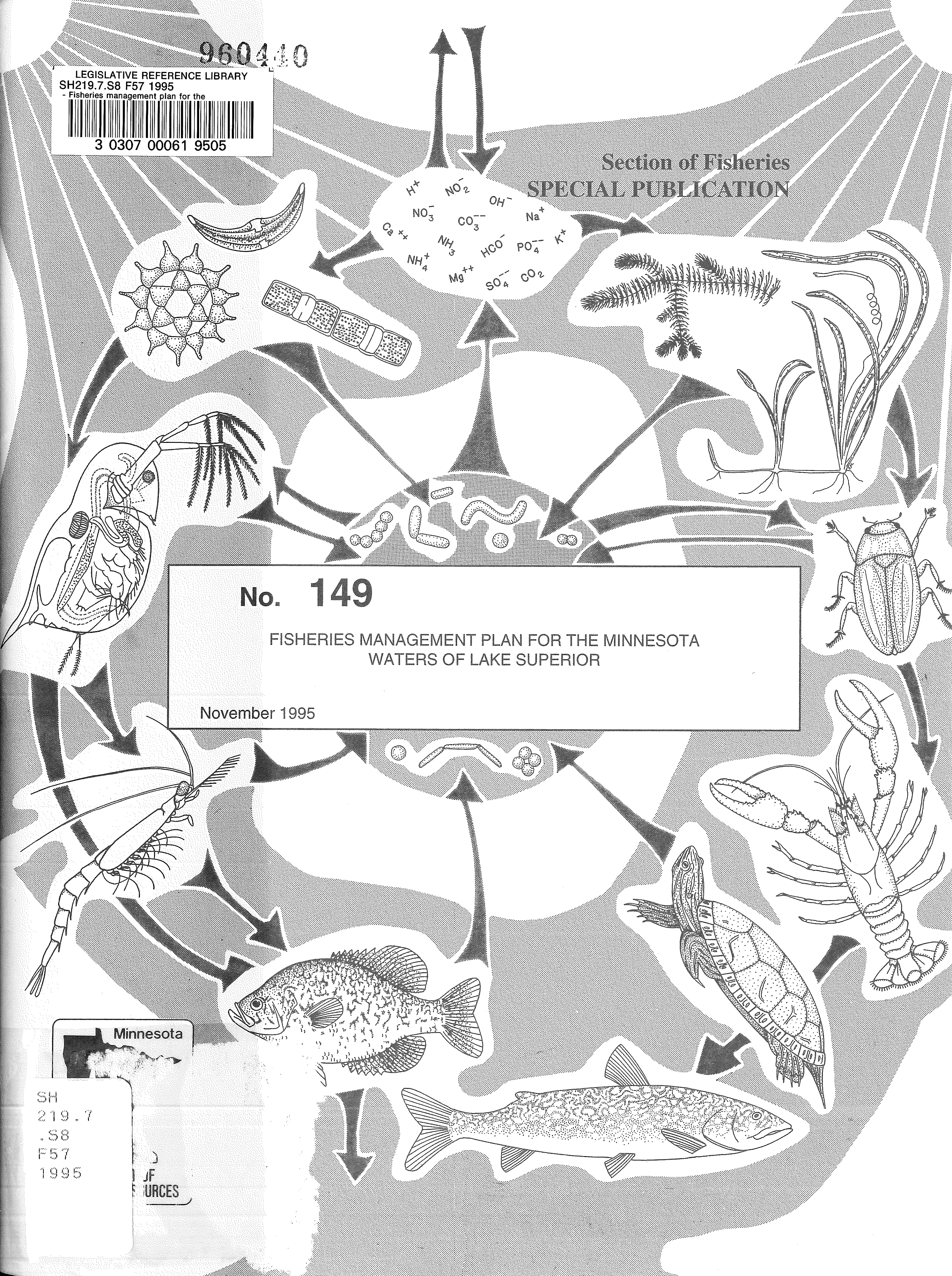

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FISHERIES MANAGEMENT PLAN FOR THE MINNESOTA WATERS OF LAKE SUPERIOR

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FISHERIES MANAGEMENT PLAN FOR THE MINNESOTA WATERS OF LAKE SUPERIOR

Prepared by

Minnesota Department of Natural Resources,
Section of Fisheries, in cooperation with the
Lake Superior Advisory Group

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Minnesota Department of Natural Resources
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EXECUTIVE SUMMARY

The Lake Superior fish community has undergone dramatic changes since the mid-1900's due to over-fishing, introduction of non-native species, pollution, and land use changes in the watershed. Since the 1950's, the Lake Superior fish community has become much more complex, and is now composed of both native and non-native species. The most devastating introduction to the Lake Superior community has been the sea lamprey, which virtually eliminated the lake trout in all but a few isolated areas of Lake Superior. Since the 1960's, rehabilitation efforts, including sea lamprey control, harvest regulations and stocking programs, along with stricter pollution standards and best management practices for land use, have led to partial restoration of healthy fish stocks.
This plan is a comprehensive guide on how to best continue management for Minnesota's portion of the Lake Superior fishery. It is written for use by both the Minnesota Department of Natural Resources (MNDNR) Section of Fisheries and citizens interested in the management of Minnesota's Lake Superior fishery resource. The plan is based on a community approach to fisheries management. The strategies and actions in this plan will focus on the work of the MNDNR Section of Fisheries over the next decade. The goals and objectives are expected to remain relevant for 10 years, but the plan is written to be flexible, and modifications are expected to occur during that time period.

Citizen participation was a critical aspect in the planning process. An advisory group that represented fishing clubs, environmental groups, Indian bands, commercial fishing interests, county organizations, and individual anglers was formed at the very beginning of the planning process. This group solicited input from their organizations, and reviewed and commented on draft chapters of this plan. In addition, three "Open House" meetings were held to get feedback on the draft plan from citizens not associated with a representative on the advisory group. All comments were summarized, reviewed, and considered for inclusion in the final draft. The final draft was thoroughly discussed within the Section of Fisheries and with the Commissioner of Natural Resources, and represents the Department's position on how to best manage the Lake Superior fishery.

GENERAL PLAN OVERVIEW

Fisheries management in Minnesota is the responsibility of the Minnesota Department of Natural Resources (MNDNR), Section of Fisheries. The long term goal for fisheries management in the Minnesota waters of Lake Superior is:

> **To protect the Lake Superior ecosystem and to develop a diverse, stable, self-sustaining fish community that provides both recreational and commercial fishing opportunities.**

The MNDNR has recently adopted the philosophy of ecosystem based management. In its mission to protect the Lake Superior ecosystem and manage the fishery based on ecological principals, the plan recognizes that:

- Fish production in Lake Superior is finite, and although users may desire more fish from its waters, the lake simply may not have the capacity to produce more than current levels. Additional stocking of trout and salmon cannot take place without considering impacts on the forage base.

- Lake Superior is the least productive, but most pristine of the Great Lakes and has demonstrated the capacity to support self-sustaining fish populations through natural reproduction. The plan emphasizes the continued need for habitat protection and the desire for managing self-sustaining fish populations that are best suited to the lakes environment.

- User groups on Lake Superior have extremely diverse interests and the plan attempts to balance resource protection, recreational opportunities, cultural beliefs and economic development for the benefit of both present and future generations. Citizen participation was the cornerstone of the planning process and will be an ongoing process once implementation begins.

- Lake Superior fishery management is an expensive program when compared to other fisheries in the state, consuming approximately 8% of the total fisheries budget. Although Lake Superior is a unique resource and offers diverse recreational opportunities, user groups must recognize that increased expenditures for Lake Superior fishery programs will be difficult to justify when viewed from a statewide perspective.

- The effectiveness of Lake Superior management programs must be continually evaluated. If established criteria indicate program changes are required, interested citizens will be consulted and the necessary action will be taken.

- Only 7% of Lake Superior falls within the state of Minnesota. The Great Lakes Fishery Commission provides the structure for cooperative management among the various jurisdictions around the lake, and continued involvement with the Commission is required to address the ever increasing complexity of issues that arise.

As we begin to implement this plan, citizen participation will be crucial, and we expect the plan will focus and stimulate ongoing conversations about future fisheries management for the Minnesota waters of Lake Superior. It is our belief that this plan is a requirement for sound management of the Lake Superior fishery, and it's success will ultimately be determined by the long term benefits to the resource and its users.

BODY OF THE PLAN

HABITAT

Background: Lake Superior is the most pristine of all of the Great Lakes, and future protection of habitat is receiving a high priority. Unimpaired habitat is critical for a productive, self-sustaining fish community. Throughout the Lake Superior basin, point source pollution has been greatly reduced in the last 20 years, but non-point and atmospheric pollution continues to cause problems with bioaccumulation of mercury, PCBs and other toxins in fish and wildlife. The St. Louis River is classified as an area of concern by the US Environmental Protection Agency and its cleanup is now being addressed through the St. Louis River Remedial Action Plan. The Binational Plan for Lake Superior will focus on the Lake Superior ecosystem including water quality, pollution, and habitat concerns.

Goal: Maintain and enhance the quantity and quality of fisheries habitat in the Minnesota waters of Lake Superior.

Proposed Actions:

- Work with other agencies and citizen groups to identify and protect critical habitat in Lake Superior and tributary streams from further degradation.
- Establish a consistent sampling protocol to monitor contaminant levels in Lake Superior and St. Louis River fish species.
- Continue to protect streams in the Lake Superior watershed from erosion, beaver damage, floods, and poor land use practices as recommended in MNDNR Fisheries stream management plans.

FORAGE

Background: Forage includes organisms from several trophic levels. This plan addresses forage fish most commonly used by salmonids in Lake Superior. In Minnesota waters of Lake Superior, lake herring were the major forage and commercial species until rainbow smelt became established in the late 1950's. From 1940 to 1985, abundance of lake herring declined, and beginning in the 1950's, rainbow smelt abundance increased. In the 1980's, this trend reversed and lake herring abundance has increased while rainbow smelt have declined. Despite the low level of abundance, rainbow smelt are still the primary forage species for salmonid predators in Minnesota's portion of Lake Superior, but lake herring are again becoming an important component of predator diets. Both lake herring and rainbow smelt support commercial fisheries in the Minnesota waters of Lake Superior. Chubs serve as forage and also support a small commercial fishery.

Goals: Rehabilitate and protect stable, self-sustaining lake herring and chub stocks to support production of predators and a limited commercial fishery. Monitor rainbow smelt stocks to determine their effects on the Lake Superior fish community.

Proposed Actions:

- Use hydroacoustic sampling, trawl surveys and bioenergetics models to assess the status of forage stocks, and determine the allocation of available forage for lake trout restoration, other predators, and commercial interests.
- Continue the November closure of the commercial fishery for lake herring and maintain or reduce stocking quotas for predator species until surplus forage production can be demonstrated.
- Limit the number of commercial operators along the Minnesota shoreline to 50.
- Conduct geographical and temporal diet studies of major predators.

LAKE TROUT

Background: Lake trout have historically been the top predator in the Lake Superior fish community and were represented by many strains or stocks. Following the invasion of the sea lamprey, many of these stocks were reduced or eliminated. Through natural reproduction by remnant stocks and management efforts by agencies around Lake Superior, most areas of the lake are again inhabited by predominately wild lake trout. However, only 25% of the lake trout captured in Minnesota waters are wild. From 1989 through 1993 the lake trout population has supported a major sport fishery with an average annual catch of approximately 15,000 fish. Lake trout have consistently been the primary species caught by anglers.

Goal: Rehabilitate self-sustaining lake trout stocks capable of supporting a sport fishery and a limited commercial fishery.

Proposed actions:

- Continue lamprey control efforts.
- Encourage voluntary release of unclipped (wild) lake trout, and all lake trout greater than 25 in.
- Use total allowable catch model to determine harvest quotas for each statistical zone, and adjust regulations if target harvest levels are exceeded.
- Reduce the number of lake trout stocked from 534,000 to 356,000.
- Reduce lake trout stocking if forage assessments indicate that forage biomass will not support the number of predators being stocked or if stocking no longer contributes.
- Discontinue lake trout stocking in a management zone when restoration criteria are met.

CHINOOK SALMON

Background: Minnesota introduced spring-run chinook salmon in 1974 and converted to fall-run chinook in 1979 because growth rates were better, and because disease-free spring run eggs were not available. Chinook salmon catch in the summer fishery since 1980 has averaged 1,600. During fall creel surveys, the average catch was 1,600. The number of adult chinook salmon returning to the

French River trap has decreased since 1990. In 1987, a lake-wide stocking evaluation began to determine the extent of natural reproduction and document the movement of stocked fish throughout the lake. Preliminary results of the study indicated substantial natural reproduction throughout the lake.

Goal: Provide a sport fishery that allows anglers the opportunity to harvest a trophy sized fish.

Proposed Actions:

- Reduce the possession limit of chinook and coho salmon in any combination, from 10 to 5.
- Manage chinook salmon by annually stocking up to 500,000 pre-smolt fingerlings spread among 5 streams.
- On a limited basis, experiment with different sizes of fingerlings stocked in an attempt to increase survival and stabilize returns.
- Reevaluate the chinook salmon program if numbers decline to the level where fewer than 150,000 fingerlings can be produced annually from gametes collected at the French River trap, for three consecutive years.
- Reduction or elimination of chinook salmon stocking should be considered if catch objectives are met by wild fish.
- Make use of chinook salmon returning to the French River trap in local food shelf programs.

COHO SALMON

Background: Coho salmon were stocked in the Minnesota waters of Lake Superior from 1969 through 1972. Because management goals for coho salmon were not met, the program was abandoned in favor of the chinook salmon program in 1972. Coho salmon have since become naturalized throughout Lake Superior and are second only to lake trout in frequency of catch by Minnesota anglers. Natural reproduction in other areas of the lake support most of the fishery in Minnesota waters. The average summer harvest of coho salmon in Minnesota waters from 1979 to 1992 was 4,100. The location of the coho salmon catch changes seasonally in Minnesota waters.

Goal: Provide a coho salmon fishery sustained by natural reproduction.

Proposed Actions:

- Reduce the possession limit of coho and chinook salmon in any combination, from 10 to 5.
- Initiate a winter creel survey, and repeat once every 3 years to monitor effects of proposed regulation change.
- Cooperate and coordinate closely with Wisconsin on wild coho salmon management because very little production of coho salmon occurs in Minnesota tributaries.
- Do not initiate a stocking program for coho salmon because the high quality fishery is based on natural reproduction.

ATLANTIC SALMON

Background: Minnesota started an experimental program for Atlantic salmon in Lake Superior in 1980 and discontinued the program in the fall of 1993. Factors which influenced the decision to discontinue the Atlantic salmon program include concern over the number of non-native predators in the Lake Superior fish community, naturalization of Atlantic salmon, low return rates, high production costs, and minimal angling interest.

RAINBOW TROUT

Background: Anadromous rainbow trout from the west coast of North America were first introduced into the Minnesota waters of Lake Superior in 1895. The species has become naturalized and supports an important recreational fishery. During the 1970's and 1980's, fishing pressure increased and anglers perceived that the number of steelhead were declining. In response, the MNDNR initiated a number of steelhead enhancement programs. However, despite these enhancement programs, the number of wild steelhead have declined through the late 1980's. To address the decline of wild steelhead, the *1992 North Shore Steelhead Plan* was developed. The *1992 North Shore Steelhead Plan* forms the basis for the rainbow trout chapter in this plan.

Goal: The long-term goal is to stop the decline of adult steelhead and to gather the necessary information to rehabilitate wild steelhead stocks.

Proposed Actions:

- Protect and improve steelhead habitat in North Shore watersheds by maintaining suitable stream flows, water temperatures, water quality and access to spawning and nursery areas.
- Pursue implementation of a regulation that prohibits harvest (catch and release only) of all unclipped rainbow trout in the Minnesota waters of Lake Superior and tributary streams below the posted boundary, based on the request by some angling organizations.
- Reinstate the experimental smolt rearing program at it's former level of 40,000 smolts annually with partial funding from interested organizations. An advisory group made up of representatives from the various organizations will be established to develop criteria for implementation and management of the smolt program and also to determine the criteria for success or failure.
- Use data from all traps to monitor steelhead populations.
- Determine the factors limiting production of adult wild steelhead.
- Determine if implementing the principals of wild trout management can provide quality angling for North Shore steelhead.
- Continue with construction of the Knife River trap for assessment of steelhead populations on a large stream.

BROOK TROUT

Background: Brook trout are native to Lake Superior and its tributaries below the first barrier. Reports from the mid-1800's through the 1920's indicate that "coasters", a brook trout strain that spends a portion of its life in Lake Superior, supported a popular fishery. Management agencies on Lake Superior have recently formed a working group to protect the remaining brook trout stocks in the lake, and gather information to address problems facing brook trout rehabilitation. All agencies understand that brook trout rehabilitation in Lake Superior will be a long-term process, and that cooperation among conservation groups, fishing clubs and management agencies will be required.

Goal: Determine if rehabilitation of self-sustaining brook trout (coaster) stocks in the Minnesota waters of Lake Superior is feasible or realistic.

Proposed Actions:

- Cooperate with other agencies on Lake Superior to gather the information needed to evaluate the feasibility of rehabilitating self-sustaining brook trout stocks in the Minnesota waters of Lake Superior.
- Use MNDNR staff report *"Lake Superior Brook Trout Plan: Recommendations for Plan Development"* and information gained from the brook trout working group to develop a rehabilitation plan, if there is potential for successful coaster rehabilitation, and support from user groups.
- Do not initiate a stocking program until a suitable plan is developed that addresses strain, size to be stocked, and criteria for success or failure.

BROWN TROUT

Background: Brown trout are not native to Lake Superior, but have established anadromous runs in a number of tributaries in other states. In Minnesota, attempts to establish anadromous populations in a number of streams met with very limited success. Brown trout are rarely caught in tributary streams below the barrier, but are caught occasionally during the summer boat fishery.

Goal: Maintain the opportunity to harvest naturalized brown trout that originate from tributaries in Minnesota and other states.

Proposed Actions:

- Allow angler harvest of brown trout in Lake Superior and tributary streams.
- No stocking of anadromous brown trout is recommended at this time.

WALLEYE

Background: Almost all walleye found in the Minnesota waters of Lake Superior originate from the St. Louis Bay population. The population is presently in good condition, but there are concerns about over-exploitation by anglers, and the potential impact of non-native species such as ruffe.

Goal: Protect the quality of the St. Louis Bay walleye fishery.

Proposed Actions:

- Manage walleye in cooperation with the Wisconsin Department of Natural Resources, as the St. Louis Bay population is a shared resource.
- Maintain quality size and catch rate of St. Louis Bay walleye through harvest regulations.
- Monitor walleye population dynamics through annual assessments.
- Protect walleye spawning habitat below the Fond du Lac Dam.

LAKE STURGEON

Background: The lake sturgeon is a primitive fish which is native to the Minnesota waters of Lake Superior. Historical records indicate sturgeon can exceed 300 lb and 100 years of age. Lake Superior and St. Louis Bay once supported a large lake sturgeon population and fishery. This population was extirpated due to poor water quality and over-fishing. In 1984, a program to rehabilitate lake sturgeon with stocked fingerlings began in St. Louis Bay.

Goal: Reestablish a self-sustaining population of lake sturgeon in western Lake Superior and St. Louis Bay.

Proposed Actions:

- Secure a reliable source of river-run lake sturgeon eggs from the Lake Superior watershed to be used in the restoration program.
- Stock lake sturgeon on a regular basis until self-reproducing stocks are established, if a proper strain can be found.
- Monitor lake sturgeon population dynamics annually.
- Develop spawning substrate suitability curves for the area between Highway #23 bridge and the Fond du Lac Dam.

PREFACE

The purpose of this plan is to guide fisheries management in the Minnesota waters of Lake Superior. It is written for use by both the Minnesota Department of Natural Resources (MNDNR) Section of Fisheries, and citizens that are interested in the management of Minnesota's Lake Superior fishery resource. This plan is based on a community approach to fisheries management and highlights why this approach is necessary. The plan begins with an introduction, a fish community chapter, and a chapter that discusses the combined aspects of habitat, water quality and contaminants. These are followed by chapters that discuss the management of individual species, but reiterate the community approach and the interdependence of one species on the others.

This plan is designed to guide effective and efficient allocation of time and money to protect the Lake Superior fish community and provide for its sustained use. It is one of many management plans being developed by the MNDNR Section of Fisheries to guide fisheries management throughout the state. Long range plans for many fish species have been developed, and individual lake management plans are being compiled for all managed bodies of water in the state. The strategies and actions listed in this plan will focus the work of the MNDNR Section of Fisheries over the next decade, as will the strategies and actions listed in other management plans.

This plan proposes both short and long-term changes in present management strategies for some species. It is anticipated that short term changes will be made in 1-3 years and long-term strategies will be carried out over a 3-10 year period. The goals and objectives of this plan are expected to remain relevant for 10 years, but it is written to be flexible, and deviations are expected to occur over that time period. Citizen participation has been a major component in the development of this plan and will be critical for its implementation. The plan's usefulness will ultimately be determined by its benefits to the resource and its users.

Chapter 1: INTRODUCTION

The Lake Superior fish community has undergone dramatic changes since the mid-1900's due to over fishing, introduction of non-native species, pollution, and land use changes in the watershed. Before 1950 the community was a relatively simple one with lake trout (*Salvelinus namaycush*), siscowet (*Salvelinus siscowet*), lake whitefish (*Coregonus clupeaformis*), brook trout (*Salvelinus fontinalis*), lake sturgeon (*Acipenser fulvescens*) and walleye (*Stizostedion vitreum*) as the top native predators. Rainbow trout (*Oncorhynchus mykiss*) had been intentionally introduced in the late 1800's and quickly established self-reproducing populations throughout the lake. The major species of prey fish were lake herring (*Coregonus artedii*), chubs (*Coregonus hoyi*) and sculpins (*Cottidae*).

Since the 1950's, the Lake Superior fish community has become much more complex, and is now composed of both native and non-native species. Introductions of non-native species were both intentional and unintentional. Introduced game fish species include chinook salmon (*Oncorhynchus tshawytscha*), coho salmon (*Oncorhynchus kisutch*), pink salmon (*Oncorhynchus gorbuscha*), Atlantic salmon (*Salmo salar*), brown trout (*Salmo trutta*) and a variety of rainbow trout strains (Kamloops, Madison, Donaldson, etc). The non-native rainbow smelt (*Osmerus mordax*) is heavily preyed upon by most game fish species, and has also become an important commercial species. The most devastating introduction to the Lake Superior community has been the sea lamprey (*Petromyzon marinus*), which virtually eliminated the lake trout, through predation, in all but a few isolated areas of Lake Superior. More recently there has been a flurry of unwanted introductions from Europe that include ruffe (*Gymnocephalus cernuus*), zebra mussel (*Dreissena polymorpha*) and the spiny water flea (*Bythotrephes cederstroemi*). Since the 1960's, rehabilitation efforts including sea lamprey control, harvest regulations and stocking programs, along with stricter pollution standards and best management practices for land use, have led to partial restoration of healthy fish stocks. This plan is a comprehensive guide on how to best continue management of the Lake Superior fishery into the future.

Fisheries management in the Minnesota waters of Lake Superior is the responsibility of the Minnesota Department of Natural Resources (MNDNR), Section of Fisheries. The MNDNR vision for natural resource management is "to work with the people of Minnesota to manage the state's diverse natural resources for a sustainable quality of life." This vision complements the MNDNR Division of Fish and Wildlife's mission which is "to protect and manage Minnesota's fish, wildlife, native plants, and their communities for their intrinsic values and long-term values to people." The primary goal of the MNDNR Section of Fisheries is "to protect, maintain and enhance the fishery resource and the aquatic community for long-term recreational, ecological and economic benefits to the state" (MNDNR, Section of Fisheries 1994). In the context of this plan, the "resource" is defined as the Lake Superior ecosystem, and includes water quality, habitat and the natural communities present.

The long term goal for fisheries management in the Minnesota waters of Lake Superior is:

> **To protect the Lake Superior ecosystem and to develop a diverse, stable, self-sustaining fish community that provides both recreational and commercial fishing opportunities.**

In the goal statement a "diverse" fish community is one that includes different strains of native and introduced species that have established themselves through natural reproduction and are presently found in Minnesota waters. "Stable" means that although the abundance of various populations may fluctuate, they do so within a limited range. A "self-sustaining" community is one in which the fish species can sustain themselves largely through natural reproduction, but may at times require assistance through management actions. The vision for the MNDNR, the mission of the Division of Fish and Wildlife and the goals of the Fisheries Section and the Lake Superior management plan all stress the need to protect the resource (ecosystem) and provide for appropriate resource use by people. There are times when these two responsibilities conflict. When such conflicts occur, the long-term protection of the resource must take precedence, because without a resource to use there can be no public benefit. The MNDNR has recently adopted the philosophy of ecosystem based management. In its mission to protect the Lake Superior ecosystem, it is the Department's responsibility to communicate that fishery production in the Lake Superior ecosystem is finite, and to identify situations when user expectations are unrealistic.

FINANCIAL RESOURCES OF DEPARTMENT

The MNDNR requires financial resources to carry out its responsibility for natural resource protection. The Section of Fisheries budget comes from the sale of fishing licenses, trout stamps and federal aid through an excise tax on fishing equipment. Trout and salmon anglers constitute 5% of the total licensed anglers in Minnesota. Over the last 5 years an average of 1.6 million fishing licenses and 85,000 trout stamps have been sold annually. Financial resources are limited and must be used efficiently to manage the vast array of lakes and streams in Minnesota. The Minnesota portion of Lake Superior is only a small part of the state's resource, and managers must decide how to best allocate limited funds.

Decisions regarding financial and resource concerns are usually initiated at the field level. On Lake Superior this usually involves collaboration among the Lake Superior Area and the three other areas along the shore; Duluth, Finland and Grand Marais. If resolution cannot be reached, the decision is passed to the regional level, and if there continues to be disagreement, the St. Paul staff becomes involved. The ultimate decision on both resource and financial issues rests with the Chief of Fisheries, the Director of Fish and Wildlife and the Commissioner of Natural Resources. Citizen input is encouraged at all levels, but is most useful when initiated at the field level.

ALLOCATION OF FUNDS TO LAKE SUPERIOR

The overall annual operating budget for the Section of Fisheries in fiscal year (FY) 1994 (July 1, 1993 - June 30, 1994) was about $17,000,000. The major source of this funding is from the sale of fishing licenses. Approximately $3,700,000 of the overall section budget, or 22% was spent on the cold water program. Trout stamp sales accounted for $430,000 which is 2.5% of the overall fisheries budget and 11.5% of the cold water budget. Major expenditures in the cold water program include fish culture and stocking, habitat improvement, lake and stream assessments and research.

Approximately 8% of the total statewide fisheries budget and 36% of the cold water budget is allocated to the Lake Superior program. We estimate that approximately $1,320,000 was spent on Lake Superior in FY 1994. Of the $1,320,000 spent on Lake Superior in FY 1994, approximately $762,000 (58%) was spent on fish culture (5-year average FY89-FY93), $358,000 (27%) on management activities, $100,000 (7.5%) on research and $100,000 (7.5%) on administration.

The 1991 Fish and Wildlife Census (U.S. Department of Interior 1991) estimated that approximately 3% of all licensed anglers participated in the Lake Superior fishery. The average annual angling pressure estimated from MNDNR creel surveys from 1990 to 1994 was 312,000 hours. This includes data from the 1990 winter creel survey and assumes that this data was typical for the period. The estimated management cost per angler hour on Lake Superior averaged approximately $4.20 from 1990 through 1994. The cost per angler hour is high when compared to estimates from other large lakes in Minnesota over approximately the same period (Table 1.1). The estimated average hatchery cost per fish stocked in Lake Superior ranged from $0.25 for chinook salmon fingerlings to $2.50 for steelhead yearlings (Table 1.2). The estimated cost per hatchery fish caught in Lake Superior ranged from $25.00 for lake trout to $720.00 for steelhead and Atlantic salmon (Table 1.2). The estimated average cost per steelhead caught is based on returns from only two year classes and could change depending on future returns. As management strategies are reviewed in times of shrinking budgets, the financial realities must be considered along with the biological and social concerns.

Fish culture is the most expensive portion of the Lake Superior program. During the five year period from FY 1989 through FY 1993, an average of 51% of the statewide cold water hatchery expenditures went toward Lake Superior stocking programs. During this period the state maintained lake trout yearlings, steelhead fry, and Kamloops, steelhead, chinook and Atlantic salmon smolt rearing programs for Lake Superior. As State budgets continue to tighten and the sale of angling licenses remains flat or decreases, the potential for expanded cold water culture programs appears remote.

Table 1.1. Average estimated production cost per fish stocked from 1988-1992 and average cost per stocked fish caught from 1988-1994.

Species	Ave. production cost/fish stocked	Size stocked	Ave. cost/ fish caught
Lake trout	$0.65	Yrl	$25.00
Kamloops rainbow trout	$1.25	Yrl	$90.00
Chinook salmon	$0.25	Fgl	$63.00
Atlantic salmon	$1.80	Yrl/Fgl	$720.00
Steelhead*	$2.50	Yrl	$720.00

* Average cost per stocked fish caught based on returns from 1989 and 1990 year classes through spring 1995

Table 1.2. Surface area, pressure, and estimated management cost per angler-hour (a-hr) for some Minnesota large lakes and Lake Miltona, from approximately 1990-1994.

Lake name	Acres	Pressure (a-hrs)	Cost/a-hr
Superior (MN waters)	1,400,000	312,000	$4.20
Mille Lacs	132,516	3,900,000	$0.03
Leech	111,527	1,200,000	$0.04
Winnibigoshish*	53,425	773,500	$0.18
Vermillion	40,557	573,000	$0.08
Rainy (MN waters)**	54,200	137,000	$0.40
Kabetogema**	25,760	450,000	$0.05
Miltona	5,838	150,000	$0.15

* Routine fish management = $0.08; bank stabilization = $0.10.
** Does not include winter pressure estimate.

RELATIONSHIPS TO OTHER AGENCIES

Lake Superior is bordered by several political jurisdictions which share fisheries management responsibilities for the lake. Approximately 7% of Lake Superior's surface area lies within Minnesota state boundaries. Fisheries management is coordinated among the various agencies in each jurisdiction under the auspices of the Great Lakes Fishery Commission (GLFC). The GLFC is an international commission established by the U.S. and Canada in 1956 to control sea lamprey, coordinate fisheries management and direct fisheries research on the Great Lakes. States bordering the Great Lakes, the province of Ontario and a number of Indian Bands are partners in the GLFC. Minnesota, as a partner in the GLFC, is represented on a variety of committees established to coordinate fisheries management throughout the Great Lakes, and specifically in Lake Superior.

The GLFC has produced two major documents, *A Joint Strategic Plan for Management of Great Lakes Fisheries (SGLFMP;* 1980) and the *Strategic Vision of the Great Lakes Fishery Commission for the Decade of the 1990's (The Vision;* 1992), which set the overall direction for fisheries management in the Great Lakes. Following the direction of SGLFMP and the Vision, *Fish Community Objectives for Lake Superior* (Busiahn 1990) was drafted by the Lake Superior Committee, and adopted by all management agencies on Lake Superior. It describes the goals and objectives for fisheries management on Lake Superior and, along with its companion documents, establishes the framework for fisheries management by participating agencies. This plan's goals and objectives for fisheries management in the Minnesota waters of Lake Superior fall within the framework proposed in the *Fish Community Objectives for Lake Superior.*

The Binational Plan for Lake Superior is another international initiative on Lake Superior that has the potential to affect fisheries management and the Lake Superior fish community. Participants in the Binational Plan include the states bordering Lake Superior, the province of Ontario, a number of Indian bands, Environment Canada and the U.S. Environmental Protection Agency (USEPA). The Binational Plan for Lake Superior has two phases. The first proposes a special designation status for Lake Superior which promotes the goal of zero discharge of nine persistent toxic substances. The second is a broader program to develop a lake-wide management plan (LaMP) for Lake Superior. The Lake Superior LaMP will focus on water quality and habitat issues, but fish management issues will also be included (Lake Superior Binational Program 1993).

CITIZEN PARTICIPATION

The most important part of the planning process has been citizen participation and the discussions generated during the formulation of this plan. An advisory group that represented fishing clubs, environmental groups, Indian bands, commercial fishing interests, county organizations and individual anglers on Minnesota's portion of Lake Superior was formed at the very beginning of the planning process. This group solicited input from their organizations and reviewed and commented on draft chapters of this plan which were initiated from the Lake Superior Area Office. These draft chapters were not given any formal review by the MNDNR Section of Fisheries before they were distributed to the advisory group. The draft chapters were expected to stimulate citizen input at the beginning of the planning process. All input on the draft chapters was compiled and distributed to all groups involved, including personnel in the Section of Fisheries.

Comments and input from the advisory group varied considerably, with some areas of common agreement and other areas where little or no agreement was apparent. After all chapters in the plan had gone through this process, a group of MNDNR fishery managers and biologists met to compile a second draft. Major changes were made in the second draft which incorporated many of the comments and concerns of the advisory group, along with the concerns and requirements of the Section of Fisheries. Comments received on the draft chapters were addressed in a response summary, and distributed to the advisory group along with the second draft. The response summary identified the major issues that were identified by the advisory group, and why they were, or were not, included as part of the plan.

Comments were again received on the second draft and major areas of concern were discussed between MNDNR representatives and individual groups comprising the advisory group. Three "Open House" meetings were also held to get feedback on the plan from citizens not associated with a representative on the advisory group. These public meetings were held in St. Paul, Schroeder, and Duluth. After meeting with the various groups and compiling comments from the "Open House" meetings, areas of concern with the second draft were identified. Controversial parts of the plan were thoroughly discussed within the Section of Fisheries and with the Commissioner of Natural Resources. Some sections of the plan were modified when agreements could be reached. Parts of the plan that could not be modified were left unchanged and remained controversial.

Early in the planning process it was clearly identified that this plan would require extensive public input and that there was great potential for conflicting views based on the diversity of Lake Superior interest groups. Attempts were made to reduce areas of conflict and all views would be listened too, however, final decisions rested with the MNDNR. The completed plan has now been distributed to all interested citizens. As this plan is implemented, citizens may inquire at the Lake Superior Area Office to receive information on its progress. This plan is expected to focus and stimulate ongoing conversations about future fisheries management for the Minnesota waters of Lake Superior.

This plan is a group effort that has involved many hours of work by many people. As among any diverse group, there are areas of disagreement, but there are also many areas of agreement. The plan needs to be followed to be effective; however, the plan is also flexible and may be modified based on: 1) major changes in the fish community; 2) the necessity to protect the resource if it is being compromised; or 3) shifts in societal values placed on the

Lake Superior fisheries resource. This plan is a requirement for sound management of the Lake Superior fishery and will ultimately move us closer to the goals we have identified.

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Chapter 2: FISH COMMUNITY INTERACTIONS

Fisheries management is in a state of transition. There is emerging evidence that current theory and methods, based on the species approach, are inadequate for understanding and managing fisheries. Both fisheries biologists and resource users must begin to recognize that a community approach to fisheries management is needed. A community approach is one that considers information about a wide variety of species from different levels in the food chain (e.g. vertebrates, invertebrates, plankton) and environmental factors (e.g. weather, water temperature, contaminants) in the context of their interactions. The community approach requires managers to integrate and synthesize information from many sources to predict the effects of management actions on species or species assemblages (Christie et al. 1987).

The MNDNR Section of Fisheries is committed to the concept of watershed, ecosystem and biological community management (MNDNR Section of Fisheries 1994). These concepts recognize that a variety of physical, biological, chemical and human induced factors affect fisheries. Fisheries management that focuses primarily on the species approach is more subject to inaccurate or incomplete analysis of problems and more prone to failure as a result of undertaking inappropriate actions. Although this problem has long been recognized, fisheries management techniques have historically emphasized the species approach because effective techniques for assessing and managing communities were not available.

The biological community consists of all the plants and animals within an ecosystem, and implies that they are self-sustaining. Many fishery management activities, such as stocking programs and the introduction of non-native species, have the potential to disrupt the interrelationships among species in the community, and therefore must be explored thoroughly before action is taken. Popular recreational fisheries are often in conflict with the integrity of the natural community, and may contribute to the instability of Great Lakes fish populations. Many anglers strongly support management for a favorite species, which is often an introduced species that can only be sustained through hatchery production and heavy stocking. Management agencies are often pressured by anglers to deliver their favorite species at larger sizes and in greater numbers on a continuous basis. In many areas the situation is compounded because of several favorite species. Continual introductions of non-native species by management agencies does not promote biological diversity. Rather, it is a prime example of the species approach and demonstrates a disregard for the overall effects on the integrity of the established fish community. Throughout the Great Lakes, and in the Minnesota waters of Lake Superior, favorite species management has occurred since the success of sea lamprey control in the mid-1960's. Obviously what has occurred in the past through intentional and unintentional species introductions has affected the present Lake Superior community. Humans have affected, and will continue to influence the Lake Superior ecosystem. If the goal of a stable self-sustaining fish community in Lake Superior is to be realized, management strategies by the agency and angler expectations must change. The expectation of many anglers for the Lake Superior fishery far exceed the reality of what the ecosystem can produce. Species based management and unrealistic expectations by management agencies and anglers have contributed to the boom-or-bust fisheries in the Great Lakes.

The MNDNR will continue to manage for a stable, diverse sport fishery in Lake Superior. Most species which have been introduced into Lake Superior have become naturalized and are now components of the fish community. Future management strategies and goals cannot ignore the established sport fisheries and economic impacts that have developed because of these introduced species. The MNDNR hopes to attain a balance between a sustainable Lake Superior fish community, the economics of the fishery and angler expectations.

A general approach to ecosystem and community management from a fisheries point of view involves the following (MNDNR 1994):

- Examination of the physical characteristics and human activities, including fishing, in the watershed to determine possible effects on the fishery.
- Survey and classification of the water body according to its physical, chemical and morphological characteristics.
- Survey of the biological community, focussing primarily on the assemblage of fish.
- Determination of whether the numbers and kinds of species in the fish community, and their yield to the fishery, conform to regional or theoretical norms for the particular water body.
- Formulation of management plans to maintain or improve the fishery based on the above evaluations.
- Implementation of management activities.
- Evaluation of the success of management and cessation or alteration of management activities as warranted by the evaluation.

Not only does a community approach to fishery management improve chances of success, but the information gathered in the process will continually lead to improved techniques. As more data are accumulated on lake norms, effective management activities are documented and unsuccessful approaches are discarded. Public acceptance of fishery management activities should be enhanced by this planned approach to management, particularly when area field staff work closely with concerned citizens.

PRESENT POPULATION DYNAMICS

In the community approach, changes which affect one species will ultimately affect other species. A study of these changes at each level in the food chain would be necessary to fully explain the processes at work. Both simple and complex models have been designed to aid in the understanding of community dynamics. Recent bioenergetics modeling of species in the Minnesota waters of Lake Superior identified the critical information needed to adequately understand the Lake Superior fish community (Negus 1995). One finding suggests that all the available forage could be consumed in a very short time, given the current rate of predator stocking and estimates of forage biomass. Although this has not been demonstrated, major shifts in forage species have occurred, and some predator species have declined in abundance. These observations suggest conservative management of the forage stocks and identify a critical need for more detailed information on forage biomass, predator diet and predator growth. Efforts to obtain the kind of diet and growth information needed for bioenergetics modeling must be intensified. Accurate forage biomass estimates are critical to the management of the Lake Superior fishery. At present, the only available estimates are provided by the National Biological Survey (NBS) trawling surveys. The NBS plans to expand their forage assessment capabilities to include hydro-acoustic biomass estimates.

The introduction and widespread naturalization of Pacific salmon in Lake Superior over the last 20 years is of major significance to the Lake Superior fish community. Chinook salmon exhibit a higher rate of predatory impact than any other salmonid species in Lake Superior and, therefore, can theoretically have the greatest impact on forage abundance over the shortest period of time (Negus 1995). The naturalization of both chinook and coho salmon throughout much of Lake Superior leaves management agencies with limited control over abundance, movement and community impact of these introduced species. However, many anglers prefer salmon to lake trout and continue to request increased stocking levels in spite of natural reproduction and poor survival of stocked fish.

A variety of recent changes in the Lake Superior fish community have been observed and appear to be interrelated. In Minnesota, while the abundance of wild lake trout is slowly increasing and stocking levels of lake trout, chinook salmon and steelhead have been expanded, lake trout growth rate, stocked lake trout survival, chinook salmon returns, and steelhead production appear to be declining (Hansen et al. 1994; Hansen 1994). A major shift in the forage base from rainbow smelt to lake herring (Hansen 1994) may have greatly influenced the community dynamics in Lake Superior. This shift could explain the increased mortality of juvenile fish and changes in the spatial distribution of predators and growth rates (Schreiner et al. 1993). In Minnesota waters there is evidence that some yearling lake trout are consumed soon after they are stocked (Schreiner et al. 1991). It seems likely that both stocked and naturally produced juveniles of all salmonids could be subject to similar predation. Predator avoidance and competition for forage among juvenile fish may cause them to disperse over wider areas and become more pelagic than in the past. Catchability of a dispersed stock usually decreases, whether the gear used is hook-and-line or gill net. Predators that expend more energy seeking and processing pelagic food items over a wide area may exhibit slower growth rates. A signal that a population has reached carrying capacity is the increase of older fish, with a stable or declining rate of recruitment. Many of these trends are evident throughout Lake Superior (Hansen 1994).

The management of a fish community approaching carrying capacity involves different considerations than rebuilding a depleted stock. For example, stocking large numbers of yearling lake trout may slow rehabilitation of native lake trout if stocked fish are in competition with their native counterparts for scarce resources (Evans and Willox 1991). If survival of stocked fish is declining, as it appears to be, stocking more fish may not have the desired results. Variable stocking levels in recent years may provide useful periods to evaluate if this competition exists.

PREDATOR YIELD IN THE MINNESOTA WATERS OF LAKE SUPERIOR

It is difficult to estimate the expected yield for predator biomass in the Minnesota waters of Lake Superior based on available information. However, a rough estimate can be made using some assumptions and educated guesses. By using historical and current information, we can determine the historical yield of predators, the present yield of predators, and estimate the potential maximum biomass of predators that can be sustained.

Prior to the invasion of sea lamprey and the extensive stocking programs that followed, lake trout were the principal top predator in the Lake Superior fish community. The average annual yield of lake trout from 1918 to 1948 in Minnesota was approximately 340,000 lb. Because this yield remained relatively stable over the 30 year period, the historical yield of 340,000 lb can be used as a benchmark for stable production of predators in the Minnesota waters of Lake Superior. It could also be assumed that lake herring, were able to sustain this level of predator production. During this period siscowet and lake trout yield was combined, and some unknown but significant portion of this yield was composed of siscowet. From reviews of historical records, and discussions with commercial operators and other fish management agencies, the estimated portion of siscowets in this yield averaged 10-20% or approximately 60,000 lb. Before lamprey invaded Lake Superior and decimated the stocks, the historical lean lake trout yield was estimated at approximately 280,000 lb or 56,000 lean lake trout that averaged 5 lb.

Over the last 10 years, a rough estimate of predator yield, obtained from creel surveys, assessment netting and estimated returns to stocked streams, was approximately 180,000 lb (Table 2.1). This is probably a minimum estimate because it does not include the winter fishery or other periods when creels are not conducted.

Table 2.1. Estimated average annual yield of major predators from the Minnesota waters of Lake Superior, 1983-1993.

Species	Weight (lb)	Number
lake trout	100,000	20,000
chinook salmon	50,000	5,000
coho salmon	10,000	5,000
rainbow trout	20,000	5,000

It has been estimated that in recent years lamprey have annually consumed between 10,000 to 20,000 lake trout weighing 50,000 to 100,000 lb. When lamprey predation is included in the yield estimates, the total annual yield for all predator species is between 230,000-280,000 lb. This rough estimate of present annual yield is approximately equal to the historical predator yield from the Minnesota waters of Lake Superior. Although these numbers are estimates and many assumptions have been made to arrive at these comparisons, they are useful to illustrate that, at present there appears to be little room for expansion of predator yield. With the recent transition in the abundance of prey species from rainbow smelt to lake herring and the instability and heavy stocking that is now inherent in the system, these numbers should be interpreted as a warning because they suggest we are close to the yield that can be expected from Minnesota waters.

The use of new technologies and models proposed in this plan will enable us to better estimate, predict and understand the dynamics of the fish community. Models that help to explain the processes affecting fish communities and populations are now being developed and will serve as useful tools in the future management of the Lake Superior fishery. A combination of bioenergetics models (Kitchell 1983) and total allowable catch models (Ebener et al. 1989) will allow managers to examine different scenarios at no cost to the resource and at little cost to the management agency or angler. The results of different management strategies could be analyzed and demonstrated to other biologists, administrators, legislators and user groups (Jones et al. 1993). However, we must acknowledge that the overall productivity of the lake will remain essentially unchanged, and the survival of a species may be more dependent on its fitness in the Lake Superior ecosystem than on the number of fish that are stocked. At worst, we may overload the system with predators and risk the collapse of the forage stocks, creating massive instability in the fish community. At best, we will waste a lot of time and money by stocking excess fish that will not survive.

GENETICS

The consequences of management actions on the genetic structure of native or naturalized stocks must be considered. The North Shore Steelhead Plan (Schreiner et al. 1992) discusses the potential conflict between wild steelhead management and management with hatchery strains. The steelhead genetics study conducted on Minnesota's North Shore (Krueger et al. 1994) also points out the risks of managing with hatchery strains when the goal is to reestablish wild steelhead stocks.

Historically, lake trout populations were subdivided into many discrete spawning stocks. These stocks used different spawning habitats and displayed different behavioral traits (Ihssen 1984). With the invasion of the sea lamprey, many of these stocks were lost and the genetic diversity of lake trout was reduced. Luckily, a few remanent lake trout stocks remained which continued to reproduce and were also used as an egg source for hatchery production. Sea lamprey predation and extensive stocking programs have undoubtedly reduced the genetic diversity of lake trout now present in Lake Superior. However, selection pressure should occur and with proper management, genetic diversity should slowly increase. Initial strain selection, hatchery breeding techniques, stocking locations, stocking rates and fishing pressure will all influence the rate of genetic differentiation in the future.

The premise of this plan is that the Lake Superior fishery is a complex, interrelated community. Throughout this plan, the idea of community is reinforced and management strategies are suggested that have their foundation in the community approach as we understand it today. If management strategies ignore the community approach, the stability of the system and the future of the resource may be a risk.

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Chapter 3: HABITAT

I. History

Habitat is defined as the place where an organism lives. In Lake Superior fish habitat is influenced by the physical properties of the lake basin and its watershed; water quality including temperature, nutrients, suspended sediment, etc.; and chemical contaminants such as heavy metals, pesticides and PCBs. Protecting the quantity and quality of habitat is the cornerstone for sustainable fisheries management. Lake Superior has the least amount of habitat degradation in all of the Great Lakes, and future protection of habitat is receiving a high priority.

Throughout the Lake Superior basin, point source pollution has been greatly reduced in the last 20 years. Non-point and atmospheric pollution continue to cause problems with bioaccumulation of mercury, PCBs and other toxicants in fish and wildlife. In Minnesota major habitat damage has occurred in the St. Louis River because of industrial discharge, sewage effluent, urban development and sedimentation. The river is classified as an area of concern by the USEPA and its cleanup is now being addressed through the St. Louis River Remedial Action Plan (RAP). Another source of habitat degradation in Minnesota's portion of Lake Superior has come from the effluent discharged by the taconite mining industry. Timber harvest has also caused streams to warm, stream hydrology to change and soil erosion and sedimentation to increase. Development of roads, homes and businesses along the coastal areas of Lake Superior have also increased erosion and sedimentation rates.

The Binational Plan for Lake Superior will focus on the Lake Superior ecosystem, including water quality, pollution and habitat concerns (Lake Superior Binational Program 1993). Activities will include defining problems and achieving a vision for the future. A number of committees have formed that will address habitat concerns, designation issues, pollution and ecosystem principals and objectives. Support for and cooperation in this initiative should help preserve habitat and water quality and reduce contaminant levels in Lake Superior.

The MNDNR, Minnesota Pollution Control Agency (MPCA) and Minnesota Department of Health (MDH) monitor contaminant levels of most Lake Superior fish species. PCBs have been monitored routinely in lake trout from western Lake Superior and have decreased over the last 20 years (Figure 3.1). In other species throughout Lake Superior most toxic contaminants have also decreased (De Vault et al. 1994). As a general rule, the longer lived and larger fish accumulate higher levels of contaminants. Although PCBs do not readily break down in the environment and are probably being recycled, it is anticipated that their levels will continue to decrease since the amount entering the lake has been reduced.

II. Goals and Objectives

Goal: Maintain and enhance the quantity and quality of fisheries habitat in the Minnesota waters of Lake Superior.

Objectives:

1. Identify and quantify potential spawning areas in Lake Superior and tributary streams so these areas can be monitored and protected from degradation.

2. Work with MNDNR Division of Waters (DOW), MPCA, and other agencies and citizen groups to reduce habitat degradation in the Lake Superior watershed through the regulatory process.

3. Work with MPCA, MDH and other agencies to establish a consistent sampling protocol to monitor contaminant levels in Lake Superior and St. Louis River fish species.

4. Monitor movement and location of different fish species to determine what habitats are being used by the different species.

III. Recommendations:

1. Fund a mapping project to identify and quantify fish spawning areas in Lake Superior so they can be protected and monitored for potential long-term changes.

2. Continue to evaluate and comment on permits issued by various agencies (DOW, Army Corps, etc.) so fishery habitat is not degraded, and enhanced where possible by potential projects.

3. Work with DOW, local units of government, the North Shore Management Board and other agencies to ensure criteria that protect fishery habitat are included in policy guidelines for zoning and development within the Lake Superior watershed.

4. Continue to work with the timber industry to ensure that best management practices are implemented and advocate for expansion of buffer zones in the riparian area.

5. Continue to increase protection of streams in the Lake Superior watershed from erosion, beaver damage, floods and poor land use practices by implementing habitat improvement recommendations found in MNDNR fisheries stream management plans.

6. Work in cooperation with the Binational Plan, St. Louis River RAP, MPCA, USEPA and other agencies to reduce contaminant input to Lake Superior from all sources.

7. Establish a task force including representation by the various agencies on Lake Superior to implement an effective long-term sampling program to monitor contaminant levels in Lake Superior and St. Louis River fish species. The task force should identify the contaminants to be monitored, the periodicity of sampling and the reporting protocol. A standardized analytical method that follows Anderson et al. (1994) should be implemented.

IV. Justification

Unimpaired habitat is critical for a productive, self-sustaining fish community for present and future generations. There are many examples to illustrate that when habitat for a species is lost, the species is also lost. In a natural community the loss of one species affects the integrity of the entire community. A very important and controversial result of unprotected fish habitat is the impaired use of affected fish by humans. Fish advisories presently suggest that humans limit their consumption of most game fish in Lake Superior because of contaminants. Older and larger individuals of a species usually have more restrictive advisories since they have been in the system longer and tend to accumulate more contaminants. Altering the species compositions of the Lake Superior fish community by trading larger, long lived species for smaller, short lived species, would only address a symptom of the problem. Instead, efforts should be intensified to correct the source of the problem which is contaminant input. In Lake Superior, lake trout and siscowet accumulate the highest contaminant load, but are also the most stable and best adapted top predators for the Lake Superior ecosystem. Because of their sensitivity to contaminants, lake trout provide a good indicator of ecosystem health and they can be used as a benchmark for progress on pollution abatement. According to current advisories, smaller lake trout less than 27 in can be consumed by humans once a month, and lake trout less than 20 in provide no more health risk than any of the other game fish species (MDH 1994).

V. Information Needs/Community Interaction

The quality and quantity of habitat affects the structure of the fish community and, in a large part, determines which species are productive and which struggle to survive. More information is needed on the habitat requirements of all the species in the Lake Superior fish community. If the quantity and quality of the habitat available to each species in the system were known, attempts to predict the productivity and compositions of the fish community could be initiated. This is a new area in fisheries science, and is critical for the efficient management of the ecosystem. Identification of critical habitat is also important if protection of that habitat is to occur. New techniques are being developed for fisheries science, and as they become accepted practice they should be applied to the Lake Superior ecosystem.

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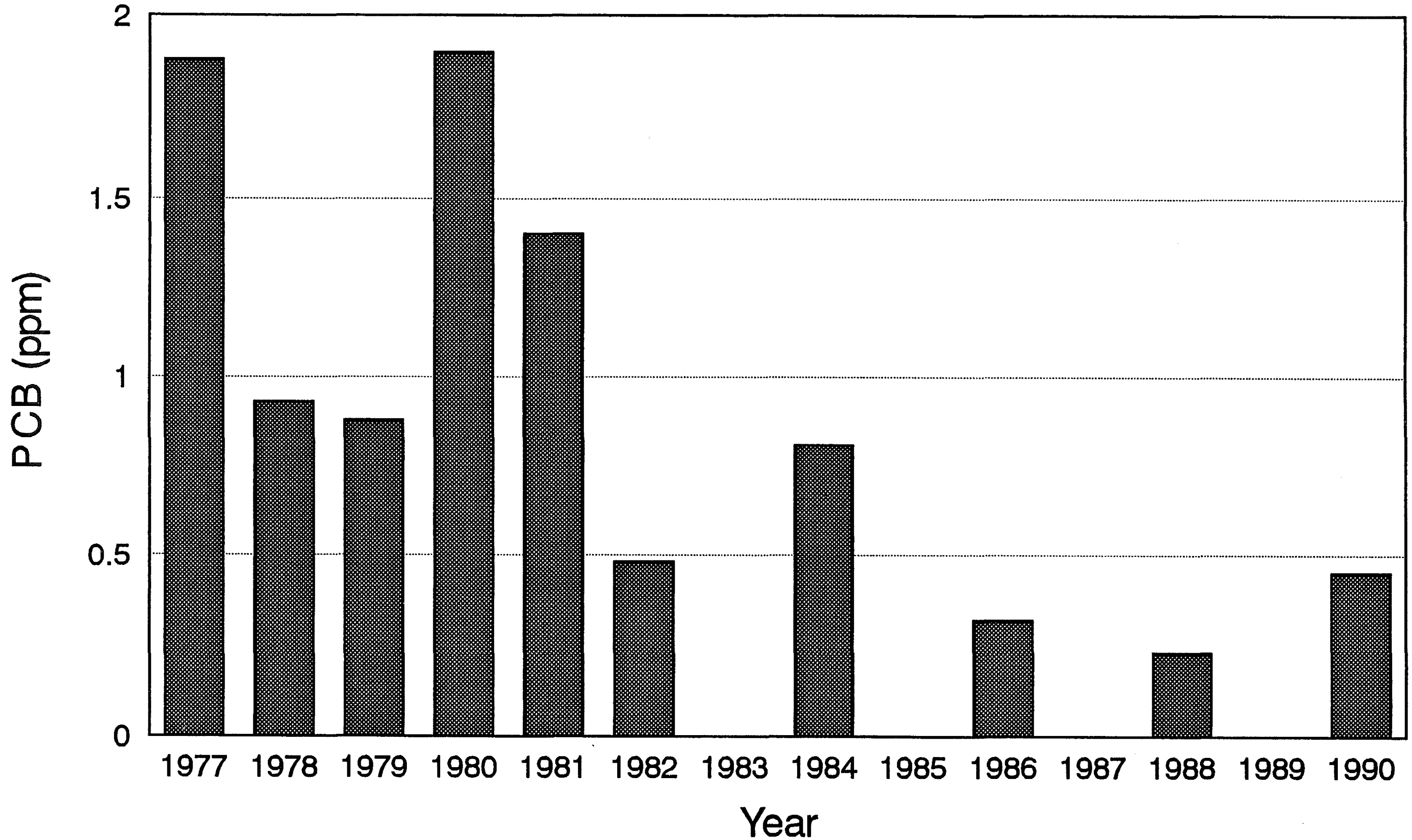

Figure 3.1. PCB trends in whole lake trout from western Lake Superior (Dave De Vault, USEPA, unpublished data).

Chapter 4: FORAGE

Forage in Lake Superior can include organisms from a variety of trophic levels, such as zooplankton, microcrustacea, aquatic and terrestrial insects, larval fish and forage fish species. In this plan the term "forage" refers to the prey fish used by trout and salmon in Lake Superior. The species of forage fish most common in Lake Superior are lake herring, chub and rainbow smelt. Less common species include members of the sucker family (*Catostomidae*) and four species of sculpin (*Cottus bairdi*, *C. cognatus*, *C. ricei* and *Myoxocephalus thompsoni*). In this plan, only lake herring, rainbow smelt and chub will be considered in detail since they are the major fish species consumed (Conner et al. 1993) and are managed by the MNDNR. Additional information needs to be collected on the use of other prey items by all predators at various life stages in Lake Superior before a more complete understanding of community dynamics is reached.

Lake Herring

I. History

In Minnesota waters of Lake Superior, lake herring were the major diet item for lake trout and the major commercial species until rainbow smelt became established in the late 1950's (Hansen and Pycha 1986). The commercial lake herring fishery in Minnesota began around 1875. Harvest increased until the 1920's, then stabilized at over 6 million pounds annually until 1940 (Figure 4.1). From 1940 to 1985 harvest of lake herring declined but since 1985 harvest has increased each year.

Major efforts to rehabilitate lake herring stocks included: a reduction in the number of commercial operators through attrition and net quotas; an inshore refuge, enacted in 1971, which prohibited harvest within 0.25 mile from shore; a closure of the fishing season in November to protect spawners, beginning in 1973; and a stocking program in the Duluth area from 1975 to 1986. Since the early 1970's, the commercial fishery for lake herring has mainly supplied fish for local restaurants, grocery stores and smoked fish shops. Residents still enjoy lake herring as a local delicacy. During the spawning season, a lucrative market sometimes develops for lake herring roe (eggs). Minnesota operators have limited access to this market because of the November closure. Although the closure is difficult for the commercial operators to accept, it is a season when lake herring stocks are vulnerable to over fishing and need protection. Very few commercial operators still make their living solely from the lake herring fishery and most are now hobby or part-time operators. Commercial operators are required to submit monthly reports that provide information necessary for the management of lake herring. If lake herring stocks continue to recover, and information indicates there is surplus lake herring to be allocated, the November closure may be relaxed.

The harvest of lake herring has been increasing in the Minnesota waters of Lake Superior since 1985. Strong year classes were produced in 1988, 1989, and 1990; however, the 1991, 1992 and 1993 year classes of lake herring were relatively weak (Hoff and Selgeby 1994). Lake herring are pelagic and utilize more of the basic productivity than any other forage fish found in Lake Superior. Because they are adapted to use most of Lake Superior, lake herring are the most appropriate forage for maximizing lake trout restoration and production of other fish species in the community. Lake herring are again established in Minnesota waters, and wise management of the stocks is critical to the stability of the predator populations and the commercial fishery.

II. Goals and Objectives

Goal: Rehabilitate and protect stable, self-sustaining lake herring stocks to support production of predators and a limited commercial fishery.

Objectives:

1. Use hydroacoustic sampling and trawl surveys to monitor year class strength and determine the biomass of lake herring in Minnesota waters of Lake Superior annually by 2005.

2. Investigate the stock structure, production, and movement of lake herring in the western half of Lake Superior annually.

3. Use bioenergetics modeling to determine the allocation of surplus lake herring production for lake trout restoration, use by other predators, and commercial harvest (Objective 1).

4. Continue the November closure of the commercial fishery until the quantity of surplus production of lake herring can be determined by using hydroacoustic sampling or a surplus population model.

5. Limit the number of commercial operators along the Minnesota shoreline to 50.

6. Maintain or reduce stocking quotas for all species dependent on lake herring for forage, and do not introduce any new species until the quantity of surplus lake herring production can be determined.

III. Present Management

A. Regulations - There is no closed season or possession limit for the lake herring sport fishery. The commercial fishing regulations for lake herring are described in Minn. Stat. section 97C.835 and Minn. Rule, part 6260.1800. Major sections of the commercial regulations include: a spawning season closure in November; a limit of 100,000 ft of total lake herring net to be allotted among license holders; and a requirement that all lake herring nets be suspended off bottom.

B. Stocking - No stocking is presently being conducted.

C. Assessment - Lake herring stocks are assessed by monitoring commercial operators throughout the year, MNDNR test nets, and NBS trawl surveys. Stomach samples from predators taken in creel surveys, fishing contests and netting assessments provide additional information. A report entitled *Lake Superior Commercial Fish Assessment Studies - Status of Lake Superior Fish Stocks* is prepared annually (Geving and Schreiner 1993).

IV. Proposed Management

A. Regulations - Limit the total number of licensed commercial operators on Lake Superior to 50. Clarify the intent of specific portions of Minn. Stat. section 97C.835 and Minn. Rule, part 6260.1800 that deal with licensing, net marking and distance of nets from shore. To reduce bycatch of lake herring, propose regulations that put restrictions on trawling for rainbow smelt during November. Explore options to utilize and distribute trout and salmon incidentally caught in lake herring nets.

B. Stocking - No stocking required.

C. Assessment - Continue present lake herring assessment program. Monitor population structure and analyze growth rates to determine what portion of the population may be vulnerable as prey. Contract or purchase equipment to conduct hydroacoustic surveys to determine biomass of lake herring available in Minnesota waters of Lake Superior. Encourage and support NBS to develop and conduct hydroacoustic sampling surveys. Increase the intensity of commercial monitoring using student interns or additional personnel, if available. Summarize historical lake herring harvest using a computer database. Conduct intensive diet studies of sport fish once every 5 years.

V. Justification

Historically, lake herring have been the principal forage species for lake trout in Lake Superior. To reach the rehabilitation goal for lake trout and to support other predators, biologists believe lake herring must be the primary forage species (Hansen et.al.1994). Successful management of lake herring is the cornerstone of a stable fish community in Lake Superior. Since 1985, lake herring stocks have been recovering; however, no increase in commercial fishing, predator stocking quotas or new species introductions should occur until the population is completely recovered. As predator stocks increase or become naturalized, consideration should be given to reduced stocking rates. Likewise, a limit on the number of commercial operators and a closed spawning season should protect lake herring from over fishing during their most vulnerable period. Restrictive regulations on commercial trawl fishing for rainbow smelt during November should be adopted to avoid excessive bycatch of herring stocks. If the number of strong lake herring year classes continues to increase, and new methods are implemented that determine the sustained yield and allocation of lake herring, informed decisions can then be made to modify harvest regulations and stocking quotas.

VI. Information Needs/Community Interactions

Information on the relationship between predators and prey in the Lake Superior fish community is necessary before increased stocking can be considered. A hydroacoustic assessment should be conducted to estimate biomass of lake herring stocks. Not all lake herring biomass will be available as prey because a portion of the biomass must be preserved to perpetuate the lake herring stocks. Once the surplus biomass is known, its allocation among competing uses can be determined. The MNDNR will cooperate with the Lake Superior Technical Committee to determine stock structure and movement in the western half of Lake Superior. Models must be developed to examine the population dynamics, stock-recruitment relationship and production potential of lake herring stocks in Lake Superior. Information on the diet of lake herring, and lake herring interactions with other forage species and the juvenile stages of predator stocks is also needed. Lake herring are now the major conduit for energy transfer between the zooplankton trophic level and the top predator level. Understanding the dynamics of lake herring stocks is critical to the success of future management for Lake Superior.

Rainbow Smelt

I. History

Rainbow smelt are a non-native species which entered Lake Superior in the early 1930's and were first reported in Minnesota waters in 1946. During the 1950's rainbow smelt became well established and supported a large commercial fishery in the Duluth-Superior area. Rainbow smelt also became a major prey species for recovering lake trout stocks and introduced Pacific salmon. Rainbow smelt were very abundant during the 1960's and 1970's when they supported large commercial harvests and an active dip net sport fishery in the spring. Rainbow smelt abundance peaked in the 1970's, but began to decline sharply in 1976, a trend which has lasted until the present (Figure 4.2). Based on records from the commercial fishery, rainbow smelt harvest in the early 1990's had declined to less than 5% of its peak levels in the early 1970's. Despite the low level of abundance, rainbow smelt are still the primary forage species for salmonid predators in Minnesota's portion of Lake Superior. Since the decline of rainbow smelt, lake herring populations have rebounded in all parts of the lake. This scenario weakens the argument that the rainbow smelt/lake herring relationship is coincidental, but a definitive cause-effect relationship has not yet been demonstrated.

II. Goals and Objectives

Goal: Monitor rainbow smelt stocks to determine their effects on the Lake Superior fish community.

Objectives:

1. Use hydroacoustic sampling and trawl surveys to determine the biomass of rainbow smelt in Minnesota waters of Lake Superior annually by 2005.

2. Investigate the stock structure, year class strength, and relative abundance of rainbow smelt in the western half of Lake Superior annually.

3. Use bioenergetics modeling and diet studies once every 5 years to determine the contribution of rainbow smelt as prey for predators in the Lake Superior fish community.

III. Present Management

A. Regulations - There is no closed season and no possession limit on rainbow smelt in the sport fishery. Transportation of live rainbow smelt is prohibited to prevent their introduction into inland lakes. A commercial license is not required to sell rainbow smelt taken from Lake Superior. Details on commercial fishing regulations for rainbow smelt in Lake Superior can be found in Minn. Stat. section 97C.835 and Minn. Rule, part 6260.1800.

B. Stocking - No stocking is being conducted.

C. Assessment - Rainbow smelt are assessed through the use of MNDNR small mesh gill nets, NBS trawling and monitoring the commercial fishery. In Minnesota the commercial fishery is a major information source for rainbow smelt assessment. Diet studies of lake trout from the assessment fishery are conducted annually. Limited monitoring of the sport dip net fishery is conducted.

IV. Proposed Management

A. Regulations - No change.

B. Stocking - No change.

C. Habitat - No change.

D. Assessment - No change.

V. Justification

Rainbow smelt are a non-native species that was accidentally introduced into the Great Lakes in 1912 (Van Ooston 1937). Although they have been utilized as forage by salmonids, their overall effect on the fish community is not well understood and may be detrimental (Evans and Loftus 1987). Since rainbow smelt are restricted to near shore waters, they do not have the same potential as lake herring to utilize the entire productivity of the Lake Superior system. Lake herring were the historical forage base in Lake Superior and should be managed as the primary forage species to maximize productivity (Hansen and Pycha 1986).

Biologist and anglers both agree that smelt are an important component of the forage base in the Lake Superior fish community. Many angling groups feel that both the commercial and sport dip-net fishery for rainbow smelt should be closed because the numbers of smelt have declined. The number of people participating in the sport dip-net fishery has decreased greatly over the last 10 years and smelt abundance in streams that are closed to dip-netting appear to have experienced similar declines to those that have remained open. Information from the MNDNR indicates that the commercial fishery takes relatively few rainbow smelt when compared to the predatory impact generated by the present Lake Superior fish community. If new information suggests that the sport and commercial rainbow smelt fisheries are having a significant impact on smelt abundance and the stability of the Lake Superior fish community, regulation changes may be required that restrict smelt harvest.

VI. Information Needs/Community Interactions

There has been no direct evidence linking rainbow smelt and lake herring abundance. Selgeby et al. (1978) documented certain areas in Lake Superior where lake herring populations successfully reproduced in the presence of strong rainbow smelt populations. In other areas of the lake with high rainbow smelt populations, there was little successful lake herring reproduction. Anderson and Smith (1969) found that rainbow smelt and lake herring consumed similar types of prey. More work is required to document the relationships between rainbow smelt and lake herring. There is evidence that rainbow smelt prey heavily on larval coregonines (Evans and Loftus 1987) and there is concern that larval salmonids are also used as prey by rainbow smelt. *Mysis relicta*, a small shrimp like invertebrate, is the major forage used by both adult rainbow smelt and lake herring but competition for mysids between these species has not been documented. More information is required on the contribution of rainbow smelt to predator diets in the Lake Superior community based on geographical (nearshore vs. offshore) and seasonal factors.

Chubs

I. History

Chubs are a deep water coregonine species and are the primary forage species for siscowets, which are commonly referred to as deep water lake trout or "fats." To a lesser extent, chubs are also consumed by lean lake trout and chinook salmon. Chubs have historically been a major species in the commercial fishery, and are widely used in the smoked fish industry. Annual harvest of chubs in Minnesota waters of Lake Superior has fluctuated greatly, ranging from approximately 3,000 to 450,000 lb (Figure 4.3). Most of the chub harvest has been dictated by market conditions. Since 1980, annual chub harvest has averaged approximately 10,000 lb, which is probably insignificant when compared to their biomass in Minnesota waters.

II. Goals and Objectives

Goal: Provide a limited chub fishery while minimizing the harvest of incidental species.

Objectives:

1. Change current regulations to require commercial operators to set nets no shallower than 300 feet or 50 fathoms within one mile of shore to minimize harvest of incidental species.

2. Do not license any more chub net than is currently allowed (120,000 feet).

III. Present Management

A. Regulations - There is no closed sport season and no possession limit for chubs. Lake Superior commercial fishing regulations for chub are detailed in Minn. Stat. section 97C.835 and Minn. Rule, part 6260.1800.

B. Stocking - No stocking is required.

C. Assessment - Stocks are assessed annually by the MNDNR with a limited number of nets targeted at chubs, and by monitoring commercial operators fishing for chubs.

IV. Proposed Management

A. Regulations - Change the minimum depth allowed for chub fishing to 300 feet or 50 fathoms within one mile of the shoreline. If depth regulation is not implemented, close chub season during the month of November.

B. Stocking - No change.

C. Assessment - No change.

V. Justification

The minimum depth for chub nets should be increased to reduce the incidental catch of lake herring and juvenile lake trout. If depth regulations are not changed, no chub fishing should be allowed during November since lake herring can be a significant bycatch of the fishery. As lake trout numbers have increased, their range has expanded and they are now routinely taken in chub nets. By changing the minimum net depth to 300 feet, more lake trout should be saved with little or no loss in the efficiency of the chub fishery.

VI. Information Needs/Community Interactions

The interactions and life histories of coregonines are poorly understood. Many biologists believe that introgression has taken place, and habitats, behavior and reproduction now overlap between species. Basic life history information and population dynamics of the chubs and other coregonines in Lake Superior must be collected to better understand the role of these species.

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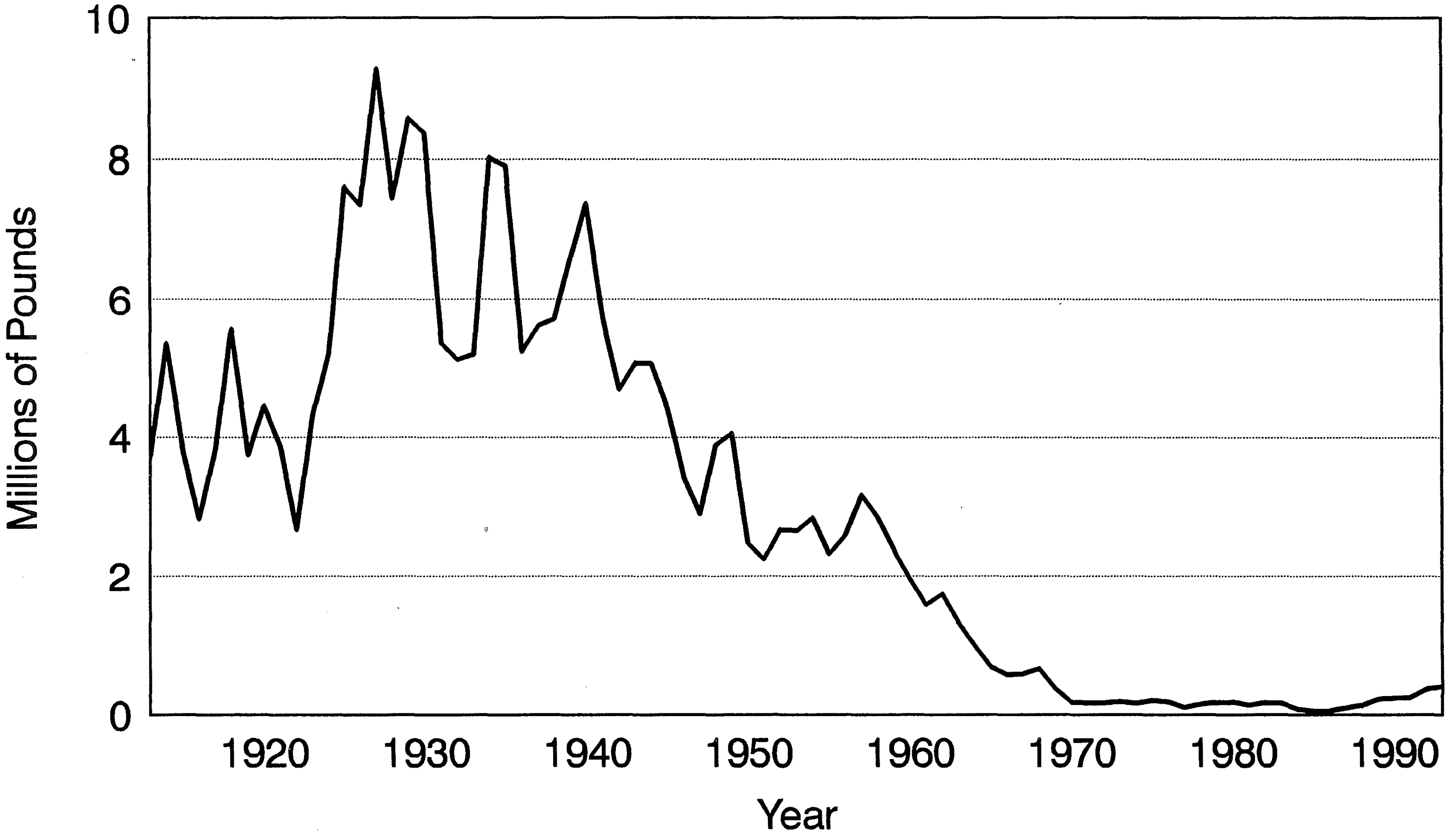

Figure 4.1. Commercial harvest of lake herring from Minnesota waters of Lake Superior, 1913-1993.

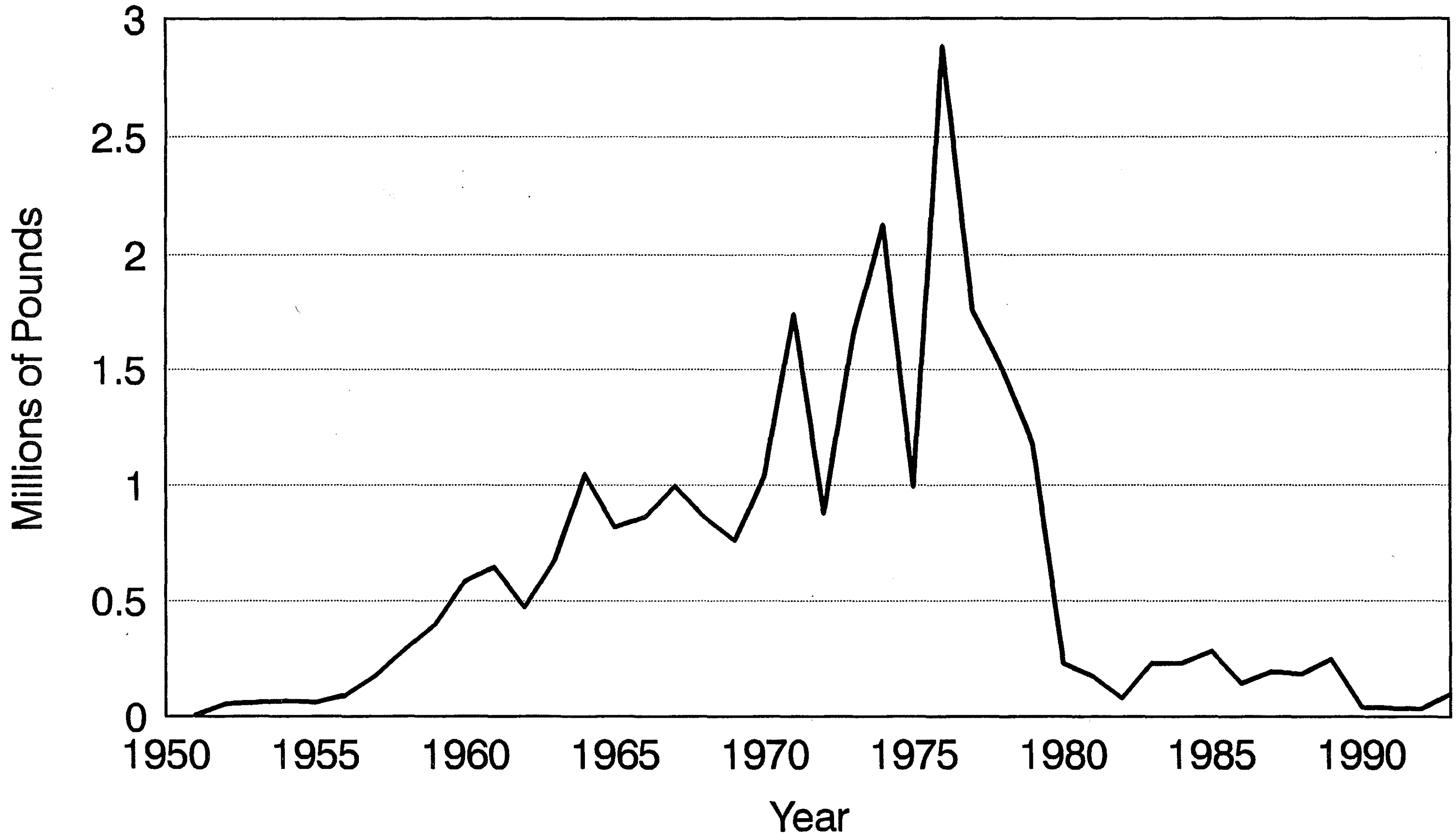

Figure 4.2. Commercial harvest of rainbow smelt from Minnesota waters of Lake Superior, 1951-1993.

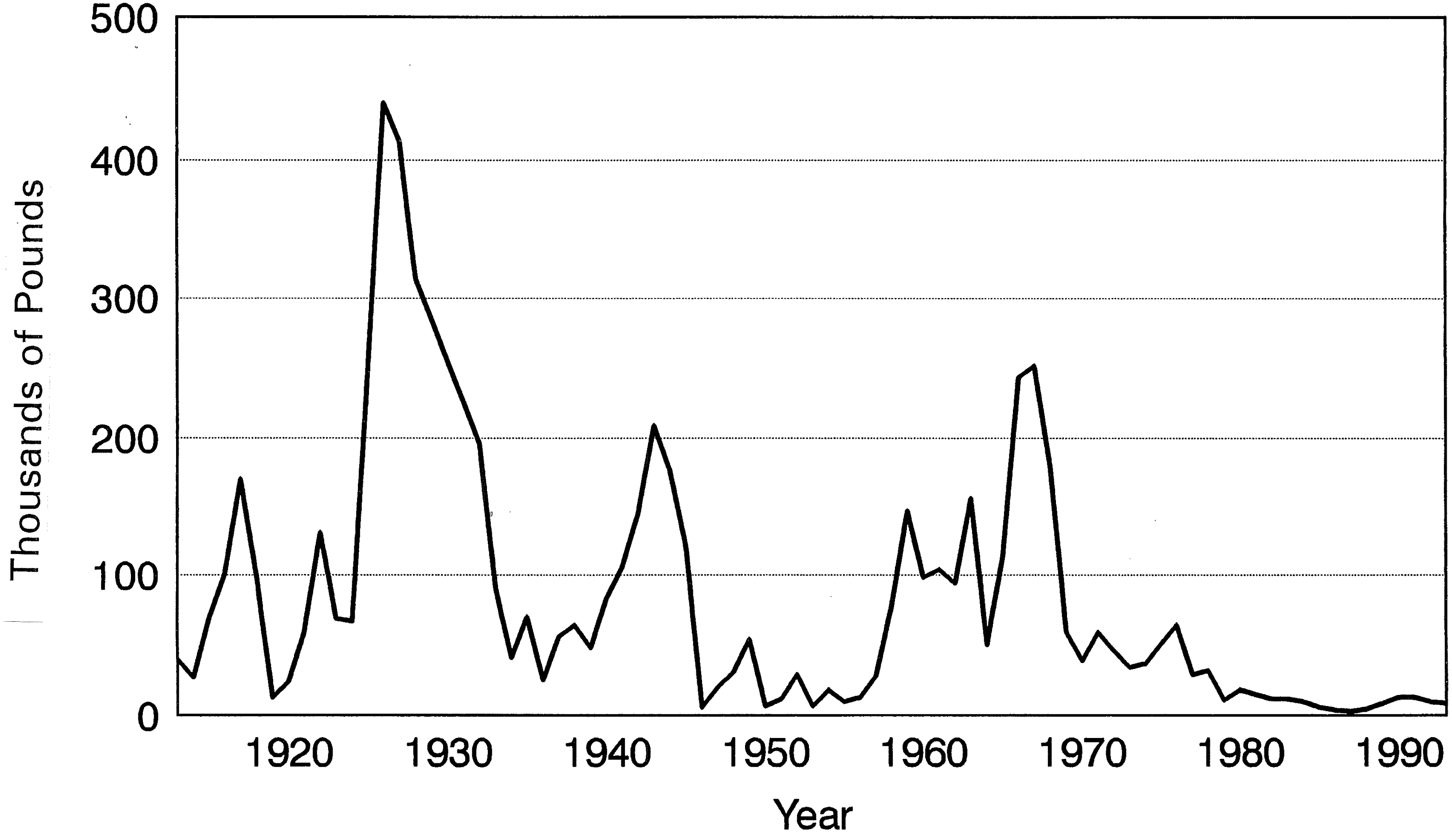

Figure 4.3. Commercial harvest of chub from Minnesota waters of Lake Superior, 1913-1993.

Chapter 5: LAKE TROUT

I. History

Lake trout have historically been the top predator in the Lake Superior fish community. Lake trout were adapted to the cold, clear, infertile waters of Lake Superior and were represented by many strains or stocks. Following the invasion of the sea lamprey, many of these stocks were reduced or eliminated. However, through natural reproduction by remnant stocks and management efforts by agencies, many areas of Lake Superior are again inhabited by predominately wild lake trout (Hansen 1994). Lake trout rehabilitation efforts by agencies include: controlling sea lamprey abundance; stocking yearling lake trout; restricting commercial harvest; identification, protection and monitoring of spawning reefs; and the imposition of possession limits and seasons on the sport fishery.

Rehabilitation of lake trout in Minnesota has lagged behind that of other jurisdictions, but continues to progress. The reasons rehabilitation has lagged may include: lack of remnant, self-reproducing lake trout stocks; extremely high lamprey wounding rates; high fishing pressure per surface acre (commercial pre-1962 and sport post-1962); lower initial stocking rates; and less spawning habitat.

Despite the slower recovery of self-sustaining lake trout stocks in Minnesota, abundance has greatly increased over the last 20 years. Angler catch and catch-per-effort (CPE), the number of fish caught per angler-hour in the sport fishery, have increased greatly since the 1970's (Figs. 5.1 and 5.2). From 1989 through 1993 the lake trout population has supported a major sport fishery with an average annual catch of approximately 15,000 fish (Halpern 1994). Lake trout have consistently been the primary species caught by anglers. Voluntary release of large lake trout is becoming more common in the lake trout sport fishery. Natural reproduction has increased over the last 15 years and the proportion of wild lake trout captured in the May assessment fishery is now approaching 25% in Minnesota (Schreiner et al. 1993). CPE of stocked lake trout captured in the May assessment netting from each management zone (Figure 5.3) has increased greatly since the assessment first began in 1963, but since 1990 CPE has stabilized or slightly decreased (Figure 5.4). CPE of wild lake trout started to increase in about 1985, and has, in general, continued to increase in all management zones (Figure 5.4).

Presently there are two major forms of lake trout in Minnesota waters. The lean lake trout is found near shore, usually at depths less than 300 feet. This is the more popular form pursued by anglers and sold in fish markets. The siscowet, or fat lake trout, is a deep water form usually caught at depths of 300 feet or greater. Traditionally siscowet were fished commercially, and sold as smoked or salted lake trout. Because they were not as susceptible to lamprey, their numbers remained relatively high during the decline of lean lake trout, however, they are of limited food value due to high contaminant levels. The MNDNR has never stocked, nor are there any plans to stock, the siscowet strain of lake trout. Throughout this plan the term "lake trout" refers to lean lake trout.

II. Goals and Objectives

Goal: Rehabilitate self-sustaining lake trout stocks capable of supporting a sport fishery and a limited commercial fishery.

Objectives:

1. Increase proportion of wild lake trout in the May assessment to 50% by 2005 and 90% by 2020.

2. Provide a self-sustaining lake trout stock capable of producing an annual yield of 75,000 lb by 2005 and 170,000 lb by 2020.

The two objectives above presume that: 1) the historical average harvest of lake trout was sustainable at 340,000 lb annually; 2) the historical catch was composed of 15% siscowets; 3) lamprey control is achieved as outlined below in objective 3; 4) forage biomass is at a level that can support the stated yield of lake trout production; and 5) naturalized non-native salmonids will replace approximately 30% of the historical lake trout yield.

3. Reduce the present adult sea lamprey population 50% by the year 2005 and 90% by 2020 in cooperation with the Great Lakes Fishery Commission and the U.S. Fish and Wildlife Service.

4. Determine biomass of forage by 2005 so it can be effectively managed.

5. Maintain lake trout total annual mortality rates at or below 45% to achieve the desired level of rehabilitation.

6. Reduce exploitation of wild lake trout and spawning sized lake trout in the sport fishery by voluntary release of unclipped (wild) lake trout and all lake trout greater than 25 in.

7. Locate and protect areas where lake trout successfully spawn.

III. Present Management

A. Regulations - The angling season for lake trout is December 1 through September 30th. The possession limit is 3 and there are no length limits. The commercial fishery for lake trout has been closed since 1962.

B. Stocking - Isle Royale strain yearling lake trout are presently stocked in Minnesota waters. No siscowet strain lake trout have been stocked by the MNDNR. Stocking quotas since 1986 were based on the Lake Superior Lake Trout Rehabilitation Plan (Hansen et al. 1986) and in the near future will be based on the revised *Lake Trout Restoration Plan for Lake Superior* (Hansen 1995). Quotas have historically been based on the area of the management zone less than 240 feet, historical lake trout production from the management zone and the stock-recruitment relationship developed for the zone (Hansen et al. 1986).

C. Assessment - Annual netting assessments are conducted in May and September using large mesh gill nets (4-1/2 in stretch) targeting adult lake trout (ages 6-20) and during the summer with small mesh gill nets (1-3/4 in - 2-1/2 in) targeting juvenile lake trout (ages 2-5). Permit netters assist with the large mesh assessments in management zones MN-2 and MN-3 (Figure 5.3). Fall spawning assessments are conducted in alternate years in at least one historical spawning location in each management zone. Egg traps have been used to assess lake trout egg deposition on suspected spawning grounds (Schreiner et al in press). Information on the sport fishery for lake trout is collected from the Lake Superior summer creel survey. This creel survey is targeted mainly at the trolling fishery and is conducted from Memorial Day weekend to September 30 annually. Charter captain reports are required monthly and these are summarized in an annual report. Commercial lake herring and chub netters are initially issued up to 20 possession tags for lake trout taken incidentally in their netting operation. These lake trout must be tagged and all information required by MNDNR must be reported. Together, commercial operators have not used more than 300 tags annually.

IV. Proposed Management

A. Regulations - No change in possession limit or season. Encourage public participation in voluntary release of unclipped lake trout (wild) and lake trout over 25 in (spawners) by including a short explanation of why this is important to sustain the fishery in the annual fishing synopsis. Continue the commercial closure on lake trout fishing except for assessment purposes under MNDNR permit.

B. Stocking - Starting in the spring of 1997 reduce the number of lake trout stocked from the high quota (5 year pulse) of 534,000 to the normal quota of 356,400 as described in the Lake Trout Rehabilitation Plan (Hansen et al. 1986). Based on the revised *Lake Trout Restoration Plan for Lake Superior* (Hansen 1995) it is likely that stocking quotas for the Minnesota waters of Lake Superior will change based on the anticipated switch to defining the stocking quota in "pounds of lake trout stocked" rather than "number of lake trout stocked" as was historically used. Request average size of hatchery reared yearlings for stocking at approximately 12/lb, rather than 20/lb. Adopt the recommendations of the Lake Superior technical committee for a revised stocking quota when a survival formula has been developed to convert from numbers of lake trout stocked to pounds of lake trout stocked. Attempt to reestablish lake trout spawning on quality habitat by experimental stocking of an early life stage (fry or eyed eggs) on a historical spawning reef. Stock healthy fish as defined by MNDNR disease policy. Discontinue lake trout stocking in a management zone when criteria proposed in the *Lake Trout Restoration Plan for Lake Superior* (Hansen 1995) are met. The criteria state that if for three consecutive years the proportion of wild lake trout in the spring assessment is greater than 50% and the CPE for wild lake trout has increased, lake trout stocking in that management zone should be discontinued. The criteria also indicate that if the survival index of stocked lake trout is less than 1, stocking should be discontinued or reexamined. The survival index is computed as: S = (cpe of age 7 stocked lake trout) /(100,000 lake trout stocked 7 years earlier). Lake trout stocking should be reduced if assessments indicate that forage biomass will not support the number of predators being stocked.

C. Assessment - Maintain present netting assessments and annual Lake Superior summer creel survey. Update and use total allowable catch model (TAC; Ebener et al. 1989) to determine harvest quotas for each statistical zone and adjust regulations if target harvest levels are exceeded on a continual basis. Monitor total annual mortality rate and take appropriate action to maintain the rate below 45% as stated in the *Fish Community Objectives for Lake Superior* (Busiahn 1990) and the revised *Lake Trout Restoration Plan for Lake Superior* (Hansen 1995). Continue to collect diet information during both May and September assessments, and from fish collected in the summer creel survey.

V. Justification

Lake trout should be given a high management priority in the fish community because they are a native species, are moving toward self-sustainability, provide a stable sport fishery and historically have been able to use the productivity of Lake Superior effectively. Both sea lamprey and fishing exploitation must be controlled if lake trout rehabilitation is to continue. The target mortality of 45% should permit rehabilitation and, at the same time, provide an active sport fishery. If the target mortality decreases below 45%, restoration should proceed at a faster rate. There is evidence that wild lake trout are more effective at natural reproduction than hatchery reared lake trout (Krueger et al. 1986). If anglers voluntarily release wild (unclipped) fish, their abundance will increase and rehabilitation should proceed at a faster rate due to enhanced natural reproduction. Commercial lake trout fishing should remain closed until self-sustaining stocks have recovered to the extent where there is surplus that can be harvested by a limited commercial fishery. Because the majority of lake trout in Minnesota are still of hatchery origin, the level of lake trout rehabilitation that would permit limited commercial fishing has not yet been achieved.

Stocking has increased the number of lake trout in Minnesota waters and still contributes greatly to the fishery. Recent information provides evidence that natural reproduction by stocked fish has occurred in Minnesota waters and that a portion of the wild fish present are produced in this manner (Hansen et al., in press). Hansen et al. (1994) provides evidence that survival of recently stocked lake trout in most of Lake Superior is declining. Survival of stocked lake trout in Minnesota waters has stabilized, but based on the most recent information may also have started to decline.

The rehabilitation process has shown some success and wild lake trout have become established in most of Minnesota waters. This suggests that stocking levels should be reduced. In many cases stocked fish have displaced wild fish by competing for limited resources (Evans and Willox 1991). The decrease in survival of stocked fish lakewide indicates that populations may be reaching the carrying capacity of the lake. The production of larger yearlings over the years has also increased the biomass (pounds) of stocked fish and exceeding this level may have negative impacts on the forage base. Reduced lake trout stocking should give wild lake trout a better chance for success and may allow rehabilitation to proceed at a faster rate. When stocked lake trout no longer contribute significantly to the population, stocking strategies should be changed or stocking should be eliminated. In addition, if hydroacoustic surveys of the forage stocks indicate that the biomass of forage available will not support the number of predators in the system, reduced stocking of lake trout should be considered.

New methods of lamprey control are now being used in Lake Superior. The sterile male program is anticipated to dramatically reduce the number of spawning lamprey in Lake Superior over the next 15 years (Klar and Weise 1994). Although streams in Minnesota produce very few lamprey, wounding rates in Minnesota waters remain among the highest in Lake Superior. A 90% reduction in lamprey mortality by 2020 could approximately double the biomass of lake trout available for harvest and increase the rate of rehabilitation. Funding for alternative lamprey control methods must remain available if reductions in lamprey are to occur.

Given a particular level of mortality, a TAC model can be used to estimate the number of lake trout available for harvest. Lamprey, fishing and natural mortality are all components of total mortality. By subtracting lamprey and natural mortality from total mortality, the target fishing mortality can be determined and the number of fish that should be harvested can be predicted. This model is presently used to determine harvest quotas for tribal, sport and state commercial fisheries in Wisconsin and Michigan.

Annual creel surveys are used to estimate fishing pressure and harvest by sport anglers. Since 1963, assessment netting has established a long-term data series on lake trout in the Minnesota waters of Lake Superior. Diet studies of lake trout sampled during assessment netting in May and September, and periodic diet sampling from the creel surveys give a seasonal perspective on forage use by lake trout. Assessment netting and creel surveys are the basis of the lake trout assessment program and should be conducted annually.

One potential limiting factor for any species is the quality and quantity of spawning habitat available. Identifying the location and quality of lake trout spawning habitat is essential for the protection of these important areas. As shoreline development increases, this becomes a more critical issue.

VI. Information Needs/Community Interactions

There is a need to determine the present forage biomass and the number of predators that can be supported in the Lake Superior community. Once these are known, forage can be allocated among the appropriate species (lake trout, salmon, burbot, etc.) or uses (predator forage or commercial fishery). More information on the diet of lake trout during all life stages needs to be collected. Diet overlap among species at different life stages must be known to understand community relationships.

Development of alternative sea lamprey control methods must be continued in order to achieve the greatest productivity of lake trout or any other species in Lake Superior. Although large lake trout are the favored target of sea lamprey in the Great Lakes, other species are attacked by sea lamprey when lake trout abundance is low. Examples are chinook salmon in northern Lake Huron and whitefish and steelhead in Lake Superior.

The relationship between wild and stocked lake trout needs to be examined. Rehabilitation efforts have shown some success, but stocking of hatchery fish must be reduced at some point to allow the wild fish the best chance of success. When stocking is reduced or discontinued, assessments must be conducted to monitor the results and add to our understanding of the rehabilitation process.

Most information on historical lake trout spawning areas in Minnesota has come from interviews with commercial operators. Little documentation presently exists on the exact location of lake trout spawning or the extent to which historical spawning reefs are now utilized. A thorough knowledge of the quantity and quality of lake trout spawning habitat in Minnesota waters would greatly assist lake trout management. There is a need to: 1) map pertinent spatial and physical characteristics of known spawning areas along Minnesota shoreline; 2) predict additional areas that might be important to lake trout spawning using surface geology, shoreline characteristics, and other data; 3) assess the relative quality of habitat; and 4) determine the production from the spawning habitat used in Minnesota waters through biological surveys of representative areas.

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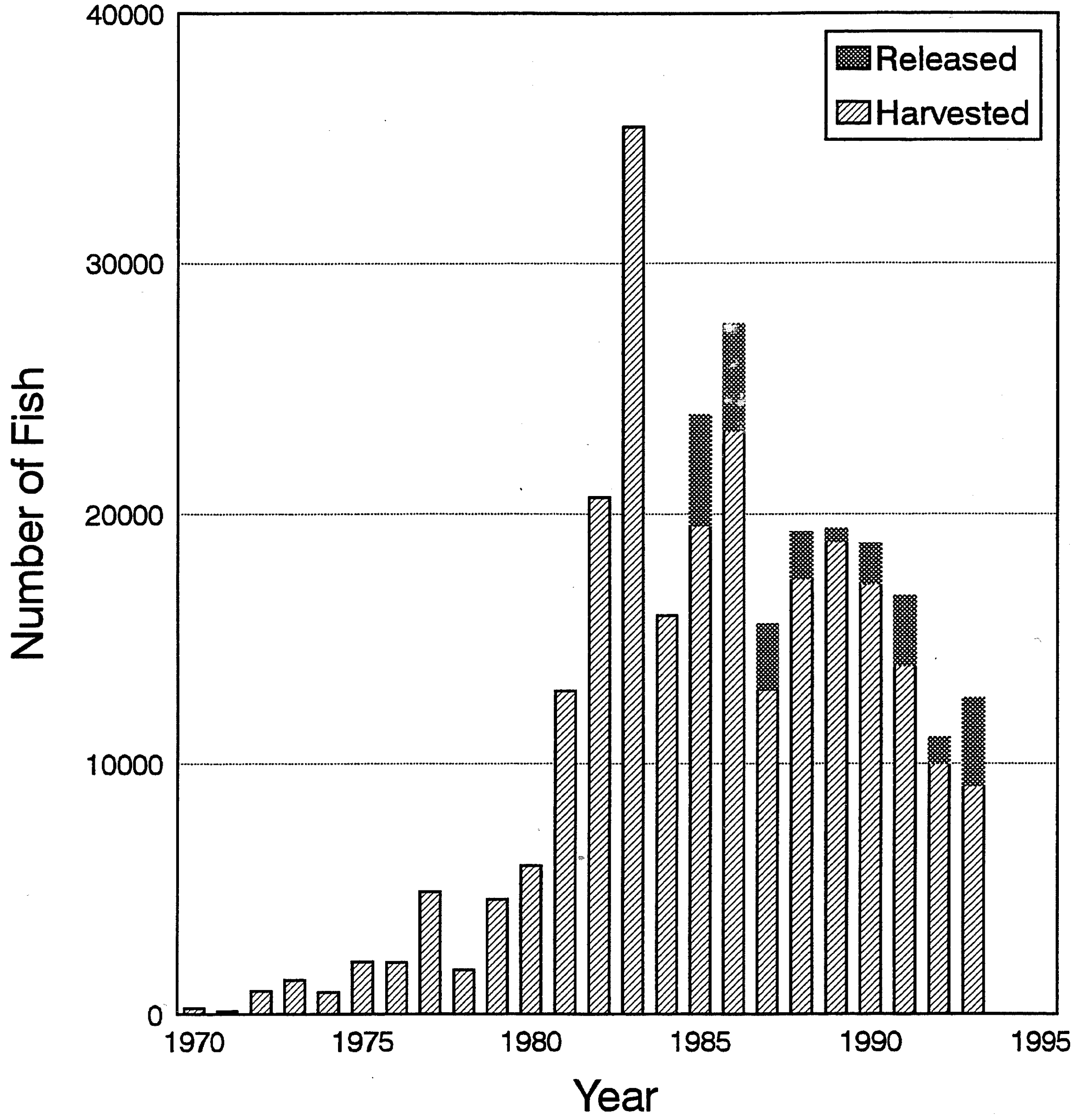

Figure 5.1. Number of lake trout harvested and released estimated from summer creel surveys on Lake Superior, 1970 - 1993. (Prior to 1985, information was not collected on released fish.)

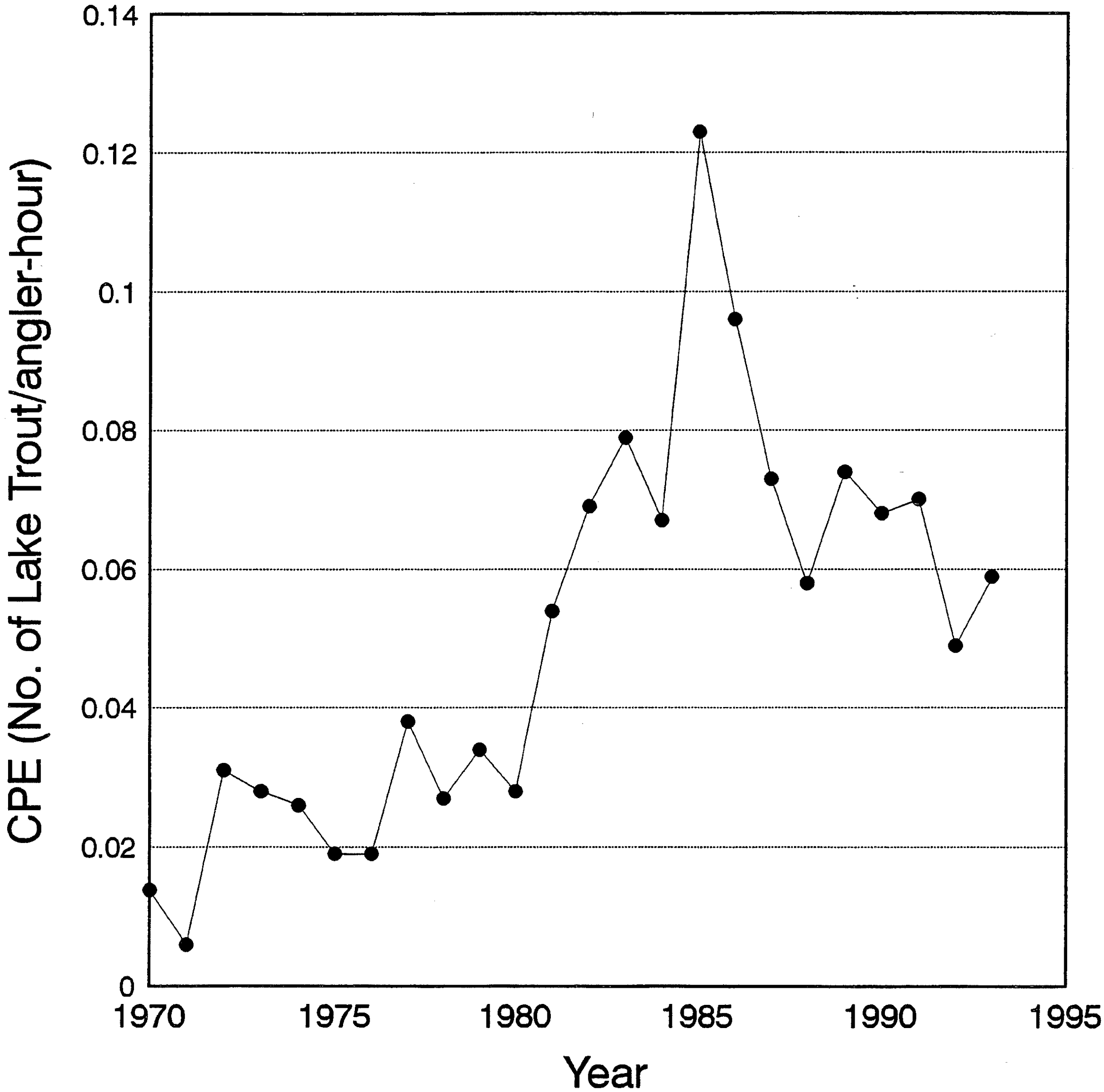

Figure 5.2. Catch per effort (CPE) of lake trout estimated from summer creel surveys on Lake Superior, 1970 - 1993. (CPE is for harvested fish only prior to 1985, and includes harvested and released fish from 1985-1993.)

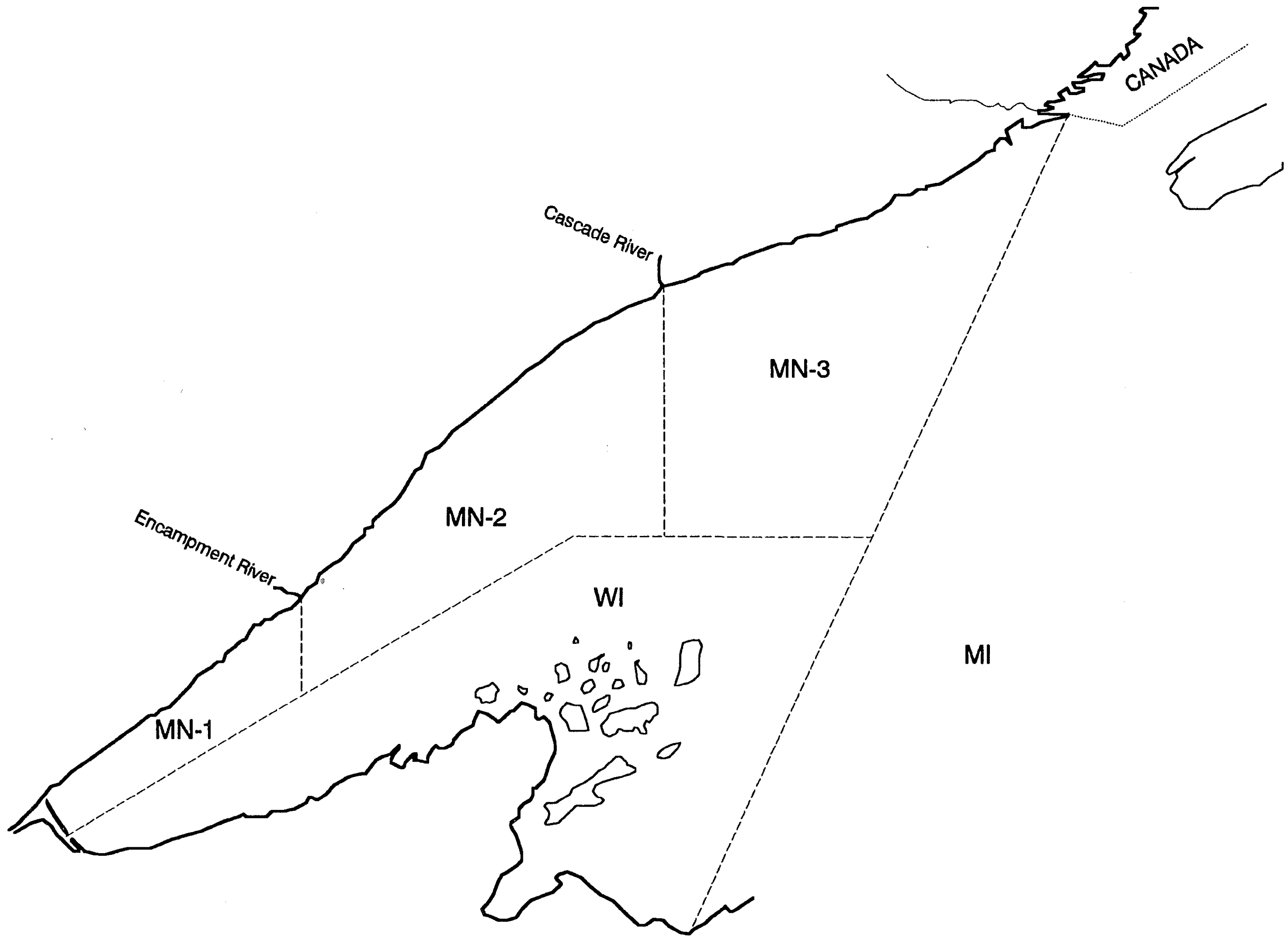

Figure 5.3. Management zones in the Minnesota waters of Lake Superior.

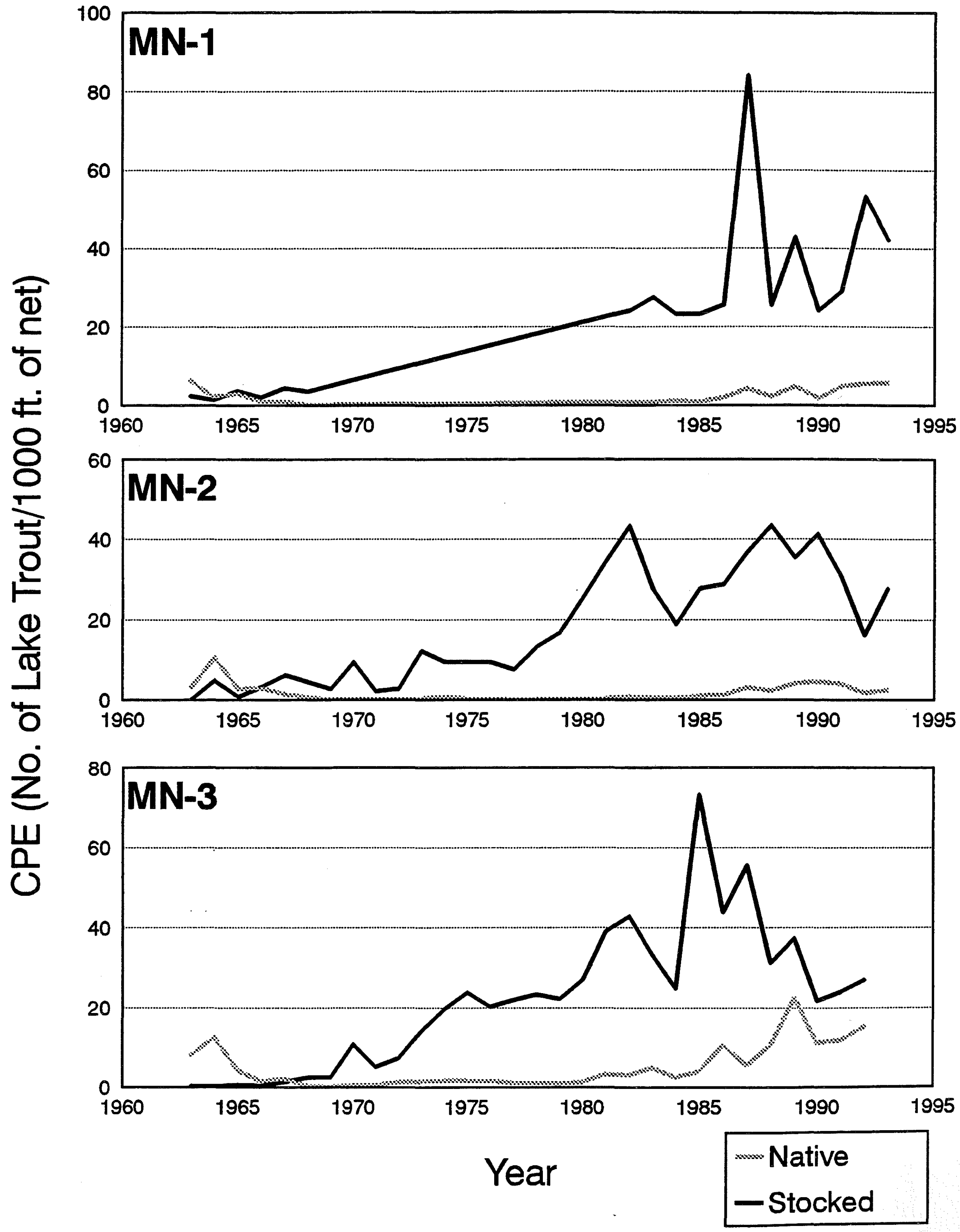

Figure 5.4. Catch per effort of lake trout in May assessment netting by management zone, 1963-1993.

Chapter 6: CHINOOK SALMON

I. History

Chinook salmon were first introduced into Lake Superior by the Michigan Department of Natural Resources in 1967 (Peck et al. 1994). Minnesota introduced spring-run chinook salmon in 1974 and converted to the fall-run chinook salmon in 1979. This change was made because fall-run fish demonstrated better growth rates and because disease-free spring-run eggs were not available. A detailed investigation of the spring run chinook salmon and a preliminary review of the fall run chinook salmon introduction were undertaken by Close et al. (1984). When the chinook salmon program was started, it was expected to create a put-grow-take fishery with no natural reproduction.

The percent return [(No. of fish returned/No. of fish stocked)*100] of adults to the French River trap has varied between approximately 0.2% and 2.0% (Figure 6.1). Over the last 4 years, the percent return to the trap has declined, and has averaged only 0.5%. Since 1980, the percent return of chinook salmon to the angler in the summer creel has ranged from approximately 0.1% to 1.0% (Figure 6.2). The percent return of chinook salmon to the fall creel has ranged from approximately 0.1% to 0.8% (Figure 6.3). Combined return rates from the summer and fall creel surveys range from 0.3% to 1.1%. The number of adult chinook salmon returning to the French River trap has decreased since 1990 (Figure 6.4). Angler harvest in the summer fishery has fluctuated, but since 1980 has averaged 1,632 fish (Figure 6.5). During the five years when fall creel surveys were conducted, the average annual angler harvest was 1,578 fish (Figure 6.6).

In 1987, a lake-wide stocking evaluation began to determine the contribution of stocked (fin-clipped) and naturally reproduced (unclipped) fish in the anglers catch and to document the movement of stocked fish throughout the lake. Preliminary results of the study showed substantial natural reproduction throughout the lake. In Minnesota waters preliminary results of the lake-wide stocking evaluation have shown that, in the summer fishery, approximately 50% of the chinook salmon were naturally reproduced, approximately 40% were stocked by Minnesota and 10% were stocked by the other agencies. In the fall stream fishery only 25% of the chinook salmon were naturally reproduced, 70% came from Minnesota stocking and 5% were stocked by other agencies. Returns to the French River trap were 95% Minnesota stocked fish and 5% naturally reproduced fish with only an occasional fish stocked by another agency. Final results of this study should be available in the spring of 1996.

The discovery of bacterial kidney disease (BKD) in chinook salmon from Lake Michigan alerted the French River hatchery staff to investigate BKD in the French River run. Since 1990, paired spawning and a detection method for BKD, called ELISA, have been used on chinook salmon taken for spawn from the French River. Only eggs that are BKD-free have been used for production of brood runs at the French River.

II. Goals and Objectives

Goal: Provide a sport fishery that allows anglers the opportunity to harvest a trophy size fish.

Objectives:

1. Manage chinook salmon by stocking up to 500,000 fingerlings so they do not severely affect the stability of the Lake Superior fish community.

2. Provide an average annual catch of approximately 1,600 chinook salmon to the trolling fishery and 1,000 chinook salmon to the fall stream fishery, realizing that there will be large annual fluctuations.

3. Use chinook salmon returning to the French River trap to supplement food shelf programs.

III. Present Management

A. Regulations - There is no closed season for chinook salmon. The bag limit is 10, or up to 10 when combined with coho, pink and Atlantic salmon. There is a minimum size limit of 10 in.

B. Stocking - Five streams are annually stocked with a total of 500,000 pre-smolt chinook salmon fingerlings: Chester Creek receives 50,000; Lester River, 150,000; French River, 100,000; Baptism River, 100,000; and Cascade River, 100,000. The MNDNR takes eggs from chinook salmon returning to the French River trap and rears them to fingerling size (100/lb) at the French River Cold Water Hatchery. Until the results of the stocking evaluation are analyzed, a cap of 500,000 chinook salmon fingerlings has been imposed on each U.S. agency. All eggs taken for the chinook salmon program are tested for BKD and only BKD free eggs are used to produce the feral broodstock.

C. Assessment - Chinook salmon are assessed by three methods in Minnesota: creel surveys, charter captain reports and returns to the French River trap. The summer creel survey monitors chinook salmon harvested in the boat fishery and the fall creel survey monitors chinook salmon caught in the streams during the spawning run. Very few chinook salmon are taken incidentally in assessment nets. Stream surveys that target juvenile steelhead have sampled a small number of naturally reproduced chinook salmon.

IV. Proposed Management

A. Regulations - Reduce the possession limit of chinook and coho salmon in any combination from 10 to 5. No season or size limit change.

B. Stocking - No change in present stocking quotas or locations. On a limited basis, experiment with different sizes of fingerlings stocked from 100/lb (3.0 in) to 70/lb (3.5 in) or larger if possible in an attempt to increase survival and stabilize returns. In experimental years, the stocking quota may have to be reduced to 400,000 to accommodate the larger fish. Continue to use only chinook salmon that return to Minnesota tributaries as an egg source for the Minnesota waters of Lake Superior and take only BKD free eggs.

If chinook salmon numbers decline to the level where less than 150,000 fingerlings can be produced annually from gametes collected at the French River trap for three years in a row, the dynamics in Lake Superior indicate that the program is no longer viable in its present form and continuation of the program should be reevaluated. If natural reproduction of chinook salmon continues and harvest objectives are met by wild fish, as determined by the results of the stocking evaluation, reduction or elimination of stocking should be considered.

C. Assessment - Continue to use the French River trap for determining percent return. The Knife River trap will be operated during the fall to assess the number of chinook salmon entering a river that is not stocked. Conduct a fall anadromous creel survey every other year and a summer lake creel survey annually to monitor angler harvest. Evaluate the catch of chinook salmon at Chester Creek to determine if continued stocking is productive. Continue to monitor and summarize charter captain reports annually.

V. Justification

The proposed regulation change is largely based on angler desire for a reduced limit on coho salmon, although many anglers also support a reduced chinook salmon limit. Also it is very difficult to distinguish between young chinook and coho salmon; therefore, their possession limit has historically been a combined limit. Information from MNDNR summer and fall creel surveys indicates the number of anglers that catch over 5 chinook and coho salmon in any combination is extremely low and biologically insignificant. However, anglers report that high numbers of coho salmon and sometimes chinook salmon are harvested during the winter fishery. Many feel that a reduction in the limit would potentially spread the catch among more anglers. The Section of Fisheries will propose the regulation change through the rulemaking process to address anglers desires. A winter creel survey targeted at coho and chinook salmon may help to evaluate the results of the proposed regulation change.

A more consistent return of stocked chinook salmon would be beneficial to both anglers and fishery managers. Experimentation with increased size at stocking may show an increase in survival and make returns more predictable. To increase the size of chinook salmon stocked, the number of hatchery-reared fish must be reduced since hatchery space is limited. By reducing numbers, the cost per fish will increase. If survival of stocked fish is improved, by increasing the size at stocking, both numbers and pounds stocked should be reduced so predatory impact does not increase. Chinook salmon harvest at Chester Creek should be examined carefully, because it may provide only a very limited fall stream fishery and a very brief summer fishery. The success of chinook salmon stocking in this stream may be limited by its marginal physical characteristics and the relatively warm summer temperatures in that area of the lake.

Chinook salmon consume more forage per individual than any other Lake Superior species (Negus 1995). In Lakes Michigan and Ontario, chinook salmon are the major predators consuming alewife stocks. Some agencies on those lakes have drastically reduced the stocking quotas for chinook salmon and are concerned about their impact on the fish community (Jones et al. 1993). In Lake Superior, the abundance of rainbow smelt, presently the major forage of chinook salmon (Conner et al. 1993), has declined severely since chinook salmon were first stocked by Michigan in 1969 (see forage chapter). Lake herring abundance has increased, but has not yet reached historical levels (Selgeby and Slade 1994). Limited evidence suggests that chinook salmon have slowly started to change their feeding habits and are now consuming some lake herring along with rainbow smelt. The impact of stocking high numbers of chinook salmon on the fish community is unknown, but is a major concern. A conservative approach to chinook salmon stocking is warranted now that they have become naturalized in Lake Superior.

If survival of stocked or wild chinook salmon increases significantly in the future, or information collected shows declining forage stocks, salmon stocking must be reduced. If the number of adult chinook salmon returning to the French River trap produce fewer than 150,000 fingerlings per year in the hatchery, over a 3 year period, the conditions in the lake have changed and can no longer support the chinook salmon program in its present form. If these criteria are met, continuation of the program should be reevaluated. Gametes collected from a source other than the French River violate the logic this criteria is based on.

VI. Information Needs/Community Interactions

Information on the interaction between chinook salmon and their forage base, and between chinook salmon and other predators in Lake Superior, is necessary before stocking quotas are increased. A hydroacoustic assessment of the forage base would estimate the biomass of forage available. Once the forage biomass is known, the allocation of the forage biomass among predator species and the commercial operators can be determined. Hydroacoustics could also provide information on seasonal habitat selection by chinook salmon. Diet studies of chinook salmon should be conducted at least once every five years to evaluate changes. Seasonal and juvenile diet studies also need to be conducted. Better estimates of survival at different ages need to be determined. Movements and distribution of chinook salmon throughout the lake are poorly understood and abundance estimates need to be refined. Initial bioenergetics modeling has been completed, but the model should be refined using the new information listed above. Completion of the stocking evaluation in 1996 will provide additional information on natural reproduction, movement, and the relative survival of stocked chinook salmon. A winter creel survey should be initiated to determine the winter harvest of chinook salmon.

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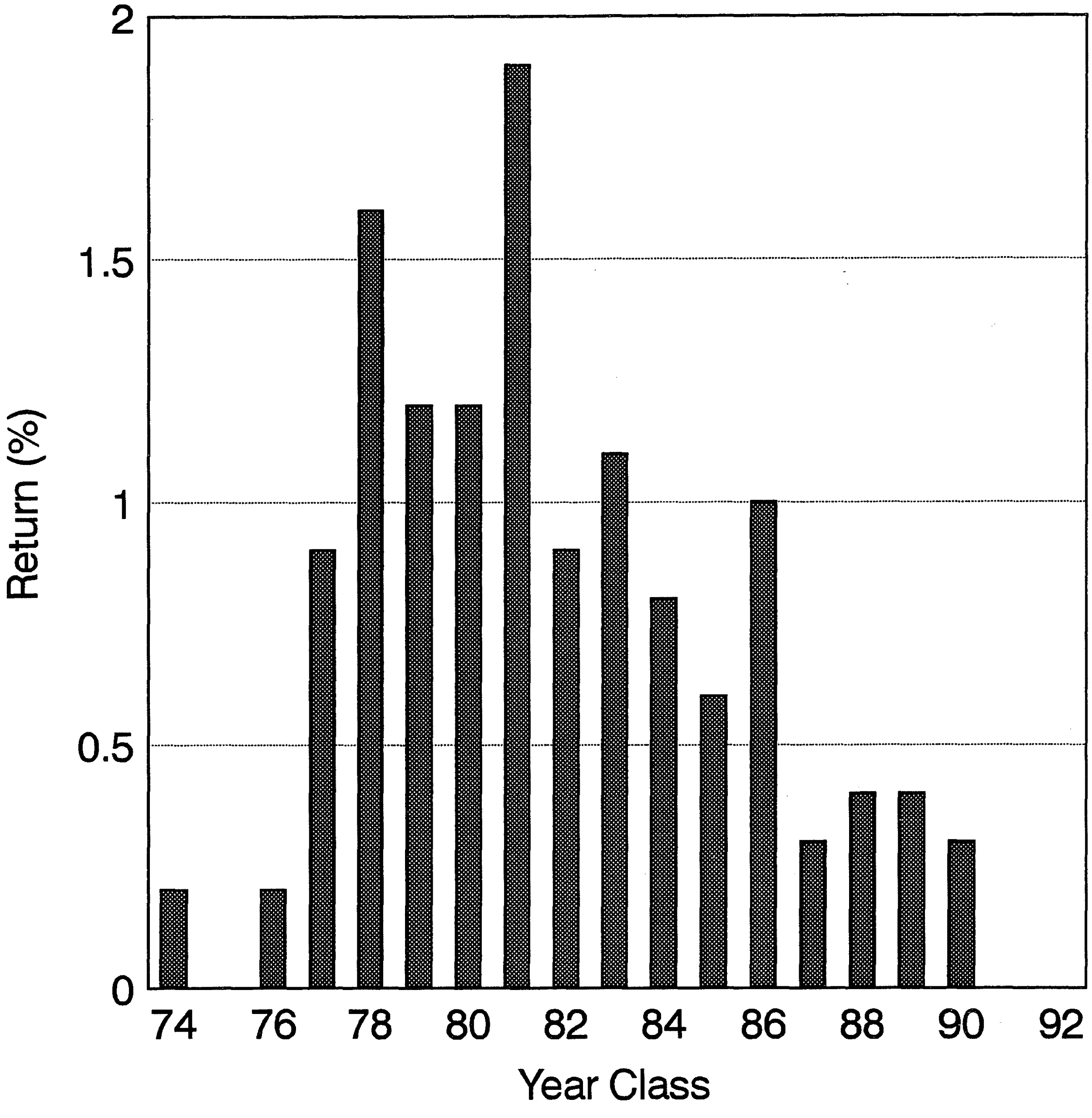

Figure 6.1. Percent return of the 1974 - 1990 year classes of stocked chinook salmon to the French River trap. Year classes after 1990 are not yet fully returned. Prior to 1985, returning chinook were all assumed to be age 4.

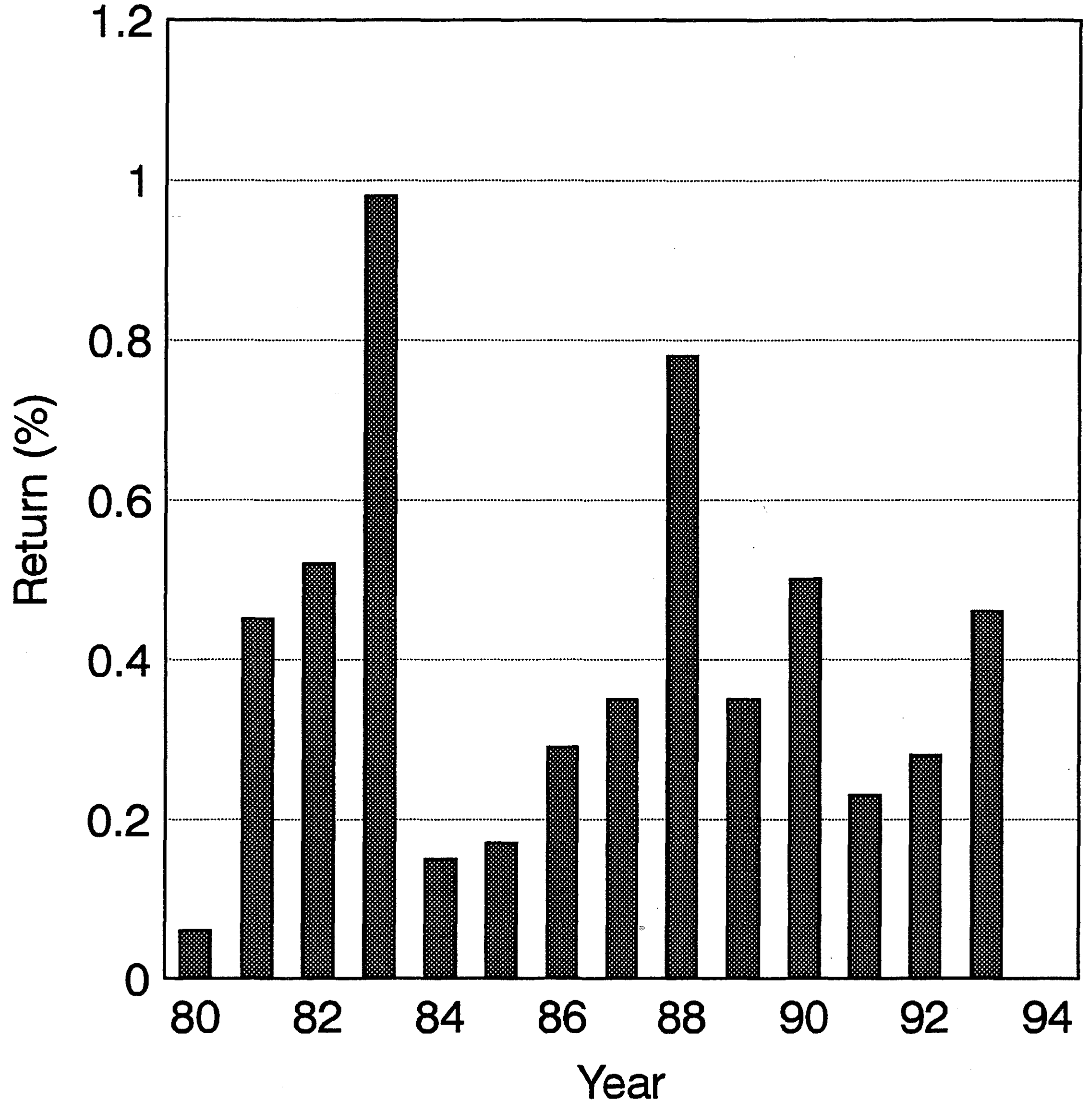

Figure 6.2. Percent return of stocked chinook salmon estimated from the Lake Superior summer creel survey, 1980 - 1993. Returns after 1983 were based on an average annual stocking of 500,000 fingerlings. Percentages for 1980 - 1982 were estimated by dividing the harvest by the average number of fingerlings stocked 2 to 4 years earlier.

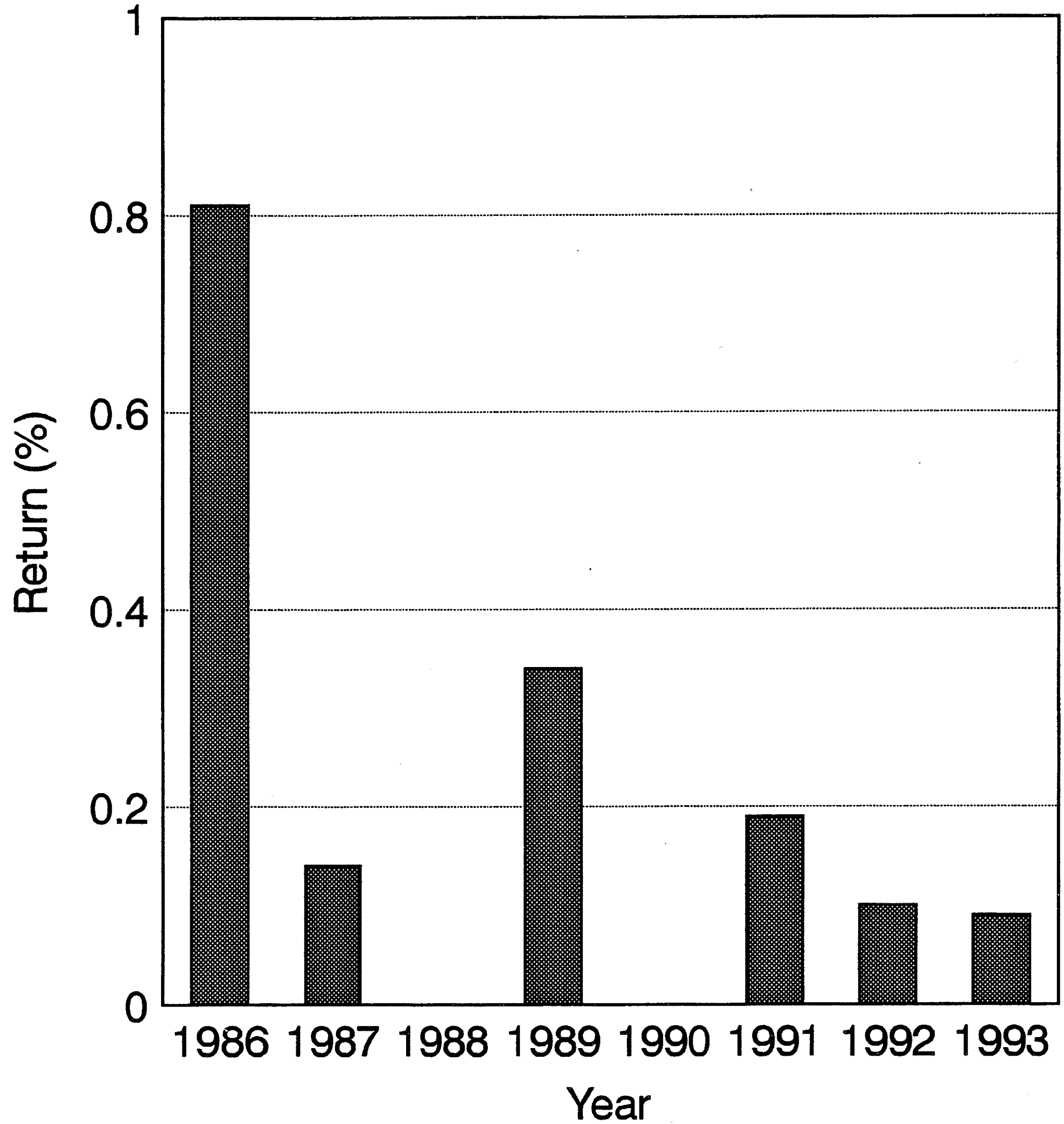

Figure 6.3. Percent return of stocked chinook salmon estimated from the fall anadromous creel survey, 1986 - 1993, based on an average annual stocking of 500,000 fingerlings. Returns in 1986 and 1987 were harvest only, while 1989 - 1992 include harvested and released salmon. Surveys were not conducted in 1988 and 1990.

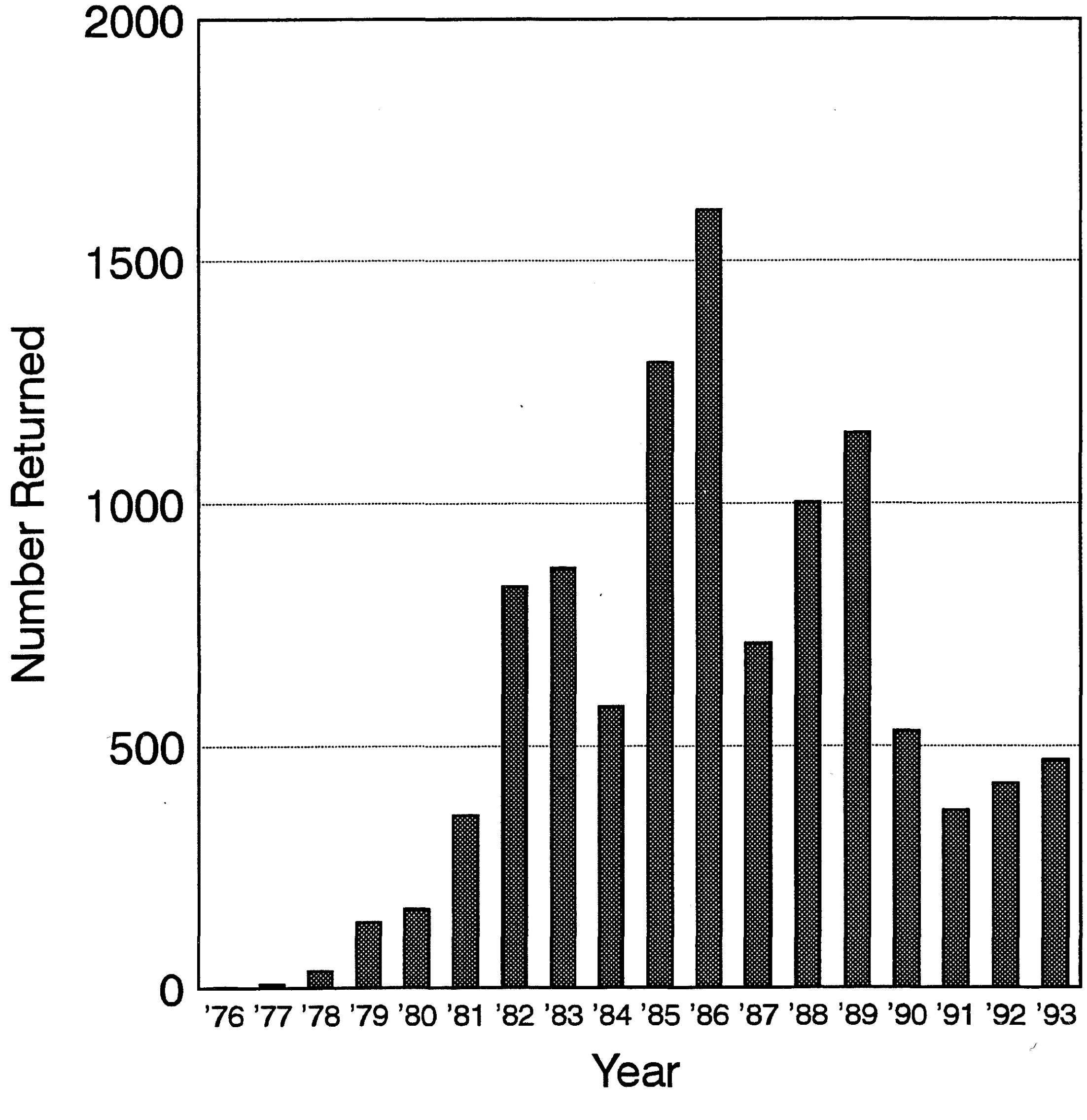

Figure 6.4. Number of spawning chinook salmon that returned to the French River trap, 1976 - 1993.

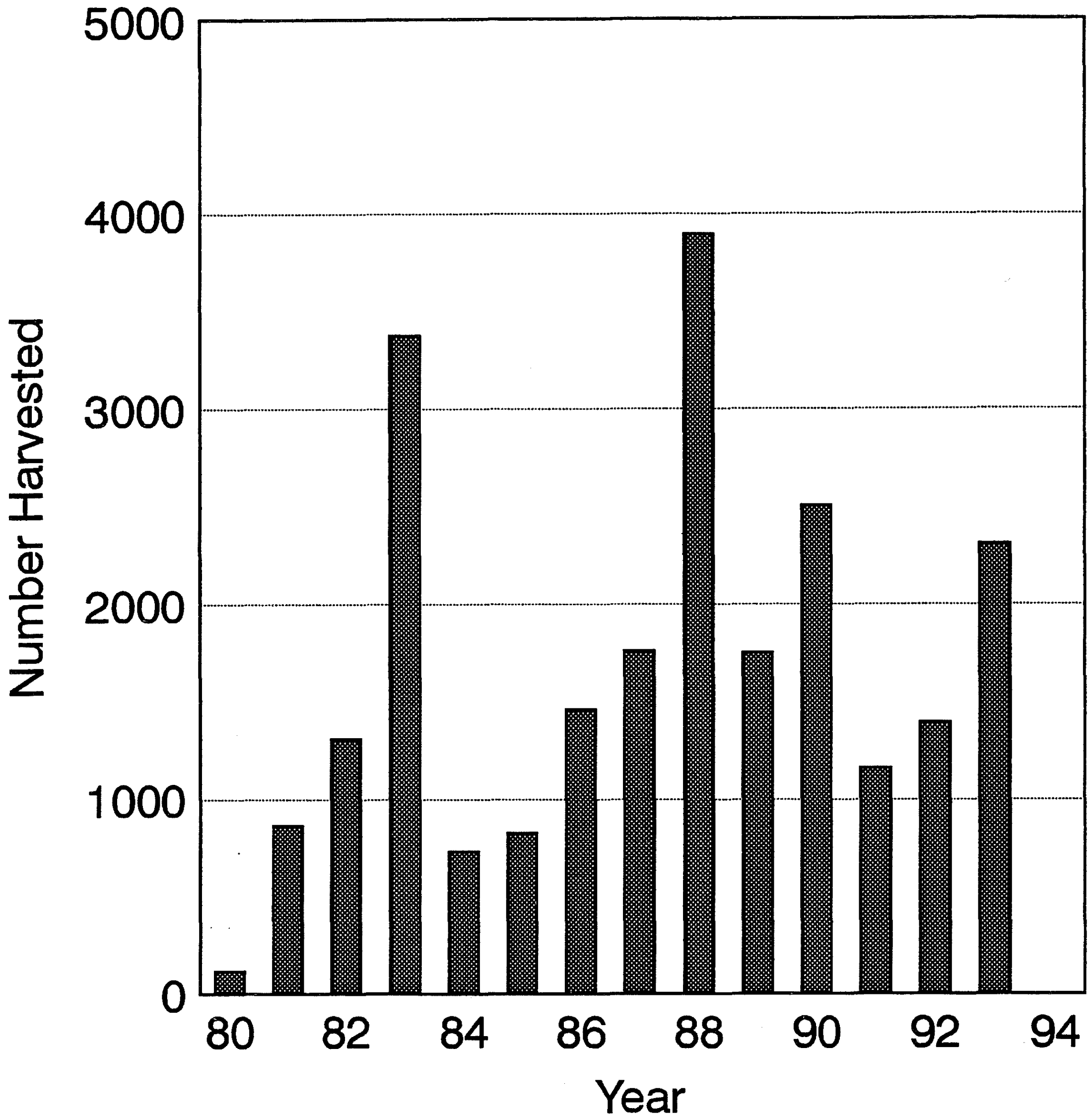

Figure 6.5. Chinook salmon harvest estimated from Lake Superior summer creel surveys, 1980 - 1993.

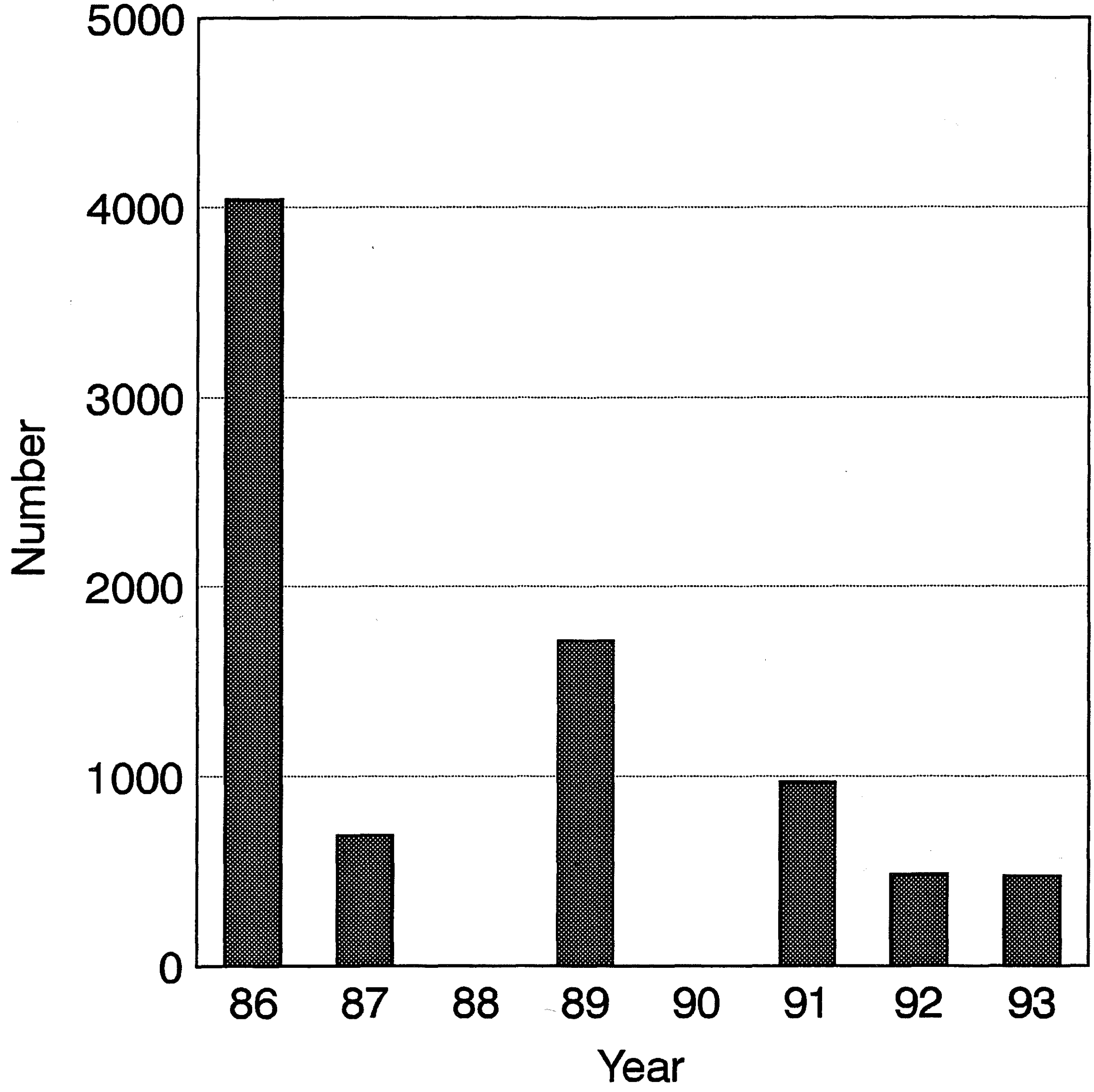

Figure 6.6. Chinook salmon catch estimated from fall anadromous creel surveys on tributaries of Lake Superior, 1986 - 1993. Only harvested fish are represented for 1986 and 1987. Harvested and released fish are included after 1989.

Chapter 7: COHO SALMON

I. History

Coho salmon were stocked in the Minnesota waters of Lake Superior from 1969 through 1972 (Hassinger 1974). Stocking was discontinued in 1972 based on slow growth rate, small size of creeled fish, low return rate, late spawning migration, high cost of the hatchery product compared to chinook salmon and low interest by anglers. Because management goals for coho salmon were not met, the program was abandoned in favor of the chinook salmon program in 1972. Currently, Michigan is the only agency on Lake Superior that stocks coho salmon, with an annual quota of 200,000. Peck (1992) found that, in Michigan waters, stocking contributes less than 10% to the overall coho salmon fishery and has made the recommendation to discontinue coho salmon stocking.

Since the early stocking efforts, coho salmon have become naturalized throughout Lake Superior and are second only to the lake trout in frequency of catch by Minnesota anglers. Spawning occurs in Minnesota tributaries, but reproductive success is low due to limited habitat. Natural reproduction in other areas of the lake and the migratory nature of coho salmon account for the fishery which has become established in Minnesota waters. Because coho salmon have only a three year life cycle and are self-sustaining, the harvest fluctuates widely. From 1979 to 1992, the harvest of coho salmon ranged from 1,024 to 11,652 fish (Figure 7.1). A strong or weak year-class can greatly effect the fishery. The average summer harvest of coho salmon in Minnesota waters from 1979 to 1992 was 4,115. The location of the coho salmon catch and the size of the fish caught changes seasonally in Minnesota waters. Smaller fish are caught in MN-1 from April to June, slightly larger fish are caught in MN-2 during June and July and the largest fish are caught in MN-3 during August and September. A growing winter fishery for coho salmon has become established in the northern portion of MN-1 and southern portion of MN-2. The fall fishery for coho salmon in Minnesota is very limited.

Since the early 1970's, anglers have looked beyond the relatively small size of coho salmon, and have accepted the fish because of it's catchability, exceptional fighting characteristics, and fine eating qualities. There is renewed interest by some anglers to reestablish a stocking program for coho salmon. Coho salmon are a low priority species for a hatchery program for the following reasons:

1) Coho salmon are expensive to rear since they spend 1.5 years in the hatchery system before being stocked. This requires more raceway space, food and personnel compared to fish that are reared to fingerling size.

2) Most coho salmon recruit to the anglers' catch at age 2 and are only available for one year before they die.

3) In Minnesota, coho salmon have returned to streams too late for a popular fall stream fishery (late October - late November).

4) In the Michigan waters of Lake Superior, when hatchery reared coho salmon were stocked into waters that already supported wild populations, their contribution to the fishery was poor (Peck 1992).

Combined, these factors create a very expensive hatchery product that is only available to anglers for a very short period of time.

II. Goals and Objectives

Goal: Provide a coho salmon fishery sustained by natural reproduction.

Objectives:

1. Sustain an average annual catch of 4,000 coho salmon from the summer fishery based on natural reproduction.

2. Evaluate the use of regulations to distribute the coho salmon catch among a larger group of anglers.

3. Cooperate and coordinate closely with Wisconsin on wild coho salmon management since very little production of coho salmon occurs in Minnesota tributaries.

III. Present Management

A. Regulations - There is no closed season for coho salmon. The bag limit is 10, or an aggregate of 10 when combined with chinook, pink and Atlantic salmon. There is a minimum size of 10 in.

B. Stocking - No stocking has been done in Minnesota since 1972.

C. Assessment - Coho salmon in Minnesota are assessed by three methods: creel surveys, charter captain reports and returns to the French River trap. In most years fewer than 25 coho salmon are captured at the French River trap. Very few are taken incidentally in lake trout assessment nets. Stream surveys targeting juvenile steelhead have sampled a small number of naturally reproduced coho salmon.

IV. Proposed Management

A. Regulations - Reduce the possession limit of coho and chinook salmon in any combination from 10 to 5. No change in season or size limit.

B. Do not initiate a stocking program.

C. Assessment - Initiate a winter creel survey and repeat once every 3 years. Continue to conduct a summer lake creel survey annually and a fall anadromous creel survey every other year to monitor angler harvest. Continue to monitor and summarize charter captain reports annually. Monitor the French River trap and Knife River trap to count adults entering those two rivers. Work closely with Wisconsin to determine what proportion of the coho salmon harvested in Minnesota are produced in Wisconsin.

V. Justification

The proposed regulation change is based on strong angler desire for a reduction in the coho salmon limit. Information from MNDNR summer and fall creel surveys indicate the number of anglers that catch over 5 coho and chinook salmon in any combination is extremely low and biologically insignificant. However, many anglers report that high numbers of coho, and sometimes chinook salmon are harvested during the winter fishery. Anglers feel that a reduction in the limit would potentially spread the catch among more anglers. The Section of Fisheries will propose the regulation change through the rulemaking process to address anglers desires. As described above, a winter creel survey targeted at coho salmon may help to evaluate the results of the proposed regulation change.

Since coho salmon have provided a high quality fishery based on natural reproduction and a hatchery program would have a low benefit:cost ratio, no stocking is recommended. There is concern among biologists that high numbers of coho salmon could affect other Lake Superior species. Coho salmon ascend tributary streams each fall in search of spawning habitat and use spring upwellings when available. They probably utilize some of the same spawning areas and food items as brook, brown and rainbow trout (Fausch and White 1986). In the lake, coho salmon have less impact than chinook salmon on large forage species and this reduces the competition with adult lake trout and chinook salmon. The coho salmon diet probably overlaps with that of rainbow trout and with juveniles of all species in the lake. The year-class strength of coho salmon fluctuates based on stream conditions during early life stages and abundance of parental stock, which could be affected by a combination of fishing mortality and predation. Since the life cycle of coho salmon is only 3 years, and the spawning population is made up of only one year class (3-year old), fluctuations in population size can be extreme and will be reflected by annual variations in angler harvest.

VI. Information Needs/Community Interactions

More information on the interactions between coho salmon and their forage base, and coho salmon and other species in Lake Superior is necessary. Diet surveys conducted every 5 years are needed to identify overlaps between coho salmon and other Lake Superior species at all life stages, in the lake and streams. The reduction in possession limit may allow more escapement of spawners during years of low adult abundance and may also distribute the available catch among more anglers. In most years, a relatively large winter fishery for coho salmon takes place in the Two Harbors area. A winter creel survey should be developed and repeated every three years to monitor this fishery. Habitat utilization and seasonal movement patterns of coho salmon should be determined using hydroacoustics, and possibly telemetry, to enhance our understanding of their role in the Lake Superior fish community.

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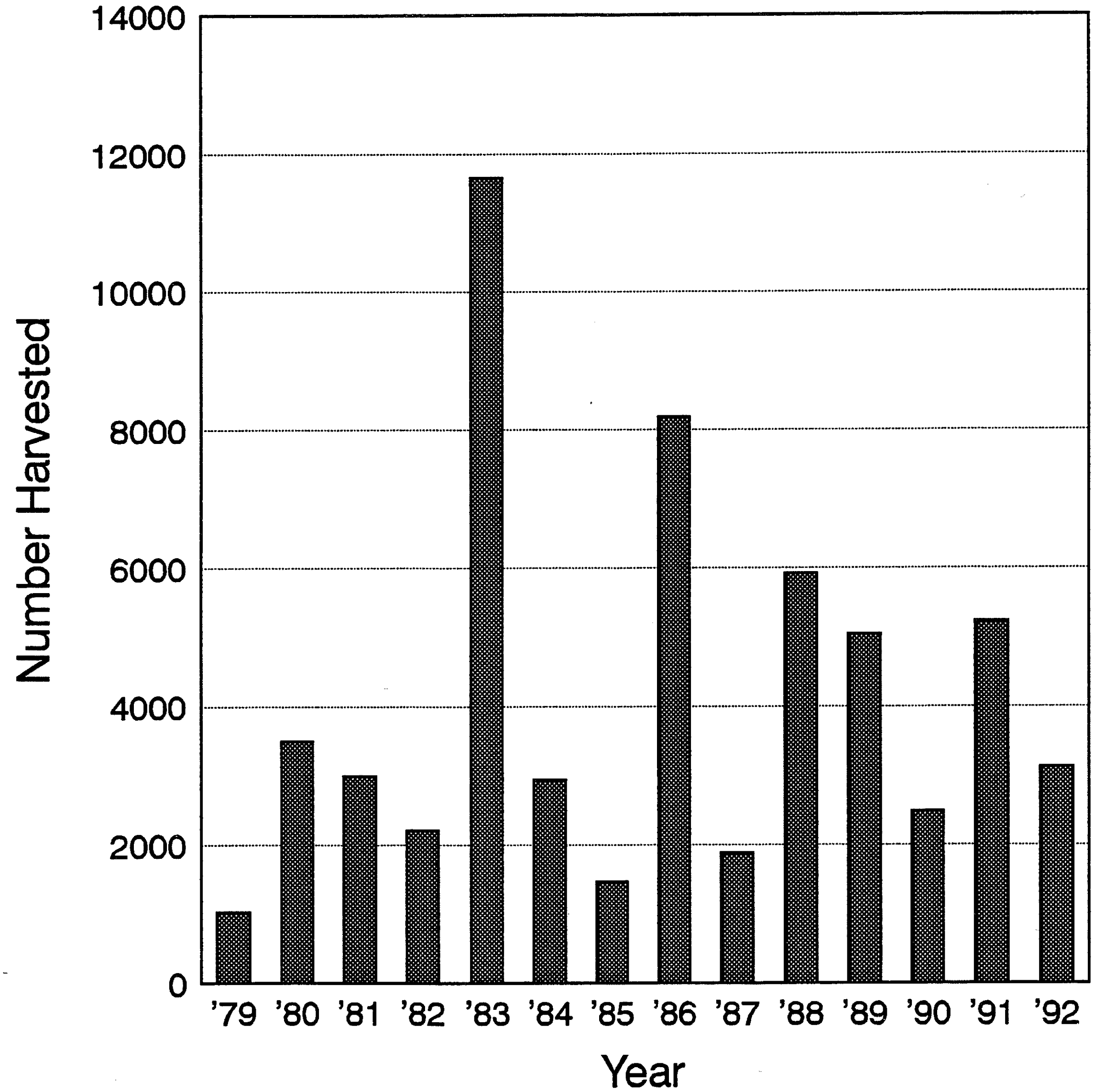

Figure 7.1. Coho salmon harvsst estimated from the Lake Superior summer creel survey, 1979 - 1992.

Chapter 8: ATLANTIC SALMON

I. History

Minnesota started an experimental program for Atlantic salmon in Lake Superior in 1980 and discontinued the program in the fall of 1993. The experimental program utilized two rivers, the French and the Split Rock, as stocking sites. A captive brood stock was established, using the Grand Lake strain of Atlantic salmon from Maine, to secure eggs for the program. Poor return to the angler and low angler interest over the first 10 years stimulated the Section of Fisheries to critically review the program. Following a series of public input meetings, the decision was made, in the winter of 1991-1992, to eliminate the Atlantic salmon broodstock, stock the fish remaining in the hatchery and continue to monitor the program.

A window of opportunity was left open to reestablish the program if returns to the angler and angler interest increased substantially over the next two years. A reestablished program would have originated with eggs collected from Atlantic salmon returning to the French River trap. The eggs would then have been used to rear smolts for stocking. In 1992 the angler catch of Atlantic salmon was relatively high compared to previous years and returns to the French River trap increased to an all time high (Figure 8.1). Although, in general, interest remained low, this prompted inquiries as to the future of the Atlantic salmon program.

The Section of Fisheries indicated that no final decision would be made on whether to reestablish the program until the 1993 angling season was monitored. The final decision was based on returns to the angler and angler interest through August of 1993. The 1993 angling season was monitored through a special Atlantic salmon creel survey (Jones 1993), charter fishing reports and routine spring and summer creel surveys. All data indicated a large decline in the catch of Atlantic salmon when compared to 1992 and that interest in the fishery continued to be low among all but a few avid anglers.

In the fall of 1993, the MNDNR, Section of Fisheries decided to discontinue the Atlantic salmon program and there are no plans to reestablish it. Anglers are expected to harvest Atlantic salmon through 1997.

II. Justification

Factors which influenced the decision to discontinue the Atlantic salmon program include:

1. Concern over the number of non-native predators in the Lake Superior fish community and the potential negative effects they may have on the forage base. There has been a severe decline in the number of rainbow smelt (Forage chapter), which were expected to be the major forage of Atlantic salmon.

2. Concern that naturalization of Atlantic salmon could occur. Atlantic salmon have not yet demonstrated high natural reproductive potential, although a few naturally reproduced smolts have been found in our stream surveys. If Atlantic salmon became naturalized, as the Pacific salmon have, there would be no practical method to control their abundance and their effect on the forage base. Reports from other agencies indicate that Atlantic salmon stocked in Minnesota have strayed. The chance that Atlantic salmon could reproduce and become naturalized in other jurisdictions is far greater than in Minnesota, because there is much more habitat suitable for natural reproduction in their streams. This has already occurred with other anadromous species in Lake Superior.

3. Concern over efficiency of Atlantic salmon program. Atlantic salmon need to be stocked at a large size before good survival can be expected. It has been our experience in Minnesota that Atlantic salmon stocked at sizes less than 5 fish/lb provide poor returns (Figure 8.2). It is our opinion that the high returns experienced in 1992 were primarily the result of stocking relatively large numbers of large yearlings. Rearing large numbers of yearlings at approximately 5 fish/lb would require a major reallocation of hatchery space and effort. Since Atlantic salmon stocking was discontinued, some of the hatchery space they occupied has been converted to enhance the quality of lake trout for Lake Superior and inland lakes, and to increase the number and quality of stream trout produced for inland stocking. Due to FY 1994 budget reductions for the Section of Fisheries, the St. Paul hatchery was closed in July, 1995.

4. Minimal angling interest in the Atlantic salmon program among all but a few avid anglers. The very late return of Atlantic salmon to the streams in the fall may be one factor in this lack of interest. In recent years the major spawning runs have been recorded in late October and November.

Although some consider the Atlantic salmon to be a premier sport fish, the reasons given above and the results of the experimental program indicated that it should not be propagated for use in Lake Superior.

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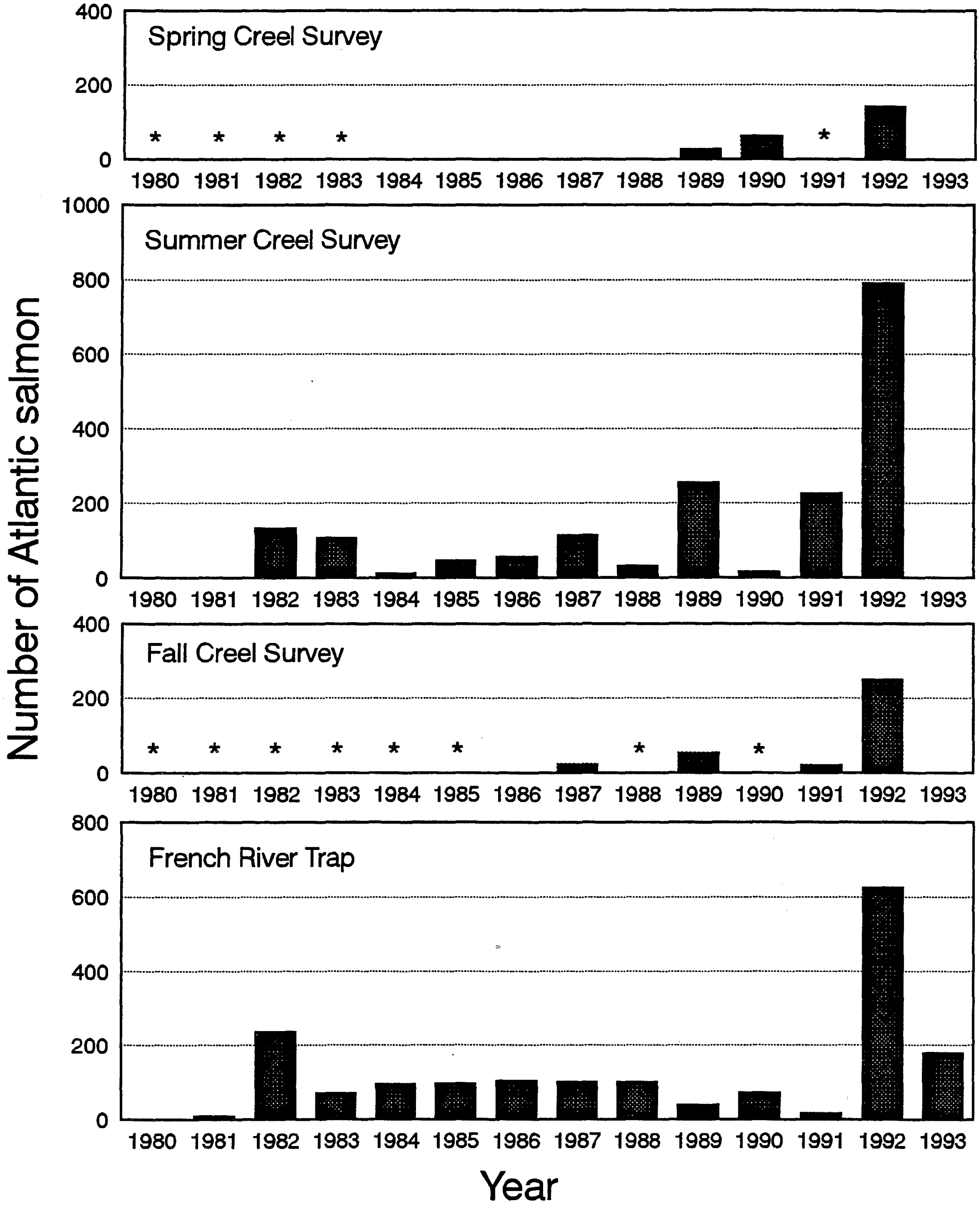

Figure 8.1. Return of Atlantic salmon to the French River trap and estimated catches of Atlantic salmon from creel surveys since 1980. Spring and fall creel surveys report estimates of total catch. Summer creel survey estimates are for harvested salmon only. * indicates years without creel surveys.

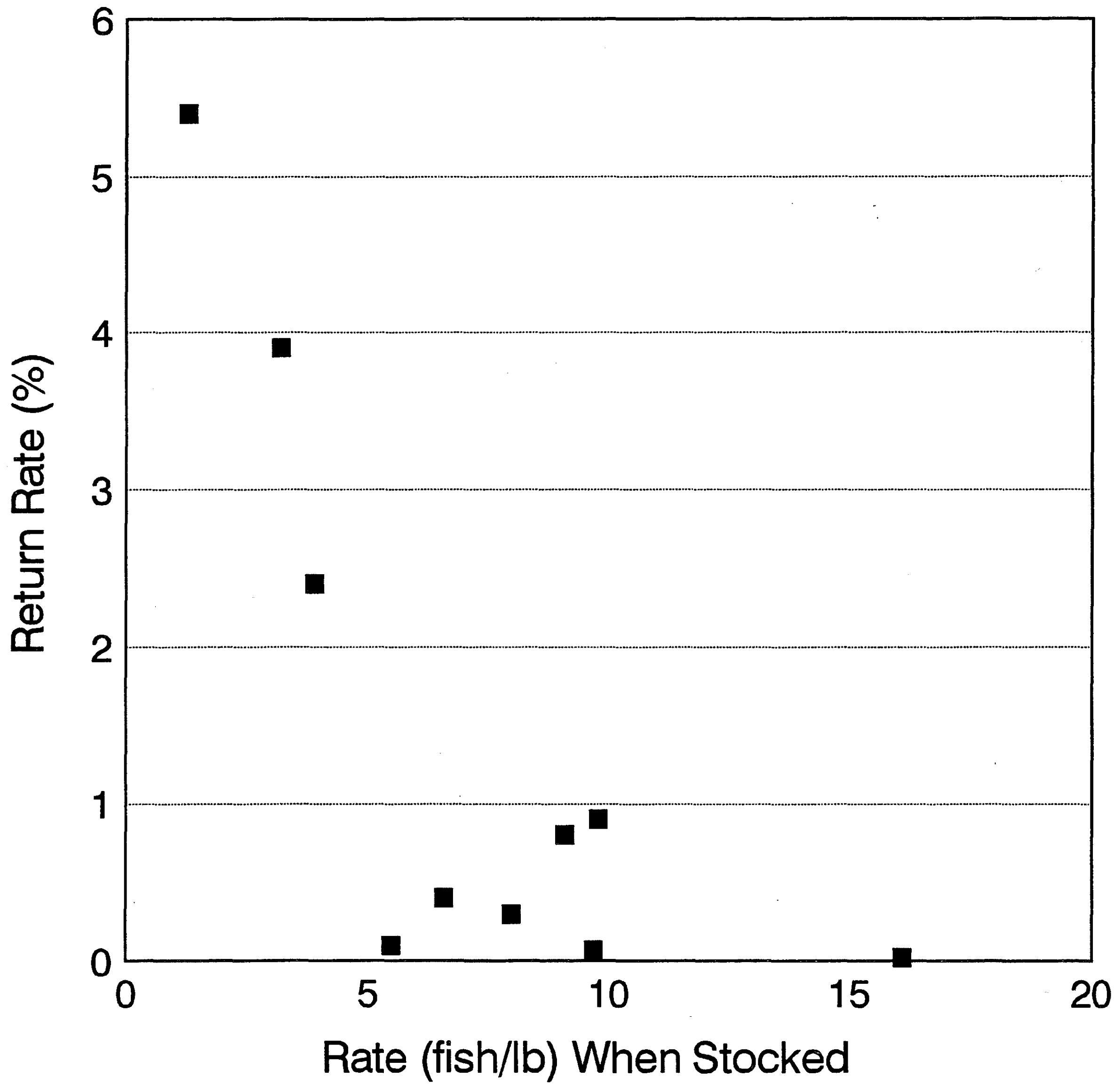

Figure 8.2. Percent return of Atlantic salmon to the French River trap based on size of fish stocked.

Chapter 9: RAINBOW TROUT

I. History

Anadromous rainbow trout from the west coast of North America were first introduced into the Minnesota waters of Lake Superior in 1895 (Hassinger et. al. 1974). The species has become naturalized and supports an important recreational fishery. Minnesota has approximately 180 miles of tributary streams accessible to steelhead, of which a more limited portion is available for spawning. For the most part, these areas supported a good fishery for naturalized steelhead from the 1940's through the 1960's.

During the 1970's and 1980's, fishing pressure increased and anglers perceived that the number of steelhead were declining. In response, the MNDNR initiated a number of steelhead enhancement programs during these years. In several streams, upstream barriers to migration were altered to permit fish passage and in-stream structures were designed to increase the amount and quality of habitat available to juvenile steelhead. Since 1981, natural reproduction of steelhead has been supplemented by stocking steelhead fry, usually in tributaries above the first barrier. A portion of the stocked fry came from eggs which were collected from adult steelhead returning to the French River trap. The remaining eggs used for fry production came from the Little Manistee River trap in Michigan. Stream surveys indicate that fry stocking has increased the number of 0+ steelhead in the streams, but that survival of fry to age 1+ is variable and dependent on climatic conditions.

A large number of rainbow trout strains, both natural and domestic, are recognized. In 1972 and 1973, three domestic strains of rainbow trout, Donaldson, Madison and Kamloops, were stocked, and their performance in Lake Superior was evaluated (Close and Hassinger 1981). Results indicated that the Kamloops strain was the best suited for a put-grow-and-take fishery that would supplement the growing harvest from the naturalized steelhead fishery. In 1976, Minnesota embarked on a Kamloops program with the goal of establishing a put-grow-and-take anadromous rainbow trout fishery. Yearling Kamloops have been reared in the hatchery system and have been stocked annually since 1976. Kamloops returning to the French River trap are used as the egg source for the hatchery reared fish. Most Kamloops are stocked at 11 months, live in the lake, and return to spawn in the streams at age 4 or 5. The Kamloops program has been successful in supporting an expanded rainbow trout fishery that supplements the harvest of wild steelhead. An advantage of the Kamloops program is their tendency to stage off river mouths in early winter and enter the streams before steelhead, creating a winter fishery in some areas.

Efforts to supplement the steelhead fishery stocks have been partially successful. However, despite these enhancement programs, anglers and biologists remained concerned because it appeared that the number of wild steelhead were still declining through the 1980's. More recently, poor returns to the French River trap and low numbers of steelhead sampled during creel surveys have heightened these concerns.

To address the decline of wild steelhead in the Minnesota waters of Lake Superior, the MNDNR, Section of Fisheries developed the *1992 North Shore Steelhead Plan* (Schreiner 1992). The goal of the plan was to stop the decline of adult steelhead and gather the information necessary to rehabilitate wild steelhead stocks. Input from the public on the steelhead plan was received at a series of public meetings held in the winter of 1991-1992. Many changes were made to the plan based on this public comment. However, there was not unanimous support for all the proposed strategies.

The steelhead plan was implemented in 1992 and its use is anticipated through the year 2002. Management strategies detailed in the steelhead plan include: restrictive angling regulations, revised stocking strategies, the construction of anadromous fish traps and monitoring stations, a genetics study, an economics study and a variety of other projects. The steelhead plan was written to be flexible and some modifications have already been made. Many strategies have been implemented since the spring of 1992. The genetics study was completed in the spring of 1993. The study found that discrete stocks of steelhead do exist on Minnesota's North Shore and there was no evidence that Kamloops had interbred with naturalized steelhead stocks (Krueger et al. 1994). A task force with public and government representatives was formed to explore construction of an anadromous fish trap on the Knife River and a consultant was hired. A feasibility study (Fish Pro 1993) and an environmental assessment worksheet (EAW) were completed. The EAW was approved and money for construction has been appropriated. Construction started in the fall of 1994. A smolt trap was installed in the French River and data collection began in the spring of 1994. Reports that summarize the progress made on the steelhead plan are produced on an annual basis and are distributed to all interested citizens.

The *1992 North Shore Steelhead Plan* and the activities outlined in the annual progress reports are being implemented. What follows in this chapter is a brief summary of the Steelhead Plan that describes the strategies that are presently in place. For more detail on specific topics please refer to the *1992 North Shore Steelhead Plan* and the annual progress reports.

II. Goals and Objectives

Goal: The long-term goal is to stop the decline of adult steelhead and to gather the necessary information to rehabilitate wild steelhead stocks.

Objectives:

1. Determine the factors limiting production of adult wild steelhead.

2. Determine if implementing the principals of wild trout management can provide quality angling for North Shore steelhead.

3. Protect and improve steelhead habitat in North Shore watersheds by maintaining suitable stream flows, water temperatures, water quality and access to spawning and nursery areas.

4. Acquire additional information necessary to answer critical questions relating to sustained production of wild steelhead in the Minnesota waters of Lake Superior.

5. Continue to implement the Steelhead Plan (1992) unless criteria outlined in Appendix 1 are met.

III. Present Management

A. Regulations - Season is continuous below the upstream boundary. Possession limit of 3, only 1 of which can have an unclipped adipose fin. The minimum size is 28 in for unclipped fish and 16 in for clipped fish.

B. Stocking - Only the gametes from steelhead and Kamloops strain rainbow trout taken from the Minnesota waters of Lake Superior will be used for stocking programs. Streams that have good potential for natural reproduction by wild steelhead, and those that have very limited fishing access, will not be stocked. Streams managed for Kamloops will be given a lower priority for steelhead fry stocking. An annual quota of approximately 500,000 steelhead fry and 92,500 Kamloops yearlings has been established. Steelhead fry will be stocked above the first barrier in selected tributaries (Table 9.1). Kamloops yearlings will be stocked in the French River, Lester River and Chester Creek (Table 9.2).

The first phase of the Knife River steelhead smolt stocking study was completed in 1993. This phase examined the feasibility and cost of rearing wild steelhead to smolt size in the French River Hatchery. This phase took place over the four year period from 1990 to 1993 (Tureson 1994). The second phase of this program will evaluate the return of the Knife River smolts to the French and Little Knife River traps. This phase will be completed when the majority of fish from all year classes have returned, in the late 1990's.

C. Assessment - Stream surveys and population assessments are conducted on Lake Superior tributaries to determine the abundance and survival of juvenile rainbow trout, along with physical and chemical characteristics of each stream.

Table 9.1. Steelhead fry stocking plan for Minnesota tributaries to Lake Superior with stocking quotas, frequency, locations, and priority.

Management area/stream	Tributary number	Stocking quota	Stocking frequency[1]	Stocking location[2]	Priority
Duluth Area					
Lester	S-5	100,000	O	12.9	3
Amity	S-5-1	40,000	E	2.4	3
Talmadge	S-7	20,000	E	3.7	2
French	S-11	200,000	A	8.5	1
Stewart[3]	S-19-1	100,000	E	7.7	2
Silver[3]	S-21	50,000	O	6.6	2
Gooseberry[3]	S-26	50,000	O	13.0	2
Finland Area					
Split Rock	S-29	100,000	O	3.9	2
Beaver	S-35	50,000	E	3.6	2
Cross	S-52	50,000	E	4.0	2
Grand Marais Area					
Temperance	S-53	50,000	E	0.6	2
Cascade	S-64	50,000	O	3.6	2

[1] A - Annual; O - Odd Years; E - Even Years
[2] Miles Above Mouth
[3] Catch and Donate Streams

Table 9.2. Kamloops stocking plan for Minnesota tributaries to Lake Superior. Tributaries will be stocked annually with yearlings.

Stream	Tributary number	Stocking quota
Chester	S-3	7,500
Lester	S-5	35,000
French	S-11	50,000

Angling pressure, catch, and catch rate of rainbow trout are determined from creel surveys conducted in the spring, summer and fall on the Minnesota waters of Lake Superior. The spring creel survey targets anadromous rainbow trout and has been conducted almost every year since 1970. The summer creel survey targets the lake fishery, but includes rainbow trout caught during this period. The fall creel survey targets the chinook salmon run, but also includes rainbow trout that are caught during this season. The French and Little Knife River traps are used to assess returns of adult rainbow trout. The French River trap has been in place since the mid-1970's and is also used for spawn-taking. In the spring of 1994, a smolt trap was constructed as part of the existing dam on the French River to enable the enumeration of smolts that originated from fry stocking. The smolt trap will greatly increase the amount of information collected on rainbow trout in a medium sized North Shore stream and will help document the effectiveness of fry stocking. The Little Knife River trap has been in operation since 1990 and data is being collected to determine trap efficiency, the smolt-adult relationship, smolt survival and other information that can be related to rainbow trout behavior in a small stream.

Efforts to maintain suitable spawning and nursery habitat in North Shore streams continue. A major problem on important steelhead spawning streams has been the establishment of beaver dams and log jams that block fish passage. Efforts to identify and remove these structures are ongoing. Easement and land acquisition programs along stream corridors has increased, but private land owners must be willing to participate before negotiations can take place. Habitat improvement projects on a number of streams are monitored to assess their benefit to smolt production.

IV. Proposed Management

A. Regulations - Based on the request by some angling organizations, the MNDNR will pursue implementing a regulation that allows no harvest (catch and release only) at any time of unclipped rainbow trout in the Minnesota waters of Lake Superior and tributary streams below the posted boundary. The MNDNR feels the present regulation affords adequate protection of spawning wild steelhead, while allowing anglers the option to harvest a trophy. The present regulation generally allows female steelhead to spawn for at least two years and males to spawn for at least three years. Only a small percentage of steelhead in Minnesota exceed the age of 8; therefore, at this time the proposed regulation is based on angler sentiment, not biological need.

B. Stocking - At this time, having not completed the Knife River smolt stocking study or the *1992 North Shore Steelhead Plan*, the MNDNR feels initiation of a smolt stocking program at any level is premature. Some angling organizations are unwilling to allow the time to carry out the Knife River smolt stocking study and the *1992 North Shore Steelhead Plan*. Since the MNDNR and these specific organizations seem to be at a major impasse, a compromise has been sought that may minimize risk to wild steelhead and satisfy the majority of steelhead anglers.

The MNDNR has proposed to reinstate the experimental smolt stocking program at the former level of 40,000 fish annually, to begin in the spring of 1996. The organizations interested in this program have been asked to assist the MNDNR by funding approximately one third the cost of the program. An advisory group made up of representatives from the various organizations will be established to develop criteria for implementation and management of the smolt program. Before the program is reinstated a memorandum of understanding between the MNDNR and the various organizations will be developed that describes the program details and responsibilities.

The MNDNR has offered this compromise, but would prefer to continue with steelhead management as outlined in the *1992 North Shore Steelhead Plan*. The plan is founded on the need to collect the information necessary to make informed decisions based on the biology of the Lake Superior fish community.

C. Assessment - Implement suggestions in the *1992 North Shore Steelhead Plan*. Complete construction of the Knife River trap for assessment of steelhead populations on a large stream. Conduct a winter creel survey targeted at the near shore rainbow trout fishery once every three years. Consider reducing the frequency of the spring creel survey to alternate years if funding is not available, or if other assessment projects are of higher priority (such as the proposed winter creel survey). Increase the number of complete stream surveys on Lake Superior tributaries and continue to standardize methods and reporting procedures among areas and jurisdictions. Conduct annual juvenile steelhead assessments at pre-determined index stations on North Shore tributaries. Calculate criteria to evaluate the steelhead program as described in Appendix 1.

V. Justification

Except for the proposed regulation change and reinstatement of the experimental smolt program, the major recommendation from this chapter is to continue with the implementation of the *1992 North Shore Steelhead Plan* that is already in place. Based on our present information, this plan was compiled to provide the best chance for protection and restoration of wild steelhead stocks on Minnesota's North Shore. The plan is oriented toward the long-term benefits of wild, self-sustaining steelhead populations, rather than a short-term approach based largely on hatchery production. A large hatchery based program increases the risk of losing the wild steelhead stocks which presently remain along the North Shore. As stated in the Steelhead Plan, a 10 year period is the minimum amount of time required to test the results of the new regulations, analyze the proposed stocking strategies and gather information that will allow us to make more informed choices in the future. If, after 10 years, we have moved no closer to self-sustaining, wild steelhead stocks, or the criteria listed in Appendix 1 are met, modification of the Steelhead Plan should be initiated based on the information collected to date and input from user groups.

VI. Information Needs/Community Interactions

Among the most critical needs for proper steelhead management is to determine whether a relationship between steelhead smolt production and the number of returning adults exists and, if it does, what the nature of the relationship is. For example, if an increase in smolt abundance equals an increase in returning adults 3-4 years later, then stream conditions that limit smolt production may be the limiting factors for adult steelhead. If this type of relationship is observed, then use of in-stream habitat improvement structures, increased escapement of wild spawners and stocking programs may increase the number of returning adults. If an increase in the number of smolts does not result in an increased number of returning adults, it suggests that the limiting factor may be in the lake. If this is the case, habitat improvement or stocking would do little to increase abundance of returning adults.

The percentage of repeat spawners, number of first time spawners and mortality rates of adult steelhead should be determined to evaluate the effects of the regulation changes and angler exploitation. The return rate of Knife River smolts and the number of adults returning to streams which are stocked or not stocked with fry must be monitored to determine the effectiveness of these stocking strategies.

Genetic analysis has already indicated that unique stocks of steelhead still remain along Minnesota's North Shore and that there is no evidence that Kamloops have interbred with wild steelhead. Studies to determine what mechanism is responsible for this perceived isolation between Kamloops and steelhead are being conducted. If Kamloops can in fact interbreed with steelhead, elimination of the Kamloops program should be considered. The fitness of hatchery reared fish and their effects on wild stocks have been studied on West Coast salmon and steelhead stocks (Miller 1990; Reisenbichler and McIntyre 1977). The studies conclude that, where wild fish are established, hatchery reared fish seldom perform as well as wild fish. Most of these studies also concluded that the fitness of wild fish decreased when they were allowed to interbreed with hatchery stocks.

The interaction between rainbow trout and other anadromous species (trout and salmon) in North Shore streams needs to be determined. North Shore streams are relatively unproductive and the number of anadromous salmonids they can support on a sustained basis is unknown. When the carrying capacity of a stream is exceeded, juvenile fish tend to leave the stream. If they are forced to leave early, at a small size, they are subject to high mortality. The carrying capacity of North Shore streams should be estimated so that allocation of stream habitat among species and realistic expectations for juvenile production can be determined, and a more effective stocking program can be developed.

An economics study of the steelhead fishery has been proposed by both supporters and opponents of the steelhead program. Supporters feel that steelhead angling has a high benefit:cost ratio and more money should be spent to increase the number of steelhead available for anglers. Opponents feel there is already too much money being spent on a species that benefits only a small group of anglers and that, if the program can not sustain itself, it should be discontinued. No information on the economic benefit of the steelhead fishery in Minnesota presently exists. An economics study should be conducted, but the valuation of the fishery will be difficult because each individual has their own concept on the monetary value of a steelhead.

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APPENDIX 1. CRITERIA FOR STEELHEAD PLAN REVISION

The steelhead plan was written to be flexible. If, within the time frame of the steelhead plan, the steelhead population declines to levels that make rehabilitation under the current plan unfeasible, then parts of the plan can be modified. Criteria based on biological principles have been developed and, when met, will initiate modification of the plan. Information from stream assessments, creel surveys and trap results will be used to monitor the status of steelhead populations and to decide whether the criteria have been met. The criteria will be applied separately to Lower Shore streams (Lester River to Split Rock River) and Upper Shore streams (Beaver River to Brule River), because of their different characteristics.

The main criteria is based on juvenile (age 0+) abundance in the streams as measured by electrofishing and the decision on when to act is based on catch rates from the creel survey. Information collected from the traps will be used to further clarify the interpretation. The criteria, and the rationale behind them are discussed below along with a flow-chart that illustrates how decisions will be made (Figure 9.1).

Juvenile Assessment

Background - Juvenile (age 0+) assessment by electrofishing is an indirect method to estimate the relative abundance of spawning steelhead in North Shore tributaries. Declines in juvenile abundance over an extended period would suggest that there may no longer be enough adults to fully seed the nursery habitat. Limitations to using juvenile abundance as an indicator of adult abundance include annual variation in survival from egg to fingerling, changes in available habitat associated with flow and variations in electrofishing efficiency.

Strategy - From 10 to 15 electrofishing sites along the entire shore will be selected as index stations. All sites will be below barriers and will have a sampling history of 10 to 20 years. Because sites are below barriers, we can assume they have not been significantly influenced by fry stocking. By sampling index stations annually, we can compare current juvenile abundance to a historical baseline level. For streams that were sampled in the 1970's, 7 years of sampling will be averaged to determine the baseline levels. For stations with sampling history in the 1980's, only the earliest 4 years will be averaged. The baseline value will be compared to the average juvenile abundance over the 4 most recent years. The criteria must be met in at least 70% of the stations along the shore (Upper or Lower) so we do not act based on results from only one or two streams. Index stations will be considered for the following tributaries: Lester River, Sucker River, Knife River (multiple stations), Stewart River, Silver Creek, Split Rock River, Onion River, Devil Track River, Kimball Creek, Kadunce Creek and Flute Reed River. Other streams with adequate sampling history could also be used.

Criteria - If the recent average juvenile abundance at 70% of the index stations is less than 70% of the baseline values for three to five years (see creel survey section and decision flow chart), the criteria are met and modification of the steelhead plan will be considered.

Creel Survey Data

Background - Creel surveys provide information on fishing pressure, catch and catch rate for different species, including steelhead. Many factors can influence these measurements, including weather, angler expectations, relative number of experienced and novice anglers, number of fish in the run and timing of the run. Because of these factors, catch and catch rates may not always change in direct proportion to the abundance of adult fish. Because of these potential biases, the importance of long-term monitoring, especially in a fishery as dynamic as the North Shore steelhead fishery, is critical.

Strategy - The steelhead catch rate, estimated from creel survey results, will be used to determine the number of years that juvenile abundance criteria must be met before changes in steelhead management will be implemented. It is possible that numbers of juveniles will decrease in some rivers, while the fishing remains good. If catch rates indicate that fishing is very poor, and juvenile abundance meets the proposed criteria, changes to the plan will be made more quickly than if fishing is good. Good fishing for wild steelhead on the North Shore has been defined as a catch rate greater than 0.04 steelhead per hour. This is below the 0.06 target level set for the Wisconsin waters of Lake Superior and recognizes the lower productivity of North Shore streams. Poor fishing has been defined as a catch rate of less than 0.02 fish per hour, and is based on current catch rates from the Lower Shore where fishing is reported to be poor.

Criteria - If steelhead catch rates are less than 0.02 fish per hour, then the juvenile abundance criteria must be met for three consecutive years before changes will be considered in the plan. If steelhead catch rates are between 0.02 and 0.04 fish per hour, juvenile abundance criteria must be met for five consecutive years. If steelhead catch rates are above 0.04 steelhead per hour, current management will continue.

The French River and Knife River Traps

Background - Returning adult steelhead are counted annually at the French River trap. With the recent construction of the French River smolt trap, smolts can also be counted. The number of smolts leaving the French River is dependent on the survival of stocked fry in the stream. If the number of smolts is known, the number of adults returning to French River will reflect the survival of smolts in the lake. The French River is different from other North Shore tributaries because steelhead are maintained annually by nearly constant levels of fry stocking. If juvenile abundance decreases in nearby streams, but not in the French River, it suggests recruitment may be limited, possibly because numbers of returning adults have decreased. If the number of adults returning to the French River trap declines while the number of out-migrating smolts remains constant, it suggests that the environment in the lake is unsuitable for the survival of juvenile steelhead. In this case, the MNDNR would have few options to rejuvenate steelhead in the short term.

The Knife River is a system that receives little stocking. When the Knife River trap is completed, similar data will be collected. When the smolt trap is incorporated into the fishway, smolt-adult relationships can be compared between wild steelhead from the Knife River and fry-stocked steelhead from the French River.

Strategy - Information from fish traps will be examined to evaluate the success or failure of potential changes in rainbow trout management. Use of trap information may prevent choosing strategies that have already been shown to be marginal or unsuccessful.

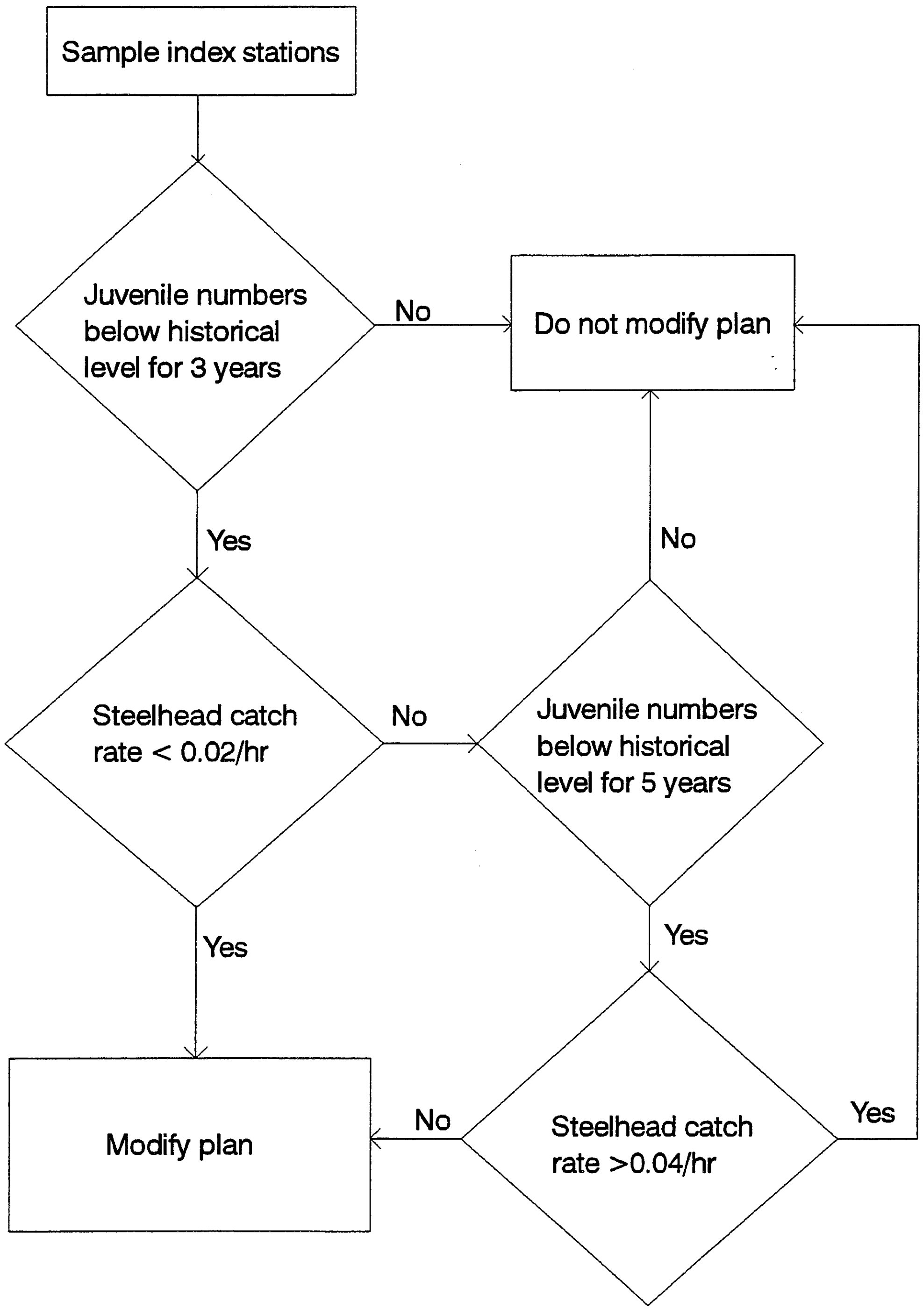

Figure 9.1. Decision flow chart to modify the Steelhead Plan. See text for complete criteria descriptions.

Chapter 10: BROOK TROUT

I. History

Brook trout are native to Lake Superior and its tributaries below the first barrier. Reports from the mid-1800's through the 1920's indicate that brook trout in Lake Superior supported a popular fishery. In Minnesota it was reported that many tributaries to Lake Superior supported a brook trout fishery below the first barrier. "Coaster" is the local term for brook trout that spend a portion of their life cycle in Lake Superior. It is believed that coasters are migratory brook trout that live their adult life in Lake Superior, but enter streams to spawn. Once in the stream, they generally seek out and successfully spawn in upwelling areas (springs). In comparison with other tributaries around Lake Superior, sections of Minnesota streams below the first barrier are probably much less productive for brook trout because they lack such springs. Recently, there is evidence that coasters may also spawn in the lake on shoals or in areas of ground water upwelling. By the early 1950's, coaster abundance had declined and reports of coasters being caught in Minnesota were rare. There is presently no major fishery for coasters in the Minnesota waters of Lake Superior, but there is some interest among user groups in developing a restoration plan for a limited coaster fishery.

Previous management efforts to rehabilitate the coaster fishery in Minnesota have involved stocking of different strains and sizes of brook trout. Stocking records before 1970 are incomplete or non-existent, although it is known that many domestic (hatchery-reared) brook trout were stocked. Since 1970 a variety of strains, sizes and numbers of brook trout have been stocked. Many were domestic brook trout that were placed in harbors or bays to establish put-grow-take fisheries. Most of these fish were harvested by anglers within the first month after stocking and little return was seen after this initial activity. No self-sustaining populations were expected to be established using this strategy. During the mid-1980's, an experimental program was conducted in which Nipigon strain brook trout were stocked in the French River for three years. The goal of the program was to determine the return rate to the French River trap and possibly to use the returns as an egg source for future programs. Results were very discouraging when only seven fish returned from 1987 to 1989 and angler reports of harvested brook trout were rare. Since 1987 there has been no stocking program for brook trout in the Minnesota waters of Lake Superior.

Within the last five years there has been renewed interest among conservation groups, fishing clubs and management agencies in rehabilitating coasters in Lake Superior. Because very few native stocks of brook trout remain in Lake Superior and very little is know about their life history and interactions within the fish community, the rehabilitation process would be both slow and difficult. Many changes have also occurred in Lake Superior since brook trout stocks were abundant. Deforestation and logging in much of the Lake Superior watershed over the last 100 years have increased stream temperatures and the range of stream flows. Over-fishing appears to have been a problem since the early 1900's. Introductions and naturalization of non-native species since the early 1900's and dramatic changes in the Lake Superior fish community may have also had adverse effects on brook trout.

Loss of genetic diversity, habitat degradation and changes in the Lake Superior fish community are all formidable obstacles to the successful rehabilitation of brook trout. Management agencies on Lake Superior have recently formed a working group to protect the remaining brook trout stocks in the lake and gather information to address problems facing brook trout rehabilitation. All agencies have agreed that the issues of genetic strain, habitat degradation, over harvest and fish community interactions must be addressed before brook trout rehabilitation could be successful. It is also well understood that brook trout rehabilitation in Lake Superior would be a long-term process and that cooperation among conservation groups, fishing clubs and management agencies will be required.

II. Goals and Objectives

Goal: Determine if rehabilitation of self-sustaining brook trout (coaster) stocks in the Minnesota waters of Lake Superior is feasible or realistic.

Objectives:

1. Cooperate with other agencies on Lake Superior to gather information for evaluating whether rehabilitation of self-sustaining brook trout stocks in the Minnesota waters of Lake Superior is feasible.

2. If there is potential for successful coaster rehabilitation and support from user groups, use *Lake Superior Brook Trout Plan: Recommendations for Plan Development* (Halpern and Schreiner 1992) and information gained from the brook trout working group to develop a rehabilitation plan.

III. Present Management

A. Regulations - There is no closed season for brook trout in Lake Superior below the first barrier. The limit is 5 in combination with brown trout. The minimum size is 10 in and not more than three may be over 16 in.

B. Stocking - No stocking has been done in Minnesota since 1987.

C. Assessment - Brook trout are assessed in Minnesota through creel surveys and returns to the French River trap. Since 1984, the estimated average number of brook trout caught in the spring and summer creel surveys, was 167 and 3, respectively. Many of the brook trout caught in the spring were probably resident stream fish and not of the larger coaster variety. From 1987 to 1993 less than five brook trout were captured annually at the French River trap. It is rare to take a brook trout incidentally in lake trout assessment nets. Stream surveys targeting juvenile steelhead have sampled a small number of naturally reproduced brook trout, but most of these are sampled above the first barrier and are not the progeny of coasters.

IV. Proposed Management

A. Regulations - Maintain present regulations. Incorporate new regulations if a rehabilitation plan is developed.

B. Stocking - Do not initiate a stocking program until a suitable plan is developed that addresses strain, size to be stocked, and criteria for success or failure. For stocking above barriers refer to MNDNR fisheries stream management plans.

C. Assessment - No major changes in creel surveys are planned at this time. Continue to monitor the French River and Knife River traps to determine the number of adults entering these two rivers. Conduct intensive habitat surveys in streams that have potential for brook trout reproduction.

V. Justification

Previous stocking of domestic strain brook trout by Minnesota and other agencies has not been successful in the restoration of self-reproducing brook trout stocks, nor in most cases has it established a viable brook trout fishery. Improper strain, hatchery selection, size at stocking, inadequate numbers stocked and competition with other salmonids have all been suggested as reasons for poor survival. Egg sources from anadromous brook trout strains in the Lake Superior watershed may be insufficient to meet the needs of all the agencies interested in restoration of coasters. The brook trout working group concluded that agencies stocking brook trout in Lake Superior should ensure that the genetics of the stock is documented because stocking non-native brook trout could adversely affect the genetic integrity of the few remaining native stocks. Agencies should work together to insure that no brook trout stocking program be implemented unless there is an adequate plan established to monitor the program (Halpern and Schreiner 1992).

If a rehabilitation plan is developed for coasters, modified regulations must be implemented. Presently most brook trout caught below the first barrier are less than 16 in and probably originate upstream above the first barrier. Brook trout are extremely vulnerable to angling and can be harvested before they spawn once. In Ontario, fishery managers on Lake Superior have proposed a limit of two brook trout, with a minimum size limit of 18 in (Trottier 1992). This regulation is expected to allow brook trout to spawn at least twice during their life.

Assessment of the brook trout fishery should remain the same unless a restoration plan is implemented. Detailed habitat assessment in streams that have the greatest potential for brook trout reproduction should be undertaken so that the most suitable streams can be identified before initiating a program. If populations are to be self-sustaining, proper habitat must be present and it must be protected.

VI. Information Needs/Community Interactions

In the initial phases of any restoration project, basic information on the species of interest is critical for success. While some information on coaster brook trout is presently available, much is lacking. Genetic identification of appropriate brook trout strains, habitat identification, and interactions with the present Lake Superior fish community are all important information needs. Genetic studies of brook trout strains in the Lake Superior watershed above the first barrier may identify possible sources for reintroduction, because they may have been taken from Lake Superior and stocked above the barriers. Nipigon River or Isle Royale stocks may also be potential egg sources, if they are available. Habitat surveys of potential streams need to be done before any program can be successfully implemented. A better understanding of the relationship between brook trout and other fish species, both in the stream and in the lake, is required if a restoration program is to be successful. Finally, a well designed restoration plan that includes criteria for success, and criteria for discontinuing the program, must be established and agreed to by all parties involved before any program is implemented.

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Chapter 11: BROWN TROUT

I. History

Brown trout are not native to Lake Superior, but have established anadromous runs in a number of tributaries in other states. In Minnesota, attempts to establish anadromous populations in a number of streams met with very limited success. Brown trout are rarely caught in tributary streams below the barrier, but are caught occasionally during the summer boat fishery, as reported from creel surveys. Annual returns to the French River trap and the summer creel survey have averaged 6 and 40 fish, respectively, from 1980 to 1993.

An experimental stocking of 63,000 yearling and 170,000 fingerling brown trout in the St. Louis River from 1985 to 1987 may have partially contributed to an average annual catch of 108 fish in the summer creel survey from 1988 to 1992. Since 1992, most of the brown trout caught were from limited natural reproduction below the barriers, fish migrating down to the lake from above the first barrier and fish originating from other states. Habitat for brown trout along Minnesota's shoreline and tributaries below the first barrier is marginal, as it is for most of the other fall spawning anadromous species.

II. Goals and Objectives

Goal: Maintain the opportunity to harvest naturalized brown trout that originate from tributaries in Minnesota and other states.

Objective:

1. Allow angler harvest of brown trout in Lake Superior and tributary streams with no active management at this time.

III. Present Management

A. Regulations - Five in combination with brook trout, with a minimum size of 10 in, and not more than 3 over 16 in.

B. Stocking - Brown trout have not been stocked since 1987.

C. Assessment - Creel surveys on lake and tributary streams.

IV. Proposed Management

A. Regulations - Maintain present regulations.

B. Stocking - No stocking is recommended at this time. For stocking above barriers refer to MNDNR fisheries stream management plans.

C. Assessment - Continue with present assessment program.

V. Justification

North Shore streams are relatively unproductive and can support only a limited number of anadromous salmonids. When the carrying capacity of the stream is exceeded, juveniles tend to leave the stream or die. If they are forced to leave early, at a small size, they suffer high mortality and few fish return as adults. There is some evidence that brown trout in streams may prey on steelhead fry and displace brook trout stocks (DeWald and Wilzbach 1992). If the priority for anadromous trout in Minnesota is steelhead, then brown trout should not be stocked.

VI. Information Needs/Community Interactions

Interactions between brown trout and other anadromous species (trout and salmon) in both the lake and North Shore streams need to be determined.

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Chapter 12: WALLEYE

I. History

Almost all walleye found in the Minnesota waters of Lake Superior originate from the St. Louis Bay population. The St. Louis Bay strain of walleye is anadromous, spending most of its adult life in western Lake Superior while utilizing St. Louis Bay for spawning and growth at the juvenile life stages. Angler exploitation of St. Louis Bay walleye was relatively light until the Western Lake Superior Sanitary District began operation in 1978. Improved water quality increased the time adult walleye spent in the bay and changed angler attitudes towards harvesting more of this resource. In 1989, results from the St. Louis Bay Creel Survey indicated one of the highest walleye catch rates in the state (Beard and Spurrier 1990). However, total harvest was less than that historically reported because of restrictive harvest regulations enacted in 1989 (Table 12.1).

The status of the St. Louis Bay walleye populations has been assessed in 10 of the 13 years between 1980 and 1993. Gill net data indicate that walleye abundance has remained relatively constant since 1986. CPE ranged from a low of 2.3 walleye per gill net lift in 1993 to 5.4 in 1986. Gill net CPE was 4.5 per lift in 1992. As expected, there is a large difference in size between walleye captured in the summer gill net assessment and the spring spawning run, because the spring spawning run does not include immature fish. The mean length of walleye sampled in the summer of 1991 was 15.9 in (or about 1.5 lb), while walleye captured in the spring of 1991 had a mean length of 19.0 in (or about 2.7 lb). St. Louis Bay walleye have slow growth rates because of the time spent in the cold water of Lake Superior.

Creel surveys were conducted on St. Louis Bay in 1980, 1981, 1982 and 1989. The estimated walleye harvest in 1980 was 45,718 fish, while estimated harvest in 1981, 1982 and 1989 was 24,141, 23,816 and 17,833 fish, respectively (Table 12.1). Creel surveys conducted on Lake Superior indicate that very few walleye are harvested in the Minnesota waters of Lake Superior.

The management of walleye, as well as the entire fishery in the St. Louis Bay, has become more complex with the introduction of several non-native species. Specifically, the invasion of European ruffe to the system has caused a major shift in fisheries management activities. A variety of methods to control non-native species have been reviewed.

Table 12.1. Estimates of fishing pressure, walleye harvest, walleye harvest rates, and walleye catch rates from St. Louis Bay in 1980, 1981, 1982, and 1989.

Year	Pressure (angler/hr)	Harvest (no. of fish)	Harvest Rate (fish/angler hr)	Catch Rate (fish/angler hr)
1980	179,745	45,718	0.221	-
1981	149,900	24,141	0.171	-
1982	134,829	23,816	0.170	-
1989	111,276	17,833	0.160	0.414

- Released fish were not included in the 1980, 1981, and 1982 creel surveys.

II. Goal and Objectives

Goal: Protect the quality of the St. Louis Bay walleye fishery.

Objectives:

1. Manage walleye populations in cooperation with the Wisconsin Department of Natural Resources, since it is a shared resource.

2. Maintain quality size and catch rate of St. Louis Bay walleye through harvest regulations.

3. Monitor walleye population dynamics through annual assessments.

4. Protect walleye spawning habitat below the Fond du Lac Dam.

III. Present Management

A. Regulations - Walleye regulations for Lake Superior were recently changed to correspond with walleye regulations in St. Louis Bay. The walleye season runs from the second Saturday in May to March 1st and the possession limit is 2 with a 15 in minimum length limit for both Lake Superior and St. Louis Bay. A fish sanctuary (no fishing allowed) is maintained from the Minnesota-Wisconsin boundary cable to the Fond du Lac Dam. In addition, to protect spawning walleye, angling is prohibited between the Highway #23 bridge and the Minnesota-Wisconsin boundary cable from the Saturday closest to March 1st through May 18th.

B. Stocking - Each year eggs are taken from St. Louis Bay walleye just below the Fond du Lac Dam and fry hatched from these eggs are stocked back into the river. From 1989 through 1993, walleye fingerlings have been stocked in the St. Louis Bay as part of a ruffe control effort. Stocking goals were set at 3,300 lb of fingerlings annually. An increased number of walleye fry (4-7 million) were also stocked from 1989 to 1993. Normal fry stocking, which is 10% from the total egg take, was resumed in 1994. This usually averages approximately 3 million fry.

C. Assessment - Population dynamics of walleye in St. Louis Bay during the summer are monitored annually using gill nets, trap nets and seines. The spawning population is monitored each spring during egg-taking operations just below the Fond du Lac Dam. Angler harvest has been monitored with creel surveys; the last one was conducted in 1989. Shallow areas within the St. Louis Bay are critical to the survival and growth of juvenile walleye. Relative abundance of juvenile walleye is monitored annually in these shallow areas by seining.

IV. Proposed Management

A. Regulations - In Minnesota walleye regulations in Lake Superior and St. Louis Bay are now the same. Minnesota and Wisconsin have common regulations for walleye in St. Louis Bay, and should continue to work toward common regulations in western Lake Superior.

B. Stocking - Discontinue stocking walleye fingerlings. Based on gill net indices, fingerling stocking has done little to augment the natural walleye population in St. Louis Bay. Stocking walleye in an effort to increase their biomass as a predator on ruffe is being examined, but appears to be ineffective due to the low predation on ruffe by walleye and the open nature of St. Louis Bay.

C. Assessment - Continue annual summer assessments. Conduct a creel survey to quantify angler pressure and harvest once every five years, if funding is available. Determine angler attitudes towards the St. Louis Bay walleye fishery.

V. Justification

The St. Louis Bay and Lake Superior walleye fishery provide an opportunity for both Minnesota and Wisconsin residents to catch trophy walleye. The anadromous behavior and slow growth rates of many walleye in St. Louis Bay, coupled with the potential for high fishing pressure, make the population vulnerable to angling exploitation. Because of the slow growth rate in this population, any downward shift in walleye size structure due to increased harvest would take many years to overcome. Conservative regulations on both the lake and river are needed to protect the quality of this important resource. Common regulations between Minnesota and Wisconsin on the lake and bay would assist in coordinating management of the resource. Common regulations would also reduce confusion and violations. Spawning and nursery habitat is critical for St. Louis Bay walleye. Protection and enhancement of shallow nursery areas within St. Louis Bay, along with clean-up efforts should be supported by working with the St. Louis River RAP process.

VI. Information Needs/Community Interaction

Additional information is needed on the harvest of large adult walleye in the Minnesota and Wisconsin portions of Lake Superior. The influence that angler harvest has on the size structure of the

St. Louis Bay walleye population needs to be examined, as does the effects of continued stocking. The relationship between ruffe and walleye in St. Louis Bay should continue to be evaluated.

References

Beard, T. D. and J. R. Spurrier. 1990. Completion report - St. Louis River creel recreational survey 1989. Minnesota Department of Natural Resources, Project F-29-R(P), St. Paul, Minnesota.

Chapter 13: LAKE STURGEON

I. History

The lake sturgeon is a primitive fish which is native to the Minnesota waters of Lake Superior. It is Minnesota's largest and most long lived fish. Historical records indicate sturgeon can exceed 300 lb and 100 years of age. Most fish do not reach spawning age until they are 15-25 years old and they may not spawn every year. Because of their longevity, slow growth, and late age of maturity, they are vulnerable to over harvest. Lake Superior and St. Louis Bay once supported a large lake sturgeon population and fishery. This population was extirpated due to poor water quality and over-fishing. Water quality within St. Louis Bay has dramatically improved since the Western Lake Superior Sanitary District began operation in 1978. Possession of sturgeon is now prohibited in the Minnesota waters of Lake Superior and St. Louis Bay.

In 1984, a program to rehabilitate lake sturgeon in St. Louis Bay began. This program focused on stocking fingerling sturgeon and on evaluating the success of stocking with annual assessments. A similar program is conducted by the Wisconsin Department of Natural Resources (WIDNR). The Wolf Lake strain from Wisconsin was used by both agencies because no sturgeon egg source from Lake Superior presently exists.

Survival of stocked fingerlings appears to be excellent, with the establishment of year classes corresponding to each year of stocking. Coded-wire tags were implanted in several year classes of sturgeon stocked by the MNDNR. Many untagged sturgeon were captured in the assessments which suggests that fry and fingerlings stocked by the WIDNR influenced year-class strength. These data show a need to evaluate the potential for successful fry stocking, which would avoid the concerns regarding the stocking of fish after the imprinting period. Lake sturgeon migrate out of the bay and into Lake Superior at approximately 20 in length, which corresponds to ages 3 and 4. The WIDNR has documented a large increase in lake sturgeon catch rates in assessment gear along the Wisconsin shoreline of Lake Superior.

Harvest of lake sturgeon in the Minnesota waters of Lake Superior and St. Louis Bay is currently prohibited. However, if rehabilitation is successful, a self-sustaining population should provide an exceptional trophy fishery. Even then, only a limited harvest would be allowed. If the rehabilitation program for lake sturgeon is successful, spawners should begin their return to St. Louis Bay in 15-25 years.

II. Goals and Objectives

Goal: Reestablish a self-sustaining population of lake sturgeon in western Lake Superior and St. Louis Bay.

Objectives:

1. Secure a reliable source of river-run lake sturgeon eggs from the Lake Superior watershed.

2. Stock lake sturgeon on a regular basis until self-reproducing stocks are established, if money for the program is available.

3. Monitor lake sturgeon population dynamics annually through cooperative assessments with WIDNR.

4. Develop spawning substrate suitability curves for the area between Highway #23 bridge and the Fond du Lac Dam.

III. Present Management

A. Regulations - Harvest of lake sturgeon in Lake Superior and St. Louis Bay is prohibited.

B. Stocking - Lake sturgeon have been stocked annually by MNDNR or WIDNR in St. Louis Bay between 1983 and 1993 except for 1987. The number of sturgeon stocked has been variable due to availability. Stocking in Minnesota was discontinued in 1992 due to lack of funds.

C. Assessment - Lake sturgeon population assessments, which were initially conducted in September, are now conducted in July along with the general population assessment on St. Louis Bay. Annual assessments have been conducted since 1988.

IV. Proposed Management

A. Regulations - Maintain present regulations. If successful natural reproduction is documented, investigate what type of harvest regulations may be feasible in the future. Continue with seasonal fishing closure between Highway #23 bridge and Fond du Lac Dam.

B. Stocking - If budget dollars are available for a sturgeon program, stock 5,000 lake sturgeon fingerlings every third year in St. Louis Bay.

C. Assessment - Continue annual assessment of lake sturgeon in conjunction with the general summer population assessment on St. Louis Bay. Evaluate the potential of stocked fry to contribute to year class strength.
Investigate spawning habitat enhancement below the Fond du Lac Dam.

V. Justification

The lake sturgeon is native to St. Louis Bay and Lake Superior. Rehabilitation of sturgeon in this system will return this fish to a portion of its native range. This project will enhance our knowledge and ability to manage and perpetuate this native species. A successful rehabilitation project within St. Louis Bay may provide a true "trophy" fishery for anglers, but it will take at least 25 to 50 years. Restrictive regulations will be required to protect lake sturgeon from over fishing and anglers must be informed on the life history and vulnerability of this species.

At present, funding is not available to support a sturgeon stocking program. The WIDNR continues to stock St. Louis Bay with the Wolf Lake strain of sturgeon. Cooperative management could continue with WIDNR supporting the stocking program and MNDNR supporting the assessment program. Levels of contaminants in St. Louis Bay sturgeon and their effects on these fish are presently unknown. Habitat requirements must be determined and habitat must be protected if rehabilitation is to succeed.

VI. Information Needs/Community Interactions

Continue to evaluate survival of lake sturgeon fry stocking. Determine if and when lake sturgeon imprint, so only fish that will "home" are stocked. Information should be collected on the ecology of lake sturgeon while they reside in St. Louis Bay and Lake Superior. Very little is known about their interaction with other species in the community. Aspects of life history such as growth rate, diet, age of maturity and lifespan are all lacking for sturgeon in western Lake Superior.

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*Complete list of all publications in the series available from Minnesota Department of Natural Resources, Division of Fish and Wildlife, Section of Fisheries, Box 12, 500 Lafayette Road, St. Paul, Minnesota 55155-4012.