A HISTORICAL ASSESSMENT OF THE COMMERCIAL AND SUBSISTENCE FISH HARVESTS OF LAKE WINNIPEG

by

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ABSTRACT

Lake Winnipeg is an important component of Manitoba's fishing community. The lake has received many pressures over the years with little knowledge of the affect these pressures have had on the fish community. This document is the first step in collating fish harvest data, both commercial and subsistence, for Lake Winnipeg. Harvest data has been obtained from historical documents. This data has been used to collate annual commercially-marketed harvests, examine relative abundance of species in various periods of the commercial fishery, calculate CPUE and estimate cullage of rough fish from commercial harvests using data from experimental netting studies.

Results indicate commercially-marketed harvests have decreased over time with peak harvests in 1903-04, 1929-30 and 1944-45. Over the years commercially-marketed harvests have fluctuated due to many variables, such as fish markets, fish prices, weather, and fishing effort. Sturgeon virtually disappeared from the commercially-marketed catch due to stock declines. Walleye and sauger became tremendously important species with the development of new technologies to preserve these species and have surpassed lake whitefish in value to the fisherman. Other species have been marketed over the years as demand warranted. Lake cisco harvests were high in the early history of the fishery but have declined over time in the commercially-marketed catches.

Rough fish species also have been marketed but harvests have depended on market demand. Experimental netting studies indicate rough species are

caught along with the desired or quota species but because of lack of demand they are culled from the catches. The amount of rough species culled has been estimated at 25-30% of the commercially-marketed catch. Cullage results suggested cisco, burbot and suckers are the most underrepresented species in the commercially-marketed catches.

CPUE was used as a method of determining whether increasing fishing effort resulted in larger catches. Effort has changed during the history of the fishery usually due to technological advances, making fishing effort more efficient and less labour intensive.

Subsistence fish harvests were recorded in the early historical records of the Department of Marine and Fisheries. These records indicated subsistence fish use was quite high but over time this use has decreased, perhaps as much as tenfold from the late 19th century to the present.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Chapter 1

Introduction

1.1 Background

Lake Winnipeg is the largest lake in Manitoba covering 23,750 km^2, with a length of 436 km and a maximum width of 111 km. The lake is divided into north and south basins which are connected by a narrow passage or channel (Figure 1). Lake Winnipeg has four major tributaries, many smaller tributaries and numerous surrounding settlements. Other characteristics of the lake are a mean depth of 12 metres and a maximum depth of 36 metres in a small area of the channel (Brunskill et al, 1980).

The first use of the fishes of Lake Winnipeg was by natives for subsistence purposes; long before a commercial fishery commenced. Homer (1987) suggests subsistence fishing by natives in the area dates to 2500 B.C. and that lake whitefish was an important component of their diet. The first Europeans who came to the area used fish for subsistence purposes also and eventually as more settlers arrived a commercial fishery developed. The Icelandic people who immigrated to the Lake Winnipeg area in the 1870's relied heavily on a fish diet, as fish is important in the Icelandic culture. A strong reliance on fish stocks for subsistence purposes, eventually grew into a commercial use. Prince (1909) cites:

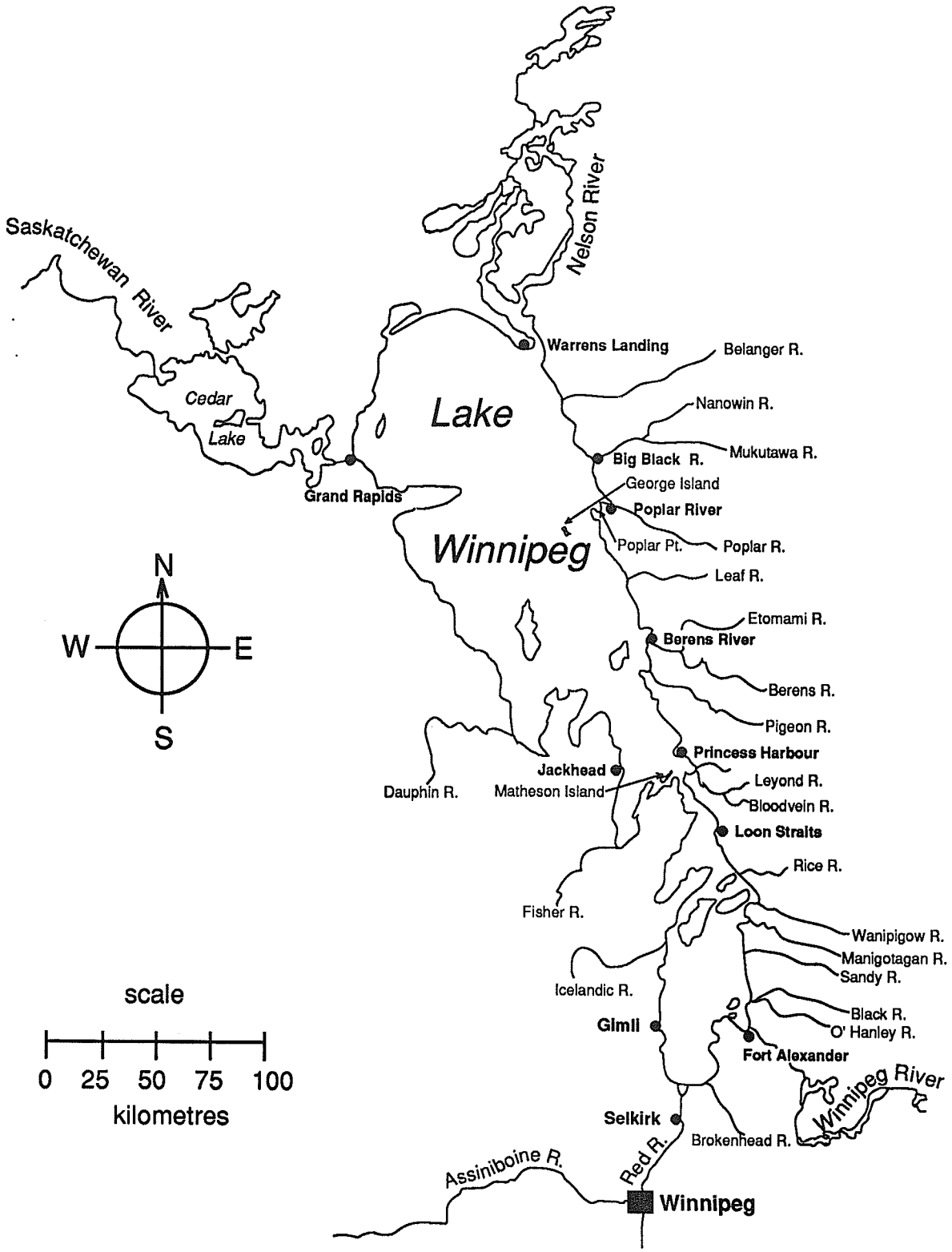

Figure 1: Lake Winnipeg, its major tributaries and fishing communities

> the earliest fishing was carried on by the native Indian tribes for food for themselves and their dogs, but the officers of the Hudson's Bay Company at their numerous posts in this region depended upon fish very largely, and since 1812, when the first white settlers were brought to the banks of the Red River by Lord Selkirk, a regular fishery has been pursued which has grown to enormous dimensions during the last thirty years.

Thus, fish species of Lake Winnipeg have been used for commercial, subsistence, and recreational purposes for a long time.

Lake Winnipeg has been the hub of commercial fishing activity in Manitoba for over a century. The A. Booth Company, later known as Booth Fisheries, was one of the first companies to begin operating on Lake Winnipeg in 1871 (McCullough, 1989). Historical reference regarding the fisheries resources of Lake Winnipeg is made in Skaptason's (1926) report <u>The Fish Resources of Manitoba:</u>

> The history of commercial fishing in Manitoba begins with Lake Winnipeg, and may be said to date back to 1872, when a few enterprising men of Winnipeg built a half-decked boat of some tonnage, and with some drag-seines and other nets, made several trips from Winnipeg to Little Saskatchewan River [Dauphin River], where they established their fishing station. The object was to supply the Winnipeg market with fish, fresh and salted, chiefly whitefish. This, however, was not a successful venture, no doubt owing to the limited market, as fish were then plentiful in both the Red River and the Assiniboine River at the City of Winnipeg.

The first viable commercial fishery began in 1883 due partly to the construction of the CPR railway and partly to the arrival of Icelandic immigrants in 1875 on the west shore of the lake (Hewson, 1960; Carruthers, 1976; and Gislason et al, 1982). The Icelandic immigrants' were the first

commercial fishermen but their equipment was not suitable for fishing on Lake Winnipeg so it was not until after several years of fishing with little success and adapting to new techniques that the commercial fishery, as it is known, truly began.

The first undertakings of commercial fishing were small attempts usually initiated by locals or foreign packing companies from the United States. The federal or provincial governments did not regulate the fishery during these initial attempts.

The first commercial undertakings focussed on lake whitefish (*Coregonus clupeaformis*). Walleye (*Stizostedion vitreum*), tullibee or lake cisco (*Coregonus artedii*), sauger (*Stizostedion canadense*), northern pike (*Esox lucius*), and sturgeon (*Acipenser fulvescens*) also have been important species in the commercial realm. Other species harvested for commercial value over the years have been catfish (*Ictalurus punctatus*), yellow perch (*Perca flavescens*), goldeye (*Hiodon alosoides*), suckers (*Catostomus* and *Moxostoma spp.*) freshwater drum (*Aplodinotus grunniens*) and carp (*Cyprinus carpio*). The commercial fishing industry has experienced many ups and downs over the years with changes among harvested species, usually in response to fish markets.

Recreational fishing has been less successful as the lake's large size and openness can be dangerous to the small craft used by anglers and even the larger craft utilized by commercial fishermen. Recreational fishing generally has been confined to tributaries, sheltered bays and coastlines. Data on catch levels of the recreational fishery only recently have become available.

In spite of these various uses of fish species over the years, and the millions of kilograms of fish which have been removed from Lake Winnipeg, a historical perspective of fish harvests never has been fully explored. Due to increasing pressures from the fishery and cultural and environmental change, the need exists for a better understanding of previous fishing harvests and the total volume removed from the lake over the years. Climate changes and changes in water quantity and quality resulting from human activity in the drainage basin could have an effect on fish stocks which cannot be assessed without the knowledge of the past history of the lake. Furthermore, little is known about the fish species in some parts of the lake, especially along the east side of the lake. Cullage, the practice of throwing away unmarketable fish species from commercial harvests, is also unknown.

Over the last few decades concern has been generated over the effect potential climate change, species introductions and water diversions would have on Manitoba waters, flora, and fauna. This concern has been heightened recently by the introduction and spread of zebra mussels in Ontario and the introduction of rainbow smelt to northwestern Ontario and Manitoba. The introduction of new, potentially harmful species, into Manitoba waters may have serious effects on the aquatic flora and fauna of this province. Without a condensed, collated account of past fish harvests from Lake Winnipeg, changes to its fish community cannot be analysed. Lake Winnipeg has the second largest inland fishery in Canada and is the third largest lake entirely within Canadian boundaries. Thus, the importance of the lake both economically and

environmentally is evident and major changes in its fish populations could have a significant effect on the province.

Lake Winnipeg is the central receiving basin for rivers from the Rocky Mountains in the west to northwestern Ontario in the east and from much of the North Dakota and Minnesota aquatic systems to the south. The Red River drains into the lake from the south, the Assiniboine and Saskatchewan Rivers from the west, and the Winnipeg River and many other Canadian shield rivers from the east . Due to this receiving nature of the lake, any changes in the watershed of the lake could result in changes in its biota.

To evaluate the effect of commercial and subsistence fish harvests, climate change or other alterations in the fish community, research is required on Lake Winnipeg fish harvests over the years to establish a basis for more detailed research. Tabulating harvest data is a first step in a long process of improving our understanding of the Lake Winnipeg ecosystem. This information can be used in the future to establish models which predict how changes to the environment might affect the abundance and distribution of the fish community.

1.2 Problem Statement

Lake Winnipeg is an important component of Manitoba's waterways and fisheries. Fishing and environmental pressures on Lake Winnipeg fish stocks over the years have been great. Despite these pressures, little is known about the abundance and composition of the fish community. The focus has been on lake whitefish with little attention toward the other species. It is, therefore,

extremely important to assess all available material on the harvests of fish in Lake Winnipeg. Once all this information has been collated into one document it can be used in other research. The knowledge collated will be useful as a management tool to the Manitoba Department of Natural Resources since all Lake Winnipeg fish harvest data finally will be presented in one detailed report.

1.3 Objectives

The primary objective of this study was to present a historical assessment of commercial and subsistence fish harvests from Lake Winnipeg; to determine the tonnage of fish removed for these purposes. To fulfill this objective, the assessment focused on the following tasks:

1. To gather all statistical data on the commercially-marketed fish harvests of Lake Winnipeg, from its beginnings in the 1870's to the present. This provides the basis for assessing the tonnage of fish harvested from the lake for commercial purposes.
2. To obtain information on subsistence fish harvest of Lake Winnipeg and attempt to estimate amount of fish removed. This provides the basis for assessing the tonnage of fish harvested from the lake for subsistence purposes.
3. To obtain an estimate of cullage of fish species in the commercially-marketed catch, which will further aid in determining the total tonnage of fish stocks harvested in commercial catches. Culled

species are not accounted for in the present-day commercially-marketed harvest data.

4. To calculate catch-per-unit-effort (CPUE) for the data collected on Lake Winnipeg commercially-marketed fish harvests. CPUE is a method more useful in assessing changes in fish harvests because it takes into account changes in demand and regulation which affect harvest rates.

5. To recommend areas where further research is needed.

1.4 Research Methods

This study was approached by reviewing the related literature and tabulating historical commercially-marketed harvest records to obtain total amounts of fish removed. Incomplete historical records date back to the inception of commercial fishing, approximately 1883. Relative abundance of fish species in the commercially-marketed harvests were calculated during four decades of the fishery. Furthermore, CPUE was calculated from most of these records, where data was available. Cullage of unmarketed fish species was estimated using CPUE plus experimental gillnetting data from provincial government studies on the lake. Subsistence harvests were examined using the available information.

1.5 Delimitations

This study is an assessment of the commercial and subsistence fish harvest and does not evaluate the fishery as a whole. Judgements on

management of the fisheries, fisheries regulations, or other aspects of the fishery were not part of the study. This study assessed commercially-marketed harvests in a quantitative method, and the results are subject to the biases of harvest records. Limitations exist in the records as many of the historical records are brief and incomplete. Also, various "fish recorders" or fish guardians for the Province of Manitoba and the Government of Canada were charged with the job of recording this data. Often these recorders used different methods each year making it difficult to compare data on an annual basis. Fishing effort data also was difficult to assess as gear type, gear size, and fishing regulations frequently changed and were not always clearly stated. This was another source of bias in assessing harvest data.

Commercially-marketed harvest data, especially more recent data, contained marketable species only. Quantities of unmarketable fish species are not recorded, an inherent bias in the commercial data. Cullage of unmarketed fish species is undocumented; therefore only estimates are made. Subsistence fishing is only partially documented in historical records, making estimates of this component difficult, if not impossible. Subsistence fish harvests are difficult to interpret and information is sketchy. Hence data for subsistence fishing and cullage is not quantitative and is presented on a qualitative basis.

Chapter 2

Review of Related Literature

2.1 Introduction

Reviewing the related literature is a necessary component of any research. This provides the background to understanding the framework of the study. In this case, the general physical, chemical, and biological features of Lake Winnipeg are discussed in the first section, followed by more specific discussions of the lake's various fisheries and a section on fisheries regulations over the years which are important components in assessing the tonnage of fish harvested over the years. The chapter concludes with a section on research of subsistence fish harvests.

2.2 Lake Winnipeg-physical, chemical, biological features

The major physical features of Lake Winnipeg are presented in Chapter 1 and can be seen in Figure 1. Lake Winnipeg is bordered on the east by the Canadian shield and the lake itself is part of the Manitoba lowlands, underlain by Paleozoic limestone and dolomite (Bird, 1980). To the west, Lake Winnipeg is bounded by the Interlake plateau. Lake Winnipeg, therefore, forms the transition zone between prairie and Canadian shield in this area.

Lake Winnipeg receives water from a large area of North America. To the west and south, the Saskatchewan, Dauphin, Red and Assiniboine rivers drain through the lake, on their way to Hudson Bay. Brunskill et al (1980) stated that these rivers drain from sedimentary rocks of shales, limestones, dolomites and sandstones overlain with glacial till and glacial Lake Agassiz sediments, which support chernozemic soils, prairie mixed deciduous and coniferous forests, prairie grasses and more recently agricultural crops. To the east, the Winnipeg, Berens, Poplar, Bloodvein rivers and many other tributaries flow off the Canadian shield into the lake. These rivers flow off of a landscape of igneous rock overlain by glacial till and glacial Lake Agassiz derived soils, muskegs and boreal forests (Brunskill et al, 1980).

Gislason et al (1982) reported that little had changed in the north basin of the lake from the time Bajkov did his limnological studies of Lake Winnipeg in the 1930's but concluded this was not the case for the south basin of the lake. Brunskill et al (1980) analysed several components of Lake Winnipeg's physical and chemical status, including the relationship between annual river discharge and annual suspended sediment transported by the three major rivers flowing into the lake (Red, Winnipeg and Saskatchewan Rivers). They also discussed the contribution of nutrients by agricultural activities in the western and southern drainage area of the lake to determine trends in phosphate/nitrate levels. Brunskill et al (1980) found little change in the lake's physical or chemical characteristics except in the south basin due to increased use of fertilizers and increased human activity along the southwestern rivers which flow into the lake. The high discharge rate of the Winnipeg river does

not appear to add to the high concentration of nutrients, salts, and sediments which are now being received by the lake from the prairie rivers (Lysack, 1986).

These high concentrations of sediments and nutrients have not resulted in any major changes to the biotic community, as Brunskill et al (1980) found no major changes in abundance or species composition of phytoplankton, zooplankton or benthic organisms from Bajkov's initial studies in the 1930's. However, two species of caddisfly, and one species of amphipod have disappeared from the south basin and densities of one species of mayfly also have declined (Lysack, 1986). Zooplankton species composition has remained fairly stable since Bajkov's studies however total biomass in the south basin has doubled since the 1930's due to increased nutrient loading (Lysack, 1986).

Brunskill et al (1979) reported on temperature, oxygen, conductivity and dissolved major elements. Remnant (1991) suggested mean values for these characteristics can not be given because the lake is not homogeneous, making mean values inaccurate. Studies of Lake Winnipeg are difficult due to its size and varying characteristics between the distinct basins.

Remnant (1991) described the original fish community of Lake Winnipeg as having 16 families, 28 genera and 48 species. No species have been lost from the community, however lake sturgeon populations have declined tremendously over the years to an insignificant level (Dr. K. Stewart, personal communication). Several times in the literature lake trout (*Salvelinus namaycush*) was mentioned and this species appeared in the commercially-marketed harvests several times over the years, but on a limited basis. Several

species have been introduced into the Lake Winnipeg fish community, namely, common carp (1938), white bass (*Morone chrysops*) (1963), black crappie (*Pomoxis nigromaculatus*) and rainbow smelt (*Osmerus mordax*) (1990).

The fish community of the lake is of a lower or mid-trophic type comprised mainly of white sucker, lake cisco (herring), lake whitefish, goldeye, emerald shiner, spottail shiner, trout perch, yellow perch, freshwater drum, and the piscivores, sauger, walleye and northern pike (Remnant, 1991). Little data is available on fish species other than the three most important in the commercial catch; lake whitefish, walleye, and sauger.

2.3 Lake Winnipeg lake whitefish fishery

Much of the research undertaken on Lake Winnipeg fisheries has focused on lake whitefish. This has happened because lake whitefish has been the major species of the commercial fishery, dominating the commercial catch for the first 25-30 years, and subsequently declining in abundance. As stated earlier, lake whitefish were utilized long before Europeans reached Lake Winnipeg. Historical information indicates natives used lake whitefish as a food source (Tough, 1984). In 1984, Wagner (1986) undertook a survey of fish consumption by native peoples. Three Lake Winnipeg communities were included in the survey and the results indicate that fish, and specifically lake whitefish, are still a major staple food of natives in the more remote locations.

The commercial lake whitefish fishery has changed greatly through its 110 year history. The first attempts at the fishery were undertaken using sailboats and steam tugs (Hewson, 1960). Gill nets were the commonly used

gear type but some pound nets have been tried periodically. Regulations also have been imposed over the years. The first restrictions were imposed as a response to overfishing allegations which occurred in the late 1880's. Early restrictions limited the number of nets per boat and permitted lake whitefish fishing in the north basin only. In 1894, the fishing season was closed October 5, probably as a measure to protect lake whitefish spawning.

The driving force behind the development of a commercial fishery was the United States market. External market production and local production were separated in 1885 to acknowledge the extent of the external market. Thus, records from 1887-1909 included a "home consumption" commercial harvest for local use only.

Large trading/fishing companies from the United States controlled the fishery for most of its history (Tough, 1984 and 1987). Dominance of the fishery by foreign companies resulted in great concern that resources would be depleted leaving the local market and people with little left of the resource. The Freshwater Fish Marketing Corporation (FFMC) established by the federal and provincial governments in 1969 helped to destroy the dominance imposed by these foreign companies.

Hewson (1960) reported that lake whitefish commercial production truly began in 1883 with a production of 73,000 pounds (33,182 kilograms), rose to a maximum production in 1904 of 7,500,000 lbs (3,409,091 kg), then declined to an average annual production over the 1980's to around 1.5 million kg. Lake whitefish catches fell in 1936 to 475,182 kg (1,045,400 lb),

their lowest level from the beginning of the fishery until its collapse in 1968-69.

Hewson (1960) in a concise account of the Lake Winnipeg lake whitefish fishery from its inception in 1883 to 1958, reported that concern arose in 1890 about the supply of lake whitefish stocks. Historical documents suggest that fishermen, Indian agents and fisheries officers voiced concern over depleting stocks of lake whitefish and were afraid the fishery would collapse. This concern arose after less than a decade of commercial fishing on Lake Winnipeg. Tough (1984) recorded many passages from reports by Indian agents and fisheries agents over this fear. The quote below explains how this concern was acknowledged by some people but the fisheries agents did not take it too seriously:

> Some apprehension being felt in various quarters that the fisheries of Lake Winnipeg will give out, it may not be out of place to state here that not more than fifty miles of these waters are being fished so far, while the lake is over 300 miles in length and on the average 50 miles wide. Although fish may be scarce at times; this in itself should not be taken as an indication that the fishing industry is depleting the supply to an undue extent. The present fishery regulations ought to be ample guard against any depletion for many years to come. If experience should prove to the contrary more stringent regulations, and a curtailment of the industry will become a necessity. (Canada. 1888).

Yet, the concerns expressed by others warranted a special report in 1890 by Samuel Wilmot addressing the lake whitefish situation. In his detailed report on the major components of the fishery at the time, Wilmot concluded:

> there is a gradual but steady depletion of the whitefish product of Lake Winnipeg going on, from the effects of the present system of fishing in certain parts of the lake...The depletion is experienced more particularly at the mouths of the larger rivers, and in the lower parts of the lake, particularly in the Little Saskatchewan River and St. Martin's Lake, caused by over-fishing at improper times, notably at the mouth and bay of the Little Saskatchewan River. This cause, if permitted to be continued here, and to be allowed in other places similarly situated in other parts of the lake, must assuredly hasten rapid depletion and eventually termination of the whitefish industry of Lake Winnipeg." (Canada.1890).[Note: Little Saskatchewan River now is known as Dauphin River]

Wilmot suggested several remedies to alleviate the situation including closed seasons and closed areas to lake whitefish commercial fishing. New regulations implemented in 1892 were; limitation of the number of nets used by each boat, a ban on Sunday fishing, and the restriction of fishing to the north basin of the lake only (Carruthers, 1976). These regulations did little to lower the annual whitefish harvests and by 1911 season quotas had to be established and the gill-net mesh size had to be raised to 5 1/2 inches (Carruthers, 1976).

Over the next 50 years, the commercial fishing industry underwent many changes in regulations and technology. The technological changes were; the move to gasoline engine boats, the change from cotton and linen gillnets to nylon nets, power lifters and the invention of the jigger which allowed for better winter fishing (Gislason et al, 1980). Up until the time of the invention of the jigger, winter fishing was difficult and mainly undertaken for local use. The jigger is a device used to set gillnets under the ice. This is done by cutting a hole in the ice and pushing the jigger under the ice in the direction

the fisherman wants his net set. A string is attached to the jigger which when pulled activates a ratchet mechanism allowing the jigger to move along under the ice (Grant, 1938).

From the early part of the 20th century to the 1940's, the lake whitefish fishery also experienced other changes. The area of activity gradually moved from the western shore to the eastern shore of the north basin. Hewson (1960) indicated this occurred due to the poor harbours on the west shore and that the few which were good were closed to lake whitefish fishing in 1911. Furthermore, the distances involved in fishing on the western shore and returning to the eastern shore for packing and shipping made fishing the western shore uneconomical. Also an abundance of unmarketable fish, such as suckers and burbot (*Lota lota*) were caught along the west shore of the lake.

As stated earlier, from the inception of the lake whitefish fishery to the incorporation of the FFMC in 1969, the fishermen were at the mercy of the packing houses. The fishermen basically were indebted to the packing companies who forced them to accept a given price or not sell their catch. This resulted in many of the better fishermen leaving the Lake Winnipeg fishery altogether (Hewson, 1960). Small and unpredictable profits forced the remaining fishermen to reduce costs, by cutting their fishing time, thus reducing their fuel costs. This resulted in a smaller area of the lake being fished.

Hewson (1960) reported that by the 1950's, "two-thirds of the fishing effort for whitefish was expended in a strip of water within 12 miles of the shore from just south of Poplar Point to just northwest of Warrens Landing"

(See Figure 1, Chapter 1). This represented only 750 square miles [1,943 km^2] out of a total of about 6,300 square miles [16,321 km^2] in the lake whitefish area as a whole (Hewson, 1960). Hewson suggested this effort represented a significant effort on only a very small portion of the lake.

During the war years of 1940-45, fishing effort was increased to facilitate higher harvests. After 1945, the lake whitefish fishery never recovered to levels of the pre-war years. Since the collapse, in 1968-69, due to increasing fishing pressure, lake whitefish harvests have gradually risen. This increase was due to reduction of quotas in 1972 which has allowed for the recovery of stocks (Lysack, 1986). Generally, lake whitefish harvests have remained fairly steady over the last decade (1980-1990).

2.4 Lake Winnipeg commercial fishery-other species

The majority of the literature produced on Lake Winnipeg fisheries has focused on lake whitefish catches. This is not to say other species have been insignificant or unimportant; actually quite the opposite is apparent by examining historical records. The first sixty years of the fishery, 1880-1940, saw a general pattern of increased catches for all species. The period 1940-1969 saw declines in catches of all species (Lysack, 1986).

The beginnings of the commercial fishery supplied a market for sturgeon, walleye, and pike. Sturgeon stocks quickly became depleted due to overfishing and the species long maturation period (Gislason et al, 1982). Lake Winnipeg, by 1926, was one of the last lakes to support sturgeon fishing in Manitoba (Skaptason, 1926). Sturgeon fishing was prohibited from 1946-

56 to aid in replenishing stocks after many years of high harvest rates. Today, sturgeon numbers remain depleted and it is only a minor species of the commercial catch.

During the first few decades of the commercial harvest, walleye was not considered as important as lake whitefish. This was due to the short shelf-life of walleye. Smoking and salting lake whitefish preserved the fish longer and facilitated shipment to the commercial market in the eastern United States. Emphasis shifted to the walleye fishery with the development of better packing, refrigeration, and transportation methods (Gislason et al, 1982). Gislason et al (1982) stated walleye was originally a "rough fish... and was kept for domestic use or culled by fishermen". Sauger, a species similar to walleye, also became a large component of the commercial catch in the 1930's. Today, walleye is the most valued species in the commercial catch, followed by sauger and lake whitefish (Lysack, 1986).

Other species which have had importance in the fishery are lake cisco, channel catfish, goldeye and various species of suckers. These species have much lower values than the quota species (lake whitefish, walleye and sauger), but have been sources of added revenue for fishermen who catch them anyway. Markets for these other species wax and wane making them marketable some years and unmarketable in other years. All species are subject to the fluctuations of the market. Even though recent records may show none of these other species were marketed, they are harvested but culled when markets do not exist for them.

Another commercial use of fish in Lake Winnipeg is an intensive bait fishery in the south basin. Emerald shiners, *Notropris atherinoides* and spottail shiners, *N. hudsonius* are the species sought in the bait fishery (Kristofferson, 1985). Little information is available on these and other forage species of the lake and research into this area is necessary as part of understanding the whole lake fish community.

2.5 Fishing regulations-changes over the years

2.5.1 Pre-FFMC

The commercial fishery of Lake Winnipeg was regulation-free for the first several years. Local concern over depleting stocks, overfishing, and decline of catches on traditional fishing grounds, resulted in regulations being implemented. These regulations have been revised continually as the fishery evolves.

Some regulations which have been implemented over the years are described below. Initially, the lake was divided into four fishing seasons, summer, fall, winter, and summer lake whitefish. The summer lake whitefish season was confined to the north basin of the lake with the season opening dates varying over the years, from the first of June to the beginning of July. The season usually ran to early or mid-August.

Numbers of lake whitefish licenses have declined over the years. Mesh size of gillnets have also changed from a high of 5.5 inch mesh to the current low of 3.00 inch mesh in the south basin and 3.75 inch mesh in the channel area. Allowable mesh sizes in the north basin were changed in 1956 to 4.25,

5.0 and 5.25 inches depending on the fishing area of the basin (Lysack, 1986, Rybicki and Doan, 1966). Lysack (1986) and Rybicki and Doan (1966) noted other regulatory and technological changes which have affected catchability and fishing effort: length of season increased from 53 to 69 days (1950's), daily gillnet yardage allowance per fisherman in the north basin increased from 5000 to 8000 yards in 1959, the move to nylon nets in 1949 followed by wide usage by 1951, power lifters on boats in 1959, and the use of trap nets prior to 1969.

2.5.2 Post-FFMC

Lysack (1986) reported that overexploitation of the lake's fisheries resulted in an economic collapse of the fishery in 1969. Lysack (1986) noted that this over-exploitation was due to: increased numbers of fishermen, technological improvements and relaxation of regulations particularly increased daily gillnet yardage allowances, increased quotas and decreased mesh sizes. The formation of the FFMC helped to stabilize the whole fishing industry and avoid these problems of the past.

The Lake Winnipeg fishery was closed in 1970-71 after mercury contamination of fish was discovered in December 1969. Commercial fishing was closed in Lake Winnipeg at the commencement of the summer season of 1970 (Manitoba, 1971). The only commercial fishing permitted on Lake Winnipeg was for mink feed for local fur farmers. The closure remained in effect until the summer of 1971 when the lake whitefish fishery was reopened. The winter sauger and walleye fishery was opened in the fall of 1971 but was

restricted to designated areas of Lake Winnipeg and to a specific size of fish (Manitoba, 1972).

Since the closure of the fishery in 1970-71, entry into the commercial fishery of the lake has been limited by licenses of quota to those individuals experienced in the industry or those dependent upon it (Wysocki, 1981). Quotas of walleye and sauger are based on the average annual catch from 1965-1969, and lake whitefish quotas are based on the average annual catch from 1964-1968 (Wysocki, 1981). These quotas can be changed as warranted by provincial biological and economical studies which suggest fish stocks are declining or increasing. The quota for the three major species of the commercially-marketed harvest is set at 6.4 million kg and catches of these three species have been about 85% of the quota in recent years (Remnant, 1991).

Other changes in the fishery have occurred over the years. Wysocki (1981) described the commercial fishery regulations for Lake Winnipeg, "the lake is divided into 12 community areas for licensing purposes...[these] are regulated by an individual quota system". Lysack (1986) listed the recent changes in regulations as:

1) three seasonal fisheries per year,
2) summer fishery encompasses all areas of the lake and begins in June,
3) summer fishery varies between 40 and 69 days depending on location,
4) maximum amount of gillnets per fisherman has increased,
5) summer quotas of fishermen have increased,

6) fall fishery starts in September and lasts approximately two months,
7) increases in quotas in the winter fishery,
8) increases in numbers of new fishermen
9) increase in numbers of retired fishermen,
10) creation of additional seasonal fisheries, and
11) increases in surface area which can be exploited in the inshore areas of the north basin
12) and the creation of three new management zones in the north basin.

Lysack (1986) acknowledged that these changes resulted in a greater surface area of the lake being exploited. The result was a totally regulated fishery with a wide variety of regulations covering various zones on the lake, covering a greater surface area of the lake, and requiring more management effort.

The provincial government introduced the transferable quota entitlement system on the lake in 1985. Scaife (1991) reported that this change was implemented to decrease the total number of fishermen and increase the average quota per fisherman. The goal was to increase economic sustainability and maintain the lake quota to prevent overharvesting (Scaife, 1991). The major features of the quota entitlement system are: transfer of quota between community licensing areas is prohibited, quota entitlements can be sold within community areas if the purchaser meets certain requirements, fishermen are now allowed a maximum of four quota licenses except in areas 4, 6, and 9 where 6 are allowed, and quotas are transferable between seasons, with some restrictions. Another change which has occurred is the combining

of several community licensing areas for quota transfers only. Twelve community licensing areas are reduced to eight areas for this component only.

2.6 Subsistence Fisheries

Research indicates historical and present day subsistence use of fish can be a significant component of fish stock removal. It is, therefore, imperative to include subsistence use in any assessment of total harvest of fish from Lake Winnipeg.

Use of fish for subsistence purposes has been a significant component of the diets of the aboriginal people and Icelandic settlers' surrounding the lake. Subsistence fisheries are known to have preceeded commercial fisheries in all societies. Regier and Hartman (1973) stated subsistence fishing was practiced in Lake Erie before the commercial industry began but this subsistence fishing was undertaken in the streams and coves of the lake. Regier and Hartman (1973) suggested commercial development of the fishery only began with urban settlements which meant urban markets and transportation systems had been developed.

In Manitoba, Tough (1987) stated fish were a reliable source of food for natives, fur traders and early settlers and this use did not deplete the resource. Tough (1987) suggested this fish use increased over time as a result of the depletion of other food staples, such as the bison. Early reports by fur traders, missionaries and travelers documented the use and importance of fish by the natives of the Northwest region and the good quality and ease of capturing this fish. Subsistence fishing which had occurred in the Lake

Winnipeg area was centred around streams, rivers and spawning areas, where the ease of catching fish was the greatest. Since the technology for catching fish was limited, only a small area of the lake was exploited compared to the commercial fishery.

Despite the knowledge of subsistence fisheries in the past, little historical research of subsistence use of fish has been undertaken in Canada. Quantifiable records of historical subsistence use have been unavailable or limited at best. Often these historical records have been indirect estimates based on commercial catches, generalized over a large area, or specific estimates of a small group of people which could not be used to generalize over a large area like Lake Winnipeg.

The earliest records of subsistence fish use in Canada were produced by Rawson (1947), who examined the communities around Great Slave Lake. Rawson (1947) and Miller (1947) estimated subsistence use of fish at 700 t/yr (700,000 kg) and 900 t/yr (900,000) for Great Slave Lake and Great Bear Lake, respectively. Per capita consumption at Great Slave Lake was estimated at 75 kg.

Since Rawson's work, subsistence fish use research has been undertaken and has focused on present day harvests of fish for aboriginal uses. Berkes (1990) synthesized all subsistence harvest data which had been undertaken in Canada. Berkes (1990) used data from 93 communities across the Canadian North and mid-North and found the subsistence fish harvest clustered around 60 kg per capita per year. Included in these data were estimates for fifteen communities in Manitoba. Green and Derksen (1984) provided subsistence

harvests for the fifteen communities and harvests ranged from 17-54 kg/capita/yr, which is less than the national average.

Specific research into subsistence fish use in Lake Winnipeg communities is limited. Green and Derksen's work examined communities in northern Manitoba, many of which are isolated and only accessible by plane or winter road. Wagner (1986) has been the only researcher to try to quantify subsistence use in some communities of the Lake Winnipeg area. His research was limited to only three communities of the Lake Winnipeg region and was part of a larger study of subsistence use of fish and wildlife in communities throughout Manitoba.

Chapter 3

Methods

3.1 Commercially-marketed harvests

This study was achieved through searches of historical records. Commercial fisheries data for Lake Winnipeg can be found dating back to 1883. Early commercially-marketed catch data were obtained from Department of Marine and Fisheries annual reports from 1883-1930. The commercially-marketed catch statistics for the period 1930-present have been obtained from the annual reports of Manitoba Department of Natural Resources.

The second component of this study involved tabulating the data for each year. Annual commercially-marketed harvest figures are derived from this data and total annual averages for 10-year periods were computed. Commercially-marketed harvest figures by species also were tabulated. This provided a relatively accurate figure of commercially-marketed fish harvests for the whole lake. Commercial harvests, in this study, mean the actual amounts marketed based on sales and do not include fish culled by the fishermen.

All historical records to 1981 were recorded in pounds; therefore all data from 1883-1980 were converted into kilograms to be consistent. Fish

yields from before 1976 were recorded by dressed or marketed weights. Dressed fish are gutted fish while round fish refer to the entire fish. The FFMC, in 1976, changed its method of recording weight to round weights (Lysack, 1986). All dressed weight data after 1976 were provided by the Manitoba Department of Natural Resources.

CPUE may be calculated using number of gillnets fished per year, number of fishermen in the commercial fishery or by length of season. Net type efficiency factor (3:1 for nylon netting (Lawler, 1950)), and mesh size efficiency factor should be considered in calculating CPUE. Mesh size efficiency may be important because catchability is increased by 1.5 times when mesh size is reduced from 5.25 to 5 inch mesh (Kooyman, 1955). Ricker (1975) described catch per unit of effort (c/y or Y/f) as the catch of fish, in numbers or in weight, taken by a defined unit of fishing effort where fishing effort (f) is the total fishing gear in use for a specified period of time.

CPUE was calculated in this study by using Ricker's method however effort data and other variables were not always available, therefore number of gillnets was used as the fishing effort from 1899-1974 inclusively and number of fishermen was used as the fishing effort from 1930-present inclusively. Net type efficiency was not factored into CPUE figures.

Rybicki and Doan (1966) suggested that exact CPUE figures cannot be totally accurate using Ricker's method because exact number of days fished and precise amount of gillnets used by fishermen are unknown values, resulting in inaccurate CPUE data. That is, it is uncertain whether all fishermen fish all possible days in a season and if they use the maximum

allowable number of nets during the fishing season. CPUE was calculated as accurately as possible given the available information.

Relative abundances of commercially-marketed harvests for four decades of the fishery were determined by calculating the percentage of each species harvested annually then calculating the mean percentage of each species per decade. These results were graphed into pie charts to show relative abundance.

3.2 Cullage of rough fish

Cullage of unmarketable fish species was estimated using commercially-marketed harvest statistics and experimental netting data from the Department of Natural Resources. These two sources provided a basis for estimating percentages of the non-marketed species by comparison of experimental netting catches and actual commercially-marketed catches. Experimental studies were carried out from 1979-1986 and provided data on catches of experimental gillnets, which were used to estimate catchability of all species in the typical commercial catch. Other experimental fishing studies done over the years also contributed to this task. Hewson (1959a, 1959b, 1957) studied commercial catches, winter and summer, for fishing success. These reports indicated relative amounts of all species caught in the experimental catches and were compared to the actual commercially-markted harvests for those years.

3.3 Subsistence harvests

Limited subsistence fishing statistics for Lake Winnipeg are available in historical records for the period 1887-1909 from annual reports of the Department of Marine and Fisheries. These statistics were given by the fish guardians of specific areas surrounding Lake Winnipeg. It is not clear whether these estimates were based on population size and from total community harvests or whether these estimates are subsistence harvests derived from the commercially-marketed harvests of the area. Many of the commercial fishermen were aboriginal people and the amount of fish caught by these fishermen was recorded, of which a certain amount was sold for market and the rest was retained for subsistence use. These estimates however may not have included those aboriginals who were not fishermen but who went out fishing for their family needs. The subsistence harvest use appeared to cover the area of the south basin of the lake only. Communities of the north basin were not included as there was no one there to record this information. The north basin/ eastern shore of the lake was and still remains sparsely inhabited which means little subsistence fishing would have been undertaken here. The western shore of the north basin may be covered in Area 2 of the subsitence harvests statistics. Amounts of fish harvested from various areas of the lake or as annual totals for the entire lake are given.

Estimates of present day subsistence use were obtained by examining the data from a study of fish use by native communities. This information was limited and thus only estimates were established. Present day use was found in a study by Wagner (1986) but covered only one year and only three

communities in the Lake Winnipeg area. This study was part of a larger study covering many communities in Manitoba and focused on fish and wildlife use, not just fish use. Other subsistence fish use was noted in some of the historical documents over the years and was used on a qualitative basis.

Chapter 4

Results and Discussion

4.1 Commercially-marketed harvests

Commercially-marketed harvest data for Lake Winnipeg are presented by species and year in tables in Appendix A. These tables indicate the breakdown of commercially-marketed harvests into species as it was found in historical Department of Marine and Fisheries reports or annual reports of the Department of Natural Resources. All other results are based on these tables. Figures showing commercially-marketed harvests over a particular period provide information of the most important species and total harvest which includes all species in the commercially-marketed harvest not just the most important species.

4.1.1 1880's

The commercially-marketed harvest data during the first decade of the industry is not very complete. Lake whitefish was the commercial species sought during the first decade, consequently lake whitefish harvest data are the most available in the literature. Record keeping, in the industry's infancy, was

poor and it was not until the end of the 1880's and rising concern over overfishing that better records were kept.

Table A-1 in the Appendix provides a complete record of the commercially-marketed harvest, as available from the literature. The years 1883 through 1886 are indicated as single years, because the winter fishery was insignificant at that time. All years following 1886 are shown as spanning two years indicating winter fishing was occurring. Fishing effort is included where available.

Less significant species in the commercially-marketed harvest were walleye, northern pike, sturgeon and lake cisco. The "mixed" category refers to species such as all suckers (white, shorthead redhorse, long nose and quillback), burbot, goldeye, or other species not specified. The "home" category referred to home consumption of all species acknowledging the subsistence use of fish. The commercial catch was divided into export and local trade (or home consumption). Home consumption was referred to in the "domestic" fishing category but it is not clear whether all fish under this category were consumed locally or were shipped to nearby areas, such as Winnipeg. It does appear, by investigating the original Marine and Fisheries reports, that most fish under the home consumption category were consumed by local natives and Icelandic settlers. Home consumption may only refer to those licensed fishermen who retained some of their harvest for subsistence use and may not have included those individuals who just fished for their family needs.

4.1.2 1890's

Collection of detailed commercially-marketed harvest data began in this decade. Records for all years are available in Table A-2. Figure 2 illustrates the commercially-marketed harvests for the most important commercial species. Lake whitefish was still the most important species with well over one million kilograms of harvest annually. Walleye, northern pike, and sturgeon were secondary species, never coming close to the lake whitefish harvests.

Except for a drop in catches in 1899-1900, due to poor weather, the trend in overall catches was generally upward through the decade. The 10-year average annual commercially-marketed catch for this decade was 2.6 million kg.

4.1.3 1900-1909

A dramatic increase in total commercially-marketed harvest occurred during the first half of this decade (Figure 3, Appendix Table A-3). Total commercially-marketed harvest reached a maximum in 1904-05 at 10.1 million kilograms. Lake whitefish catches also rose to a high in 1904-05 of 3.4 million kg, thereafter decreasing for the next three years to below 1 million kg in 1907-08. In 1907-08, walleye harvests surpassed lake whitefish harvests for the first time.

Sturgeon harvests declined during this decade from a high in 1900-01 of 446,000 kg to 23,700 kg by 1909-10. Fishermen never again obtained the

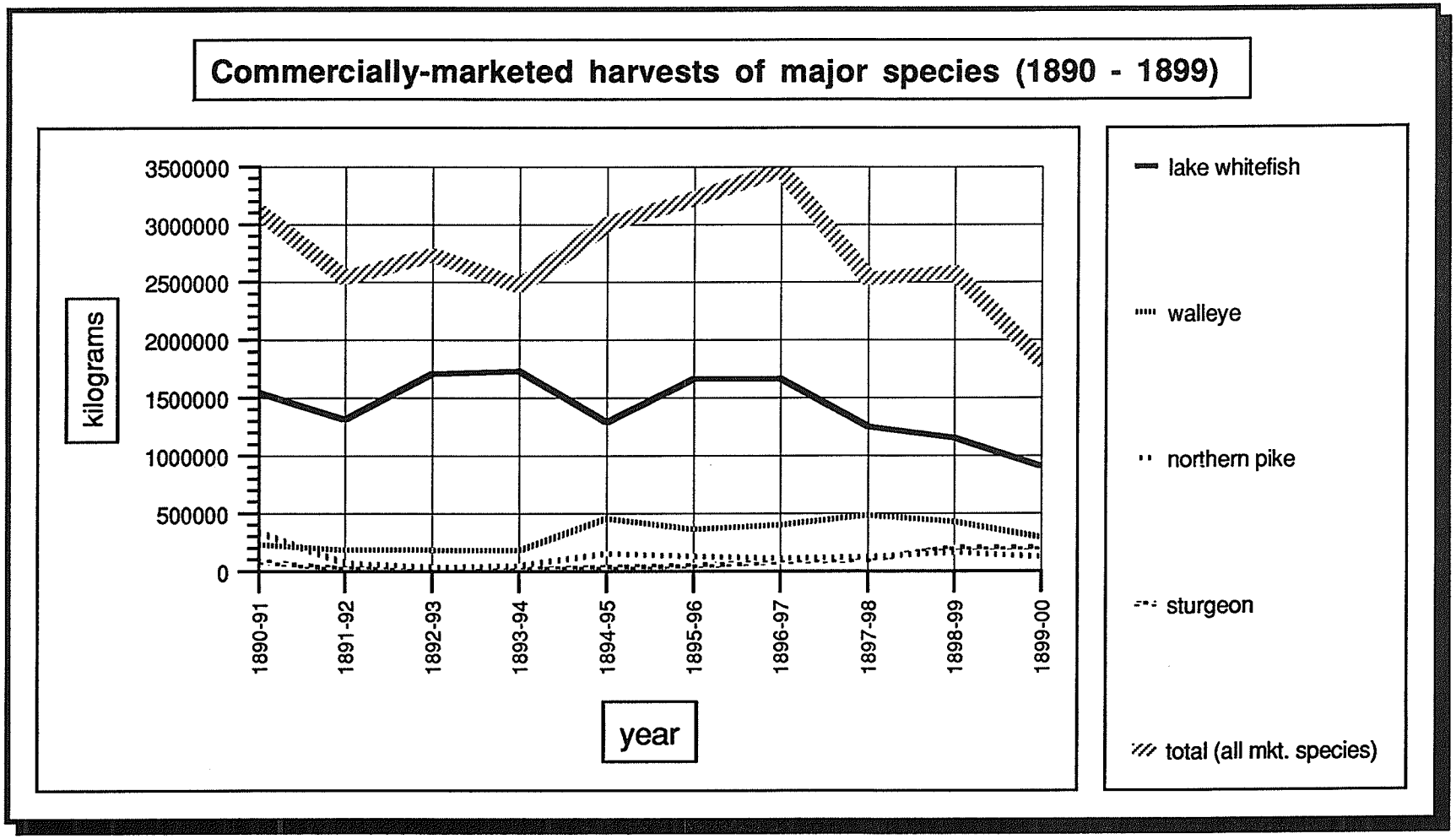

Figure 2: Commercially-marketed harvests of major species in kilograms (1890 - 1899)

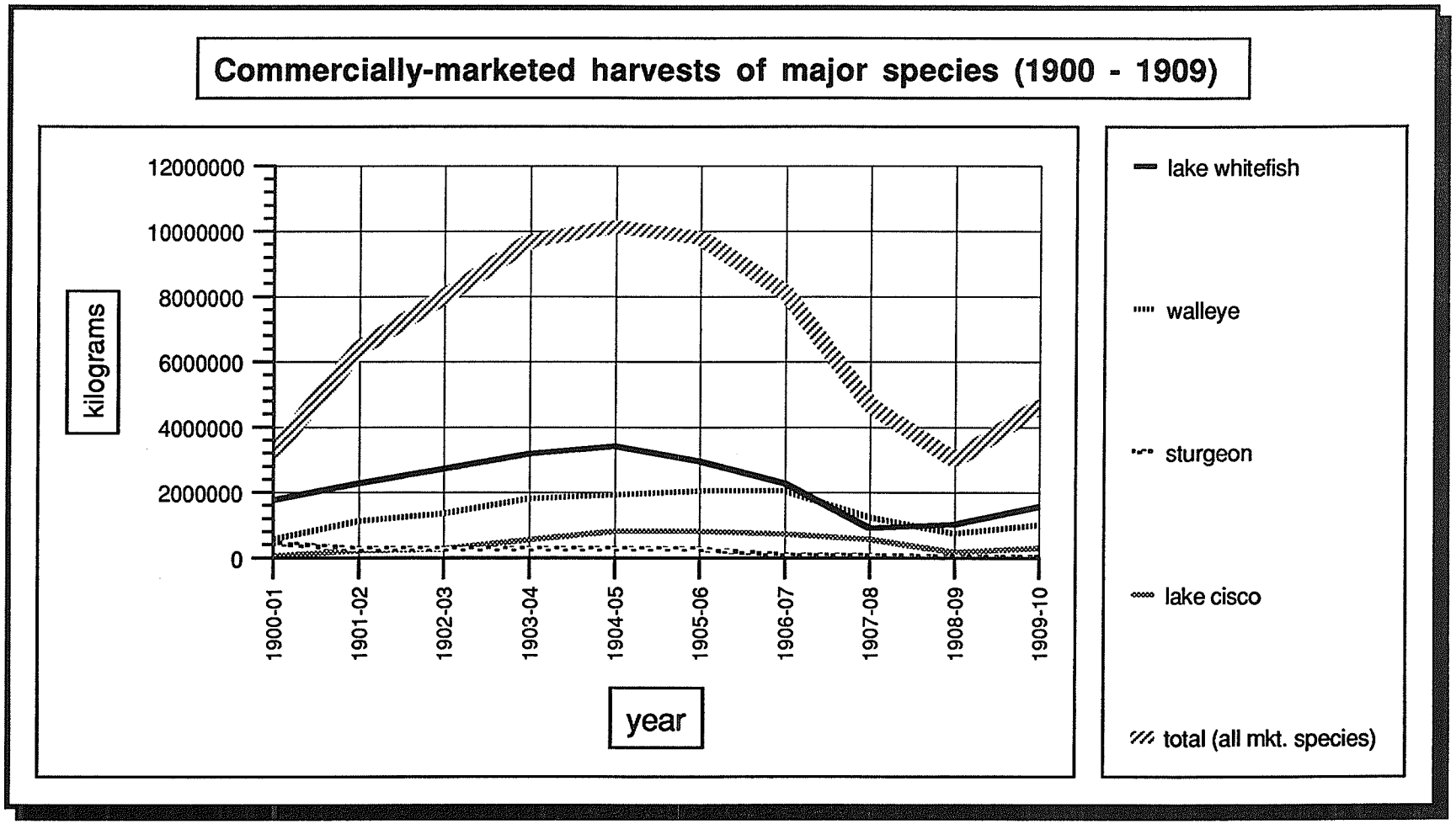

Figure 3: Commercially-marketed harvests of major species in kilograms (1900 - 1909)

sturgeon harvests of the 19th century. The 10-year average annual commercially-marketed catch for this decade was 6.7 million kg.

4.1.4 1910-1919

During this decade, commercially-marketed harvest levels stabilized somewhat with a 10-year average of 5.4 million kg. Figure 4 and Table A-4 in the Appendix provide the commercially-marketed harvest data for this decade. Lake whitefish harvests remained below 1.5 million kg, with walleye harvests decreasing during the decade. The entrance of lake cisco as a major species in the last half of the decade helped keep the total commercially-marketed harvests high. During this decade, home consumption was combined with mixed species, eliminating the importance of recording subsistence fish use in the records.

4.1.5 1920-1929

A large increase in total commercially-marketed harvest over that of the previous decade occurred in 1920-29 (Figure 5, Appendix Table A-5). Commercially-marketed harvest levels have never again reached the highest level recorded in 1929-30 at 10.5 million kg.

Commercially-marketed harvests of individual species varied little during the period. Walleye and lake cisco continued to be harvested at high rates but were still secondary to lake whitefish. Sauger was introduced as a commercial species during this decade. The 10-year average annual commercially-marketed catch for this decade was 6.8 million kg.

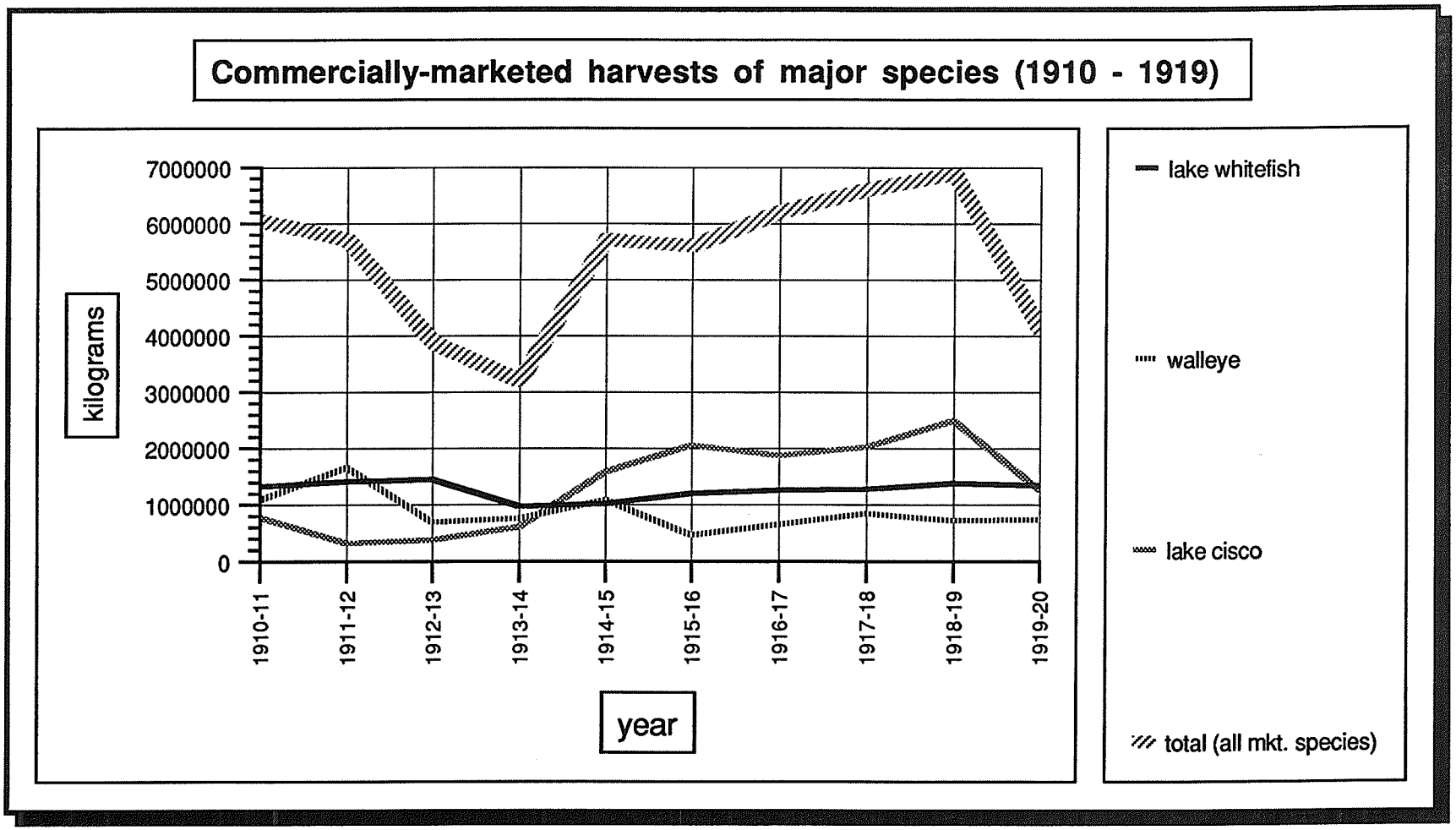

Figure 4: Commercially-marketed harvests of major species in kilograms (1910 - 1919)

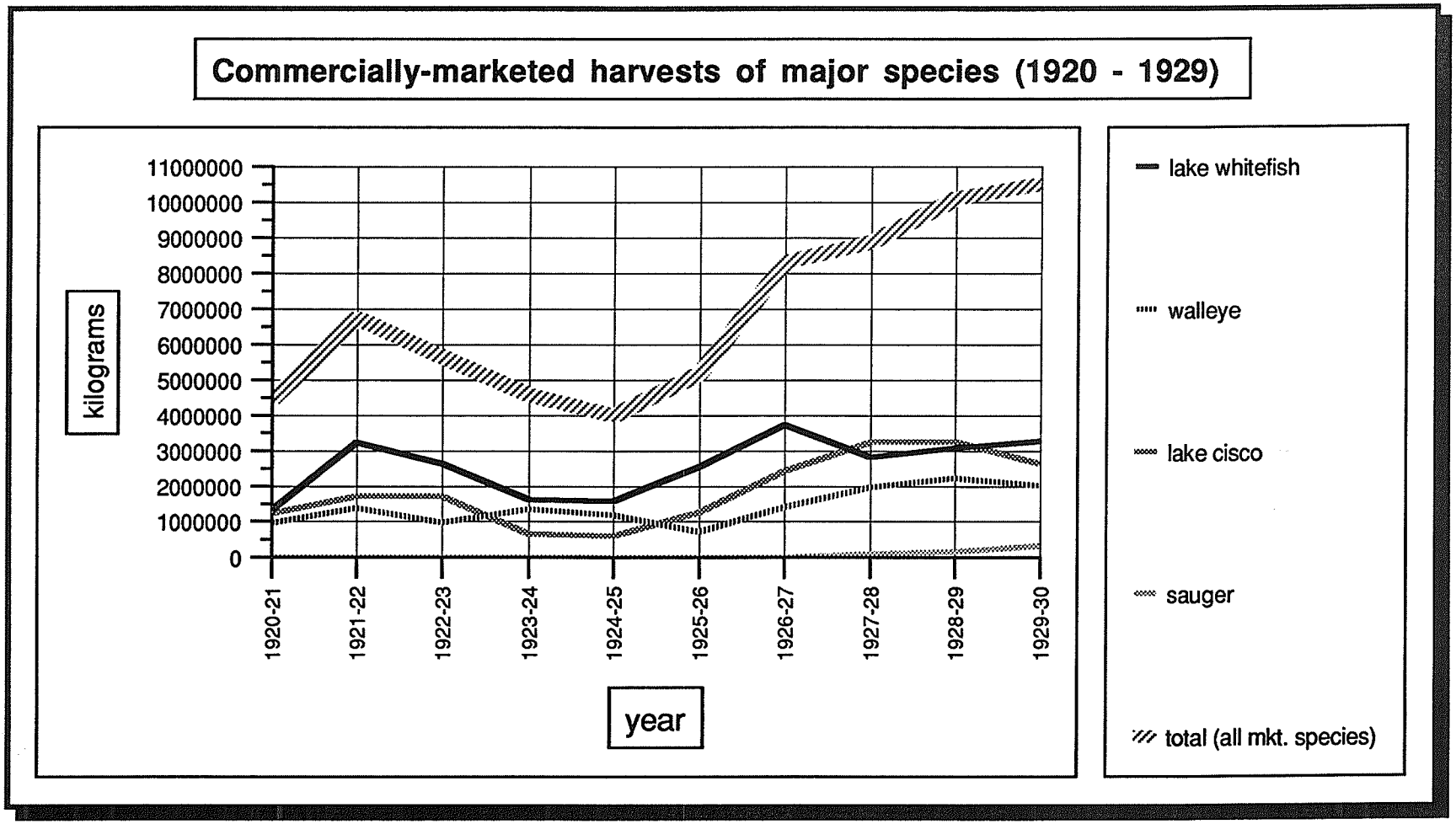

Figure 5: Commercially-marketed harvests of major species in kilograms (1920 - 1929)

4.1.6 1930-1939

Total commercially-marketed harvests of the major commercial species trended upward during this decade (Figure 6, Appendix Table A-6), but lake whitefish harvests declined to below 1 million kg in the last four years of the decade. Walleye and sauger harvests increased to more than lake whitefish harvests, with sauger harvests reaching a maximum of 4.3 million kg in 1938-39. Lake cisco harvests slowly decreased through the period. The largest annual commercially-marketed catch for the decade occurred in 1938-39, corresponding with the highest sauger catch. The 10-year average annual commercially-marketed catch for this decade was 5.7 million kg, more than 1 million kg lower than the previous decade.

4.1.7 1940-1949

The highest commercially-marketed catch of this decade was taken in 1940-41 and commercially-marketed catches trended downward for the rest of the decade (Figure 7, Appendix Table 7). Exceptionally high total commercially-marketed catches in all years of this decade resulted in a 10-year average annual commercially-marketed catch of over 7.8 million kg; the highest 10-year average in the history of the commercial fishery.

4.1.8 1950-1959

Total commercially-marketed harvests during these ten years were high but fell considerably in the last year, 1959-60, to below 4.5 million kg (Figure 8, Appendix Table A-8). The 10-year average annual commercially marketed

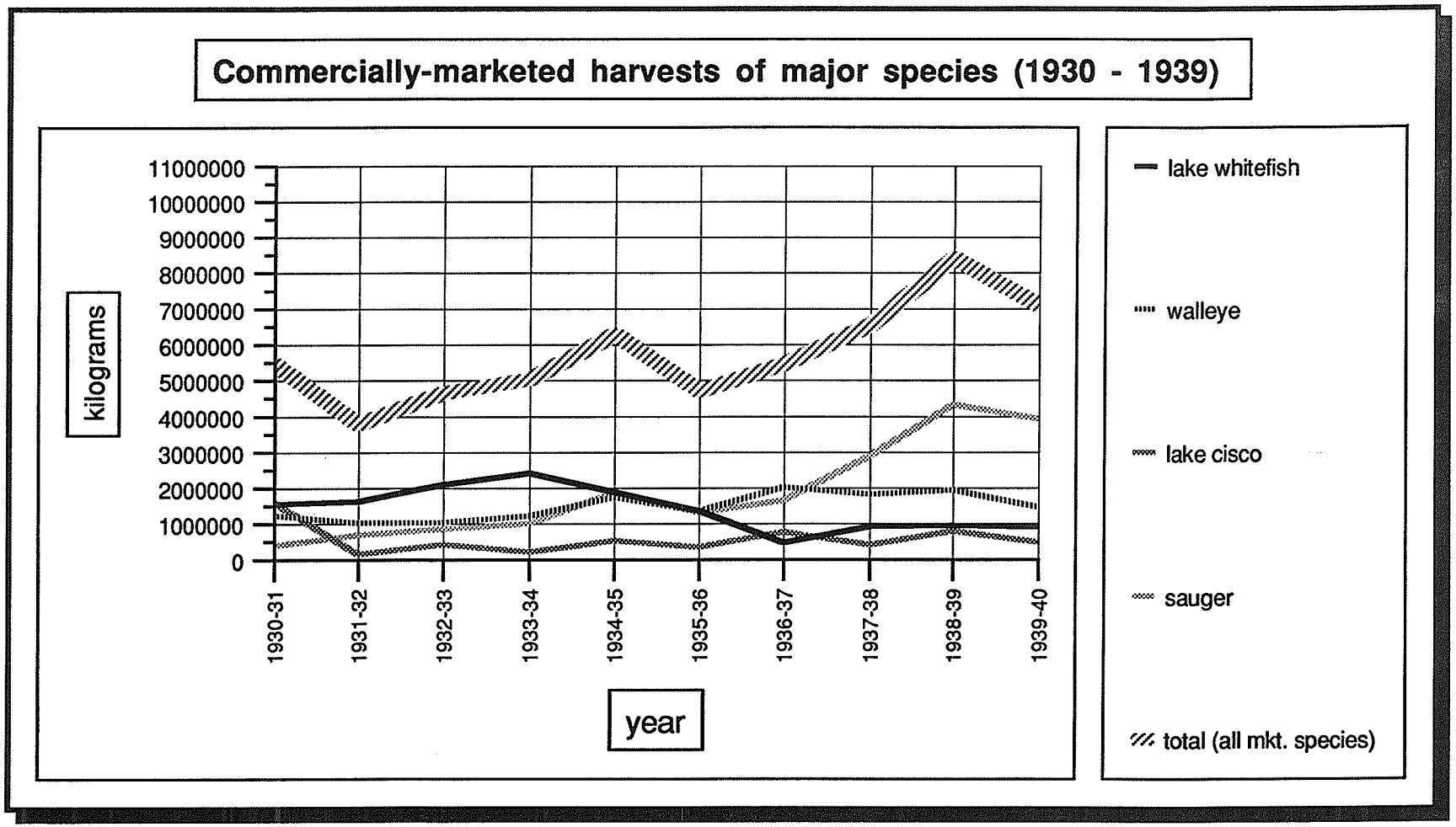

Figure 6: Commercially-marketed harvests of major species in kilograms (1930 - 1939)

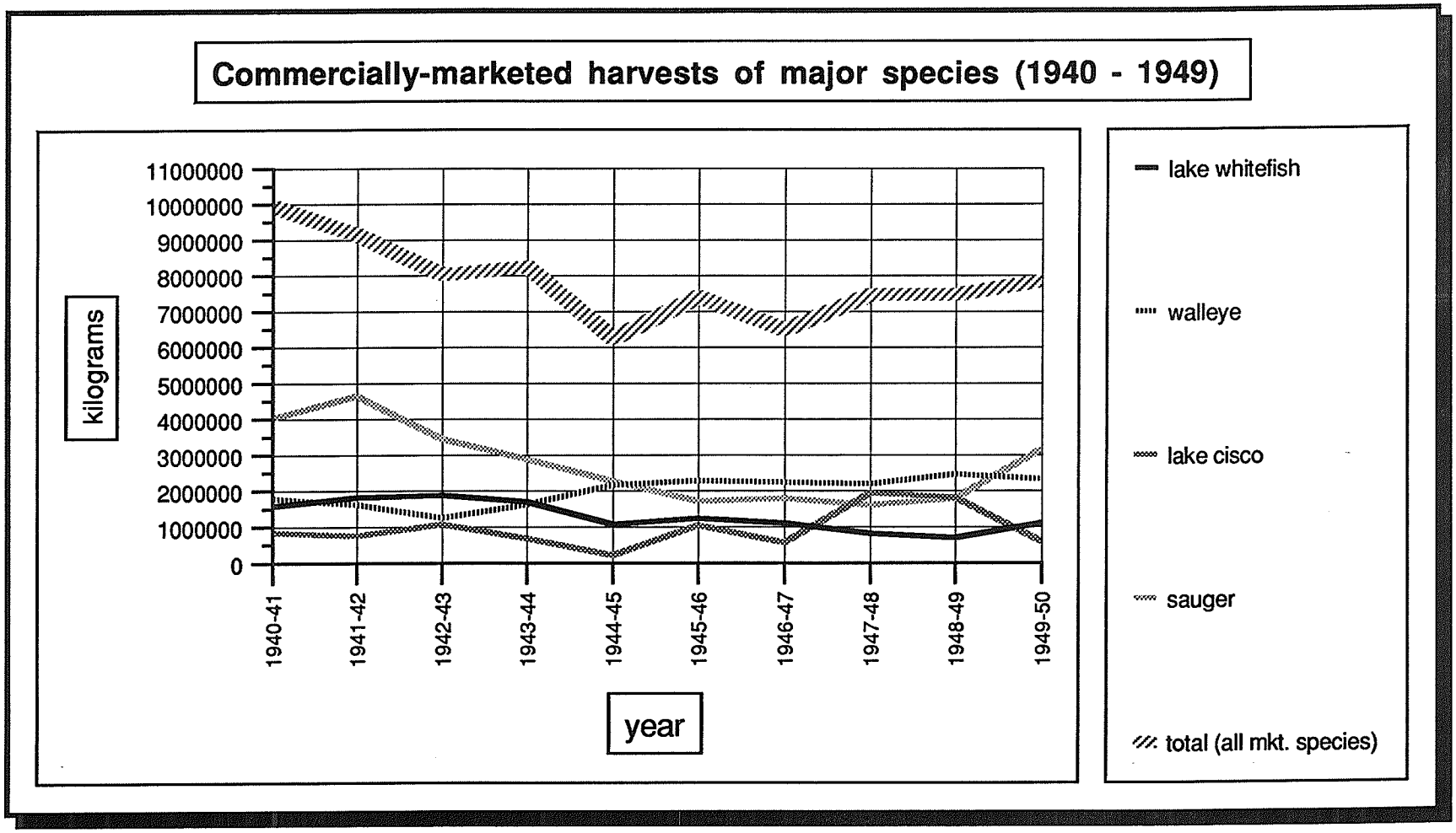

Figure 7: Commercially-marketed harvests of major species in kilograms (1940 - 1949)

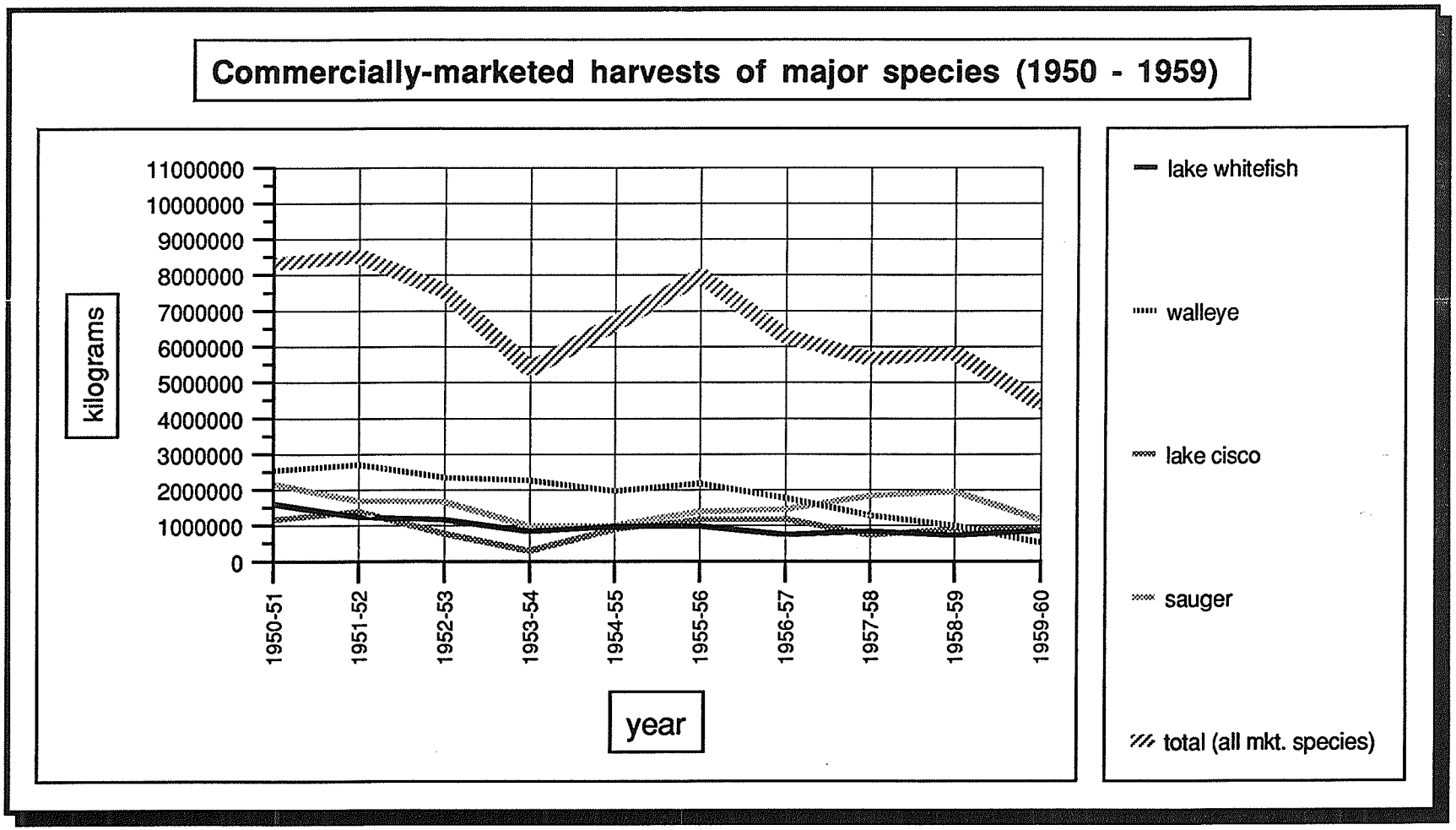

Figure 8: Commercially-marketed harvests of major species in kilograms (1950 - 1959)

catch for this decade was 6.6 million kg, down from the previous decade but still high in comparison with the commercially-marketed catches of the following 30 years of the fishery.

4.1.9 1960-1969

The beginning of a shift in the commercial fishery, marked by a continued decline in commercially-marketed harvests from the previous decade occurred in the 1960's, with a general trend downward through the decade to a low in 1969-70 (Figure 9, Appendix Table A-9). The 10-year average annual commercially-marketed catch for this decade was 3.9 million kg, a considerable decline from the previous 60 years.

4.1.10 1970-present

This 20-year period represented a new era in commercially-marketed fish harvests from Lake Winnipeg. The mercury closure of 1970-1971 appeared to help fish stocks to replenish following a period of intense fishing and high harvests. The outcome of this recent period is a fishery dominated by three species, lake whitefish, walleye, and sauger. Other species in the commercially-marketed catch were relatively insignificant. Also, the Freshwater Fish Marketing Corporation (FFMC), established in 1969, began to have its effect on fish marketing. A slow rise in annual commercially-marketed catches occurred after the closure of the fishery and commercially-marketed harvests continued to increase throughout the seventies and the eighties with a 10-year average annual commercially-marketed catch in the

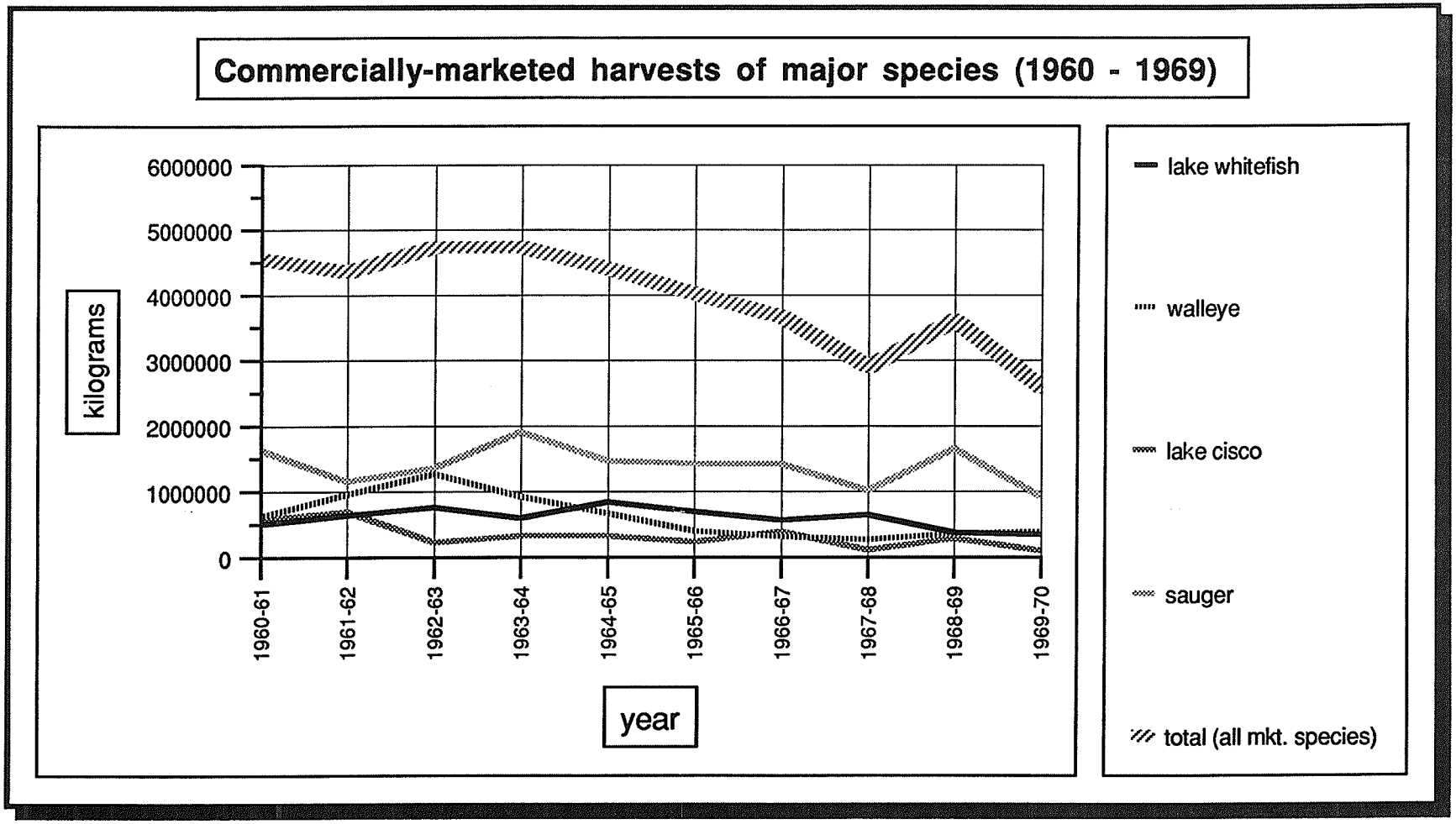

Figure 9: Commercially-marketed harvests of major species in kilograms (1960 - 1969)

1970's and 1980's of 3.4 and 5.3 million kg respectively. Commercially-marketed harvests in the 1990's appear to be following a trend similar to that of the eighties (See 1990-91 annual catches below). The introduction of the FFMC, the mercury closure of 1970-71 and a fairly steady fishing effort due to stricter regulations have contributed to a more consistent harvest annually with fewer fluctuations in total harvests.

Figures 10 and 11 and Appendix Tables A-10, A-11 provide the annual commercially-marketed harvest data for these two decades. Because statistics for commercially-marketed harvests in the 1990's are available only for one year, the harvest figures are presented here in kilograms; lake whitefish (927,614), walleye (1,823,259), sauger (1,777,709), northern pike (69,008), yellow perch (71,085), goldeye (57,729), white bass (49,722), others (25,965), burbot (3,285) and total harvest (4,805,376).

4.1.11 Summary of commercial harvests

A summary of the commercially-marketed harvests for the three most important commercial species and the total of all marketed species of Lake Winnipeg is provided in Figure 12, as 10-year averages over the history of the fishery. Peaks in harvests have occurred throughout the history of the fishery, with a slowly rising total average harvest until the 1940's. After the 1940's, harvests declined until the 1970's when harvests began to rise again but at a much slower and steadier pace. Figure 12 shows lake whitefish harvests dominating the commercially-marketed catch until the 1930's. After

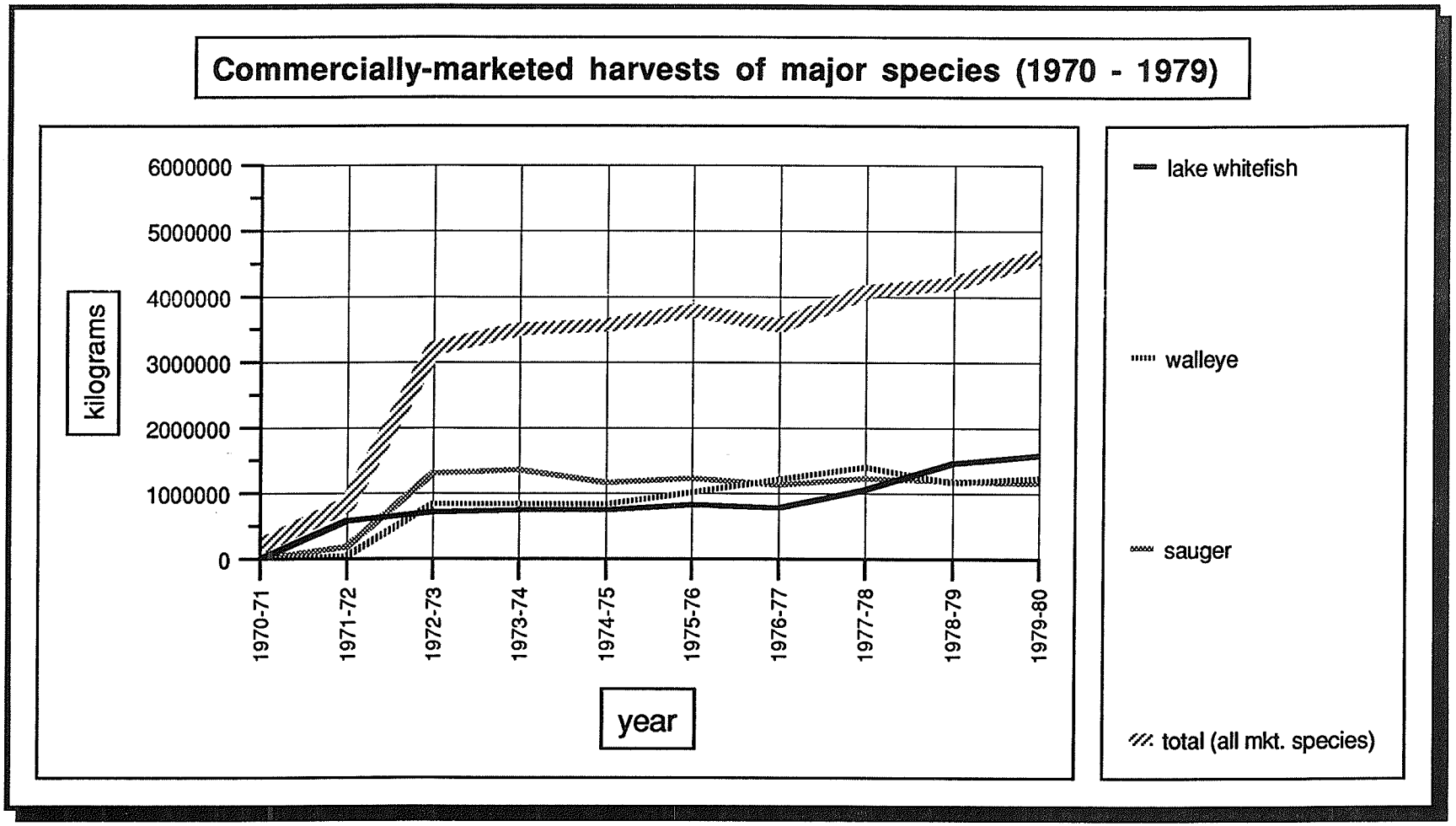

Figure 10: Commercially-marketed harvests of major species in kilograms (1970 - 1979)

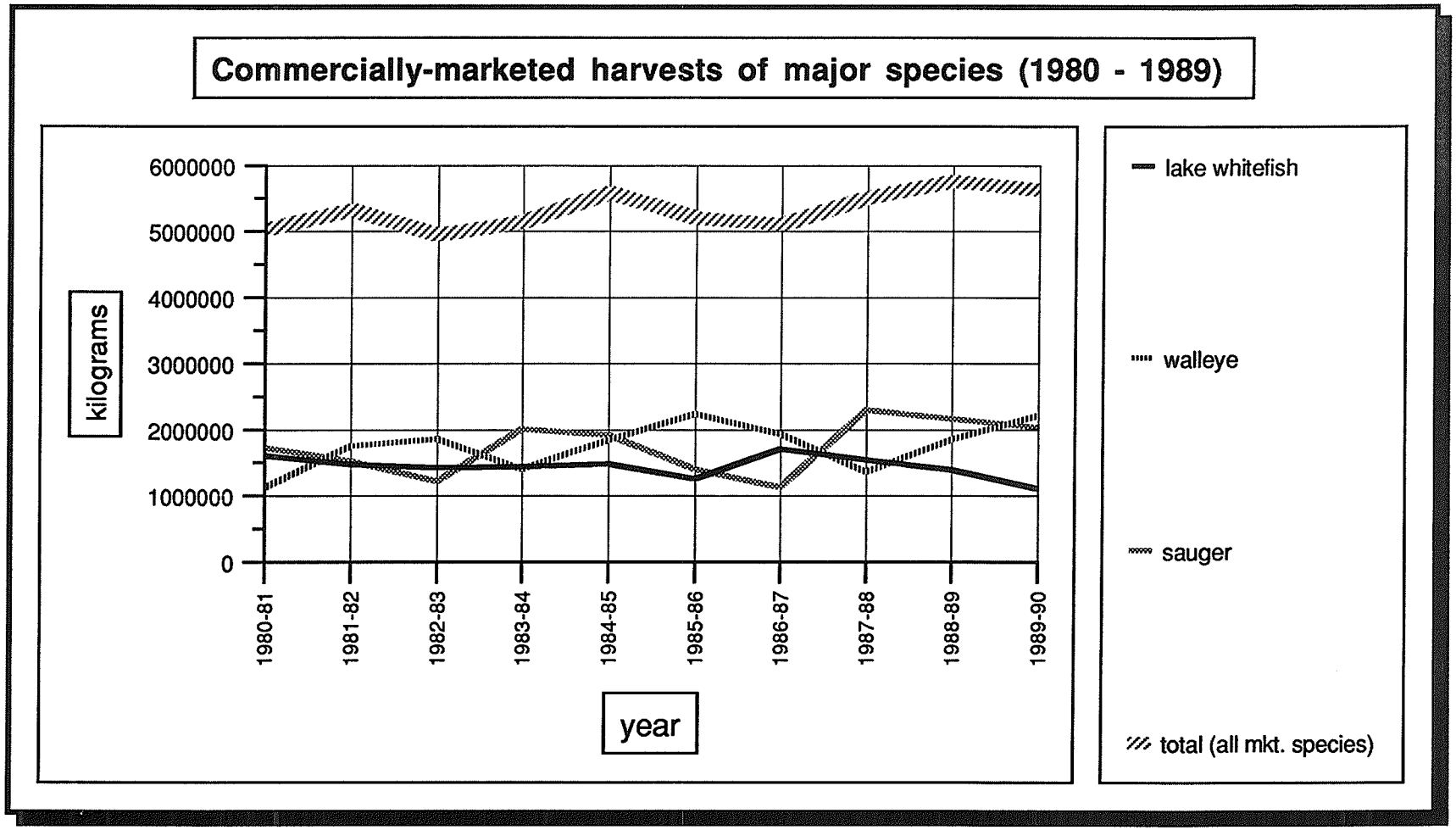

Figure 11: Commercially-marketed harvests of major species in kilograms (1980 - 1989)

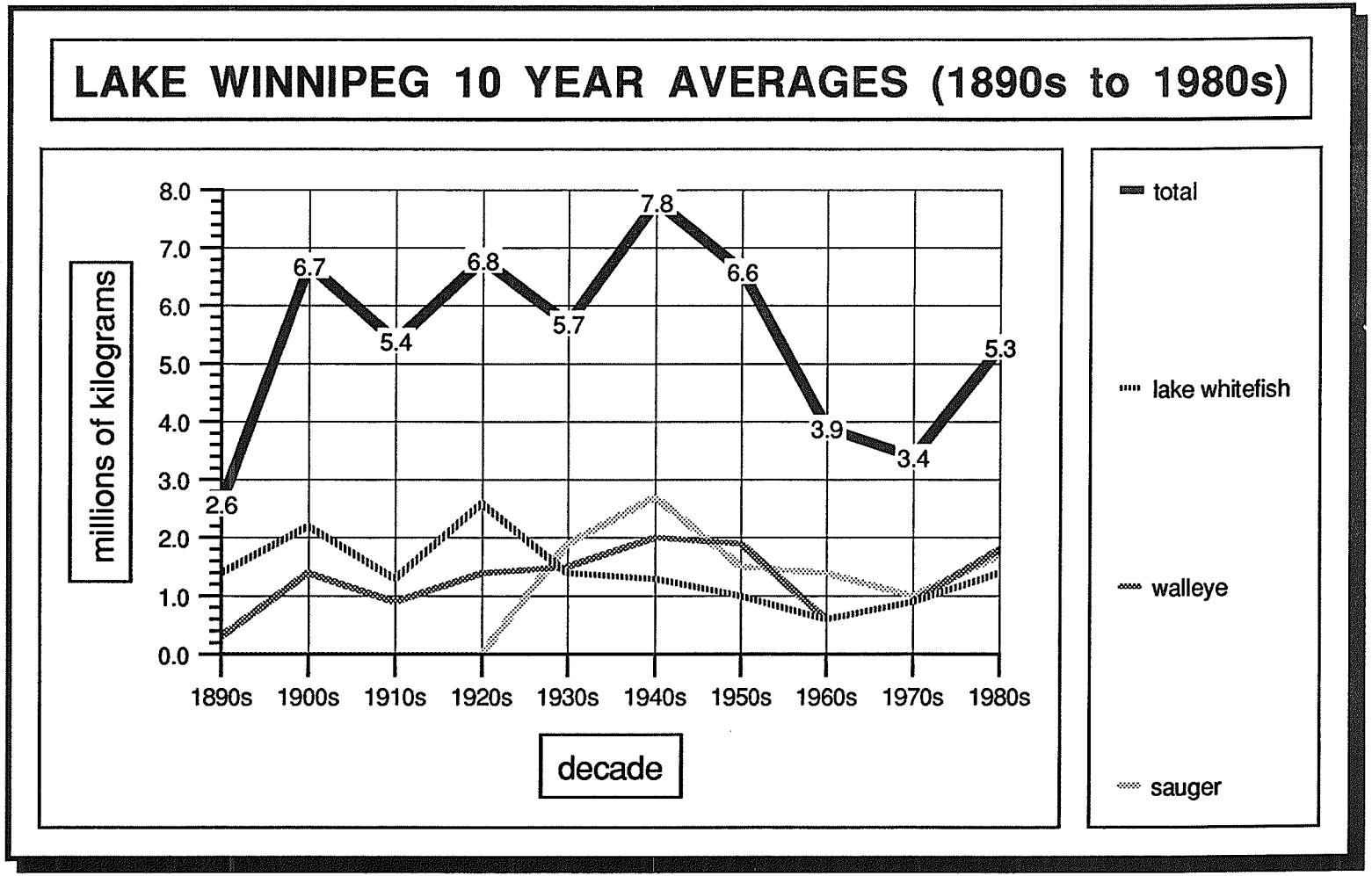

Figure 12: Lake Winnipeg 10 year commercially-marketed harvest averages

the mid-1930's, walleye and sauger harvests dominate the commercially-marketed catches.

Relative abundance of species in the commercially-marketed catches is useful to determine if changes have occurred in species composition in the lake. Commercially-marketed harvest data however reflects market prices, market demand, effort and other variables and might not reflect species composition of the lake. A summary of relative abundance of the commercially-marketed catch is given in pie charts in Figures 13 and 14 during four decades of the commercial fishery.

Figure 13 shows species abundance through the 1890's and 1930's. The 1890's was the first decade in which complete commercially-marketed harvest data was available and the entire lake was fished. The 1930's represent a decade when harvests were peaking. Figure 14 shows relative abundance in the 1960's and the 1980's. The 1960's was the decade when commercially-marketed catches were dropping due to overfishing. The 1980's represents the present day trend in the commercial fishery.

Sturgeon, although comprising a small percentage of the catch in the 1890's, is virtually eliminated by the 1930's through to the present. Sturgeon was important in the early years of the fishery but overfishing resulted in its decimation. Sturgeon is not represented in the other pie charts as it was either not marketed in the commercially-marketed harvests or its catches were too low to show in the pie chart.

Lake whitefish represented 50% of the commercially-marketed catch in the 1890's, only 27% in the 1930's, and 15.2% and 27.3% in the 1960's and

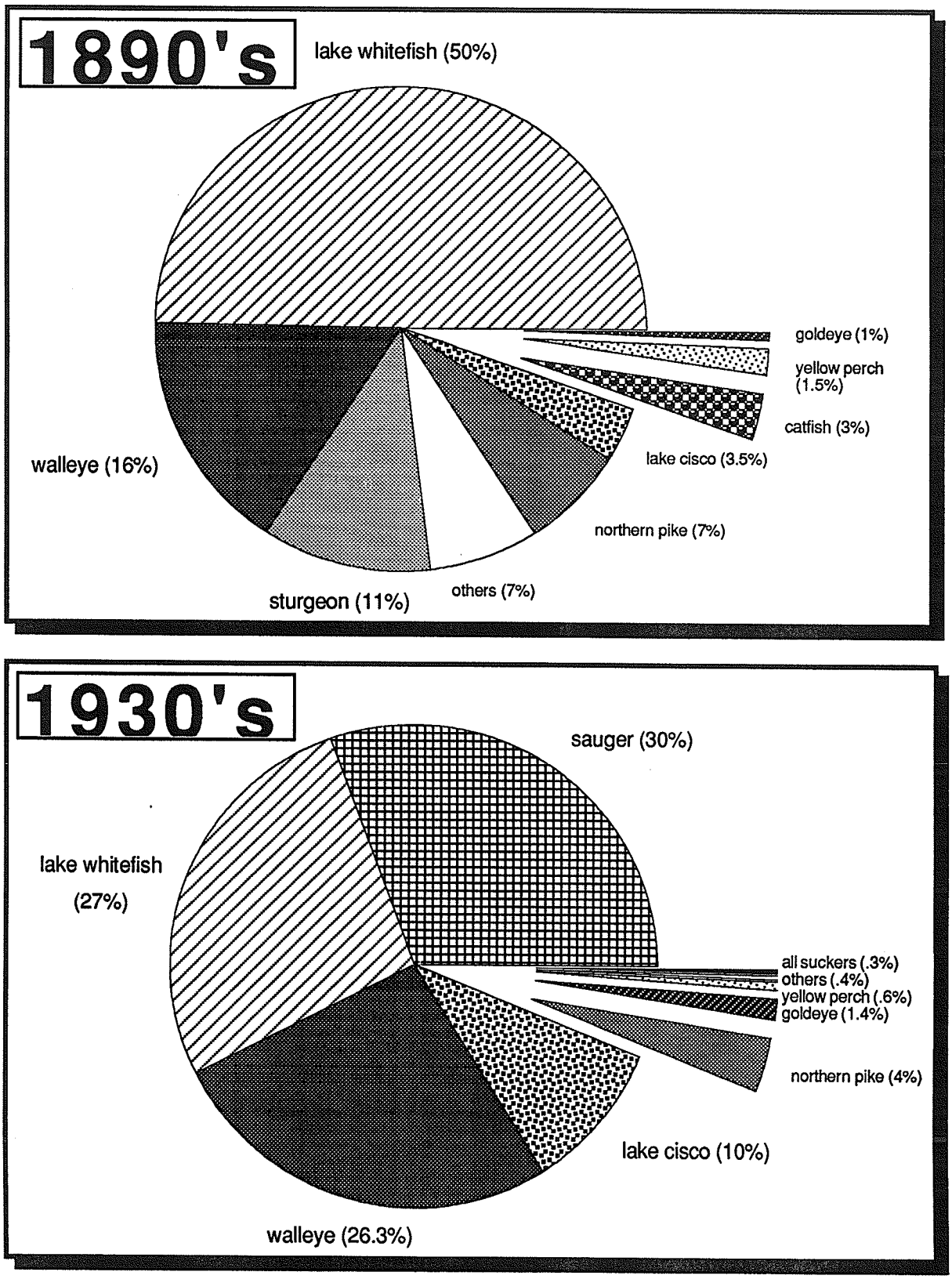

Figure 13: Relative abundance of species as % of total commercially-marketed harvest

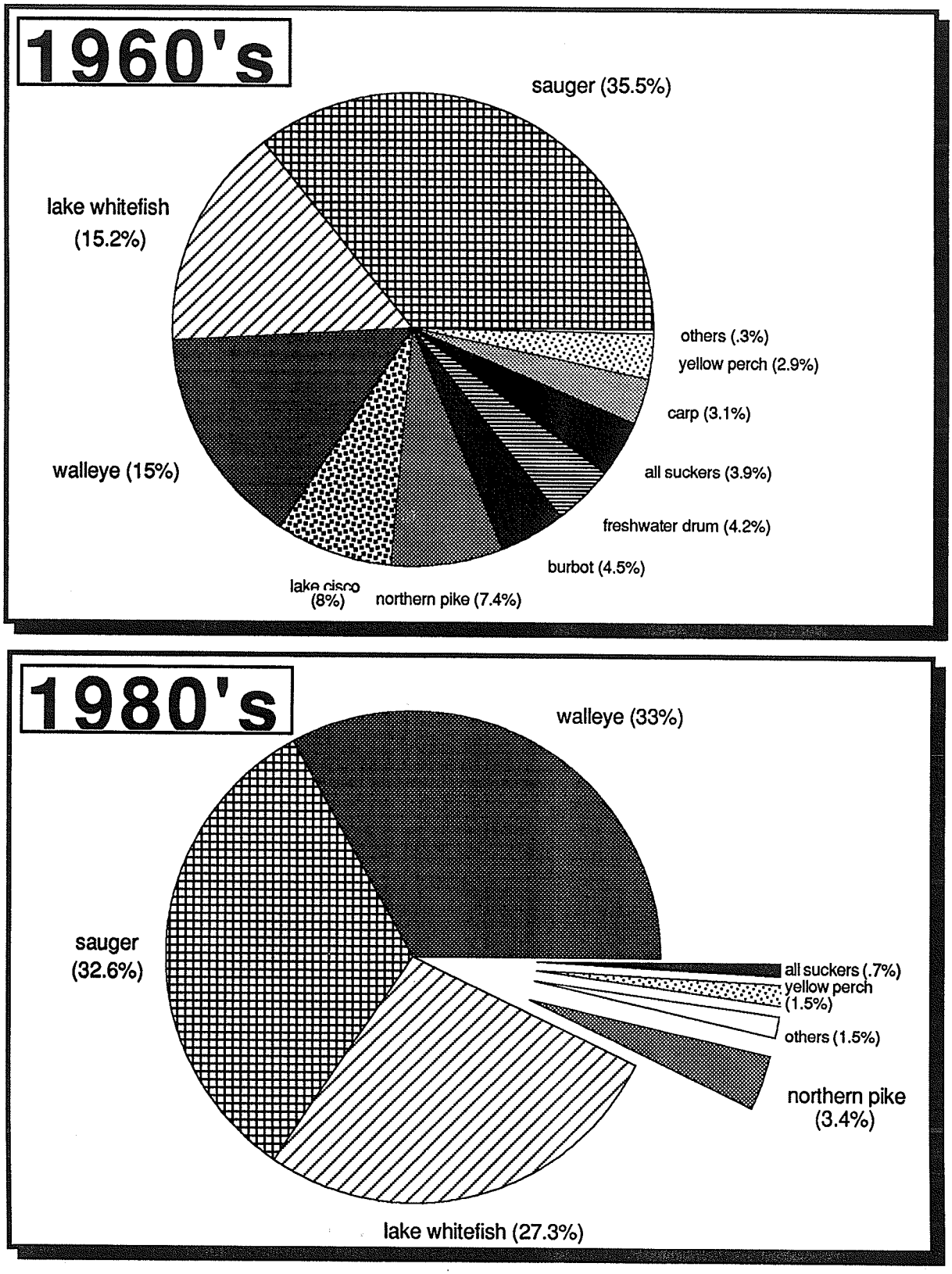

Figure 14: Relative abundance of species as % of total commercially-marketed harvest

1980's, respectively. Walleye harvests were 16% and 15% in the 1890's and 1960's respectively, while in the 1930's and 1980's walleye harvests were 26.3% and 33% respectively. The pie charts show lake whitefish and walleye harvests have fallen to 15% each of the total commercially-marketed catch in the 1960's. This shows the effects of overfishing on the abundance of these two species. Lake whitefish, walleye, and sauger harvests have risen since the time of the mercury closure. In the 1980's, walleye harvests decreased when sauger harvests increased and vice versa. The reason for this is not known but may have to do with fish prices, species quotas or abundance of fish stocks.

Sauger were not commercially harvested in the 1890's. In the 1930's, after only being harvested commercially since 1927, sauger represented 30% of the total commercially-marketed catch. Sauger catches have remained well over 30% since this time. In the 1960's, sauger dominates the catch at 35.5% of the total commercially-marketed harvest.

Other species in the commercially-marketed catch were quite highly marketed until the 1960's. In the 1980's, a three species fishery, dominated by walleye, sauger and lake whitefish clearly appeared. Since the FFMC came into being in 1969, the variety of species in the marketed commercial harvest has narrowed. Lake cisco represented a small, but significant, portion of the commercially-marketed harvest from the 1890's (3.5%) to the 1960's (8%) but had fallen so low in the 1980's they were included in the others category at 1.5%. Other species in the commercially-marketed catches had fallen to less than 10% of the total harvests in the 1980's. Northern pike and yellow perch

were small but consistently harvested species throughout the history of the commercially-marketed catch.

4.2 Catch per unit effort

As indicated earlier, catch per unit effort (CPUE) is a measure more indicative of what is happening in a fishery. Commercially-marketed harvest statistics presented in section 4.1 of this chapter are useful for obtaining values of total commercially-marketed harvests of a particular species or of a particular year. The fact that one year has a high commercially-marketed harvest does not mean that fishing was particularly good that year unless effort is considered. A year with a high harvest could mean a high effort rate was used, particularly good fishing occurred because of abundant fish stocks, or another variable, such as good weather, good fish markets or high fish prices were responsible. CPUE data provide a better indication of whether one of these other variables affected harvests or if effort itself was the variable responsible.

CPUE data for fifty years of the commercial fishery (1899-1974 inclusive) are given in Figure 15. The number of gillnets fished was used as the unit of effort. This unit of effort was used because it was the only consistent unit of effort available from the historical records for this period. Figure 16 shows more recent CPUE for the period 1930-1989 (inclusive), which is given in number of fishermen.

There were two major peaks in the CPUE between 1899-1974 (inclusive). One peak was in 1900 with a CPUE of 2849 and the other

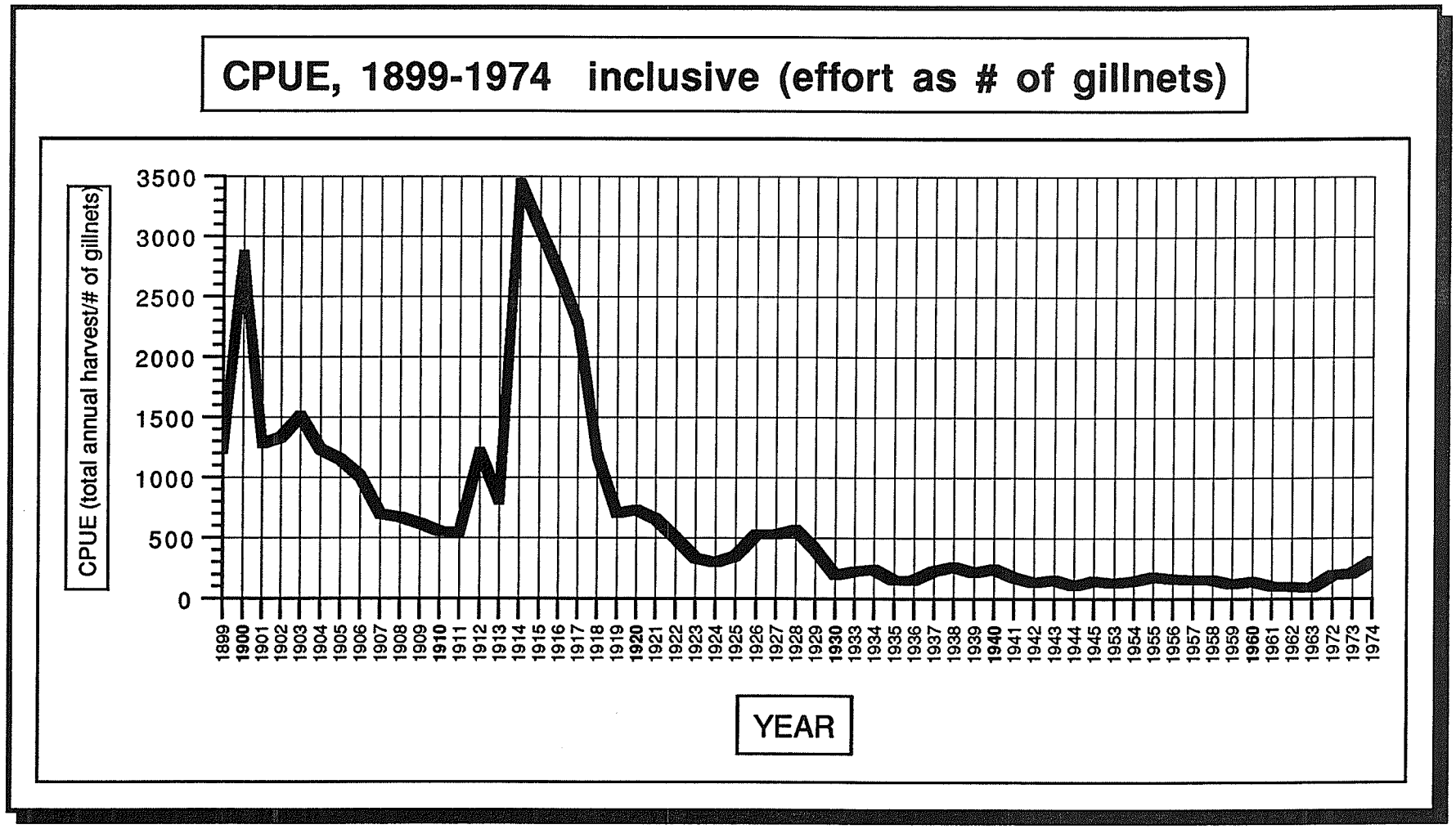

Figure 15: CPUE, 1899-1974 inclusive (effort as # of gillnets)

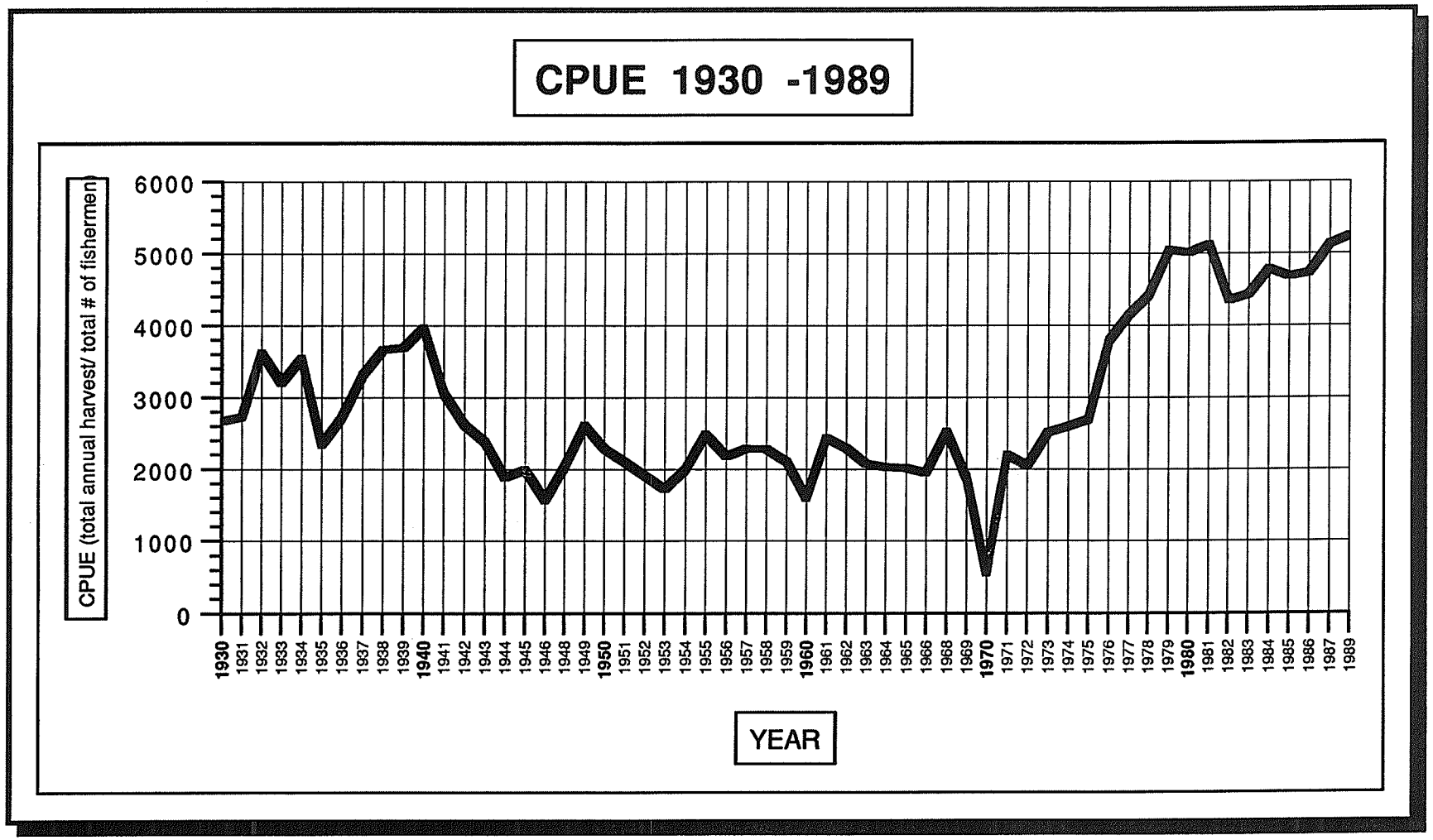

Figure 16: CPUE, 1930 - 1989 inclusive (effort as total number of fishermen)

occurred between 1914 and 1917 when CPUE exceeded 2000 meaning less effort was used to catch more fish or higher catches occurred with the same effort.

Reasons for differences in CPUE for the two high values of CPUE in 1900 and between 1914-1717 (Figure 15) could be several. One possibility is an error in the effort data. Historical records were not always consistent with or applicable to today's data or interpretation. Assuming historical data is correct, other variables affecting CPUE could be the introduction of the jigger in 1900 accounting for initial high catches in 1900, but not accountable for the lower CPUE after 1900.

Weather often plays a role in whether there are good or bad harvests. Ease of net setting during the winter and time and condition of ice freeze-up are factors often noted as hampering fishing operations. For example, as noted earlier, 1899-1900 was hampered by poor weather, "The season was not favourable and considerable loss was sustained by the fish becoming unmarketable in the nets, on account of wind being too high to lift them at the proper time" (Canada, 1901). This should mean less effort was used during that year. No specific reason is given in the historical documents which accounts for the high CPUE in 1900-01.

During the period 1914-17, CPUE rose but catches remained fairly average. The CPUE peak in 1914-17 could have been due to the introduction of cotton replacing linen twine in nets. Cotton nets were more efficient than linen nets. The First World War also resulted in less people available to fish thereby increasing the use of gas fishing launches and mechanical net lifters

which contributed to increasing fishing effort (Cauvin, 1992). This means fewer nets were used more efficiently to catch the same amount of fish, possibly explaining the high CPUE during this time.

Department of Marine and Fisheries annual reports suggest several reasons for the high catches during these years. The annual report for 1915-16 suggested that the introduction of whitefish fry into the lake each year resulted in higher catches:

> This is the first year that I have heard the fishermen express themselves that the size and quantity of fish were better on account of the great number of young whitefish fry put into the lake each year...(Canada, 1917)

Other reasons for harvest or effort changes are cited below:

> You will see by the annual returns that a larger amount of whitefish were caught in the summer of 1915-16 than in that of 1914-15. Very few men were fishing in the winter for whitefish, which accounts for the small quantity caught. You will note that tullibee caught are in excess of last year, and also that more gear was used in the present year. The price of fish was the same as last year,... and There was very little fall fishing done in my district. On account of so many pickerel being held over in cold storage, none of the large companies handled any last fall.(Canada, 1917)

The report for 1916-17 suggested that at that time the fisheries officers thought the reasons for high yields that year were that: the fish were larger that summer, strict enforcement of the close season, and the stocking of large quantities of fry each year (Canada, 1918). The annual report for 1918 suggested that harvests were high because:

> ...fishing had to be stopped before the end of the whitefish season as the fishermen had caught the quantity allotted them, which quantity was 500,000 pounds more than the season of 1917, which I think was partly due to the number of fish deposited in the lake from the hatcheries, also to the strict enforcement of the law.(Canada, 1919)

Furthermore, the report stated:

> I find there is a large decrease in the catch of pickerel this year, which I cannot account for, as there were as many fishermen working as last year. There is also a decrease in the tullibee catch. This can be accounted for by the open fall; the fishermen could not get their nets in the water during the time the fish were running, as there was no ice. When the lake was frozen hard enough to go on the fish were gone. This, I think, is partly the reason for the decrease in pickerel also.(Canada, 1919)

These explanations did not calculate CPUE and are merely based on yield and give insight into how harvest rates were perceived in the past.

After 1917, CPUE decreased but remained fairly steady until 1930. From 1930-1945, CPUE was low. Cauvin (1992) explained that the depression of the 1930's resulted in a decline in prices and therefore an increase in effort to harvest more fish to obtain the same level of income as before the depression. Cauvin (1992) further suggested that during World War II, the fisheries served to provide as much food as possible. This accounted for the continued increase in effort which began in 1929-30, but the low CPUE suggested that fishermen were not catching more with the increase in number of gillnets. CPUE, using number of gillnets as the type of effort, during the years 1960-63, remained low and even decreased. CPUE began to increase during the years 1972-74 using data on number of gillnets.

For the period 1930-1989, number of fishermen provide a continuous record of CPUE. Figure 16 shows high CPUE through the 1930's and 1940's. Fewer fishermen were employed in the early 1930's but still managed to harvest good volumes of fish to maintain a high CPUE. The late 1930's and early 1940's have very high CPUE values probably due to the Second World War and the increase in the need for fish as food. This contrasts to the CPUE values using gillnets as the unit of effort. Using gillnets, CPUE was low compared to the previous period. Perhaps CPUE would have been high also for number of fishermen prior to 1930, but this data was not available. For the number of fishermen CPUE, the values start off high and decrease to a fairly steady level around 1945.

CPUE (number of fishermen) after 1950 fluctuates somewhat but remains around 2000 until 1970. The mercury closure causes a significant drop in CPUE but rises to pre-closure values the year after the fishery reopens. In 1976, CPUE appears to rise dramatically and remain high from the previous forty years. This rise can be explained by a change in how number of fishermen was calculated in the records. Before 1976, annual number of fishermen was calculated over all seasons and those fishermen fishing in more than one season were counted for each season in which they fished. After 1976, no duplication of fishermen was recorded over the seasons. CPUE after 1976 appears to be following a similar pattern to the previous years.

In assessing commercially-marketed harvest records, it was important to examine technological changes, changes in fishing regulations, fish markets

and prices, weather, and fish stocks, which play significant roles in CPUE and harvests. Trying to pinpoint the exact reason for a high harvest rate or CPUE was difficult due to the wide variety of variables affecting the industry. The CPUE data of number of fishermen and number of gillnets overlaps for a period of 44 years. A comparison between the two methods of effort suggests number of fishermen is a slightly better method of correlation of effort versus catch.

4.3 Cullage of fish from commercial harvests

Cullage of rough fish from commercial harvests is virtually unknown. Although experts suspect cullage represents a significant portion of harvests annually, research has never been undertaken into this subject on Lake Winnipeg. Many of the historical records mention the cullage of fish species in the commercial harvest. The 1887 Annual Marine and Fisheries report states:

> he [J.B. Johnson, guardian Bull's Head region] noticed very few coarse fish in the possession of fishermen, and on enquiry ascertained that when coarse fish were found in the same nets with whitefish, only the latter were retained.(Canada, 1888)

One year later, G.D. McVicar wrote to John Schultz (Lieutenant Governor of Manitoba at that time):

> A very great waste is taking place as all fish in the nets are thrown away except whitefish and trout. While I was at Grand Rapids besides the great waste of other kinds of fish they had to throw away about

> 2000 whitefish which were allowed to spoil in the nets on account of stormy weather.(PAM, 1888)

In 1889, J.H. Davis wrote to John Schultz:

> ...wanton destruction of fish during the summer months, thousands upon thousands are destroyed daily, and gives an instance out of one day's catch of the smallest firm; 6000 whitefish were caught and only 800 saved....on the departure of one firm's men 1000s of whitefish were seen floating on the lake.(PAM, 1889)

Further reports of cullage of rough species are given by Tough (1984), where McColl stated in 1888:

> ...and the wanton destruction of other varieties of fish which are caught in large numbers along with the others in the nets and dumped in the vicinities of the fisheries and left to putrefy...(Tough, 1984)

The report of J. Begin at Grand Rapids stated, "...of 10,000 pounds of fish that were landed in one day only 4,000 were fit for the market", and then from near Dauphin River, "the fishing overseer reported that coarse fish were not kept by the fishing companies."(Tough, 1984). Tough concluded that the cullage of a significant portion of fish from commercial operations explains some of the decline of the fish stock and that the previous subsistence lifestyle of the natives was less wasteful of this resource.

An interview in 1959 with Gudmundur Solmundson, a Lake Winnipeg fisherman of seventy years on the lake reveals similar comments:

> and I tell you it was no sale for pickerel, we threw all those fish way, or...all pickerel [were considered rough fish], no sale for pickerel, there was no sale for tullibees, no sale for nothing but whitefish and

> sturgeon, or we seen lots of saugers but they didn't have any sale for saugers either for a number of years first.(Solmundson, 1959)

Solmundson indicated that the rough fish caught were suckers, saugers, lake ciscos, walleye and northern pike. He explained that when lots of rough fish were caught fishermen would move their nets to avoid these species as the law required fishermen to bring them ashore and not dispose of them in the lake.

These comments illustrate the cullage of rough fish in Lake Winnipeg commercial fishing operations. These comments are however qualitative only and do not provide quantitative analysis of amounts of fish culled. A quantitative analysis of rough fish cullage was undertaken using experimental gillnetting data and actual commercially-marketed fish harvests. This analysis provided an estimate of the possible cullage of rough fish from commercially-marketed harvests.

The Manitoba Department of Natural Resources undertook an experimental gillnetting program between 1979-1986 in various locations in the three distinct areas of the lake; north basin, channel and south basin, to examine rough fish numbers. Data were recorded as mean number of fish per gang per night (Walt Lysack, Manitoba Department of Natural Resources, personal communication with permission). The experimental netting study used mesh sizes ranging from 3 inches to 4.25 inches in the south basin. In the channel and north basin these same mesh sizes were used plus 5 and 5.25 inches.

During the first five years of the experimental netting study, netting was undertaken in various locations all over the lake and did not always

correspond with where the commercial fishermen were fishing. Experimental netting, paralleling the commercial fishermen, was undertaken after 1983. The commercial fishermen seek areas of high catches of quota species and have learned to target these areas. This was noted earlier when fishermen moved their efforts from areas of high catches of rough fish species to areas with low catches of rough species.

Data, from the experimental netting study, are recorded in Appendix Table B-1 as percentages of the total annual experimental catch. Abundance of each species is calculated as a percentage of the total catch. The catches for the specific areas of the lake (ie. north basin, south basin, and channel) have been pooled into total catch as commercially-marketed harvests are grouped accordingly. Appendix Table B-2 provides the percentages by species for the actual commercially-marketed catch for the years of the experimental study (1979-1986).

Walleye, sauger and whitefish percentages are included in the data to calculate total percentages but are not used in the rough fish analysis. Table 1 below provides the mean percentages of rough fish for the experimental netting and for the commercially-marketed harvests for the 8 year period of the study, which have been derived from Tables B-1 and B-2.

Table 1: **Cullage of Rough Fish from Experimental Netting Study and Commercially-Marketed Catch of Rough Species(mean percentages over 1979-86 calculated from Appendix Tables B-1 and B-2)**

	Experimental Gillnet Study	Commercially-Marketed Catch
Goldeye	.73	.01
Catfish	.01	.09
Bullhead (includes brown and black)	.06	.01
Lake cisco	13.32	.1
Burbot	5.19	0
Yellow perch	2.74	1.15
White bass	.22	.14
Northern pike	.79	4.17
All suckers	8.86	1.29
Freshwater drum	4.36	.05
Common carp	.12	1.50

Table 1 shows that three species are highly underrepresented in the commercially-marketed catch; lake cisco, burbot, and the suckers. Lake cisco catches average 13.32% of the total catch in the experimental netting, while the commercially-marketed catch has a mean percentage of lake cisco at .1% of the total catch for the 8 year period. Burbot is also underrepresented in the commercially-marketed catch at 0%, which really means none was marketed. In the experimental netting study, the mean percentage of burbot is 5.19% of the catch. The suckers are also underrepresented at a mean percentage of 1.29 of the commercially-marketed catch compared to a mean of 8.86% of the experimental catch. Freshwater drum, bullheads (brown and black), yellow

perch and goldeye are slightly underrepresented in the commercially-marketed catch as few were marketed during those years. All other species are fairly well represented in the commercially-marketed catch as compared to their abundance in the experimental netting study.

Taking the average total harvest for this 8-year period and the ranges of percentages of the rough species underrepresented, total volumes can be estimated for the rough fish. Lake cisco harvests are estimated from 208,000-1,770,000 kgs in the commercially-marketed harvests. Burbot harvests are estimated between 52,000-521,000 kgs and the sucker harvests between 260,000-625,000 kgs for the commercially-marketed harvests of this 8-year period. This represents a significant portion of fish being harvested but not accounted for in the harvest records. These figures are estimates based on preliminary cullage data and are only applicable to the years of the study.

The results of the experimental netting study suggest that 520,000-2,916,000 kg of burbot, lake cisco and suckers are culled annually, or a mean culled harvest of 1.7 million kg. The actual mean commercially-marketed harvest during this period was over 7 million kg therefore culled species represent an estimate of 25-30% of the annual total commercially-marketed harvest. The fact that cullage of fish occurs in the commercially-marketed harvests is known. The extent of this cullage is not known; however the above analysis gives insight into how great this cullage might be. This data is representative only for the eight years of the experimental netting study which means it cannot be quantitatively applied to other years during the history of the commercial fishery. If this data is representative of all years in the

commercially-marketed harvest, many more fish have been caught than recorded; approximately 25-30%.

Burbot were recorded in the historical commercially-marketed harvests but no longer are marketed. The provincial experimental netting study indicated that burbot should occur more frequently in the commercially-marketed harvests. Burbot harvests were quite high from 1951-1969 when the provincial government offered a bounty on them. Fishermen, who caught burbot incidentally or specifically sought burbot, could get extra money for this species. Similarly, the provincial experimental netting study indicated that lake cisco probably still are harvested in fairly high numbers even though almost none are marketed.

Hewson (1957, 1959a, 1959b, 1960) undertook several studies to examine the relationship of fish populations to fish harvests. Hewson's first study (1957) was an experimental gillnetting study of fish populations in Lake Winnipeg using graded mesh sizes, over a three year period, 1948-1951. Table 2 provides the results of this study and shows many species other than the target species were caught in experimental nets.

Hewson (1959a) did a similar analysis of fishermen's summer catches over a seven year period (1948-1957 inclusive). This study targetted lake whitefish so the results may not be comparable with the above experimental netting of the Hewson (1957) study. Hewson (1959b) also examined the harvest of the winter commercial fishery during 1951-55. The results of all three of Hewson's studies are given in Table 2 along with the commercially-marketed harvests over the years of his studies.

Table 2: Summary of Hewson's studies and commercially-marketed catches in mean percentages of total harvest and (range of percentages) from 1948 - 1957

species	Hewson (1957) Study	Hewson (1959a) Study	Hewson (1959b) Study	Commercially-marketed
lake whitefish	0	40 (31-54)	0	14 (9-19)
walleye	39 (7-71)	5 (4-6)	19 (4-28)	32 (27-42)
sauger	14 (1-23)	1.4 (1-2)	42 (29-60)	23 (15-40)
freshwater drum	24 (11-48)	.14 (0-1)	17 (12-23)	3.9 (0-7)
burbot	9 (1-18)	30 (17-49)	11 (3-17)	9 (0-15)
all suckers	5 (1-8)	11 (3-18)	2 (0-4)	5 (0-7)
yellow perch	10 (1-17)	minimal	2.25 (0-3)	1.9 (1-3)
northern pike	minimal	minimal	minimal	5 (4-8)
lake cisco	10 (1-30)	13 (7-18)	14 (4-31)	10 (6-25)
others	minimal	0	1.7 (0-3)	minimal

These results suggest that several species of rough fish formed a significant portion of the catch yet were not represented in the commercially-marketed harvest data. Thirty percent of the 7-year catch was burbot, yet in 1948 and 1950 during the first two years of this study, burbot did not appear in the commercial catch statistics. A bounty was paid for burbot after 1950 and the species was better represented in the commercially-marketed catch statistics after that point. Hewson (1959a) acknowledged that burbot could be a significant species in the commercially-marketed catch yet the amount of this species culled from the commercially-marketed harvests has never been recorded.

Although it is difficult to compare harvests between commercially-marketed catches and Hewson's varied studies, it appears most species were marketed in a reasonably representative manner. An estimate of cullage of rough species of fish can be made using Table 2. Freshwater drum appears to be the only species with a slightly lower representation in the commercially-marketed catch compared to catches in Hewson's studies. Commercial markets for rough species seemed to follow more closely the actual harvests the fishermen were catching during the 1950's. This is a qualitative conclusion based on comparisons between different types of studies. The differences between the experimental studies and the commercially-marketed harvests are difficult to assess forty years later. The results seem plausible, however, as a wider variety of species were marketed forty years ago. The marketability of rough species in the 1940's and 50's probably resulted in less cullage of these species than is presently done.

Cullage of rough species was found to have been prevalent in very early periods of the fishery, as noted earlier. Better refrigeration and transportation, better developed markets and the trend to fish areas of high catches of target species, especially the east side of the lake where rough fish were not caught as frequently, may have resulted in less cullage of rough species of fish.

4.4 Subsistence Harvests

Fish have been caught from Lake Winnipeg for hundreds of years for subsistence purposes and must be considered in any analysis of fish stock removals of the lake. The potential impact of subsistence fishing on Lake Winnipeg fish populations was and still is regarded as important to the overall stocks of fish. The assessment of the subsistence fishery of Lake Winnipeg is a difficult task due to the lack of accurate data or any data at all.

Some historical records documented the amount of fish used for subsistence purposes in the early years of the commercial fishery. Early historical reports and more recent research by Tough (1984) indicated that the introduction of the commercial fishery depleted the fishery and impoverished the native lifestyle. Furthermore, the availability of other consumer goods, especially foodstuffs, reduced dependency on fish and wildlife. The introduction of snow machines also reduced the need for fish for feeding sled dogs. Food for sled dogs appears to have been a major use of subsistence fish harvests, possibly as much as or more than for human consumption. Subsistence data often refers to the native use of fish for this purpose but it is

apparent home consumption for subsistence use included the Icelandic population and other European settlers.

Alex McQueen, Inspector of Fisheries for Manitoba stated in 1885:

> I would strongly urge that the exportation of all fish, other than pike and catfish, be prohibited... for the following reasons:...Our supply, at amply remunerative prices, will be consumed by domestic requirements...that a great source of food supply for our present inhabitants and in-coming settlers would be practically destroyed. The importance of the fisheries, as a source for food supply for the Indian population, can hardly be anticipated (Canada, 1885).

The 1886 report of Marine and Fisheries stated, "Indian consumption for Manitoba and the Northwest Territories as a whole is estimated at 1,500,000 lbs" (Canada, 1887). There is no indication, in the report, of how this estimate was derived. Subsistence fishing on Lake Winnipeg was reported to be "predicted at 200,000 lbs. of fish (all whitefish) used for home consumption by Indians and approximately 250,000 lbs. of other kinds of fish for home consumption" in 1886 (Canada, 1887). It is not clear whether this includes all natives in the Lake Winnipeg region or just in the areas of Fisher River, Beren's River, Jack Head, and Dog's Head.

The report of 1887 stated, "Indians can now dispose of their fresh fish, and obtain such requisites as pork, beef, flour, etc., and do not require so large a number of fall fish to carry them over during the winter months" (Canada, 1888). The 1886 Marine and Fisheries report speaks of Indians at the mouth of the Dauphin River: "There were upwards of one hundred Indians engaged [in] fishing, who traded their fish for flour, bacon, tea,

tobacco, twine, clothing, &c., supplied from two stores" (Canada, 1887). Reduced dependency on fish and wildlife occurred as European settlers moved into the area and a commercial industry was established. The availability of other foodstuffs reduced the need for fish and game.

The Marine and Fisheries report for the year 1887 reported that at the Bull's Head district of Lake Winnipeg:

> The quantity of fish used for home consumption he [the guardian] estimates at 200,000 lbs; caught principally by Indians during the close season, and 200,000 lbs. more may be added, used in feeding dogs,-all whitefish. No correct estimate can be given of other kinds of fish, but an approximate one places the catch at about 250,000 lbs. (Canada, 1888)

This represents 650,000 lbs (295,455 kg) of fish harvested in one district for this one year.

In the same year, in another district of Lake Winnipeg, John Wood reported, "100,000 lbs of a total 314,000 lbs was sold to the trade. That leaves 214,000 lbs to be used for local use" (Canada, 1888). This amount of local fish use may have been based on the commercially-marketed harvest of licensed fishermen. This probably did not include those individuals who were not licensed for commercial fishing but fished for family needs.

The 1888 Marine and Fisheries annual report estimated the Indian consumption of fish for the entire province at 1,500,000 lbs (681,818 kg) (presumably this included the Northwest Territories as in the former

estimate). Total use for the entire province is often the only reference to subsistence harvests and these figures are only estimates.

Detailed reports by guardians of the Department of Marine and Fisheries provide some insight into subsistence use. Guardian John Helgason, in the community of Gimli, reported 651,800 lbs (296,273 kg) of fish were caught of which 461,000 lbs (209,545 kg) were for local use. Helgason reported that this was achieved by 30-40 men employed at the fishing station and 100 settlers fishing year round for their own use. Guardian J.B. Johnson, Beren's River district reported that there were five bands of Indians in his area using fish for subsistence purposes and estimated their catch at 200,000 lb (90,909 kg). Johnson provides no basis for this estimate and no population figures are given to establish use/capita. Finally John Wood, Fort Alexander district, estimated 144,000 pounds (65,455 kg) of all species were used for subsistence purposes mainly by Indians (Canada, 1889).

Table 3 illustrates recorded subsistence harvest of fish in various settlement areas of the lake over a 23 year period (1887-1898). The years 1899-1909 are reported only as total subsistence use for the entire lake. Using the total annual harvests from Table 3, the annual mean subsistence harvest for this 23 year period was calculated at 342,456 kg/yr. Using Rawson's (1947) estimate of subsistence fish harvests of 700,000 kg/yr (700 t/yr) at Great Slave Lake and Miller's (1947) estimate of 900,000 kg/yr (900 t/yr) at Great Bear Lake, Lake Winnipeg's historical subsistence harvests appear low. This could be due to the nature in which subsistence harvests were based. Subsistence harvests were probably based on what the commercial fishermen kept for

Table 3: Recorded subsistence fish harvest in kilograms (1887 - 1909)

	Area 1	Area 2	Area 3	Area 4	Total
1887	188181	0	90909	0	279090
1888	65455	209545	90909	0	365909
1889	53208	0	102272	0	155480
1890	0	168863	207003	20455	396321
1891	274432	137863	165909	32773	610977
1892	204863	46673	208772	0	460308
1893	74557	189886	0	36455	300898
1894	0	159090	189886	164090	513066
1895	160963	142400	236363	0	539726
1896	159090	0	290909	10594	460593
1897	0	17727	159863	24545	202135
1898	0	0	0	252318	252318
1899	0	0	0	0	54773
1900	0	0	0	0	125818
1901	0	0	0	0	159090
1902	0	0	0	0	227272
1903	0	0	0	0	272727
1904	0	0	0	0	454545
1905	0	0	0	0	454545
1906	0	0	0	0	454545
1907	0	0	0	0	340909
1908	0	0	0	0	227272
1909	0	0	0	0	568181

Note: Area 1, east shore from Red R. to Brokenhead R.
Area 2, west shore
Area 3, east shore north of Brokenhead R.
Area 4, Red R.

local use from their commercial catches and did not include those individuals who did not fish commercially but caught fish for their family's needs. Without accurate population figures from Lake Winnipeg communities at this time, harvest per capita can not be calculated for comparative purposes.

After 1909, subsistence fish statistics are unavailable, except for the occasional reference in annual reports. The annual report for the year 1914-15 stated:

> At the mouth of the Winnipeg river we have the Indian reservation of Fort Alexander,with a population of about 700 Indians. These Indians catch fish during the whole year, using nets of about 100 yards. In September, 1915, nine fishermen were granted licenses and caught 24,671 pounds of pickerel, 1,137 pounds of jackfish and 318 pounds of catfish. In November, 12 fishermen were granted licenses and caught 11,000 pounds of pickerel and 10,125 pounds of tullibee.(Canada, 1915)

Using the above information, this community of 700 people caught 21,478 kg of fish in only two months. This information provided some indication on the extent of subsistence fish use after 1909, but again the reference is to the 'licensed' fishermen of the reservation, and probably does not include the catches of those people not engaged in the commercial fishery.

Wagner (1986) recently undertook a preliminary study, based on interviews, into present day subsistence use of fish and wildlife of several native communities in Manitoba. Although his attempts were preliminary and his methods have been criticized, Wagner's results do suggest a much lower use of fish from the late 19th century and the early 20th century to present day.

Wagner's study included three communities in the Lake Winnipeg area. Results from his study are presented in Table 4 and annual fish use/capita was calculated. Wagner also questioned what species of fish were harvested. The Brokenhead community consumed walleye and sunfish (freshwater drum) most frequently. The Berens River community consumed walleye, northern pike, lake whitefish and sauger most frequently. The Hollow Water community consumed walleye, freshwater drum (sunfish), lake whitefish and northern pike most frequently.

Table 4: Subsistence use of fish in three Manitoba communities,1984

	Population*	Annual Harvest of Fish (kg)*	Annual Fish Use/Capita (kg)
Berens River	780	7510	9.6
Brokenhead	190	2450	12.9
Hollow Water	430	3120	7.3

*From Wagner 1986.

Wagner (1986) interviewed fishermen in each of the communities and found the mean harvest per fisherman in each of the communities. Annual mean harvests per fisherman were: Brokenhead, 47.5 kg; Berens River, 63 kg; and Hollow Water, 38.5 kg.

Wagner (1986) showed subsistence fish harvests in 1984 were approximately 13,000 kg for three communities surrounding Lake Winnipeg and annual fish use per capita was between 7.3 - 12.9 kg/yr. Wagner's results show a very low fish harvest per capita when compared to other communities

as given in Berkes (1990), where most per capita fish consumption clustered around 60 kg. Annual mean harvests per fishermen were also low in Wagner (1986). The most remote community, Berens River had the highest annual harvest of fish and the highest mean harvest per fisherman. Brokenhead had the highest per capita use of fish, indicating remoteness does not necessarily mean high fish use per capita, or something else was responsible for these values.

Subsistence fishing from Lake Winnipeg appears low in both the past and present estimates. However, subsistence harvests appear to have been reduced over time using the available data as compared to empirical data provided by Berkes (1990), Rawson (1947), and Miller (1947). Subsistence use of fish was higher in the past due to several factors, not just food consumption alone. The higher volume of fish harvest in the past was probably due to higher fish consumption but also more likely for the use of feeding sled dogs. A good estimate places subsistence use at about one-tenth of the use from the early years of this century.

Chapter 5

Summary, Conclusions and Recommendations

5.1 Summary

This study examined historical commercial and subsistence harvest data and cullage from commercial fish harvests for Lake Winnipeg. This study was undertaken to collate historical data into one document to facilitate further research on the fish resources of Lake Winnipeg.

Commercial fish harvests from Lake Winnipeg have fluctuated over the years but major species in the harvest have changed relatively little. A major goal of this study was to estimate the aggregate of fish which has been removed from Lake Winnipeg for commercial purposes. A summary of these total amounts by species over the history of the commercial fishery is listed below in millions of kilograms: lake whitefish, 147; walleye, 128; sauger, 106; lake cisco, 67; northern pike, 27; yellow perch, 8; sturgeon, 3; all others, 71; and total of all species, 557.

Overall commercially-marketed fish production from Lake Winnipeg was calculated at approximately 2.19 kg/ha/yr between 1883 and 1991. This did not include any estimates of subsistence fish use or cullage from commercially-marketed harvests. Lysack (1986) calculated the long-term

mean observed commercial yield of the Lake Winnipeg fishery at 2.57 kg/ha/yr for the period 1931-1983. The calculated fish yield for Lake Erie, a lake of similar area and with a long history of commercial fishing, for comparative purposes, was 9.72 kg/ha/yr (Matuszek, 1978).

Potential fish yield can be calculated using several models. Leach et al (1987) compared potential fish yield estimates (in kg/ha/yr) obtained from other researchers using several empirical models for Lake Winnipeg and Lake Erie:

	Lake Winnipeg	Lake Erie
Yield as a function of chlorophyll a	1.27-2.06	3.16-5.70
Yield as a function of surface area	2.0	1.97
Yield as a function of macrobenthic biomass	2.93	8.77
MEI (total dissolved solids/ mean depth)	n/a	3.70

The morphoedaphic index (MEI) (Ryder, 1965) is a simple method of predicting potential fish production from a lake. Leach et al (1987) compiled the MEI for the Great Lakes and Lake Erie's was 3.70 kg/ha/yr. MEI was not calculated for Lake Winnipeg. Leach et al (1987) suggested the MEI was not an appropriate method of estimating potential fish production for use in Lake Erie or Lake Winnipeg because Lake Erie's nutrient loadings and Lake Winnipeg's tributary and total dissolved solids (TDS) loadings do not meet criteria of the index. Lysack (1986) stated that MEI-type indices of fish yield

became less static and varied with tributary flow regimes. He suggested that the dynamics of tributaries need to be incorporated in MEIs to improve future predictions. Overall, Leach et al (1987) suggested MEI was the best method for comparing predicted fish yields, but concurred with Lysack (1986) that improvements were needed in the MEI.

No fish species have been lost from Lake Winnipeg, but sturgeon populations have been decimated and may even be endangered. This is known through paleontologic studies of dispersal of fish species, anthropological studies of fish use, and dispersal of fish species around Lake Winnipeg (Dr. K. Stewart, personal communication). Several species are new to the lake but to date their harvests have remained small. Relative abundance of species in the commercial harvest has changed over the years, probably more as a result of markets and prices than population changes. The basic environment of Lake Winnipeg has changed somewhat according to several studies, but overall the environment has remained adequate for the fishery to continue.

A mean of 342,456 kg/year of subsistence fish harvests was taken over the years 1887-1909. This mean harvest appears to have dropped dramatically since that time, perhaps as much as ten-fold, due to availability of other foodstuffs, a changing lifestyle, easier access to other areas and markets and the cessation of the use of sled dogs. These subsistence harvest levels appear low in comparison to other research in this area. Low subsistence harvest values are probably due to the manner in which these values were calculated.

Cullage of fish from commercial harvests is well-documented in a qualitative manner. A quantitative estimate of cullage from commercial

harvests may be as high as 25-30% of the commercially-marketed harvest, and represents a significant portion of unaccounted harvest. Cullage may have been even higher in the past as poorer refrigeration and transportation methods would have resulted in higher fish spoilage.

CPUE, an estimate of the efficiency of a fishery, has peaked several times through the history of the fishery. These peaks and drops are probably due in part to fish demand, fish prices, weather, efficiency of fishing effort and abundance of fish stocks.

5.2 Conclusions

Historical records provide a relatively complete picture of the commercially-marketed harvests of Lake Winnipeg. Records are difficult to find for subsistence fish use or cullage of fish from the commercial harvest. Interpretation of these records is even more difficult.

This study provides a complete chronology of commercially-marketed fish harvests for Lake Winnipeg from 1883-present, fulfilling a main study objective. This record is useful because never before have all these data been collated into one document. A synopsis of these data has been requested by the Manitoba Department of Natural Resources. This record can provide insight into changes in the harvests due to cultural, economic, technological or climatic variables. Long-term sustainability of Lake Winnipeg's fishery can be assessed much more easily with commercial fishery data collated into one document.

Estimates of harvests for subsistence use have been established. Further research needs to be done on subsistence fish harvests, both past and present for Lake Winnipeg. More detailed studies, similar to that of Wagner (1986) are necessary and should focus on fish harvests alone. Historical records will be more difficult to obtain. Interviews with native elders, examination of historical reports and the use of other studies on this subject may be a helpful means of undertaking this task.

Cullage of fish species from commercially-marketed catches has been examined and found to represent a much greater portion of the catch than was originally thought. Fish cullage practices in the commercial fishery of Lake Winnipeg and elsewhere bear further research. The provincial government is continuing to do annual experimental netting to obtain information on rough fish cullage on Lake Winnipeg. It is important to know what is caught, but not marketed, and when and if markets for presently unmarketable species are found. The potential to expand the commercial industry is possible in the future if good information is obtained now on stocks and harvests of rough species. Further research may show that cullage and subsistence harvests have played an even bigger role in shaping the current fish community of Lake Winnipeg.

CPUE has been calculated for most of the history of the commercial fishery. Possible reasons for high and low CPUE have been discussed. Assessing changes in the fishery based on CPUE is a difficult task which requires examining all the variables which can affect harvest rates. Changes in harvest rates are not easily explained by one simple variable. Technological

changes, such as gasoline boats, nylon nets and refrigeration and transportation, appear to have been major reasons for changes in CPUE over the years. These technological changes have greatly affected the fishery over the years.

5.3 Recommendations

1. A database of commercially-marketed harvests is useful for further studies of Lake Winnipeg fish stocks. Compilation of the annual commercially-marketed harvest data should be continued to maintain an up-to-date chronology of these data for future or present use.

2. Cullage of fish species from commercially-marketed harvests has had unknown effects on individual fish stocks. Experimental netting in Lake Winnipeg should be continued to provide a base of information on cullage of rough fish. This project must entail a strict sampling design which defines gear to be used and areas to be sampled. These variables should be consistent with the commercial operations of the day to ensure comparison. This will be useful in examining changes in culled fish stocks. Cullage of large quantities of rough fish could have consequences on the entire fish community. Determining these harvests will be beneficial to understanding any aspect of the fish community in the future.

3. A survey of fishermen's total catches, including all rough species culled, should be undertaken as often as possible. Implementation of fishing logs for

all fishermen might be a means of obtaining this information. This would provide much needed information on species cullage in the commercial catches.

4. Native participation in the commercial fishing industry in Manitoba is quite high, which must be acknowledged. Native self-government and management of natural resources must be coordinated into some type of co-management to maintain the long-term sustainability of Lake Winnipeg fish stocks and other fish stocks in Manitoba.

5. It was announced recently that fishermen may be allowed to market fish directly to the public and not have to sell to the FFMC (Lett, 1992). A method will be needed to accurately record this information. Maintenance of accurate commercial harvests in the future depends on this process. Continuation of commercial fishery data collection will be important, as these data have been collected for over one hundred years and provide a wealth of information on the lake - past, present, and future.

6. Studies of subsistence fish use should be undertaken in the communities surrounding Lake Winnipeg to determine present fish use, species used, methods of fishing and other relevant data. Harvest rates can be established for subsistence use and can aid in assessing fish stocks.

7. More information on historical subsistence fish use should be gathered. This should include other areas of Manitoba and Canada. This information will be useful to future researchers assessing past and present subsistence use and its relationship to fish stocks.

8. Effort to find markets for rough fish species should be undertaken to better use culled species. The volume of culled fish from commercial nets appears to be a tremendous waste of our fisheries resource.

9. Recreational harvests of all areas of Lake Winnipeg should be examined. This would include surveying areas presently used and those areas suitable for use in the future. The east side of Lake Winnipeg appears to have many suitable areas for angling. The impact of increased recreational fishing on abundance of fish stocks in these areas and on the commercial fishery should be examined.

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Table A-1: Commercially-marketed harvests in kilograms (1883 - 1889)

species	1883	1884	1885	1886	1887-88	1888-89	1889-90
lake whitefish	72867+	359000+	759730+	800000+	781625	1004556	1270350
walleye	n/a	n/a	6455*	n/a	30909	99252	127911
northern pike	n/a	n/a	0	n/a	24091	64822	170623
sturgeon	n/a	n/a	19091	n/a	11364	7027	58576
lake cisco	n/a	n/a	4182	n/a	18182	47775	27190
yellow perch	n/a	n/a	227	n/a	0	453	1637
catfish	n/a	n/a	1136	n/a	11364	1639	355
goldeye	n/a	n/a	n/a	n/a	0	0	227
mixed	n/a	n/a	n/a	n/a	113636	182727	3042
home	n/a	n/a	n/a	n/a	279090	365909	155480
lake trout	n/a	n/a	n/a	n/a	n/a	5500	55
total	72867	359000	759730	800000	1270261	1779660	1815446

Note: n/a = not available
* = pike and walleye jointly recorded

Table A-2: Commercially-marketed harvests in kilograms (1890 - 1899)

species	1890-91	1891-92	1892-93	1893-94	1894-95	1895-96	1896-97	1897-98	1898-99	1899-00
lake whitefish	1546465	1312052	1712090	1732252	1288956	1666609	1668555	1250256	1153191	907509
walleye	229867	184218	187640	182494	454509	364245	398786	486795	429737	292617
northern pike	338219	71181	37027	47682	153755	127907	108035	124685	159535	122390
sturgeon	85377	22282	42314	16909	34668	47382	79885	102554	203414	202176
lake cisco	81227	77773	68182	3182	153647	122091	104545	116414	100645	65885
yellow perch	0	0	0	0	8379	10659	18545	21562	29905	27733
catfish	0	0	0	4614	27154	36238	80909	42120	74710	56660
goldeye	0	0	0	0	0	0	0	0	0	11764
mixed	431241	258855	234682	179886	371605	264227	560682	183591	187695	79136
home	396321	610977	460308	300898	513066	589726	460593	202135	252318	54773
total	3108717	2537338	2742243	2467917	3005739	3229084	3480535	2530112	2591150	1820643
# gillnets	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	1236

Note: n/a = not available

Table A-3: Commercially-marketed harvests in kilograms (1900 - 1909)

species	1900-01	1901-02	1902-03	1903-04	1904-05	1905-06	1906-07	1907-08	1908-09	1909-10
lake whitefish	1770500	2272727	2727273	3181818	3409091	2954545	2272727	909091	1022727	1576409
walleye	569727	1136364	1363636	1818182	1931818	2045455	2045455	1250000	750000	1017500
northern pike	138318	454545	454545	545455	556818	568182	454545	342727	215909	354455
sturgeon	446136	272727	272727	272727	272727	272727	90909	68182	36136	23727
lake cisco	53136	227273	272727	545455	818182	818182	727273	568182	170455	311000
yellow perch	21818	12955	18182	454545	56818	56818	34091	34091	16636	26364
catfish	83818	250000	272727	227273	250000	227273	90909	79545	91682	39636
goldeye	1636	90909	136364	136364	136364	136364	136364	181818	261364	380636
mixed	47909	1545955	2272727	2272727	2272727	2272727	1818182	909091	204545	363636
home	125818	159090	227272	272727	454545	454545	454545	340909	227272	568181
total	3258816	6422545	8018180	9727273	10159090	9806818	8125000	4683636	2996726	4661544
# gillnets	1144	5000	6000	6420	8225	8500	8000	6666	4425	7460

Table A-4: Commercially-marketed harvests in kilograms (1910 - 1919)

species	1910-11	1911-12	1912-13	1913-14	1914-15	1915-16	1916-17	1917-18	1918-19	1919-20
lake whitefish	1326136	1419682	1453409	973455	1021636	1202409	1262545	1279591	1387500	1352500
walleye	1085955	1664091	697955	763045	1094818	470682	656727	845500	725500	741500
northern pike	190409	282955	200136	123636	197409	118318	167727	182682	150136	171682
lake cisco	781364	324045	382273	614091	1588136	2064136	1876409	2033727	2504409	1270182
yellow perch	23364	27000	15864	11045	16136	18500	368500	368318	22318	18864
sturgeon	92727	0	0	0	0	0	52636	38773	6136	5636
catfish	35955	0	0	29455	34136	63000	49318	18182	31682	19864
goldeye	339227	0	0	223636	323091	165500	277545	344045	160091	34636
mixed/home	2183500	1998955	1143636	467727	1440909	1500000	1500000	1500000	1909091	3773
freshwater drum	0	0	727	0	1636	364	0	0	0	0
all suckers	0	0	0	0	0	0	0	0	0	509091
total	6058637	5716728	3894000	3206090	5717907	5602909	6211407	6610818	6896863	4127728
# gillnets	10822	10400	3204	3931	1659	1831	2303	2907	5775	5860

Table A-5: Commercially-marketed harvests in kilograms (1920 - 1929)

species	1920-21	1921-22	1922-23	1923-24	1924-25	1925-26	1926-27	1927-28	1928-29	1929-30
lake whitefish	1319545	3243000	2639400	1626400	1591000	2559000	3741700	2826000	3089300	3287800
walleye	962182	1393045	974000	1357545	1182455	723500	1411500	1982318	2235409	2024091
northern pike	230182	198591	151773	281545	292545	190636	331227	281818	297773	642182
sturgeon	18045	39727	11409	23955	40273	31682	14045	15364	0	0
lake cisco	1226682	1722273	1722045	655273	602182	1266136	2429136	3254773	3270227	2651955
yellow perch	3045	6273	6273	82727	67364	39864	74864	17273	26364	19409
catfish	10909	35364	35364	35955	63545	161182	28682	65182	46273	5273
goldeye	129773	95818	95409	515091	164273	186455	245091	327773	201409	307864
mixed/home	43636	0	0	0	1136	8045	6318	9864	750909	1231818
freshwater drum	0	0	0	0	0	0	0	8818	6455	0
all suckers	529318	22591	18500	8136	11318	17091	51364	3955	20909	26364
sauger	0	0	0	0	0	0	0	100955	165136	323227
total	4473317	6756682	5654173	4586627	4016091	5183591	8333927	8894093	10110164	10519983
# gillnets	6080	10206	11181	13570	13200	14700	15700	16700	17700	25936

Table A-6: Commercially-marketed harvests in kilograms (1930 - 1939)

species	1930-31	1931-32	1932-33	1933-34	1934-35	1935-36	1936-37	1937-38	1938-39	1939-40
lake whitefish	1565727	1638318	2108182	2424318	1889318	1361818	475182	932545	954136	922364
walleye	1242227	1041727	1056591	1235182	1760591	1371545	2028091	1833227	1950955	1469591
sauger	394636	701046	867909	1022227	1881955	1326000	1671545	2905500	4335136	3929409
northern pike	470636	143773	84364	67318	126409	175955	334227	203545	188500	163182
sturgeon	0	0	0	0	0	0	0	12364	10409	4500
lake cisco	1589364	165818	433909	214091	541636	357500	779045	418227	804909	490636
yellow perch	25182	17773	25091	28136	33409	20136	53500	45682	50000	69636
catfish	15409	7864	14636	6045	8818	20955	14455	4909	6182	6909
goldeye	162182	59364	84909	40364	40636	36136	66182	171545	102727	36773
mixed/home	1045	0	0	1000	1409	2591	591	2545	0	0
freshwater drum	273	0	546	0	0	3318	9318	9091	4818	273
all suckers	5000	11909	0	4545	15864	41045	37000	12500	3909	5955
all bullheads	0	4136	3227	0	0	0	0	0	11636	3591
carp	0	0	0	0	0	0	0	0	5818	0
lake trout	0	0	0	0	0	91	0	0	0	0
total	5471681	3791728	4679364	5043226	6300045	4717090	5469136	6551680	8429135	7102819

# gillnets	27792	n/a	n/a	22131	25760	30567	34625	28367	31545	32057
# fishermen	2046	1389	1291	1573	1776	2017	2005	1978	2297	1923

Table A-7: Commercially-marketed harvests in kilograms (1940 - 1949)

species	1940-41	1941-42	1942-43	1943-44	1944-45	1945-46	1946-47	1947-48	1948-49	1949-50
lake whitefish	1591591	1823636	1880727	1699091	1071273	1236909	1100409	816864	696318	1099682
walleye	1791364	1639136	1255136	1629364	2175909	2287682	2243591	2199409	2466136	2331864
sauger	4043000	4651227	3453409	2899773	2275545	1728227	1802318	1622136	1793182	3159227
northern pike	1394545	137955	204364	392636	333636	454045	425045	496545	404273	364591
sturgeon	5500	5545	2955	1318	318	500	0	0	0	0
lake cisco	843364	753864	1074591	685818	220227	1042864	555864	1954455	1830818	600227
yellow perch	248864	119682	129000	96182	49682	90500	101727	114318	109955	86455
catfish	3091	5545	3591	7273	545	182	2000	1500	1273	8409
goldeye	15909	17091	24773	12000	7773	1500	273	591	1591	1455
freshwater drum	5591	3773	9591	132864	51091	153591	186773	183318	99273	151045
all suckers	4955	2455	1500	705227	65500	384000	63409	75864	62636	56227
all bullheads	4318	4455	1318	1364	45	0	1000	1455	5773	5227
carp	0	0	0	1955	45	42864	21773	5409	4909	4136
lake trout	0	0	0	45	0	0	0	0	0	0
total	9952092	9164364	8040955	8264910	6251589	7422864	6504182	7471864	7476137	7868545

# gillnets	40072	50925	58130	52512	56111	50052	n/a	n/a	n/a	n/a
# fishermen	2508	2992	3066	3463	3320	3718	4137	n/a	3676	3013

Note: n/a = not available

Table A-8: Commercially-marketed harvests in kilograms (1950 - 1959)

species	1950-51	1951-52	1952-53	1953-54	1954-55	1955-56	1956-57	1957-58	1958-59	1959-60
lake whitefish	1605227	1246500	1169136	838591	980636	989909	749955	840591	734682	850227
walleye	2539364	2707591	2353818	2279500	1970318	2186682	1777227	1299500	1001000	524591
northern pike	337409	426273	583273	366045	266727	357626	357318	289682	235000	137545
sauger	2164773	1705000	1662318	997455	1006500	1401182	1458091	1830182	1963273	1168091
lake cisco	1163591	1398136	780545	296636	906500	1173682	1178182	730636	917182	892500
yellow perch	96227	184182	235364	129409	111364	217545	177364	165409	178955	122409
catfish	1818	2682	2273	4227	1955	1955	3909	3727	4364	1318
goldeye	3182	3727	818	318	1227	8955	9227	15636	12273	4045
freshwater drum	258318	576273	503591	188182	316364	194136	255455	183455	302318	220682
all suckers	103000	121364	125818	115409	123000	188818	218227	233545	200455	147818
all bullheads	53636	131909	121182	140682	61136	31091	22955	35909	80227	36136
carp	4818	19091	16364	20136	18773	29227	30727	28455	100045	63455
burbot	0	8864	2364	227	899545	1205500	50409	9273	104955	248864
sturgeon	0	0	0	0	0	0	0	5500	7545	3727
total	8331363	8531592	7556864	5376817	6664045	7986308	6289046	5671500	5842274	4421408
# gillnets	n/a	n/a	n/a	40284	44753	43433	37924	36227	36458	35251
# fishermen	3643	4046	3941	3118	3340	3203	2880	2473	2557	2102

Table A-9: Commercially-marketed harvests in kilograms (1960 - 1969)

species	1960-61	1961-62	1962-63	1963-64	1964-65	1965-66	1966-67	1967-68	1968-69	1969-70
lake whitefish	509000	633727	759818	598455	841955	692955	566364	642364	374955	342682
walleye	618182	959682	1274273	926273	671864	396318	320182	271045	355136	389955
sauger	1633091	1154864	1364000	1907182	1471273	1424773	1416773	1018182	1650909	924682
lake cisco	579727	692318	227136	321955	329182	237636	391636	115000	288000	103727
northern pike	178045	220227	235136	292455	278136	245409	252318	307864	405909	328318
sturgeon	4091	3591	3045	2409	2318	1273	591	182	545	3409
yellow perch	155091	189273	157864	115000	121455	155045	181955	62591	72364	0
catfish	4955	1318	1091	2818	2273	727	727	273	182	0
goldeye	545	2227	2000	727	727	955	409	136	0	0
freshwater drum	265227	152955	138818	159727	189273	153000	170273	249636	176227	0
all suckers	172091	66455	245909	125909	200318	334273	220455	94000	132000	0
all bullheads	35818	18545	6409	6864	3818	3091	4000	4955	2273	0
carp/others	94091	9000	29864	33773	54409	53182	33364	66227	90364	497136
burbot	306409	257136	300591	246455	244909	321227	106227	67273	65591	0
total	4556363	4361318	4745954	4740000	4411910	4019864	3665274	2899728	3614455	2589909
# gillnets	31005	40247	46828	51249	n/a	n/a	n/a	n/a	n/a	n/a
# fishermen	2852	1787	2062	2278	2166	1994	1878	n/a	1429	1380

Note: n/a = not available

Table A-10: Commercially-marketed harvests in kilograms (1970 - 1979)

species	1970-71	1971-72	1972-73	1973-74	1974-75	1975-76	1976-77	1977-78	1978-79	1979-80
lake whitefish	0	580921	714636	750173	742080	829750	779137	1059474	1463241	1586746
walleye	0	44808	835227	841028	833504	1017114	1212954	1404754	1163119	1237101
sauger	0	184655	1309136	1364108	1163969	1227594	1130207	1231479	1192975	1154783
northern pike	0	10908	303909	281855	269677	350806	372502	311149	270021	291304
sturgeon	0	0	227	91	0	25	0	0	35	56
lake cisco	0	1673	0	131014	281504	213105	10175	4545	1490	32060
yellow perch	0	1014	21273	41312	58465	42447	32107	30936	48853	47031
catfish	0	0	0	0	0	0	1189	1367	3546	6873
goldeye	0	0	0	0	91	239	7571	1262	156	58
freshwater drum	0	0	0	46560	27826	7922	4171	1163	5865	17301
all suckers	0	5600	29409	43315	88085	54913	1327	31677	42166	150247
all bullheads	0	0	0	0	0	0	1345	0	2	0
carp/others	195955	6791	0	5909	964	50237	7657	11398	19393	97573
burbot	0	0	0	8930	99874	0	1693	0	0	402
lake trout	0	0	223	335	52	0	0	0	0	0
total	195955	836370	3214040	3514630	3566091	3794152	3562035	4089204	4210862	4621535

# gillnets	n/a	n/a	16442	16804	11510	n/a	n/a	n/a	n/a	n/a
# fishermen	35	380	1185	1396	1006	1408	939	984	953	915

Note: n/a = not available

Table A-11: Commercially-marketed harvests in kilograms (1980 - 1989)

species	1980-81	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90
lake whitefish	1610992	1477675	1429472	1448083	1487748	1258373	1706361	1542241	1397182	1105128
walleye	1126055	1758477	1863095	1408331	1849899	2242177	1940472	1366827	1860728	2220255
sauger	1730977	1528445	1226784	2010848	1920677	1407421	1133070	2300941	2167924	2037457
northern pike	249836	283073	251203	161853	156331	158631	135036	125005	145296	107727
sturgeon	0	0	0	0	49	16	0	0	45	0
lake cisco	78	17	203	31	22	858	2158	78	2	10
yellow perch	76785	81762	38665	62050	80067	34682	54999	110806	121919	134364
catfish	10257	10899	2283	783	2375	2975	1691	2553	1106	0
goldeye	1256	1468	322	372	196	82	1702	1195	3136	7914
white bass	1750	345	16	4080	4725	18606	29707	11428	5885	19466
all suckers	100546	54234	105036	15435	48351	38309	1794	2816	6773	1057
all bullheads	4223	0	1	0	0	0	14	0	0	0
carp/others	124457	134058	38466	38458	45123	42259	97724	54378	56190	865
black crappies	0	0	0	0	0	418	112	0	0	0
burbot	0	0	0	0	0	0	52	5	0	239
total	5037212	5330453	4955546	5150324	5595563	5204807	5104892	5518273	5766186	5634482
# fishermen	1005	1040	1139	1162	1170	1112	1079	1076	n/a	1076

Table B-1: Experimental netting study percentages of species (1979 - 1986)

species	1979	1980	1981	1982	1983	1984	1985	1986
lake whitefish	12.68	23.60	31.15	21.87	22.23	14.29	17.27	25.81
walleye	9.88	5.73	8.58	8.88	4.33	31.92	35.28	27.54
sauger	15.48	20.80	22.62	32.72	36.32	30.54	23.22	26.07
northern pike	1.25	1.19	0.46	0.17	0.26	0.63	1.78	0.59
yellow perch	3.44	1.87	1.34	3.25	2.83	5.41	2.42	1.37
all suckers	6.69	5.54	9.33	12.54	14.28	5.77	8.15	8.58
lake cisco	34.37	22.64	16.60	7.15	11.09	5.67	4.69	4.38
white bass	0.05	0.03	0.00	0.00	0.00	0.25	0.85	0.60
catfish	0.00	0.00	0.05	0.02	0.01	0.01	0.02	0.00
goldeye	2.06	0.06	0.36	0.93	0.49	1.42	0.25	0.30
all bullheads	0.13	0.15	0.08	0.01	0.00	0.08	0.00	0.02
carp	0.07	0.05	0.03	0.01	0.04	0.07	0.20	0.31
burbot	7.41	9.75	1.74	6.65	7.68	2.47	4.02	1.81
freshwater drum	6.46	8.60	7.67	5.80	0.45	1.47	1.86	2.60
total	99.96	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Table B-2: Actual commercially-marketed harvests in percentage by species (1979 - 1986)

species	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87
lake whitefish	34.33	31.96	27.70	28.86	28.12	26.55	24.16	33.43
walleye	26.70	22.40	33.00	37.57	27.34	33.06	43.08	38.01
sauger	25.00	34.36	28.69	24.76	39.04	34.33	27.04	22.20
northern pike	6.36	5.00	5.31	5.07	3.14	2.80	3.05	2.65
yellow perch	1.02	1.52	1.53	0.78	1.20	1.43	0.67	1.08
all suckers	3.25	1.98	1.02	2.12	0.30	0.90	0.74	0.04
lake cisco	0.70	0.00	0.00	0.00	0.00	0.00	0.02	0.04
sturgeon	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
white bass	0.00	0.03	0.01	0.00	0.08	0.08	0.36	0.58
catfish	0.15	0.18	0.20	0.05	0.02	0.04	0.06	0.03
goldeye	0.00	0.02	0.03	0.01	0.01	0.00	0.00	0.03
all bullheads	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00
carp/others	2.11	2.47	2.51	0.78	0.75	0.81	0.81	1.91
black crappies	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
burbot	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
freshwater drum	0.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00
total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00