A REVIEW OF THE STATUS OF WESTERN LAKE SUPERIOR FISH POPULATIONS -- INCLUDING QUOTA RECOMMENDATIONS FOR HERRING, CHUB, AND WHITEFISH

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February, 1981

ACKNOWLEDGEMENTS

This report was funded by a grant from the Ontario Ministry of Northern Affairs to the Ontario Council of Commercial Fishermen.

The fisheries biologists and officers of the Terrace Bay, Nipigon, and Thunder Bay offices of the Ontario Ministry of Natural Resources were all most obliging and helpful. Special thanks to W. MacCallum and R. Hamilton, and also to L. Greig of the Toronto O.M.N.R. office (who made available the grid summaries of the C.F.-1 data).

Acknowledgements to H. A. Regier for his advice, and to M. MacKenzie, manager of the O.C.C.F., for his skills in coordinating meetings and money.

Too numerous to name, the fishermen and residents of the western Lake Superior region were both invaluable in their assistance and kind in their hospitality.

This manuscript was typed by D. Ronayne.

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1. INTRODUCTION

While fish quotas are by no means a new phenomena to Lake Superior, the magnitude of imposition currently proposed by the Ontario Ministry of Natural Resources is unprecedented. Their rationale has been described by Hamilton (1980):

> "The region and districts of western Lake Superior recognized that the future of some species could be in jeopardy if methods were not devised for protection of sufficient stock."

A grant to the Ontario Council of Commercial Fishermen (from the Ministry of Northern Affairs) made possible the following study. It is presented as input to investigations currently being conducted by O.M.N.R. personnel, who echo the desire of all concerned that a wise and equitable strategy of quota management can be devised.

We have concentrated our efforts of analysis on whitefish (*Coregonus clupeaformis*), herring (*Coregonus artedi*), and chub (*Coregonus spp.*) populations. It is assumed that quotas will be applied to these species, and we have not concerned ourselves with whether they should be applied. In addition, problems of equitable quota allocation (rather than zone quota determination) lie at the root of many concerns voiced by western Lake Superior fishermen. Any attempts at resolving this thorny question have been outside the mandate of our study.

In June of 1980 interviews were conducted with as many commercial fishermen and Minstry personnel as possible. General problem areas were identified, and a preliminary report was issued in July. This report reviews the general histroy and philosophy of western Lake Superior quota management, and discusses ideas expressed by both government employees and fishermen. It provides background information relevant to the present study and so has been included as Appendix I.

While we have attempted to review all available data, certain methodological and interpretational limitations have been encountered. These are made apparent in the following report. Some amount of additional analysis and review is demanded, and it is assumed that the O.M.N.R. will devote special attention to resolving any problems and patching up any "flaws".

Without a large base of previously collected data, assignment of new quotas must be, to some extent, a trial and error affair. This underscores the need for constant sampling and constant reassessment. The stochastic nature of ecological systems, which tend to show large and often unpredictable fluctuations, demands that management quotas not be "graven in stone".

2. APPROACHES TO ASSESSING THE STATUS OF FISH POPULATIONS

Within the constraints of both available time and data, an attempt has been made to utilize a number of different fisheries models in assessing the current status of western Lake Superior fish species. MacCallum (1980) has considered some of these in his review of eastern Lake Superior whitefish populations and has stressed the Healey (1975) approach and Abrosov (1969) approach (discussed below). Traditionally, the O.M.N.R. has also placed special emphasis on the use of catch per unit effort measurement (C.U.E.'s) as indicaters of fish abundances. An O.M.N.R. report, employing the techniques of MacCallum (1980), has not be issued for western Lake Superior fish species.

The present study has attempted to refine and assess the validity of certain analytical strategies employed by the O.M.N.R. as well as to introduce certain previously untried techniques.

2.1 COMPARISONS OF GROWTH AND MORTALITY RATES

Healey (1975) concluded that estimates of growth and mortality rates provide useful tools for a manager attempting to assess the potential productivity of a fishery. Obviously, as exploitation increases, fishing mortality, and consequently total mortality (fishing mortality plus natural mortality) increases. Healey also presents evidence from many lakes, both exploited and unexploited, which show that whitefish tend to respond to an increase in fishing intensity by increasing their growth rate, (often at a rapid rate). He concludes that:

> "...Populations with slow growth rate and low mortality should, therefore, have the best fishery potential, while those with a high growth rate and high mortality have a low fishery potential. Further it is possible to judge the fishery potential of a population or its stage of exploitation from relatively simple measurements of mortality, growth, age structure, and maturity."

Although Healey's study was concerned strictly with whitefish, there is reason to believe his principles are applicable to other coregonid species (such as herring and chub).

2.2 MEAN AGE AT MATURITY

The Abrosov (1969) model, in conjunction with investigations by Christie and Regier (1973), suggests that the mean age of whitefish in a commercial catch should be 1.5 to 2.0 years greater than their mean age at maturity if the fishery is to remain a stable one.

Studies of the mean age at maturity for Canadian Lake Superior whitefish do not exist. MacCallum (1980) suggests a mean age of five years for eastern Lake Superior whitefish based on the age of samples taken on the spawning grounds (such an estimate could be too high or too low depending on when samples were taken. At some locations larger, and probably older fish apparently spawn later; Goodier 1981). Peck et al. (1974) report a mean age of maturity of 4.5 years based on samples from Whitefish Bay and Marquette gathered in 1972. Dryer (1963) found Wisconsin Lake Superior whitefish to mature at an average of 5.97 $\pm$ 0.46 years in the 1950's. Whitefish of other lakes have exhibited far lower mean ages at maturity. Van Oosten and Hile (1947) recorded many whitefish of Lake Erie mature by age 2 and all mature by age 4. Brown (1968) and Mraz (1964) found Green Bay (Lake Michigan) whitefish to have a mean age of maturity between 2 and 3 years. In southern Georgian Bay Cucin and Regier (1965) found a majority of whitefish mature before age 4.

Clearly, mean age at maturity can vary not only between lakes but between different populations in the same lake. The situation is complicated by the fact that whitefish can respond to exploitation with reduced age or size at maturity (Clady 1967; Healey 1975), as well as increased fecundity (Nikolsky 1962). Clearly age at maturity data must be assessed from western Lake Superior. It is quite possible that the mean age of 6.5 to 7.0 years suggested by MacCallum (1980) as optimal to the Abrosov model could be an overly conservative estimate for some western Lake Superior whitefish populations.

Van Oosten (1929) found a mean age at maturity of 2.8 for lake herring samples taken during the years 1921 to 1924. Likewise, Dryer and Beil (1964) note the mean age at maturity of Lake Superior herring, taken from American waters between 1950 and 1959, to have been about 3.0 years (reported in Lawrie 1978).

Studies of bloaters (*Coregonus hoyi*) from Lake Michigan and southern Lake Superior reveal a mean age at maturity of about 3 years. (Table 30; Dryer and Beil 1968; Keller et al. 1974; Brown 1979). Assuming that bloaters, like whitefish, should be allowed (on the average) to breed 1.5 to 2 times, this dictates that the mean age of the commerical catch should be 4.5 to 5.0 years old.

2.3 CATCH PER UNIT EFFORT MEASUREMENTS

Catch per unit effort (C.U.E.) measurements have proven themselves to be valid indicators of trends in fish abundances. They are, however, most valuable when backed up by a knowledge of year to year changes in the age structure of the fish populations. Cycles of strong and weak year classes are natural to many coregonid populations (such as the whitefish, herring, and chub species with which this report deals), and as they enter the commercial fishery, these year classes cause fluctuations in C.U.E. levels. Ample evidence exists to suggest that water temperature is a major criterion in determining success or failure of year-classes (Lawler 1965; Christie and Regier 1973). Investigation of annual climatological conditions, such as that conducted by Lawler (1965) for Lake Erie, could shed more light on patterns of abundance change for western Lake Superior fish species; such a task was beyond the scope of this study, however.

It is clear that factors in addition to year class fluctuations can affect the availability of fish. One fishermen has succinctly summarized the impressions of his fellows concerning those factors which alter catch levels and, in some cases, C.U.E.'s:

"(1) fish move off to other areas, other depths, or other food.

(2) fishermen cannot get to the grounds.

(3) weather is bad: stormy, too calm, too hot, or too cold.

(4) water currents change, temperatures are not right.

(5) gear is outdated, techniques poor or not yet tried.

(6) market conditions change; prices are too low, or there is a glut of fish so more cannot be handled.

(7) fishermen change the species they seek.

(8) water levels may change (higher or lower)

(9) fish spawn at different depths in different years.

(10) quotas filled on 1 species [such as can be the case with whitefish and trout] prevent fishing for others."

Thus, due to the fact that C.U.E's may show wide fluctuations from year to year, efforts should be made to obtain as many years of data as possible.

2.4 EQUILIBRIUM YIELD MODELS

Attempts were made to apply two different equilibrim yield models to certain districts of western Lake Superior: the Ricker dynamic pool model (Ricker 1958, 1975) and the Schaefer logistic model (Schaefer 1954; Pella and Tomlinson 1969). Both provide estimates of maximum sustainable yield (MSY), i.e. the point at which fish harvest is balanced by fish production. With some success, both have been applied by various researchers to quota management of Great Lakes fish species (Walter and Hogmans 1971; Sakagawa and Pycha 1971; Eshenroder and Haas 1974; Keller et al. 1974; Jensen 1976, 1978; Patriarche 1977; Ebener 1980).

Application of these models to western Lake Superior fisheries has suffered from a lack of data, however. The logistic model needs many years of catch-effort data to be highly reliable: 24 years (the maximum number available) is considered a small data set to use (Pella and Tomlinson 1970). The dynamic pool model, on the other hand, requires reliable estimates of natural and fishing mortalities, but these have not been readily available. In addition, each requires certain assumptions be made which are not always met by the Lake Superior fisheries. Stable age composition and constant catchability (i.e. no gear changes) is demanded by the logistic model. The dynamic pool model assumes that the stock is in equilibrium and that recruitment remains independent of stock size (Royce 1972).

Since the two models arrive at independent estimates of equilibrium yield an advantage lies in using the two in conjunction: this approach has been taken where possible. Care should be taken in interpreting results, however.

3. DATA SOURCES AND ANALYTICAL TECHNIQUES

3.1 CATCH-EFFORT STATISTICS

The earliest catch statistics for Lake Superior date from the first report of the Department of Marine and Fisheries (or the Department of Fisheries) in 1867. Beginning in 1871, catch and quantity of gear was reported by station of landing. The provincial Game and Fisheries Department of Ontario produced its first report in 1907, but discontinued the break-down by station of landing in 1923.

Early herring and whitefish statistics for the Black Bay and Thunder Bay area, (1871 to 1922) are presented in Table 12A. While outlining a general picture of fishing levels, it should be remembered that there are a number of possible sources of error. Fish landed at a certain station may have come from far more distant grounds. In addition, data collection was difficult in these early years and, to a large extent, depended on the goodwill of fishermen in filling out reports. It is noted in the government report for 1893 that:

> "Overseer D.F. Macdonell again refers to the great difficulty he experiences in obtaining reliable data from fishermen of their catch of fish."

Table 12A, thus would tend to underestimate actual annual catches. Total catches for all of Lake Superior (1867 to 1977) are reproduced in Table 12B.

In 1948 the government of Ontario first required that fishermen complete monthly catch-effort forms (C.F.-1's). Records from 1956 to 1976 have been summarized by statistical district and entered in the System 2000 computer of the Toronto office of the O.M.N.R. Obtaining records prior to 1956 would require many months of tedious calculations from original CF-1 forms.

Data from 1974 to 1979 is entered in the computer by fishing location. Data from 1974 to 1976 is coded by fishing ground, while data from 1976 to 1979 is coded by 5 minute grid location. This break-down has permitted examination of fishing patterns within statistical districts However, it is usually difficult to make conclusive statements concerning trends on the basis of only six years data.

Catch-effort data is, of course, reliable only to the extent that fishermen correctly fill out their C.F.-1 forms. In addition, inaccuracies can occur from keypunch errors of data entry, miscoding of fishing locations, or in some cases the unavailability of C.F.-1 forms prior to deadlines for issuing reports. Although Toronto office attempts to remove errors whenever possible, the reliability of the C.F.-1 data base entered in the computer has been called into question by Ministry personnel of the Thunder Bay District office. Fisheries officer, R. Hamilton,made recalculations of C.F.-1 catch records independent of those of Toronto (1964 to 1979 for whitefish, 1968 to 1979 for herring of Thunder Bay, and 1971 to 1979 for herring of Black Bay). Significant differences exist between Mr. Hamilton's estimates and those of the data base. These may be seen for the years 1974 to 1979 (Thunder Bay and Black Bay) by comparing the tables for whitefish and herring (Table 12C and 21, calculated by Hamilton; Table 13 and 22, calculated for this report from the data base). In 1977, for example, 83,420 lbs. of herring were wrongly assigned to statistical district 1 (Thunder Bay).

In order to reduce bias in their calculation, catch per unit effort figures are based only on catches reported with effort. In addition, incidental catches have been omitted by excluding all whitefish catches made with nets less than 4 1/2 inch mesh, and all herring and chub catches made with large mesh nets (Mr. R. Hamilton has likewise omitted incidental catches from his calculations). It should be noted that any Ministry reports (such as summaries of total catch issued by Toronto office) that do not exclude these incidentals will tend to underestimate C.U.E.'s.

Annual catch-and effort data (1956 to 1979) are presented by statistical district in Tables 12C (whitefish, districts 1 to 5), 22 (herring, districts 1 and 2), and 28 (chub, districts 1, 3, 4 and 5). Total whitefish catches from Black Bay and Thunder Bay have been broken down into spring and fall seasons. Herring catches have been subdivided into the months of November and December. Trend through time graphs of catch (with effort only), effort, and catch per unit effort are shown in Fig. 4, A-J (whitefish) and Fig. 7, A-E (herring). It has been assumed that Mr. R. Hamilton's C.F.-1 analyses are generally the most accurate, and his data has been used when available (Statistical districts 1 and 2).

Breakdown of C.F.-1 statistics by 5 minute grid location is shown by quota zone (1974 to 1979) in Tables 13 (whitefish, zones 1, 2, 3, 4A and 5A), 22 (herring, zone 1, November and December fishery), and 27 (chub, zones 3, 4A, 4B, 5A, and 5B). Difficulty of access has generally prevented Lake Superior Ministry offices from examining this data at the grid (and individual fishing ground) level. Summaries were made available to me in January, 1981 through the cooperation of the Toronto O.M.N.R. office. The Assessment Unit has relied, to a large extent on C.U.E.'s derived from the CAEF-1 forms; the "green sheets" fishermen voluntarily fill out. CAEF-1 forms contain additional parameters C.F.-1 forms do not (such as meshes deep, nights out). Unfortunately only 4 years are entered in the computer (IBM 370) and available for analysis.

Catchability coefficients were calculated by the Leslie method. (Leslie and David 1939) of fitting a regression line to the plot of catch per unit effort during one year (t) versus cumulative catch (K_t; see Table 14 for whitefish and Table 23 for herring). Catchability (q) is defined by Ricker (1975) as:

> "...The fraction of a fish stock which is caught by a defined unit of the fishing effort. When the unit is small enough that it catches only a small part of the stock - 0.01 or less - it can be used as an instantaneous rate of computing population change."

Obviously catchability calculations will be biased if catch statistics are not reliable. In addition, the necessary assumption that natural mortality remains relatively constant through time is violated by Lake Superior whitefish (and to a lesser degree herring) which were depleted by lamprey predation in the 1960's.

One would expect catch per unit effort to decrease as the cumulative catch of a fish stock increased. In western Lake Superior, however, relationships between these two parameters were found to be positive in all districts, suggesting that, between 1956 and 1976, whitefish have not been sufficiently exploited to create significant long-term decreases in C.U.E. These positive relationships still permit qualitative comparisons of fishing intensities and success between districts and seasons.

Catchability regression lines for herring were negative, but significant at a 0.95 percent confidence level for Thunder Bay only (December and all year).

3.2 LENGTH AND AGE DATA

Sample data collected by the Lake Superior Fisheries Assessment Unit from 1975 to 1979 have been entered in the computer and were available for study.

According to Ministry personnel, it has in the past been easier to obtain samples from some areas and some fishermen than others. Thus certain grid locations are well represented, while others (which contain fishing grounds)are lacking. Certain years of data are also missing from certain sample areas.

A quota zone will contain a number of discrete or semi-discrete stocks of a particular species of fish. These may differ greatly in their growth patterns, mortality rates, breeding habits, and so on, and could therefore demand different management strategies. In assessing zone quotas it is therefore desirable to sample as many different fishing grounds within the zone as possible. In many instances, time, money, and current fishing patterns have prevented O.M.N.R. from accomplishing this.

An additional and valuable source of sample data will currently be available to the Ministry for study. Mr. A. Lawrie (Director of Research Section, Fisheries Branch, Maple) has recently had coded in computer analyzable form Lake Superior sampling data dating from the early 1960's. It is desirable (and according to Mr. W. MacCallum, intended) that the Lake Superior Fisheries Assessment Unit examine this data in the process of reassessing quotas in the coming years.

3.2.1 WHITEFISH

All whitefish scales have been aged for the years 1975 and 1976, in addition to a significant proportion from 1977 to 1979. Whitefish scales for 1975 and 1976 were read by Mrs. Irene Weir, and the 1977 to 1979 scales were read by Mr. J. Smith, both readers of considerable experience. Cucin and Regier (1966) and Spangler (1974) attest to Mr. Smith's accuracy. It is true however that younger age-groups are easier to read than older age-groups. Cucin and Regier (1966) studied whitefish from southern Georgian Bay, and note that their scale readers (D. Cucin and J. Smith), "considered many of the decisions on fish with apparent ages over 10 years as tentative" (see also Power 1978).

It has been possible to gain a clear picture of the age structure of whitefish populations at the level of both entire sample areas and five minute grid locations. Five years of data are generally insufficient, however, to make conclusive statements concerning long-term trends in mortality, growth rate, and age composition.

A computer program developed by Mr. W. MacCallum (AGEDIST) was used to summarize age distribution and length frequency data by both sample area and 5 minute grid location (Tables 1 and 2; Figs. 1, A-J and 2, A-J). All lengths are presented as fork length in centimeters. In an attempt to remove some of the variability introduced by fluctuating year class strength, data for the years 1975 to 1978 was also combined by sample area. Sample statistics from 1979 had not yet been entered in the computer when these calculations (as well as breakdown of the data by grid location) were performed. An exhausted computer budget prevented recalculation.

Commercial gill nets tend to select against small and large fish, MacCallum (1980) summarizes the problem:

> "The implications of gear selectivity to our sampling are that the smaller (younger) and larger (older) fish will be under-represented. The effect will be more significant for the younger fish than the older ones because of the [positively] skewed [net selectivity] curve and because nets up to 5 1/2" mesh contributed to the catch."

Five and one-half inch mesh is of, course, even more strongly biased toward larger fish than 4 1/2 inch mesh (although only a small number of those nets were used in taking samples). In consequence, the mean ages of Tables 1 and 2 slightly underestimate the true mean ages of the whitefish populations. Time has not permitted these ages to be recalculated according to selectivity corrections.

Selectivity corrections by Regier and Robson (1966; Table 3) for 4 1/2 inch mesh gillnets were, however, used to recalculate mean length at age data by sample area for aged samples. (Table 4; length classes with greater than 15 percent of their samples outside the 29 to 55 cm. range were omitted due to bias introduced by inflated efficiency factors.) Fig. 2, A-J summaries growth patterns for both uncorrected (squares) and corrected (circles) mean lengths. Each graph also shows the upper and lower limits of growth in unexploited whitefish populations, as summarized by Healey (1975) from 32 lakes.

Length frequencies are also presented by year class for each sample area (Table 5). Uncorrected length frequencies broken down by grid location are shown in Table 6.

3.2.2 HERRING AND CHUB

Black Bay herring samples have been aged for the years 1965 to 1976 (excluding the years 1967 and 1975). These are not available in computer analyzable form, but have been summarized in a number of publications (Table 19; Rahrer and Elsey 1972; Anon 1975, 1977). All samples were aged by scale analysis, except those for 1976 whose ages were determined from pectoral fin ray sections (Anon 1977).

No herring samples from Thunder Bay, and no recent samples from Black Bay have been aged. MacCallum (1978) has noted that "perplexing difficulties" have been encountered in the aging of recent samples (as reported in Lawrie (1978).

Chub samples from western Lake Superior have neither been aged nor separated into species. Three species of chub commonly make up the commercial catches of northeastern Lake Superior; however, it is not unreasonable to assume that a large percentage of the commercial catch (which is limited to waters greater than 50 fathoms) is comprised of bloaters (*Coregonus hoyi*). The lack of knowledge of the recent age structure of resident herring and chub populations has hindered the analyses of this study.

Herring length frequency data are available from 1962 (Johnson 1966), 1967 (Lawrie 1968), and 1975 to 1979 for Black Bay and Thunder Bay (Table 17, Figs. 5, A-G and 6). Length frequency data for chub are available for the years 1977 to 1979 and sample areas 4, 6, 9 and 15 (Fig. 9, A-D). Data from 1975 to 1979 (part of the Assessment Unit's data base) was summarized by sample area with the aid of a computer program developed by Mr. W. MacCallum (LENFREQ). Without aged samples, breakdown of the data by grid location was not considered valuable enough to warrant computing expenses.

3.3 GROWTH RATES

3.3.1 WHITEFISH

Two approaches were taken to quantifying growth rates. In each, selectivity corrected lengths were used, and age classes comprising 1 percent or less of the total sample were omitted.

Ricker (1975) defines the instantaneous rate of growth (G) as:

> "...the natural lagarithm of the ratio of final weight to initial weight of a fish in a unit of time, usually a year".

Growth rates for each age were determined by sample year (Table 8) and year class (Table 8A) for each sample area. Lacking length-weight data for western Lake Superior whitefish, a conversion formula was applied based upon samples of female whitefish taken at Gros Cap (eastern Lake Superior) in November of 1977:

$$\text{Weight (kg.)} = 5.388 \times 10^{-6} \times \text{Length (cm.)}\ 3.2207 \times 1.048$$ [1]

The equation is typical of those determined for other whitefish populations (Carlander 1969). Determination of Brody growth coefficients (Ricker 1975) was the second approach to quantifying growth rate. Brody (1927, 1945) noted that, for many animals, when their length was plotted against time an S-shaped growth curve resulted. When length at age $t+1$ is plotted against length at age t, his coefficient may be derived from a regression line fitted to the plotted points. Such graphs are known as Ford-Walford graphs (Ford 1933; Walford 1946) and are presented by sample area for each sample year and year class (only those year classes with three or more available data points were considered; Fig. 3, A-J).

Estimates of the Brody growth coefficient (K) were clearly biased by the erratic nature of many of the plots, as well as apparent variability in annual growth rates. A refinement was made to certain plots by omitting small size classes (less than 42 cm.) to which the Ford-Walford relationship did not appear to apply. It was also possible to gain some idea of the relative variability of K between sample areas and sample years by forcing each regression line to pass through a prechosen asymptotic

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[1] 1.048 is a correction factor to convert geometric mean weight to arithmetic mean weight (Ricker 1975).

length (L_∞). On the basis of literature concerning Great Lakes whitefish (Van Oosten and Hile 1947; Edsall 1960; Cucin and Regier 1965; Ebener 1980) 60 cm. was chosen for L_∞. Careful study of all Ford-Walford graphs suggests certain general ranges and approximate means: the "best estimates" of Table 7.

3.3.2 HERRING AND CHUB

Growth rates for Black Bay herring may be estimated from the length-age data of Table 19 (Anon 1975). No growth rate data is available for western Lake Superior chub.

3.4 MORTALITY ESTIMATES

3.4.1 WHITEFISH

The total instantaneous mortality rate (Z) is a measure of the rate at which a population is declining in numbers (and equals the absolute natural logarithm of the survival rate). The youngest completely vulnerable age groups used in calculating the mortality rates of Tables 10 (by sample area) and 11 (by grid location) were determined by the method of Robson and Chapman (1961). Instantaneous mortality rates were estimated by the slope of the regression line through the right hand arm of the catch curve (log frequency versus age). All age classes over 11 comprising less than 1.0 percent of the total sample were excluded, as also were old age classes deviating strongly from a linear trend.

Fluctuating year-class strengths make unbiased estimation of total mortality rates difficult, and necessitate careful interpretation of results. The presence of a strong age class in the vulnerable age group will tend to cause Z to be too large, while a weak year class will have the opposite effect. Certain catch curves proved too erratic to yield satisfactory total mortality rates by the fitting of regression lines (especially in the years 1978 and 1979).

The virtual population method provided an alternative method for determining mortality rates for quota zone 1 (Thunder Bay, sample areas 1 and 2 combined) and quota zone 5A (sample area 8). This technique is useful in removing some bias introduced by variable year class strength:

> "The virtual population is the sum of the fish belonging to a given year class, present in the water at any given time, that are destined to be captured in the fishery in that year and all subsequent years." (Fry 1957).

Estimates of the numbers of whitefish caught each year by age class employed the average age class weights used previously in calculating growth rates (Table 8 and 8A). Total mortality rates were estimated from the slope of the regression line of virtual population/annual effort versus age for each completely vulnerable age group (Table 9). The method is reliable to the extent that accurate measurements of annual catch and effort have been obtained. It was inapplicable to quota zones 2, 3, and 4A, (see Table 9).

3.4.2 HERRING AND CHUB

Total mortality rates have been determined for aged Black Bay herring samples by the method of fitting a regression line to the right-hand arm of the catch curve (Table 20).

In the absence of age composition data, estimates of total mortality rates may be obtained from length frequency graphs (Tables 18 and 26).

Length frequencies for the 1975 to 1979 data were determined at 1 cm. intervals. Herring frequencies for the years 1962 and 1967 were set at 0.5 in. (1.3 cm.) intervals. Ricker (1975) notes:

> "Mortality rate estimates...always tend to be too small, if absolute rate of increase in length is decreasing with age."

Such a decrease is not apparent for the herring samples of 1965 to 1970 (Table 19), but is apparent after age 4 in subsequent years.

Using the total instantaneous mortality data of Table 20 and data of annual effort, an estimate of instantaneous natural mortality for Black Bay herring was calculated (Gulland 1976). Although the resultant instantaneous natural mortality rate of 0.75 (Fig. 8) is not an unreasonable figure, the regression line was found to be significant at only the 75 percent confidence level (based on a t-distribution test). Little data from other waters which concerns the natural mortality rates of lake herring is available in the literature. Miller (1949) has demonstrated, in one instance at least, that application of natural mortality rates from an unexploited population to an exploited one can lead to serious errors.

3.5 SURPLUS PRODUCTION MODELS

3.5.1 WHITEFISH

Estimates of fishing and natural mortality are not available for western Lake Superior whitefish, and one must turn instead to values recorded for other populations.[1] Based on his study of exploited populations, Healey (1975) found a mean natural mortality of 0.35 (M = 0.43). Cucin and Regier (1965) estimated an average rate of 0.34 (M = 0.42) for Georgian Bay fish, while Lake Michigan populations (ages 4 and greater) have shown natural

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[1] Natural mortality rates may be estimated from tagging and recapture experiments, such as those of Cucin and Regier 1966, Spangler 1974, and Ebner 1980. Such surveys tend to be rather consumptive of time, money, and manpower, however.

mortality rates ranging from 0.34 (M = 0.42) to 0.38 (M = 0.48; Patriarche 1977; Rybicki and Keller 1977; Ebener 1980). Lake Winnipeg whitefish exhibited mortality rates of 51 percent (M = 0.71; Davidoff et al. 1973). Cucin and Regier (1966) noted that older whitefish (such as those of the Lake Winnipeg population) tended to possess higher natural mortalities.

For the purposes of this study, a rate of 46 percent (M = 0.45) was assumed to represent the natural mortality of western Lake Superior whitefish. Calculations were performed for quota zones 1 (Thunder Bay) and 5A, the two zones for which virtual population mortality estimates were available (Table 9, Table 16). Only the completely vulnerable age groups, 6 to 8, were included. "Best estimates" of average mortality and growth were gleaned from the combined data of Tables 8, 8A, 9, 10, and 11.

The computer program TCPF7 (formally IFOP21) was developed by Tomlinson (n.d.) and provides an exact solution for the Schaefer Model. It is a simplified version of the more generalized logistics program GENPROD (Pella and Tomlinson 1969), and assumes that equilibrium yield is a simple parabolic function of fishing intensity. (The GENPROD program, on the other hand, allows for the introduction of a skewed relationship.) An internal sub-routine, not present in GENPROD, generates guesses for the population parameters Umax, F_{opt}, q, and r, as defined by Pella and Tomlinson (1969).

In the case of Black Bay and Thunder Bay, two sets of computer runs were performed; the first employed catch-effort data of 1964 to 1979 only, while the second included the full complement of data years (1956 to 1979). The former incorporates only data calculated by Hamilton (1978a). While reducing the size of the data set (which increases the possiblity of biased answers), it has the advantage of omitting some of the heaviest years of sea lamprey predation.

3.5.2 HERRING

The Ricker dynamic pool model was applied to data from the Black Bay lake herring fisheries 1972 to 1974, and 1976 (Table 25). The instantaneous total mortality rates of Table 20 and the instantaneous natural mortality rate of Fig. 8 were employed in the model. Instantaneous growth rates were estimated from the 1973 trout sample (Table 19) and were utilized in all year calculations.

Maximum sustainable yield estimates were also estimated with the Schaefer model and the computer program TCPF7 (Table 24)

4. DISCUSSION AND RECOMMENDATIONS

4.1 HERRING

The Great Lakes Fishery Commission has outlined the pattern of decline of Lake Superior herring abundances which followed 1960 and conclude that overfishing was a major reason. They also note that "analysis of the traditional commercial fisheries statistics (C.U.E.) [is] often unreliable for detecting all but extremely large changes in the herring populations." (Statistics examined only at the statistical district level tended to mask a sequential fishing out of different stocks which was apparently occurring in certain waters; Lake Superior Herring Subcommittee 1972).

4.1.1 THUNDER BAY QUOTA ZONE 1

The lake-wide pattern of decline noted above seems also to be reflected by the catch-effort statistics of Thunder Bay. Large increases in effort began in 1959. Yield and C.U.E.'s continued at high levels for 5 years, but C.U.E.'s fell suddenly after 1964. Such evidence tends to implicate the fishery (Table 21).

The factors affecting patterns of population change are not well understood, however. Scott (1951) demonstrated that for 50 years the Lake Erie cisco fishery endured evident fluctuations not necessarily related to fishing effort:

> "From 1910 to 1925 these fluctuations were especially marked. During the period 1926-1944 the fishery was virtually extinct, but in 1945 and 1946 the cisco reappeared in numbers comparable to the best years of the fishery... The history of past population supports the theory that previous periods of abundance resulted from the occurrance of dominant year-classes."

He also points out that "under favourable conditions, an unusually small spawning population can produce a large year-class." Similarly a large year-class does not necessarily generate another large year-class

(Lawler 1965; see also Section 4.3.1). On the whole, fisheries biology is not at the stage where it adequately understands the mechanisms of fish population oscillations, nor can it predict the magnitude of such oscillations with any great degree of certainty. It should be noted, however, that large increases in fishing effort during the low part of an abundance cycle could seriously, and permanently, damage a fishery.

There is evidence that Thunder Bay yielded, at one time, herring harvests in great excess of those currently taken. It was noted by an overseer in 1907:

> "In the Thunder Bay grounds the herring fishing was particularly good, some good large catches being made. As high as seven tons having been taken from the nets in one instance."

Harvests taken predominantly from the Thunder Bay area[1] between 1915 and 1922, averaged over 1.5 million lbs. (Table 12A). A major decline was observed after 1920 but this may as easily be attributable to post-war economic conditions as to a general reduction in abundances. Table 12B suggests a resurgence of herring catches after 1925. It is noted by the biologist Koelz (1929) that:

> "Commercial fishing operations for the species in Thunder Bay date from the Great War, and almost incredible quantities were taken by the virgin fisheries."

In 1980 Mr. G. Humby (pers. comm. Feb., 1980) reported that catches of herring from quota zone 1 approached 1 million pounds, with large and unprecedented catches being taken in the vicinity of Pie Island.

In the years 1975 to 1977, 70 to 95 percent of the annual herring catch was taken from the north end of the bay (grid locations 740-742, 838, 839; Table 22). In 1978 and 1979, 45 percent of the total catch came

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[1] Only limited herring fishing was conducted within Black Bay until the 1930's, and most Canadian Production came from Thunder Bay (Goodier 1981; Ont. Dept. Game and Fisheries Reports).

from this area. Fishermen note that the herring fishery is growing, and currently seeking new grounds.

Apparently mortality rates for Thunder Bay herring were lower in the years 1975 to 1979 than 1962 and 1967 (Table 18). As might be expected by the more intensive fishing effort, total mortality rates for inner Thunder Bay (sample area 1) were higher than those for outer Thunder Bay (sample area 2). Mortality rates for inner Thunder Bay were higher than those for Black Bay (except for the year 1975) while rates for outer Thunder Bay were lower. Over the years 1975 to 1979, sample area 1 fish averaged 1 cm. larger than sample area 2 fish; a significant difference.

Differences in mortality and growth rates may also be linked to the presence of different stocks. It is the opinion of some fishermen that not only are the herring of Black Bay different from those of Thunder Bay, but that distinct movements of different groups of lake herring are to be found within the Thunder Bay region. Koelz (1929) notes:

> "In Thunder Bay, out of Port Arthur and Fort William, Ontario, the schools begin moving in from the west between Pie Island and the mainland about the middle of November and spread northward and eastward. They remain until early December and depart then rather suddenly over the same clay bottom... John and Lew Maloney, James and Frank Gerow, and Oscar Anderson, of Port Arthur, affirm the correctness of the above account."

General movements of herring arond Thunder Cape, northward to the head of the bay and westward toward the Welcome Islands, have also been reported (Mr. G. Tyska, Mr. J. Sameluk, pers. comm. 1980). Differences in spawning periods also suggest stock discreteness:

1) The Indian grounds - spawning begins about November 20th.

2) Welcome Islands - herring appear in 20 fathoms around November 7th to 10th, but spawning generally continues later than in the north end of the bay.

3) Wild Goose Point area - fish appear December 1st in 20 fathoms.

4. North of Caribou Island - spawning begins about November 25th and peaks December 1st.

Catch per unit effort levels have shown a general increase during the 1970's (Fig. 7, A-C). November and December figures have exceeded 1500 lbs./1000 yds. of gill net each year. (A depressed level in 1976 has been attributed to poor weather and market conditions. Whitefish C.U.E.'s may also have been affected; see Table 12C.) Such figures exceed abundance estimates from all statistical districts of Michigan Lake Superior waters made during the years 1970 to 1972 (Peck et al. 1974).

Concern has been expressed by Hamilton (1978b) over an apparent decline in November C.U.E.'s for the bay. Fishermen explain that the depth distribution of herring in November is strongly influenced by temperature and winds: cold weather will drive the fish to the bottom. Unlike the fishermen of Black Bay, Thunder Bay fishermen have only very recently begun to float their nets to take advantage of periods when herring are pelagic (Mr. G. Humby, pers. comm. Jan., 1980). In addition, C.F.-1 data reveal that certain grid locations retained much higher C.U.E.'s in November than the bay as a whole. Catchability coefficients for November and December are almost the same (Table 23).

Despite higher exploitation rates in comparison to the rest of the Bay, C.U.E. levels of the North end have remained high; i.e. in excess of 3000 lbs./1000 yds. of gill net in 1974, 1975, 1977, and 1978, and around

2000 lbs./1000 yds. in 1976 and 1979 (Table 22). Zone B (grid locations 837, 937, 941, 1038-1040) C.U.E.'s have increased from 1500 in 1974 to 3000 in 1979. The Indian grounds (1037, 1136, 1137) have shown lower C.U.E.'s but these are probably biased by the less efficient nature of the fishery. Insufficient catches are made outside Thunder Bay to permit conclusions to be drawn regarding herring abundances.

Averaged over the years 1975 to 1979, the length frequencies of Thunder Bay herring (sample areas 1 and 2 combined; Fig. 5, A-G) and Black Bay herring are similar (with an identical mean length of 34.6 cm. and similar standard deviation, except in 1978). This may relate to a comparable age composition. In 1974 and 1976 Black Bay herring samples averaged 5.0 and 4.7 years respectively, thus satisfying the minimum requirements of the Abrosov model (Table 19; see Section 2.2).

The Schaefer logistic model predicted a maximum equilibrium catch of 560,000 lbs. based on the years 1956 to 1979 (Table 24,A -C). However, an unreasonably high catchability coefficient, as predicted by the computer program TCPF7, has, undoubtedly, strongly biased the result.

4.1.1.1 RECOMMENDATIONS

The currently proposed overall bay quota is 650,000 lbs. (500,000 lbs. with a hold-back of 150,000 lbs. round weight). On the basis of the above evidence,it is recommended that the fishermen's request for this increase be considered, conditional upon subdivision of quota zone 1 into smaller subzones. Those already proposed by the fishermen and Mr. R. Hamilton seem to be satisfactory.

On the basis of C.U.E.'s alone, there ~~is~~ are no obvious criteria for partitioning the quota. Special emphasis should be placed on the opening of new grounds. Encouragement should be given to shifting fishing effort to times of the year other than November and December.

The Ministry should make efforts to age herring scale samples from Thunder Bay (1975 to 1980) and, in the light of this data, review the quota in 1982 or 1983. Examination of C.F.-1 forms prior to 1956 could shed more light on the potential herring productivity of the bay (this is the stated intention of the Fisheries Assessment Unit, pending time and available funds).

4.1.2 BLACK BAY - QUOTA ZONE 2

The first major herring fishery in Black Bay began in 1939 from Camp V dock (Squaw Bay), although limited fishing from Hurkett had commenced many years previously. At this time only 2 1/2 inch nets were allowed, all of which were cotton (Mr. V. Bergman, pers. comm. June, 1980). As in the Thunder Bay fishery, mesh sizes were progressively increased to 2 5/8 inches and then to 3 and 3 1/4 inches. Trawling first began in 1962. Today it employs 1 1/4 to 2 inch mesh. (Trawling was a part of the Thunder Bay fishery in the late 1960's and early 1970's, but is absent today.)

The decline in C.U.E.'s apparent in Thunder Bay in the 1960's was also evident in Black Bay, although levels remained somewhat higher. Prior to 1971, ages 4 and 5 dominated the catch, with age 5 herring being most abundant. This situation,accompanied by increased growth rates, suggested an unstable herring fishery (Rahrer and Elsey 1972; Table 19). Such age structure and growth rate modification has also been described by Clady (1967) for an over-exploited herring population (in Birch Lake, Michigan).

A herring quota was imposed for Black Bay in 1972. After 1971, although age 5 fish were still dominant in the catch, recruitment of younger age classes increased; this suggests improved reproduction. In addition, fish of age 7 appeared for the first time in 1971 and were followed by fish of age 8 in 1974.

Decreases in the growth rates of older age classes were evident after 1971 and most pronounced in 1976. The samples of 1976 were characterized by what Hile (1936) called a "cisco-type" of growth, i.e.:

> "...a rapid growth in length during either the first or second years of life, followed by a gradual decrease in growth rate there after" (Clady 1967).

Mean increase in fork lengths of Black Bay herring was 1 cm. between 1975 and 1979, indicating a decrease in a trend which had been seen since the early 1960's (between 1966 and 1972, mean fork length increased approximately 4 cm.).

Gillnet C.U.E. estimates for 1977 to 1979 were high and at pre-1961 levels (Table 21). Hamilton (1978d) reports a slight downward trend in trawl net C.U.E.'s, based on catch per hour estimates for the years 1973 to 1978. He notes:

> "Outdated and worn-out trawls have been suggested as a reason for the slight decline. It most be realized that the experience of the fishermen and use of sonar and radar should have the opposite affect on this fishery. The present trend of the trawlers partially switching to gillnets and fishing at other times of the year may be the factor required to resolve this problems."

C.U.E.'s based on catch per lift estimates also reveal this trend (Fig. 7, E). It should be noted, however, that post-1970 C.U.E.'s have tended to be higher than those from before 1970. On the whole, trawl net abundance estimates have shown more stability that gillnet figures. With the exception of three years, all C.U.E.'s from 1962 to 1978 have been within the range of 4,900 to 6,500 lbs/lift.

Herring spawn at an earlier date in Black Bay than in Thunder Bay. In late October or early November, the species "hits bottom", and moves onto the spawning grounds a short time later. The floating of fall herring nets has been a feature of the Black Bay fishery far longer than the Thunder Bay fishery, and a greater proportion of the catch is taken in months other than November and December. In fact, during the 1970's the December fishery has declined steadily in importance (Table 21).

In the fall, herring push northward as far as the head of the Bay, although the most intensive fishing occurs south of Enterprise Bay (based on examination of C.F.-1 summaries by grid location). Trawling grounds cover much of the eastern side of the bay. While not all fishermen are pursuing their trade intensively, block licenses cover the rest of the bay's area, and it is presumed that most herring grounds are known to the fishermen, and that many are currently being exploited.

The possibility that different herring stocks have in the past, and perhaps still frequent Black Bay in the fall has been raised by a number of fishermen. Various classes were commonly recognized and known as "green backs", "bluefins", "brown-backs" and so one. According to some fishermen, certain of these have been lost from the bay, although the reason for this is not clear. Koelz (1929) notes that Black Bay herring were known to be deeper bodied and more compressed than those of the main lake.

The dynamic pool model supported the current quota of 1.55 million pounds (Table 25), while the Schaefer logistic model suggested it might be increased (Tables 24, D and E). The limitations of both models have been discussed above.

4.1.2.1 RECOMMENDATIONS

Current fishing levels and existing data do not seem to warrant a sudden large increase in the zone quota. Recent high C.U.E. levels and the improving age structure of the samples from 1971 to 1976 suggest that the population has been gaining in strength. The O.M.N.R.'s current policy of incrementally increasing the quota by 50,000 lbs. annually is considered a wise one. The 1980 quota was 1.55 million pounds.

As mentioned already, recent herring samples should be aged at the earliest opportunity.

4.2 CHUB

4.2.1 QUOTA ZONES 4 (A AND B) AND 5 (A AND B)

Current O.M.N.R. estimates for chub quotas are based on a maximum sustainable yield (MSY) figure of 1/2 lb./acre for waters 50 to 100 fathoms. This figure has been augmented in statistical district 1 by an additional 1/4 lb./acre for waters 100 fathoms and greater. Such an addition has not, as yet, been proposed by O.M.N.R. for zones 4 and 5.

The source of the MSY estimate is not clear. Minutes for the O.M.N.R. Fishermen's meeting in August 1980 report its origin in experience with chub populations in eastern Lake Superior and in American waters. W. MacCallum (pers. comm. Nov., 1980) reports that it has been calculated as a percentage of Ryder's (1965) overall estimate of the potential fish production for all species of Lake Superior, based on morphoedaphic index (M.E.I.) calculations. These relate production to the abiotic factors of mean water depth and total dissolved solids.

M.E.I. estimates have become popular among many fisheries biologists as predictors of fish yield. Their popularity is not without some justification when applied at the level of large whole lake ecosystems. Still, it is obviously a crude estimate and, in the case of individual lakes, may be strongly biased by the action of a number of biotic and abiotic factors. Matuszek (1977), for example, considered catch data from the period 1934 to 1948 as the best indicator of the potential average fish yield for Lake Superior. He estimated a potential yield (all fish species) of 1.19 kg/hectare/year (lbs/acre/year) compared to Ryder's (1965) estimate of .83 kg./ha./year. Matuszek notes:

> "... for specific lakes a two-step process may be best: the calculation of a timely, rough, empirical prediction followed by a more lengthy development of a more accurate prediction of maximum sustainable yield."

In certain instances, whole lake M.E.I. estimates might be refined by applying the calculations to individual basins. M.E.I. calculations by Hamilton (1979), however, greatly underestimated the apparent historical harvest capabilities of Thunder Bay and Black Bay. (These M.E.I. estimates were not used for the proposed quotas). Application of M.E.I. calculations to open areas of water are likely to be even more biased, through ignoring movements of stocks between different zones and depths and variable fishing patterns within zones (especially when zones are as large as 4 and 5). The Ministry of Natural Resources should therefore justify the validity of the 1/2 lb. per acre MSY estimate for chub. Is it based only on estimates from waters deeper than 50 fathoms? It is clear that chub production may come not only from waters greater than 100 fathoms, but also from strata less than 50 fathoms. Experience in American waters indicates that the greatest abundances (and possibly the greatest productivity) occur in these shallower waters (Jobes 1947; Dryer 1966; Wells 1968; Reigle 1969).

Eastern Canadian waters have supported a growing chub fishery since the early 1970's. Chub fisheries have been established for longer periods of time in American waters, and certain areas have recently been showing declines in abundance and production (Schorfhaar 1977; King and Swanson 1978).

The chub fishery of western Canadian waters is a very recent one. Only low levels of exploitation occurred in zones 4 and 5 prior to 4 years ago. C.U.E.'s have been far higher than any estimated from eastern Lake Superior and the American waters of Lake Superior and Lake Michigan (Tables 27 and 28; Peck et al. 1974; King and Swanson 1978).[1] Although the present C.U.E. levels of quota zones 4 and 5 undoubtedly do not represent the long-term productive capacity of a thriving fishery, they do point to high chub abundances in these waters.

Ignorance of the age structures of western Lake Superior chub populations, and the very recent development of the industry, prevented the application of surplus production models. It also makes biological assessment difficult.

Survival rates estimated from length frequency distributions are high (even assuming overestimation; see Section 3.4.2): approximately 0.50 to 0.55 in 1977 to 1979 for offshore waters of sample areas 4 and 9. Even higher was the rate calculated for 360 samples taken from eastern Nipigon Bay in 1979.

Jobes (1947), also using length-frequency distributions, estimated survival rates of 0.35 for Lake Michigan bloaters in 1930 to 1932. This was a period of stability for the chub populations, with low exploitation.

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[1] In Michigan Lake Superior waters, Reigle (1969) found chub abundances to have been lowest in the eastern end of the lake (Whitefish Point area).

Survival rates between 1963 and 1972 ranged from 0.23 to 0.31 based on the age composition of bloater samples (Keller et al. 1974). Aged chub samples (species unknown) taken in 1971 and 1972 from the Michigan waters of Lake Superior revealed survival rates of 0.36 to 0.43 for ages 6 to 9 (statistical districts MS2, MS3, and MS6; Peck et al. 1974).

The mean lengths of chub from sample areas 4 and 9 were 27.2 cm. in 1977 to 1979. Examination of growth data derived from a number of Great Lakes studies of *Coregonus hoyi* and *Coregonus kiyi*, suggest that this represents a mean age of 5 years (Scott 1961; Carlander 1969; Ontario Ministry of Natural Resources 1973; Keller et al. 1974; Brown 1979). This satisfies the criteria of the Abrosov (1969) model as described in Section 2.2 (assuming a mean age of maturity of 3.0 years for the chub populations).

The chub fishery of quota zone 4 is distributed over a number of different grounds, with especially high catches being taken in the Fluor Island area (grid locations 551, 651, and 652), south of Simpson Island (555 and 556), and southwest of Copper Island (560) - all located east of Nipigon Strait.

The major grounds of zone 5 are situated in the northeast corner, among the extensive series of shoals known as the Pic Bank. In 1978 and 1979, 52 and 73 percent of the total zone 5 catch came from grid locations 769 to 771 and 870. C.U.E.'s from these banks are the highest in western Lake Superior.

4.2.1.1 RECOMMENDATIONS

The chub fishery of zone 4 surpassed the quota of 233,888 lbs. in 1977. District summaries issued by O.M.N.R. report a catch of approximately

200,000 lbs. in 1978, while calculations for Table 28 show a catch of approximately 160,000 lbs. On the basis of the apparent abundances and health of the resident chub populations, an experimental increase of 15 percent is suggested for 1981 making an overall zone quota of 270,000 lbs. round.

Annual chub harvest in zone 5 has increased steadily since 1977, but in 1979 was still only about 75 percent of the zone quota. It must be assumed, therefore, that the major problem among fishermen of this zone is one of allocation - too many obtaining permits who do not effectively fish them. Insufficient data exists to determine whether the current quota represents the long-term production capability of the present grounds. The fishery should be closely monitored and any increase should be reviewed as soon as chub samples have been aged.

4.2.2 THUNDER BAY - QUOTA ZONE 1

From 1956 to 1965 chub production from quota zone 1 averaged 43,756 lbs. round, with a peak of 24,911 lbs. (Table 27). A slump of ten years followed 1965. Production for the past five years has averaged 25,740 lbs. (excluding 1977 when catch and C.U.E. was abnormally low), and abundance estimates have been in great excess of pre-1966 levels.

Only 15 chub samples were available from Thunder Bay (prior to 1980), and population assessment is not possible. The most important chub grounds lie east of Thunder Cape and south west of Pie Island.

The recent zone quota increase of 25,000 lbs. has proven satisfactory to the fishermen.

4.3 WHITEFISH

4.3.1 THUNDER BAY - QUOTA ZONE 1

A brief survey of historical records dating from before 1950 (and the ravages of the sea lamprey) yields startling accounts of the productivity of the Thunder Bay District. For approximately 30 years prior to World War I, the Thunder Bay-Black Bay area sustained total annual whitefish catches of 150,000 to 300,000 pounds (Table 12A). The Department of Marine and Fisheries report for 1886 notes:

> "During the first three weeks of December 179,000 lbs. of whitefish were caught in Thunder Bay alone."

A sharp decline in 1914 was marked by a shift in effort to the herring fisheries. Inspector Duncan wrote in 1911 that:

> "The west end of Lake Superior is about depleted of whitefish and trout, as a result of overfishing with pound and gillnets." (Canada Department of Marine and Fisheries Annual Report 1912).

Few subsequent references were available, except the following by hatchery manager McNab (Dec. 31, 1920):

> "The catch of Whitefish taken from the waters in the vicinity of Caribou Island beats all records...nearly 32 tons... [one fisherman] with a gas boat from Oct. 15th to Dec. 15th killed over 10,000 lbs. of Whitefish.
>
> The estimate of Whitefish peddled all over the city over and above what went through the Booth fish house is 40,000 lb. The above catch does not include the spring fishing by three tugs, 30 days fishing in Thunder Bay. Each Tug kills Whitefish and Trout 24,000 lb. Nearly all the fish were killed at the lower end of the Bay.

Since 1960 Thunder Bay has shown a general upward trend in C.U.E.'s, especially during the fall (September to November) fishery (Fig. 4, A-C). The regression of C.U.E. versus cumulative catch (used in estimating catchability coefficients) supports this, showing positive slopes which were greatest for the fall season (Table 14).[1]

During the years 1974 to 1979, 70 to 75 percent of the annual zone 1 catch has come from the north end of Thunder Bay (grid locations 740-742, 838-841). Despite this concentration of effort, C.U.E. levels have remained above 200 lbs./1000 yds. of gillnet, and no decline is apparent (based on the data of Table 13). The traditional grounds about Caribou Island yield the highest catches (grid locations 741 and 742). C.U.E.'s from the rest of quota zone 1 have generally been lower. Large fluctuations are visible in area B (grid locations 837, 937, 941, 1038, 1040), while insufficient catches are made outside Thunder Bay to make abundance estimates meaningful (grid locations 1041-1043, 1138-1142). Estimates from the Indian grounds (grid locations 1037, 1136, 1137), were around 105 lbs./1000 yds., but these may be abnormally depressed due to the relative inefficiency of the fishery.

Biases in estimating total mortality rates and mean ages of the whitefish catch have been introduced by fluctuating year-class strength. The 1974 year-class was weak (Table 9), and its entry into the fishery accounts for the apparent decrease in mean age and mortality rate of sample area 1 (inner Thunder Bay) whitefish in 1978 and 1979 (Tables 1 and 10). Analysis of sample area 2 (Outer Thunder Bay) samples is further confounded by a strong 1972 year-class, a phenomenon not apparent in inner Thunder Bay (or in Black Bay). This year-class has abnormally depressed the mean age of 1975.

Considering quota zone 1 as a whole, the mean ages of Thunder Bay whitefish do not satisfy the requirements of the Abrosov model as stated

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[1] The low C.U.E. estimate for 1976, as determined by Hamilton 1978a (Table 12C), was not supported by the grid analyses of Table 13.

in Section 2.2. However, samples from inner Thunder Bay contained fish older (approximate mean age of 6.0 years) than those from outer Thunder Bay (approximate mean age of less than 5.5 years, taking into account year class variability).

Outer Thunder Bay whitefish tended to be longer and have higher growth rates than those of inner Thunder Bay. Fish from both sample areas show considerable yearly fluctuation in their age-class growth rates but no trends are evident (Tables 8 and 8A, Figs. 2, A, B). On the whole, whitefish from sample area 2 grew faster at ages 3 and 4, but at age 5, were surpassed by area 1 whitefish. All of the outer Thunder Bay samples in 1975 to 1977 came from east of Thunder Bay (grid locations 1051 and 1042; Table 2). Exploitation on these grounds is low and fishing pressure has probably had no effect on growth rate or mean age. All evidence points to the existence of a separate stock.

Fishermen describe different movements of whitefish as occurring within the Thunder Bay area; Mr. G. Tyska (pers. comm. June, 1980), for example, has found 4 varieties of distinctive appearance frequenting the northern waters of the bay. Historical records (such as those of the Hudson Bay Company prior to 1860) reveal that two distinct runs of whitefish could be found on certain spawning grounds. At one time whitefish even ran up the Kaministikwia River, although this stock probably disappeared prior to 1920 (McNab Sept. 18, 1920; Goodier 1981). Further data analysis may reveal Thunder Bay and vicinity to be characterized by a number of different stocks.

During the years 1975 to 1979 no samples were taken from the Welcome Island grounds (grid locations 937-939). Samples from the Indian fishery of 1978 (grid location 1136), show an overwhelming representation of age 6 fish (82 percent, a higher percentage for a single age class than in any other grid location for any year). It is important that 1979 and 1980 samples from the Indian grounds be analyzed to discover if this situation has continued. MacCallum (1980) writes:

> "The number of year-classes that should be contributing to the fishery is also a question that must be answered. A review of the published literature shows that no author recommends that the fishery be based on one year-class. Most authors recommend at least two year-classes, and preferably three. The Manitoba Department of Natural Resources recommends that three year-classes should contribute to the fishery (a contribution is defined as at least 15% of the age distribution) and that two of the year classes should be at least 75% mature (W. Lysack, personal communication).

All grid locations in quota zone 1 (except 1136) have each year supported a fishery on at least two year-classes and in many instances three.

The fluctuating patterns of dominance which are a feature of many coregonid populations have been discussed in Sections 2.3 and 4.1.1. At the recent meeting of the Ontario Council of Commercial Fishermen in Toronto, a number of fishermen proposed "floating" quotas, which would be adjusted upward as soon as it became apparent that a strong year-class had entered the fishery. To reiterate, there are no reliable methods of predicting the advent of these year classes in advance (see also Lawler 1965). Whitefish enter the Thunder Bay fishery at age 3 and attain maximum vulnerability at about age 6 (Tables 10 and 11). Two years of sampling data would be required to ascertain year-class strength, thus maximum vulnerability would be achieved before quota modification could be implemented. By this time a significant proportion of a weak year-class might already have been removed by a fishery operating under a high quota. In addition, the reproductive success of whitefish, like herring (see Section 4.1.1), is not necessarily related to year-class strength, but is under the control of a number of uncontrolable factors, such as temperature, wind, ice thickness, and species interactions (Anon n.d.; Christie 1955; Cucin and Regier 1965; Ebener 1980). It has been the conclusion of a number of researchers that a floating quota, with its "boom or bust", economy can lead to species instability and is less desirable than attempting to arrive at an optimum long-term yield (Miller 1949; Christie 1963: Bell et al. 1977).

Neither the Schaefer logistic model, nor the Ricker dynamic pool model (using M = 0.45), indicated that the proposed overall bay quota should be raised. If, on the other hand, M is set greater than 0.70 (i.e. a natural mortality rate of more than 50 percent) the Ricker model would tend to indicate that such an increase was in order (see Section 3.5). It is believed that the results of the logistic model have been strongly biased by an unreasonable catchability coefficient being generated by the computer program TCPF7.

4.3.1.1 RECOMMENDATIONS

Present Thunder Bay harvests are below the O.M.N.R. proposed zone quota of 106,200 lbs. (94,400 lbs. with a hold-back of 11,800 lbs), but the industry is considered a growing one. Average annual catch from 1970 to 1979 has been 61,000 lbs. round, with a peak of 86,000 lbs. in 1975 (as reported by Hamilton 1978a; Table 12C).

Despite the present high C.U.E.'s of the North-end, it is desirable that new grounds should also be opened if any significant increase in the proposed quota is to be contemplated. Division of the zone into smaller subunits would improve the O.M.N.R.'s ability to monitor and manage individual stocks and fishing grounds; certainly an ideal of any fisheries management scheme. Such a step would allow the overall bay quota to be raised. Preferential treatment in quota assignment could be given to traditional whitefish grounds which have shown low exploitation levels in recent times: examples include northern Pie Island, the Hare Island reefs, and the Welcome Islands. As few samples exist from these grounds, a biological survey should be made as soon as possible, and any applied quotas be reassessed in light of this new evidence. In view of the possible dominance of the Indian fishery by one year-class, special attention should be given to these grounds. In subdividing the zone, attention might also be given to the apparent existence of a separate whitefish stock east of Thunder Cape (possible concentrated in the Shangoina Island area).

4.3.2 BLACK BAY - QUOTA ZONE 2

R. Hamilton (1978a) notes:

> "This fishery has also improved over the years but deals in much smaller quantities than Stat. Area 1. The C.P.E. showed good increases to the peak in 1972 but since has followed a definite decline back to the 1967-1968 years... The harvests in spring and fall tend to be quite different in most years. Generally the spring harvest is double that of the fall and with the exception of 1968 and 1972 it is as much as 5 times greater. In later years where the difference is greatest it may be due to pressures being placed elsewhere such as on early herring fishing."

The decline referred to by Mr. Hamilton occurred between the years 1972 and 1974. Except for a slight slump in 1977, steady increases have been apparent since 1974 (Fig. 4, D-G). The low of 1979, shown in Table 12C is not borne out by data calculated for the present report (based on grid location summaries). Table 13 shows 1979 to have had the highest

C.U.E. on record. (The source of the discrepancy between the two estimates is not known, however).

Despite greater harvests the spring fishery has shown the highest C.U.E.'s and most dramatic increases. Fall C.U.E.'s have risen since 1974; at the time they were at the lowest level since 1967 (Table 12C). Plots of C.U.E. versus cumulative catch (1964 to 1974) show a greater positive slope in spring (Table 14).

Black Bay whitefish tend to be younger than those of Thunder Bay. In Black Bay the 1973, rather than the 1974, year-class proved to be a weak one, biasing mean age estimates in each sample year. The average age for years 1975 to 1978 (4.8 years) is probably representative of the true mean age of the population. Despite this low age, 3 year-classes sustained the fishery in 1975 and 1978 and two in 1976 and 1979. In 1978 and 1979 recruitment to the fishery occurred at age 2.

Black Bay whitefish grow rapidly during their third year, and this rate of growth has increased significantly from 1975 to 1979, (Tables 8 and 8A). Total mortality rates increased from 0.68 in 1975 to 0.79 in 1975, and appear to be higher than those of Thunder Bay. On the basis of his study of 27 whitefish populations, Healey (1975) found average mortality of unexploited populations to be 0.49 and of exploited populations to be 0.64.

Samples were taken exclusively from southern Black Bay (grid locations 745, 843-845) in the years 1975 to 1978. It is possible that population parameters differ in more northern locations where significant whitefish harvests are also taken (Table 13). Some fishermen claim to recognize differences in taste and appearance between northern and southern Black Bay whitefish. In addition to influxes of whitefish from the main lake, a resident population has been described (Mr. V. Bergman, Mr. M. Gerow, Mr. J. Nuttall, Mr. A. Nuttall, Mr. W. Pawluk, pers. comm. June, 1980; also see Koelz 1929).

The Schaefer logistic model predicted an equilibrium yield of about 32,000 lbs. round (gillnets and pound nets combined, for the years 1956 to 1979, and 1964 to 1979; Table 15, D,E). The estimated catchability coefficient was more reasonable than that generated for Thunder Bay (see Section 4.3.1).

4.3.2.1 RECOMMENDATIONS

C.U.E. abundance levels suggest that current fishing levels are below their optimum, (although a long term quota is not to be easily determined). It is quite possible that the proposed quota of 41,300 lbs. (37,760 lbs. with a hold-back of 3,540 lbs. round) is reasonable. Although, 1978 and 1979 harvests were high at 90 percent of this quota, it is too early to tell if the increase they represent will affect the bay's whitefish.

Current data, considered in the light of all the assessment approaches described in Section 2, indicate that whitefish of southern Black Bay are beginning to show signs of stress (high growth and mortality rates, low mean age, early recruitment to the fishery). The Assessment Unit should review sample data from 1979 and 1980 to determine if it supports this conclusion. Emphasis sould be placed on gathering samples from the northern half of the bay for comparison. In addition, analysis of Mr. A. Lawrie's data (see Section 3.2) could yield valuable information on the population dynamics of the Black Bay stocks and be of great use to long-term quota management.

Because of the possible presence of discrete or semi-discrete stocks frequenting Black Bay, consideration might be given to dividing the zone into two parts, each with a separate quota assessment (this might prove to be a strategy for raising the overall zone quota).

4.3.3 QUOTA ZONES 3 AND 4A.

Nipigon and Terrace Bay O.M.N.R. offices have proposed that whitefish zone quotas be based upon Ryder's (1965) morphoedaphic index (M.E.I.) calculations. The limitations of applying M.E.I. to quota zone management are discussed in Section 4.1.1 and Appendix I. Since 1977 three different quota proposals have been issued for zone 4A. We recommend that M.E.I. calculations be abandoned as a method of zone quota determination.

In 1978 the Ministry of Natural Resources reported "our records indicate that the whitefish in this zone are presently not being over-harvested." Indeed, C.U.E. levels have steadily increased since the early 1970's in both statistical districts 3 (which includes quota zone 3) and 4. Levels are 5 to 10 times what they were prior to 1960. C.U.E.'s for 1979 were somewhat less than those for 1978 (Tables 12C and 13).

Since 1971 effort has been decreasing with district 3 witnessing the most rapid decline (largely due to fishermen leaving the industry, or shifting their efforts to other species). Catch levels have fluctuated, but district 4 has shown significant increases in the past several years; the 1979 harvest was at a record high.

A majority of the zone 4A harvest is procured west of Nipigon Strait (sample area 3); the largest catches of recent years were made in the vicinities of Point Magnet (grid location 945), Shaganash Island (grid location 846), and Sheesheeb Bay to Clarke Bay (grid locations 648, 747, and 748). In recent years high market prices have stimulated a successful winter fishery in the latter area. Since 1974 C.U.E.'s have generally been greater than 150 lbs./1000 yds. of gill net (Table 13). Grid location 747 has averaged 285 lbs./1000 yds., with a visibly upward trend.

Insufficient annual catches are made east of Nipigon Strait to justify abundance estimates based on C.U.E. calculations. In 1977 and 1978 Nipigon Bay (quota zone 3) C.U.E.'s were the highest in western Lake Superior, showing sharp increases over those of 1974 and 1975. The major fishery occurs west of Rainboth Point, especially in grid locations 250, 252, and 353.

From 1975 to 1978 sample area 3 samples came exclusively from the Sheesheeb Bay vicinity (grid locations 648 and 748). Far fewer were from area 4 (outside the Nipigon Islands), where grid locations 552, 555, and 558 are represented. (A large number were procured in 1979, but these could not be analyzed by grid location).

Sample areas 3 and 4, and probably also 5 and 6, experienced a strong year class in 1970, and possibly another strong one in 1972. (A strong 1972 year class was also seen in sample area 2 -- Section 4.3.1). Their presence would tend to depress mean age calculations for 1975 and inflate those for 1979. Whitefish of sample area 3 enter the fishery at ages 3 and 4, while those of area 4 enter one year later. The fishery is sustained each year by two and usually three year-classes. It is reasonable to assume that the 1970 and 1972 year classes have had a similar effect on age-structures from the different sample areas and permit direct comparison. The mean age of Sheesheeb Bay whitefish was significantly lower than that of sample area 4 whitefish in 1975, but the same age in 1979. Thus a drop from age 7.0 to 6.1 was experienced by sample area 4 fish (Table 1). Unfortunately, few samples are available from 1976 and it is not known if this has been a continuous trend or merely an aberration of the 1979 sampling year (or the effect of the 1971 year-class).

Prior to about age 6, sample area 4 fish grow more slowly than those of sample area 3 (Tables 8 and 8A). Estimated mean Brody growth coefficients were 0.16 and 0.30 respectively (Table 7). Fig. 2,G reveals even slower growth rates for Nipigon Bay whitefish during the years 1977 and 1978. These growth curves are within the range Healey (1975) describes for moderately exploited populations. (Rate of change was more rapid in 1975, the year in which a majority of the samples came from grid location 353). Nipigon Bay whitefish possess the oldest age distributions found in western Lake Superior (with a mean age of over 7.0, taking into account the effects of the strong 1970 and 1972 year-classes). They are also characterized by the smallest mean lengths (Table 1). Such evidence supports the contention of some fishermen that Nipigon Bay whitefish (at least from the western portion) are peculiar to these waters, and tend to remain within the bay. These bay whitefish, like the former stock of bay lake trout, tend to be shorter but deeper than those of the main lake (Mr. F. Legault, pers. comm. July, 1978; Mr. W. Schelling, pers. comm. June, 1980).

It is certain that in a quota zone as large as 4A, a number of different whitefish stocks also exist. Significant differences are even to be found, for example, in the mean age and size of whitefish taken inside and outside of Sheesheeb Bay. Fish from grid location 748 are older and longer than those from 648 (Table 2). The growth rate of whitefish from the latter location decreased steadily between 1975 and 1978. Samples taken in 1975 and 1976 from grid 748 show an increase instead (Table 6). While such evidence is somewhat ambiguous, and can suggest the effects of differential fishing pressures, it could also indicate the presence of different stocks. It is obvious that assigning large quotas to large quota zones increases the possiblility of overfishing single stocks if fishing effort is concentrated in small areas of the zone.

The Schaefer logistic model predicted a maximum equilibrium catch of approximately 90,000 lbs. for statistical zones 3 and 4 combined (essentially the same as quota zones 3 and 4A combined). It is believed that this is an underestimate when this area is considered in smaller subunits.

4.3.3.1 RECOMMENDATIONS

Quota zone 4A is unmanageably large. We propose that it be divided into two at Nipigon Strait, and that quotas for the two parts be assigned separately.

The low intensity of the fishery east of Nipigon Strait, and the apparent strength of the whitefish populations as reflected in their age structure, suggests that significant increases in production could safely be allowed. The possible reasons for the decrease in the mean age of the 1979 samples should be considered in more detail, however.

C.U.E. levels west of Nipigon Strait are high and suggest an increase in production would not be unwarranted. However, samples have not been obtained from a number of major grounds (1975 to 1978) and thorough assessment of whitefish population status is not possible. It may be of advantage to both the fishery and fishermen east of Nipigon Strait if the development of new whitefish grounds were encouraged (to avoid excess pressure being placed on old).

Nipigon Bay (quota zone 3) whitefish are not displaying signs of stress, and room is therefore available for industry growth. Current fishing levels are at about 60 percent of the proposed quota of 46,181 lb. round (Table 13). This is a reasonable first estimate for a new quota. If the industry grows to meet this quota, reevaluation should be undertaken; a further increase might be possible at that time.

In the process of making any quota boundary changes, consideration should be given to the possibility that the Nipigon Bay fishery is exploiting at least two different stocks of whitefish: resident bay fish, and those that migrate in from the main lake. More samples are required from sample area 5 (where one would expect the greatest concentrations of resident fish).

4.3.4 QUOTA ZONE 5A

The original proposed quota for zone 5A was 25,000 lbs. round weight. The Terrace Bay office of the O.M.N.R. reports this to be the average current harvest, although C.F.-1 summaries indicated lower levels (Table 13). The source of the discrepancy is not known.

Average C.U.E. from 1974 to 1979 was 160 lbs./1000 yds. of gill net; i.e. about 40 percent lower than those of quota zones 3 and 4A. In 1978 and 1979 increases occurred, however.

Few samples are available from sample area 9. Whitefish in sample area 8 enter the fishery at age 5. The strong 1970 year-class noted in section 4.3.3 was especially dominant in this sample area: it comprised 80 percent of the sampled catch in 1977 (Table 4; Fig. 1,H). Despite this preponderance, a significant proportion of the 1977 and 1978 catch (over 10 percent) was comprised of fish 10 years of age and over. This increase in the percentage of older fish parallels decreases in mean age class lengths over 1975 to 1976 levels (Table 4). Older fish appear to have been more susceptible to the gill nets in 1977 and 1978.

The logistic model indicated that present fishing levels were well below maximum equilibrium yield (Table 15,J). On the other hand, the Ricker dynamic pool model does not support this conclusion, when calculated using the growth and mortality rates of Table 16. It is possible that the mean natural mortality rate is underestimated, however: employing a 52 percent natural mortality (M = 0.73) would recommend an increase.

4.3.4.1 RECOMMENDATIONS

The above evidence suggests that there is some room for fishery expansion. The major catches are currently being made on the grounds from Terrace Bay to Jackfish. Old-timers from Marathon, Heron Bay, Port Coldwell, and Jackfish report a number of more eastern grounds as having been once (and perhaps still) of high productivity.

We recommend an increase of 5,000 lbs. over the proposed quota -- i.e. 30,000 lbs. round.

4.4 PERCH

Yellow perch (*Perca flavescens*) quotas have been proposed for both Black Bay Nipigon Bay. The fate of both fisheries rests to a large extent on future O.M.N.R. policy regarding the reestablishment of walleye (*Stizostedion vitreum*) populations. The recovery of this species could mean a closure of the perch fisheries of the two bays (quota zones 2 and 3).

The general scope of our study precluded a detailed examination of perch data. In both Nipigon Bay and Black Bay, exploitation was limited until 1972. Mr. R. Hamilton has reviewed data from Black Bay which indicates that the resident perch population is growing in vigour. Samples have been aged for the years 1974 and 1977. Samples from 1974 were dominated by age groups 3 and 4, but by 1977 a shift had occurred, and the fishery was cropping major percentages of age 6 and 7 fish. Hamilton (n.d.) has summarized what is currently known about Black Bay perch:

> "The yellow perch have been quite cyclic with population abundances occurring every fourth year (i.e. 1972, 1976). The trend in the years between the boom years has been a slow but steady increase. Originally the fishery was dependent on only one or two year classes, but this has changed and the fishery now harvests from 3 or even 4 year classes.
>
> Generally the harvest and catch per unit effort are increasing. A harvest level of 120,000 lbs. is available in most years and it would seem that in some years even a greater amount could be taken. Because of this and new aspects of the perch fishery the ministry will hold an additional 20,000 pounds of quota which may be allocated under the following circumstances:
>
> 1) If the harvest statistics showed an exploratory expansion of the fishery was warranted,
> 2) When it is indicated that many fishermen are not filling their quotas while others have and wish to continue fishing this species,
> 3) Some new fisheries have only fished perch for one year and have not had a chance to establish their potential."

In 1979 96,999 lbs. (round) of perch were taken from Black Bay (based on C.F.-1 summaries issued by the Toronto O.M.N.R. office).

No perch samples from Nipigon Bay (quota zone 3) have been aged. Local fishermen have accepted the proposed quota of 30,000 lbs.

4.5 LAKE TROUT

As in the case of perch, we have regarded an assessment of the status of lake trout (*Salvelinus namaycush*) populations as outside the scope of this study. Unlike perch, much has already been written concerning the lake trout by both Ontario and American government agencies. Since the late 1950's, and the advent of the sea lamprey, much attention has been paid to establishing a firm data base for *S. namaycush.*

Appendix I reviews the history of lake trout quota management in western Lake Superior. Both fishermen and government agencies attest to the great abundance increases that have been seen in the 1970's (Lawrie 1978). Despite this fact, quotas have not been changed since 1967. The O.M.N.R. states that they are currently under review. Due to international agreements, and to the high priority which the Ontario government places upon lake trout rehabilitation, it will not be on the decision of district offices alone that quotas will be raised.

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APPENDIX I

WESTERN LAKE SUPERIOR FISH QUOTAS:
A REVIEW

July 14, 1980

(A study supported by the Ontario Council of
Commercial Fisheries).

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GENERAL CONSIDERATIONS -- RULES AND REGULATIONS

Rules and restrictions are imposed upon fishermen in the form of regulations and license (or permit) conditions. Regulations are comparatively difficult to change, requiring the approval of both the federal and provincial governments. Regulations reflect long-term fishing policies. Conditions, on the other hand, are imposed at the discretion of the regional or district offices of the Ministry of Natural Resources. These may be subject to review and change from year to year.

A fisherman will require either a permit or a license to fish, depending upon the species sought and the location of the grounds. An "exploratory" or "experimental" permit must be applied for each year, and it may be cancelled at any time by the Ministry of Natural Resources. Licenses, on the other hand, cannot be changed during a fishing season without the permission of the fishermen involved. To be precise, licenses are not renewed each year but reissued. Fishermen must obtain a license or permit for each quota zone in which they wish to fish (Fig. 1).

The traditional method of licensing in western Lake Superior is the block system, which has existed, with modifications, since the late 1800's. A fisherman enjoyed exclusive fishing rights on his block and was permitted to sell his block with his license. In time blocks became vacant (especially during the fishing doldrums of the 1950's and 1960's when the lake trout populations collapsed) and were regarded as common property. When lake trout quota changes were institued in 1976 (see below) it was considered desirable to gradually phase out the block system:

> "For the transition period a fisherman may elect to drop his exclusive right to his present block and fish any part of the zone he is licensed in except "restricted areas and occupied blocks. A fisherman may elect to retain his present blocks for a number of years but if so, he must fish only inside his own blocks." (OMNR Dec., 1974).

In Thunder Bay and Black Bay many fishermen elected to retain their blocks. In Black Bay, at least, fishermen will fish a block other than their own with permission, and some sense of cooperation and mutual consideration has developed among these fishermen over the years. In Thunder Bay (Zone 1) letters of authority from the Ministry are required for unoccupied areas. In Zone 4A only two blocks remain and perhaps a similiar number in Zone 5A.

There are no blocks associated with a tug license. An operator must obtain a separate license for each zone he wishes to fish but may fish anywhere within the zone except on occupied blocks or restricted areas.

In general,

- chubs must be taken from waters greater than 50 fathoms
- whitefish and lake trout may be taken with a minimum 4½" mesh extension measure, and no 4½" mesh or larger is permitted after the lake trout quota is taken
- 2¼" to 3¼" mesh multifilament nylon gill net may be used to take chub
- herring and ciscoes may be taken with gill nets less than 4½" extension measure, but nets may not be set in more than 10 fathoms of water.

Species currently on quotas in western Lake Superior include:

- lake trout in all zones
- herring in Black Bay
- chub (by license or permit condition)

In view of the slow expansion of the western Lake Superior fisheries and the potential danger of overharvesting, the Ministry of Natural Resources has proposed quotas on all species. These will take effect in 1981. To avoid certain problems encountered with the open quota policy of eastern Lake Superior, it is intended than a system of individual quotas will be introduced for western waters. The reasons for these decisions have been summarized in a paper entitled "Rationalization -- Commercial Fishing Quotas and Why" (Hamilton 1980) and circulated among the fishermen.

In addition to certain of the proposed zone quotas, the Ministry will retain certain hold-back poundages. These, they state, would be used under the following circumstances:

"1) All the harvest statistics showed that an exploratory expansion of the fishery was warranted.
2) Exploratory fishing of new grounds to validate economically viable fisheries.
3) When it is indicated that many fishermen will not be totally filling their quotas and an allocation from the hold-back will not exceed the total zone quota. The allocation in this case would be to those who have filled their quotas."

(OMNR Jan, 1980. Letter to all Commercial Fishermen).

QUOTAS -- PAST, PRESENT, AND PROPOSED

A. THUNDER BAY DISTRICT

WHITEFISH

Zone 1*

The proposed quota is 80,000 lb. dressed (94,400 lb. round) with a hold-back of 10,000 lb. dressed (11,800 round).

Total yearly production in Thunder Bay has usually been well below this quota, but the fishery is growing.

Average annual production	1960 - 69	30,499 lb. round
	1970 - 74	62,221 lb. round
	1975 - 79	59,645 lb. round

* Note, the present quota zones 1 and 2 are the same as the Statistical Districts 1 and 2 (Fig. 2).

Zone 2

The proposed whitefish quota is 32,000 lb. dressed (37,760 lb. round) with a hold-back of 3,000 lb. dressed (3,540 lb. round). This quota was approached in 1978 (37,352 lb. round) and possibly in 1979.*

Average annual production	1960 - 69	14,785 lb. round
	1970 - 74	27,902 lb. round
	1975 - 78	26,968 lb. round

HERRING

Zone 1

The proposed quota is 500,000 lb. round with a hold-back of 150,000 lb. round,

The Ministry of Natural Resources proposal, which was presented to the fishermen, states:

> "There is no question that this fishery has some room for expansion over its present 300,000 to 400,000 lb. harvest. As this fishery expands it may validate a further expansion of the herring quota."

Average annual production	1960 - 64	832,777 lb.
	1965 - 69	366,739 lb.
	1970 - 74	406,930 lb.
	1975 - 79	403,057 lb.

Production in 1979 was 607,135 lb. round.

Rahrer and Elsey (1972) reported declining C.U.E. estimates in the 1960's and early 1970's, although it is not yet known if this trend has continued. These authors remark:

> "The status of any fish stock which is determined from C.U.E. estimates, such as those from Thunder Bay, can only be tentative at best. The C.U.E. estimates are probably influenced by such factors as market conditions, weather, and changes in the fishery such as the switch of a progressive fisherman from gill nets to trawls."

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* Mr. R. Hamilton (personal comm. 1980) reports a catch of 21,216 lb. round in 1979. Summaries issued by the O.M.N.R. office of Toronto report a catch of 47,429 lb.

All of these points are also stressed by the fishermen I have interviewed. In 1971 77 percent of the November to December catch was taken with trawls (Rahrer and Elsey 1972), but in 1980 trawls are absent from the bay.

Zone 2

The first herring fishery in Black Bay began in 1939 from Camp V dock (Squaw Bay). Trawling was introduced in 1962 and escalated after 1967. The popularity of gear prompted the fishermen to agree among themselves that the number of trawls would be limited to five.

Since 1960 Black Bay has supplied over 50 percent of the total herring catch made in Canadian waters. In 1967 and 1968 Black Bay contributed over 70 percent of the total production (Rahrer and Elsey 1972).

In 1972 the Department of Lands and Forests (MNR) first imposed a herring quota of 1.5 million lb. round weight. It is explained that this was due to the C.U.E. fluctuations and accelerated growth rates. (Herring ran 3 to the lb. in the early 1950's; now they average 1 lb. each. Mr. B. Hamilton, personal comm. 1980). In addition, Rahrer and Elsey (1972) also report an increase in the average age in 1971, along with the unprecedented appearance of age VII fish (prior to 1971 ages IV and V dominated the catch). This appears to have also been the case in 1972 and 1973, but data from subsequent years has not yet been examined.

The present 1.55 million lb. quota is allocated as 100 tons round to each of the trawlers, and the rest to the gill net fishermen (ranging from 16,000 to 200,000 lb. round each). The eastern portion of the bay north of Foster Point constitutes the trawling zone.

CHUB

Zone 1

Thunder Bay District does not contain important chub waters. Traditionally in Zone 1 most fishing has concentrated south of Thunder Cape. New grounds are gradually being opened, however.

In the 1950's and the first half of the 1960's, Thunder Bay supported a small chub fishery with a peak in 1958 of 74,911 round. Average production from 1956 to 1965 was 43,756 lb. (reported weight). From 1966 to 1974 few chub were taken, until in 1975 an experimental permit fishery was established.

The Ministry's chub quotas are based on a potential production figure of ½lb./acre (derived from literature values) calculated for waters 50 to 100 fathoms. The Zone 1 quota is set at 20,000 lb., somewhat higher than this production figure dictates (i.e. 16,542 lb. Mr. R. Hamilton, personal comm. 1980).

In 1979 (1980?) fishermen argued that chub production also occurs in waters below 100 fathoms, which are not included in the quota calculations. Bob Hamilton agreed to an additional 25,000 lb. on permit, on condition that it be obtained from new fishing grounds.

In Thunder Bay District a fisherman who has not fished for 2 years forfeits his right to a chub permit. This is felt to be fair to the fishermen, by discouraging people from applying and not fishing. Chub fishing is on permit only at the present time, but licensed quotas are proposed.

Zone 2

Black Bay can presently support little chub fishing due to the 50 fathom depth regulation. No quota is proposed. Records show, however, that prior to 1966 the Black Bay chub catch frequently equalled or exceeded that of Zone 1. (Average annual production from 1956 to 1965 was

43,468 lb. reported weight, species not known).

It is reported that chub could at one time be taken in Middlebrun Channel in 15 to 16 fathoms of water (Mr. V. Bergman, personal comm. 1980). These are referred to as brown-backed chubs and were known to mix with herring on the grounds. Mr. A. Nuttall (personal comm. 1980) notes that these brown chub were often up to 1½ lb. each, and occasionally they would push far northward into the shallow waters of the bay. The brown chub supposedly disappeared in the late 1950's and a different "breed" was subsequently taken (known to some fishermen as "bloats").

After 1965 insignificant amounts of chub were taken. Ridgley (July 30, 1979) and OMNR (1979) show respectively 26,729 lb. and 27,820 lb. round of chub taken from Zone 1 in 1978 and 1979. Mr. R. Hamilton (personal comm. 1980) explains that these are incorrect in including chub from outside waters.

PERCH

Zone 2

Black Bay supports an important perch fishery, with spawning grounds concentrated in the shallow waters at the head of the bay. Perch fishing was formerly by license, but since 1976 (?) has been allowed by permit only. The proposed quota is not yet known to myself.

LAKE TROUT

Under the impetus of the Great Lakes Fishery Commission, lake trout quotas were first imposed in 1961. In the face of declining lamprey predation, it was hoped that viable lake trout populations could be restored in the Great Lakes. On the Canadian side of Lake Superior, 7 quota zones were established (and Whitefish Bay was closed to commercial fishing (Fig. 3). Quotas were determined on the basis of the number of lake trout samples required by the Fisheries Research Board and the lamprey-control programmes. The fishing season was divided into a spring term and a fall term, and in 1964 fishing was prohibited in January, February, March, and December (subsequently the month of April was also closed).

In 1967 the total area of the offshore zones was enlarged, and their number increased from 3 to 5 (Fig. 4). New offshore quotas were calculated on the basis of .07 lb./acre for water to a depth of 80 fathoms, increasing the total offshore quota from 55,000 to 75,000 lb. As little fishing was conducted in the fall, the two seasons were amalgamated into one (May 5 to Nov. 30). Quotas for the inshore zones remained the same (Anon Nov. 8, 1966).

It soon became very apparent that a small number of fishermen were filling the zone quotas in a short period of time. It has also been noted that market prices were more easily manipulated against the fishermen with the then existing quota system. New zones were proposed based on the existing quota zones and the original statistical districts (Fig. 2) of the Fisheries Research Board. These were introduced in 1975, and the seasonal quotas abolished for the inshore areas. The dividing line between the eastern and western divisions was set at Sewell Point. (There has always been a tradition, however, that east end fishermen would fish as far as the Pic River. In 1978 the dividing line was officially situated at the Pic River -- Fig. 1).* In the west, the total lake trout quota established in 1967 was reduced to take into account the closure of three prime fishing areas:

- the northeast end of Thunder Bay (open for whitefish and only May 1 to June 15, Sept. 15 to Nov. 30, Jan. 1 to March 31).
- the Rossport Islands area (closed completely to gill nets).

(The two existing closed areas, the Slate Islands and Pigeon River to

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* In addition to quota zones and statistical areas, the Lake Superior Fisheries Assessment Unit also utilize 17 sampling areas from Thunder Bay to the Soo (Fig. 5).

Jarvis Point remained restricted). These quota zone changes have not appeared as changes in the regulations.

In 1978 individual quotas were introduced to the inshore zones. These quotas were divided by license condition according to one share per 6000 yd. of net, while offshore zone fishing (zones 4B and 5B) was conducted by permit only.

Zone 1

The total zone quota is 18,200 lb. dressed, divided among the fishermen at 934 lb. dressed (1102 lb. round) per 6000 yd. of gill net license.

When the quota zones were changed in 1975, the new quota for Zone 1 was based on past harvests -- i.e. the sum of the average of the best 3 years of fishing for each fisherman, determined over the previous 7 years (1969 to 1975). A brief sent to all commercial fishermen on Dec. 10, 1975 (signed J. E. Hamilton, District Manager) shows the harvest figures employed in these calculations. These are at great variance with those published in the 5-year summaries of the OMNR:

	Brief (Dec. 10/75)	5-year Summary	
1969	8470	22142	(OMNR 1972)
1970	7369	12142	
1971	9617	17461	(Ridgley 1976)
1972	9353	7683	
1973	2232	4917	
1974	9658	10403	
1975	10243	28342	

The source of these descrepancies is not yet known to myself.

Zone 2

The total zone quota is 5400 lb. dressed, but the figures used in its calculation are not available. Fishermen whose blocks are in the northern part of the bay receive a smaller allocation than those whose grounds are in the southern part, where lake trout populations are far more abundant in the spring and fall. Individual quotas range from 125 lb. dressed (148 lb. round) to 1091 lb. dressed (1287 lb. round). Fishermen are now taking 2/3 of the existing quota (OMNR Feb. 21, 1980. Meeting with Commercial Fishermen, re. Individual Fish Quotas in Black Bay).

An attempt has been made by Wayne Macallum to quantitatively define a state of lake trout rehabilitation in Lake Superior.: surplus yield should be 0.25 kg/ha. and standing stock should be 2.5 kg/ha. (MacCallum April 14, 1980. Notes: definition of lake trout rehabilitation.)

B. NIPIGON DISTRICT

WHITEFISH

Zone 4A

In September of 1977 a quota of 49,300 lb. round was proposed to the fishermen. It was determined by "taking the mean between the average catch per year over the past five years and the average catch per year for the best three years for each fisherman" (OMNR Jan 18, 1978. Letter to all Commercial Fishermen Zone 4A). The zone fishermen refused to accept a quota based strictly on past harvests.

The Ministry noted in 1978 that "our records indicate that the whitefish in this zone are presently not being overharvested", and raised the quota to 66,224 lb. round, based on M.E.I. calculations made by Dave Penny (former fisheries officer 1978). Only waters less than 50 fathoms were considered:

Mean Depth = 270 ft.
Production = .86 lb./acre/yr.
Whitefish production = .344 lb./acre/yr.

Ross Chessle (present fisheries officer, Nipigon) disagrees with the rationale of this method and has recalculated the quota, considering all waters within Zone 4A:

Total area of Zone 4A = 409,249.2 acres

T.D.S. = 50 mg./l. (from Lawrie and Rahrer 1972).

Mean Depth = 402·6 ft.

M.E.I. = .12

Production = $2\sqrt{\text{M.E.I.}}$ = .70 lb./acre/yr.

Whitefish production = 40% of total = .28 lb./acre/yr.

Total production of whitefish = 409,249.2 x .28

= 115,380 lb./yr. (or 52,336 kg./yr.)

Pending approval by the Lake Superior Assessment Unit, Ross Chessle plans to propose this modified quota to the fishermen.

It is worth noting that a new whitefish production figure may be determined by considering the M.E.I. for all of Lake Superior:

Mean Depth = 486 ft.

T.D.S. = 50 mg./l.

M.E.I. = .10

Whitefish production = .26 lb./acre/yr.

Total production of whitefish for 4A = 409,249.2 x .26

= 105,013 lb./yr.

All three methods leave something to be desired.

Zone 3

The proposed whitefish quota for zone 3 is 46,181 lb. round. Ross Chessle believes this number was also arrived at through M.E.I. calculations. At a meeting in 1978 with the four Nipigon Bay commercial fishermen, all agreed to this quota and to its allocation on the basis of one share per 6000 yards of gill net license (9236 lb./share).

It should be noted that Nipigon Bay is divided between the jurisdictions of Nipigon and Terrace Bay MNR offices.

HERRING

No herring quotas are proposed for zones 3 and 4A, and the fishery is not a significant one.

CHUB

Zone 4A

The chub fishery in both zone 4A and 4B has only been developed within the last four years. Until 1979 chub fishing in zone 4A was on permit only. Now an individual's quota is shown as a condition of license.

Potential harvest for chubs was calculated on the basis of ½ lb. per acre for waters between 50 and 100 fathoms for all of statistical area 4 (233,888 lb./yr. -- Fig. 2). This figure was divided appropriately between zones 4A and 4B.

The quota for 4A is 134,962 lb., allocated on the basis of one share per 6000 yd. of gill net license (12,250 lb./share in 1980). Fishermen wishing to fish chub in this zone must relinguish their block if one is held.

Zone 4B

This is an open zone and all chub fishing is on experimental permit only. The total zone quota is 98,926 lb. which is divided equally among all fishermen who have applied by April 15. In 1980 the share per permit is 12,350 lb.

No chub nets may be set within 2 miles of Batteau Rocks.

Zone 3

There is little chub fishing in Nipigon Bay, although some experimental permits have been issued for waters less than 50 fathoms.

PERCH

Zone 3

The original proposed quota was 27,709 lb. The fishermen requested that this be increased to 30,000 lb. which was acceptable to the Ministry. 28,800 lb. will be allocated to the two traditional perch fishermen of Nipigon Bay. It is not known how the the zone quota was determined.

In recent years anglers (the majority docking at Red Rock) have lobbied against the fishermen of western Nipigon Bay. Years ago there existed a gentleman's agreement between the anglers and fishermen that no nets would be set north of Vert Island, from approximately the Jackpine River to Five Mile Point. After the walleye populations collapsed, angling decreased and the traditional agreement was forgotten. Now in 1980, pressure placed upon the Ministry by local angling associations have forced the closure of an area around Hughes Point until June 30th each year.

LAKE TROUT

Zone 4A

The zone quota is 6,400 lb. dressed, with each fisherman licensed for 1050 lb. in 1980.

Zone 3

The zone quota is 11,200 lb. with each fisherman (and the Pays Plat Indian Band) licensed for 2,250 lb. dressed in 1980.

Zone 4B

The zone quota is 4,400 lb. dressed with each fisherman receiving a permit share of 880 lb. dressed in 1980. The Batteau Rocks area is the only lake trout ground in the zone.

C. TERRACE BAY DISTRICT

WHITEFISH

Zone 5A

The proposed quota, as presented to the fishermen was 25,000 lb. This was calculated using a whitefish production figure of .344 lb./acre. (Dave Penney's original calculation for zone 4A) -- "This gave 24,018 lb. of whitefish while catch records averaged 25,000 lb./year" (OMNR Feb. 8,1978). At the request of Jim Chappell (Fisheries Officer, Terrace Bay), Ross Chessle is redoing these original calculations according to the method he is currently using for zone 4A. The modified quota is not yet available.

HERRING

No herring quotas are proposed.

CHUB

Zone 5A

Potential harvest for chubs was calculated on the basis of ½ lb./acre for waters between 50 and 100 fathoms for all of statistical area 5 (456,800 lb./yr -- Fig. 2). This figure was then divided appropriately between zones 5A and 5B.

The quota for 5A is 49,939 lb., allocated on the basis of one share per 6000 yd.of gill net license (12,500 lb./share in 1980). The chub quotas first appeared on the licenses in 1978. Fishermen wishing to fish chub in this zone must relinquish their block if one is held.

Zone 5B

This is an open zone and all chub fishing is on experimental permit only. The total zone quota is 406,861 lb. which is divided equally among all fishermen who have applied by April 15th. In 1980 the share per permit is 27,450 lb.

LAKE TROUT

Zone 5A

The total zone quota is 6,400 lb. dressed.

Zone 5B

The total zone quota is 20,000 lb. dressed, divided equally among all permittees (2000 lb./ fisherman in 1980).

PROBLEM AREAS

Three interrelated problems are most often discussed by west end Lake Superior fishermen:

1) market prices
2) zone quotas
3) quota allocations

All fishermen will not necessarily be in agreement on the emphasis placed on each.

1) MARKET PRICES

The 1980 season is showing significantly depressed prices over 1979. All stand to be hurt, but the small operator will, of course, take the worst beating. Some fishermen have only recently entered the fishery and are in the process of gearing up. At least two have recently invested in new tugs. The seriousness of the situation may be seen by comparing prices in 1979 and 1980:

	1979 - June	1979 - year avg.	1980 - June
Perch	80 - 85¢	80¢ (round)	22¢
Whitefish	54 - 60¢	63¢ (round)	45¢
Chub	62 - 66¢	65¢ (round)	55¢

Overproduction of perch from Lake Erie waters in 1979 has contributed to this specie's low market value.

A few fishermen have expressed concern that raising quotas will only lead to even more deflated prices.

2) ZONE QUOTAS

There is a fear among many fishermen that once quotas are set by the Ministry of Natural Resources, they will remain inflexible through perpetuity. Often cited as a case in point are the lake trout quotas.

The Ministry offices understand the need for periodic quota review, but believe a conservative policy to be the best in the assignment of new quotas. It is, of course, easier to give than to take away. A quota which may be incrementally increased through future years may be preferable to one which is immediately set at a long-term maximum sustainable yield. Ministry personnel are aware of certain inadequacies in their data base and analytical procedures -- this dictates caution in matters of quota assessment.

The fishermen are also aware of inadequacies in the Ministry of Natural Resources' data base and conclude that certain quotas have been improperly assessed. One fisherman, for example, remarks upon the emphasis placed upon C.U.E., which:

> "... is only a record of how many fish were caught and does not reflect such variables as weather, breakdowns of boat or equipment, pursuit of other species if market or availability of species is a factor. Weather alone is a big factor; early spring, hot weather, late spring, cold weather, rough fall, torn nets, inability to set in shallow water all should be considered..." (Tyska Aug. 4, 1979).

Zone 1

Some fishermen have suggested that zone 1 should be broken into four herring zones including:

1) Caribou Islands - North End (showing the best C.U.E.)
2) Welcome Islands (2nd best C.U.E.)
3) Indian grounds (3rd C.U.E.)
4) Outside area (Fluctuating C.U.E.)

The Ministry is receptive to this idea, and Bob Hamilton is currently reexamining CF-1 data on the basis of these proposed areas. (The four areas are also appropriate to analysis by the 5' grid system, currently being used by fishermen to report fishing locations. The system was introduced in 1978 -- Fig. 6). It was suggested at a commercial fish meeting with the Fort William Indian Band (Feb. 27, 1980) that this system, when completed, might give the band a larger herring quota. In October herring move northward into Thunder Bay. It is possible that different stocks are present at this time.

In general, however, it is felt that the proposed quota of 650,000 lb. is too small. Some fishermen have suggested an overall bay quota of 1 million pounds round (including the hold-back poundage).

Dissatisfaction has also been expressed over the proposed whitefish quota. Some believe 100 ton to be more realistic, although at least one fishermen felt this to be excessive. It has been suggested that the zone quota might also be partitioned according to the 4 subzones described above. It is probable that different stocks frequent the bay. Preliminary examination of age frequency summaries for sample area 1 (Inner Thunder Bay -- Fig. 5) and 2 (Outer Thunder Bay) reveal an older age distribution in area 1. It was noted by a couple of interviewees that Thunder Bay whitefish were greasier than those caught outside. Whitefish, like herring, move northward along the shores of Thunder Bay. Different stocks may move along the east and west shores. Three forms of whitefish have been distinguished in the northern part of Thunder Bay according in colouration, shape, average weight, and spawning location (Mr. G. Tyska, personal comm. 1980). As noted by Purvis (1977) spawning is predominantly along the northern shore, due in part to the topography of the bottom.

Some whitefish fishermen express greater concern over the low lake trout incidental quota than over the proposed whitefish quota. From time to time their fishing will be frustrated by the ease with which lake trout are taken in their whitefish nets. This problem is greatest during the spring months, and may also be more acute northward from Wild Goose Point where the provincial government has concentrated their stocking efforts in the past decade. It has been noted by Mr. R. Hamilton, that a regular whitefish fisherman who has reached his quota may obtain permission to take additional lake trout, as long as the zone quota has not been exceeded.

Zone 2

No strong complaints against the Black Bay herring quota have been expressed, and it is generally considered satisfactory. Raising this quota could help to alleviate worry over other species' quotas (especially among the smaller gill net operators). The recent addition of 50,000 lb., distributed equally among all fishermen, will have little effect on individual incomes.

In recent years, the fishing patterns for herring in Black Bay have altered for a number of reasons:

- the increased use of floating nets
- the development of the herring roe industry

- mesh size changes
- a large increase in the percentage of fish taken at times other than the spawning month of November.

Additional assessment of the fishery may be in order.

Many Black Bay fishermen are most disturbed by the proposed whitefish and perch quotas. Although the proposed quota has only been exceeded in 1979, fishermen explain that this is due not to any lack of fish, but to preferred harvesting of herring. In recent years herring has tended to often be more profitable, but the fishermen wish to leave open an option to fish whitefish when they choose. The availability of both whitefish and herring in Black Bay is also greatly under the influence of the vagaries of wind and weather. For example, according to Mr. O. Kukko (personal comm. 1980), herring tend to move out of Black Bay in a northeast wind, while whitefish tend to move in. This year June catches of herring in southern Black Bay (Middlebrun Channel) have been very poor, a fact which has been attributed to weather conditions.

In addition to the whitefish that move into Black Bay from the main lake, some fishermen believe Black Bay to contain its own population, which winters at the head of the bay and remains in the bay throughout the year. Black Bay whitefish are described as being shorter, fatter but deeper, than those from outside. Quota calculations should consider the possible existence, and distribution, of different whitefish stocks within Black Bay.

The incidental lake trout quota poses a problem for the whitefish fishermen of southern Black Bay only (i.e. about Edward Island and Middlebrun Channel). Lake trout rarely push into the central and northern areas, but will congregate in spring and fall in the southern waters.

Zone 4A

The fishermen of Zone 4A are strongly opposed to the proposed whitefish quota of 66,224 lb. (The reworked quota described above may alleviate some of their worries). The whitefish fishery here is still in its developmental stages. Following the ravages of the sea lamprey, a slow growth period occurred. until today fishermen believe that the whitefish populations are stronger than ever. This may be supported by the age frequency summaries which show the whitefish of sample area 3 (Black Bay Peninsula) to have had a mean age of 5.9 in 1975 and 6.2 in 1976. Those of sample area 4 (Outside Nipigon Islands) had a mean age of 7.0 in 1975. It is said that catches in recent years do not reflect the true status of the populations. Harvesting in the fall months, for example, has not been heavy because some fishermen chose to fish herring in Black Bay instead.

As a quota unit, zone 4A is unmanageably large, with little biological significance or relevance to actual fishing patterns. The danger of overfishing parts of it may be a real one -- last winter great quantities of whitefish were taken through the ice in the Lasher Island area (when the price was as high as $1.70 per lb.). A strong case may be made for subdivision, and Wayne Macallum of the Lake Superior Assessment Unit is currently reviewing alternatives.

Fishermen complain that the 4A chub quota is too small. It was the opinion of one fishermen that there are too many fishermen who are taking out licenses and not fishing, thereby depriving others of higher personal quotas.

It is not known if the lake trout incidental quota poses a problem for these fishermen.

Mr. P. Hamilton (personal comm. 1980) has suggested to Nipigon MNR that

Moffat Strait be reopened to gill netting, limited to those times of year when anglers are not present.

Zone 3

As mentioned above, the Nipigon Bay fishermen have accepted the proposed whitefish quota. (It may be noted in passing that Nipigon Bay whitefish are thought to be unique stocks. They are smaller than those outside, remaining in the bay but moving into Nipigon Straits as far as Moss Island and into Moffatt Strait -- Mr. W. Schelling, personal comm. 1980). Lamprey wounding of whitefish in the Nipigon Bay area is reportedly high this year (according to local fishermen).

Two men, fourth and fifth generation fishermen, were affected by the restriction of perch fishing in the Hughes Point area. The closure means an annual loss of approximately $2000 to each. A petition is currently being circulated by the local anglers' associations demanding the complete closure of Nipigon Bay to commercial fishing. Ross Chessle states that this will not happen, unless pickerel populations are found to be making a comeback to Nipigon Bay.

Zone 4B

The major complaint comes from the chub fishermen: too many fishermen are being licensed for a quota which is so low.

A similiar complaint has been made for the lake trout quota at Batteau Rocks, for the number of people applying for permits has increased over the past two years. One fisherman claimed that occasionally a fisherman will take out a permit and fill his quota on some other ground.

Zone 5A

Mr. Jim Chappell (Fisheries Officer, Terrace Bay) reports no major complaints from fishermen in this zone. It remains for me to contact some of these men.

Zone 5B

The problems involving the chub and lake trout fisheries of Zone 4B also apply to Zone 5B. Drastic reductions in individual allocations have occurred:

Chub	1978	40,686 lb./fisherman
	1979	67,833 lb./fisherman
	1980	27,450 lb./fisherman

Lake trout	1979	5000 lb./fisherman extended during the season to 7500 lb./fisherman
	1980	2000 lb./fisherman

Too many fishermen are applying for permits. In the minds of the west end fishermen, the situation is aggravated by the fact that east end fishermen are also being permitted in this zone. It should be noted, however, that at the beginning of the chub fishery applications first came from east end fishermen. In addition, Superior Shoal has traditionally been a lake trout ground frequented by both east and west end fishermen.

3) QUOTA ALLOCATIONS

It is the general desire of Ministry of Natural Resources personnel that the fishermen decide among themselves on an equitable system of zone quota allocations. To encourage discussion the Ministry has proposed a number of alternatives:

1) Allocation by straight division by the number of licensed fishermen.
2) Allocation of one equal share per license of 6000 yd. of

gill net.

3) Allocation on the basis of each fisherman's best year of harvest (for the available years of data).
4) Allocation of the basis of the average of the best three years of fishing (over the past six years).
5) Some combination of the above.

In the absence of a decision on the part of the fishermen, the Ministry will probably favour no. 4 alone, or in some combination with the other alternatives.

Many of the western Lake Superior fishermen have expressed doubt that a decision will be reached among themselves. Some are of the opinion, however, that the government-preferred allocation system will tend to encourage opportunistic fishermen. Fishermen will feel a need to intensify their operations in order that any future allocations will be higher. In addition, the kind of cooperation which presently prevails between the fishermen of Black Bay could be damaged -- fishermen would understandably come to feel themselves in competition with their fellows for a greater share of the zone quotas.

Many of the fishermen, especially those of long-standing, feel that six years of catch data are insufficient for arriving at equitable figures for individual allocations. These figures they believe do not reflect the true status of the species on their grounds. Certain of their arguments have already been discussed above. A particular species may have been less intensively fished by choice for a few of these years. Economic conditions may have altered fishing patterns. A number of cases require special consideration. One fisherman has been ill for several years and has engaged in little fishing. Another fisherman has been prevented from reaching his grounds for the spring herring fishery by late ice conditions (a problem not experienced by his neighbours in other areas of the zone). Another purchased a license a few years ago which had been seldom fished by its former owner.

In general, there is a feeling that MNR personnel do not spend enough time on the tugs where they would be able to see actual fishing conditions first-hand. Mr. W. MacCallum promises that more emphasis will be placed on on-boat sampling in the fall season of 1980. The general problem is lack of manpower and money. Ministry policy has tended to favour fishermen sampling their own catch with remuneration. Placing samplers on the boats can result in many lost hours through inhospitable weather, travel time, and just poor fishing. It is felt to be more efficient to meet the boats at the docks on their return.

On the other hand, a valuable opportunity for Ministry-fishermen interaction is lost. Certain patterns in the behaviour of both fish and fishermen can be understood only through direct experience. Such contact can only foster increased understanding of the problems encountered on both sides, and the reassurance of the fishermen that the Ministry is actively participating in, and concerned with, their industry. (It should be noted that the monthly meetings between MNR personnel and fishermen's representatives, which were begun in 1980, seem to be working well. The next one is scheduled for August 28th).

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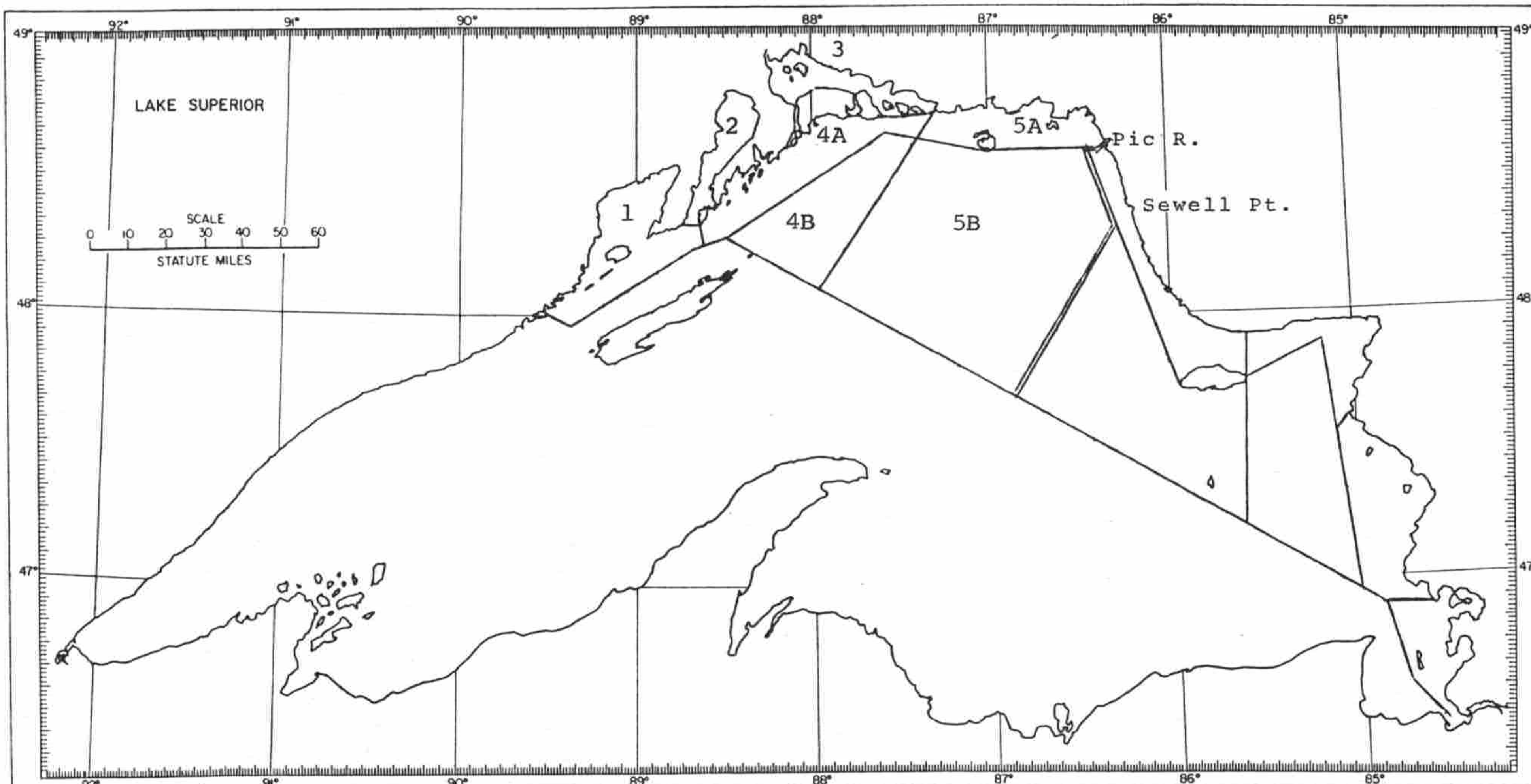


Fig. 1. PRESENT LAKE SUPERIOR QUOTA ZONES

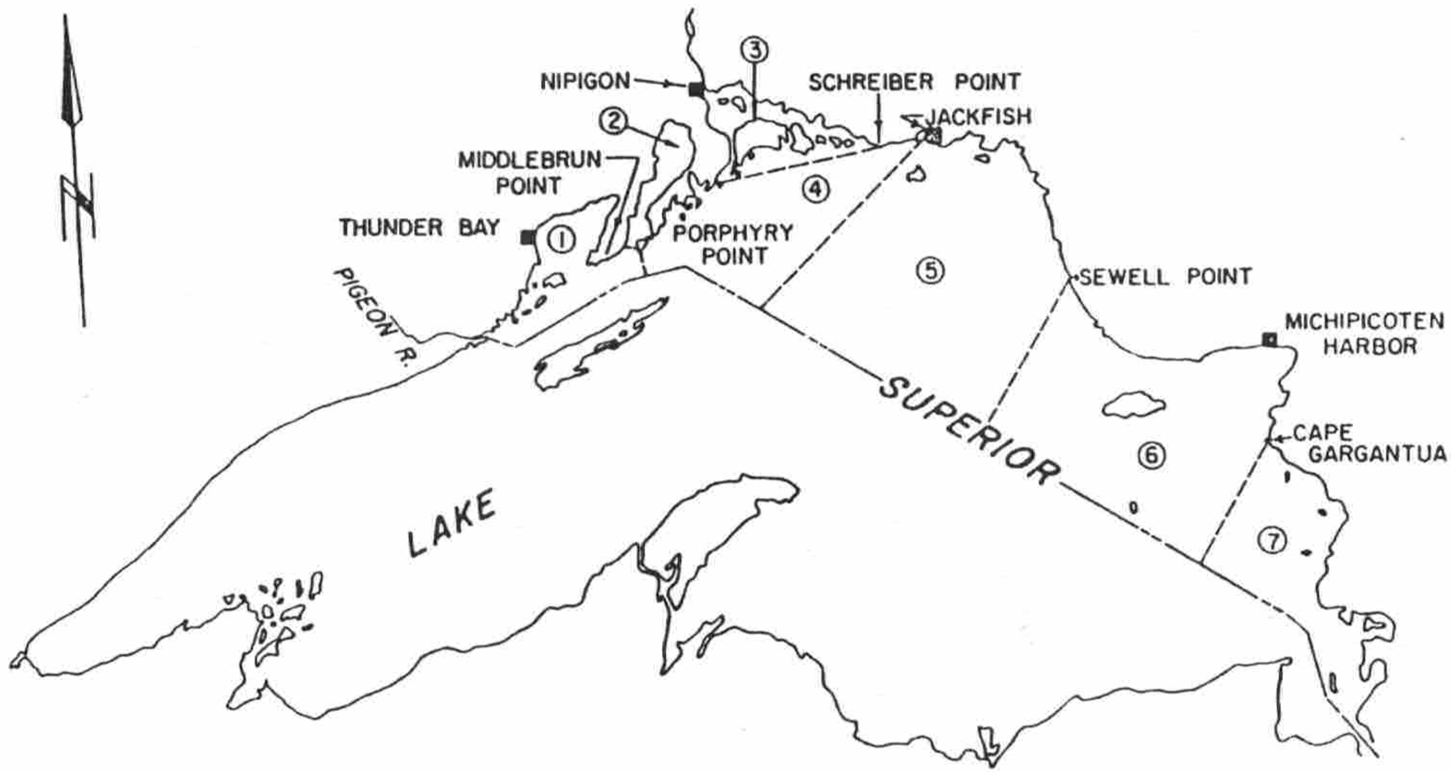


Fig. 2. Lake Superior Statistical Districts.

(From MacCallum 1980)

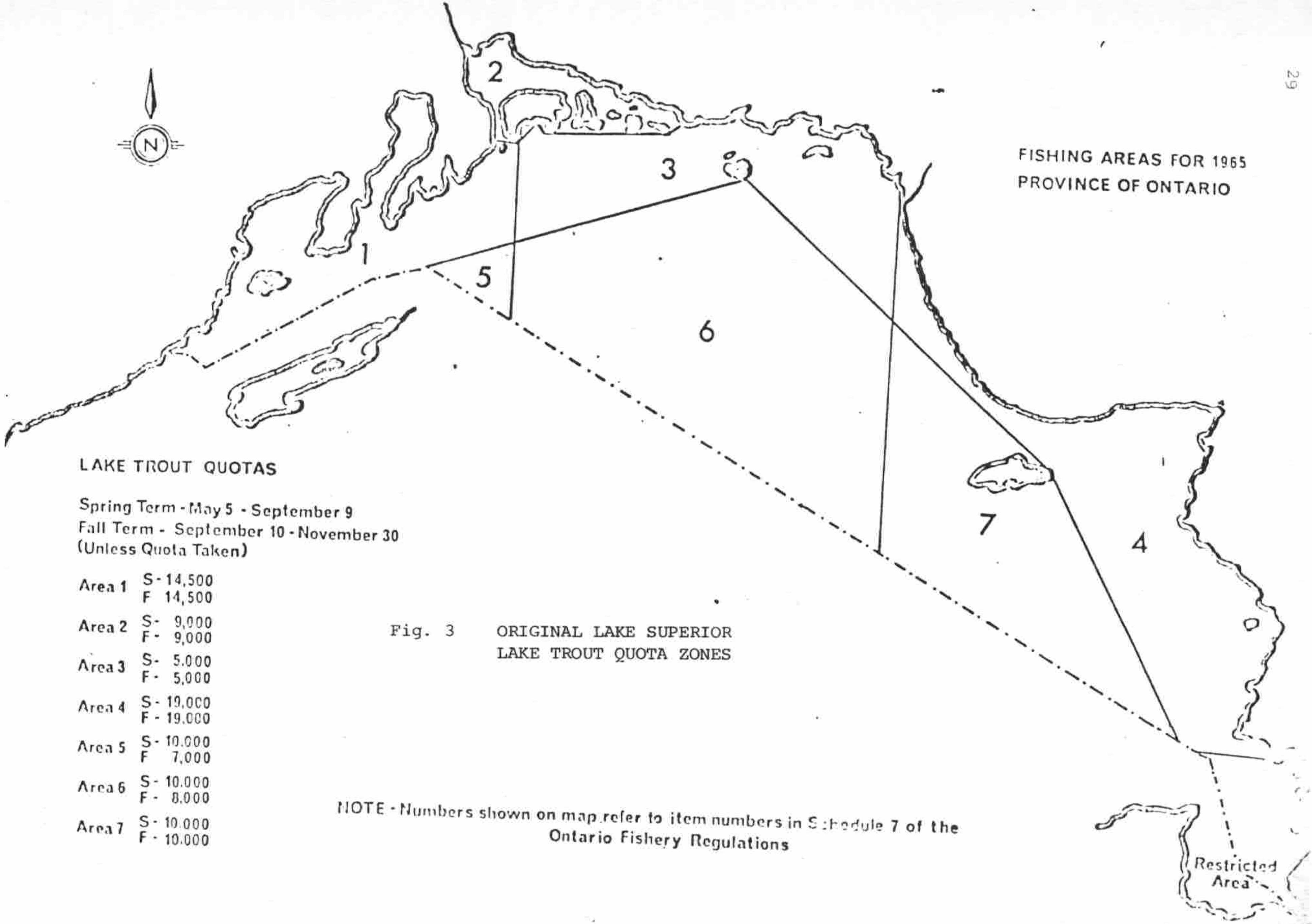
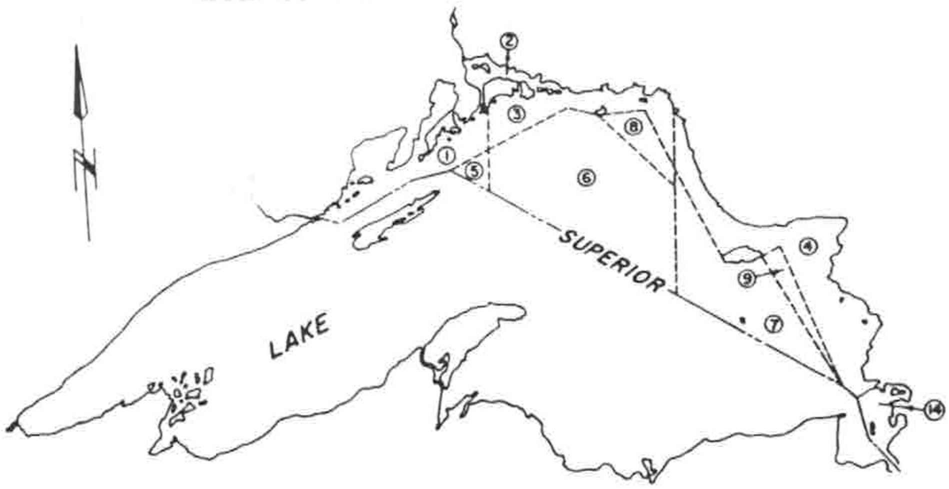


Fig. 3 ORIGINAL LAKE SUPERIOR LAKE TROUT QUOTA ZONES

Fig. 4

Revised -- 1967

LAKE SUPERIOR LAKE TROUT QUOTA AREAS



PERIOD OF TIME FOR COMMERCIAL FISHING UNDER QUOTAS

INSHORE AREAS

SPRING TERM - MAY 5th. TO SEPTEMBER 30th.

FALL TERM - SEPTEMBER 10th TO NOVEMBER 30 th

OFFSHORE AREAS

TERM MAY 5th TO NOVEMBER 30 th

QUOTA AREAS SHOWN THUS -------------- ⑦

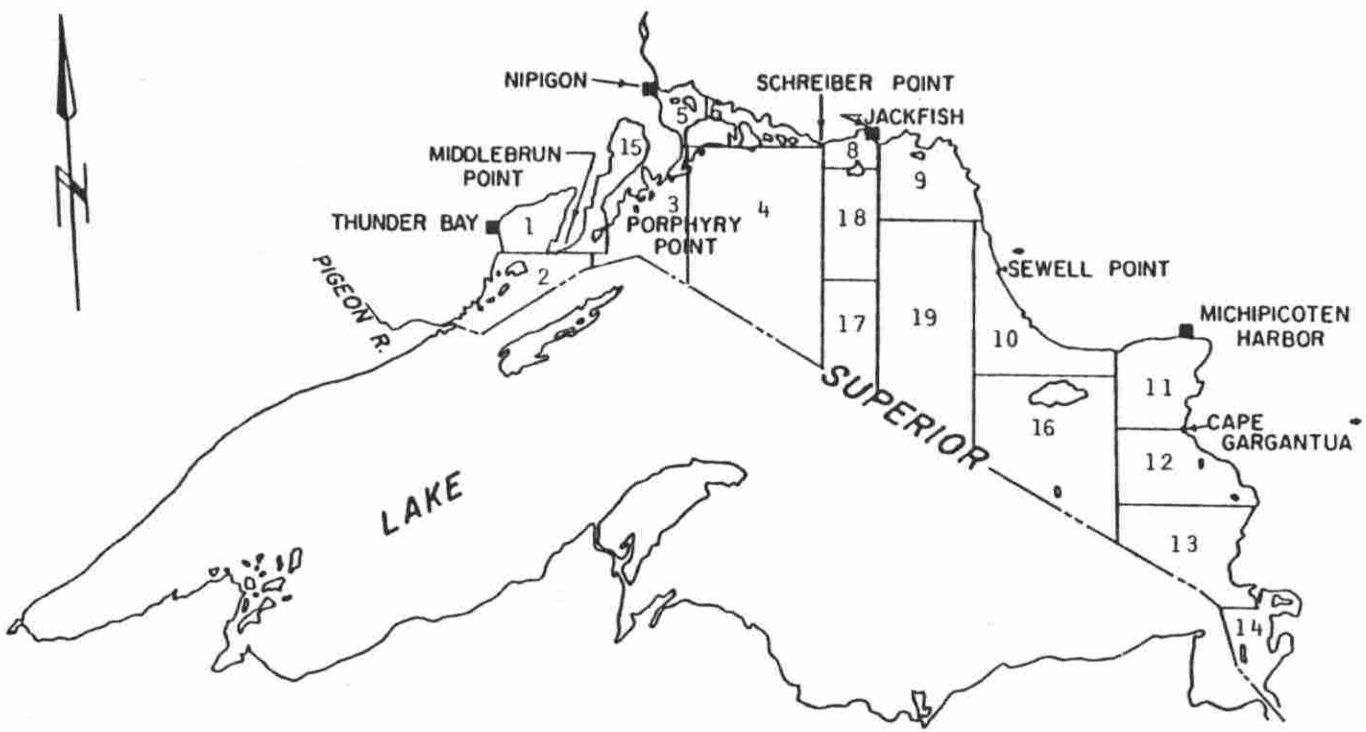


Fig. 5. Lake Superior Assessment Zones.

(From MacCallum 1980)

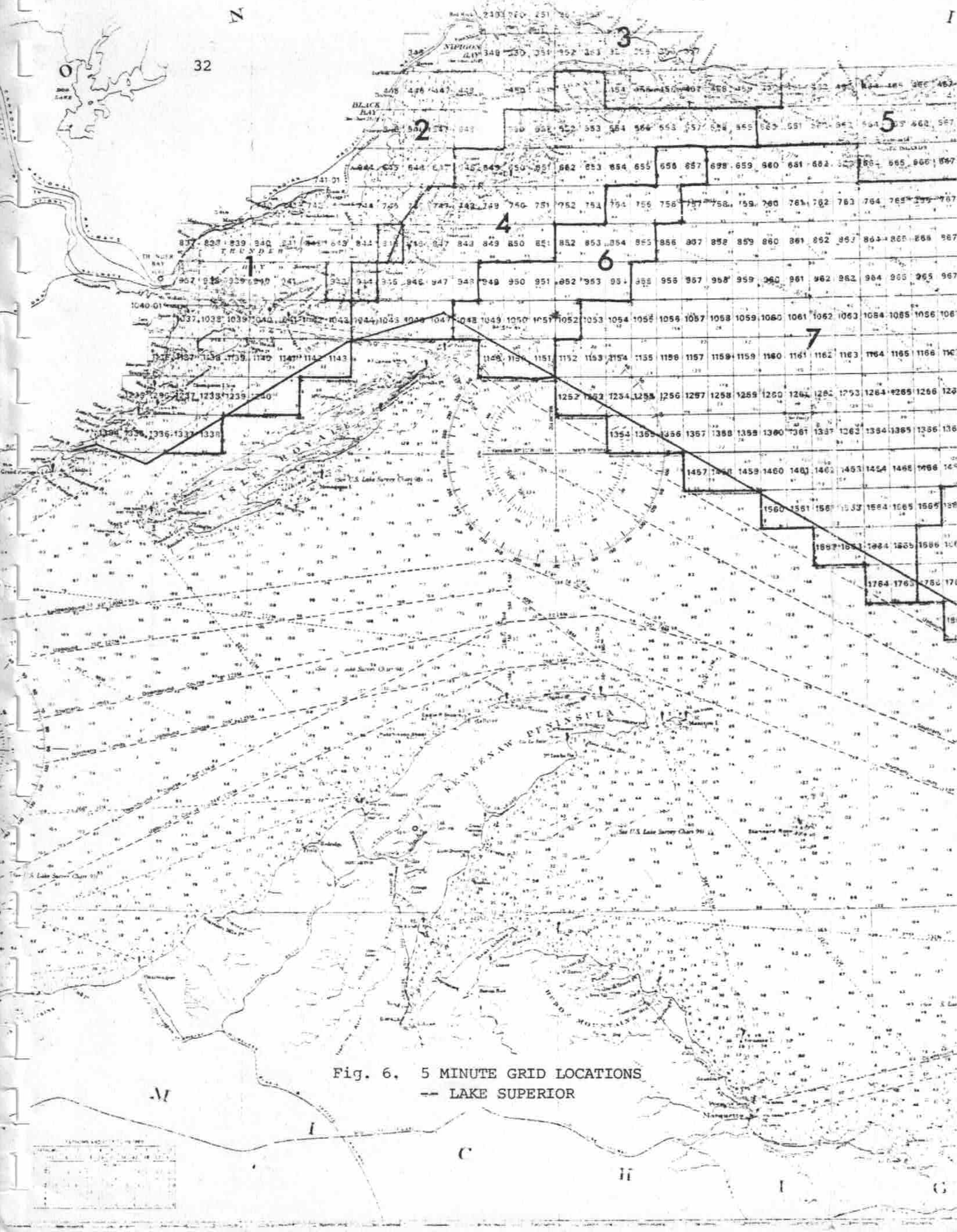
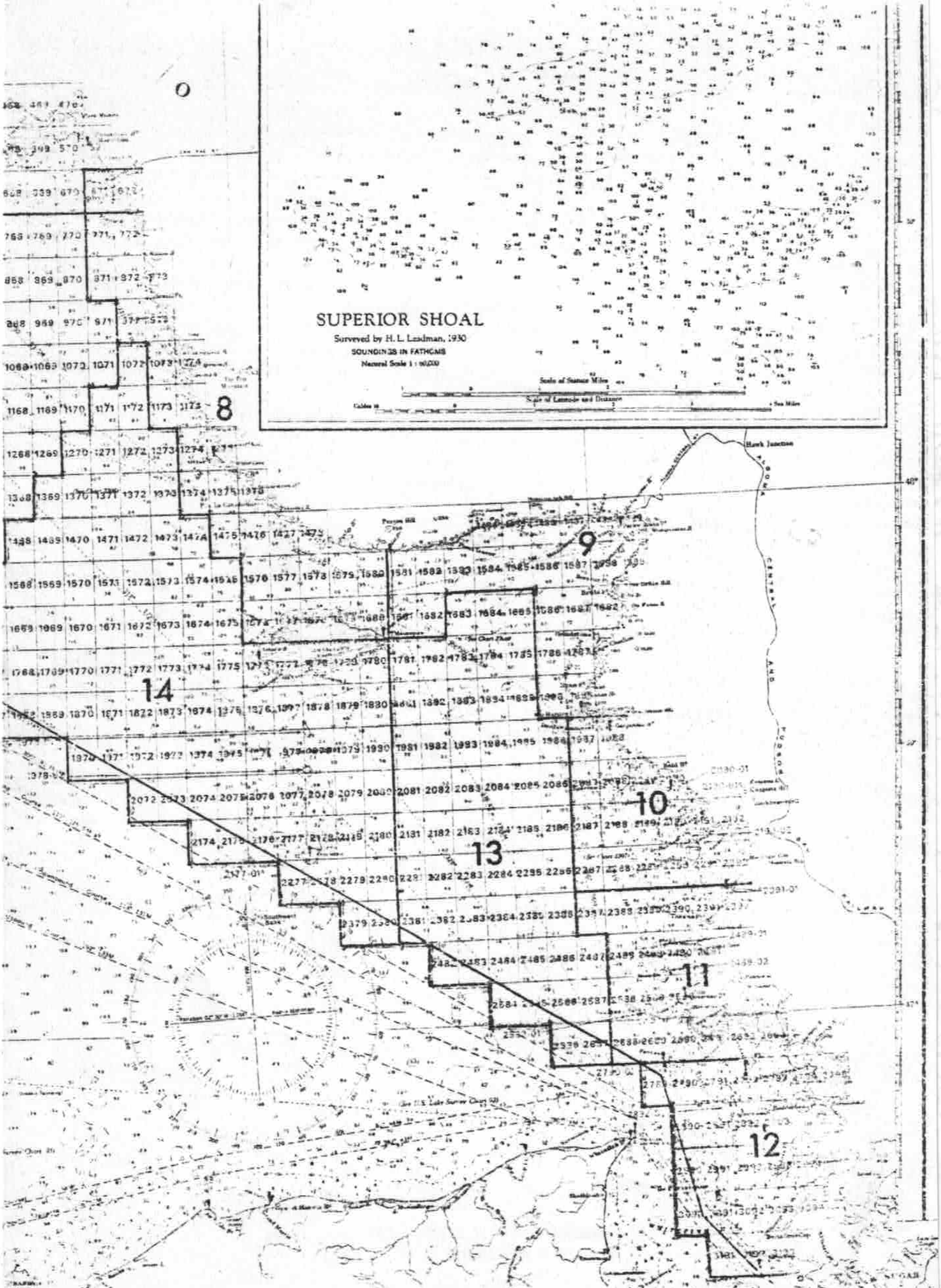


Fig. 6. 5 MINUTE GRID LOCATIONS
-- LAKE SUPERIOR


SUPERIOR SHOAL
Surveyed by H. L. Leadman, 1930
SOUNDINGS IN FATHOMS
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