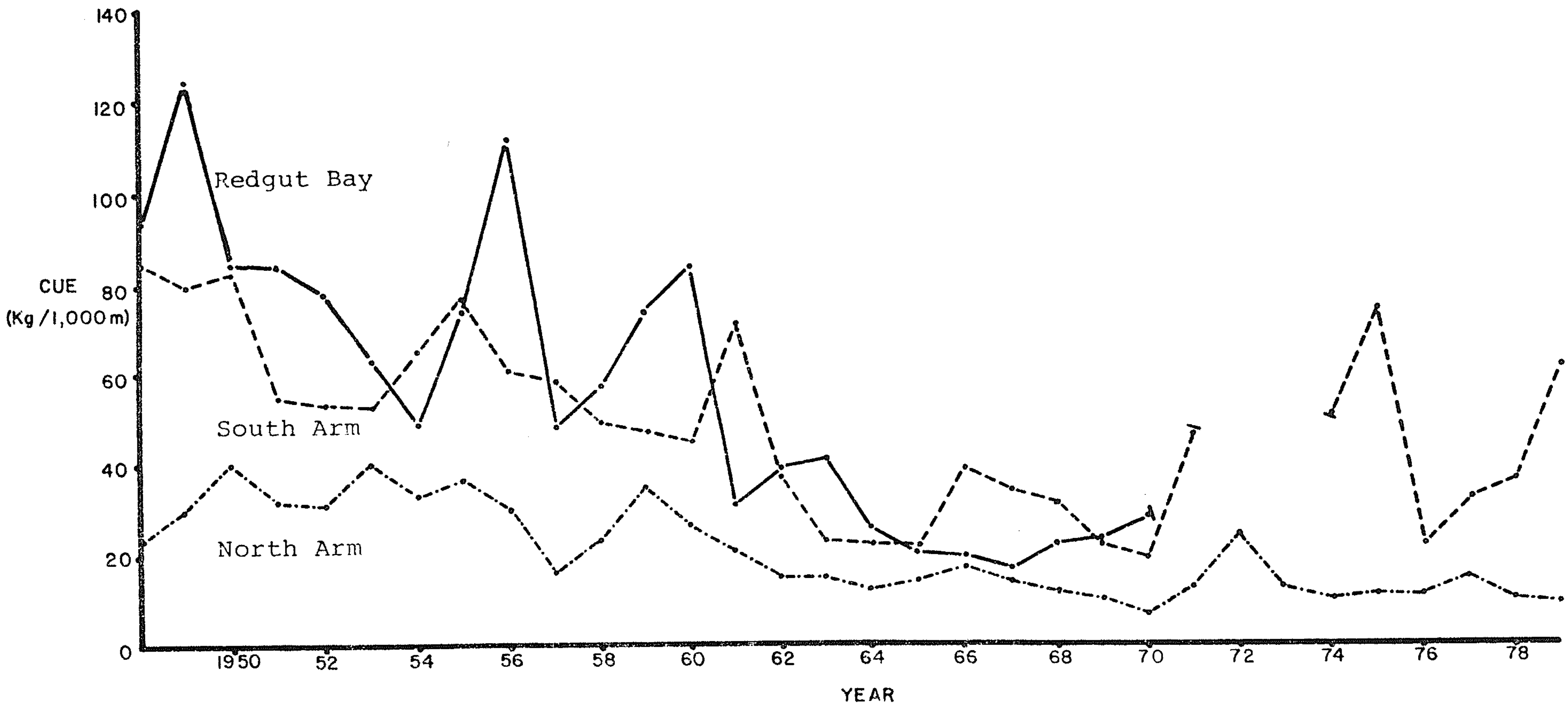


Fig. 4.5. Commercial walleye CUE (kg/1,000 m net) for each basin composing Rainy Lake, 1948-79.

paralleled the drop in age of commercially caught walleye (Fig. 4.6). The observed decrease in mean age was probably a result of the increase in walleye growth rates (Fig. 4.7). Test netting performed by the Ministry of Natural Resources demonstrated a decrease in relative abundance by a 1959 average walleye lift of 2.9 kg (6.5 lb) per net compared with the 1963 average of 0.68 kg (1.5 lb) per net. Increased growth of the Rainy Lake walleye population was probably a compensatory response to decreased abundance (Chevalier 1977).

Commercial catch data for 1965 revealed a further shift in walleye age composition where age group III constituted over 63 percent of the North Arm harvest and age class IV made up 77 percent of the South Arm commercial catch. The dependancy of the fishery on single year classes was re-enforced further by a disappearance of older age groups in the commercial harvest (Fig. 4.8). This probably reflects a similar loss from the population in general. Johnson et al. (1966) recommended restrictions on both sports and commercial fisheries as immediate measures to restore the walleye stock. Water levels during spring spawning was found to have some relationship with walleye year class abundance. It was postulated that low spring water levels restricted the available spawning habitat and therefore affected the number of surviving eggs. However, Johnson (1967) suggested that lower production was most likely caused by a substantial reduction in the number of eggs spawned rather than a poor hatch. He

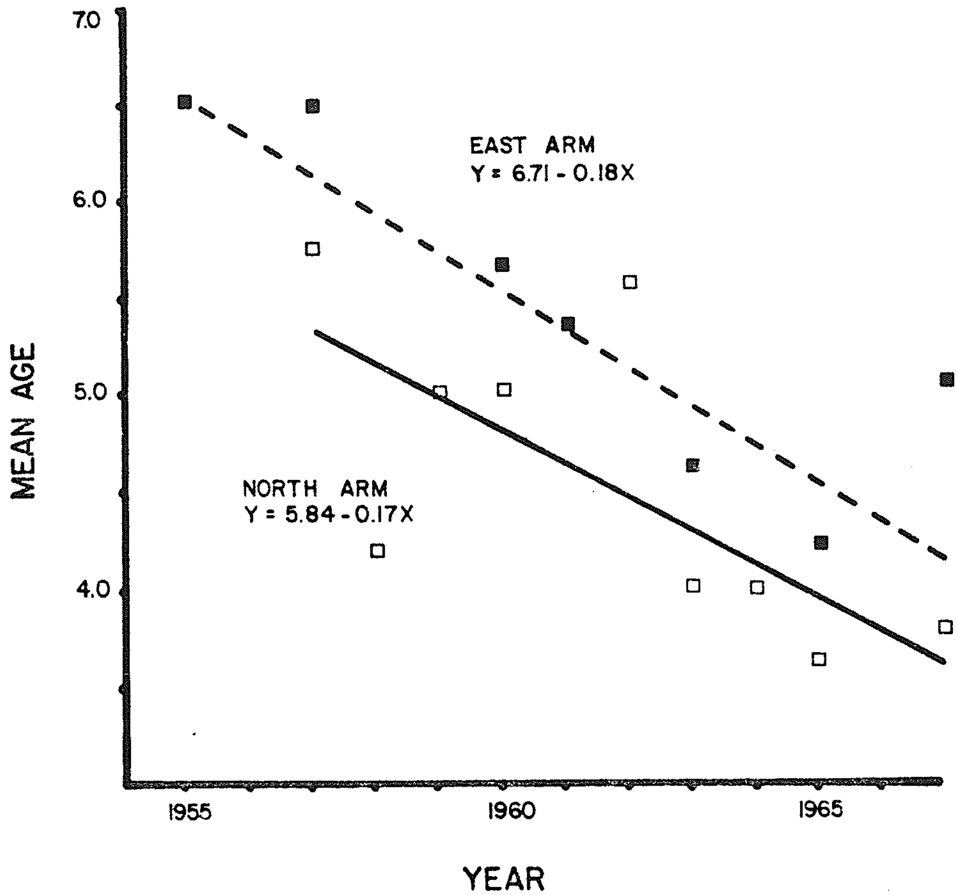


Fig. 4.6. Mean ages of walleye from the commercial 102 mm mesh gill net catches in late August and early September for the North Arm (1957-67) and the South Arm (1955-67). Redrawn from Cevalier (1977).

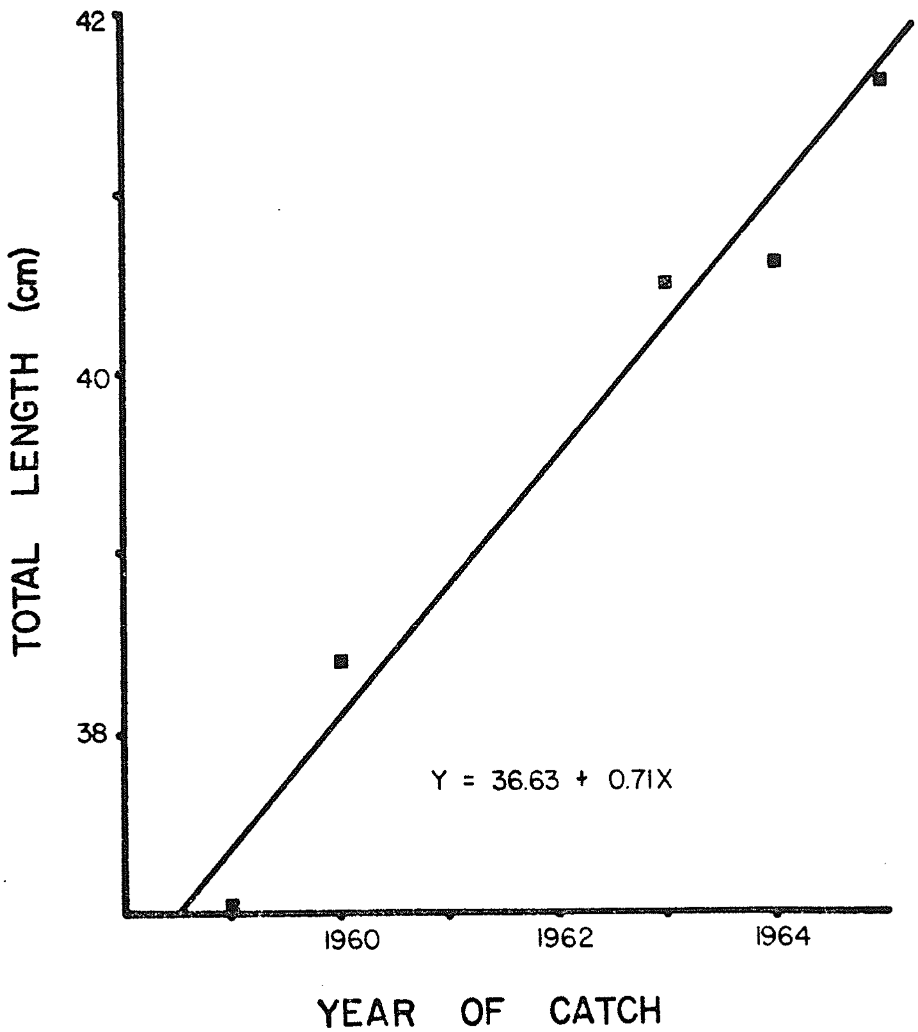


Fig. 4.7. Mean total lengths of age IV walleye (back calculated from IV+ to IV, 35 fish per sample except 13 in 1959) from the commercial 102 mm mesh gill net catch, North Arm, 1959-1965. Redrawn from Chevalier (1977).

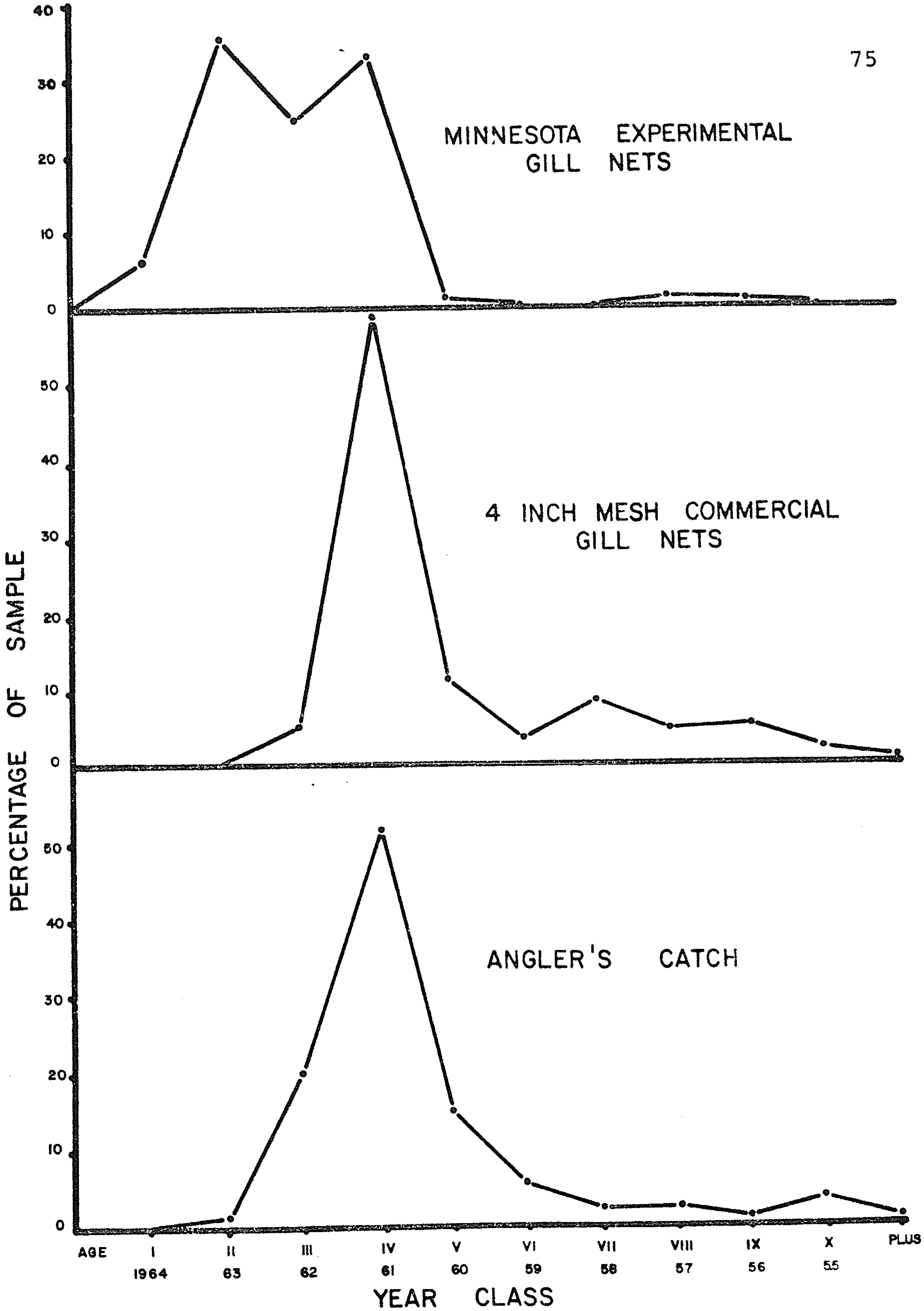


Fig. 4.8. Age distribution of walleye revealed in three types of samples, Rainy Lake, 1965. Redrawn from Johnson et al. (1966).

attributed the poor production in 1966, when water levels were considered optimal, to be a result of the depressed number of spawning adults. As in 1965, lakewide restrictions on walleye harvest to allow escape of the spawning stock and maintenance of optimum spring water levels were recommended for restoration of the fishery (Johnson 1967). Only commercial operations have witnessed regulations aimed at controlling harvest levels through mesh size increases, quotas and restricted entry. The recreational fishery has not experienced controlled harvest.

Walleye production has changed considerably over the last 32 years from a maximum production of 98,413 kg in 1953 to a low of 9,791 kg in 1973. The 1973 low was probably a result of the ban on fishing in both Redgut Bay and the South Arm, representing only the catch from the North Arm (Fig. 4.4). The reopening of the South Arm fishery in 1974 increased the output of walleye to a relatively stable level of 13,986 kg, the seven year average between 1974-80. In comparing the average walleye production from the North and South Arms during the 14 year period betweeen 1948-61 (71,763 kg) with the average production over the last seven years (13,986 kg), it can be seen that there has been an 80.5 percent reduction in output.

Relative abundance of walleye in the North and South Arms can also be shown to be decreasing by the percentage of walleye in the commercial catch and the CUE. At one time, walleye constituted over 20 and 30 percent of the North and South Arm commercial catch respectively. Presently, the composition has decreased to less than 10 percent in the

North Arm and under 20 percent in the South Arm (Fig. 4.9). The commercial walleye CUE has also decreased from over 30 kg/1,000 m of net in the North Arm during the early 1950's to less than 10 kg/1,000 m of met in the last few years. The South Arm has also demonstrated a decline in the CUE from a ten year average of 66.9 kg/1,000 m between 1948-57 to a ten year average of 29.6 kg/1,000 m of net from 1962-71. The walleye CUE rose dramatically after the two years of no fishing to give a six year average of 45.8 kg/1,000 m of net between 1974-79 (Fig. 4.5).

The 1981 commercial walleye quota for the entire lake is 20,866 kg (46,000 lb.) but the five year average commercial harvest between 1976-80 has been only 13,689 kg, 66 percent of the quota. Commercial harvest of walleye is allowed from the North and South Arms only, where the combined MEI allowable harvest is 21,483 kg. This means that over 97 percent of the allowable harvest is presently allocated to the commercial fishery.

4.1.2 Northern Pike

None of the remaining fish species have received the same management efforts given to the walleye. For this reason, the following discussions are limited to analysis of yield and commercial CUE data. Total lake production of northern pike had been relatively stable between 1948-70 until 1971 when a rapid decrease became evident (Fig. 4.10). This decrease begins at the same time the minimum commercial gill net mesh size was raised to 108 mm from 102 mm. Com-

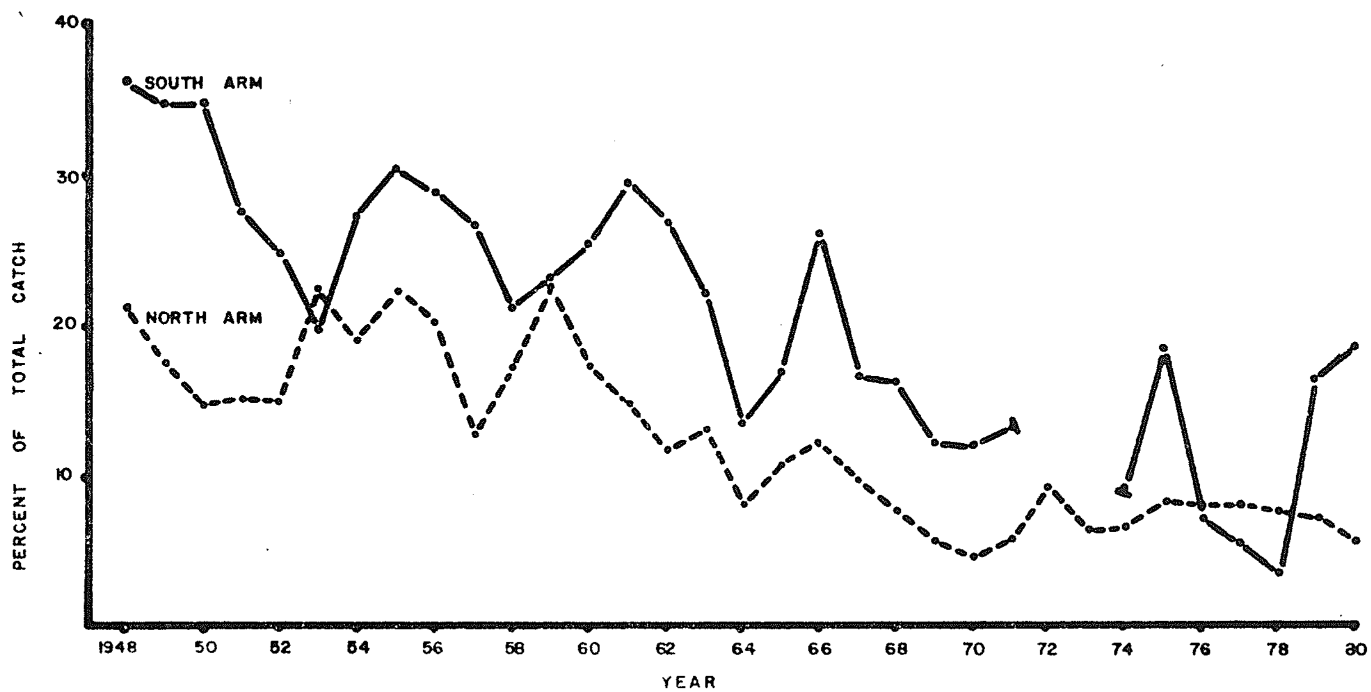


Fig. 4.9. Walleye biomass as a percentage of total harvest in the North and South Arms of Rainy Lake, 1948-80.

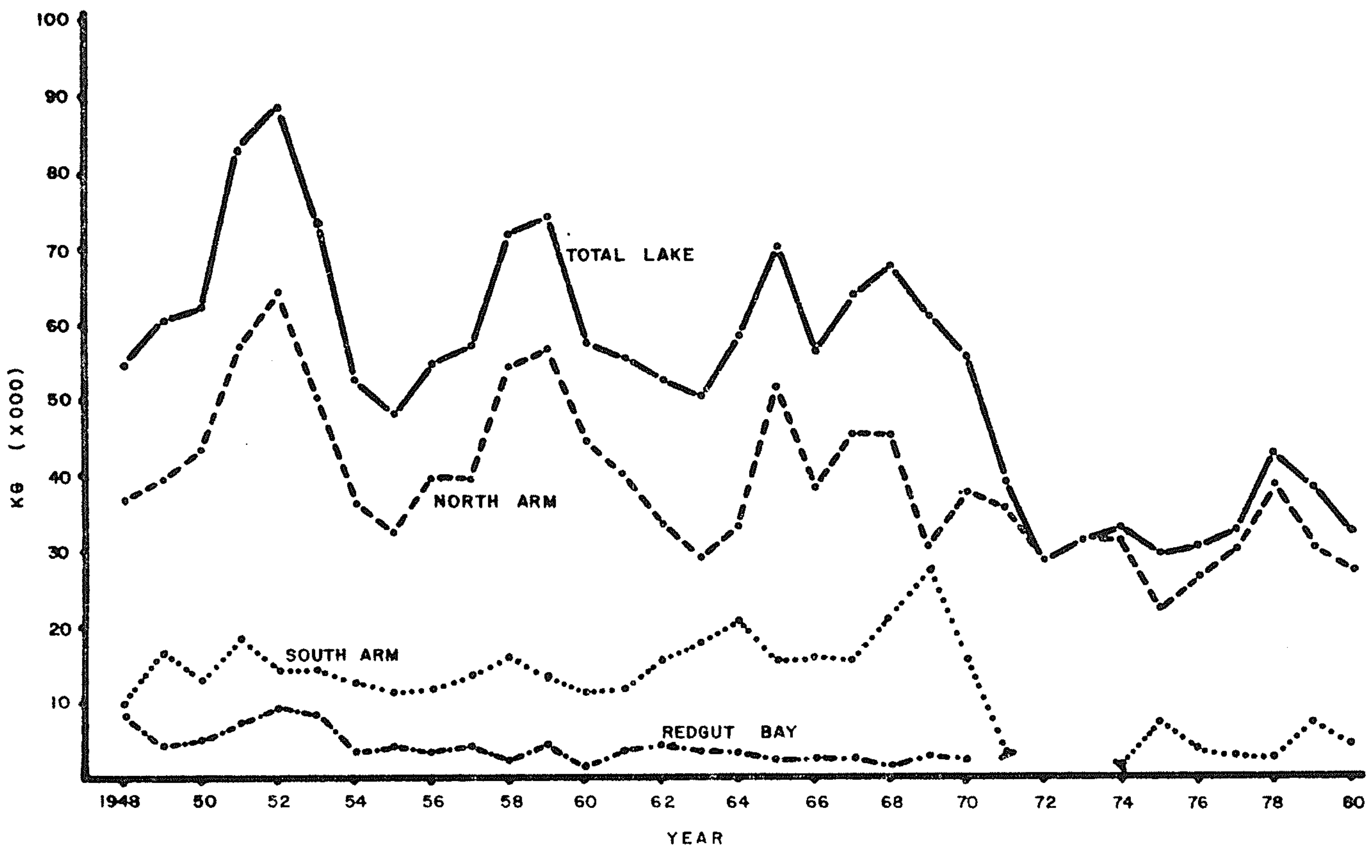


Fig. 4.10. Commercial northern pike yield by basins composing Rainy Lake, 1948-80.

mercial fishing in Redgut Bay ceased at this time, and South Arm commercial harvest was stopped for the two years of 1972-73, which most likely contributed to the lakewide decrease. Northern pike are also on a limited quota system, with a quota of 1,134 kg (2,500 lb) in RL-5 of the North Arm and all South Arm fishing areas, for a total quota of 10,206 kg (22,500 lb) for these areas (Fig. 4.2). The remaining areas have no quota restrictions.

The North Arm has typically produced the majority of northern pike but demonstrates a slight, but continuous, decline since the early 1960's (Fig. 4.10). However, if commercial returns are considered a reflection of the population in general (Ricker 1975), then the commercial northern pike CUE and percentage of basin catch indicate an expansion of the population. Commercial CUE in the North Arm has increased from a 16 year average of 29.3 kg/1,000 m of net for the period 1948-63 to an average of 38.4 kg/1,000 m of net between 1964-79 (Fig. 4.11). At the same time, the percentage of total North Arm harvest composed of northern pike has increased from a 16 year average of 18.1 percent from 1948-63 to 24.7 percent for the 16 year average between 1964-79 (Fig. 4.12). Expansion of the northern pike population is evident when species composition of the North Arm commercial harvest is examined (Fig. 4.13). The increasing northern pike catch is related to the decreasing walleye catch. Although it appears that the density has increased, the 16 year average annual yield has decreased

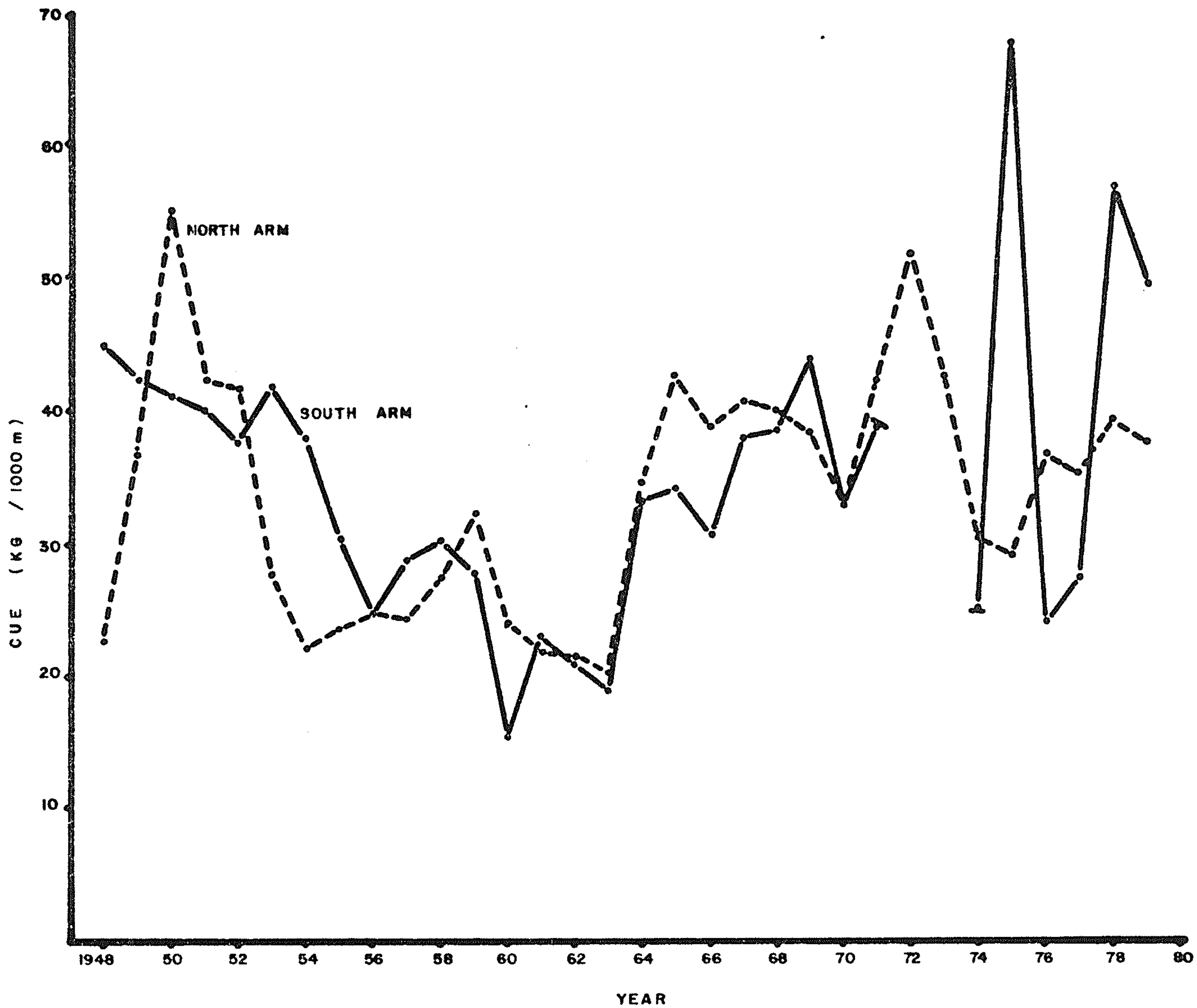


Fig. 4.11. Commercial northern pike CUE (kg/1,000 m net) for the North and South Arms of Rainy Lake, 1948-79.

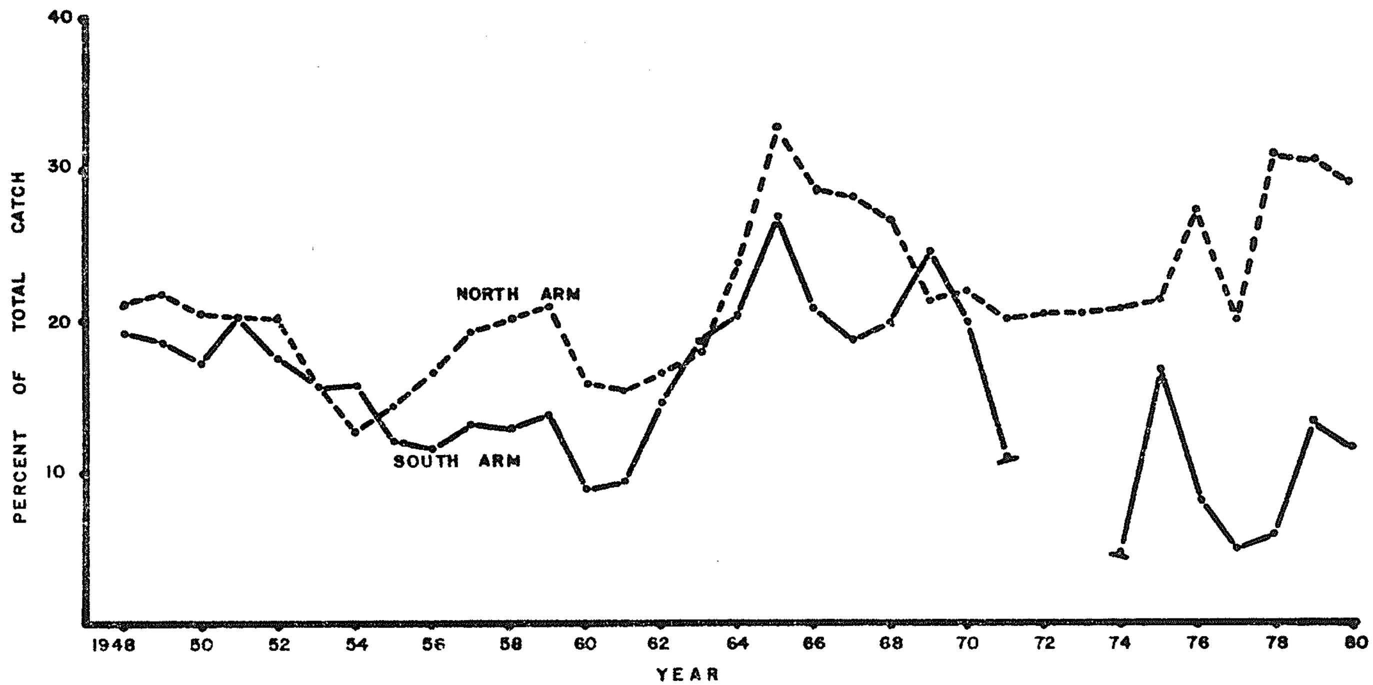


Fig. 4.12. Northern pike biomass as a percentage of total commercial harvest in the North and South Arms of Rainy Lake, 1948-80.

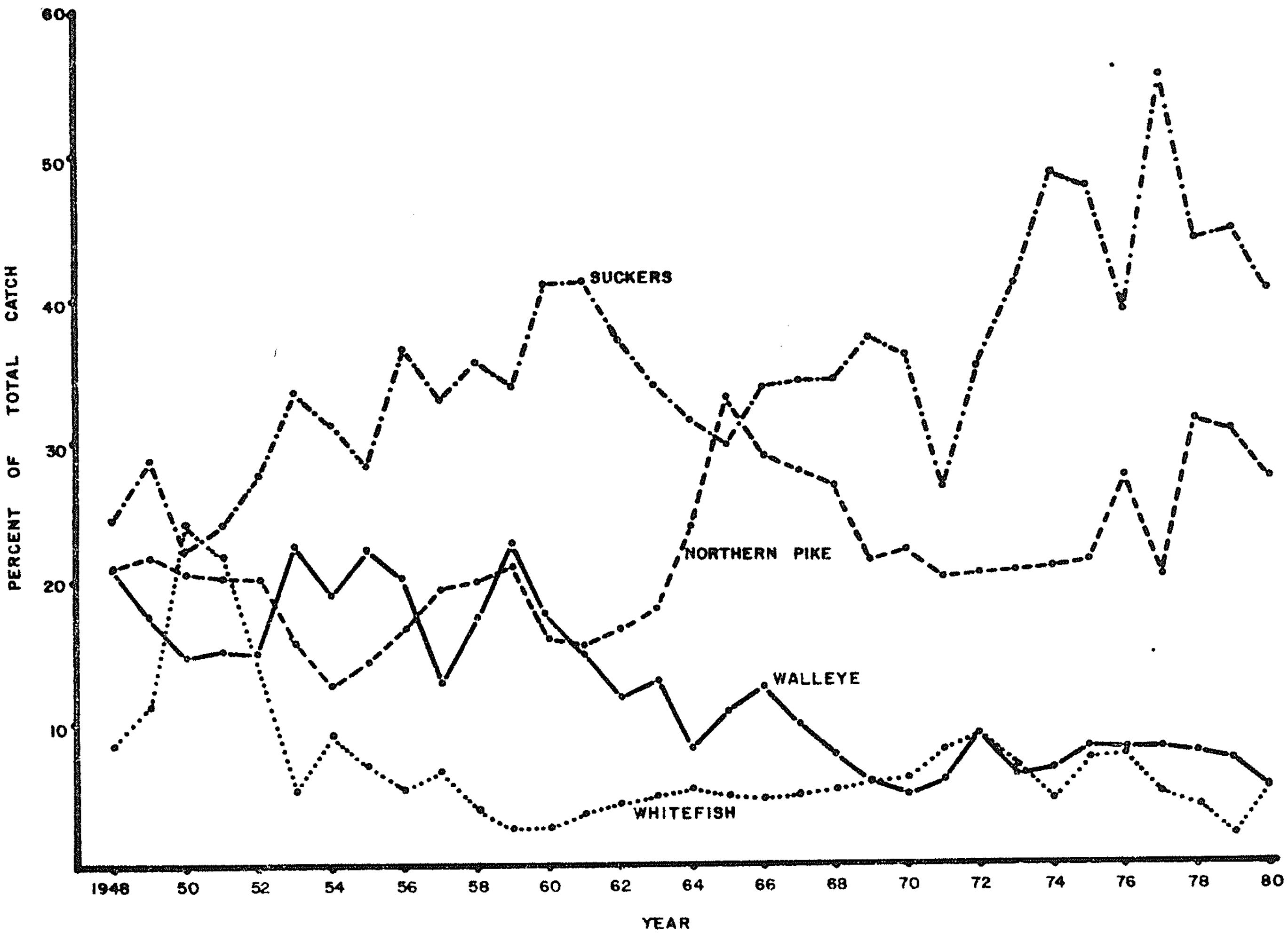


Fig. 4.13. Species biomass composition as a percentage of total commercial harvest in the North Arm of Rainy Lake, 1948-80.

from 43,608 kg between 1948-63 to 36,684 kg between 1964-80 (Fig. 4.10.).

The South Arm demonstrates the same general trend as the North Arm except in the composition of the commercial catch (Fig. 4.12.). This may, in part, be due to the large effort for whitefish. Regardless, the commercial CUE reflects an increase that appears to be inversely related to the walleye catch. For the period 1948-63, the northern pike CUE averaged 30.0 kg/1,000 m of gill net but had increased to an eight year average of 36.3 kg/1,000 m between 1964-71. After two years of no fishing, harvest has again been on a regular basis since 1974, demonstrating an average CUE of 41.9 kg/ 1,000 m for the last six years (Fig. 4.11). Total basin production can also be divided into three periods. The average annual production between 1948-63 was 13,891 kg and increased to 16,849 kg for the period 1964-71. Production had decreased to 4,719 kg, the seven year average annual yield between 1974-80 (Fig. 4.10). The recent decrease in annual production has probably been influenced by the 50 percent reduction in overall effort.

4.1.3 Whitefish

Whitefish are the only cold water fish of commercial importance harvested from Rainy Lake. The tagging studies from the late 1950's indicate that there are three isolated populations discrete to each basin. Total lake harvest has fluctuated from a 1951 high of 70,573 kg to a low of 9,714 kg in 1965. Since then, harvest has been steadily increasing to reach a 1978 high of 36,489 kg. The North Arm had the largest contribution to total lake catch between 1948-56, with the South Arm consistently being the strongest contributor between 1972-80. Redgut Bay was initially well below the North Arm production, but since its reopening in 1976, the yield has almost equalled that of the North Arm (Fig. 4.14).

The commercial whitefish CUE has demonstrated widely fluctuating values over time. Between 1948-56, the average North Arm CUE was 261.1 kg/1,000 m of net, and has decreased to the ten year averge from 1970-79 of 33.7 kg. The South Arm has been more stable with an average CUE value of 110.3 kg for the period 1948-56 to the last ten year average of 88.8 kg/1,000 m of net. Redgut Bay commercial whitefish CUE had been typically below that of the North Arm from 1948-56 at a level of 59.1 kg/1,000 m net. However, after the fishery was inactive for three years and reopened in 1976, the average CUE has increased to 43.6 kg/ 1,000 m of net, surpassing the North Arm CUE value (Fig. 4.15).

The importance of whitefish in the South Arm commercial catch has increased dramatically since the fishery was closed for northern pike and walleye in 1972. Before the closure, whitefish contributed approximately ten percent of the South Arm harvest, increasing to 42 percent after 1972. As a percentage of the North Arm harvest, whitefish have presently dropped to a 20 year low of only 2.5 percent (Fig. 4.16). Coupled with the decrease in the North Arm CUE, it appears

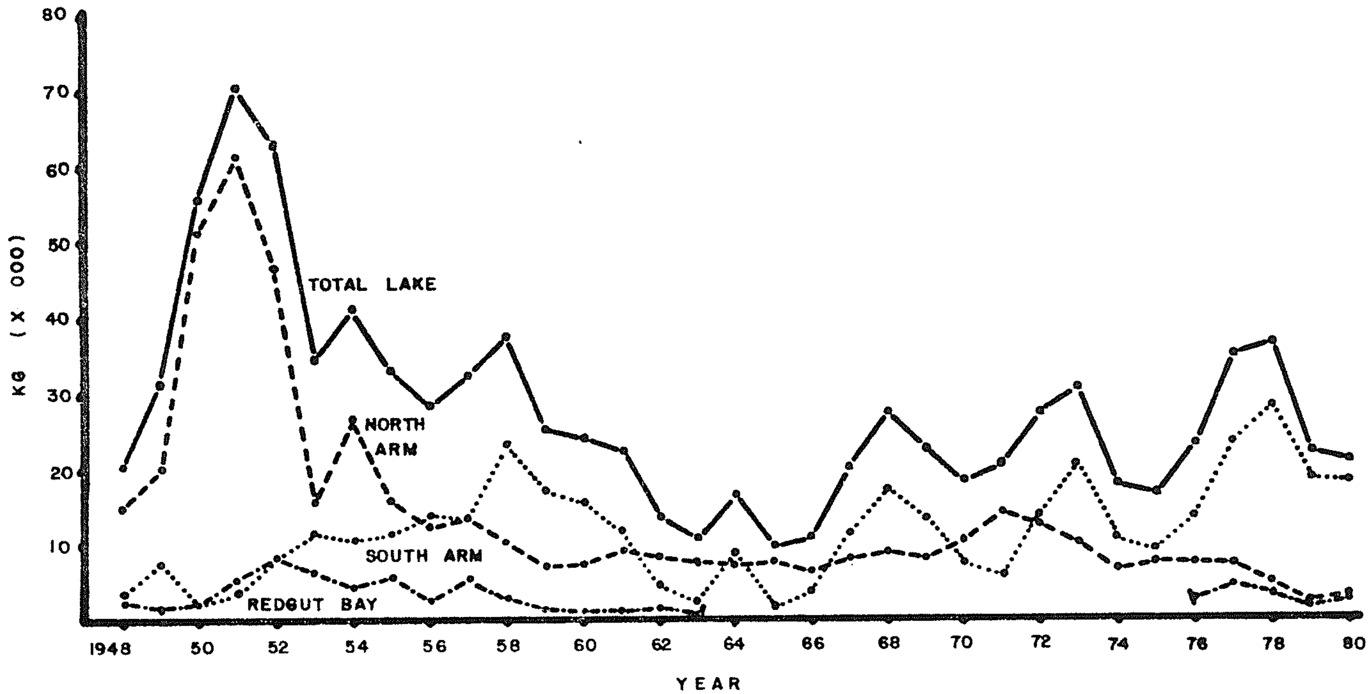


Fig. 4.14. Commercial whitefish yield by basins composing Rainy Lake, 1948-80.

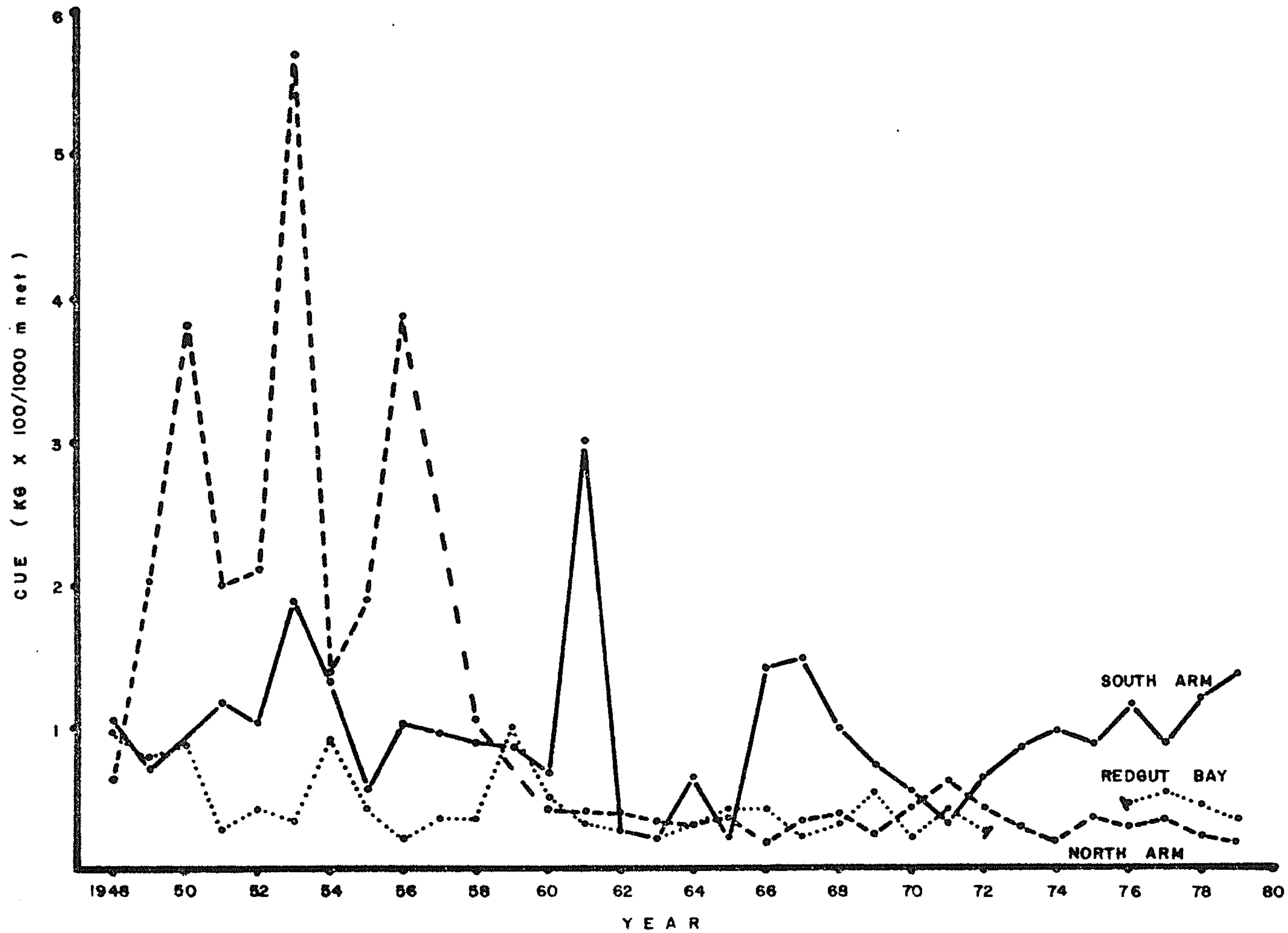


Fig. 4.15. Commercial whitefish CUE (kg/1,000 m net) for basins composing Rainy Lake 1948-79.

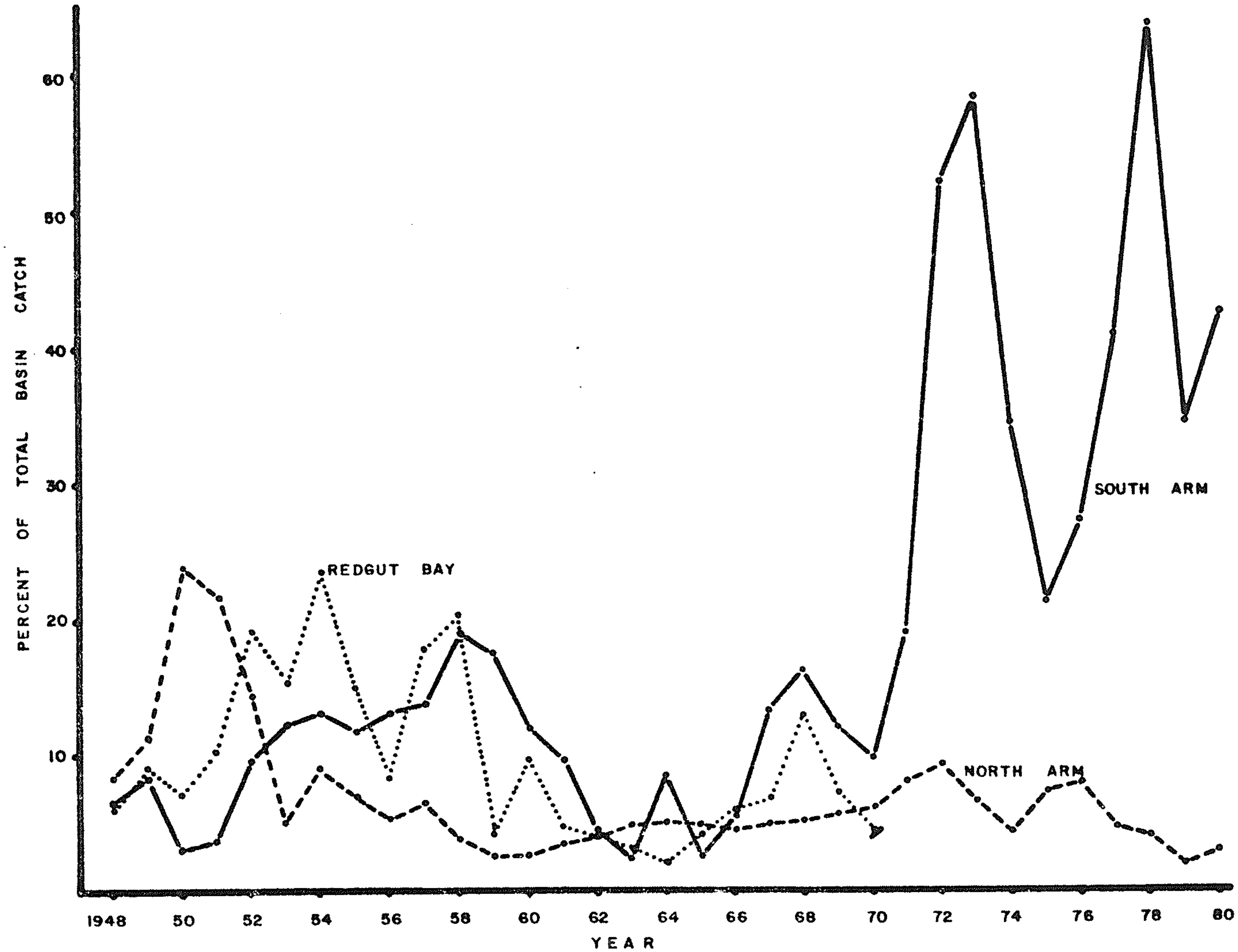


Fig. 4.16. Whitefish biomass as a percentage of total commercial harvest from the basins composing Rainy Lake, 1948-80.

that the whitefish population should be closely scrutinized to determine if overexploitation is contributing to the apparent depressed stock.

4.1.4 Black Crappie

Crappie had been introduced to Rainy Lake sometime before 1921 and are harvested primarily by means of trap nets. Prior to 1967, their contribution to the total commercial yield was consistently below 3,000 kg until 1968 when it appears that the population began to expand rapidly. A historical maximum production of 35,637 kg was produced from the North Arm in 1971. Production decreased rapidly, so that by 1975 harvest totaled only 125 kg, but has been rising at a steady rate since (Fig. 4.17). The initial increase in crappie closely parallels the decline in walleye production, and peak crappie catch occurred in a year when both walleye and northern pike populations appeared to be low.

The rapid decline in crappie production was suspected to be a result of overexploitation, so quotas have been introduced for the 1981 fishing season. Redgut Bay and the North Arm are the only two areas that demonstrate significant production, so fishing areas RL-5 of the North Arm has a quota of 2,268 kg (5,000 lb) and Redgut Bay (under licence for RL-13) has a quota of 2,722 kg (6,000 lb). The 1981 total quota for crappie is 4,990 kg (11,000 lb) for these two areas with the remaining fishing grounds unrestricted by quotas (Fig. 4.2).

4.1.5 Suckers

Total sucker production in both the North and South Arms has decreased over time. The 15 year average annual yield

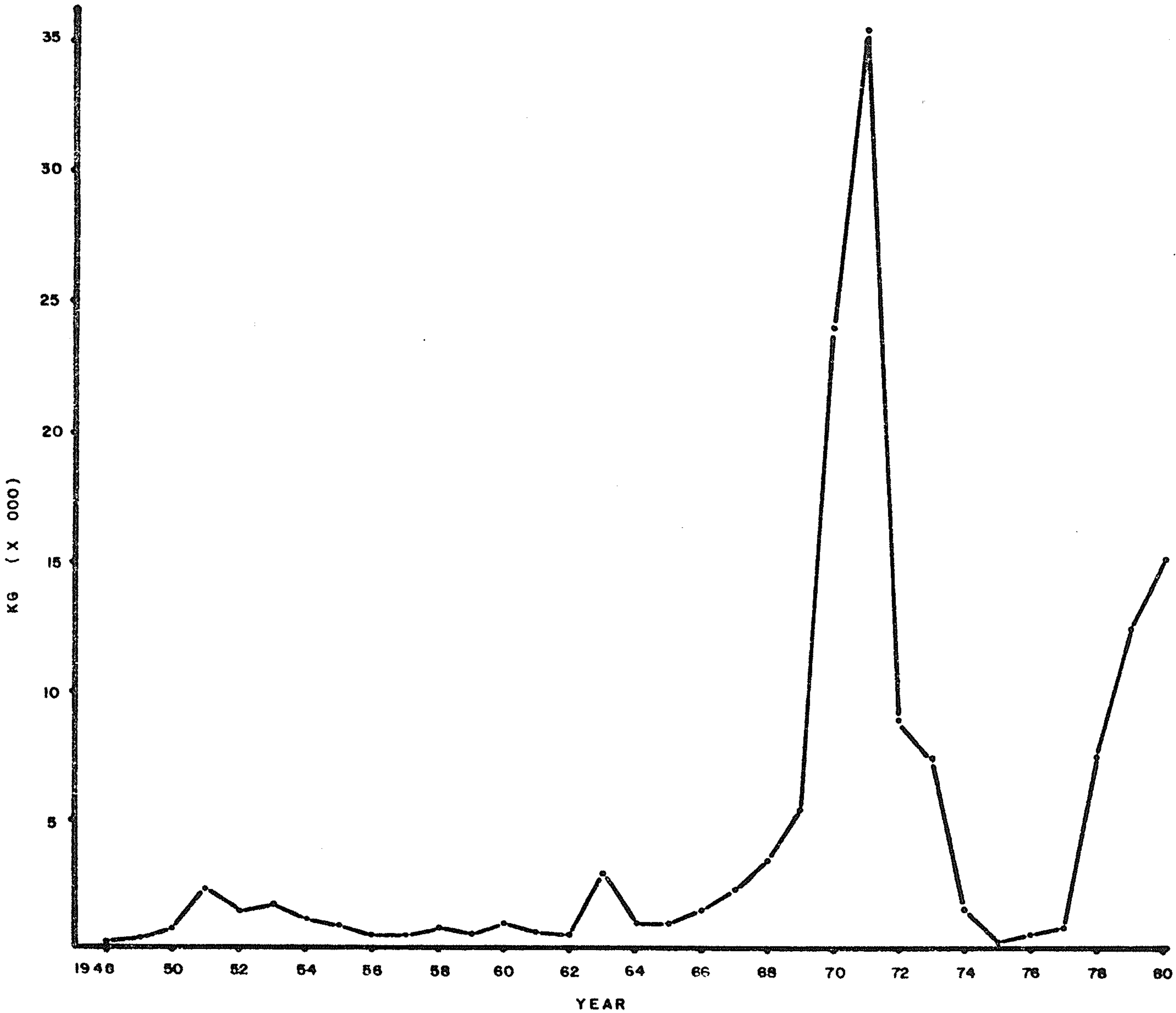


Fig. 4.17. Commercial black crappie yield from Rainy Lake, 1948-80.

from the North Arm between 1948-62 was 79,733 kg decreasing to the average annual yield of 53,471 kg from 1963-80. The South Arm has also demonstrated a decrease from an 18,933 kg average between 1948-70 to 9,053 kg for the last ten years (Fig. 4.18). However, decreased production may be due to a decrease in overall effort, and not because of a depressed population. Sucker populations may be considered to be expanding relative to the other species by demonstrating an increase in commercial sucker CUE and their percentage of total basin catch. The North Arm commercial CUE has increased from an average annual value of 49.3 kg between 1948-68 to 68.1 kg/1,000 m of net for the period 1969-79. Similarly, the South Arm CUE averaged an annual value of 39.2 kg/1,000 m between 1948-70 and after the two years without fishing has averaged 103.8 kg over the last six years (Fig. 4.19). Along with the increasing CUE, suckers constitute a larger percentage of the total North Arm harvest. Between 1948-68, they averaged 32.1 percent of the catch, increasing to 41.3 percent of the annual harvest for the last 12 years. The South Arm demonstrates widely fluctuating values in the last ten years, but an overall increase in the percentage of suckers in the commercial catch does not appear to have occurred (Fig. 4.20). To some degree, the increased sucker harvest reported by commercial fishermen may be influenced by the subsidy of \$0.18/kg (\$0.08/lb) for rough fish.

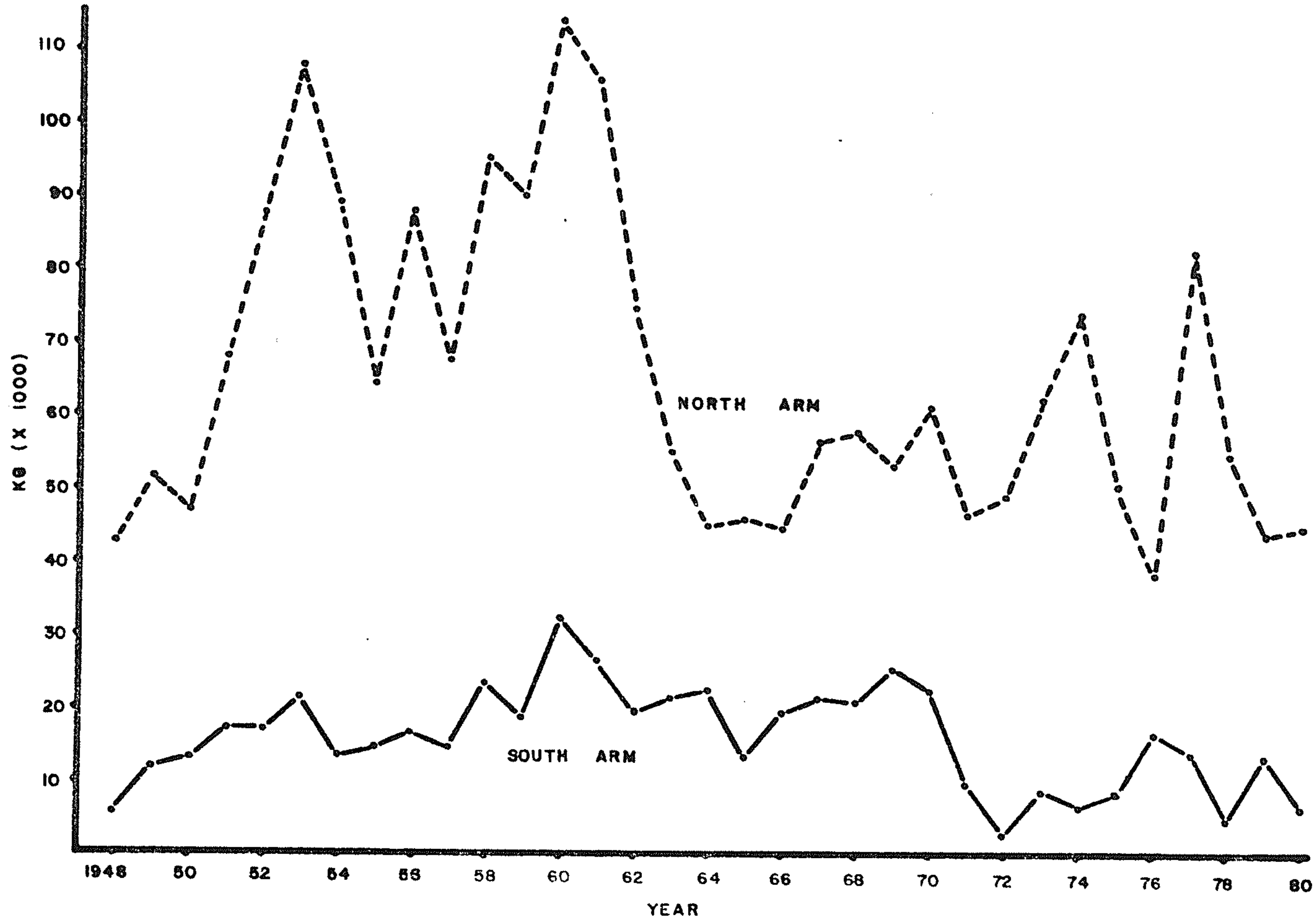


Fig. 4.18. Commercial sucker yield from the North and South Arms of Rainy Lake, 1948-80.

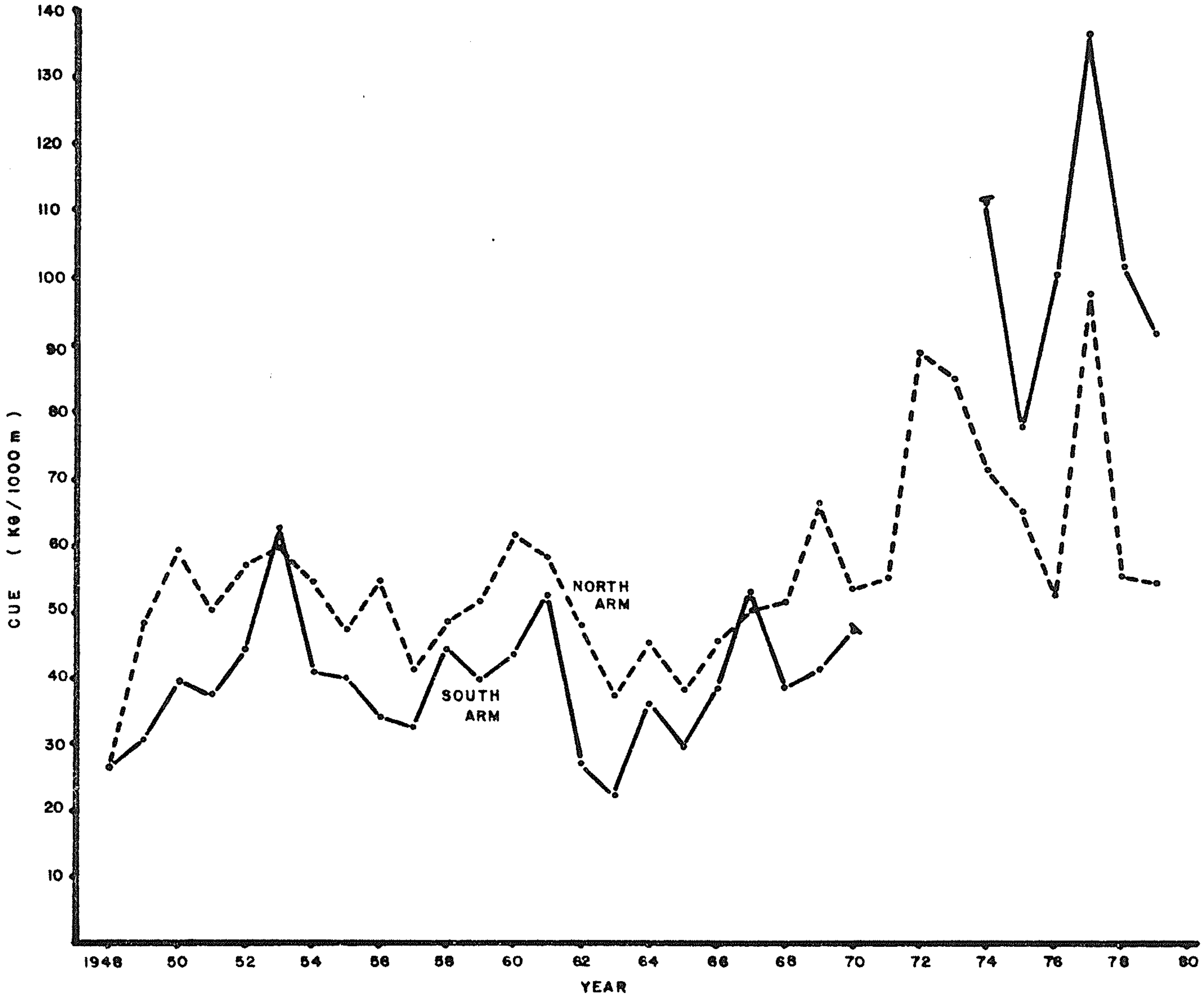


Fig. 4.19. Commercial sucker CUE (kg/1,000 m net) for the North and South Arms of Rainy Lake, 1948-79.

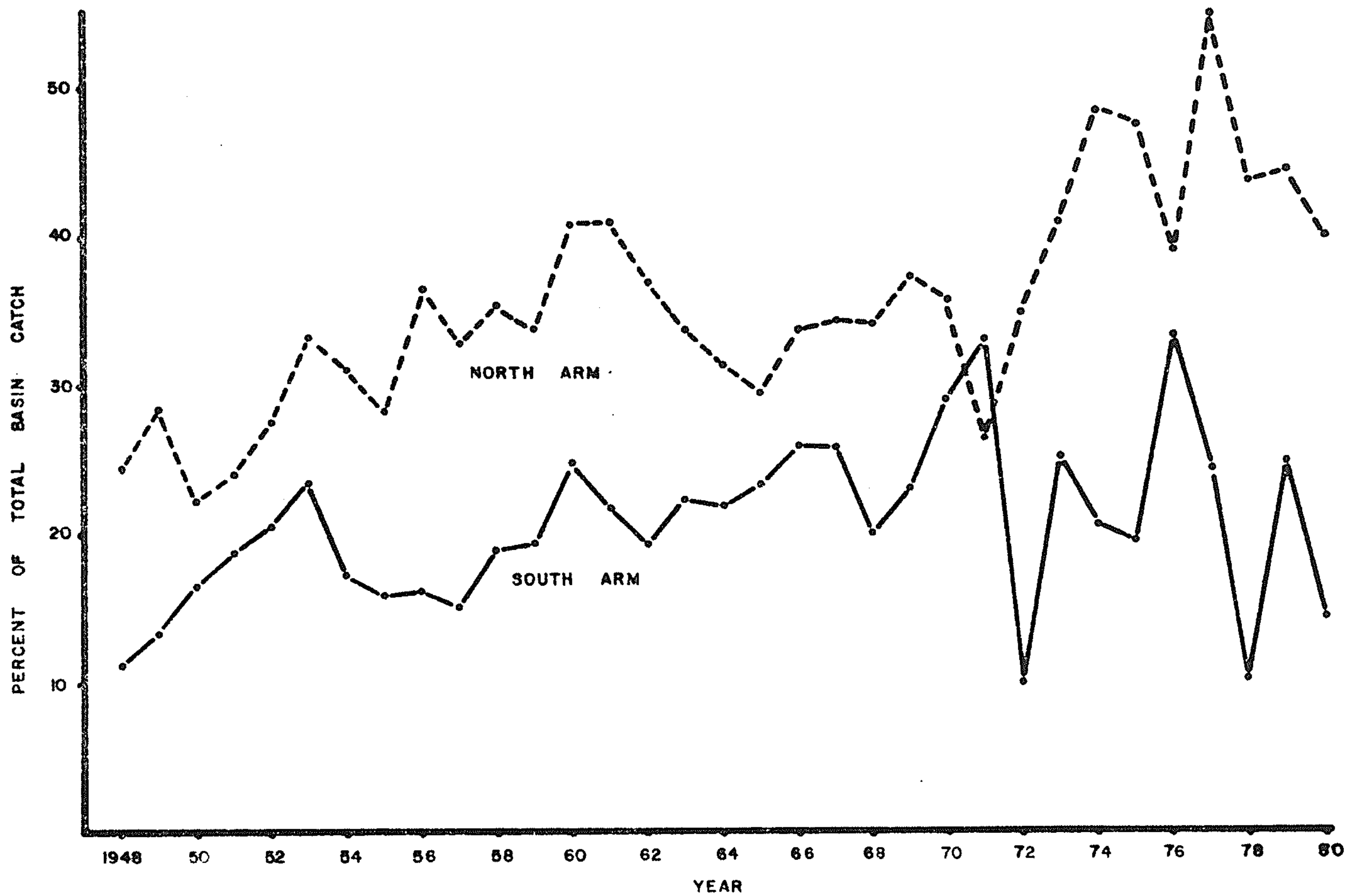


Fig. 4.20. Sucker biomass as a percentage of total commercial harvest from the North and South Arms of Rainy Lake, 1948-80.

4.1.6 Employment

The Rainy Lake commercial fisheries presently employs 13 individuals native to the local area. Of the 13, eight hold the licences for the ten fishing areas and five are employed as crewmen. Six licence holders depend entirely on fishing as a source of employment and may supplement their annual income through government transfer payments in the off season. Two of these six fishermen engage in some type of winter fishing, but the majority of harvest is taken in the open water summer fishery between May and October. Two individuals supplement their annual income through winter trapping.

The open water summer fishery has been estimated to be of 150 days duration and supports 1,950 man days or 7.8 man years of employment annually (assuming 250 days=1 man year). The winter fishery is approximately 90 days and employs 360 man days, or 1.4 man years. The total Rainy Lake commercial fishery can therefore be considered to offer 2,310 man-days or 9.2 man-years of employment annually. No employment can be attributed to processing Rainy Lake fish caught by commercial fishermen. All fish caught are either sold locally to restaurants or the fish distributor in International Falls, Minnesota. Consequently, the actual processing of these fish does not create any secondary employment opportunities for Ontario residents.

4.1.7 Gross Landed Value

Fish harvested from Rainy Lake by commercial operations are exported directly to the United States market, with a small amount sold to local Fort Frances, Ontario, restaurants. However, this domestic sale is limited and is considered insignificant. The 1980 gross revenues generated by the sale of commercial fish production from Rainy Lake and sold to the United States is presented in Table 4.1. Walleye continue to provide the best economic return, despite low production. Crappie provided the next best return followed by whitefish and northern pike. Sale of these four species constitute 93.5 percent of the total revenue generated by the commercial fishery. Suckers, rock bass and perch made up the remaining revenue by contributing $9,918.29 in total. The gross landed value of the Rainy Lake commercial fisheries production in 1980 was $151,543.54 (Table 4.1).

Table 4.1. Gross landed value of the Rainy Lake commercial fisheries production, 1980. Price per pound is the average price paid to fishermen between May and October. All values in Canadian currency.

Species	$/kg	Total kg	Value Can $
Walleye	2.98	13,628	40,611.44
Crappie	2.43	15,189	36,909.27
Whitefish	1.43	23,656	33,828.08
Northern Pike	0.94	32,209	30,276.46
Suckers	0.22	44,707	9,835.54
Rock Bass	0.55	150	82.50
Perch	0.55	0.45	.25
		129,539	151,543.54

4.1.8 Commercial Fishing Costs

The commercial fishing industry on Rainy Lake certainly has inherent costs associated with fishing activities, unfortunately, no estimates are available. For this reason, costs to the commercial skiff fisheries of Western Canada have been applied to the Rainy Lake skiff fishery to provide some sensitivity to what the net revenues might be. The analysis is not intended to be a precise reflection of the industry's performance, but to illustrate the data required for this type of analysis.

Total Rainy Lake commercial production has been divided equally among the ten licenses in operation during the 1980 fishing season to give an average production of 12,954 kg per license. Thompson (1981) has established the costs associated with different production categories from the Western Canada region, assuming costs are related to the volume of fish caught. Costs experienced by the 11,340 - 13,600 kg (25,000-30,000 lb) production interval from Western Canada have been applied to the Rainy Lake fisheries. Two types of costs have been considered; variable and fixed costs (Table 4.2).

4.1.8.1 Variable Costs

Variable costs vary in some direct proportion to the amount of fishing activity. Six main variable costs have been identified (Table 4.2).

(1) Fuel. Fuel costs include gasoline, oil and grease purchases. Assuming fuel costs are similar between all ten

Table 4.2. Costs and net revenue calculation for the Rainy Lake commercial skiff fishery, 1980. Costs for one licence have been multiplied by a factor of 10 to provide an estimate for the entire industry.

	One Licence[a]	Rainy Lake Industry
Variable Costs		
Fuel	$ 900.00	$ 9,000.00
Repairs	37.00	370.00
Provisions[b]	275.00[b]	2,750.00[b]
Labour		51,480.00
Supplies	271.00	2,710.00
Miscellaneous	361.00	3,610.00
		61,820.00
Fixed Costs		
Licenses	40.00	400.00
Overhauls	686.00	6,860.00
Semi-variable	117.00	1,170.00
Interest	158.00	1,580.00
Depreciation	1,103.00	11,030.00
		21,040.00
Capital		
Skiffs	2,392.00	23,920.00
Motors	1,911.00	19,110.00
Nets	1,659.00	16,590.00
Other	1,332.00	13,320.00
		72,940.00
Total Costs (Variable & Fixed)		82,860.00
Gross Landed Value of Production		151,544.00
Net Revenue		68,684.00

a) Geometric mean for a one license production category of 11,340 - 13,600 kg (25,000 - 30,000 lb) from the Western Canada Region (Thompson 1981).

b) Arithmetic mean for a one license fishery from Gimli, Manitoba, 1976. (Thompson 1981; pers. comm.).

fishing areas, total fuel expenditures by the Rainy Lake commercial fisheries are estimated at $9,000.00 per season.

(2) Repairs. Maintenance and repair costs are of an on going nature and are relatively minor. These include engine tune-ups, replacement parts such as propellers and maintaining vessels. The costs to the Rainy Lake fishery are $370.00 per year.

(3) Provisions. Food costs are applicable when operators and crews are required to spend extended time on the lake during fishing operations. Rainy Lake fishermen do not usually incur excessive provision costs as most activity is based from a home location on the lake. For this reason, costs for food and other provisions by the fisherman from Gimli, Manitoba, on Lake Winnipeg, have been applied to the Rainy Lake fishery. This fishery reflects similar conditions experienced on Rainy Lake so these annual costs are approximately $2,750.00 (Thompson pers. comm.).

(4) Labour. As with other cost categories, data on returns to labour are not available. Often a fisherman's wages will consist of a residual payment after all other costs have been covered, or a percentage of the landed value of production. In the absence of complete information it is necessary to estimate a proxy value for labour. For the purpose of this study, a proxy value based on the Ontario minimum wage rate ($3.30/hour) has been used to impute labour costs for self-employed fisherman and their crew members. This method

provides crew members with an estimated annual income of $19, 800.00 and $31,680.00 for the eight license holders, indicating a total return to labour of $51,480.00.

(5) Supplies. These costs cover a large range of items necessary for fishing operations such as rope, knives and net repair equipment. The yearly costs imposed on the Rainy Lake commercial fisheries amount to an estimated value of $2,710.00.

(6) Miscellaneous. The most common cost in this category is for ice, but includes other expenditures that do not normally fit into the cost categories. The Rainy Lake industry has an approximate miscellaneous cost of $3,610.00 annually.

4.1.8.2. Fixed costs

Fixed costs do not vary with the level of fishing activity and are relatively constant throughout the season. Five fixed cost categories have been applied to the Rainy Lake industry as estimated for the skiff fisheries in western Canada (Table 4.2) (Thompson 1981).

(1) Licenses. Annual license fees of $40.00 per licence are required to conduct fishing operations on Rainy Lake. The ten active licenses during the 1980 fishing season incurred a total cost of $400.00.

(2) Overhauls. Overhaul costs do not tend to be of a reocurring nature and do not usually vary directly in proportion to the level of fishing activity. These costs

include both engine overhauls and boat repairs that have an estimated value of $6,860.00 per year for the entire industry.

(3) Semi-variable. Semi-variable costs include such items as payroll taxes, rental costs, UIC payments and insurance. These costs approximate $1,170 for the Rainy Lake fisheries.

(4) Interest. Interest expenses reflect the financial charges for equipment purchases and borrowed working capital. They have an estimated value of $1,580.00 annually for the commercial fishing industry.

(5) Depreciation. The last fixed cost is the depreciation expense. This is an accounting practice which reflects an annual cost attributable to the fisherman's assets. Depreciation estimated in Table 4.2 is for the replacement value of the industry's capital equipment, amounting to $11,030 annually.

4.1.9 Net Revenue

The short run economic performance of the Rainy Lake commercial fishery will be assessed through net revenue calculations. Net revenue is the difference between the 1980 gross landed value of production and the combined variable and fixed costs of this production level. It is a measure of the net proceeds earned by the industry after operating expenses have been met. Positive net revenue values indicate the industry is in a healthy position, whereas a negative value may indicate that the industry is in an unstable financial position.

The net revenue generated by the Rainy Lake commercial skiff fishery after the 1980 fishing season had a value of $68,684.00 (Table 4.2). The net revenue per license is therefore, $6,868.00. However, these revenues are not evenly distributed among the participants. Two individuals hold two licenses and some licensees do not employ crewmen. In addition, area quotas impose restrictions that limit the amount and type of species harvested. For example, area RL-5 of the North Arm has a crappie quota of 2,268 kg and 1,134 kg of northern pike, in comparison to RL-13 which has a walleye quota of 4,536 kg, no quota restrictions for northern pike and a crappie quota of 2,722 kg from Redgut Bay. For this reason, the commercial fishing industry will be treated as an aggregate unit.

4.1.10 Cash Flow

The preceding section may be regarded as an annual "snap shot" picture of the industry, whereas an evaluation of the long run economic viability of the industry may be desirable. Economically viable industries are defined as those industries that can earn profits commensurate with investments in labour and capital (Thompson 1980). This is commonly evaluated by cash flow analysis. The return to labour has been calculated by applying the Ontario minimum wage to time spent fishing, so the analysis is primarily concerned with estimating the returns to capital.

For the purposes of this analysis, the cash flow is defined as the net revenue generated by the industry plus depreciation and interest expenses (Cauvin and Thompson 1977). This type of analysis considers long term industry performance potential in an attempt to assist in proposed investment decisions. The estimated annual cash flow is projected over the investment period and the discounted sum of future revenues is the present value of future earnings. The present value may then be compared with the cost of initial investment to determine if the investment will be profitable.

The annual cash flow of the commercial skiff fishery on Rainy Lake for 1980 has been projected over a ten year period (Table 4.3). Some assumptions have been incorporated that require clarification. First, it is assumed that the level of harvest experienced in 1980 will remain unchanged over the time period. This would allow for the second assumption of constant costs and revenues so that the 1980 cash flow value may be projected over the ten years. This is an abstraction from reality in light of the fact that all things cannot be held constant, however, for purposes of comparison with the tourist lodge industry, the exercise illustrates deflated dollars. In this regard, a discount rate of 10 percent, reflecting a real, as opposed to nominal, interest rate is employed. Finally, the investment period is of ten years duration, which is the assumed life span of the equipment.

Table 4.3. Present value of cash flow for the Rainy Lake commercial fishing industry.

Year	Cash Flow	P.W.F.[a] 10%	Present Value
1	$81,294.00	.9091	$73,904.00
2	81,294.00	.8264	67,181.00
3	81,294.00	.7513	61,076.00
4	81,294.00	.6830	55,524.00
5	81,294.00	.6209	50,475.00
6	81,294.00	.5645	45,890.00
7	81,294.00	.5132	41,720.00
8	81,294.00	.4665	37,924.00
9	81,294.00	.4241	34,477.00
10	81,294.00	.3855	31,339.00
Present Value		$499,511.00	
Capital Investments[b]		$ 72,940.00	
Net Present Value		$426,571.00	

a Present worth factor
b From Table 4.2

The present value of the projected cash flow for the Rainy Lake commercial skiff fishery has been calculated to be $499,511.00 for the next ten years (Table 4.3). This is the value of production the industry can expect to generate as a going concern under the conditions of the 1980 season. The net present value is what remains after capital investments have been made. The cost of the capital assets required to operate the commercial skiff fishery are approximately $72,940.00 (Table 4.2). The net present value is the residual cash flow after all other factors of production have received a return, which includes operating costs, returns to labour and capital. Returns to labour have been assumed to equal renumeration at the Ontario minimum wage rate and returns to capital are assumed to be at a rate of 10 percent. The net present value is, therefore, the amount remaining to pay wages over and above minimum wage plus supply a return to the resource. The return to the resource, as defined in Chapter II, is the potential value of the rent available. In the example of the Rainy Lake commercial fishing industry, the net present value is $426,571.00, which is the amount that the license holders are capable of paying in the form of a rent over the next ten years. This rent is presently captured entirely by the industry participants.

4.2 Recreational Fishery

The Rainy Lake sports fishery has been traditionally supported by the walleye and northern pike, but also offers crappie, smallmouth bass, sauger, muskellunge, yellow perch and mooneye. The region attracts anglers from great distances, with the area from Rainy Lake to Lake of the Woods being recognized as having considerable potential for tourist trade since the turn of the century (IJC 1917). The impact of the developing sports fishery on fish stocks did not receive much attention until an obvious decline in densities became apparent. The Ministry of Natural Resources conducted the first angler creel surveys from 1956-62 (then the Department of Lands and Forests) to give some indication of angling success and compare this success with that of other sports fisheries. A common complaint during this period was of small walleye size, not abundance (Bonde et al. 1961). Creel census data are usually expressed as the number of fish caught per man- hour spent fishing, and as such does not facilitate estimates of harvested biomass. The sports fishery impact on Rainy Lake fish stocks will be analyzed through the available creel survey data. Because the walleye have consistently been the target species of angling activities, this species has again attracted the most intensive data collection efforts.

Survey results should be viewed as trends rather than exact indices of fishing success or stock abundance. The large surface area and irregularity of the lake impose a problem for complete and accurate surveys. Variations in sampling dates, percentage of total angling man-hours sampled, location of survey and survey techniques show considerable variation from year to year, so comparative analysis should be approached with caution.

Creel data had been collected annually between 1956-62 for all sections of the lake with the exception of 1957. Surveys have not been performed on an annual basis since then. However, a definite decline in walleye angling success is evident with the lowest success rates experienced during the most recent periods in the North and South Arms (Table 4.4). This closely parallels a similar decline in commercial catch. Despite the declining walleye catch rate, it is still

Table 4.4. Rainy Lake angling success rates. Values are numbers of fish caught per man-hour spent fishing. Data from OMNR surveys.

	North Arm			South Arm			Redgut Bay		
	Walleye	N.Pike	SMBass	Walleye	N.Pike	SMBass	Walleye	N.Pike	SMBass
1956	1.21			.31			.78		
1958	.59			.26			.69		
1959	.51			.41			.58		
1960	.43			.42			.85		
1961	.13			.27			.44		
1962	.28			.40			.66		
1964	.21			.60			.56		
1965	.48[a]			.42[a]			.37[a]		
1969	.16			.50			.53		
1970	.13	.15	.04	.45	.09	.03	.58	.04	.004
1977			.02[b]	.29[b]	.27[b]	.03[b]	.16[b]	.11[b]	
1978	.11[b]	.26[b]		.22[b]	.17[b]		.34[c]	.06	.01
1979	.02								

a Minnesota data from Johnson et al. (1966).
b Minnesota data from Ernst and Osborn (1980).
c Mean value from OMNR survey and Ernst and Osborn (1980).

the most preferred species, particularly by the local residents (McGregor 1970). The clientele of the Rainy Lake tourist lodges also favour walleye as well as the non-residents fishing Canadian waters from United States access points (Ernst and Osborn 1980).

4.2.1 Walleye Harvest

The most severe drop in walleye angling success has occurred in the North Arm where success decreased from 1.21 fish per man-hour of fishing in 1956 to 0.02 walleye per man-hour in 1979. Fishing success in Redgut Bay, although exhibiting a decline over the years, appears to be the highest in the lake. The South Arm also demonstrates a decline, but has remained above the North Arm harvest (Table 4.4).

Estimates of total harvest are difficult to generate because of the uncontrolled access experienced on such a large lake. However, it is widely believed that anglers harvest at least the same proportion of walleye as the commercial fishery (Johnson et al. 1966; Chevalier 1977). Evidence that this estimate is near correct is found from the tagging program performed between 1957-63. Of the 4,167 fish tagged, 48 percent of the returned tags were recaptured by anglers (Caldwell n.d.). These tagged walleye were from spawning populations where 80 percent of the individuals were of age class V or older (Bonde et al. 1961). Creel surveys have established that the majority of angler catch (69 percent) is of age class III or IV (McGregor 1970). If anglers recaptured almost half of the tagged fish that were five years old or older, and 69 percent of the angler creel is of age three and four fish, then it would appear that the angler harvest exceeds the commercial catch.

A recent sports fishing summary for the Voyageurs National Park (Ernst and Osborn 1980) provides some indication of angling pressures on Rainy Lake during the two years of 1977-78. The study estimates that an average of 11,065 kg of walleye are landed at access points within the United

States from fishing locations within Ontario. This group of anglers represents 48 percent of the total angling pressure experienced in the Canadian waters of Rainy Lake (see Section 4.2.4). In this regard, the estimated angler harvest of walleye is 23,052 kg annually. Commercial harvest has averaged 13,701 kg over the last five years, suggesting that 63 percent of the total walleye harvest is taken by the recreational fishery. The last available estimate of total angler harvest is from the 1970 creel survey by McGregor (1970), where 16,550 kg were believed to have been removed.

The harvest of walleye by the recreational fishery has been rapidly increasing. The percentage return of mature tagged walleyes almost tripled from 7.0 percent in 1958 to 20.4 percent in 1963. An extraordinarily high catch rate occurred in 1962 when 33.2 percent of the fish tagged in Northwest Bay of the North Arm were caught. As harvest increased, the walleye catch rate dropped from 0.59 fish per man-hour in 1958 to 0.21 fish per man-hour in 1964 (Table 4.4). The walleye catch rate in Black Bay, in the United States portion of Rainy Lake, demonstrated a decrease from 0.32 fish per man-hour for the opening two weeks (May 15-31) to 0.08 fish per man-hour for the remainder of the summer. To some degree, this decrease may have been a result of fish redistribution, but the summer test netting results suggested that the sports fishery removed a substantial portion of the available stock. The heavy early season harvest is probably a major factor contributing to the low summer catch rate and depletion of the Black Bay spawning stock (Johnson et al. 1966).

The heaviest angler harvest is traditionally the first few weeks of the angling season. The Northwest Bay harvest mentioned above, and the Stanjikoming Bay harvest, both of the North Arm, experience the heaviest angling pressures during this period. Recaptures of spawning fish from the tagging program indicate identical trends as those for Black Bay. The mature population eventually redistributes throughout the basin, but not before a substantial portion of the brood stock is removed by anglers in, or near, the spawning areas.

4.2.2 Northern Pike Harvest

The northern pike is also a selected species by Rainy Lake anglers, although most catches are incidental while fishing for walleye or smallmouth bass. For this reason, the number of fish caught per man-hour fishing is a conservative estimate, and it does not reflect the success rate of those individuals fishing for northern pike (Table 4.4). Total angler harvest must again use the study from Voyageurs National Park (Ernst and Osborn 1980). They estimate that an average of 10,136 kg of northern pike are landed at United States access points from Canadian waters of Rainy Lake. This represents 48 percent of the angler days in Ontario, giving an estimated total harvest of 21,117 kg. No other estimates are available for comparison.

4.2.3 Smallmouth Bass Harvest

Using the same procedure as for walleye and northern pike, the smallmouth bass harvest from the Ontario portion of Rainy Lake is estimated to be 3,363 kg annually. This fishery is still developing, and may be a response to the decreasing walleye catch, particularly in the North Arm.

4.2.4 Residency of Anglers and Fishing Pressure

Angler residency can be divided into two categories; local residents and non-residents. Local resident is self-explanatory, but the non-resident sector can be further divided into the contributors and non-contributors. Contributors are those individuals who utilize the services of the tourist lodges, therefore, making expenditures in Ontario. The non-contributors are those individuals who, aside from purchasing an Ontario non-resident angling license, make no other expenditure in Ontario. Non-residents have consistently contributed over 80 percent of the angling pressure on Rainy Lake. Redgut Bay is the most heavily fished area by Americans, who represented 92 percent of the anglers in 1969, 88.9 percent in 1970 (McGregor 1970) and 80.5 percent in 1978. The South Arm experienced 85 percent of the man-hours spent fishing by Americans and the North Arm 79.8 percent in 1970 (McGregor 1970). The predominance of Americans fishing Canadian waters is because Rainy Lake is a boundary water with 25 percent of its surface area in Minnesota. In addition, 98 percent of the people staying at lodges on Rainy

Lake are from the United States.

Ernst and Osborn (1980) have estimated that 59.3 percent of the visitors to the Voyageurs National Park using the Rainy Lake access points fish in Canada. Additional access to Rainy Lake exists between International Falls, Minnesota and Black Bay (Fig. 4.21). Applying this figure to the angling pressure observed in Ontario waters suggests that a minimum of 48 percent of the total man-hours spent fishing is by individuals using United States access. This portion of the total fishermen are classified as non-contributors. The contributing sector of non-residents, staying at one of the lodges in Ontario (Fig. 4.22), apply approximately 32 percent of the total angling pressure and local residents supply the remaining 20 percent. A winter ice fishery also exists, but no estimates are available for man-hours spent fishing or harvest rates.

The total number of man-hours spent sports fishing on the Ontario portion of Rainy Lake is estimated to be 312,488 annually. This figure was generated by the estimated 149,994 man-hours contributed by the non-contributing sector (Ernst and Osborn 1980). No estimates are available for the man-hours spent fishing in Canadian waters from access points between International Falls, Minnesota, and Black Bay. Lake access from this area is freely available, suggesting that the estimated non-contributing angler pressure in Ontario waters of Rainy Lake is conservative. These estimates are also three years old, and because angling activities have

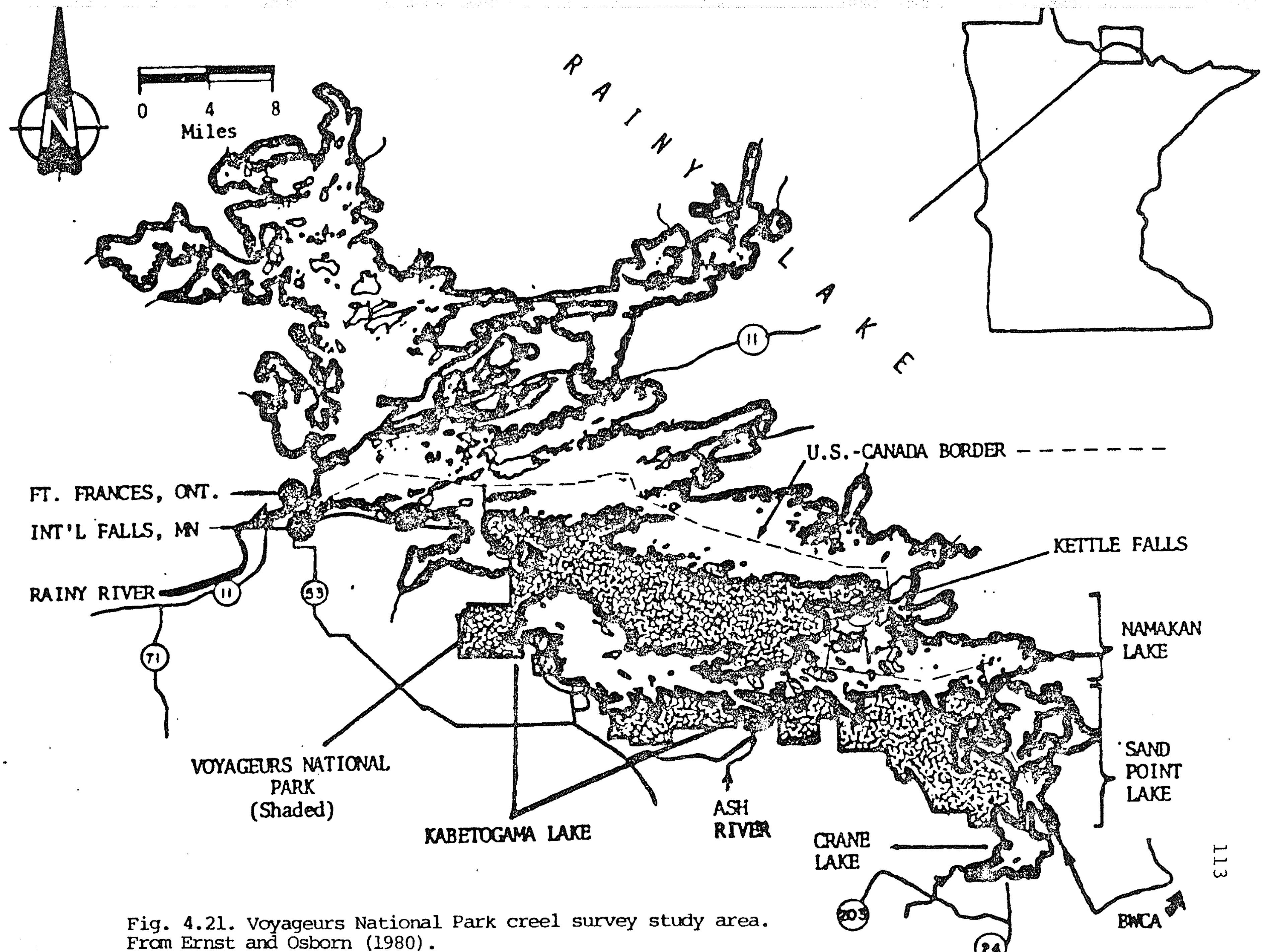


Fig. 4.21. Voyageurs National Park creel survey study area. From Ernst and Osborn (1980).

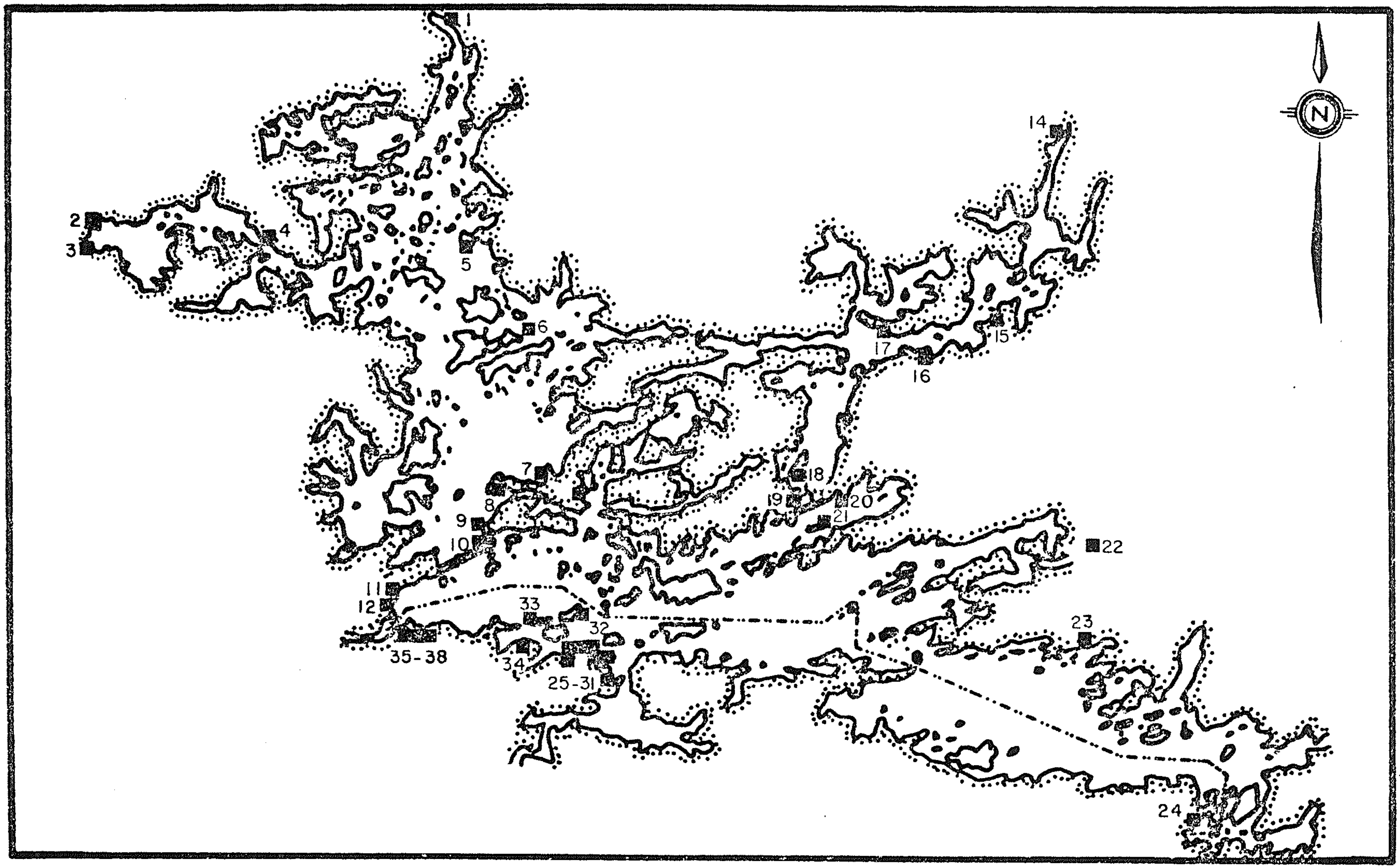


Fig. 4.22. Tourist lodge establishments on Rainy Lake,1980.

been increasing, they may be underestimating actual pressures. The development of Voyageurs National Park may also increase time spent fishing in the Ontario portion of Rainy Lake by park visitors.

4.2.5 Tourist Lodge Industry

Benefits to Ontario residents as a result of the Rainy Lake recreational fishery are difficult to establish. Some local residents offer guiding services to non-resident anglers, but the number of man-hours actually employed by these activities is not available. In addition, economic activity in the town of Fort Frances can be attributed to sports fishing on Rainy Lake, but this is also difficult to determine because this local town services a large area encompassing several tourist areas where angling occurs. In light of these deficiencies, the tourist lodge industry has been selected as a partial sample of economic activities generated by the Rainy Lake sports fishery.

A questionnaire survey of all active tourist lodges based on the Ontario portion of Rainy Lake was attempted to establish the contribution of this industry to the local economy (see Appendix B). A total of 17 lodges were contacted by mail and the response received forms the basis for the following discussion. Only seven (41 percent) of the 17 lodges returned the questionnaire. One respondent provided comments only, choosing not to answer any of the questions. The remaining six answered the questions at their discretion, with some questions being answered by only three respondents.

Individual lodge facilities demonstrate considerable variation, so assuming a cross section representing the industry from the six responses may be presumptuous, but the following discussions will specify survey results.

4.2.5.1 Employment

Tourist lodge operations provide seasonal employment from May to October. Four of the six lodges answering the questionnaire employ a total of 16 persons full time, at an average of 48.3 hours per week for 19 weeks. This does not include the owners or any of their family. For the six camps, a total of 7.3 man-years of full time employment (250 days/man-year) may be credited to these operations. If the 35 percent response is applied to the entire Rainy Lake industry, 21.0 man-years of full time employment are generated. The part time staff employed by these six camps were seven people, who worked an average of 46.5 hours per week for 8.5 weeks. This amounts to 1.4 man-years of part time staff employment. If this is representative of the industry, 4.0 man-years of part time employment are provided. In addition, the camp owners are involved in running the camp, so that 17 camps generate 8.5 man-years of employment for the six months of operation. From this analysis, an estimated 33.5 man-years of employment may be attributed to the Rainy Lake industry.

All staff, both full and part time, are local Ontario residents, with five of the seven part time staff being native Indians. These figures should not be applied to the entire industry because hiring practices are the preference of camp owners and may vary between years depending on the availability of labour. As with the commercial fishery, the seasonal nature of the tourist industry may allow individuals to supplement incomes through alternative employment during the winter.

4.2.5.2 Gross Revenues

Gross revenues to the tourist association represent the expenditures made by anglers for the services rendered by tourist lodges. All six questionnaire respondents supplied estimates of their gross revenues for the 1980 season. The estimates provided ranged between $18,000.00 - $180,000.00. Total revenues of the six lodges was $435,000.00. Assuming the 35 percent response can be applied to the entire industry, gross revenues would approximate $1,243,000.00. This estimate compares favorably with a 1977 estimate of $1,173,000.00 for lodges in the Rainy River District (Ruston/Shanahn and Associates Ltd. et al. 1979).

4.2.5.3 Lodge Operating Costs

Considerable variation occurs among the tourist lodges on Rainy Lake in the type of facilities offered and the size of operation, so the industry will be treated as an aggregate unit. This will also allow for a comparison with the commercial fishing industry. Annual operating costs have been represented as a percentage of gross revenues for the entire industry in northwestern Ontario by Ruston/Shanahn and Associates Ltd. et al. (1979), and these are applied to the Rainy Lake industry (Table 4.5). Costs can again be broken down into variable and fixed costs. Only the variable cost of labour will be discussed.

Table 4.5. Costs and net revenue calculation for the Rainy Lake tourist lodge industry, 1980.

	% of Gross Revenues[a]	
Variable Costs		
Supplies and goods sold	24.4	$303,292.00
Labour	24.1	
Staff	19.6	243,628.00
Owners	4.5	56,100.00
Utilities	5.2	64,636.00
Repairs	3.9	48,477.00
Advertising	3.0	37,290.00
		753,423.00
Fixed Costs		
Equipment and Miscellaneous	3.2	39,776.00
Insurance	2.4	29,832.00
Property and Business Tax	1.5	18,645.00
		88,253.00
Total Costs (Variable and Fixed)	$841,676.00	
Gross Revenue	$1,243,000.00	
Net Revenue	$401,324.00	

a From Ruston/Shanahn and Associates Ltd. et al. (1979)

Wage income to Ontario residents attributable to the sport fishing have been estimated by applying 19.6 percent of gross revenues to this cost ($243,628.00) plus a proxy value for the return to the camp owners labour ($56,100.00). This proxy value has been calculated by applying the Ontario minimum wage to the six months of operation (125 days x 8 hours x $3.30/hour x 17 camps). The total return to labour is estimated at $299,728.00 annually (Table 4.5).

4.2.5.4 Net Revenue

The short-run economic performance of the Rainy Lake tourist lodge industry can be assessed through net revenue calculations. Subtracting the total cost estimate of $841,676.00 from the $1,243,000.00 of gross revenues gives a net revenue calculation of $401,324.00 annually. This value may be divided equally between the 17 lodges to yield a net revenue of $23,607.00 per lodge. It must again be stressed that this value is likely not evenly distributed among the lodges because of the variation in facilities. However, the net revenue is positive, suggesting the tourist industry is in a short term position of being able to meet all operating expenses.

4.2.5.5 Cash Flow

Net revenue calculations are again only a short term indicator of economic viability, whereas an analysis of cash flow will demonstrate the long term viability of the industry. The returns to labour have already been determined from the net revenue calculations, so the remaining returns to capital will be demonstrated by the cash flow analysis. The annual cash flow of $401,324.00 has been projected over the next ten year period and the discounted present value of these revenues has been compared with the estimated value of capital investments (Table 4.6). Again, some assumptions have been incorporated into the analysis. First, constant costs and revenues have been assumed to allow the projection of the 1980 cash flow over the ten year period. Second, the investment period is assumed to equal ten years, allowing a comparison of present values with the commercial fishing industry.

Table 4.6. Present value of the cash flow for the Rainy Lake tourist lodge industry.

Year	Cash Flow	P.W.F.[a] (10%)	Present Value
1	$401,324.00	.9091	$364,844.00
2	401,324.00	.8264	331,654.00
3	401,324.00	.7513	301,515.00
4	401,324.00	.6830	274,104.00
5	401,324.00	.6209	249,182.00
6	401,324.00	.5645	226,547.00
7	401,324.00	.5132	205,959.00
8	401,324.00	.4665	187,218.00
9	401,324.00	.4241	170,202.00
10	401,324.00	.3855	154,710.00
Present Value	$2,465,935.00		
Capital Investment	$2,777,800.00		
Net Present Value	$(311,865.00)		

a Present Worth Factor

The projected cash flow has been discounted at an annual interest rate of 10 percent to provide a present value of cash flow in 1980. The projected cash flows have a 1980 present value of $2,465,935.00 for the tourist industry on Rainy Lake under the conditions experienced in 1980 (Table 4.6). This is the present value of future earnings that the industry can expect to receive. At this point, it is noticeable that the tourist industry has the potential to generate a present value of $2,465,935.00 whereas the commercial fishing industry of only $499,511.00. If the comparative evaluation were to conclude at this point, then the present value of tourist operations would appear to far outweigh the present value of the commercial fishery. This result may prompt a tendency to favour the tourist industry over the commercial fishery during allocation deliberations. Such a conclusion would be incorrect because a complete analysis has not been performed, which could lead to misallocation of the resource.

To complete the analysis, capital investments necessary to conduct the business of tourist lodges must be considered. The net present value for the tourist industry indicates the value of the residual cash flow after all factors of production have received a return. Returns to labour have already been considered by the variable costs during net revenue calculations. The return to invested capital is therefore the concern of the cash flow analysis in Table 4.6.

The average replacement value of lodges within the Rainy River District has been calculated to be $163,400.00 per lodge (Ruston/Shanahn and Associates Ltd. et al. 1979). The 17 lodges forming the Rainy Lake industry would therefore have a total market value of $2,777,800.00. If this is considered the value of the capital investments necessary for the industry, then the net present value of the industry after ten years of operation is minus $311,865.00, indicating that the capital is not receiving a 10 percent return. This has some implications that should be pursued.

The long standing argument in commercial fisheries that open access policies will result in the expansion of fishing effort until the point is reached where all potential rents are dissipated seems to have some application to the Rainy Lake tourist industry. Because the net present value of production is negative, it implies that overcapitalization or overinvestment has occurred so that no potential rents are available. It is possible that the net present value of the tourist industry could be increased by reducing the number of establishments and, therefore, increasing the occupancy rates of those remaining lodges. The resulting net present value would probably indicate a higher return to invested capital plus a positive value for the rent.

A positive value for a potential rent to the tourist industry must exist theoretically. The industry has developed by depending indirectly on the fisheries resources in that no fish means no fishing clientele. It would appear that the common property nature of the resource has again resulted in the expansion of investments as long as some profits are available, until all rents are dissipated among the lodge owners. The Rainy Lake commercial fisheries do not demonstrate this same condition because free entry is no longer possible, but tourist lodge entrepreneurs face no access constraints. Free access and the common property nature of the resource appears to be having the same impact on the tourist lodge industry as once feared for the commercial industry.

4.3 Domestic Fishery

Domestic fishermen are native people living on one of the seven reservations adjacent to Rainy Lake (Fig. 4.23). Under Treaty 3, these people have no legal rights to the fish resource (SPOF 1978e). However, Indian people native to this area have depended on fish as a food source since before the appearance of the fist Europeans (IJC 1917). Consequently, this fishery is classified as traditional or cultural use of the resource.

Domestic harvest is difficult to establish because licenses are not required and fishing is allowed throughout the year. The preferred species is the walleye, with harvest of any other species incidental. At best, only traditionally

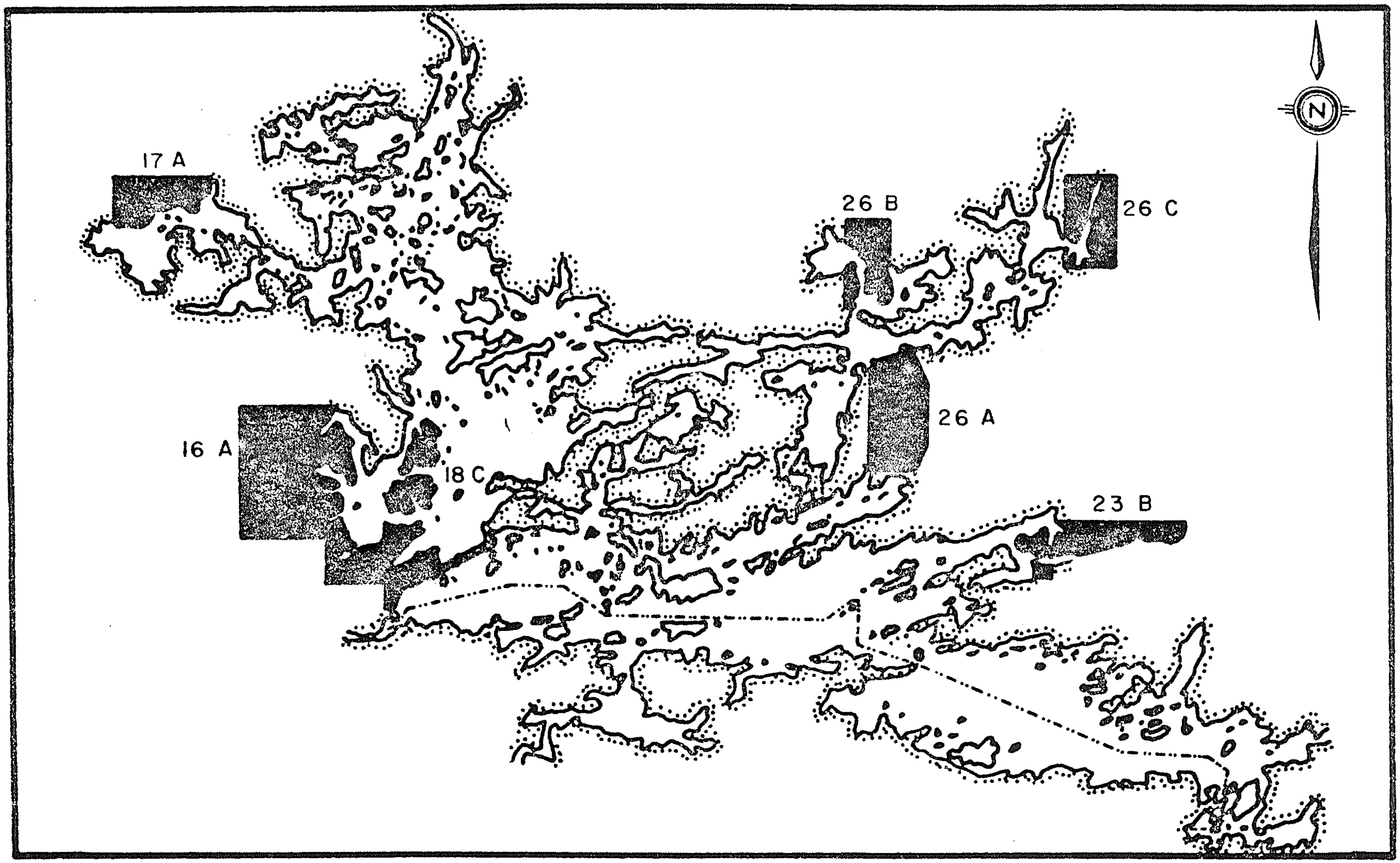


Fig. 4.23. Indian reservations bordering Rainy Lake.

fished areas adjacent to the reservations and an estimate of the total lake harvest is possible.

The area experiencing the heaviest pressures is the North Arm. Stanjikoming Bay and Northwest Bay, particularly in the spawning streams of these bays, supply the majority of domestic harvest (Fig. 4.23). These two areas combined probably account for an annual walleye harvest of 300 kg. The reservations bordering the shores of Redgut Bay supply an estimated 100 kg to the residents and the people on reservations bordering the South Arm probably remove 100 kg annually (Caldwell pers. comm.). The combined walleye harvest of the seven reservations on Rainy Lake amount to an estimated 500 kg annually. Removal of other fish species may be considered insignificant because of the incidental nature of this harvest.

4.4 Summary

The three user groups of the Rainy Lake fisheries resources include the commercial, recreational and domestic fisheries. The total harvest by these user groups has been estimated for individual species during the 1980 fishing season (Table 4.7). Commercial harvest data are the five year average annual yields between 1976-80. Recreational harvest figures rely on the most recent harvest estimates from 1977-78 by Ernst and Osborn (1980). Domestic harvest is an approximate value as this fishery is largely uncontrolled (Caldwell pers. comm.).

Table 4.7. Harvest estimates by species for the three user groups on Rainy Lake, 1980. All values in kilograms.

	Commercial	Recreational	Domestic	Total
Walleye	13,689	23,052	500	37,241
N. Pike	35,495	21,117		56,612
SM. Bass		3,363		3,363
Whitefish	28,194			28,194
Crappie	7,249	3,500		10,749
Cisco	8,876			8,876
Sucker	64,032			64,032
Ling	13,077			13,077
	170,612	51,032	500	222,144

CHAPTER V

SUMMARY AND ALLOCATION

5.1 Allocation Guidelines

The procedure developed by the fifth SPOF task force report for rational allocation of Ontario fisheries resources will be followed to test the applicability to Rainy Lake. Analysis of data required for allocation decisions is presented in the same order as that given in "An Allocation Procedure" of the allocation policy report, summarized as follows (SPOF 1978 e):

"An Allocation Procedure"

"A.1. Review allocation policy (rationale).

B.1. Identify fish community and fish habitat, including general description of area.

B.2. Identify components of resource required for special maintenance or rehabilitation needs and special management or research needs.

B.3. Identify and quantify, if any, components of fish community unfit for human consumption.

B.4. Identify and quantify components of the fish community and habitat to be allocated for harvest and non-consumptive use.

C.1. Identify and quantify present benefits, cost and user groups and applicable legal rights, if any.

C.2. Establish relationship of harvest to benefits and cost occurring to residents.

D.1. Identify and quantify any competition for scarce resources and value conflicts between users.

E.1. Identify alternative uses which would eliminate the competition and reduce value conflicts.

F.1. Decide on allocation; or submit analysis, alternatives and recommendations to Minister."

Most of the data are presented in earlier chapters of the study, therefore, the reader is referred to the appropriate sections where the information was initially presented. Each of the above sections will be discussed separately, with summaries of the relevant information used for analysis.

5.1.1 Review allocation policy (rationale).

This will form the bais of discussion in Section 5.2 of Chapter V.

5.1.2 Identify fish community structure and fish habitat, including general description of area.

The physical and biological characteristics of Rainy Lake have been discussed in Chapters I and III. Rainy Lake has been divided into three independent regions based on the physical parameters of basin morphometry and water quality. Biological parameters include fish community structures which are unique to each basin and discrete sub-populations of walleye and whitefish that are restricted to the defined basins. These data strongly suggest the possibility of individual basin management.

Walleye, northern pike and smallmouth bass are the top predators in all three communities, although their representations in the community structure differ among basins. There appears to be minimal degradation of water quality, however, fluctuating spring water levels may affect reproductive success of walleye and northern pike to some degree.

5.1.3 Identify components of resource required for special maintenance or rehabiliation needs and special management or research needs.

Walleye is the only species that requires special maintenance efforts in the North Arm and Redgut Bay. Overexploitation is prevalent in both areas with symptoms of this population stress discussed in Chapter IV. Redgut Bay has not experienced the decline in abundance demonstrated in the North Arm, but at the present level of harvest, a similar deterioration would appear inevitable.

Special management or research needs includes several fish species. First, smallmouth bass population data are non-existent. This fish is present in all three basins, but its composition within individual basins is unknown. In addition, biological information regarding competition among the smallmouth bass, walleye and northern pike is needed. The specific role that the bass maintains in the community would assist in determining future community alterations. Second, northern pike are presently overharvested from the North Arm. Age and size frequency data are needed to determine acceptable harvest levels. Third, whitefish appear to be overharvested from all three basins. The North Arm has demonstrated the lowest commercial yield and CUE in history during the last three years. Redgut Bay and the South Arm commercial harvest are presently in excess of historical yield levels and sustained harvest may not be possible. Background age and size frequency data are needed for these populations. Finally, the high incidence of suckers within the North Arm community and the apparent underutilization of this species from Redgut Bay and the South Arm require investigation to determine what actions should be implemented to control their expansion.

5.1.4 Identify and quantify, if any, components of fish community unfit for human consumption.

All fish are fit for human consumption although anglers are advised to eat only occasional meals of walleye and northern pike from some areas within the South Arm due to mercury contamination. The commercial fishery was closed for the two years of 1972-73 in the South Arm, but has been reopened.

5.1.5 Identify and quantify components of the fish community and habitat to be allocated for harvest and non-consumptive use.

Allowable harvest of individual species has been determined by the MEI estimate and species composition of the commercial and test netting catch. It is assumed that the total potential yield of the separate basins is represented by the MEI estimator, and that the current use patterns are reflected by the commercial catch and test netting results which indicate the proportions of species available. No attempt has been made to quantify the magnitude of the various fish populations required to assure a perpetual annual yield, or simply, that portion of the stocks required for maintenance purposes, as total population data are not available. Rather, the MEI estimate, determined by the method previously outlined in Chapter III, has been used to determine safe harvest levels that are assumed to represent the biological surplus of the species most heavily exploited (Table 5.1).

Table 5.1. Allowable harvest of fish species from the three geographical areas of Rainy Lake, 1980. All values in kilograms.

	North Arm	South Arm[a]	Redgut Bay	Rainy Lake[a]
Walleye	9,212	12,270	4,197	25,679
N. Pike	38,092	12,885	4,529	55,506
Whitefish	4,973	28,224	1,707	34,904
Crappie	3,165	68	356	3,589
Cisco	3,165	3,681	3,178	10,024
Sucker	50,412	15,885	9,699	75,996
Ling	7,347	7,226	1,802	16,375
	116,366	80,239	25,468	222,073

[a] Ontario portion only.

5.1.6 Identify and quantify present benefits, costs, user groups and applicable legal rights, if any.

5.1.6.1 Benefits

Benefits attributable to the fisheries resources of Rainy Lake are discussed as they pertain to Ontario residents only.

(a) Employment. The commercial fisheries employed 13 men seasonally, of which eight men held the ten licenses and employed an additional five crew members. Total employment generated by the Rainy Lake commercial fishing industry during the 1980 season was 9.2 man-years. No employment is provided to Ontario residents from processing the commercial catch because all products are exported and processed in the United States.

Man-years of employment resulting from the sports fishery on Rainy Lake are not available. Many jobs in the nearby town of Fort Frances and the several marina located in the area can be attributed, in part, to this fishery. The tourist lodge industry, catering primarily to the non resident sports fishermen, offers 83 seasonal jobs for an estimated 33.5 man-years of employment.

(b) Income. A proxy value for the return to labour in the commercial fisheries has been estimated by applying the Ontario minimum wage rate to the time spent fishing, amounting to $51,480.00 annually. The tourist lodge industry supplies 19.6 percent of its gross revenue for income to staff ($243,620.00) plus a proxy value for camp owner labour ($56,100.00), based on the minimum wage rate, for an annual total of $299,728.00. These values represent only an initial bench-mark for preliminary comparative analysis of the two industries.

(c) Food. The walleye fisheries in Rainy Lake supply an estimated 9,220 meals to Ontario residents. This estimate is determined by assuming two meals per kilogram of round fish and 20 percent of the angler harvest taken by local residents. Northern pike supply approximately 8,450 meals annually when estimated in the same manner as for the walleye. Domestic harvest removes approximately 500 kg of walleye, supplying about 1,000 meals. Total meals supplied to Ontario residents from the Rainy Lake fisheries resources amount to 18,670 annually. The commercial fisheries supply few meals to Ontario residents as most fish are exported.

(d) Recreation. Ontario residents spend approximately 62,500 man-hours, or 7,800 man-days fishing on Rainy Lake between May and September. A winter ice fishery exists, but no estimate of winter user days is available.

5.1.6.2 Costs

Almost half of the sport harvest from the Canadian waters of Rainy Lake is removed by anglers who gain access from points located within the United States. These individuals make no contribution to the Ontario economy, other than purchasing an Ontario non-resident fishing license. For this reason, these anglers are referred to as non-contributors. The cost to Ontario residents for this uncontrolled access to the fish stocks is not satisfactorily demonstrated by the analysis used in this study. However, it is evident that the decline in fish stocks is having some influence on the resident sport fishery, commercial fishing industry and tourist lodge industry that depend on the fish stocks.

Costs associated with operating the commercial fisheries have been approximated by applying cost data from the Western Canadian commercial skiff fishery to the Rainy Lake industry.

Total costs have been calculated to be $82,860.00 for the 1980 fishing season (Table 4.2).

Operating costs experience by the tourist lodge industry have been expressed as a percentage of gross revenues and have an estimated value of $841,680.00 for the 1980 season (Table 4.5).

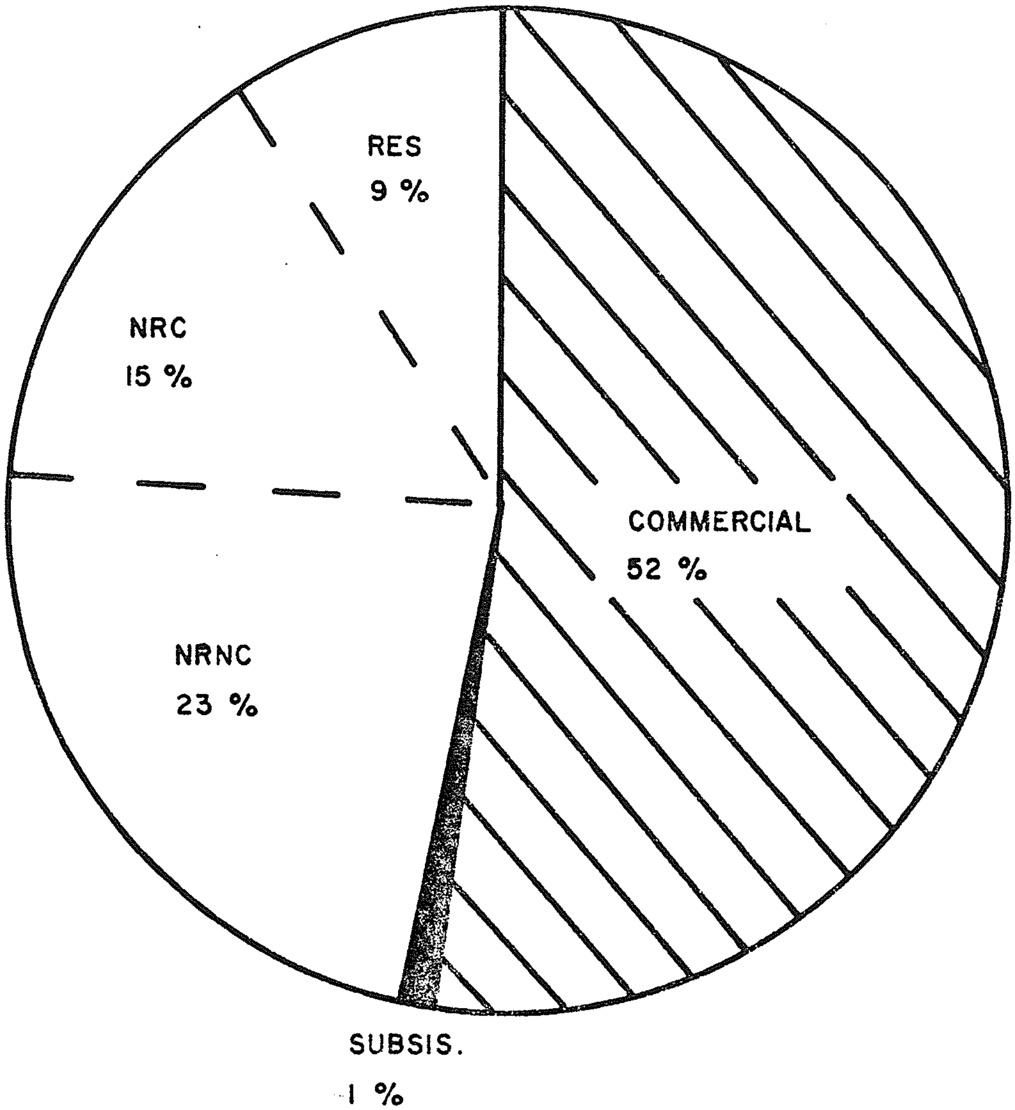
5.1.6.3 User Groups

The user groups that have been identified in Chapter IV are summarized as follows:

1. Commercial Fishermen - residents of Ontario
2. Recreational Fishermen - i) residents of Ontario
   ii) non-residents
   - extended users
     contributors
     non-contributors
   - day users
     contributors
     non-contributors
3. Domestic Fishermen - native Indians

The extended users are people whose angling trips are more than one day long, and the contributors refer to those individuals who contribute to the economy of Ontario through the purchase of goods and services. Non-contributors, under extended use, are the people who bring all supplies with them, such as campers and American based houseboats.

Walleye and northern pike, representing the top predators in each community, are the species generating the most competition among the various user groups. Figure 5.1



RES Resident
NRC Non-resident contributor
NRNC Non-resident non-contributor
SUBSIS Subsistence (Domestic)

Fig. 5.1. Distribution of top predator (walleye and northern pike) harvest among user groups of the Rainy Lake fisheries resources, 1980.

demonstrates the present harvest distribution of the top predators by the competing users.

5.1.7 Establish relationship of harvest to benefits and costs occurring to residents.

Relating harvest to benefits among user groups has been indirectly presented in previous sections, but will be summarized in this section.

The commercial fisheries presently remove 37 percent of the total walleye harvest, 63 percent of the northern pike, approximately 67 percent of the crappie and is responsible for the incidental harvest of lower trophic level fish species. This harvest provides 9.2 man-years of employment with an annual net revenue of $68,684.00 and a present value of $499,500. Economic benefits such as income and employment are the easiest to measure, however, other benefits occur to Ontario residents that are not easily discernible.

An important component of the Rainy Lake commercial fisheries has been the removal of lower trophic level species. This aspect of the industry provides benefits to the recreational fisheries as well as the commercial fishing industry itself. Sports harvest selects the top predators that removes the natural regulation of lower trophic populations. With the developing importance of the sports fisheries, vulnerability of all species to gill nets of the commercial fishery has probably delayed severe community structure alterations until now.

The biological information supplied by commercial catch records provide an important data base for establishing trends in population abundance, community structure, size and age structure of individual fish populations. This type of information is essential for management that would otherwise be costly to accumulate. In addition, cultural and traditional values are direct benefits from the commercial fishing industry.

The recreational fisheries harvest approximately 63 percent of the walleye, 37 percent of the northern pike and 33 percent of the crappie. These fisheries supply approximately 17,670 meals and 7,800 days of recreation to Ontario residents. The tourist lodge industry provide 33.5 man-years of employment with an annual income value of $299,730.00. The industry generates a net revenue of $401,324.00 annually with a present value of $2.5 million after a projected ten year period.

The domestic harvest provides an estimated 1,000 meals from 1.3 percent of the annual walleye harvest. Cultural and traditional values are also associated with this domestic use.

5.1.8 Identify and qualify any competition for scarce resources and value conflicts among users.

Competition occurs among the various users of the Rainy Lake fisheries resources for some fish species. Table 5.2 quantifies the magnitude of imbalance between potential yield and actual harvest, indicating the species experiencing overexploitation from competition among the various user groups. From the perspective of the entire lake, walleye, northern pike and crappie appear to host the greatest competition. Based on the limited angler creel surveys, recreational walleye harvest approximates 23,050 kg annually and the commercial walleye harvest is 13,690 kg. Consequently, there is competition for this species as the combined walleye harvest of 37,240 kg exceeds the MEI allowable yield of 25,680 kg by 11,565 kg. Competition for northern pike has also led to an overharvest of 1,104 kg annually and 5,332 kg for crappie. Competing user groups, however, are unique to each basin in Rainy Lake (Table 5.2).

The North Arm walleye competition is between the commercial and recreational fisheries. Total harvest is estimated to be 14,343 kg and potential production is only 9,212 kg annually, suggesting an overharvest of 5,131 kg (Table 5.2). The North Arm is presently experiencing a commercial harvest of 8,543 kg, the last five year average annual yield. The average yield over the last two years has been the lowest in history at 6,414 kg. It is of interest to note that the total quota for walleye from this area is 12,702 kg, implying that the commercial harvest is achieving

Table 5.2. MEI allowable harvest and actual harvest by individual user groups on Rainy Lake, 1980. All values in kilograms.

	MEI Allowable	Domestic	Commercial	Harvest Res[b]	Recreational[a] NRC[c]	NRNC[d]	Difference
NORTH ARM							
Walleye	9,212	300	8,543	1,100	1,760	2,640	- 5,131
N. Pike	38,092		30,696	1,900	3,050	4,570	- 2,124
Sm. Bass				300	500	750	+
Crappie	3,165		5,037	+	+	+	- 1,872+
Whitefish	4,973		4,940				33
Cisco	3,165		4,910				- 1,745
Sucker	50,412		51,602				- 1,190
Ling	7,347		7,409				- 62
SOUTH ARM[e]							
Walleye	12,270	100	5,030	1,430	2,285	3,430	- 5
N. Pike	12,885		4,257	1,725	2,760	4,140	3
Sm. Bass							+
Crappie	68		59	+	+	+	
Whitefish	28,224		20,511				7,713
Cisco	3,681		3,735				- 54
Sucker	15,885		10,878				5,007
Ling	7,226		4,935				2,291
REDGUT BAY[f]							
Walleye	4,197	100	116	2,080	3,330	5,000	- 6,429
N. Pike	4,529		542	595	950	1,425	1,017
Sm. Bass				50	80	120	+
Crappie	356		3,825				
Whitefish	1,707		2,742				- 1,035
Cisco	3,178		231				2,947
Sucker	9,699		1,552				8,147
Ling	1,802		733				1,069
RAINY LAKE[e]							
Walleye	25,679	500	13,689	4,610	7,375	11,070	-11,565
N. Pike	55,506		35,495	4,220	6,760	10,135	- 1,104
Sm. Bass				350	580	870	+
Crappie	3,589		8,921				- 5,332+
Whitefish	34,904		28,193				6,717
Cisco	10,024		8,876				1,148
Sucker	75,996		64,032				11,964
Ling	16,375		13,077				3,298

a Estimated from Ernst and Osborn (1980) except for Redgut Bay
b Residents of Ontario
c Non-resident contributors
d Non-resident non-contributors
e Ontario portion only
f Recreational harvest estimations from OMNR Creel Survey, 1978
\+ Suspected underharvest

only 50 percent of its allocated harvest. In addition, more than 100 percent of the available resource is presently allocated to the commercial fishery and 70 percent of the total allowable harvest is taken by this industry if the last two year average is used. Some adjustments would appear to be necessary.

The commercial fishery in the North Arm will require reorganization. The smaller allocation of walleye will remove some of the incentive to continue commercial operations. Judging from the apparent overharvest of nearly all species within the North Arm fish community (Table 5.2), it appears that too many licenses are issued for this area. Throughout the preceding analysis, it has never been suggested that the commercial fishing industry is operating under optimum conditions. By reducing the number of individuals presently holding licenses, the potential exists to increase the net present value of the industry. It is not the purpose of this study to identify the licenses that should be retired, but only to quantify the harvestable portion of the resource.

The North Arm also demonstrates competition between commercial and recreational fishing interests for northern pike, with an annual overharvest of 2,124 kg (Table 5.2). Northern pike available for harvest amounts to 38,092 kg and the commercial fishery has averaged 30,696 kg over the last five years, representing 81 percent of the available yield. Competition between these user groups is also evident for the available crappie harvest. However, in two organized fishing areas, commercial harvest has been restricted for the 1981 season through a 4,990 kg quota.

The remaining competition in the North Arm for scarce fish stocks is among the commercial fishery participants. Although whitefish appear to be harvested near the MEI allowable harvest level, the last three year average has been only 3,289 kg. This competition may be alleviated by quota allotment and a reduction in the number of licenses granted in this area.

The South Arm does not appear to be experiencing direct competition for scarce fish stocks at present. The commercial walleye and northern pike harvest is not competing with the recreational harvest so that overexploitation results (Table 5.2). Value conflicts, more than competition for scarce resources, may be the situation. Conflicting values can be defined as resentment by one user group towards another user group which is allowed to conduct operations within the vicinity. This type of conflict may be reinforced because the commercial fishery is presently allocated 67 percent (8,165 kg) of the walleye and 70 percent (9,072 kg) of the northern pike allowable yield through quota allotment. Should either user group increase their respective harvest levels of walleye or northern pike, competition for scarce fish stocks may follow (Table 5.2). This would appear to be a reality should commercial operations attempt to capture their present quota or the non-resident non-contributors be directed from the North Arm and Redgut Bay to the area of the South Arm.

Redgut Bay competition is primarily among anglers for the walleye. The potential walleye yield of 4,197 kg is considerably less than the combined harvest of 10,410 kg by the local residents, non-resident contributors and the non- resident non-contributors (Table 5.2). The commercial crappie fishery is also competing with the recreational harvest, but has been restricted by the 2,722 kg quota presently imposed on some commercial operations. The only other species appearing to be overharvested is whitefish (Table 5.2). Sustained whitefish yield has historically been below 2,000 kg, suggesting that the present harvest should be reduced.

5.1.9 Identify alternative uses which would eliminate the competition and reduce value conflicts.

Reducing the competition for walleye may be possible by encouraging recreational harvest of smallmouth bass. This fish is classified as a game species so commercial harvest is not allowed. Encouraging commercial harvest of underutilized species may reduce some conflicts, but at present, fishing activities are focused towards the species providing the best economic returns. This situation would appear difficult to alter as market demand would require a change. Commercial fishermen must have the necessary economic incentives to remain in operation, so the conflicts now present would appear difficult to alter in this manner.

Controlling the recreational walleye harvest from the North Arm will be difficult to achieve under present conditions. For this reason, a portion of the area set aside for rehabilitation efforts is recommended. This would include restricting the harvest from a particular area where walleye are vulnerable to angling pressures. As an initial measure, the area of Stanjikoming Bay is suggested as a potential walleye sanctuary area. The bay is traditionally subjected to extensive pressures from the recreational fishery during the opening weeks of the angling season. No commercial fishing operations are conducted in the bay and there are no tourist lodges in the vicinity. The only harvest that should be allowed is that of the domestic fishery, providing harvest can be restricted to the 300 kg required by this user group. In addition, efforts should be made to restrict the harvest by the non-contributing non-resident sector of the recreational fishery operating in the North Arm.

5.2 Allocation Deliberations

Three general priorities requiring consideration in the management of Ontario fisheries resources have been identified. First, maintenance and/or rehabilitation of the resource receives the highest priority. Second, fishing rights of Treaty Indians must be acknowledged. The third priority is to allocate the remaining resource among the various user groups through the assessment of optimum sustained benefits

(SPOF 1978 e). The report of SPOF Working Group Number Five (1978 e) established a list of priorities for the final allocation:

1. Native Subsistence (Domestic) Fishery
2. Resident Anglers
3. Non-Resident Anglers
4. Commercial Fishery

The report also noted that "Ideally, no fish should be allocated to non-contributing non-residents. Since it is virtually impossible to separate this group from the contributors, the only practical solution is to allocate whatever fish these two groups require up to the allowable harvest" (SPOF 1978 e). It is of interest to note that it has been possible to separate that group of non-contributing non-resident anglers who gain water access to fish stocks in Canada from the United States. In this regard, it is possible to exclude these anglers, assuming enforcement costs are nominal, and provide them with a residual harvest after all other uses have been satisfied. In following the established list of priorities, therefore, the following series of allocation iterations will allocate any residual harvest to the non-resident non-contributors last.

5.2.1 Allocation to Resource Maintenance

Few arguments can be presented to question the maintenance of the resource as a first priority, as this recognizes that the resource is held in trust for the residents of the Province by the Crown in right of Ontario (SPOF 1978 e). Therefore, the first responsibility is to ensure that the resource is maintained for present and future generations.

As indicated previously (Section 5.1.5), the physical quantification of fish populations in numbers or weight is beyond the current state of the art for fisheries management in Rainy Lake. For this reason, specific levels of permissible harvest have been estimated from historical yield levels and the morphoedaphic index. In this regard, historic harvest levels will be adjusted to correspond to the annual allowable harvest based on the morphoedaphic index. In the case of walleye, for example, this involves decreasing the North Arm harvest by 5,131 kg and 6,431 kg from Redgut Bay (Table 5.2). Similarily, there is a need to adjust the annual harvest of northern pike in the North Arm by 2,124 kg. Whitefish appear depressed in the North Arm and harvest levels should be reduced to 3,000 kg as the last three year annual average has been only 3,289 kg. Redgut Bay whitefish harvest is also in excess of the MEI potential yield estimate and historical sustained production levels. Table 5.2 indicates an estimated overharvest of 1,035 kg, so it is recommended that the present harvest be reduced to the MEI level. The South Arm demonstrates whitefish production in excess of historical sustained yield levels, suggesting a need to reduce harvest by establishing a quota of 20,000 kg to restrict any additional effort.

5.2.2 Allocation to Domestic Use

The second priority is to make available fish according to the requirements of people with Treaty rights or traditional needs. The native people do not have legal rights to the resource under Treaty 3, but are considered traditional or cultural users. The estimated harvest of 500 kg of walleye annually from Rainy Lake has therefore been allocated to this user group. Table 5.3 illustrates the allocation of Rainy Lake fish stocks to Treaty Indians and the surplus harvest available to the resident anglers.

Table 5.3. Domestic fisheries allocation of the Rainy Lake fisheries resources, 1981. All values in kilograms.

	MEI Allowable	Historic Harvest	Allocation (1981)	Residual Harvest Available
North Arm Walleye	9,212	300	300	8,912
South Arm[a] Walleye	12,270	100	100	12,170
Redgut Bay Walleye	4,197	100	100	4,097

[a] Ontario portion only

5.2.3 Allocation to Resident Anglers

Local resident anglers are considered to derive the greatest benefits from the Rainy Lake recreational fisheries (SPOF 1978 e). This sector contributes 20 percent of the angling pressure and the estimated historic harvest is allocated to this group. This involves a total of 4,610 kg of walleye partitioned according to the separate basins of 1,110 kg from the North Arm, 1,430 kg from the South Arm and 2,080 kg from Redgut Bay (Table 5.2). Northern pike allocated to this group includes 1,900 kg from the North Arm, 1,725 kg from the South Arm and 595 kg from Redgut Bay (Table 5.2). Allowable harvest of crappie and smallmouth bass is difficult to ascertain because of the inability to establish an MEI allowable yield. However, a small portion of the allowable yield of these species is allocated to the resident sports fisherman, although it is not quantified. Table 5.4 illustrates the second allocation iteration of Rainy Lake fish stocks to resident anglers and the surplus harvest available for the non-resident contributors.

5.2.4 Allocation to Non-Resident Contributors

The tourist lodge industry offers goods and services to the non-resident angler in pursuit of recreational fishing opportunities. In keeping with the SPOF allocation policy, the next allocation iteration allocates whatever fish non-resident contributors require up to the allowable harvest.

Table 5.4. Resident angler allocation of the Rainy Lake fisheries resources, 1981. All values in kilograms.

	Residual MEI Allowable	Historic Harvest (1977-78)	Allocation (1981)	Residual Harvest Available
North Arm				
Walleye	8,912	1,100	1,100	7,812
N. Pike	38,092	1,900	1,900	36,192
Crappie	3,165	+	+	+
Sm. Bass		300	300	+
South Arm				
Walleye	12,170	1,430	1,430	10,740
N. Pike	12,885	1,725	1,725	11,160
Crappie	68	+	+	+
Sm. Bass		+	+	+
Redgut Bay				
Walleye	4,097	2,080	2,080	2,017
N. Pike	4,529	595	595	3,934
Crappie	356	+	+	+
Sm. Bass		50	50	+

+ Unknown positive value

This volume of fish would maintain the tourist lodge industry's contribution to the local Rainy Lake economy. As in the case of all allocations, it is assumed that requirements will be based on historic harvest levels. As indicated previously, it has been possible to separate the non-resident non-contributors from contributors in the sense that harvest by non-resident anglers gaining water access to fish stocks in Canada from the United States have been estimated (Table 5.2). Maintaining the propositon that non-resident non-contributors should not be allocated fish, the following allocation in Table 5.5 is to those non-residents who gain access to fish stocks in Canada from Canadian locations. The surplus harvest available is for the commercial fishing industry.

Table 5.5. Non-resident contributor allocation of the Rainy Lake fisheries resources, 1981. All values in kilograms.

	Residual MEI Allowable	Historic Harvest (1977-78)	Allocation (1981)	Residual Harvest Available
North Arm				
Walleye	7,812	1,760	1,760	6,052
N. Pike	36,192	3,050	3,050	33,142
South Arm				
Walleye	10,740	2,285	2,285	8,455
N. Pike	11,160	2,760	2,760	8,400
Redgut Bay				
Walleye	2,017	3,330	2,017	0
N. Pike	3,934	950	950	2,984

Due to the difficulty in establishing an MEI allowable harvest level for crappie and smallmouth bass, they have not been included in Table 5.5. As for residents, non-resident angling pressure is not considered to be overharvesting these species. Until estimates become available for these fish, the present harvest levels are allocated to the non-resident contributors. Redgut Bay demonstrates the first shortfall in walleye harvest to this point. The volume of walleye allocated to the non-resident contributing anglers requires a 1,313 kg reduction to adjust the Redgut Bay harvest to the MEI allowable harvest level (Table 5.5).

5.2.5 Allocation to the Commercial Fisheries

The allocation of fish stocks to commercial fishermen, as a fourth priority, appears to reflect the perception that commercial fisheries production contributes less to the welfare of Ontario residents than the recreational use of fisheries resources. This matter will be discussed in more detail in Section 5.3. Table 5.6 illustrates the remaining harvest available to the commercial fishing industry after domestic, resident angler and non-resident contributor needs have been satisfied. Any surplus harvest available after commercial fishing allocation is for the non-resident non-contributing sector of the recreational fishery.

The first repercussion from Table 5.6 is the restricted allocation to the commercial fisheries of the North Arm. It would appear that reorganization of this fishery may be required as previously discussed in Section 5.1.8, therefore failing the goal of preventing social dislocation (SPOF 1978 e). However, it will be seen that the disbenefits of the allocation presented in Table 5.6 have been minimized by omiting any allocation of fish stocks to the non-contributing non-resident anglers.

The volume of harvest by the non-contributors would further reduce the allocation to the commercial fisheries by the amount estimated in Table 5.2. This reduction would remove more incentive to continue commercial fishing opera-

Table 5.6. Commercial fisheries allocation of the Rainy Lake fisheries resources, 1981. All values in kilograms.

	Residual MEI Allowable	Historic Harvest (1976-80)	Allocation (1981)	Residual Harvest Available
North Arm				
Walleye	6,052	8,543	6,052	0
N. Pike	33,142	30,696	30,696	2,446
Crappie		2,268[a]	2,268	
Whitefish	4,973	4,940	4,940	33
Cisco	3,165	4,910	3,165	0
Sucker	50,412	51,602	50,412	0
Ling	7,347	7,409	7,347	0
South Arm				
Walleye	8,455	5,030	5,030	3,425
N. Pike	8,400	4,257	4,257	4,143
Crappie	68	59		
Whitefish	28,224	20,511	20,511	7,713
Cisco	3,681	3,735	3,681	0
Sucker	15,885	10,878	10,878	5,007
Ling	7,226	4,935	4,935	2,291
Redgut Bay				
Walleye	0	116	0	0
N. Pike	2,984	542	542	2,442
Crappie		2,722[a]	2,722	
Whitefish	1,707	2,742	1,707	0
Cisco	3,178	231	231	2,947
Sucker	9,699	1,552	1,552	8,147
Ling	1,802	733	733	1,069

a 1981 quota

tions and lead to additional withdrawal from the industry, causing more social dislocation than what would occur under conditions of Table 5.6. This decrease in commercial fishing effort would limit the balanced harvest of all trophic levels as commercial and recreational fisheries compete for the top predators. This situation may lead to increased government programs in an attempt to maintain community composition. Another questionable aspect of restricting commercial fishing operations centers on local economic stability. Diversifying the local economic base is not permitted by such an allocation decision, and eliminating the commercial fishing industry does not seem appropriate. Finally, some measure of the trade offs among the priority schedule is necessary to determine if enhanced welfare is actually being realized, or if misallocation results. This last issue will be examined regarding recreational and commercial fishing industries in Section 5.3.

5.2.6 Allocation to Non-Resident Non-Contributors

The final allocation of Rainy Lake fish stocks is to the non-resident non-contributing anglers. These fishermen generally fish Canadian waters from ports and/or tourist facilities in the United States. In this regard, they are not considered to contribute to the economy of Ontario through expenditures on goods and services. Table 5.7 illustrates the remaining available harvest to this sector of recreational fishermen after all other user groups have received their required allocation.

As with the allocation to other sectors of the recreational fishery, an additional allocation of crappie and

Table 5.7. Non-resident non-contributor allocation of the Rainy Lake fisheries resources, 1981. All values in kilograms.

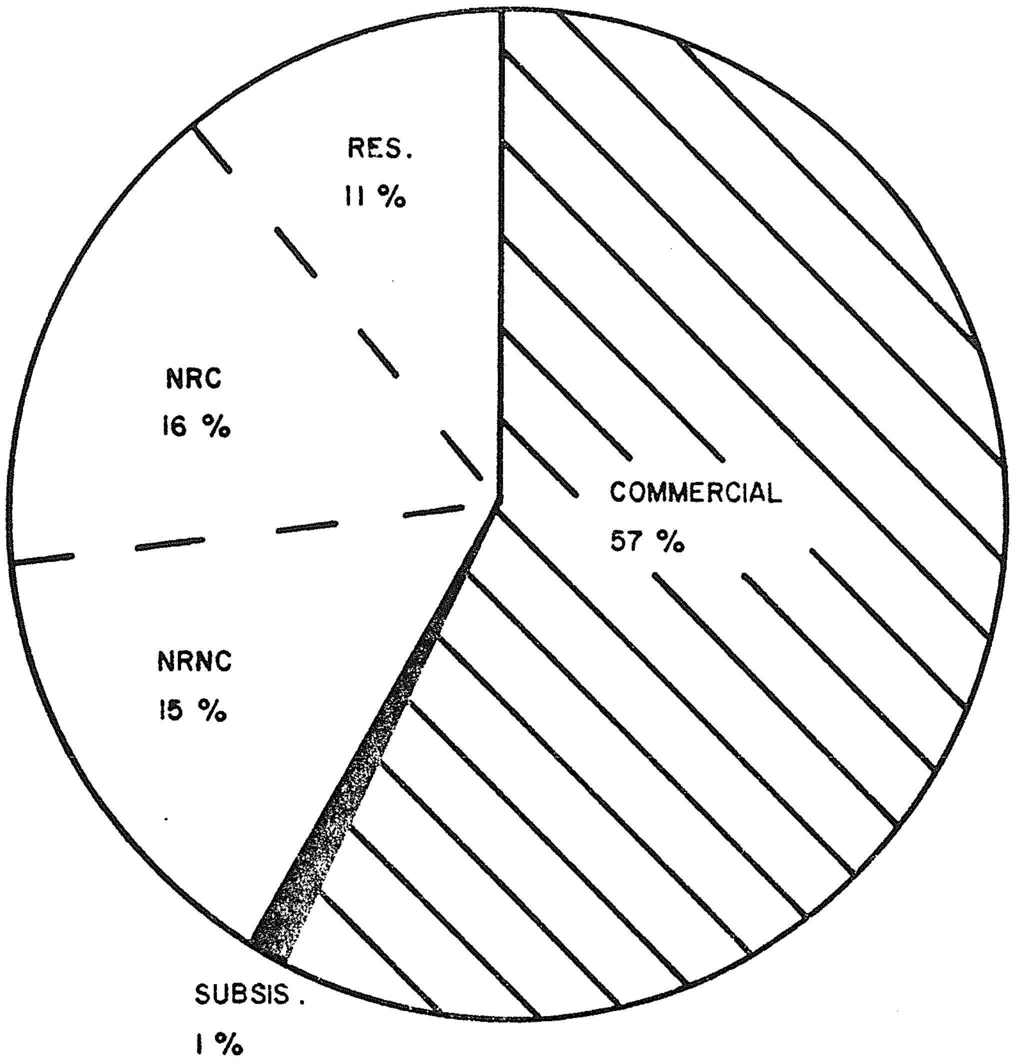
	Residual MEI Allowable	Historic Harvest (1977-78)	Allocation
North Arm			
Walleye	0	2,640	0
N. Pike	2,446	4,570	2,446
South Arm			
Walleye	3,425	3,430	3,425
N. Pike	4,143	4,140	4,143
Redgut Bay			
Walleye	0	5,000	0
N. Pike	2,442	1,425	2,442

smallmouth bass is available for the non-resident non-contributors, although not quantified. The most striking feature of Table 5.7 is that no walleye harvest is available for the fishermen in this group from the North Arm or Redgut Bay. This suggests that access to these waters should be completely restricted for non-contributors, or that retention of species other than walleye should only be permitted. Both of these bays are entirely within Ontario jurisdiction with water access restricted to narrows where check stations could be positioned, suggesting the feasibility of such a decision. However, the decision to give non-resident non-contributors the last priority will result in foregoing direct returns to the resource in license fees as a trade off to the benefits generated by Canadian tourist establishments providing goods and services to anglers. Questions concerning direct benefits versus indirect benefits will be discussed in Section 5.3.

In reference to the SPOF recommendations that "... some mechanism be developed to make contributors out of non-contributors ..." (SPOF 1978 e), it might be possible to use a differential license pricing policy to compensate for the benefits foregone as a result of non-contributors. For example, license fees to non-residents who do not gain access to Canadian waters through Canadian lodge operations could be required to pay higher license fees than those non-residents who use Canadian lodges. Further, it may be possible to use a differential license fee structure between the South Arm, North Arm and Redgut Bay to reflect the scarcity of fish stocks.

5.2.7 Summary and Conclusions

The foregoing allocation results generally follow from the SPOF (1978e) recommendation to "... achieve the best mix of benefits." In this regard, Figure 5.2 portrays the allocation of top predators resulting from the allocation deliberations of this study. Because the benefits and costs associated with generating these benefits are not clearly understood, the question arises whether the results of this



RES Resident
NRC Non-resident contributor
NRNC Non-resident non-contributor
SUBSIS Subsistence (Domestic)

Fig. 5.2. Top predator (walleye and northern pike) allocation among user groups of the Rainy Lake fisheries resources, 1981.

allocation decision achieve the best mix of benefits. This matter will be discussed in Section 5.3.

In looking at the allocation of residual fish stocks between commercial and recreational uses, it should be noted that the success of these industries are contingent on the condition of the stocks. Should the walleye be irreversibly depressed, the commercial fisheries would lose an important contribution to their annual income and tourist lodges would lose a portion of their fishing clientele, thus reducing occupancy. Consequently, direct competition between these user groups for the available supply of walleye has led to a combined harvest that exceeds the productive capacity of the Rainy Lake resource. The present situation requires allocation decisions that will reduce competition for the finite stocks. The Federal-Provincial Strategic Planning for Ontario Fisheries, Fourth Report (1976) has identified the need for a stated allocation rationale based on societal values regarding alternative uses. Some measure of societal values must therefore be presented. Comparative valuation of fisheries resources for commercial production and recreational benefits must also be considered. For commercial fisheries, the landed value of production has been used and expenditures by non-residents has been used to establish a value for the tourist industry. These valuation techniques are inconsistent, incorrect and incomplete, and may result in the misallocation of resources between these two industries.

These allegations have been dealth with in Chapter II.

5.3 Fisheries Allocation Revisited

From an economic perspective, fisheries resources should be allocated to that use or combination of uses that enhances the welfare of all Ontario residents. This perspective is not unlike the criteria stated in the Fourth Report, Federal-Provincial Strategic Planning for Ontario Fisheries (1976) which states "... that allocation of allowable yields among competing users is based on ongoing appraisal of society's values regarding use of the fisheries resource..."

Traditional wisdom appears to suggest that "societal values" of commercial and recreational use of fisheries resources may be measured by the "economic worth" of commercial and recreational enterprises. Allocation decisions based on this proposition could lead to some interesting results.

5.3.1 Commercial and Recreational Industry Values

As indicated previously (Sections 4.1.9 and 4.1.10), the annual net value of commercial production has been estimated at $68,700.00 per year. The present value of this annual income over a ten year time horizon was estimated to be $499,500.00. On the other hand, the net value of recreational lodge operations was estimated at $401,300.00 per year with a present value of $2.5 million. Based on these relative aggregate figures, it might be assumed that the recreational lodge industry generates greater benefits and should be allocated the greatest portion of the fisheries resource pie. This does not necessarily follow, however.

When the estimated capital assets required to generate the recreational and commerical benefits are deducted from the present values, the performance of the respective industries changes. The net present value of the commercial fishing industry has been estimated at $426,000.00. This sum may be regarded as a rent, a residual return to the resource after all other factors of production (labour and capital) have been paid. Despite the observation that it accrues to the industry, it may be regarded as the value of Rainy Lake fisheries resources in commercial production. In comparison, the net present value of the recreational fishing industry is minus $311,865.00, and is therefore not receiving a return to total capital asset investments or generating a rent. From this perspective, it might be argued that the value of the resource in recreational production is negative. It must be stressed that these relative values are for illustrative purposes only. Nevertheless, to the extent that they are a reflection of reality, the allocation decisions would be reversed.

5.3.2 Resource Valuation

Cauvin (1981) has suggested that the foregoing measures of value are incomplete and provide insufficient criteria to make allocation decisions. In this regard, the valuation of recreational fisheries resources based on the performance of the industry may underestimate the value of fisheries resources in recreational activities. According to Cauvin (1981), the primary value or benefit of recreational use of the fisheries may be measured by what anglers would be willing to pay for the opportunity to fish rather than forego the experience. This represents the final "demand" for recreational fisheries. Obviously, the costs of "supplying" fish for recreational use would have to be deducted to measure the net primary value. These costs would include the public costs of management.

Because resident anglers are not required to pay for the opportunity to fish and non-resident anglers are required to pay a nominal license fee, which may not reflect the willingness to pay, tangible evidence of the primary value of recreational fishing on Rainy Lake is not readily available. This situation does not enchance the fisheries manager's opportunity to make rational allocation decisions. It does not permit tangible evidence of direct or primary benefits associated with resident and non-resident anglers.

Secondary values, or benefits associated with recreational fishing can also be important. They can also be troublesome. These benefits are usually defined as being increases in incomes to factors of production (labour and capital) that provide services to the primary beneficiaries of recreational fisheries - anglers. Profits to lodges which are induced by or derived from the final demand for the opportunity to fish could be expected to fall into this category. Unfortunately, the data required for making allocation decisions is incomplete. The only perspective is of the contribution of the industry serving a fraction of the Rainy Lake recreational fishermen. A measure of the willingness to pay, therefore, whether by actually charging a price or by estimating proxy values, would be of considerable assistance in measuring the importance of resident and non-resident anglers.

Paralleling the recreational fisheries, the final demand for commercial fisheries production may be measured by what consumers are willing to pay for fisheries products. Thus, the primary value of commercial production may be measured by the market value; or the final demand, for commercial production less the costs of that production. Costs will include the industry's costs of harvesting, processing and marketing plus the public sector costs of "supplying" the resource. Public sector "supply" costs are generally ignored, however. To the extent that public costs are incurred to manage fisheries resources for commercial production, the rent may be less than suggested in Section 4.1.10.

The commercial fishery will also induce secondary benefits. For example, the demand for fishing boats is derived from the demand for fish. Thus, the increases in net incomes to factors of production building fishing boats could be included as secondary benefits. It should be stressed that secondary benefits and/or multipliers are implicit in the production of all goods and services in the Canadian economy. They are not unique to fishing based industries. Given the difficulties of estimating such second round benefits, the question arises whether we would be better off to measure primary benefits well.

To the extent that all of the required valuation data discussed above could be made available, aggregate data would still represent an insufficient basis on which to make allocation decisions. Required is a measure of the incremental trade offs between commercial and recreational uses. This is the subject of the next section.

5.3.3 Resource Allocation: An Economic Perspective

In making resouce allocation decisions, it is important to know what society will forego if one resouce use displaces another. This observation is just as true of the trade off between recreational and commercial use of fisheries resources as it is in the case of the displacement of fisheries resources by acid rain. Further, it is of interest to know whether the benefits generated by an allocation decision are sufficiently great to compensate, in principle, for the benefits foregone from an alternative use.

Theoretically, the trade offs between the recreational and commercial fishing industries can be represented by Figure 5.3. This graphic analysis can illustrate the data required for rational allocation between these industries.

The explicit assumption being that as one industry is allocated a larger portion of the resource, the present value of future earnings will increase at the expense of a decrease in the present value of the alternative industry's earnings. The combined present values can be maximized by allocating an optimum portion of the resource to each respective industry. With regards to Figure 5.3, the potential present values of the tourist and commercial fishing industries are represented by the curves PP and P_1P_1. Curve PP is the combined present value possibilities for a specific level of aggregate harvest, whereas curve P_1P_1 is the present value possibilities for a smaller aggregate harvest level. More simply, curve PP represents the present value possibilities of a larger resource pie than curve P_1P_1.

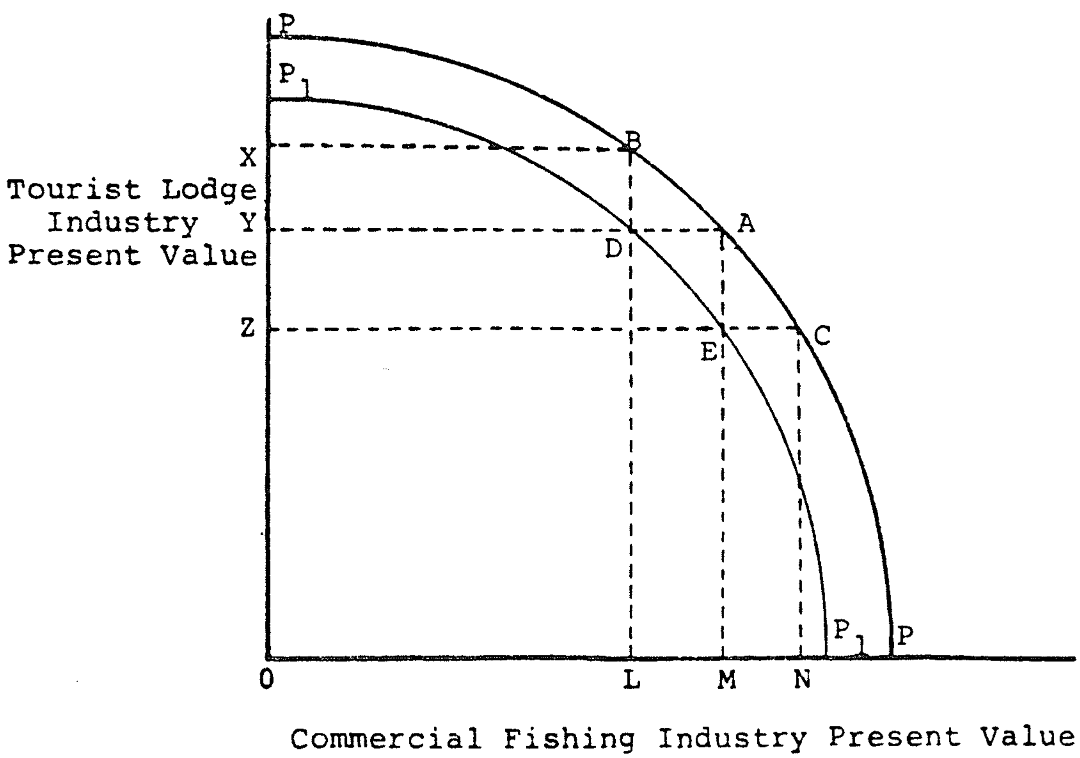


Fig. 5.3. Combined present value possibilities of the recreational and commercial fishing industries

Beginning at point A, if more of the resource is allocated to the tourist industry, the additional supply of fish would probably enable the tourist lodges to increase their occupancy rates, and therefore increase the present value of potential earnings. Because we are dealing with a finite stock, the increase in allocation to the anglers from the tourist industry will reduce the potential commercial fisheries harvest and result in a decrease in the present value of the commercial fishing industry, approaching point B. At this allocation position, the tourist industry has increased it's present value by the amount ABXY, but the present value of the commercial fishing industry has decreased by the amount ABLM (Fig. 5.3). If the combined present value of both industries at the new point B is greater than the previous combined present value at point A, then a rational allocation decision has been made. This implies that the tourist industry has gained more than what was lost by the commercial fishing industry, which would enable the gainers to compensate the losers, in principle, and still demonstrate a net gain.

Conversely, if allocation decisions shift the combined present value towards point C (Fig. 5.3), resulting in a value less than at point A, then the resource has been misallocated because the present value is not maximized. In the example portrayed in Figure 5.3, the commercial fishery has increased it's present value by the amount ACNM, but the present value of the tourist industry has decreased AYZC. If the increased value of the commercial fishing industry is insufficient to compensate, in principle, for the loses experienced by the tourist industry, the resulting allocation would be sub-optimal.

This type of analysis can also be used when the combined harvest of the tourist and commercial fishing industries is in excess of the potential production of the resource. Referring once again to Figure 5.3, the original position is at point A. If harvest must be reduced to maintain the resource, the present value of the industries must be decreased to some position along the P_1P_1 curve. One possibility is to place the entire burden on the commercial fisheries by moving from point A to point D, causing no change in the tourist industry but a loss of ADLM to the commercial fishing industry. This is essentially what was done in following SPOF (1978e) criteria. The other possibility is to move from point A to point E, at a cost of AYZE to the tourist industry but no change to the commercial fisheries. Optimum allocation should be concerned with maximizing the combined present values, but this would probably involve losses to both industries, lying somewhere between points D and E on the curve P_1P_1 (Fig. 5.3). Once again marginal cost analysis is required to determine who gets what share of the resource pie.

The foregoing discussion provides a brief profile of the economic requirements for making allocation decisions. As in the case of the biological data requirements, there are some enormous information gaps. The collection, collation and synthesis of these data are considered the major challenges for the fisheries resource manager.

5.3.4 Some Concluding Comments

One more important issue that must be examined before allocating the resource between tourist lodge and commercial fishing industries is that of the non-contributing non-residents. As demonstrated previously, uncontrolled access to various fish stocks by these non-residents is contributing to the overharvest of some valuable species. The social costs of this harvest to the residents of Ontario have not been satisfactorily demonstrated, although it can be seen to have an impact on the resident sport fishery, commercial fishing industry and tourist lodge industry. The costs imposed by these non-contributing anglers are, therefore, the foregone benefits to Ontario commercial and recreational interests. In this regard, all tourist lodge operators responding to the questionnaire survey indicated resentment that American based houseboats are allowed access to the fisheries resources in the Ontario portion of Rainy Lake. The question arises as to the rationale behind allocation deliberations between local businesses when the resource base is supporting industries across the international border at a price which may not reflect the value of the resource. At the same time, it must be noted that the license fees paid by foreign, non-contributing anglers, nominal as they may be, provides a measure of the primary value of the recreational use of fisheries resources. It might be argued, therefore, that a decision to exclude the so called non-contributors would result in a trade off between the primary benefits of the recreational use of fisheries resources and the secondary benefits associated with the industry servicing anglers. The potential exists to alleviate the problem through the use of pricing techniques that would convert the non-contributors into contributors.

Pricing the opportunity to fish has been previously discussed in Chapter II as a means of establishing the level of willingness to pay. In the attempt to quantify the value of the resource through prices, the ability of government to assess future demand could be accomplished, allowing rational decisions on directing expenditures based on consumer sovereignty. Imposing a price on the resource is the first step towards the realization that fisheries resources are, in fact, scarce. As seen by the biological analysis in this study, competition among user groups for scarce walleye stocks is leading, or has led, to the depressed state of the resource. With regard to the renewable aspect of fisheries resources, it would seem a calamity if irreversible damage to fish stocks was allowed without receiving some measure of compensation from all groups involved in the harvest. Should government decide the resource is worth maintaining, prices could be used to control demand pressures. This would involve collecting a portion of the rent from the commercial fishing industry as well as the angler. Success has already been demonstrated in organizing and distributing goods and services that are considered necessities, such as food, clothing and shelter. It would appear that price control can be rationalized to maintain the resource and provide for its perpetuity for the good of all society. Of paramount importance to the Rainy Lake fish stocks is the need to control harvest, or demand, by the non-contributing sector of the recreational fishery because this group is presently removing 50 percent of the harvest. In this regard, a price system would make contributors out of non-contributors.

In the absence of a pricing system that will generate demand signals, it would be necessary to calculate hypothetical proxy values by such techniques as a willingness to pay survey. It should be noted, however, that the veracity of such estimates will only be determined by requesting the recreational fishermen to actually pay a price.

LITERATURE CITED

Bonde, T.J.H., C.A. Elsey, and B. Caldwell. 1961. A preliminary investigation of Rainy Lake, 1959. Minn. Dept. Conserv. Div. Game Fish Sect. Res. Plann. Invest. Rep. 234: 43pp.

Bonde, T.J.H., C.A. Elsey, and B. Caldwell. 1965. A second Rainy Lake report, 1957-1963. Minn. Dept. Conserv. Div. Game Fish Sect. Res. Plann. Invest. Rep. 284: 44 pp.

Bultin, J. 1975. Optimal depletion of a replentishable resource: an evaluation of recent contributions to fisheries economics. in P.W. Pearse (ed.) Economics of natural resource depletion. MacMillan, London.

Caldwell, B. no date. Tagging of walleye (Stizostedion vitreum vitreum) and lake whitefish (Coregonus clupeaformis) on Rainy Lake, 1957-1960. OMNR, Fort Frances, unpublished manuscript.

Caldwell, B. 1980. Fisheries Management officer. OMNR, Fort Frances. personal communication.

Cauvin, D.M. 1979. Regulating access in Canada's inland fisheries. J. Fish. Res. Board Can. 36: 827-836.

Cauvin, D.M. 1980. The valuation of recreational fisheries. Can. J. Fish. Aquat. Sci. 37: 1321-1327.

Cauvin, D.M. 1981. The consistency of contemporary fisheries valuation techniques. Discussion paper presented to the DFO Economic Methodology Workshop, Winnipeg, Manitoba. 15 pp.

Cauvin, D.M., and P.C. Thompson. 1977. Rainbow trout farming: an economic perspective. Can. Fish. Mar. Serv. Ind. Rep. 93: 24 pp.

Chevalier, J.R. 1977. Changes in walleye (Stizostedion vitreum vitreum) population in Rainy Lake and factors in abundance, 1924-75. J. Fish. Res. Board Can. 34: 1321-1327.

Christie, W.J. 1978. A study of freshwater fishing regulations based on North American experience. FAO Fish. Tech. Paper, Rome. 180: 46 pp.

Clark, C.W. 1977 a. Control theory in fisheries economics: frill or fundamental? in L.G. Anderson (ed.) Economic impacts of extended fisheries jurisdiction. Ann Arbor Science Publishers Inc., Ann Arbor, Michigan.

Clark, C.W. 1977 b. Overcapitalization in commercial fisheries: symptoms, causes and cures. Env. Biol. Fish. 2: 3-5.

Clawson, M. 1959. Methods of measuring the demand for and value of outdoor recreation. Washington, D.C. Resources for the Future Inc., 36 pp.

Cole, G.A. 1975. Textbook of limnology. C.V. Mosby Co., St. Louis. 283 pp.

Copes, P. 1980. Rational resource management and institutional contraints: the case of the fishery. in J. Bultin (ed.) Resources and the environment: studies in environmental economics and natural resource use. Longman Publ., in press.

Crutchfield, J.A. 1962. Valuation of fisheries resources. Land Economics 38 (2): 145-154.

Crutchfield, J.A. 1975. An economic view of optimum sustained yield. in P.M. Roedel (ed.) Optimum sustained yield as a concept in fisheries management. Am. Fish. Soc. Spec. Publ. 9.1.

Crutchfield, J.A., and G. Pontecorvo. 1969. The Pacific salmon fisheries: a study of irrational conservation. Baltimore, John Hopkins Press.

Dickie, L.M. 1979. Perspectives of fisheries biology and implications for management. J. Fish. Res. Board Can. 36: 838-844.

Ernst, D., and T.C. Osborn. 1980. The summer sportfishery in Voyageurs National Park and surrounding waters for 1977 and 1978. Minn. Dept. Nat. Res. Div. Fish Wildlife Sec. Fish. Inves. Rep. 370: 27 pp.

Gordon, H.S. 1954. The economic theory of a common property resource: the fishery. J. Polit. Econ. 62: 124-142.

Hardin, G. 1968. The tragedy of the commons. Science. 162 (3059): 1243-1248.

Hayes, F.R., and E.H. Anthony. 1964. Productive capacity of North American lakes as related to the quantity and the trophic level of fish, the lake dimensions, and the water chemistry. Trans. Am. Fish. Soc. 93: 53-57.

Hirshleifer, J., J.C. DeHaven, and J.W. Millman. 1970. Water Supply. The University of Chicago press. Chicago, Ill. 386 pp.

IJC. 1917. Lake of the Woods reference: final report of the International Joint Commission. Ottawa-Washington. Washington Government Printing Office. Washington D.C. 261 pp.

Johnson, F.H. 1961. Walleye egg survival during incubation on several types of bottom in Lake Winnibigoshish, Minnesota, and connecting waters. Trans. Am. Fish. Soc. 90: 312-322.

Johnson, F.H. 1967. Status of the Rainy Lake walleye fishery, 1966. Minn. Dept. Conserv. Div. Game Fish Sect. Res. Plann. Invest. Rep. 295: 16 pp.

Johnson, F.H. R.D. Thomasson, and B. Caldwell. 1966. Status of the Rainy Lake walleye fishery, 1965. Minn. Dept. Conserv. Div. Game Fish Sect. Res. Plann. Invest. Rep. 292: 22 pp.

Kendall, S., J.R. Paine, and W.F. Sinclair. 1977. Lake Erie fishery management plan. OMNR. 277 pp.

Krebs, C.J. 1978. Ecology: the experimental analysis of distribution and abundance. second ed. Harper and Row Publ. Inc. N.Y. 678 pp.

Larkin, P.A. 1977. An epitaph for the concept of maximum sustained yield. Trans. Am. Fish. Soc. 106: 1-11.

Laub, M.E. no date. Economic evaluation of outdoor recreation. mimeograph manuscript. University of Manitoba. Dept. Econ. 20 pp.

McGregor, D.B. 1970. Creel census of Rainy Lake. OMNR, Fort Frances. unpublished manuscript. 73 pp.

Munro, G.R. 1977. Canada and fisheries management with extended jurisdiction: a preliminary view. in L.G. Anderson (ed.) Economic impacts of extended fisheries jurisdiction. Ann Arbor Science Publishers Inc., Ann Arbor, Michigan. 428 pp.

Musgrave, R.A., and P.B. Musgrave. 1976. Public finance in theory and practice. McGraw Hill Book Company, New York. 778 pp.

Northcote, T.G., and P.H. Larkin. 1956. Indeces of productivity in British Columbia lakes. J. Fish. Res. Board Can. 13: 515-540.

Pearse, P.H., and G.K. Bowden. 1969. Economic evaluation of recreational resources: problems and prospects. Thirty fourth North American Wildlife and Natural Resources Conference, Wildlife Management Institute, Washington, D.C.: 283-293.

Quirk, J.P., and J.J. Smith. 1969. Dynamic economic models of fisheries. in A.D. Scott (ed.) Economics of fisheries management: a symposium. H.R. MacMillan Lectures in Fisheries, University of British Columbia.

Rawson, D.S. 1951. The total mineral content of lake waters. Ecology 32: 669:672.

Rawson, D.S. 1952. Mean depth and fish production of large lakes. Ecology 33: 513-521.

Ricker, W.E. 1973. Two mechanisms that make it impossible to maintain peak period yields from stocks of Pacific salmon and other fishes. J. Fish. Res. Board. Can. 30(9): 1275-1286.

Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish populations. Bull. Fish. Res. Board. Can. 191, 382 pp.

Roedel, P.M. 1975. A summary and critique of the symposium on optimum sustained yield. in P.M. Roedel (ed.) Optimum sustained yield as a concept in fisheries management. Am. Fish. Soc. Spec. Publ. 9.1.

Royce, W.F. 1972. Introduction to the fisheries sciences. Academic Press, New York. 351 pp.

Royce, W.F. 1975. Use of yield models in fisheries management. in P.M. Roedel (ed.) Optimum sustained yield as a concept in fisheries management. Am. Fish. Soc. Spec. Publ. 9.1.

Ruston/Shanahan and Associates Ltd.; Hough, Stransbury & Associates Ltd; and J.B. Ellis and Associates Ltd. 1979. The fishing hunting lodge industry in northern Ontario. Prepared for the OMNA and the NOTOA. 120 pp.

Ryan, P.A. 1980. An analysis of the factors affecting the phytoplankton standing crop and potential fish yield of West Patricia Lakes. OMNR. West Patricia Land Use Plan. Fish. Tech. Rep. 7. unpublished manuscript.

Ryder, R.A. 1965. A method for estimating the potential fish production of north-temperate lakes. Trans. Am. Fish. Soc. 94: 214-218.

Ryder, R.A. S.R. Kerr, K.M. Loftus, and H.A. Regier. 1974. The morphoedaphic index, a fish yield estimator, review and evaluation. J. Fish. Res. Board Can. 31: 663-688.

Samuelson, P.A. 1947. Foundation of economic analysis. McGraw Hill Book Company, New York.

Scott, A.D. 1955. The fishery: objectives of sole ownership. J. Pol. Econ. 63: 116-124.

Sinclair, W.F. 1977. Management alternatives and strategic planning for Ontario fisheries. Ontario Region, Fisheries and Marine Services. 56 pp.

Sirkin, G. 1968. The visible hand: the fundamentals of economic planning. McGraw Hill Book Company. New York.

SPOF. 1974. Strategic Planning for Ontario Fisheries: First report of the Federal-Provincial working group. OMNR. 97 pp.

SPOF. 1976. Fourth report of the Federal-Provincial working group. OMNR.

SPOF. 1978 a. Designation of assessment units: working group number one. OMNR. 65 pp.

SPOF. 1978 b. Public involvement in Ontario fisheries: working number two. OMNR. 25 pp.

SPOF. 1978 c. Experimental management: working group number three. OMNR. 44 pp.

SPOF. 1978 d. Ontario fish yield estimates: working group number four. OMNR. 37 pp.

SPOF. 1978 e. An allocation policy for Ontario fisheries: working group number five. OMNR. 39 pp.

SPOF. 1978 f. Towards a more rational commercial fishery in Ontario: working group number six. OMNR. 31 pp.

SPOF. 1978 g. A resident sport fishing license for Ontario: working group number seven. OMNR. 34 pp.

Thompson, P.C. 1980. Economic performance of the Western Canada commercial skiff fishery. Dept. Fish. Oceans. Freshwater Institute, Winnipeg, Manitoba. unpublished manuscript.

Thompson, P.C. 1981. Economic performance of the Western Canada commercial skiff fishery. Dept. Fish. Oceans. Ind. Rep., in press.

Thompson, P.C. 1981. Fisheries economist. Dept. Fish. Oceans. Freshwater Institute, Winnipeg, Manitoba. personal communication.

Topolniski, D. 1980. Economics and the management of the recreational fishery of the Northwest Territories: issued and opportunities. Dept. Fish. Oceans. Freshwater Institute, Winnipeg, Manitoba. unpublished manuscript.

Turvey, R. 1970. Optimization and suboptimization in fishery regulation. Am. Econ. Rev. 54: 64-76.

Wilkins, B.T. no date. Estimating demand and evaluating economic benefits in recreational fisheries. Cornell University. mineograph manuscript.

APPENDIX A

WATER CHEMISTRY DATA

Table A.1. Conductivity, total dissolved solids (TDS) and total inflection point (TIP) alkalinity values for the 35 sampling stations in Rainy Lake, 1980.

Station	Conductivity (umhos/cm at 25°C)	TDS[a] (mg/l)	TIP Alkalinity (mg/l)
North Arm			
4	68.2	53.53	24.62
5	69.2	54.16	25.49
6	68.3	53.59	25.16
7	67.4	53.02	24.94
8	67.5	53.08	24.66
9	68.0	53.40	25.16
10	72.7	56.39	26.72
11	73.0	56.59	26.63
12	69.7	54.48	25.13
32	77.25	59.28	27.92
33	70.25	54.83	25.41
34	69.8	54.54	25.45
35	69.9	54.61	25.37
	70.09	54.73	25.59
South Arm[b]			
2	39.0	34.98	9.32
3	40.0	35.61	9.26
18	54.5	44.82	16.33
19	56.4	46.03	15.64
20	52.0	43.24	13.46
21	49.0	41.33	13.17
22	49.0	41.33	13.19
23	50.0	41.97	13.21
24	55.9	45.70	16.94
25	56.0	45.78	16.54
26	56.6	46.13	16.99
27	57.0	46.41	16.51
28	51.6	42.98	13.56
29	55.5	45.46	14.13
30	53.0	43.87	15.21
31	40.3	35.80	9.66
	50.98	42.59	13.95
Redgut Bay			
1	37.0	33.71	8.55
13	36.0	33.07	7.96
14	37.0	33.71	8.23
15	38.0	34.34	9.78
16	38.0	34.34	8.83
17	46.8	39.93	12.69
	38.8	34.85	9.34

a TDS = (Conductivity) (0.6353) + 10.2 (OMNR 1978 Lake Survey Manual)

b Ontario portion only

Compiled from Ryan (1980).

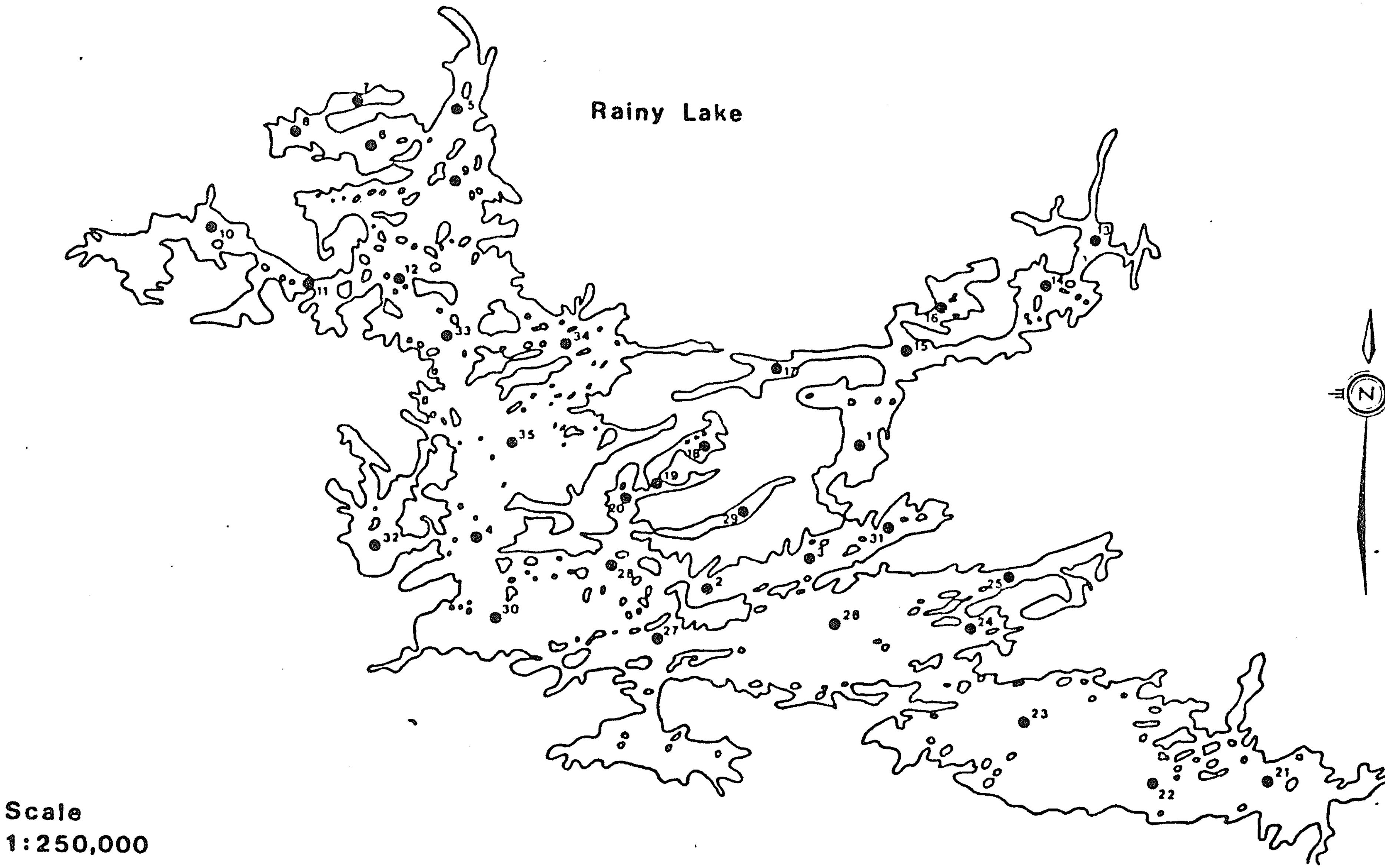


Fig. A.1. Water chemistry sampling locations, Rainy Lake, 1980.
From Ryan (1980).

APPENDIX B

TOURIST LODGE QUESTIONNAIRE

Dear Lodge/Camp Owner:

I am writing to ask your participation in a study of your industry, being undertaken by myself under contract to the Ontario Ministry of Natural Resources.

The purpose of the study is to determine the degree of dependancy of your industry on the fisheries resource base in Rainy Lake, and the socio-economic impact on the local economy. It will also provide you with the opportunity to express your opinions regarding fisheries management so they may be incorporated into allocation recommendations in the Rainy Lake Fisheries Management Plan.

The success of the study and its potential benefits to you as a lodge/camp operator on Rainy Lake, depends on your candid participation. Confidentiality of your information is protected by not requesting the name of your lodge/camp and having all returns going to the contractor at the University of Manitoba.

Enclosed is some background information on the status of the Rainy Lake fisheries resource base identifying the need for a management plan. I would greatly appreciate you taking the time necessary to complete the questionnaire at the end of the report and returning it to me in the self-addressed envelope.

This study can be of great benefit to you as an operator, and for future fishing success. Any questions you may have, may be directed to the Ontario Ministry of Natural Resources office in Fort Frances, or contact me at the address provided on the envelope.

Kindest Regards,

Yours sincerely,

Randy Wepruk
Graduate Student

Encl.

LODGE/CAMP OPERATORS' QUESTIONNAIRE

This questionnaire is divided into four sections covering various topics. In some questions I would like you to write in your answers while in others to place a tick in the ( ) next to your selected answer.

Section 1: In this first section of the questionnaire I would like you to provide details about the lodge/camp you operate.

1a). What type of accommodation services did you offer in 1980? PLEASE TICK UNDER "YES" OR "NO" FOR EACH TYPE.

	YES	NO
American Plan	( )	( )
Housekeeping	( )	( )
Trailer/Tent spaces	( )	( )
Outpost sites	( )	( )
Other ______ (please specify)	( )	

1b). Would you write in the number of units you have and the number of guests who can be accommodated in these units (in total) for each type of unit listed below?

	#units	#Guests (who can be accommodated)
Main base-Resort lodge rooms	______	______
Cottages or cabins	______	______
Remote locations-outpost camps	______	______
Total (write in please)	______	______

1c). And if you have a trailer/tent campground, how many sites do you have?

No. of sites ______

1d). Is your main accommodation accessible by road?

( ) YES
( ) NO

2a). Which month does your lodge/camp open, and which month does it close?

OPEN ______ CLOSE ______

2b). For each of the months in which your lodge/camp is open, what is the approximate percentage of all available accommodation which was occupied (on average) during last year (1980)?

Percent of Accommodation occupied for each Period

____% May	____% September
____% June	____% October
____% July	____% November- April
____% August	

Section 2: This section of the questionnaire is about your guests. If you cannot provide the exact figures please write in your best estimate: this will help in obtaining a better idea of the visitors.

3a). Approximately how many guests did you have during the 1979 and 1980 season?

1979 __________ (total no. of guests)
1980 __________ (total no. of guests)

3b). What percentage of these guests came from the various areas listed below? The total should add to 100%.

Percent of guests	From
______%	Ontario
______%	Other Canadian Provinces
______%	U.S.A.
______%	Other Countries

3c). In 1980, what percentage of your guests were "new visitors" who had not been to your lodge/camp before?

______% New Visitors

4a). Please tick opposite the type of services you consider your <u>lodge/camp to offer</u>.

( ) The fishing experience
( ) The wilderness experience
( ) Vacation package, including fishing
( ) Vacation package for the whole family (water skiing, sun bathing etc.
( ) Other (please specify)

____

4b). Which one of the following do the majority of your customers come for?

( ) The fishing experience
( ) The wilderness experience
( ) Vacation package, including fishing
( ) Vacation package for the whole family (water skiing, sun bathing etc.)
( ) Other (please specify)

____

4c). Over the past few years have you noticed any changes in the types of visitors to your lodge/camp? Would you please tick, for each type listed below, whether you now have more, less, or about the same as before?

	More	Less	About Same
Fisherman	( )	( )	( )
Families/Vacationers	( )	( )	( )
Spring Visitors	( )	( )	( )
Summer Visitors	( )	( )	( )
Fall Visitors	( )	( )	( )
Winter Visitors	( )	( )	( )

4d). In total, do you have more, less, or about the same number of visitors now compared to a few years ago?

( ) More
( ) Less
( ) About Same

5a). Of the fish species listed below, would you please rank the species fished for by your customers? (1 denotes the most sought after species through to 6 which represents the least sought after).

RANK (1 to 6)	Species
______	Walleye
______	Northern Pike
______	Small-mouth Bass
______	Muskellunge
______	Crappie
______	Yellow Perch
______	Other (please specify) ______________________

5b). Of the fish species listed below, would you please rank the species most often caught by your customers? (1 denotes the species most often caught through to 6 which represents the species least often caught).

RANK (1 to 6)	Species
______	Walleye
______	Northern Pike
______	Small-mouth Bass
______	Muskellunge
______	Crappie
______	Yellow Perch
______	Other (please specify) ____________________

Section 3: In the section I would like your opinions about the fishing in your area and your suggestions about what can be done to improve the situation.

6. How long have you lived in this area?

______Years

7. Based on your experience in the area, is the supply (number) of fish increasing, decreasing or stable? (PLEASE TICK ANSWER FOR EACH BELOW)

Species	Increasing	Decreasing	Stable	Species Not in Area
Walleye	( )	( )	( )	( )
Northern Pike	( )	( )	( )	( )
Small-mouth Bass	( )	( )	( )	( )
Muskellunge	( )	( )	( )	( )
Crappie	( )	( )	( )	( )
Yellow Perch	( )	( )	( )	( )
Other ______________ (please specify)	( )	( )	( )	( )

8. How adequate is the current supply of each of these in your area for your customers' satisfaction? (PLEASE TICK ANSWER FOR EACH SPECIES)

Species	Seriously Inadequate	Slightly Inadequate	About Adequate	More than Adequate	Species Not In My Area
Walleye	( )	( )	( )	( )	( )
Northern Pike	( )	( )	( )	( )	( )
Small-mouth Bass	( )	( )	( )	( )	( )
Muskellunge	( )	( )	( )	( )	( )
Crappie	( )	( )	( )	( )	( )
Yellow Perch	( )	( )	( )	( )	( )
Other ______________ (please specify)	( )	( )	( )	( )	( )

9. Listed below are a number of practices or techniques which are either currently used or could be introduced to increase the quality or quantity of fishing success. I would like your opinion on each of these practices. FOR EACH LISTED PLEASE INDICATE, BY A TICK IN THE APPROPRIATE ( ), HOW STRONGLY YOU AGREE OR DISAGREE WITH THE PRACTICE TO IMPROVE FISHING.

PRACTICE	Strongly Agree	Agree	Disagree	Strongly Disagree
Intensive stocking (put and take fishing)	( )	( )	( )	( )
Catch/release (eg. barbless hooks)	( )	( )	( )	( )
Artificial lures only (no live bait)	( )	( )	( )	( )
Smaller catch limits	( )	( )	( )	( )
Size limits	( )	( )	( )	( )
Sanctuaries (ie. restricted harvest in certain areas)	( )	( )	( )	( )
No harvest (eg. walleye)	( )	( )	( )	( )
Rotational harvest (ie. walleye season once every three years)	( )	( )	( )	( )
Boat limit	( )	( )	( )	( )

10. Please write in the factors which you feel are limiting the quality or quantity of fishing opportunities for your customers. (THE BACK OF THIS PAGE MAY BE USED FOR ADDITIONAL SPACE IF REQUIRED)

____

____

____

____

11a). Would you like to see changes in fisheries resource management practices?

( ) YES
( ) NO

11b). If YES; what kind of changes would you like to see? (THE BACK OF THIS PAGE MAY BE USED FOR ADDITIONAL SPACE IF REQUIRED).

____

____

____

Section 4:	Sport fisheries is an important contribution to the economy of the area. This section is about your business practices. The information is important to provide an overall picture of the economics of the Rainy Lake Lodge industry. The information about your business will be combined with the other questionnaires and analyzed in total. The information you supply will be kept in absolute confidence by ~~the researcher~~.

12a). Is your lodge/camp your principle place of residence or do you live elsewhere?

( ) Lodge/camp principle residence
( ) Elsewhere (please specify) ______________________________

12b). Is the running of the lodge/camp a primary or secondary source of income?

( ) Primary source of income
( ) Secondary source of income

13. Which, if any, of the factors listed below do you consider to be serious problems that face your industry?

( ) Depletion of fish stocks
( ) Too short of a season
( ) Consumer resistance to higher rates
( ) Too many similar facilities on Rainy Lake
( ) Declining interest in Canada vs. U.S.A.
( ) Others (please specify) ______________________________
____

14a). How many staff, excluding family, work at your lodge/camp during the season?

Full-time staff ________persons
Part-time staff ________persons

14b). On average, how many weeks do the full-time and part-time staff work in a season?

Full-time staff ________weeks
Part-time staff ________weeks

14c). How many hours, in an average week, does the staff work?

Full-time staff ________hours/week
Part-time staff ________hours/week

14d). And from where does your staff originate? (TICK FOR EACH TYPE YOU EMPLOY)

( ) Ontario (white)
( ) Ontario (Treaty Indian)
( ) U.S.A
( ) Other (please specify) ______________________________

15. What are your <u>average</u> daily and weekly price rates? (PLEASE WRITE IN)

Daily rates $____________
Weekly rates $____________

16. What is the gross revenue of your lodge/camp for the 1980 season?

$________________

17a). Listed below are possible expenditures necessary to maintain a lodge/camp. Would you please write in your expenditures for the 1980 season?

Operating expenditures

Full-time staff	$________________
Part-time staff	$________________
Gas and oil	$________________
Live bait	$________________
Food	$________________

Capital expenditures

Boats, motors, paddles etc.	$________________
Lodge/camp maintenance	$________________

17b). Would you please specify where most of the expenditures were made?

per cent

_______% Fort Frances Area
_______% Other parts of Ontario
_______% U.S.A
_______% Other (please specify) ____________________________

18. Finally, would you please add any comments which you would like to make about the industry or the fish resource.

____
____
____

THANK YOU VERY MUCH FOR YOUR TIME
AND CONSIDERATION

Randy Wepruk

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