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FISHERIES MANAGEMENT PLAN FOR THE MINNESOTA WATERS OF LAKE SUPERIOR

Third Edition

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PREFACE

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

> *To protect the Lake Superior ecosystem, rehabilitate and protect its watershed, and manage for a diverse, stable, self-sustaining fish community that provides recreational, commercial, and tribal fishing opportunities.*

The Lake Superior fish community has undergone dramatic changes since the mid-1900s due to over-fishing, introduction of non-native species, pollution, and land use changes in the watershed. Since the 1950s, 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 (*Petromyzon marinus*), which virtually eliminated the Lake Trout (*Salvelinus namaycush namaycush*) in all but a few isolated areas of Lake Superior. Since the 1960s, 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 restoration of healthy fish stocks throughout much of Lake Superior. In Minnesota waters, wild Lake Trout abundance has increased to where stocking for the purposes of rehabilitation is no longer effective and continued stocking may in fact do more harm than good.

The major threats to Lake Superior today are the same threats faced 70 years ago –overexploitation of fish stocks, impacts from invasive species, and habitat degradation. These threats have taken different forms through time and the cumulative impacts have been substantial. In this plan, the reader will find fisheries management strategies interwoven with our knowledge of the impact of these threats and how best to mitigate them for the long-term sustainability of fish stocks.

This plan is a comprehensive guide on how to best manage Minnesota's portion of the Lake Superior fishery. The plan is written for use by both the MN DNR Fisheries Management Section and citizens interested in the management of Minnesota's Lake Superior fishery resource. This plan is based on a fish community approach to fisheries management and highlights why this approach is necessary. The strategies and actions in this plan will focus on the work of the MN DNR Fisheries Management Section over the next decade. 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. 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 the plan is 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. An advisory group that represented fishing clubs, environmental groups, Treaty and Tribal entities, commercial fishing interests, county organizations, and individual anglers was formed at the beginning of the planning process. This group was involved with discussions on all issues, solicited input from their organizations, and reviewed and commented on the draft plan. The plan's usefulness will ultimately be determined by its benefits to the resource and its users. This third edition of a *Fisheries Management Plan for the Minnesota Waters of Lake Superior* (LSMP) is intended to build on the successes of the past plans, address new and emerging issues, and provide a clear path forward for fisheries management on Lake Superior until the revision process begins again in 2024.

CHAPTER 1: INTRODUCTION

> ***"I fish because I love to; because I love the environs where trout are found which are invariably beautiful, and hate the environs where crowds of people are found, which are invariably ugly; because of all the television commercials, cocktail parties, and assorted social posturing I thus escape; because, in a world where most men seem to spend their lives doing things they hate, my fishing is at once an endless source of delight and an act of small rebellion; because trout do not lie or cheat and cannot be bought or bribed or impressed by power, but respond only to quietude and humility and endless patience; because I suspect that men are going along this way for the last time, and I for one don't want to waste the trip; because mercifully there are no telephones on trout waters; because only in the woods can I find solitude without loneliness; because bourbon out of an old tin cup always tastes better out there; because maybe one day I will catch a mermaid; and, finally, not because I regard fishing as being so terribly important but because I suspect that so many of the other concerns of men are equally unimportant- and not nearly so much fun."***
>
> ***-Robert Traver (Anatomy of a Fisherman), 1964***

Although Mr. Voelker's (pen name Robert Traver) gratitude for the lack of telephones on fishing waters would quickly fade were he alive today, the passion he shares with anglers for their sport never will. Minnesota anglers spend $2.8 billion a year on fishing-related recreation, which ranks third in the nation behind only Florida and Texas. The average Minnesotan spends $1,985 per year on fishing (gas, gear, bait, lodging, refreshments, etc.) with about 1% of that expenditure going towards the actual cost of their fishing license. Minnesota anglers' passion for their sport supports large and small businesses alike including hotels, restaurants, resorts, bait shops, large national retail chains, and major boat manufacturers, just to name a few. Minnesota has two catfish capitals, an eelpout festival, an ice-fishing extravaganza worth $150,000, is a major exporter of Lake Superior caviar, and has no less than 27 fish statues ranging from lutefisk to tiger muskie. Minnesota is second to none when it comes to passion for fishing!

Technological advances in fishing gear have made anglers more effective at finding and catching fish. Today's advanced sonar units give anglers the ability to find "structure" to fish, allow anglers to mark tracks and waypoints where they catch fish so they can employ the same successful strategy the next trip, and view the lake bottom with side-scan sonars that produce an actual three-dimensional picture of the underwater world, something that had to be imagined only 10 years ago while we sat in our boats suffering the psychological effects of getting "skunked." Tech-savvy anglers on Lake Superior also have at their disposal daily satellite images to search for murky water which tends to hold baitfish or to find the slight temperature differences that can translate into higher catches of salmon and Lake Trout. If fishing success remains difficult to come by, anglers can peruse the numerous online fishing forums where folks post details about their successful outings including general location, depth fish were caught in, type and color of lure used, speed of boat, as well as other tips, tricks, and suggestions.

Although beneficial to the angler, higher catch rates increase the challenge of managing the fishery within defined goals, particularly with long-lived species such as Lake Trout, which management agencies have been working to rehabilitate in Lake Superior for over 50 years. Wildlife managers can visually count game animals or observe evidence the animals leave behind, require that all harvest of big game be reported, and produce more precise and accurate estimates of hunting's impacts on populations. Forestry managers can cruise timber and estimate board feet within a stand of forest and be reasonably confident those metrics will not change due to movement, behavior, or unaccounted harvest of trees. However, fisheries managers must make decisions based on surveys in environments they cannot see, estimate harvest from a limited sample of angler reports, trust anglers will abide by regulations, and know that at least some anglers and other resource users will challenge the agency's authority or reasoning for existing or new regulations. Regardless of the influences on the management process, the Minnesota Department of Natural Resources is tasked with providing for the long-term sustainability of the fishery resources on Lake Superior as directed by the Minnesota State Legislature.

Beside the effects of recreational and commercial fishing on fish communities, additional impacts from invasive species, watershed impairments, a changing climate, and all the issues that come with large multi-jurisdictional fisheries increase the challenge of managing Great Lakes fisheries. But through continuous development of tools and methods such as using long-term trend analysis from assessment netting, regularly surveying angler harvest, monitoring commercial harvest, creating technological advancements of our own, and adopting the best available science, we have succeeded in rehabilitating Lake Trout stocks, reversing the trend of declining steelhead stocks, and increasing the size of coaster Brook Trout in North Shore streams, to name a few successes.

1.1 GOALS AND GUIDING PRINCIPLES

Fisheries management in the Minnesota waters of Lake Superior is the responsibility of the MN DNR, Section of Fisheries, as directed by the Minnesota State Legislature. The MN DNR mission as stated in *A Strategic Conservation Agenda 2015 – 2025* (MN DNR 2015) is "to work with citizens to conserve and manage the state's natural resources, to provide outdoor recreation opportunities, and to provide for commercial uses of natural resources in a way that creates a sustainable quality of life." This mission complements the MN DNR Section of Fisheries mission which is "to protect and manage Minnesota's aquatic resources and associated fish communities for their intrinsic values and long-term ecological, commercial, and recreational benefits to the people of Minnesota." In the context of the LSMP, "aquatic resources" are defined as the Lake Superior ecosystem and its watershed, which includes water quality, habitat, and the natural communities present within.

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

> *To protect the Lake Superior ecosystem, rehabilitate and protect its watershed, and manage for a diverse, stable, self-sustaining fish community that provides recreational, commercial, and tribal fishing opportunities.*

In the goal statement a "diverse" fish community is one that includes different strains of native and naturalized introduced species that have established themselves through natural reproduction and are presently found in Minnesota waters. "Stable" means that although the abundances 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 such as stocking.

The mission for the MN DNR, the Section of Fisheries, and the Lake Superior Management Plan all stress the need to protect the resource (ecosystem) and provide for appropriate resource use by people. Sometimes resource users' understanding of "appropriate use" conflicts with protection of the resource or ecosystem. When such conflicts occur, the long-term protection of the resource must take precedence, because without a resource to use there can be no sustained public benefit.

The MN DNR uses an ecosystem-based management approach. 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 and most pristine of the Great Lakes and supports 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 lake's environment.
- User groups on Lake Superior have diverse interests and the LSMP 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 expensive compared to other fisheries programs in the state. Although Lake Superior is a unique resource and offers diverse recreational opportunities, these opportunities are subsidized by anglers who do not fish on Lake Superior and thus 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 is evaluated continually. 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 lies within the state of Minnesota. The Great Lakes Fishery Commission facilitates 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 implement this plan, citizen participation will again 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 its success will ultimately be determined by the long-term benefits to the resource and its users.

1.2 FINANCIAL RESOURCES OF THE DEPARTMENT

The MN DNR requires financial resources to carry out its responsibility for natural resource protection and management. The Section of Fisheries budget comes from the sale of fishing licenses, fishing stamps, and federal aid through an excise tax on fishing equipment. Over the last 5 years, an average of 1.067 million fishing licenses and 95,281 trout stamps have been sold annually. Trout and salmon anglers constitute 9% of the total licensed anglers in Minnesota.

1.3 MANAGING SHARED RESOURCES

Two binational commissions exist to address fishery and water resource issues between the United States and Canada. The Great Lakes Fishery Commission (GLFC) was established in 1956 to control Sea Lamprey, coordinate fisheries management, and direct fisheries research on the Great Lakes. In 1965, the GLFC established a Lake Committee for each Great Lake to help facilitate information sharing among agencies. Each agency appointed a representative, typically a senior official, to develop shared fish community objectives, establish appropriate stocking levels and harvest targets, set law enforcement priorities, and formulate management plans (GLFC 1997). The eight U.S. states that border the Great Lakes along with the Province of Ontario, three U.S. intertribal agencies, and several federal agencies developed and are signatory to *A Joint Strategic Plan for Management of Great Lakes Fisheries* (GLFC 1997). Through this plan, agencies commit to cooperation, consensus, strategic planning, and ecosystem-based management on a lake-wide basis so goals and objectives are consistent for each agency.

On Lake Superior waters, Minnesota shares fisheries management responsibility with the states of Wisconsin and Michigan, the province of Ontario, the Great Lakes Indian Fish and Wildlife Commission, the Chippewa Ottawa Resource Authority, the 1854 Treaty Authority, the US Fish and Wildlife Service, and the United States Geological Survey. The *Fish-Community Objectives for Lake Superior* (Horns et al. 2003) were developed in 2003 by the Lake Superior Committee and provide consistent goals and objectives for management of Lake Superior fish stocks. These fish community objectives are the basis on which individual species goals and objectives in this plan were developed.

The International Joint Commission (IJC) is a binational commission formed in 1909 and is similar to the Great Lakes Fishery Commission but focuses on water resource issues between Canada and the United States. The *Great Lakes Water Quality Agreement* (GLWQA) is a commitment between the U.S. and Canadian governments to protect and restore water quality in the Great Lakes and gives the IJC the role of analyzing information, assessing the effectiveness of programs, and reporting on progress toward meeting the objectives of the GLWQA. Within the GLWQA are annexes that provide the purpose and objectives for specific water quality protection and restoration efforts (IJC 2012).

1.4 CLIMATE CHANGE

The impact of a changing climate is already noticeable on Lake Superior with increased surface water temperature and decreased ice cover. The *Lake Superior Climate Change Impacts and Adaptation* report (Huff and Thomas 2014) synthesizes the available science and adaptation strategies for the Lake Superior ecosystem and identifies impacts to the fish community such as decreasing numbers of coldwater fish, increasing numbers of warmwater fish, increased size and growth of Sea Lamprey, and increased abundance of zebra and quagga mussels, among others. This report serves as a valuable tool to better understand the potential impacts of a changing climate on the entire Lake Superior ecosystem and should serve as a reference document for those interested in climate change impacts that are not addressed in this fishery management plan.

1.5 CITIZEN PARTICIPATION

The cornerstone of the Lake Superior planning process has been citizen participation. When the 1996 LSMP was developed, a group of interested citizens, the Lake Superior Advisory Group (LSAG), was formed and was instrumental in developing the plan. That group was reassembled in 2004 and again in 2014 to assist with drafting the second and third editions of the LSMP. In 2015 the LSAG was composed of 26 members. Members of the LSAG represent fishing organizations, environmental groups, tribal resource managers, commercial fishing interests, local governments, watershed groups, Great Lakes Fishery Commission advisors, commercial fishing operators, and individual anglers interested in fisheries management in Minnesota's portion of Lake Superior.

In discussions with members of the LSAG a “kick-off” conference was planned to begin revision of the LSMP. The *Lake Superior Fisheries Conference* was open to all citizens interested in Lake Superior Fisheries management and was held on December 6, 2014. The goal of the conference was to provide information to interested citizens and to identify major issues for the MN DNR and the LSAG to address in the revised LSMP. During the conference MN DNR biologists and invited scientists addressed various aspects of fisheries management in Lake Superior through a variety of brief presentations. Citizens engaged in a one-hour breakout session where they discussed and identified important issues for the MN DNR and the LSAG to address in the revised plan. After the conference, issues identified by the participants were summarized and prioritized based on topic areas. Six meetings were held over a 6-month period with the LSAG where more in-depth information was presented and issues were discussed or clarified. Each member was asked to meet with their respective group and to reply to each of the various issues. All input on each issue was compiled and distributed to all groups involved, including personnel in the Section of Fisheries.

Comments and input from the LSAG varied considerably, with some areas of common agreement and other areas where little or no agreement was apparent. After all the issues had been discussed by the LSAG, each organization’s comments were recorded and summarized. The comment summaries were used by a group of MN DNR fishery managers and biologists who met to compile a set of recommendations to address the various issues raised by the citizens and discussed by the LSAG. These recommendations were crafted into a revised draft LSMP and reviewed by regional and central office fisheries staff. The draft LSMP was distributed to the LSAG for comment and discussion. Comments received from the LSAG were reviewed and the draft LSMP was modified. The draft LSMP was then distributed to the general public for comment and review.

The LSMP is a group effort that has involved many hours of work by many people. Among any diverse group, there are areas of disagreement, but there are also many areas of agreement. The LSMP is expected to focus and stimulate ongoing conversations about future fisheries management for the Minnesota waters of Lake Superior. 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 resources that are being compromised, or (3) shifts in societal values placed on the Lake Superior fisheries resource. We believe the LSMP is a requirement for sound management of the Lake Superior fishery and will ultimately move us closer to the goals we have identified. The passion of Minnesota anglers, conservationists, commercial fishers, and resource professionals involved in the LSMP revision process is admirable and commendable.

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CHAPTER 2: THE LAKE SUPERIOR FISH COMMUNITY

2.1 CHANGES IN THE LAKE SUPERIOR FISH COMMUNITY

The Lake Superior fish community has undergone dramatic changes through time due to overfishing, introduced and invasive species, and habitat degradation. In the late 1800s concern of commercial overharvest in Lake Superior was apparent and habitat degradation from intensive logging operations severely impacted tributaries and embayments, but the native fish community remained relatively intact. Prior to non-native species invasions, the Lake Superior fish community was a relatively simple one with lean Lake Trout (*Salvelinus namaycush*), siscowet Lake Trout (*Salvelinus namaycush siscowet*), Lake Whitefish (*Coregonus clupeaformis*), Brook Trout (*Salvelinus fontinalis*), Lake Sturgeon (*Acipenser fulvescens*), and Walleye (*Sander vitreus*) as the top native predators. Rainbow Trout (*Oncorhynchus mykiss*) had been intentionally introduced in the late 1800s and quickly established self-reproducing populations throughout the lake. The major species of prey fish were Lake Herring (*Coregonus artedi*), chubs (Bloater *Coregonus hoyi* and Kiyi *Coregonus kiyi*) and sculpins (Cottidae).

The Lake Superior fish community has become much more complex since the 1950s, and is now composed of both native species and non-native species that were introduced intentionally or invaded on their own. 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 (for example, Kamloops, Madison, and Donaldson). The non-native Rainbow Smelt (*Osmerus mordax*) was heavily preyed upon by most game fish species, became an important commercial species, and in some areas negatively impacted native Lake Herring recruitment. The most devastating introduction to the Lake Superior community has been the Sea Lamprey (*Petromyzon marinus),* which virtually eliminated Lake Trout through predation in all but a few isolated areas of Lake Superior. A substantial number of invasive species from Europe entered the lake in the 1980s, including Eurasian Ruffe (*Gymnocephalus cernuus*), zebra mussel (*Dreissena polymorpha*), quagga mussel (*Dreissena rostriformis*), and spiny water flea (*Bythotrephes cederstroemi*).

Many changes have occurred in the Lake Superior fish community since 1970. Lake Trout populations have become self-sustaining, with the exception that some localized stocks are still suppressed by a combination of high fishing pressure and Sea Lamprey mortality. The deep-water fish community composed mainly of siscowet, Burbot (*Lota lota*), deep-water chubs, and sculpin remains relatively undisturbed. Pacific salmon populations are now naturalized and self-sustaining, which makes continued stocking ineffective in most areas of the lake. Lake Herring stocks rebounded in much of the lake throughout the 1990s, but consistent recruitment failure and localized commercial overharvest have caused stocks to decline in the late 2000s. From 2006 to 2012, lake-wide prey fish biomass declined to the lowest levels observed likely due to the resurgence of Lake Trout in nearshore waters and infrequent and weak recruitment of Lake Herring and Bloater (*Coregonus hoyi*) (Gorman et al. 2015). Management techniques for prey fish are somewhat limited; regulating commercial harvest and management of game fish stocks have been the primary strategies for prey fish management.

Pacific salmon have spread throughout Lake Superior over the last 30 years. The Chinook Salmon eats more prey per day for each pound of predator than does 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, some anglers prefer salmon to Lake Trout and continue to advocate for salmon-stocking programs.

A number of trends continue in the Lake Superior fish community and appear to be interrelated. In Minnesota, predator abundance has increased, which has resulted in higher predation on young salmonids, including stocked yearling Lake Trout which are not conditioned to avoid predators. Higher predator consumption may also be suppressing other fishes such as Rainbow Trout, Brook Trout, Brown Trout, and salmon. 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. Pratt et al. (*in review*) conclude that declining prey biomass and declining lean Lake Trout abundance and growth are indicators of a maturing, restored Lake Trout-dominated ecosystem, but warn they could also be early warning signs of concern for a sustainable ecosystem.

2.2 INVASIVE SPECIES

Historically, aquatic species invaded the upper Great Lakes at a very slow rate due to the presence of significant natural barriers such as oceans or major waterfalls like Niagara Falls. Since the late 1800s, the United States and Canada have built canals and other means of transport that reduced or eliminated barriers to fish movement from within and through the Great Lakes. Subsequently, improved transportation led to more international trade including the use of large ships to haul cargo through the Great Lakes. Unfortunately, the cargo ships also transported and discharged millions of gallons of ballast water which sometimes contained aquatic invasive species. Major pathways for new species introductions to the Great Lakes remain almost entirely human related. This section will briefly summarize the history and impacts of invasive species on the Lake Superior fish community, and what steps must be taken to minimize future introductions.

At least 139 non-indigenous aquatic organisms (including 25 fish species) have become established in the Great Lakes since the 1980s (Mills et al. 1993). Lake Superior has had the least introductions of invasive species of all Laurentian Great Lakes (Mills et al. 1993), likely due to its lower annual water temperature and primary productivity. Over 66% of all new species introductions to Lake Superior have occurred since 1970. Since 1970, 39 new non-indigenous aquatic organisms have entered Lake Superior which included 9 fish species, 7 aquatic invertebrates, 8 fish diseases and parasites, and the remainder composed of various aquatic plant species (Bronte et al. 2003). All new fish and three of the four aquatic invertebrate species introduced to Lake Superior after 1970 were attributed to inter-lake movement of foreign cargo ships (Bronte et al. 2003). Many of the initial discoveries in the Minnesota waters of Lake Superior occurred in the St. Louis Harbor, the busiest inland port in the United States with over 1,000 vessel trips annually.

The short-term ecological and economic impacts of invasive, non-indigenous species on the native Lake Superior fish communities are well documented (Lake Superior Binational Program 2014). The most recognized and detrimental of all non-indigenous, invasive species in Lake Superior was the Sea Lamprey (*Petromyzon marinus*) in the early 1930s. The Sea Lamprey invasion resulted in hundreds of millions of dollars in loss to fish stocks and in rehabilitation efforts as well as ongoing Sea Lamprey control costs. Sea Lamprey control efforts have reduced Sea Lamprey-induced annual mortality to less than 10% for Lake Trout in Lake Superior. The success of the Sea Lamprey control program may be threatened by an emerging factor within the watershed, which is the loss of dams as barriers to spawning habitat in tributaries. As dams age and deteriorate, agencies, citizen groups, and the communities near the dams must decide to rebuild, remove, or ignore the failing dams. If dams are removed or allowed to fail, Sea Lamprey abundance will increase, which will lead to higher wounding and mortality rates of Lake Superior fish populations and to higher costs related to control efforts. This scenario is currently playing out on the Black Sturgeon River in Canada where angling groups are seeking to remove the Camp 43 dam to allow Walleye and Lake Sturgeon access to historic spawning grounds. Removing the dam would allow Sea Lamprey access to 32 miles of prime spawning habitat which could increase Sea Lamprey abundance in Lake Superior. This may have a greater impact on adjacent Minnesota management zones where currently very few Sea Lampreys are produced.

Other than the Sea Lamprey, most recent introductions of invasive species in the Great Lakes have largely been confined to estuaries, bays, and tributaries. In the Minnesota waters of Lake Superior, introductions were primarily discovered in the St. Louis River Estuary (SLRE). Ruffe (*Gymnocephalus cernuus*), zebra mussel (*Dreissean polymorpha*), White Perch (*Morone americana*), rusty crayfish (*Orconectes rusticus*), and Round Goby (*Neogobius melanostomus*) are examples of invasive species that have become established in the SLRE. The spiny water flea (*Bythotrephes cederstroemi*) and fish hook flea (*Cercopagis pengoi*), non-indigenous predacious zooplankton, have been found throughout the pelagic zone of Lake Superior and prey on native zooplankton, which could disrupt the lower food web and negatively affect recruitment of fish populations that rely on native forage.

The newest aquatic invasive threat appears to be from invasive carp (i.e., Bighead Carp (*Hypophthalmichthys nobilis*) and Silver Carp (*Hypophthalmichthys molitrix*) which invaded the Mississippi River system from flooded aquaculture ponds in the southern United States. The potential impact of invasive carp on the Great Lakes ecosystems is not yet well understood but suitable habitat to support invasive carp populations exists in all of the Great Lakes. The invasive carps are filter-feeders that could potentially disrupt the lower trophic food web and cause major disruptions to sport and commercial fisheries (GLFC 2012).

Prevention of future invasions of non-native species will be critical to ensure protection of the Lake Superior ecosystem. Changes to the Lake Superior ecosystem, particularly at the lower trophic levels, may negatively impact fish populations lake-wide. The effective treatment and management of ballast water from international and inter-lake vessels is critical if new introductions are to be curtailed. The development and continued implementation of public education programs to promote greater awareness of invasive species from all sources, and the general public role in the introduction and movement of non-indigenous species, will also help minimize future introductions.

2.3 ECOSYSTEM-BASED MANAGEMENT

The MN DNR Section of Fisheries is committed to the concept of watershed, ecosystem, and biological community management (MN DNR 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 issue has long been recognized, fisheries management techniques have historically emphasized the species approach because effective techniques for assessing and managing aquatic 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. In the Great Lakes popular recreational fisheries are often in conflict with the integrity of the natural community, and may contribute to instability in the aquatic community. Throughout the Great Lakes many anglers still strongly support management for a favorite species, which are often introduced, and can only be sustained through heavy stocking. Management agencies are often pressured by anglers to deliver their favorite species at larger sizes and in greater numbers on a continual basis. In many areas the situation is compounded because of angler demands for several favorite species.

Since the 1995 LSMP, the MN DNR Section of Fisheries has adopted an ecosystem-based management strategy for the Minnesota waters of Lake Superior fishery. Much progress has been made over the last 20 years in the formulation of ecosystem-based management strategies and citizens' understanding of how the fish community functions. Although anglers still have their favorite species, many have recognized the need to consider the entire ecosystem, and the opportunities or constraints that Lake Superior poses for assemblages of certain fish species. By gaining a better understanding of the ecosystem dynamics in Lake Superior, many anglers have also recognized that their expectations for the Lake Superior fishery far exceeded the reality of what the fish community could produce on a sustainable level. By using an ecosystem-based approach, fish management agencies may reduce the potential for the boom-or-bust fisheries anglers have experienced in the other Great Lakes. Management emphasis on self-sustaining native and naturalized species assemblages, an understanding of their prey base, and adequate protection of habitat will ensure a healthy, sustainable fishery into the future.

The MN DNR will continue to manage for a stable, diverse, self-sustaining sport fishery in Lake Superior. Most species that have been introduced into Lake Superior have become naturalized and are now permanent 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 MN DNR strives to attain a balance between a sustainable Lake Superior fish community, the economics of the fishery, and angler expectations.

A general approach to ecosystem management from a fisheries point of view involves the following (MN DNR 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, focusing 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.

An ecosystem approach to fisheries management improves the chances for success, and the information collected in the process continually leads to improved techniques. Public acceptance of fish management activities has been enhanced by this planned approach to ecosystem-based management, particularly when MN DNR staff communicates frequently and works closely with concerned citizens.

Ecosystem-based management relies upon adequate understanding of predator-prey interactions, impacts and community responses to invasive species, energy flow through the food web, and potential impacts of management strategies. Initial bioenergetics modeling of the fish community in the Minnesota waters of Lake Superior identified critical information needs to adequately understand the dynamics of the Lake Superior fish community (Negus 1995). This modeling effort identified a need for more detailed information on prey biomass, predator abundance, predator diet studies, and predator growth as well as determining the link between fish and the lower aquatic trophic levels to better understanding the Lake Superior food web.

In 2004, initial discussions began on a large lake-wide project known as the Great Lakes Cooperative Science and Monitoring Initiative (CSMI) to address the relationships between all trophic levels in Lake Superior, with the ultimate goal of determining the productive potential of the lake in terms of prey fish abundance and ultimately predator abundance. The field portion of this project began in 2005 and required use of three large vessels and a number of smaller vessels to collect temporal and spatial information over a two-year period. This project was a collaborative effort between the Department of Fisheries and Oceans, Canada, the US Geological Survey, Ashland Biological station, the USEPA Mid-Continent Research Lab in Duluth, a number of scientists from surrounding universities, and most of the fish management agencies on Lake Superior. Information gained from this project was the first all-encompassing study that examined the entire aquatic community and the interactions between trophic levels in Lake Superior. This intensive ecosystem sampling regime is now standard in the Great Lakes on a 5-year rotation (each lake is intensively sampled once every five years).

Ecosystem-based computer models were developed for Lake Superior to assist in understanding the dynamics of the food web and assist in evaluating management options. Kitchell et al. (2000) used an equilibrium mass balance model (Ecopath) with a dynamic food web model (Ecosim) to evaluate ecological consequences of alternative management impacts to the slow-growing native predators and prey (for example, Lake Trout, Burbot, Lake Herring, and Bloater) and the fast-growing exotic predators and prey (for example, Chinook Salmon, Coho Salmon, and Rainbow Smelt). Their evaluation found abundance of prey fish was a key constraint for all salmonids in Lake Superior, and *Mysis* and Rainbow Smelt were important to trophic structure. Strong management actions that disrupt equilibrium in the food web could have negative repercussions on the overall fish community. In 2014, the Lake Superior Technical Committee began to update the Kitchell et al. (2000) ecosystem model to explore how recent changes in fish abundance could be influencing the food web, how the ecosystem may respond to current and potential threats, and how to predict ecosystem responses to potential management actions (Dan Yule, USGS, personal communication).

These ecosystem-based modeling efforts complement the MN DNR's community-based approach of fisheries management on Lake Superior. A community- or ecosystem-based management approach is one that considers information about a wide variety of species from different trophic levels (e.g. plankton, invertebrates, vertebrates) 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 assemblages or aquatic communities (Christie et al. 1987).

The continued use of new technologies and community-based models proposed in this plan will enable us to better estimate, predict, and understand the dynamics of the fish community. As described above, models that help to explain the processes affecting fish communities have been developed and will evolve to serve as useful tools in the future management of the Lake Superior fishery. The application of bioenergetics models (Negus 1995, 2007), ecosystem models such as Ecopath-Ecosim (Kitchell et al. 2000), and statistical catch at age models (Ebener et al. 1989) will allow managers to examine different scenarios at no cost to the resource and at minimal cost to the management agency or angler. The results of different management strategies can be analyzed and demonstrated to other biologists, administrators, legislators, and the public (Jones et al. 1993). As MN DNR gains a better understanding of the Lake Superior fish community it is wise to remember that the overall productivity of the lake will remain essentially unchanged, and the production of a species will largely depend on the critical habitat available, and how well the species is adapted to the Lake Superior ecosystem.

2.4 GENETICS

To create a sustainable fish community the consequences of management actions on the genetic structure of native or naturalized stocks must be considered. A number of studies have described the potential conflict between wild trout management and stocking. Much has been published over the last two decades on the use of stocking to rehabilitate depleted fish stocks (Krueger et. al 1994; Stroud 1986; Hallerman 2003). Significant genetic problems can occur when high numbers of hatchery fish are stocked into waters with remnant wild populations (Ferguson 1990; Evans and Willox 1991; Utter 2003). Specific research targeting restoration of native species by stocking has been conducted on a variety of species (Krueger and Ihssen 1995; Hallerman 2003; Nickum et al. 2004).

Lake Trout populations were historically subdivided into 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 (Meffe 1995). Fortunately, a few remnant 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 has reduced the genetic diversity of Lake Trout now present in Lake Superior. Baillie et al. (2015) found that genetic diversity in Lake Trout declined by 20-36% between 1948 and 2013 and genetic differentiation between Lake Trout ectomorphs has collapsed by 57% since 1959. To prevent further loss of genetic variation they suggested separating management of ectomorphs by location, protecting stocks during spawning season, using extreme caution in regards to stocking as a management tool, avoiding low population abundance, setting fishery regulations by ectomorph, and providing continued control of Sea Lamprey.

Detailed genetic studies by a number of research scientists discuss the potential consequences of stocking on coaster Brook Trout rehabilitation in Lake Superior (Burnham-Curtis 1996, 2001; Wilson et al. 2008). Few wild coaster populations are sufficiently abundant to be used as a source population for gametes. If Brook Trout are stocked to rehabilitate populations, strategies should include maintaining genetic variability and using best management practices for creating broodstock in all hatcheries (Allendorf and Ryman 1987; Miller and Kapuscinski 2003; Cooper 2004). The MN DNR does not currently use stocking of coaster Brook Trout as a management tool for rehabilitation although it is used by other jurisdictions around Lake Superior. Substantial genetic diversity still exists within Brook Trout populations along the North Shore and protection of this genetic diversity is the best way to ensure long-term persistence of coaster Brook Trout (Burnham-Curtis 2001). Stocking hatchery-reared Brook Trout where wild brook trout populations exist may reduce the overall genetic diversity of North Shore populations.

Studies on West Coast steelhead and salmon have described the negative consequences that domesticated hatchery fish have on wild stocks (Chilcote et al. 2011). Based on studies conducted by MN DNR research biologists and university scientists, hybridization between Kamloops and wild steelhead is a risk in Lake Superior and would likely be detrimental to wild steelhead rehabilitation efforts through dilution of steelhead gametes. Initial studies at the University of Minnesota have indicated lower survival of fry produced from hatchery-reared steelhead than steelhead fry produced by wild Knife River steelhead (Caroffino et al. 2008). Additional genetic information on Rainbow Trout can be found in Chapter 8 of this plan.

2.5 SUMMARY

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

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CHAPTER 3: HABITAT

3.1 WATER QUALITY

The Federal Water Pollution Control Act of 1948 was the first major U.S. law addressing water pollution. It was amended in 1972 and became known as the Clean Water Act (CWA). Because water pollution does not stop at international boundaries, the Great Lakes Water Quality Agreement of 1972 (GLWQA) was signed as a formal international agreement between the U.S. and Canada that reflected the commitment of the two countries to protect and restore water quality in the Great Lakes. The CWA and GLWQA required the United States Environmental Protection Agency (EPA) to establish water quality criteria for the Great Lakes addressing 29 toxic pollutants and identify maximum levels of these pollutants that are safe for humans, wildlife, and aquatic life. If pollution measurements exceed maximum levels, a water body is defined as "impaired" and a Total Maximum Daily Load (TMDL) study is developed to assist in meeting water quality standards. The EPA's Lake Superior Lakewide Management Plan (LaMP) (2004) is the primary plan of action to achieve the goals of the CWA and GLWQA in open lake waters.

In Minnesota, the Clean Water Legacy Act of 2006 appropriated $25 million to increase monitoring and assessment of the EPA's water quality standards and in impaired waters conduct TMDL studies to set pollution reduction goals and implement corrective measures. The Minnesota Pollution Control Agency (MPCA) is tasked with the monitoring and assessment of water quality through the Federal Clean Water Act and the State of Minnesota Clean Water Legacy Act. The MPCA also developed the Lake Superior Basin Plan (MPCA 2004), a watershed approach to managing the Lake Superior Basin. The plan extended the local initiatives and plans that already existed, and was developed to address increasingly complex water quality problems. The Lake Superior Basin Plan defines strategies, priorities, and goals for management of water resources in the Minnesota portion of the lake. The Lake Superior Basin Plan also sets guidelines and recommendations to restore degraded resources, and protect the high quality of water in the basin.

3.2 LAKE SUPERIOR HABITAT

Much of the Lake Superior basin is composed of bedrock overlain with a thin layer of relatively infertile soil, so the runoff is very low in nutrients. The temperature of the lake water remains low, which affects the growth of organisms at all trophic levels. Factors such as these limit the productivity of Lake Superior and the fisheries that it can support. Farther to the south, ice-age glaciers removed less material and also deposited nutrient rich materials, which resulted in more fertile waters compared to Lake Superior. Primary productivity in Lake Superior is one-half or less than in the other Great Lakes (Horns et al. 2003). Although activities within the basin, as well as contaminants from point and non-point sources, can alter the habitat in the lake, most of the impact to fish habitat has occurred in tributaries rather than in the lake, due to the lake's large size relative to the small size of its watershed.

Historically, Lake Superior has been impacted by the following factors: point source pollution from industrial discharges, sewage effluent, urban development, and sedimentation in urban areas such as the St. Louis River corridor; dumping of mine tailings into nearshore areas; airborne contamination of mercury, PCBs, and other toxicants from outside the area; and invasions by non-native aquatic species. Throughout the Lake Superior basin, point source pollution has been greatly reduced in the last 30 years. For example, from 1955 to 1970, the Reserve Mining Company dumped tons of iron ore tailings into the lake at Silver Bay years before being forced to dump the waste into ponds. To improve conditions in the St. Louis River, the Minnesota legislature created the Western Lake Superior Sanitary District (WLSSD) in 1971. The WLSSD Wastewater Treatment Plant was initially commissioned in 1978 and the continuously improving effluent treatment has led to lower nutrient input into the St. Louis Estuary, which has produced habitat and water conditions that are more suitable for various fishes. The U.S. Environmental Protection Agency (USEPA) designated the St. Louis River as an Area of Concern (AOC) in the Great Lakes Water Quality Agreement of 1987. This designation, and the accompanying funding, enticed State, Federal, and Tribal agencies to pour substantial resources into correcting the significant damage that had occurred from industrialization and from lack of water treatment along the St. Louis River. In early efforts, the Lower St. Louis River Habitat Plan established conservation goals to facilitate the protection of the ecological diversity of the river (SLRCAC 2002). The river's cleanup is now being addressed through the St. Louis River Remedial Action Plan (RAP).

On a larger scale, atmospheric and other non-point sources of pollution continue to produce contaminant loads for fish and wildlife in the lake. The MN DNR, Minnesota Pollution Control Agency (MPCA), and Minnesota Department of Health (MDH) monitor contaminant levels of most Lake Superior fish species. Contaminants such as polychlorinated biphenyls (PCBs) and mercury concentrations in Lake Trout decreased by 60-80% from 1990 to 2005 (Gorman et al. 2010a), but health consumption advisories still remain.

The Great Lakes Fishery Commission has recently reclassified Lake Superior habitat into three zones: offshore, nearshore, and inshore. Each zone supports a characteristic trophic structure and fish community (Gorman et al. 2010b) and the habitat in each zone varies considerably. The offshore habitat includes waters that are greater than 260 feet deep and cover about 77% of the surface area in Lake Superior. The offshore fish habitat is mostly pelagic rather than benthic, particularly for fishes that currently interest fisheries managers. The nearshore habitat includes waters that are 45 to 260 feet deep and covers roughly 16% of the surface area in Lake Superior. The nearshore habitat is a mix of pelagic and benthic areas, and many species use this zone regularly or intermittently. The remaining inshore zone includes waters less than 45 feet deep and covers 7% of the surface area. The inshore zone includes riparian areas, bays, estuaries, and tributaries and the substrate is the major component of fish habitat. In Minnesota's portion of Lake Superior, the inshore and nearshore zone combined composes approximately 10% of the total surface area, while the offshore zone makes up about 90%. The inshore zone in Minnesota includes the St. Louis Estuary, which is a significant part of the habitat in this category. The major sport and commercial fisheries in Lake Superior are located in the inshore and nearshore zones and many fish species use inshore and nearshore habitats to spawn (e.g., Lake Trout, Lake Herring, Lake Whitefish, and Round Whitefish).

3.2.1 GOALS AND OBJECTIVES (2016-2025)

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

Objectives:

1. Work with MN DNR Division of Ecological and Water Resources (EWR), MPCA, and other agencies and citizen groups to reduce habitat degradation in the Lake Superior watershed through the regulatory process.
2. Work with EWR, 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.
3. Protect, restore, and enhance riparian areas in the Lake Superior watershed.
4. Work with federal, state and local governments, along with citizens to prevent the introduction and spread of unwanted invasive species and assist, when feasible, with the protection and restoration of water quality in Lake Superior.
5. Encourage citizens to request reductions in climate-warming pollutants.
6. Work to increase the awareness among environmental agencies, local governments, and citizens of the effects of contaminants on Lake Superior fisheries. Work in cooperation with, and encourage to the extent possible, the Lake Superior Partnership (previously known as the Lake Superior Binational Program), MPCA, USEPA, and other agencies to reduce contaminant input into Lake Superior from all sources.
7. Identify and quantify spawning areas and other critical habitats in Lake Superior so these areas can be monitored and protected.

3.2.2 JUSTIFICATION

Objective 1: Work with MN DNR Division of Ecological and Water Resources (EWR), MPCA, and other agencies and citizen groups to reduce habitat degradation in the Lake Superior watershed through the regulatory process.

Unimpaired habitat is critical for a productive, diverse, self-sustaining fish community. When habitat for a species is degraded or destroyed, the species will be affected and local populations may disappear. The loss of a species can affect the integrity of the entire community. In Lake Superior, habitat includes thermal and oxygen conditions as well as substrates. Substrate habitat destruction has been lessened through various regulatory policies and actions; however, future protection of fish habitat is necessary to ensure the persistence of the fish community in Lake Superior for present and future generations. Although habitat in Lake Superior has been degraded less than in other Great Lakes, the Lake Superior watershed continues to be developed through increased access to land that is then modified for residence and businesses. This development will occur with little impact on the lake when existing protective policies are enforced, policies that minimize erosion and instability from construction.

Objective 2: Work with EWR, 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.

Adequate zoning and development codes exist in North Shore jurisdictions to protect the fishery resources from human activities. However, future demand for development could result in weakened regulations, particularly along the North Shore and in the upper portions of the Lake Superior watershed to the north. The various agencies involved in setting regulations, including the MN DNR, local units of government, and the North Shore Management Board, should be encouraged to maintain regulations that effectively limit runoff.

Objective 3: Protect, restore, and enhance riparian areas in the Lake Superior watershed.

The Lake Superior watershed near the shoreline is covered in many places by highly erodible clay soils. Lake Trout spawning habitat may be prevalent near the shoreline and thus may be vulnerable to siltation from shoreline runoff. Shoreline development should be monitored through the MN DNR permitting process for all work done below the high-water mark. Also, better protection of the shoreline will occur when local units of government collaborate with the MN DNR when reviewing development plans.

Objective 4: Work with federal, state and local governments, along with citizens to prevent the introduction and spread of unwanted invasive species and assist, when feasible, with the protection and restoration of water quality in Lake Superior.

Habitat can be altered not only by local development actions, but also by invasive species. One such invasive species, the zebra mussel, was brought into Lake Superior via ballast water from ocean-going ships and became established in bays and harbors. Zebra mussels have changed the substrate composition dramatically in other lakes and have altered prey dynamics enough to affect interactions among game fishes (Miehls et al. 2009). The cold and nutrient-poor environment in Lake Superior limits zebra mussels; however, climate warming may yield more rapid nutrient cycling and warmer water, which may lead to enhanced growth and survival of zebra mussels on shoals and the potential for negative impacts on spawning habitat for Lake Trout. In a warming climate, other species may also become established in the lake and influence the fish community. Ballast water is a primary pathway for invasions of non-native species (Rup et al. 2010). Ocean-going ships continue to transport ballast water from overseas, despite concerns about invasive species. The participants in this Plan encourage local, state, and federal agencies to pursue more strict ballast water regulations so that additional invasions are prevented.

In past decades, local and regional governments constructed dams on tributaries and near Lake Superior. Over time many of these dams have degraded and are expensive to replace. Many of these dams are being removed, which increases connectivity between the lake and the upstream areas of tributaries. Connectivity enhances the populations of certain gamefishes such as Walleye and Lake Sturgeon; however, connectivity also increases access to gravel and rubble habitat for spawning Sea Lamprey and the nursery habitat for young lamprey, or ammocoetes. Increased production of Sea Lamprey may lead to substantially increased costs for Sea Lamprey control in these newly exposed spawning and nursery areas. For example, the Camp 43 dam, located 10 miles upstream on the Black Sturgeon River, cuts off access to spawning habitat for native migratory fishes. Removing the dam would reinstate access to naturally occurring spawning habitat, an essential step in the large-scale rehabilitation of the Black Bay and Black Sturgeon River native fish community. Populations of several migratory fish species would benefit, including Walleye, Lake Sturgeon, and coaster Brook Trout. Removal of the dam will also result in the infestation of 32 miles of the Black Sturgeon River as well as four tributaries to the Black Sturgeon River by Sea Lamprey, and result in an incremental increase in parasitic Sea Lamprey in Lake Superior. Costs for lampricide treatment in the Black Sturgeon River are likely to be high relative to the Lake Superior control budget for Sea Lamprey. The added expense may result in less treatment in other streams that are closer to Minnesota, which could lead to substantially more lamprey predation on Lake Trout in Minnesota.

Careful consideration should be given to the potentially high cost of removing dams, and more consideration should be given to creating other structures, such as low-head dams, that inhibit Sea Lamprey movement but allow other fishes to move upstream to spawn. Sea Lamprey abundance may also increase in habitats that are improved for gamefishes, habitats such as the spawning area that was constructed to increase Lake Sturgeon spawning success in the St. Louis River.

Objective 5: Encourage citizens to request reductions in climate-warming pollutants.

Changing climate conditions will also impact efforts to protect and restore Lake Superior. Warmer conditions and other effects of climate change will increase the susceptibility of Lake Superior ecosystems to invasive species (Kling et al., 2003), drive changes in species composition (Cline et al. 2013), and disrupt the water balance (Hall et al., 2007; Chiotti and Lavender 2008). Wuebbles and Hayhoe (2004) predicted that temperatures in the Lake Superior basin will increase approximately 2 to 4 ºC (3.6 to 7.2 ºF) in winter and 4 to 6 ºC (7.2 to 10.8 ºF) in summer by 2070-2099, relative to 1961-1990 average values. Wang et al. (2012) concluded that Lake Superior ice cover decreased by a rate of 2% per year for the period 1973-2010, for a total decrease of 79% over the course of the 37-year analysis period. Rook et al. (2013) found that Lake Herring recruitment was positively correlated with warmer spring temperatures. Climate change is likely to increase the capacity of the lake to support fishes that anglers prefer (Cline et al. 2013). However, warmer temperatures could also allow more non-native species to become established and negatively impact Lake Herring survival, much as Rainbow Smelt did during the middle of the 20th century.

Objective 6: Work to increase the awareness among environmental agencies, local governments, and citizens of the effects of contaminants on Lake Superior fisheries. Work in cooperation with, and encourage to the extent possible, the Lake Superior Partnership (previously known as the Lake Superior Binational Program), MPCA, USEPA, and other agencies to reduce contaminant input into Lake Superior from all sources.

Although not strictly a habitat issue, reductions in contaminants will benefit the citizens' use of the Lake's fishery resources. Contaminants, and especially persistent toxic chemicals, limit the safe use of fish by humans. Without a safe food source from Lake Superior, the public is less likely to support actions to protect the fish community, which could lead to reduced habitat protection and an eventual decline in a self-sustaining fish community. Increased contamination could lead to requests for other, less sustainable species. For example, current advisories suggest that Lake Trout less than 22 inches can be safely eaten once per week, 22-37-inch Lake Trout should only be eaten once per month, and Lake Trout greater than 37 inches should be eaten less than once every two months (MDH 2015). Consumption of the faster-growing salmon is less restrictive and the dietary guidelines limit consumption to one meal per week for most salmon. Although Lake Trout in Lake Superior accumulate higher contaminant loads than other predators, Lake Trout are the best- adapted top predators in the Lake Superior ecosystem. Trying to replace them with shorter-lived species with lower contaminant loads would only address a symptom of the problem and, as demonstrated, management efforts have had limited success. Our major objective with respect to contaminants is to encourage continued reductions of contaminants, potentially to zero (Horns et al. 2003), in the diets of citizens who use the fishery resources consumptively.

Objective 7: Identify and quantify spawning areas and other critical habitats in Lake Superior so these areas can be monitored and protected.

Lake Superior is vast; however, much of the Lake Trout spawning area is limited to offshore and inshore shoals. The inshore shoals are vulnerable to siltation and other debris that can kill eggs. Richards et al. (1999) mapped potential spawning habitat along the North Shore. Potential spawning habitat was identified throughout a substantial portion of the shoreline. The available habitat should be surveyed to find the most-used areas, which should then be protected by enhancing the monitoring of permit applications in habitat that has been identified as high-quality spawning habitat.

3.2.3 INFORMATION NEEDS

The quality and quantity of habitat determine species productivity and affects fish community structure. The Lake Superior Technical Committee has formalized evaluation of the linkages between habitat and productivity, as part of the *Fish-Community Objectives for Lake Superior* (Horns et al. 2003). Management agencies within the Lake Superior basin evaluate the habitat-productivity linkages to better predict productivity and fish community composition and to protect the most valuable habitat as the fish community changes and as environmental conditions change. For the sport and commercial fisheries of Lake Superior, knowledge is most lacking regarding the spawning and nursery habitat for Lake Trout. Such knowledge is also lacking for coaster Brook Trout and Lake Herring. After identifying what the most valuable habitat looks like, suitable habitats should be measured and mapped to support future protection efforts and to measure the potential fish production of the managed species. For example, management agencies could use more information about Brook Trout nursery habitat to determine the relative importance of stream and nearshore lake habitats. New techniques are being developed for fisheries science, and as they prove effective they should be applied to the management of the Lake Superior ecosystem.

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"A river is the report card for its watershed."

-Alan Levere, Connecticut Department for Environmental Protection, 2000.

3.3 TRIBUTARY HABITAT

3.3.1 BACKGROUND

This section outlines MN DNR's goals for protecting, restoring, and remediating fisheries habitat in Minnesota's tributaries to Lake Superior. It defines a new approach of evaluating watershed and stream health and then correcting the systemic causes of historic stream degradation in a manner that addresses the five-component framework adopted by the MN DNR in 2006 (online: http://www.dnr.state.mn.us/whaf/index.html). This chapter outlines the values of preliminary, comprehensive watershed assessments which are in line with the Great Lakes Fishery Commission's fish-community objectives for habitat in Lake Superior (Horns et al. 2003), and which support the MN DNR's Section of Fisheries mission as stated in Section 1.1. This chapter also redefines the MN DNR's focus for habitat protection and restoration in the Minnesota waters of the Lake Superior basin. Sediment and stream reach stability problems have traditionally been treated by fixing symptoms rather than by fixing the problem. Early stream projects often hardened stream channels with rip-rap to reduce localized bank erosion or to mitigate flooding and rarely incorporated broad geomorphic and ecological principles. Now, habitat restoration, enhancement, and protection incorporate new understandings of the cumulative watershed impacts of land use-related changes on stream function to produce the most sustainable reparations.

In the simplest terms, a stream is formed by water running off the surrounding landscape and the geology that lies under its bed. The width, depth, flow, shape, and substrate of the stream are all dictated by the processes occurring in its watershed. In undisturbed and historically old watersheds, the attributes of a stream change slowly because the processes that form the stream are consistent. A stream is considered to be stable when it transports its water and sediment without eroding its bed and banks (i.e., degrading) or depositing excess sediment (i.e., aggrading) in response to current hydraulic and environmental conditions. Without drastic changes in its environment, a stable channel typically maintains its form and function, including the structure and diversity of its habitat, and maintains the reconstitution of natural aquatic ecosystems (Doll et al. 2003). Disturbances within the watershed, such as large-scale clear-cutting of the forest, cause the river to change its shape in response to increased or decreased runoff. For example, Sebestyen et al. (2011) reviewed 50 years of watershed studies at the Marcell Experimental Forest in Itasca County, Minnesota, and found increased velocity and volume of episodic stream flows (2 to 3 times greater storm peaks) after forest harvesting; this effect decreased as the forest regrew to maturity over 15 years of age. More and faster water runoff produces a larger stream channel through erosion of the stream's bed and banks (Nieber et al. 2008). The bed and banks of the stream continue to erode until the shape of the channel matches the amount of water running off the landscape (Rosgen 1996). Unfortunately, the process for an unstable stream (responding to changes in its watershed) to find stable form and function can take decades or even centuries. During this period of stream evolution, habitat degradation increases, negatively impacting organisms in the stream as well as the organisms relying on the stream for food, water, transportation, and recreation.

Streams can become unstable due to changes in streamflow, vegetative cover, percent impervious surface, surface disturbance, sediment supply, and direct alteration to stream channels. Instability in physical characteristics can lead to impairments and loss of biological function which leads to negative impacts on fishes and their environment. Along the North Shore, human expansion and watershed development led to extensive timber harvest, forest fires, filling of wetlands, channelization of streams, and construction of impassible dams. As disturbances restructured the landscape (watersheds), streams were forced away from efficient, stable forms. Significant changes occurred in the rivers' geomorphology (dimension, pattern, and profile), hydrology (flow duration, frequency, and timing), water quality, biology, and connectivity (lateral: connection to its floodplain; longitudinal: along the entire length of the stream; and vertical: groundwater and surface water interactions). As streams continually adjusted in search of their stable form, stream channel instability caused excess sediment deposition and severe biotic impacts on food chains, spawning and rearing habitat, instream cover, and water temperatures. Predictably, many Lake Superior fish populations that relied on stream habitat have declined or disappeared. The cumulative loss of habitat quality, quantity, and river process that once sustained habitat for stream fishes before European settlement had a major influence on the decline of fish species in the tributaries of Lake Superior (e.g., coaster Brook Trout).

Much of the habitat degradation in the Lake Superior basin is apparent in tributaries, embayments (harbors), and nearshore waters that harbor important sport and commercial fisheries. Tributaries and nearshore waters are diverse and contain important nursery and rearing habitat for migratory fish species including coaster Brook Trout, Brown Trout, Lake Sturgeon, Rainbow Trout, Pacific salmon, and Walleye. Management and rehabilitation of migratory fish populations in the Minnesota waters of Lake Superior have been manipulated in many ways (e.g., fish stocking, modification of barriers, and regulation of harvest). Although some populations showed short-term rebound, progress of rehabilitating fish populations has been slow. This is likely due to a focus on the basic consequences of habitat degradation (e.g., decline in sport fish numbers) and implementing management strategies to address the consequence (e.g., stock more sport fish) rather than the underlying processes causing the population decline (i.e., habitat degradation).

For example, the first documented stream habitat improvement efforts in Minnesota tributaries of Lake Superior began in the 1930s with the Civilian Conservation Corps, which was a work relief program for unemployed, unmarried men as part of President Franklin D. Roosevelt's New Deal that provided unskilled manual labor jobs related to conservation and natural resources. Most of these efforts included placement of structures such as rock rip-rap for erosion control (small rocks worked by hand), a small number of log cribs, wood and rock deflectors, Hewitt ramps, rock dams, and cover rocks. Log dams, stream-side fencing, tree plantings, stiles, floodgates, digger logs, and spawning areas were also used. Larger equipment was eventually used to place larger sized rocks for rip-rap and build lunker structures. Many natural structures, such as waterfalls, were modified to improve fish passage. By the 1990s, projects included the use of natural structures (e.g., large wood logs and root wads) for cover and erosion control. Over time, resource managers have learned how stream habitat improvement projects can be built to better maintain proper stream stability and function. Unfortunately, many historic structures were designed and installed without an understanding of stream process and function, and many failed to meet project goals (e.g., reduce erosion, improve habitat). Although many historic structures still exist in Lake Superior tributaries, some continue to disrupt natural stream process and reduce aesthetic, recreational, and natural resource values.

Resources available to address habitat degradation issues were substantially enhanced by the Clean Water Legacy Act of 2006 (CWL) and the Clean Water Land and Legacy Amendment of 2008 ("Legacy Amendment"). The Legacy Amendment is a voter-approved amendment to the Minnesota constitution to raise the sales tax by 3/8 of one-percent with proceeds going to protect drinking water sources; to protect, enhance, and restore wetlands, prairies, forests, and fish, game, and wildlife habitat; to preserve arts and cultural heritage; to support parks and trails; and to protect, enhance, and restore lakes, rivers, streams, and groundwater. The Outdoor Heritage Fund (OHF) appropriated 33% of the annual Legacy Amendment funds to restore, protect, and enhance habitat for fish, game, and wildlife, and prevent forest fragmentation, encourage forest consolidation, and expand restored native prairies. The Lessard-Sams Outdoor Heritage Council (LSOHC) was established by the legislature with the responsibility of providing annual funding recommendations from the OHF that are consistent with the constitution and state law. Prior to the OHF, limited monetary resources were available for habitat improvement projects. In its first four years (2010-2013), the Clean Water Legacy Act provided about $6.25 million to implement projects that were related to water resource protection in the Lake Superior watershed. The Legacy Amendment will provide millions of dollars for at least the 25 years for which it has been established (http://www.legacy.leg.mn/funds/outdoor-heritage-fund).

3.3.2 MANAGEMENT HISTORY (1996-2015)

The MN DNR's long-standing goal for tributary habitat has been to protect, restore, and enhance the quality and quantity of fisheries habitat in the Minnesota waters of Lake Superior. Budget and time constraints have historically been the MN DNR's biggest limiting factor in achieving that goal. For instance, one objective in the 2006 plan was to identify and prioritize degraded reaches on North Shore tributaries. Unfortunately, MN DNR had limited resources to achieve this objective. Had this objective been achieved, a list of habitat restoration projects would have been generated and available to any partners interested in stream habitat improvement work. Instead, many groups had to begin stream improvement efforts based on experience and best judgement alone, without guidance to suggest where they could provide the best ecological and economical outcomes. This approach has left a patchwork of habitat improvement projects that have not addressed the underlying mechanisms of stream habitat degradation nor considered watershed scale impacts, leaving them more susceptible to failure.

In 2006, the MN DNR adopted the Watershed Health Assessment Framework (WHAF) that provides a comprehensive overview of the ecological health of Minnesota's watersheds. In the WHAF, health scores are used to provide a baseline for exploring patterns and relationships in emerging health trends in Minnesota. Natural resource systems are summarized into five ecological components: hydrology, geomorphology, biology, connectivity, and water quality. The five-component framework for evaluating the health (quality) of a stream system is applied in a Watershed Assessment Tool (http://www.dnr.state.mn.us/watershed_tool/index.html) with health scores and the condition for major watersheds (HUC 8; N=81) and some catchments (sub-divided HUC-12; N=10,000+) in Minnesota.

In 2008, the MPCA adopted a watershed approach to restoring and protecting Minnesota's rivers, lakes, and wetlands that complements its work on impaired waters. This watershed approach was recommended by Minnesota's Clean Water Council and directed by the Minnesota Legislature. This approach centers on intensive monitoring of each of Minnesota's 81 major watersheds on a continuous 10-year cycle. A primary product of this effort is the development and application of a Watershed Restoration and Protection Strategy (WRAPS) that contains strategies and actions designed to achieve and maintain water quality standards and goals. Partnerships with state agencies (including DNR) and various local units of government are critically necessary to the development and implementation of the WRAPS (http://www.pca.state.mn.us/index.php/water/water-types-and-programs/surface-water/watershed-approach/index.html).

In 2012, the Minnesota legislature passed the One Watershed, One Plan (1W1P) program, developed by the Minnesota Board of Water and Soil Resources (BWSR), allowing local governments charged with water management responsibility, to organize and develop focused implementation plans on a watershed scale. The vision for 1W1P is to align local water planning on major watershed boundaries with state strategies towards prioritized, targeted, and measurable implementation plans in Minnesota. The BWSR recently developed pilot watershed areas to organize and develop watershed-based plans to help develop, test, and inform the 1W1P program framework, policies, criteria, and guidance. One of these pilot areas is on the northeast end of the North Shore (http://www.bwsr.state.mn.us/planning/1W1P/index.html).

The MNDNR Fish Habitat Plan was recently initiated by the MN DNR Section of Fisheries. The Fish Habitat Plan was initiated to protect, enhance, and restore fish habitats in lakes and streams of Minnesota, with intent to advocate for fish habitat protection, enhancement, and restoration within the context of each partner's authority and scope of work. The objectives are to establish landscape scale conservation zones, engage partners, prioritize project areas, project identification and tool selection, track results, education, affect changes in natural resource policy, and learn and adapt (http://files.dnr.state.mn.us/fish_wildlife/fisheries/habitat/2013_fishhabitatplan.pdf).

3.3.3 GOALS AND OBJECTIVES (2016-2025)

Goal: Protect, restore, and enhance the quantity, quality, and diversity of habitats that support the expression of distinct life histories, evolutionary legacies, or key production areas for fish in the Minnesota tributaries of Lake Superior.

Objectives:

1. Continue to protect sensitive riparian and stream habitats through purchase of conservation easements from willing landowners.
2. Assist in coordination, development, and facilitation of integrated natural resource watershed plans and demonstrate, advocate, and promote the use of Outdoor Heritage Funds for comprehensive integrated natural resource watershed planning to the Lessard-Sams Outdoor Heritage Council.
3. Continue to consult with groups using Outdoor Heritage funds so resources are best allocated to maintain or improve fisheries resources in the Minnesota waters of Lake Superior.
4. Continue to require completion of the MN DNR– Section of Fisheries Checklist for Stream Habitat Improvement Projects on MN DNR easements and fee title lands.

5. Work with appropriate agencies and citizens to identify watershed impairments, to identify, prioritize, and restore degraded stream reaches in Lake Superior tributaries, and utilize the Rosgen Classification System (Rosgen 1994a) and the Natural Channel Design approach (Rosgen 1994b; Rosgen 1996).
6. Require use of Natural Channel Design in the assessment and design of stream habitat improvement projects on MN DNR easements and MN DNR fee title lands. Require justification as to how habitat improvement projects will address the five components of ecosystem health (connectivity, geomorphology, water quality, biology, and hydrology) on MN DNR easements and MN DNR fee title lands. Develop evaluation criteria for post-project assessment, if feasible.
7. Assess biological (fish) community response to habitat improvement projects, when feasible.
8. Protect water quality and riparian areas near streams and wetlands by working with forest managers to ensure best management practices, as outlined in the Minnesota Forest Resource Council (MFRC) site-level forest management guidelines (MFRC 2013), are understood and implemented.
9. Maintain or restore stream channel stability and function, and the natural hydrological regimes on which they depend, by encouraging land managers to work cooperatively in considering the percent open land in watersheds when making management decisions.

3.3.4 JUSTIFICATION

Objective 1: Continue to protect riparian and stream habitats through purchase of conservation easements from willing landowners.

Conservation easements provide a cost-effective tool to protect increasingly threatened land and water resources, preserve fisheries habitat, and safeguard waters and shoreland in Minnesota. The easement program was developed with the basis that protecting unimpaired habitat is significantly cheaper than restoring degraded habitat. Protection of unimpaired tributary habitats is essential for the persistence of Lake Superior fish populations, particularly for species with migratory life-history forms that require tributary habitat at some stage of their life (e.g., coaster Brook Trout, steelhead Rainbow Trout, Lake Sturgeon).

The Minnesota DNR has increased conservation easements on trout streams along the North Shore which provides anglers access to the stream and provides the MN DNR and partners with opportunities to improve stream habitats. In 2011, MN DNR initiated a riparian easement acquisition program on Lake Superior tributaries with a $200,000 grant from the National Fish Habitat Initiative-Great Lakes Partnership and approximately one million dollars from the LSOHC. The MN DNR purchased easement rights in the riparian corridors of trout streams in the Lake Superior watershed from private landowners. These are perpetual easements, meaning they never expire. Acquiring and preserving riparian easements helps ensure that future generations of anglers have access to North Shore streams. The project was completed on July 1, 2014. Land ownership was mapped on 60 Lake Superior tributaries spanning 764 miles of stream along the North Shore. Of the 764 river miles, 246 are under private ownership. The program has agreements with 31 landowners to purchase 12.04 river miles that will protect 232 riparian acres and add 21 new angler access points at an estimated cost of $812,004.85. The easements will also connect over 95 miles of currently unconnected public river miles. Purchasing conservation easements expands opportunities to restore and maintain natural resource values on private lands while benefitting wetlands, reducing soil erosion, reducing phosphorus and nitrogen loading, improving wildlife habitat, and creating opportunities to improve aquatic and terrestrial corridors and permanent riparian buffers. Some Lake Superior tributaries have been listed on Minnesota's Impaired Waters List (e.g., Knife River TMDL 2011), and await restoration.

The conservation easement program maintains cooperation between MN DNR and other local government entities (e.g., SWCDs, USDA Natural Resources Conservation Service [NRCS], Minnesota Board of Water and Soil Resources [BWSR]), and allows others to utilize MN DNR easements in their watershed or stream restoration programs. The program also fulfills objectives in Annex 7 of the 2012 Great Lakes Water Quality Agreement: *"to contribute to the achievement of the General and Specific Objectives of this Agreement by conserving, protecting, maintaining, restoring and enhancing the resilience of native species and their habitat, as well as by supporting essential ecosystem services* (https://binational.net/annexes/a7/)."

Objective 2: Assist in coordination, development, and facilitation of integrated natural resource watershed plans, and demonstrate, advocate, and promote the use of Outdoor Heritage Funds for comprehensive integrated natural resource watershed planning to the Lessard-Sams Outdoor Heritage Council.

Integrated natural resources management at the watershed scale is needed to protect, rehabilitate, and restore fisheries and degraded stream habitats. A river's response to past watershed use and its current stream habitat stability and form is an important but often overlooked component in fisheries management. A comprehensive watershed plan with detailed stream inventory will help resource managers better understand how streams responded to past watershed activities and determine what restored stream segments should look like in their stable form under the current conditions. This will provide a structured prioritized plan with specific defined goals and objectives that can help stakeholders and resource managers prioritize future habitat work in a watershed. Ultimately, this plan will help to determine how MN DNR can improve fish habitat and prevent future habitat degradation in Lake Superior tributaries.

When possible, the MN DNR will help to formulate and guide an integrated natural resource management group during watershed planning processes so that the plans will accomplish objectives for multiple users of the watershed. The integrated group is essential to ensure that land managers (Federal, State, local, and private) are aware and willing participants during development of these plans. The group should involve all pertinent land and resource managers (e.g., local SWCD, EWR, MPCA, USEPA, university representatives, other environmental agencies), including other local stakeholders and citizens. Expertise and experience from this group should be used to determine habitat restoration priorities in the watershed. Using the integrated approach, watershed plans can then be used as a guide for future habitat restoration in the watershed of interest, and a valuable resource for stakeholders applying for OHF and other grants.

Watershed plans should incorporate pertinent supporting documents from other agencies (e.g., MPCA TMDL impaired waters list, MPCA 2012) and local stakeholder and landowner inputs to prioritize watershed and stream work, and provide baseline data required for future restoration of degraded stream habitats. The plan should incorporate quantifiable methods of watershed assessment such as Watershed Assessment of River Stability and Sediment Supply (WARSSS; Rosgen 2006), and others that can utilize and complement other works (e.g., MPCA TMDLs and WRAPS, MPCA Lake Superior Basin Plan 2004, Lake Superior LaMP (Lake Superior Binational Program 2008), 1W1P, MN DNR Fish Habitat Plan 2013). At a minimum, these plans should quantitatively delineate stream reaches, describe existing conditions, discuss existing biological and physical data, provide restoration goals and objectives, and individual reach restoration plans with multiple restoration options (e.g., Bidelspach 2011, Rosgen 2011). For more detail on the watershed plan planning process see Rosgen (2006).

Stream restoration must begin with a plan to identify not only unstable/degraded stream reaches (habitat) within a stream, but the underlying mechanisms in the watershed that caused the problem. The WARSSS method is a geomorphology-based procedure to quantify the effects of land uses on sediment relations and channel stability (Rosgen 2006). The method rapidly assesses large watersheds with a practical, rapid screening component that integrates hillslope, hydrologic, and channel processes. The method identifies the location, nature, extent and consequence of various past, as well as proposed, land use impacts and is compatible with integration of biological assessments, such as fish habitat indices, and with restoration designs that require a stability assessment to address the causes, consequences, and corrections of river impairments.

This assessment can lead to more cost-effective solutions and preventative strategies in lieu of habitat restoration. This method can also be used to implement clean sediment TMDLs and emphasize the potential proportion contribution of sediment sources influenced by land uses, and the values are then used to appropriate relative source contributions and assess likely consequences for beneficial uses (e.g., Bidelspach 2011). The underlying purpose of WARSSS is to better understand the cause of the impairment (problem), the consequence of change, the correction (prevention, mitigation, stabilization, restoration) of the problem, and the communication of assessment results and recommendations. Unfortunately, obtaining funding for WARSSS assessments has been difficult due to the prerequisite for "shovel-ready" projects many funding sources require.

Objective 3: Continue to consult with groups using Outdoor Heritage funds so that resources and efforts are best allocated to maintain or improve fisheries resources in the Minnesota waters of Lake Superior.

Unlike any other state, the funds provided by the Legacy Amendment offer Minnesotans an incredible opportunity to begin to rehabilitate, restore, and enhance degraded stream habitat. Because the OHF funding source is only guaranteed for 25 years, recipients should use these funds responsibly and effectively in a way that produces optimal long-term benefits to our natural resources and their human users. Resource managers must continue to consult with recipients of OHF funding because not all recipients of OHF funding have habitat restoration and/or fisheries related expertise. Ultimately, maintaining a good working relationship and frequently consulting with stakeholders will enhance the Lake Superior fishery.

Objective 4: Continue to require completion of the MN DNR– Section of Fisheries Checklist for Stream Habitat Improvement Projects on MN DNR easements and fee title lands.

All projects on MN DNR lands require completion of the MN DNR – Section of Fisheries Checklist for Stream Habitat Improvement Projects (provided via request by local MN DNR Area Fisheries offices). This checklist is intended for work with cooperative partners who use Lessard-Sams Outdoor Heritage Council (LSOHC) funds to complete instream habitat improvements on MN DNR-administered lands. Additionally, this checklist can assist with smaller projects with these cooperative partners using LSOHC funds such as fencing, riparian vegetation management, etc. If the checklist was used for those smaller projects, many or some of the permits and procedures would not be required. The checklist guides MN DNR Fisheries staff and cooperative partner project leaders through the habitat restoration process and provides consistency among MN DNR Fisheries Regions.

Objective 5: Work with appropriate agencies and citizens to identify watershed impairments, to identify, prioritize, and restore degraded stream reaches in Lake Superior tributaries, and to utilize the Rosgen Classification System (Rosgen 1994b) and the Natural Channel Design approach (Rosgen 1994a; Rosgen 1996).

Planning and implementing programs to protect, restore, or enhance fisheries habitats requires the skill of several disciplines. Successful stream restoration begins with a plan to identify not only unstable/degraded stream reaches (habitat) but also the underlying mechanisms in the watershed that caused the problem. The MN DNR has adopted the Rosgen Classification System (Rosgen 1994a) and the Natural Channel Design (NCD) approach (Rosgen 1994b; Rosgen 1996) to identify, prioritize, and restore degraded stream reaches in Lake Superior tributaries. These methods have benefits over traditional hydraulic engineering principles because they provide critical fish habitat information and provide repeatable methods that can be used in watershed planning and stream restoration (Rosgen 2006). Furthermore, these methods could be used in conjunction with fisheries assessments to gain a better understanding of fish habitat use. The NCD concept recreates stable channel geometry and normal ecosystem structure and function in a degraded stream reach by mimicking geomorphology and fluvial processes in a stable reference reach with similar stream type, valley type, and driving processes (variables) from its watershed (Rosgen 1994a; Doll et al. 2003). Channel restorations that implemented NCD and also increased habitat heterogeneity yielded fish communities that shifted from a few overabundant species that were tolerant of high sediment loads to more balanced assemblages with a greater number of species that were generally larger and less tolerant of high sediment loads (Riley and Fausch 1995; Shields et al. 1995, 1998, 2000; Flebbe 1999; Dethloff et al. 2001; Roni and Quinn 2001). Many LSOHC-funded stream habitat projects in Minnesota are using NCD techniques (listed online: http://www.legacy.leg.mn/funds/outdoor-heritage-fund).

Objective 6: Require use of Natural Channel Design in the assessment and design of stream habitat improvement projects on MN DNR easements and MN DNR fee title lands. Require justification as to how habitat improvement projects will address the five components of ecosystem health (connectivity, geomorphology, water quality, biology, and hydrology) on MN DNR easements and MN DNR fee title lands. Develop evaluation criteria for post-project assessment, if feasible.

The MN DNR will seek to ensure that all successful bidders of stream restoration projects use NCD concepts in their design and implementation. Rosgen (1996, 2006) promoted use of consultants and contractors who understand NCD concepts, design, and implementation, and have proven their expertise in these areas by previous good work, and are required for watershed assessments. It would be irresponsible to allow any consultant or contractor to design or build a bridge and it would be just as ecologically and economically irresponsible to let anyone rebuild a stream. Currently, no requirement of certification is required for stream restoration practitioners. In addition, MN DNR staff will work to develop a standard set of criteria to assess the fishery benefits of habitat improvement projects.

Objective 7: Assess biological (fish) community response to habitat improvement projects, when feasible.

Natural channel design is a relatively new approach to stream restoration in Minnesota. NCD has provided a multitude of benefits to aquatic life in other states (Riley and Fausch 1995; Shields et al. 1995, 1998, 2000; Flebbe 1999; Dethloff et al. 2001; Roni and Quinn 2001); however, skepticism still exists (see Lave 2009 for review). Furthermore, no data are available to address the biological (fish) community response to these projects in Minnesota's tributaries to Lake Superior. Funds provided by the Clean Water, Land and Legacy Amendment have greatly increased stream restoration projects in Minnesota, many of which use the NCD approach. In many cases, projects that claimed to use the NCD approach have not provided the quality of work that is expected from the MN DNR permit grantees. In many of these cases, thousands of OHF dollars were spent on projects that appear to have little or no hydrologic, geomorphic, or biotic benefits, and/or the structures built appear to have caused additional problems downstream. Stream habitat projects will continue to be built in tributaries to Lake Superior as Clean Water funding is available over the next two decades. At this time, the MN DNR Section of Fisheries has been provided few resources to study the fishery response to habitat project improvement projects. Assessing the biological (fish) response to NCD projects could provide useful, quantifiable information on fisheries habitat use, and to determine if, how, and why the new approach benefits the aquatic resources in Lake Superior tributaries. Rosgen (2006) suggested implementing NCD restoration demonstration projects and monitoring variability in water quality, flood hazard control, aquatic habitat condition, fisheries, and property protection issues before and after implementation. The pre- and post- implementation periods of monitoring should be at least two years each (preferably up to five years) as suggested by Clausen and Spooner (1993) and Spooner et al. (1995).

Objective 8: Protect water quality and riparian areas near streams and wetlands by working with forest managers to ensure best management practices, as outlined in the Minnesota Forest Resource Council (MFRC) site-level forest management guidelines (MFRC 2013), are understood and implemented.

The nature and quality of stream habitats are directly linked to those of adjacent terrestrial environments (Kershner et al. 1991), known as riparian areas. The MFRC voluntary site-level forest management guidelines are a set of best practices to reduce the potential for negative environmental impacts resulting from timber harvesting and other forest management activities and include best management practices for forest management within and around riparian areas. Adequate planning of forest management impacts can result in practices that promote a forest condition that maintains or enhances watershed conditions. Riparian areas are critical to fish, wildlife, and certain forest resources. Forested lands act to filter and store water, and are a key component in the hydrologic cycle for sustaining high-quality water and hydrology. Forest management operations can have a direct impact on surface water quantity and quality (MFRC 2013). Forestry and fisheries management goals are most likely to be achieved simultaneously if they are based on prior assessments of the ecological capability of the resource, the legal and institutional requirements placed on the managers, and the social and economic expectations of the resource users. Therefore, it is vital to maintain coordination with other agencies that manage upland and riparian habitats, such as MN DNR Division of Forestry, county foresters, and SWCDs.

Objective 9: Maintain or restore stream channel stability and function, and the natural hydrological regimes on which they depend, by encouraging land managers to work cooperatively in considering the percent open land in watersheds when making management decisions.

Studies have shown that when open lands in a watershed exceed 60%, the timing of peak flows changes and the intensity of runoff increases, resulting in damaging changes to stream channels. The need to maintain healthy hydrologic function is even more critical now that climate change is likely to result in an increase in severe storm events. "Open lands" include young forest (stands under 15 years), and development or agricultural areas. Land managers, working together, can minimize the percentage of open lands within a watershed over time to avoid the sixty percent threshold, or at least reduce the amount of time at or beyond the threshold through timber planning, acceleration of regeneration, and limiting development.

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CHAPTER 4: NATIVE PREY FISH

4.1 BACKGROUND

Prey in Lake Superior includes organisms from a variety of trophic levels, such as zooplankton, microcrustacea, aquatic and terrestrial insects, and numerous fish species. In this plan the term "prey" refers to the prey fish used by trout and salmon in Lake Superior. In this chapter we will discuss the changes that have occurred in the Lake Superior native prey fish community, then discuss harvest and management strategies for native prey fish targeted by commercial fishing operations.

4.2 CHANGES IN THE PREY FISH COMMUNITY

Historically, native coregonids were the primary forage of Lake Trout in Lake Superior (Dryer and Beil 1964); however; drastic changes in the fish community during the mid-part of the 20th century changed fish community structure in the lake. The invasion of Sea Lamprey in the 1940s and the subsequent crash of Lake Trout stocks led to a drastic reduction in predators. With few predators in the lake, the invasion and subsequent explosion of Rainbow Smelt further changed Lake Superior prey fish composition. Lake Herring populations crashed in the 1950s leaving an open niche for Rainbow Smelt to fill. By the mid-1960s Rainbow Smelt had become the most common prey item in the stomach of Lake Trout. Rainbow Smelt populations peaked in the 1970s, but declined thereafter due in part to massive die-offs and predation by increasing Lake Trout populations.

Since 1978, the United States Geological Survey in Ashland, Wisconsin, has conducted nearshore bottom trawl surveys to monitor prey fish populations around Lake Superior. This survey estimates year-class strength for primary prey species (Cisco or Lake Herring *Coregonus artedi*, Bloater *Coregonus hoyi*, Rainbow Smelt *Osmerus mordax*, and Lake Whitefish *Coregonus clupeaformis*) and also provides trends in biomass for other prey species including sculpins *Cottus* spp. and ninespine stickleback *Pungitius pungitius*. Lake-wide prey fish biomass declined considerably through the mid-1990s, which was attributed to increased predation by rehabilitated Lake Trout populations and weak recruitment by Lake Herring and Bloater (Figure 4.1; Gorman et al. 2013).

The decline in prey fish biomass led to investigations of prey fish production and predator consumption, also known as bioenergetics. In one bioenergetics study, Negus et al. (2007) concluded 50% or more of the available coregonines and Rainbow Smelt may be consumed annually in nearshore waters. In 2012, prey fish biomass reached the lowest point ever sampled in the USGS bottom trawl survey, but reductions in prey fish biomass should be expected given Lake Trout rehabilitation (Figure 4.1).

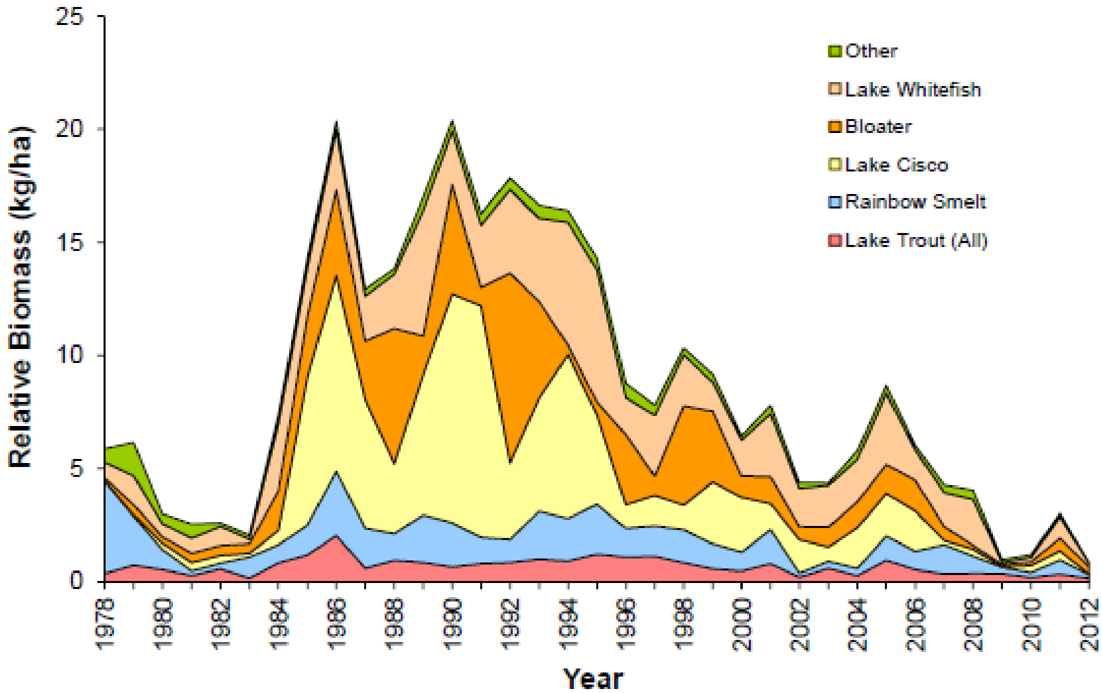

FIGURE 4.1: Mean relative biomass (kg/ha) of the fish community caught in bottom trawls at all nearshore sampling stations in Lake Superior, 1978-2012. Courtesy USGS, Ashland, Wisconsin.

4.3 COMMERCIAL HARVEST AND MANAGEMENT STRATEGIES

Lake Herring are well-adapted to the Lake Superior ecosystem and their habitat overlaps with lean Lake Trout, making them the most appropriate prey for maximizing Lake Trout rehabilitation and maximizing production of other nearshore fish species in the community. They typically form large aggregations and spawn in shallower water during November, which makes them easy targets for commercial operators. Lake Herring grow quickly until approximately age-4, then body growth slows as energy is shunted into reproduction. Otolith analysis shows that Lake Herring, which are typically 14 to 17 inches long as adults, can live at least 30 years. As one of many long-lived species in Lake Superior, Lake Herring are particularly vulnerable to recruitment overfishing. The *Fish-Community Objectives for Lake Superior* (Horns et al. 2003) recognizes limitations exist in what management agencies can do to change prey fish populations, but limiting the commercial harvest of Lake Herring can minimize mortality of spawning populations. Since the early 1970s, the commercial fishery for Lake Herring has mainly supplied fish for local restaurants, grocery stores, and smoked fish shops. Tourists and residents alike enjoy Lake Herring as a local delicacy. During the fall spawning season a lucrative market develops for Lake Herring roe (eggs) most of which is exported to Sweden as caviar.

In Minnesota waters of Lake Superior the commercial Lake Herring fishery began around 1875. Harvest increased until the 1920s, then stabilized at over six million pounds annually until 1940. Harvest of Lake Herring then declined by 98% from approximately seven million pounds in 1940 to 185,000 pounds in 1970. Major rehabilitation efforts, which began in the early 1970s, included the following actions: reducing the number of commercial operators through attrition and limited entry; establishing an inshore refuge, enacted in 1971, which prohibited harvest within 0.25 mile from shore; closing the November fishing season in 1973 to protect easily caught aggregations of spawning Lake Herring; and stocking Lake Herring in the Duluth area from 1975 to 1986. Strong year classes were produced in the mid to late 1980s and commercial harvest increased. In 2006, the Lake Herring population was deemed healthy enough to re-open fishing in November under a total-allowable-catch-based quota system. Since that time, commercial harvest has declined 51% to just under 215,000 pounds (Figure 4.2).

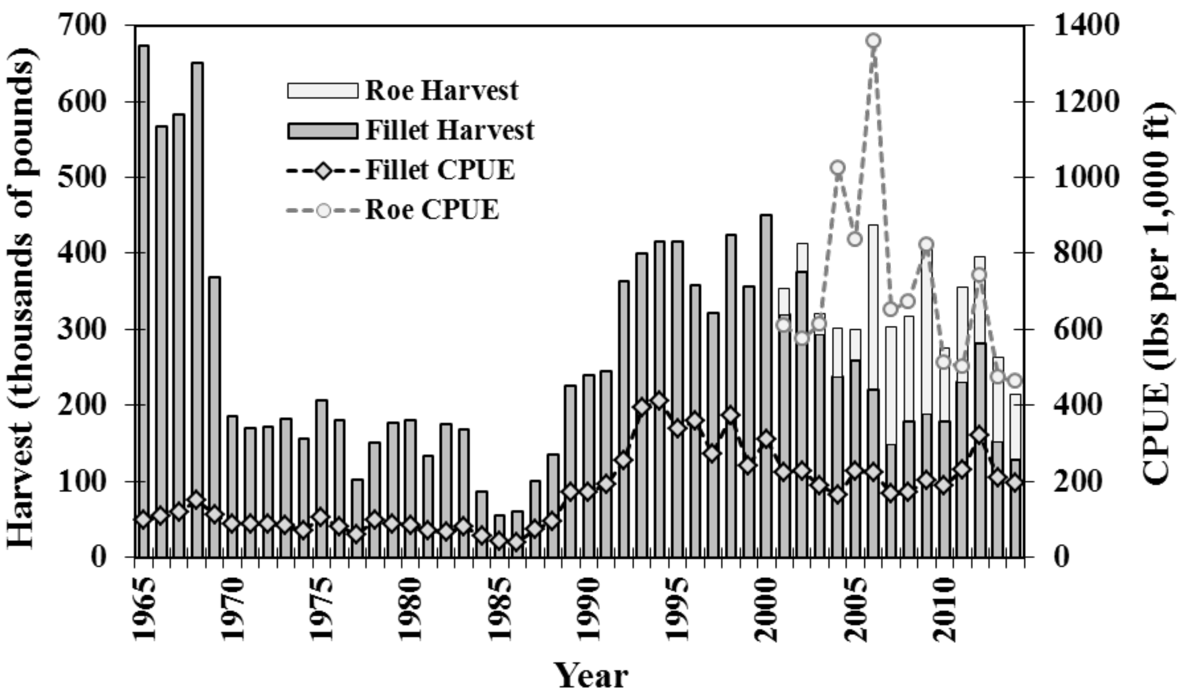

FIGURE 4.2: Thousands of pounds of Lake Herring harvested in the fillet and roe fishery (left axis) and catch-per-unit-effort in pounds per 1,000 feet of net (right axis).

Regulation and commercial yield of Lake Herring in Lake Superior varies by jurisdiction. Minnesota and Ontario manage their fisheries with quota systems based on spawning stock biomass. As spawning stock biomass decreased, commercial yield decreased accordingly. Wisconsin imposes no harvest restrictions or quotas and in recent years yield increased to approximately 900 metric tons (almost two million pounds) due to the demand in the lucrative roe market (Figure 4.3). Permitted harvest in Michigan waters of Lake Superior is very small and typically only allowed as incidental harvest in the chub (Bloater and Kiyi [*Coregonus kiyi*]) fishery.

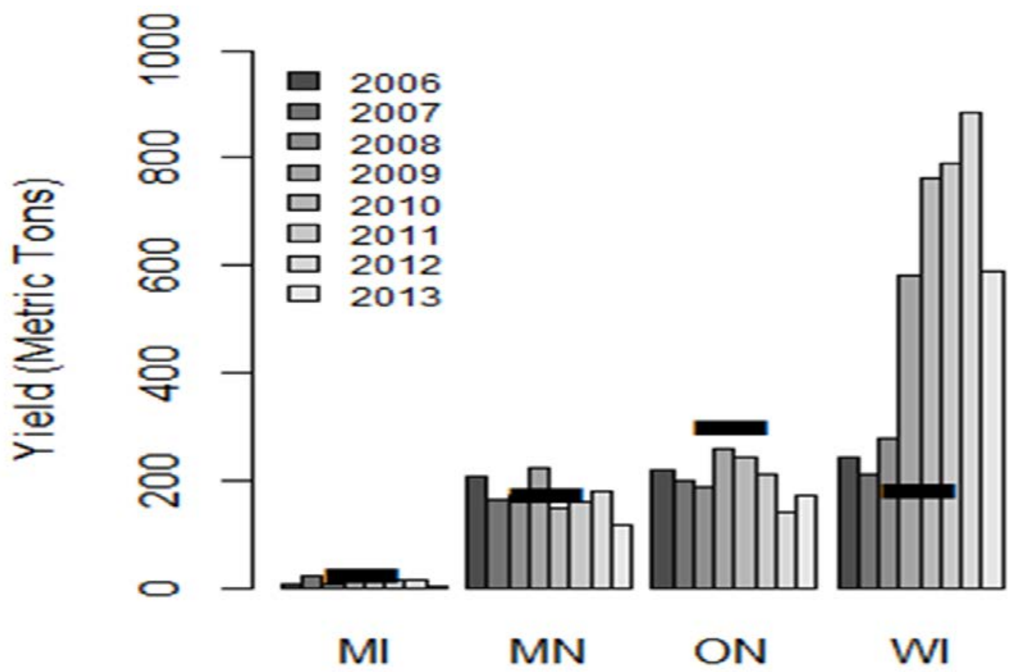

FIGURE 4.3: Commercial yield (metric tons) of Lake Herring in Lake Superior by jurisdiction, 2006 – 2013. Black horizontal bars indicate average harvest from 1990-2005.

Lake Herring recruitment has varied substantially since the major decline started in the late 1940s. Strong year classes were produced in 1984, 1988, 1989, and 1990 and moderate year classes were produced in 1998 and 2003. Year classes have been nearly nonexistent since 2003 except in 2005 and 2009 when year classes were weak, based on USGS year-class strength estimates (Figure 4.4; Stockwell et al. 2005). The 2005 year class fully recruited to the commercial fishery in 2009 and by 2014 contributed only weakly to commercial harvest (Figure 4.4). The 2009 year class is likely to follow the same trend given that its year-class strength and its contribution to commercial harvest are similar to that provided by the 2005 year class, particularly in November. Otolith analysis revealed that Lake Herring fully recruit to the commercial fishery at age-4. The latest available data suggest that the 2014 year class recruited successfully; however, the USGS year-class index was weak for the 2014 year class (Figure 4.4). Because of the four-year lag between hatching and recruitment to the commercial fishery, additional biomass of Lake Herring will be limited until 2018 and conservative management will be required to ensure sustainability of Lake Herring into the future.

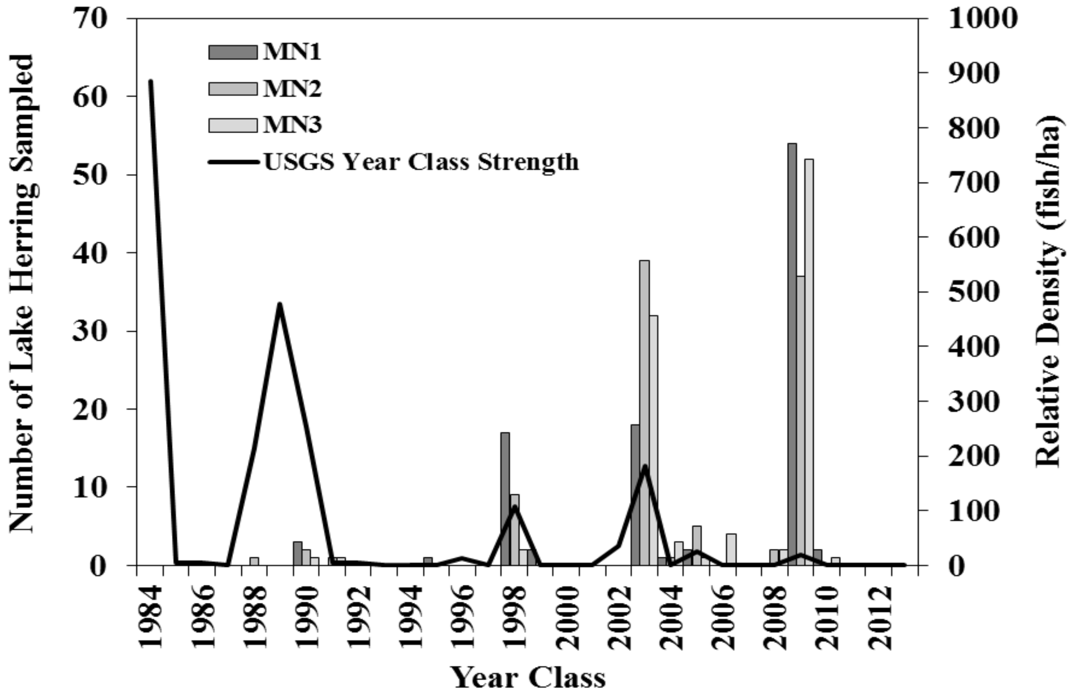

FIGURE 4.4: Number of Lake Herring by year class and management zone in a 300-fish sample of the November roe commercial fishery (left axis). USGS year-class strength estimate from bottom trawl surveys is represented by the black solid line (right axis).

The MN DNR has managed the commercial Lake Herring fishery under a total-allowable-catch-based system since the November fishery was re-opened in 2006. The amount of fish available for harvest is based on Lake Superior Technical Committee recommendations of not exceeding 10-15% harvest of spawning stock biomass annually (see Section 4.4.1 Regulation History on page 50). Minnesota's approach to Lake Herring management has been viewed as conservative by some, relative to the nearly unregulated fishery in Wisconsin waters. In 2015, the Lake Superior Committee of the Great Lakes Fishery Commission and the MN DNR sent letters to the Wisconsin DNR and tribal chair-persons regarding unregulated commercial harvest of Lake Herring in Wisconsin waters and the impact to commercial operators in other jurisdictions, particularly the adjacent waters of Minnesota. Both letters also expressed concern over the potential for commercial overharvest of Lake Herring to jeopardize gains made in Lake Trout rehabilitation by further reducing prey fish biomass, which reached historic lows in 2012. These discussions are ongoing. Author Mark Kurlansky forecasts the response to the lack of sustainable management in his book *Cod: A biography of the fish that changed the World* when he describes the relationship between government regulation and commercial fisheries: "Fishermen rarely consider regulation their responsibility. As they see it, that is the duty of government - to make the rules - and it is their duty to navigate through them. If the stocks are not conserved, government mismanagement is to blame." From Mr. Kurlansky's astute observation, conserving stocks through regulation is the preferred option, however unpopular, because at least with that option there will be stocks left to rehabilitate should the fishery crash.

Lake Superior supports two smaller coregonid species that occupy deep-water habitats. These are the two chubs, Bloater and Kiyi, which along with sculpin and Burbot *Lota lota* make up the primary prey for siscowet Lake Trout. To a lesser extent, lean Lake Trout and Chinook Salmon also consume chubs. Chub species identification is difficult because morphology varies greatly within and across populations. Correct classification of chubs to species is often subjective and requires extensive experience. Therefore these species are combined under "chubs" for assessment and management purposes. Chubs have historically been a minor component of commercial fishing in Minnesota. Chub harvest has been dictated by market conditions within the smoked fish industry. Annual harvest of chubs in Minnesota waters of Lake Superior has fluctuated greatly, ranging from 0 to 250,000 pounds (Figure 4.5). Since 2003, chub harvest has been insignificant in Minnesota waters. Chub nets must be fished at depths greater than 300 feet to minimize bycatch of juvenile Lake Trout which could jeopardize gains made in Lake Trout rehabilitation. Commercial chub fishing effort is monitored closely to ensure that Lake Trout by-catch remains low.

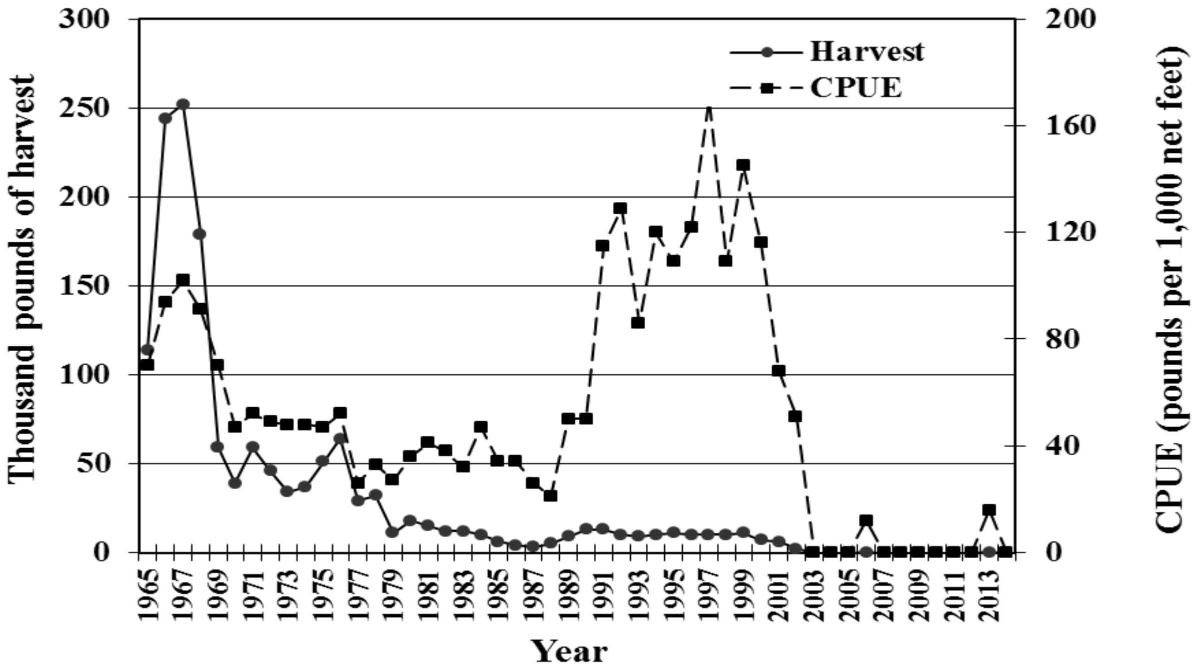

FIGURE 4.5: Harvest and CPUE (catch per unit effort) of chub taken in the commercial gill net fishery, Minnesota waters of Lake Superior, 1965-2014.

4.4 MANAGEMENT HISTORY (1996-2016)

4.4.1 REGULATION HISTORY

The number of commercial operator licenses in Minnesota waters of Lake Superior was reduced from 50 in the 1996 plan to 25 in the 2006 plan. Harvest rules were also changed from unlimited harvest with a November spawning closure in the 1996 plan to a total-allowable-catch (TAC) quota with a permitted November roe fishery in 2006. The 2006 quota was based on 10% of the lower 95% confidence limit of the average spawning stock biomass of Lake Herring greater than 12 inches. The spawning stock biomass estimate was based on hydroacoustic survey results that were averaged over a three-year period. When the TAC-based fishery was first implemented, quotas for each management zone were established and commercial operators could fish until the zone quota was reached. As biomass and quotas declined, individual quotas were implemented to avoid creating a "derby" style commercial fishery. Lake Herring are also targeted by sport anglers, particularly during relatively infrequent and brief periods of ice fishing. The sport harvest is minimal and the fishery remains open year-round with no possession limits.

4.4.2 STOCKING HISTORY

Lake Whitefish and Lake Herring were stocked in the late 1800s in Minnesota waters when the Lester River Federal Fish Hatchery began operations. Records indicate Lake Herring were stocked sporadically with the last fry stocking event occurring in 1987. No stocking has taken place since then.

4.4.3 ASSESSMENT HISTORY

The 1996 LSMP called for assessing Lake Herring stocks by monitoring commercial operators, setting MN DNR test nets, and receiving data from USGS (U.S. Geological Survey) spring trawl surveys. Hydroacoustic assessments were first used in 1997 and 1998 during a pilot study to estimate prey biomass in the western arm of Lake Superior. They were again used in 2003-2005 to determine prey biomass estimates and determine an optimal design for a long-term survey program (Hrabik et al. 2006). In the 2006 plan, monitoring the commercial fishery and DNR test netting remained as assessment methods and hydroacoustic assessments were proposed for a one-in-three-year cycle. Due to the re-opening of the November roe fishery in 2006, hydroacoustic assessments have been conducted annually to estimate spawning stock biomass of Lake Herring for the TAC quota fishery. All commercial operators must report monthly harvest in Minnesota and the MN DNR produces an annual harvest report for the Minnesota waters of Lake Superior.

The 1996 and 2006 plans both called for regular examinations of predator diets from creel and assessment netting samples. This information is critical to understanding the predators' effects on prey fish populations, which informs management decisions regarding prey fish stocks and commercial harvest. However, limited resources have prevented obtaining and analyzing regular collections from the sport fishery.

4.5 GOALS AND OBJECTIVES (2016-2025)

Goal: Rehabilitate and protect self-sustaining coregonid stocks (predominately Lake Herring) to support stable production of predators, tribal harvest, and a limited commercial fishery.

Objectives:

1. Obtain annual estimates of spawning stock biomass for Lake Herring using hydroacoustics and mid-water trawling.
2. Investigate annual year-class contribution, catch per effort, and yield from the commercial fishery annually.

3. Maintain conservative harvest of Lake Herring by continuing the total-allowable-catch quota (TAC) system in the November roe fishery.
4. Investigate seasonal differences in spawning stock biomass estimates from hydroacoustic and mid-water trawling assessments.
5. Continue assisting with research investigating Lake Herring population dynamics, particularly issues related to recruitment.
6. Update bioenergetics modeling to determine the allocation of Lake Herring biomass and production among predators and commercial harvest.
7. Continue to support establishing a lake-wide stock assessment model to complement existing acoustics-based quota calculations.
8. Continue to support adoption of the Lake Superior Technical Committee's commercial harvest recommendations by all jurisdictions around Lake Superior.

4.6 MANAGEMENT STRATEGIES (2016-2025)

4.6.1 Regulations

No regulation changes. Commercial fishing regulations for Lake Herring and chubs are described in Minn. Stat. section 97C.835 and Minn. Rule, part 6260.1800.

4.6.2 Stocking

No stocking.

4.6.3 Assessment

Continue present MN DNR Lake Herring assessment program. Conduct hydroacoustic surveys and determine TAC annually to determine biomass of spawning Lake Herring available for harvest in Minnesota waters of Lake Superior. Develop internal expertise to conduct surveys based on design developed by Hrabik et al. (2006). Continue contracting with the University of Minnesota-Duluth Large Lake Observatory's Research Vessel Blue Heron for offshore hydroacoustic and mid-water trawling assessments. Conduct intensive diet studies of sport fish once every five years to determine importance of coregonids in diet. Implement any standardized Lake Herring assessment protocols recommended by the LSTC.

4.7 JUSTIFICATION

Objective 1: Obtain annual estimates of spawning stock biomass for Lake Herring using hydroacoustics and mid-water trawling.

Hydroacoustic and mid-water trawling assessments in Minnesota waters of Lake Superior were conducted in 1996-1997 and 2003-2005 to estimate prey fish biomass. Since the inception of a TAC-based quota system, the same hydroacoustic assessment sampling design has been used to estimate Lake Herring spawning stock biomass. These assessments occur in August when water temperatures are stratified and environmental conditions on Lake Superior are better suited for overnight sampling. Annual estimates of spawning stock biomass using hydroacoustics and mid-water trawling will assist in setting TAC quotas that allow the harvest of no more than 10-15% of spawning stock biomass, as recommended by the Lake Superior Technical Committee (Stockwell et al. 2009).

Objective 2: Investigate annual year-class contribution, catch per effort, and yield from the commercial fishery annually.

Annual monitoring and sampling of commercial harvest has enabled MN DNR to track year-class contribution in the commercial fishery which has corroborated USGS bottom trawl surveys estimating year-class strength and will be useful data for future stock assessment analysis. Continued collections will allow future comparisons of year-class strength indices and percent contribution of year classes to annual commercial harvest which could assist in refining harvest policies based on specific year-class biomass estimates. For instance, tracking year classes has shown the 2005 and 2009 year classes were relatively weak and currently contribute very little to the commercial fishery. If year classes of this magnitude persist for ten years or less with no major year classes forecasted, MN DNR and commercial fishers can better plan, prepare, and inform others of difficult fishing ahead.

Objective 3: Maintain conservative harvest of Lake Herring by continuing the total-allowable-catch quota (TAC) system in the November roe fishery.

Year classes of Lake Herring in Lake Superior are not consistently produced. Therefore, conservative management of Lake Herring stocks through commercial fishing regulation is needed to ensure long-term sustainability of the resource. The 2003 year class was the most recent substantial input of lake herring into the system. This leaves managers and commercial fishers with only two options – harvest year classes intensively as they become available to the fishery or harvest conservatively for the long-term sustainability of the population and fishery.

Objective 4: Investigate seasonal differences in spawning stock biomass estimates from hydroacoustic and mid-water trawling assessments.

Yule et al. (2009) found that spawning Lake Herring abundance in Lake Superior is best estimated with a November survey. In 2014, MN DNR began investigating seasonal differences in spawning stock biomass estimates from hydroacoustic surveys and the subsequent difference in TAC quota calculations. Hydroacoustic assessments were conducted in August and October of 2014 and 2015. MN DNR is also investigating other methods of hydroacoustic analysis and quota calculations. Analysis and external review of this work is ongoing with a tentative completion date of September 2016.

Objective 5: Continue assisting with research investigating Lake Herring population dynamics, particularly issues related to recruitment.

Managers and researchers have learned a great deal regarding Lake Herring population dynamics in the past ten years. Sporadic, weak year-class production appears to be the new norm for Lake Herring populations and very little can be done to change that. Myers et al. (2015) found spatial synchrony in recruitment events between Lake Herring populations in the Great Lakes and inland lakes in northern Minnesota, indicating successful recruitment may be driven by broad-scale climatic factors. Other research conducted by Myers et al. (2014) indicated Rainbow Smelt may limit larval Lake Herring survival in certain areas of Lake Superior including the Twin Ports area. Myers et al. (2014) also found that starvation may be a major source of mortality of larval Lake Herring.

Objective 6: Update bioenergetics modeling to determine the allocation of Lake Herring biomass and production among predators and commercial harvest.

Understanding the bioenergetics needs of organisms at each trophic level will assist in determining the feasibility of management actions for Lake Herring sustainability. Invasive zebra and quagga mussels are filter-feeders that can become so abundant they filter most of the nutrients out of the water column and sequester that energy to the bottom of the lake instead of it being available to small organisms, including fish. In Lake Michigan and Lake Huron, impacts of these invasive mussels on lower trophic food web bioenergetics led to the collapse of Alewife and salmon populations in those systems. Understanding these food web stressors will assist managers in making decisions that complement bioenergetic availability and not further compromise ecosystem stability.

Results from Myers et al. (2015) suggest successful recruitment of Lake Herring is related to timing of larval Lake Herring emergence and availability of exogenous food sources. If exogenous food sources are not available by the time the larval yolk-sac disappears, starvation likely occurs and no adult fish are produced from that year class. If this is the case, little can be done to actively manage for more Lake Herring except conservative management of the commercial fishery.

Objective 7: Continue to support establishing a lake-wide stock assessment model to complement existing acoustics-based quota calculations.

Stock assessment models have been developed for Lake Trout and Lake Whitefish populations in Lake Superior. A Lake Herring stock assessment model would complement the current hydroacoustic-based assessments, enhance our understanding of year-class-specific population dynamics, and model the effects of different harvest scenarios.

Objective 8: Continue to support adoption of the Lake Superior Technical Committee's commercial harvest recommendations by all jurisdictions around Lake Superior.

In 2009, the Lake Superior Technical Committee recommended no more than 10-15% of spawning stock biomass of Lake Herring should be available for harvest annually to ensure sustainability of the stocks (Stockwell, et al. 2009). This recommendation was immediately adopted by the MN DNR; however, this harvest policy has not been implemented by all jurisdictions around Lake Superior. Failure to implement this harvest policy at a lake-wide level creates conditions considered unfair to commercial fishing operations that are regulated by agencies that implemented the recommendation. Without adoption and implementation of the Lake Superior Technical Committee recommendation, the sustainability of Lake Herring stocks and the harvest policies of agencies that implemented the recommendation are jeopardized. If Lake Herring populations continue to decline, the MN DNR will work through the LSTC to assist in determining an appropriate response by all jurisdictions.

4.8 INFORMATION NEEDS

A better understanding of the trophic relationships in the Lake Superior fish community is necessary. Trophic relationships can be examined within ecological simulation models (ecosystem models) and the model outputs can help define how much prey biomass the lake can support and in turn how many predators could be supported by the prey biomass. A better understanding of the linkage between all life stages of coregonids and the lower trophic level would be very useful in determining the potential prey biomass in Lake Superior as well as provide additional insight into issues surrounding the lack of successful recruitment events. The Lake Superior Technical Committee is currently creating an ecosystem-based model and MN DNR will continue to support and contribute to those efforts.

Continued research into the effect of Rainbow Smelt predation on larval Lake Herring, particularly in the Twin Ports area, would be useful to increase understanding of the factors that limit Lake Herring recruitment. The current management strategy of managing Lake Trout abundance at high levels to suppress Rainbow Smelt predation effects may also affect Lake Herring recruitment. However, liberalizing harvest regulations to decrease Lake Trout abundance would allow Rainbow Smelt abundance to increase, which could suppress recruitment of Lake Herring.

Typical hydroacoustic survey methods include deployment of equipment from a large research vessel capable of handling rough seas and multi-day deployments as well as a crew to operate the vessel and scientific equipment. These surveys are typically both time-consuming and expensive. Technological advancements in the delivery methods of hydroacoustic equipment for fisheries surveys have made long-term deployment and data collection possible without the full-time commitment of vessel and scientific crews. In 2012, the MN DNR and USGS along with BioSonics and Liquid Robotics, Inc. teamed up to launch the first ever unmanned hydroacoustics survey in the Great Lakes using the WaveGlider platform. The WaveGlider is an unmanned autonomous robot that converts wave motion into forward propulsion, creating a self-contained system that requires no refueling and minimal maintenance. A BioSonics DTX sub with a BioSonics120-kHz transducer was towed behind the WaveGlider and collected hydroacoustic data over a three-day period with no human contact. The system can be monitored and operated via smartphone or staffed data center. Continuous deployment of the WaveGlider platform with BioSonics DTX tow sub would provide a much broader window of data collection and could reduce variability associated with short-term surveys typical of vessel-based operations. A small fleet would be capable of surveying the entire Western arm of Lake Superior and would provide a more precise estimate of spawning stock biomass.

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CHAPTER 5: NON-NATIVE PREYFISH

5.1 BACKGROUND

Rainbow Smelt and Alewives are non-native species that entered Lake Superior in the early 1930s and 1954, respectively. Alewives were unable to expand in Lake Superior, but during the 1950s Rainbow Smelt became well established and supported large commercial harvests and an active dip net sport fishery in the Duluth-Superior area. Rainbow Smelt also became a major prey species for stocks of recovering Lake Trout and introduced Pacific salmon during the 1960s and 1970s. Rainbow Smelt abundance peaked in the 1970s, declined sharply after 1979, and was so low after 2001 that commercial harvest was minimal (Figure 5.1). Based on records from the commercial fishery, annual harvests during 1990-2015 were less than 5% of the peak levels from the 1970s. Despite the low level of abundance, Rainbow Smelt are still important prey for salmonids in Minnesota's portion of Lake Superior, especially in the inshore areas during spring and early summer. The decline of Rainbow Smelt in Minnesota mirrors a lake-wide decline. The decline was driven largely by predation (Bronte et al. 2003; Gorman 2007; Negus et al. 2008). Abundance of older and larger Rainbow Smelt declined dramatically during the early 1980s while abundance of lean Lake Trout and Pacific salmon increased (Gorman 2007). Early diet studies (Conner et al. 1993) confirmed the presence of larger Rainbow Smelt in stomachs; however, more recent information indicates Rainbow Smelt longer than 8 inches are scarce in both diets and assessments (Ray 2004).

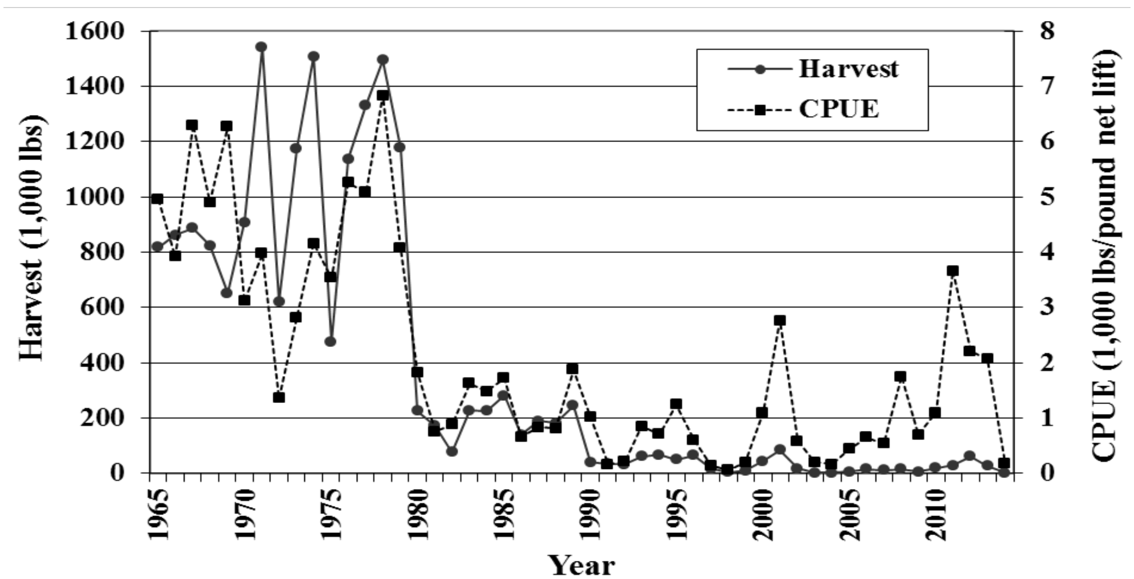

FIGURE 5.1: Harvest and CPUE (catch per unit effort) of Rainbow Smelt taken in the commercial pound net fishery, Minnesota waters of Lake Superior, 1965-2014.

After Rainbow Smelt abundance declined, Lake Herring populations rebounded throughout the lake, suggesting an inversely dependent relationship; however, Lake Herring populations declined again despite the reduced Rainbow Smelt population. The abbreviated size structure and lower abundance are probably due to intense predation (Gorman 2007). The amount of commercial harvest of Rainbow Smelt is insignificant when compared to predator demand (Negus et al. 2008).

5.2 MANAGEMENT HISTORY (1996-2015)

5.2.1 REGULATION HISTORY

During the past 20 years the sport dip-net fishery has remained open and without possession limits. The sport fishery has been limited by gear restrictions, including a maximum length of seine. Transportation of live Rainbow Smelt is prohibited to prevent their introduction into inland lakes. Only one commercial netter has been allowed to fish for smelt in the past decade. 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.

5.2.2 STOCKING HISTORY

No stocking.

5.2.3 ASSESSMENT HISTORY

Rainbow Smelt have been assessed through the use of MN DNR small-mesh gill nets, USGS bottom trawls, MN DNR hydroacoustic surveys, and monitoring the commercial fishery. In Minnesota, the commercial fishery is an important information source for Rainbow Smelt assessment and has been used to reflect lake-wide abundance (Bronte et al. 2003). Lake Trout diets from the MN DNR assessment fishery are examined annually. Lake Trout diets from angler-caught fish were last collected and examined in 2005.

5.3 GOALS AND OBJECTIVES (2016-2025)

Goal: Provide a nearshore prey base sustained by natural reproduction that supports a spring dip net fishery for Rainbow Smelt.

Objectives:

1. Use hydroacoustic sampling and trawl surveys to monitor Rainbow Smelt biomass in Minnesota waters of Lake Superior.
2. Monitor catch and effort in the commercial Rainbow Smelt fishery and obtain age and size structure data from a sample of the catch.
3. Update bioenergetics models to determine proportion of Rainbow Smelt consumed by predators and compare to commercial fishery harvest.
4. Conduct predator diet surveys annually to determine the contribution of Rainbow Smelt as prey in the Lake Superior fish community.
5. Investigate and continue to support research of Rainbow Smelt impacts on Lake Herring populations.

5.4 MANAGEMENT STRATEGIES (2016-2025)

5.4.1 REGULATIONS

Limit commercial fishery for Rainbow Smelt to the one active commercial operator in MN-1. Limit the number of pound nets that operator can use in the Rainbow Smelt fishery to five.

5.4.2 STOCKING

No stocking.

5.4.3 ASSESSMENT

Continue to assess predation on and abundance of Rainbow Smelt through hydroacoustic and mid-water trawling, monitoring the commercial fishery, and assessing predator diets.

5.5 JUSTIFICATION

Objective 1: Use hydroacoustic sampling and trawl surveys to monitor Rainbow Smelt biomass in Minnesota waters of Lake Superior.

Rainbow Smelt abundance has been monitored historically through commercial catch records. The population declined to such low levels in the 1980s and 1990s that commercial fishing was reduced until just one commercial fisher was permitted to fish. The information from just one source produces a very limited understanding of the population; therefore, Rainbow Smelt abundance has also been estimated in hydroacoustic and open-water trawl surveys by the MN DNR and by the US Fish and Wildlife Service. These efforts are needed to produce robust estimates of population abundance and size structure at costs which are minimal because the samples are already used to estimate the abundance and size structure of Lake Herring, Bloater, and Kiyi.

Objective 2: Monitor catch and effort in the commercial Rainbow Smelt fishery and obtain age and size structure data from a sample of the catch.

To prevent over-exploitation of Rainbow Smelt, MN DNR will continue to limit the commercial effort to no more than five-pound nets. If Rainbow Smelt abundance increases dramatically, increased harvest may be considered.

Objective 3: Update bioenergetics models to determine proportion of Rainbow Smelt consumed by predators and compare to commercial fishery harvest.

Some citizens value Rainbow Smelt as food for their favored predator species and have proposed closing the commercial and sport dip-net fisheries for Rainbow Smelt, whereas others value smelt as food for themselves and want the Rainbow Smelt fishery to remain open. Participation in the sport dip-net fishery decreased greatly in the 1980s after the catches of Rainbow Smelt declined abruptly. Abundance of Rainbow Smelt declined in streams that were closed to dip-netting, indicating the dip-net fishery did not cause the decline. Rainbow Smelt yield in the commercial harvest should be compared to consumption by predators to determine the influence of the commercial harvest on the entire population. Bioenergetics models are the most appropriate tool to synthesize the diet and abundance data and produce estimates of consumption versus harvest.

Objective 4: Conduct predator diet surveys annually to determine the contribution of Rainbow Smelt as prey in the Lake Superior fish community.

Rainbow Smelt have become an important prey species in the Lake Superior fish community. Results from bioenergetics modeling indicate that the commercial fishery takes relatively few Rainbow Smelt compared to the numerous predators in the lake (Negus 1995, Negus et al. 2008). The predatory demand on Rainbow Smelt is likely to be influenced by predator abundance and composition. Another round of diet samples should be collected from predatory fishes to measure the consistency of diets over a long time span and to identify changes in diets as the predator abundance has stabilized and now reflects a fish community that is close to or at maximum yield given the existing forage base.

Objective 5: Investigate and continue to support research of Rainbow Smelt impacts on Lake Herring populations.

Although preyed upon by salmonids, the effect of Rainbow Smelt on the fish community is not well understood and may be detrimental to other prey species (Evans and Loftus 1987; Gorman 2007). Rainbow Smelt are restricted to inland or nearshore waters and therefore influence the entire lake's productivity to a much less degree than do Lake Herring. Lake Herring were the historical prey base in Lake Superior and should be managed as the primary species to maximize productivity (Horns et al. 2003). To ensure that Lake Herring remain the primary forage species, the effects of Rainbow Smelt on Lake Herring survival should be investigated. A primary question to be answered is this: do Rainbow Smelt suppress Lake Herring populations, and if so, under what conditions? The answer to this question should provide ideas for limiting the suppression of Lake Herring populations.

5.6 INFORMATION NEEDS

There has been some 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, Lake Herring reproduction was minimal. Anderson and Smith (1971) found that Rainbow Smelt and Lake Herring consumed similar types of prey; however Selgeby et al. (1994) suggested that larvae of the two species are separated by time and space and therefore competition for food is minimal. Cox and Kitchell (2004) suggested that Lake Trout can control abundance of Rainbow Smelt and in turn exert a positive influence on Lake Herring recruitment. Myers et al. (2014) suggested that Rainbow Smelt may limit Lake Herring recruitment in specific habitats, such as in turbid water as is often found near Duluth; however, the authors asserted that starvation may be a major source of mortality at most locations. O'Brien et al. (2012) measured differences in survival and abundance that were driven by temperature differences. Studies from inland lakes provide evidence that Rainbow Smelt prey heavily on larval coregonids (Evans and Loftus 1987) and there is concern that Rainbow Smelt also may prey on larval salmonids. *Mysis relicta*, a small shrimp-like invertebrate, is the major prey used by both adult Rainbow Smelt and Lake Herring, but competition for mysids between these species has not been documented. Since the late 1980s Rainbow Smelt abundance has been low, yet Lake Herring recruitment has been extremely variable, indicating little direct interaction (Bronte et al. 2003). Year-class strength has varied inversely between age-1 and age-2 smelt, which indicates that cannibalism is intense (Gorman 2007). Based on this scientific evidence, it is clear that more work is required to document the relationships between Rainbow Smelt and Lake Herring. We must also increase our understanding on the contribution of Rainbow Smelt to predator diets in the Lake Superior community based on spatial (nearshore vs. offshore) and temporal (seasonal) factors.

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CHAPTER 6: LEAN LAKE TROUT

6.1 BACKGROUND

Lake Trout are given high management priority because they are the native top predator in Lake Superior, they thrive in the cold, clear, low-productivity waters, and they have provided for important commercial and sport fisheries for many generations. Following European colonization of the Laurentian Basin in the eighteenth and nineteenth centuries, Lake Trout populations declined due to rapid expansion of commercial fisheries, habitat degradation, and, more recently and most detrimental, the invasion of the Sea Lamprey via shipping channels. Re-establishing self-sustaining Lake Trout populations has been the primary goal of management agencies in the Great Lakes since an effective chemical control for Sea Lamprey was developed in the 1950s.

Throughout this chapter, we will refer to Lake Trout populations as being "re-established" if reintroductions (i.e., stocking of hatchery-reared Lake Trout) have been followed by long-term persistence of populations through natural reproduction; however, the self-sustainability of the population remains to be tested outside the influence of a stocking program. We will refer to a population as "rehabilitated" when it has shown long-term persistence through natural reproduction of wild fish, has remained self-sustaining given current and anticipated future rates of exploitation, and has done so without the influence of a stocking program. Similar descriptions have been used in plans and publications around the Great Lakes (Muir et al. 2012; Ontario Ministry of Natural Resources 1996; Zimmerman and Krueger 2009) and differ from "restoration" or "recovery" which infers returning to a previous historical condition, something now acknowledged to be unachievable due to irreversible alterations of native fish communities (Zimmerman and Krueger 2009).

Multi-jurisdictional efforts to rehabilitate Lake Trout in Lake Superior began in the 1950s with targeted Sea Lamprey control efforts. In 1951, construction of instream mechanical control devices for Sea Lamprey began in eastern Lake Superior and progressed west as Sea Lamprey abundance increased. In 1954 and 1955, Sea Lamprey spawning runs in Wisconsin's Amnicon River were so large that local landowners forbade their children from swimming in the river (Smith 1971). Chemical control of instream larval Sea Lamprey began in 1958 and in 1962 the number of spawning adult lamprey collected at electrical barriers declined 86% (Smith et al. 1974). Parasitic phase Sea Lamprey numbers declined, which led to reduced wounding and subsequent mortality of Lake Trout (Smith et al. 1974). Chemical control of instream larval Sea Lamprey in the Great Lakes was the foundation for which Lake Trout rehabilitation efforts in Lake Superior could progress and remains the primary control mechanism today.

Successful control of Sea Lamprey led to large-scale stocking efforts in the 1960s; however, Lake Trout were stocked in Minnesota waters of Lake Superior ever since the construction of the United States Fish Hatchery on the Lester River in Duluth in the late 1880s. The hatchery was built out of concern by commercial fishers that Lake Whitefish may go extinct due to overharvest (Game and Fish Commission of Minnesota 1892). Plans for a state-owned hatchery began in 1913 when the Minnesota state legislature appropriated $1,000 to the Game and Fish Commission to acquire land on the North Shore to build the Lake Superior State Fish Hatchery. The new hatchery was finished in 1917 and began to buy Lake Trout eggs from Minnesota commercial fishermen, rear the eggs in the hatchery, and return the fish as fry or fingerlings to the commercial fishermen who then stocked them into Lake Superior. In 1947, the United States Fish Hatchery at Lester River was closed due to an ongoing water supply issue and in 1962 Minnesota began receiving Marquette strain Lake Trout from federal hatcheries as reimbursement for fish lost due to Sea Lamprey invasion through the Welland Canal. From 1981 to present, the Minnesota and federal hatchery systems propagated Isle Royale strain Lake Trout to stock into Minnesota waters for rehabilitation efforts (Schreiner et al. 2015). Stocking peaked in the 1990s at over 500,000 yearlings per year on average in Minnesota waters.

Progress towards Lake Trout rehabilitation was first observed in offshore shoal areas of Wisconsin and Michigan where remnant wild stocks persisted. Later, hatchery-reared Lake Trout began to spawn and produce offspring in nearshore areas. Self-sustaining Lake Trout populations were slower to establish in Minnesota waters than in other jurisdictions possibly due to the lack of remnant, self-reproducing Lake Trout stocks in Minnesota waters, extremely high localized lamprey mortality, high fishing mortality from commercial fishing prior to 1962 and recreational fishing after 1962, lower initial stocking rates, and less spawning habitat. However, through a dedicated stocking program, conservative harvest limits, and continued Sea Lamprey control efforts, wild Lake Trout abundance has increased and self-sustaining stocks have been re-established in each management zone in Minnesota waters of Lake Superior.

Within specific areas of Lake Superior, Lake Trout rehabilitation in western Lake Superior is still progressing as evident by continuing increases in abundance. Lake Trout populations in central Lake Superior are experiencing declines in abundance due to higher levels of fishery exploitation. Lake Trout populations in eastern Lake Superior are considered to be in a post-rehabilitated state as evident by decreasing abundance. In U.S. jurisdictions of Lake Superior, Lake Trout growth rates have declined substantially since the 1980s, possibly due to increasing abundance of Lake Trout and decreased abundance of prey fish (Pratt et al. 2015). As Lake Trout rehabilitation continues in Minnesota waters, basic ecology principles (Odum 1959) suggest that populations will increase to a point, then possibly decline before the population reaches equilibrium, similar to what occurred in eastern Lake Superior.

6.2 MANAGEMENT HISTORY (1996-2015)

6.2.1 REGULATION HISTORY

Prior to 2006, anglers could legally fish for Lake Trout from December 1 to September 30. The season was extended from December 1 through the first full weekend in October, beginning in 2006, to reduce restrictions where the benefit of restrictions was minimal. The possession limit of three Lake Trout has been consistent since 1970.

6.2.2 STOCKING HISTORY

As the self-sustainability of Lake Trout populations in MN-3 and MN-2 progressed and abundance of wild Lake Trout increased, stocking as a management tool in these zones became ineffective. Criteria to discontinue Lake Trout stocking were met in management zones MN-3 and MN-2 and stocking ceased in 2003 and 2007, respectively. In the 2006 Lake Superior Management Plan revision, stocking in management zone MN-1 was reduced from 232,000 to 170,000 yearlings annually and further evaluation of stocking effectiveness was necessary as Lake Trout rehabilitation progressed.

6.2.3 ASSESSMENT HISTORY

Efforts to assess Lake Trout populations were relatively consistent from 1996-2015 except for the Fall Assessment, which was discontinued in 2009 because similar data were being collected in the Expanded Assessment and Spawning Assessment surveys. Most of the Minnesota-based surveys conform to standardized lake-wide surveys developed and implemented by management jurisdictions around Lake Superior and have focused on monitoring the recovery of wild stocks, determining when to discontinue stocking for the purposes of Lake Trout rehabilitation, and overall predator abundance. These surveys include the May, Small Mesh, Spawning, and Siscowet Assessments. Minnesota DNR has also surveyed summer anglers annually since the 1970s to estimate harvest and catch rates. All assessments have regularly collected age and diet information, except for the summer angler survey. The 2006 revision proposed that staff collect age and diet data from anglers' catches in summer; however, limited resources prevented the collection and analysis of these data.

Between the 1996 and 2006 plans, more technical evaluations of Lake Trout populations became possible with advancements in technology. The 2006 Plan included an objective to assess Lake Trout populations with computer-based statistical-catch-at-age (SCAA) models, particularly total annual mortality which is the sum of natural, fishing, and Sea Lamprey-induced mortality. Similar to other management jurisdictions, MN DNR developed and maintained SCAA models and total annual mortality threshold criteria to assist in determining when harvest should be reduced. The 2006 plan set the total annual mortality thresholds at less than 45%. If total annual mortality exceeded 45% in any zone for five consecutive years, or the average exceeded 50% for three consecutive years, sport harvest of Lake Trout would have been reduced. Total annual mortality remained below 45% from 2006 through 2014 (Figure 6.1), which is the last year for which data are currently available.

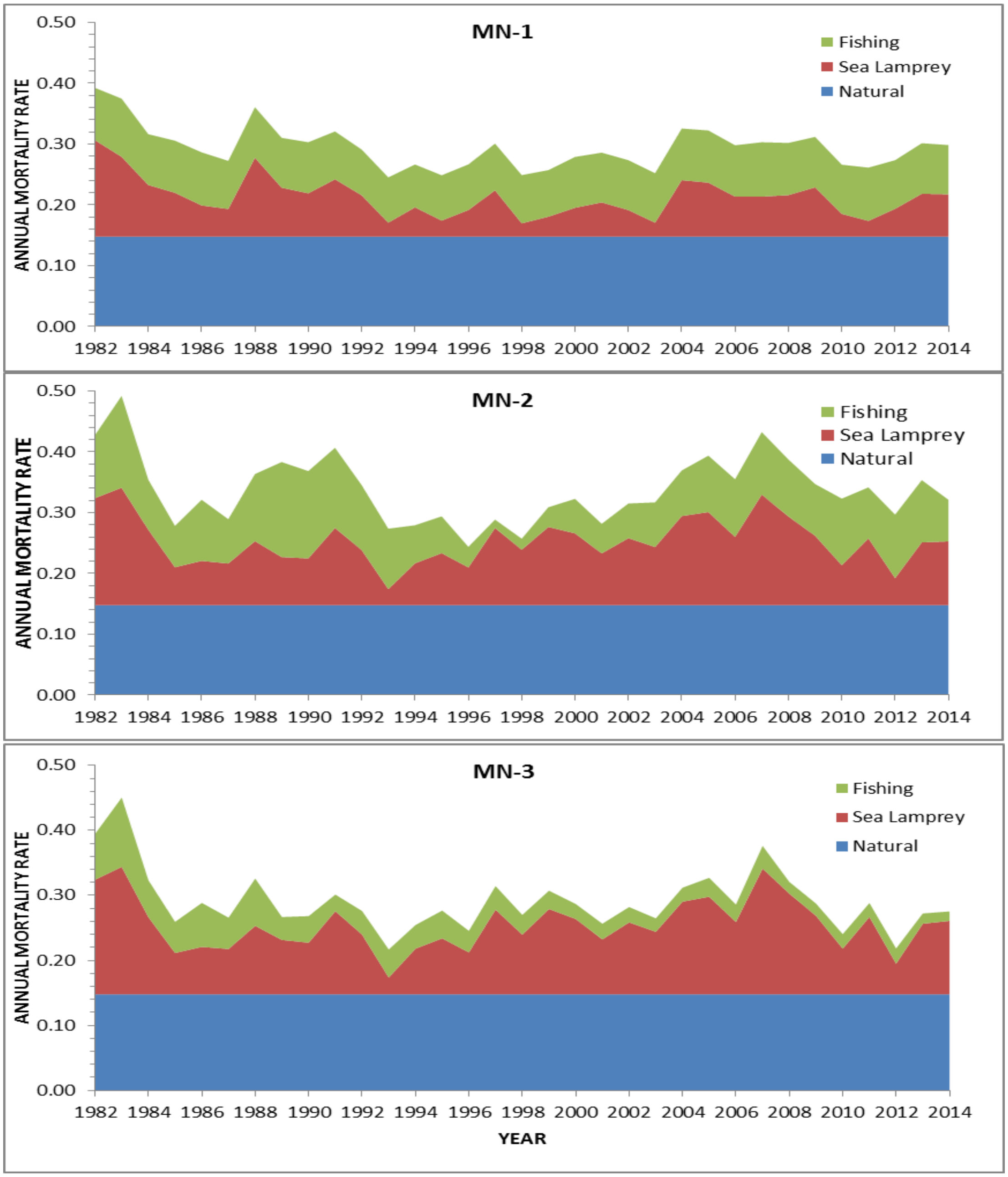

FIGURE 6.1: Lake Trout mortality by source and Management Zone, 1982-2014.

Minnesota closed commercial fishing in 1962; however, some commercial operators were able to continue harvesting Lake Trout through permitted assessments in management zones MN-2 and MN-3. In preparing the 2006 Lake Superior Fisheries Management Plan (2006 Plan), MN DNR considered a proposal to increase the commercial assessment harvest of Lake Trout by 2,400 in MN-3 where Lake Trout populations had increased. The proposal also discussed potentially implementing a similar but reduced fishery in MN-2. The proposal was not implemented in the final version of the 2006 Plan. However, in 2007 the Minnesota legislature enacted the Lake Superior Lake Trout Expanded Assessment Harvest statute (Minnesota Statute 97C.836) that authorized the commissioner of MN DNR to expand the taking and sale of Lake Trout by licensed commercial operators in MN-3 and MN-2. The legislation enacted a total-allowable-catch quota of 3,000 Lake Trout in MN-3 and 2,000 Lake Trout in MN-2 with an open season from June 1 to September 30. Under terms of the permit, commercial operators record data of Lake Trout captured in the Expanded Assessment that is then used in SCAA modeling. Through this legislation and the cooperative efforts of the commercial operators, MN DNR has received data on over 17,000 Lake Trout it otherwise would not have gotten due to limited resources.

6.3 GOALS AND OBJECTIVES (2016-2025)

Goal: Maintain self-sustaining Lake Trout stocks that provide recreational, commercial, and tribal fishing opportunities.

Objectives:

1. Discontinue Lake Trout stocking in MN-1 by 2017.
2. Maintain Lake Trout total annual mortality rates below 40% for each management zone based on statistical-catch-at-age mortality estimates.
3. Extend the spatial coverage of the MN DNR May Lake Trout Assessment into MN-2 and MN-3.
4. Use winter creel surveys to evaluate the potential impact of recreational fishing during periods of ice-cover.
5. Establish an Expanded Assessment Harvest Zone for Lake Trout in MN-1 and institute a limited Expanded Lake Trout Assessment fishery in those waters with a quota of 500 Lake Trout.
6. Support Sea Lamprey control efforts by the Great Lakes Fishery Commission and the U.S. Fish and Wildlife Service with a goal of maintaining wounding rates below five percent.
7. Locate and protect areas where Lake Trout spawn successfully.
8. Maintain the current fishery closure during the spawning season to control mortality of spawning Lake Trout.
9. Work with other management jurisdictions on ecosystem modeling efforts to better understand predator-prey dynamics and bioenergetic demands in Lake Superior.

6.4 MANAGEMENT STRATEGIES (2016-2025)

<u>6.4.1 REGULATIONS</u>

No changes to regulations are proposed at this time. Anglers may possess three Lake Trout in Minnesota waters.

<u>6.4.2 STOCKING</u>

Discontinue stocking hatchery-reared Lake Trout in MN-1. This will end all Lake Trout stocking in Minnesota waters of Lake Superior. An additional year class of age-1 Lake Trout was expected to be stocked from the Crystal Springs hatchery in southeastern Minnesota in the spring of 2016; however, an outbreak of furunculosis has forced the MN DNR to depopulate the hatchery and begin disinfection procedures. Once disinfected, the hatchery must remain disease-free for three years before fish can be stocked again. The MN DNR has begun taking steps to ensure it is able to respond if a local or lake-wide stocking effort is required to meet state fishery goals, or recommended by the Lake Superior Committee of the Great Lakes Fishery Commission in the future. Genetic analysis of wild Lake Trout has begun to determine the amount of genetic diversity in the Lake Trout population on the North Shore, which will guide selection of the best broodstock source, should the need arise in the future. The MN DNR has also communicated with other Lake Superior border states, Ontario, and the US Fish and Wildlife Service to assess their capacity and ability to provide stocked Lake Trout to MN DNR waters in the event that it is deemed critical and time sensitive to reinitiate a stocking program.

Based on what was observed with post-rehabilitated Lake Trout populations in eastern Lake Superior, it can be expected in Minnesota waters that wild Lake Trout abundance will continue to increase to its peak and subsequently decline to a point of equilibrium. It is also expected that the increase in wild Lake Trout abundance will negate any potential negative effect of discontinuing stocking with little overall impact to the sport fishery. This scenario is similar to what occurred in other management zones following the discontinuation of stocking. MN DNR will continue Lake Trout assessment activities to determine whether rehabilitated wild stocks can remain self-sustaining given current and anticipated future rates of harvest.

6.4.3 ASSESSMENT

Continue the annual Lake Superior Summer creel survey, the annual May and Small Mesh Assessment survey, biennial Spawning Assessment survey, and triennial Siscowet Assessment survey. Expand MN DNR effort into MN-2 and MN-3 while maintaining current sampling effort in MN-1. Establish an Expanded Assessment commercial fishing zone and permit-based commercial Expanded Assessment fishery in MN-1 with an annual quota of 500 Lake Trout. Continue to collect age and diet data from all predatory fish collected during assessment operations.

6.5 JUSTIFICATION

Objective 1: Discontinue Lake Trout stocking in MN-1 by 2017.

Re-establishing self-sustaining Lake Trout populations in Lake Superior has been the primary goal of management agencies around Lake Superior since the 1950s when overfishing and Sea Lamprey predation caused lake-wide stock collapses (Hansen 1996). Lake Superior was the only Great Lake whose Lake Trout population was not completely extirpated by overfishing, Sea Lamprey predation, and habitat destruction (Muir et al. 2012). These wild remnant stocks served as sources of brood stock for stocking programs which were the foundation of rehabilitation efforts.

A Lake Trout Restoration Plan for Lake Superior hereinafter referred to as “the restoration plan” (Hansen 1996) outlines criteria for management jurisdictions to determine whether it is appropriate to discontinue stocking for the purposes of Lake Trout restoration and serves as the basis for MN DNR’s decision to discontinue stocking in MN-1. From the restoration plan:

Application of the following criteria is recommended to determine whether Lake Trout stocking should be discontinued in United States management areas. The criteria only apply to

Lake Trout stocked as part of the restoration plan. Some fishery-management agencies also stock Lake Trout to enhance fisheries in their jurisdictions. The appropriateness of such stocking should not be evaluated under these criteria. Although stocking can be discontinued based on any one of the following criteria, all four criteria should be examined before action is taken.

1. Political commitment to Lake Trout restoration: Stocking should be discontinued in any area where the management agency or agencies fail to support Lake Trout restoration.
2. Harvest Control: Agencies committed to Lake Trout restoration should institute programs of fishery regulation and enforcement. Discontinuance of stocking should be considered for any area where the allowable harvest is exceeded by more than 10% for three successive years.
3. Wild-Fish Abundance: Evaluation of Lake Trout restoration is based on the relative numbers of wild and stocked fish in the spawning stock and the stability of the wild component of the stock. Stocking should be discontinued in any area where: (a) wild fish compose at least 50% of the catch of spawning-size Lake Trout in the spring assessment fishery, (b) wild-fish abundance is stable or increases for three consecutive years.
4. Stocked-Fish Survival: Even exceptional commitment and regulatory enforcement by managers may be inadequate to ensure the survival of stocked fish in Lake Superior. Stocking should be discontinued in any area where the survival index for stocked fish falls below 1.0 for three successive years. Relative survival is calculated as the number of age-7 stocked Lake Trout caught per 304 m (1,000 feet) of gillnet divided by the number (in 100,000s) of Lake Trout stocked seven years earlier multiplied by 100,000.

Minnesota has maintained a political commitment to Lake Trout restoration and harvest control; therefore, criteria #1 and #2 are not applicable. Two metrics of wild fish abundance, percent wild fish and catch rate of wild fish in the May assessment in MN-1, were met in MN-1 in 2001 (Criteria #3a; Figure 6.2), and 2009 (Criteria #3b; Figure 6.3). The magnitude of perceived decline in Lake Trout abundance in the 2015 May assessment (Figure 6.3) did not transpire in the 2015 spawning assessment (Figure 6.4) and may be attributed to Lake Trout targeting age-1 Cisco from the 2014 year class further offshore instead of targeting Rainbow Smelt nearshore where assessment netting takes place. Criteria #4, survival of stocked fish, was met in MN-1 in 2004 when relative survival for stocked fish fell below 1.0 for three successive years (Figure 6.5). Relative survival remained below 1.0 through 2014, the last year for which age data are available.

As mentioned in the restoration plan, these criteria only apply to Lake Trout stocking as part of rehabilitation efforts, not enhancing the sport fishery. Successful rehabilitation will occur when the Lake Trout population is self-sustaining given current and future rates of natural mortality, fishing mortality, and Sea Lamprey mortality. The sum of these mortality rates, known as total annual mortality, is monitored by MN DNR using SCAA modeling (Figure 6.5) and is the primary indicator MN DNR uses to evaluate harvest rates.

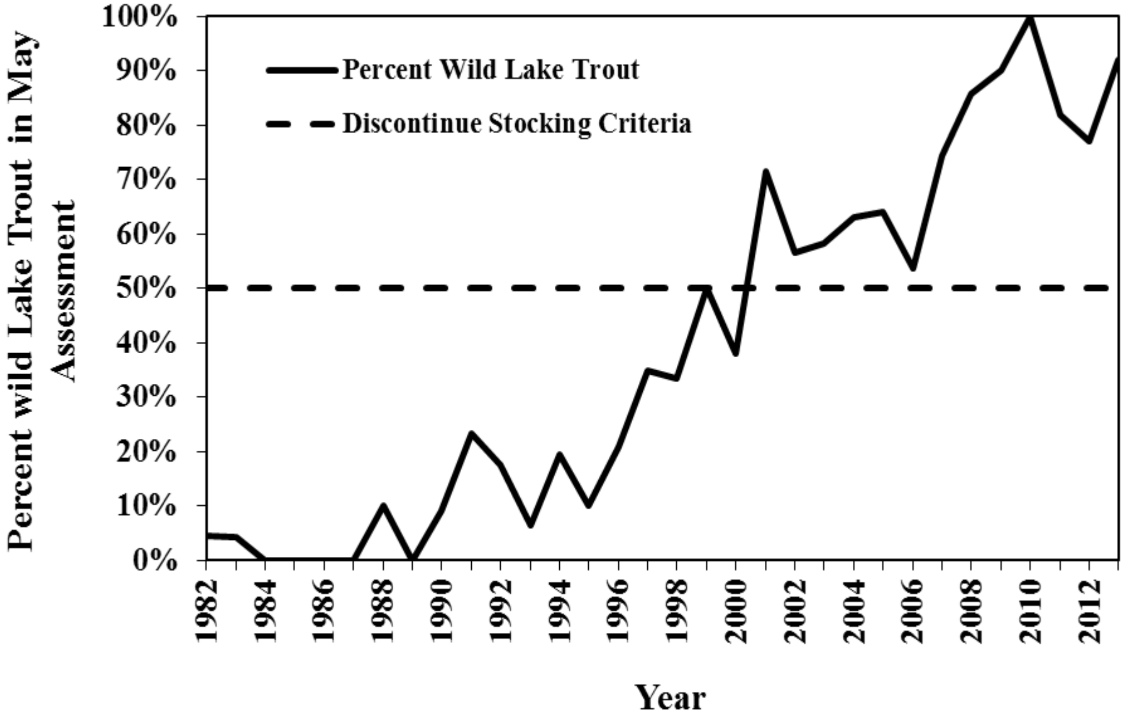

FIGURE 6.2: Percent wild Lake Trout in the May Assessment for management zone MN-1, 1982-2014. The dashed line represents criteria 3a in *A Lake Trout Restoration Plan for Lake Superior* to discontinue stocking when the proportion of spawning-sized wild Lake Trout exceeds 50%.

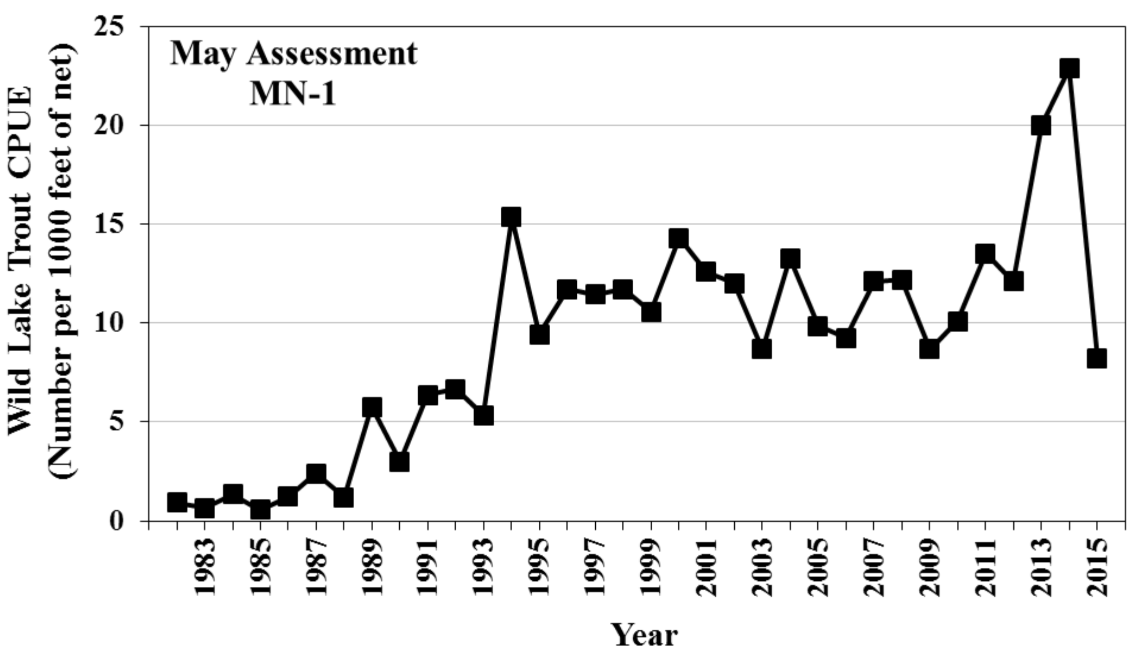

FIGURE 6.3: Catch per-unit-effort (CPUE; number of fish per 1,000 feet of net) of wild Lake Trout in MN-1 May Assessment by year.

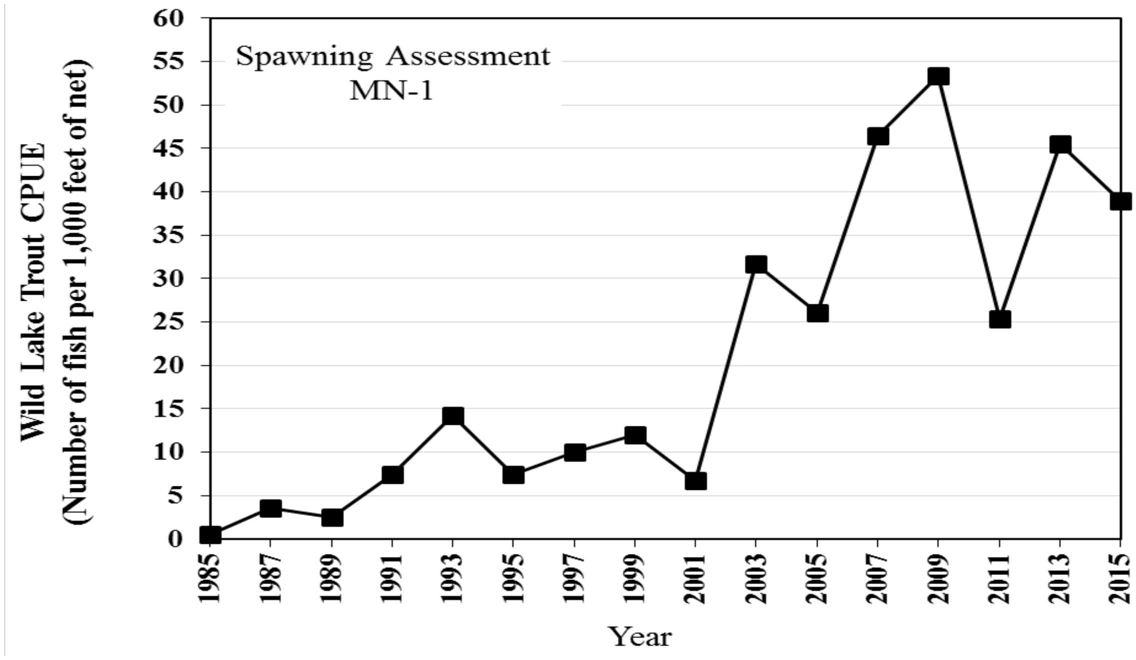

FIGURE 6.4: Catch per-unit-effort (CPUE; number of fish per 1,000 feet of net) of wild Lake Trout in MN-1 Spawning Assessment by year.

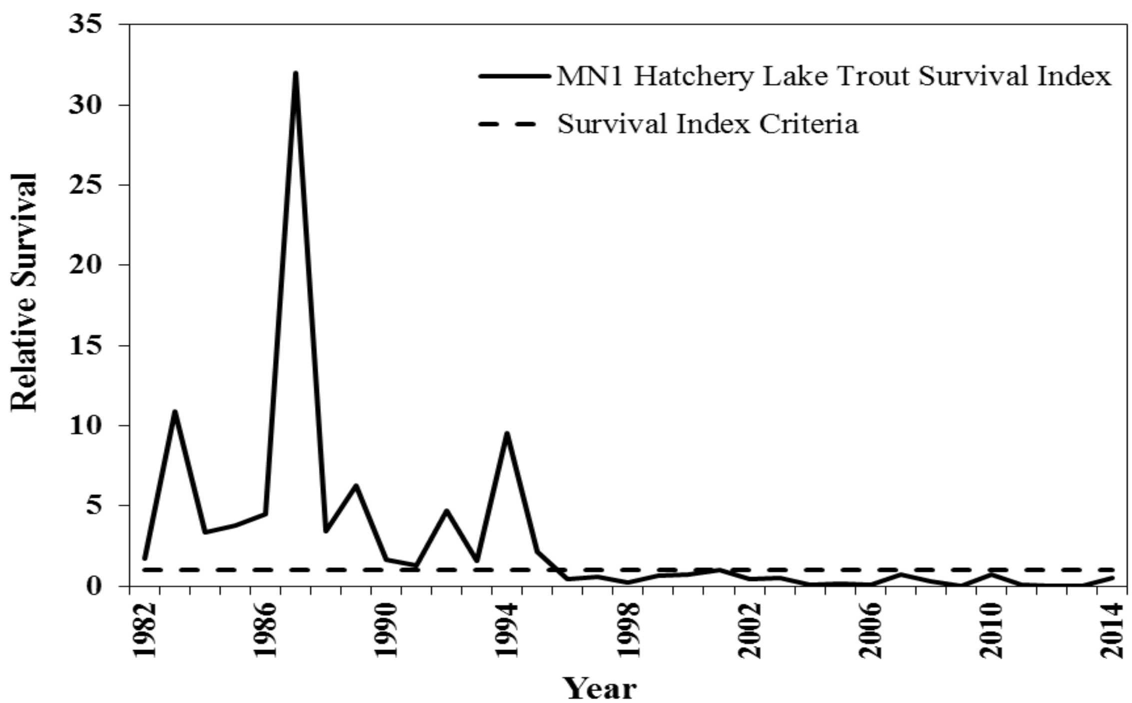

FIGURE 6.5: Relative survival of stocked Lake Trout in management zone MN-1, 1982-2014. The dashed line represents criteria 4 in *A Lake Trout Restoration Plan for Lake Superior* to discontinue Lake Trout stocking when relative survival falls below 1.0 for three years. Criteria 4 has been met in MN-1 since 2004.

Objective 2: Maintain Lake Trout total annual mortality rates below 40% for each management zone based on statistical-catch-at-age mortality rates.

Healey (1978) suggested that a Lake Trout population will decline when total mortality is more than 50%. Subsequently, the restoration plan revised the maximum target mortality level downward to 45% in response to results from additional modeling (Technical Fisheries Review Committee 1992; Ebener et al. 1989). Nieland et al. (2008) suggested Lake Trout populations in the eastern Wisconsin waters of Lake Superior are likely to be sustainable when total mortality is 40% or less. Nieland et al. (2008) also suggested that assessment error in SCAA models be more accurately quantified, low spawner abundance be avoided through the use of threshold management strategies, and commercial fishing quotas be closely monitored and enforced. Currently, spawning stock biomass thresholds for Minnesota waters do not exist.

Similar to what occurred with post-rehabilitated Lake Trout populations of eastern Lake Superior, it can be expected that Lake Trout populations in Minnesota will reach peak abundance and subsequently decline to a state of equilibrium based on recruitment rates, mortality rates, and prey availability. As Lake Trout abundance declines, total annual mortality will likely increase and may exceed the threshold target of 40%. If this should occur, regulation changes may be needed to bring mortality rates back below 40%.

Objective 3: Extend the spatial coverage of the MN DNR May Lake Trout Assessment into MN-2 and MN-3.

Minnesota DNR relies almost solely on assessment netting data from standardized surveys and the commercial Expanded Assessment to monitor the Lake Trout population in Lake Superior. MN DNR standardized Lake Trout assessments are based on LSTC protocol that all management agencies around Lake Superior follow to ensure data are comparable across the lake. Since at least the 1940s MN DNR has relied upon commercial assessment netters in MN-2 and MN-3 to provide data that MN DNR did not have the resources to collect. In the past few decades the number of commercial assessment netters has declined to only two in MN-2 and one in MN-3. In order to obtain more spatial coverage in the spring (May) assessment, MN DNR will expand standardized assessments into MN-2 and MN-3 beginning in 2016. Commercial assessment netting operations during the May assessment will continue to maintain the existing long-term datasets and complement data collected in MN DNR assessments.

Objective 4: Use winter creel surveys to evaluate the potential impact of recreational fishing during periods of ice-cover.

During the winters of 2013-2014 and 2014-2015 thick ice cover on Lake Superior enabled ice fishing on the main lake in management zone MN-1, where the highest amount of fishing pressure already occurs. The rare opportunity to ice fish on Lake Superior was popular with anglers and on busy weekends over 100 ice-fishing shacks were counted in impromptu estimates of fishing pressure. During this time, MN DNR received reports of concern from some anglers that too many large Lake Trout were being caught and kept and that future fishing success could be jeopardized. These concerns led to the realization of the need to conduct winter creel surveys when ice conditions allow for fishing on the main lake. This would enable fishing mortality estimates from ice fishing to be included in SCAA modeling and be incorporated into the total annual mortality estimated used to determine whether harvest restrictions are needed to ensure sustainability of wild stocks.

Objective 5: Establish an Expanded Assessment Harvest Zone for Lake Trout in MN-1 and institute a limited Lake Trout Expanded Assessment fishery in those waters with a quota of 500 Lake Trout.

Establishing an Expanded Assessment Harvest Zone and instituting an Expanded Assessment for Lake Trout in those waters will provide currently unavailable age and diet data in MN-1 while allowing for limited harvest by commercial operators which is currently available in MN-2 and MN-3. The commercial fishing zone will encompass an area extending from the tip of the break-wall at Knife River Marina east to the Minnesota/Wisconsin boundary and north to the boundary with management zone MN-2 (Figure 6.6). The commercial fishing zone is necessary to reduce negative encounters between commercial operators and sport fishers since MN-1 sees over two-thirds of the fishing effort but only comprises 10% of total surface area of Minnesota waters of Lake Superior. The initial quota of Lake Trout available for harvest by commercial operators will be 500 Lake Trout, which is approximately 2.7% of angling harvest based on MN DNR creel surveys in MN-1.

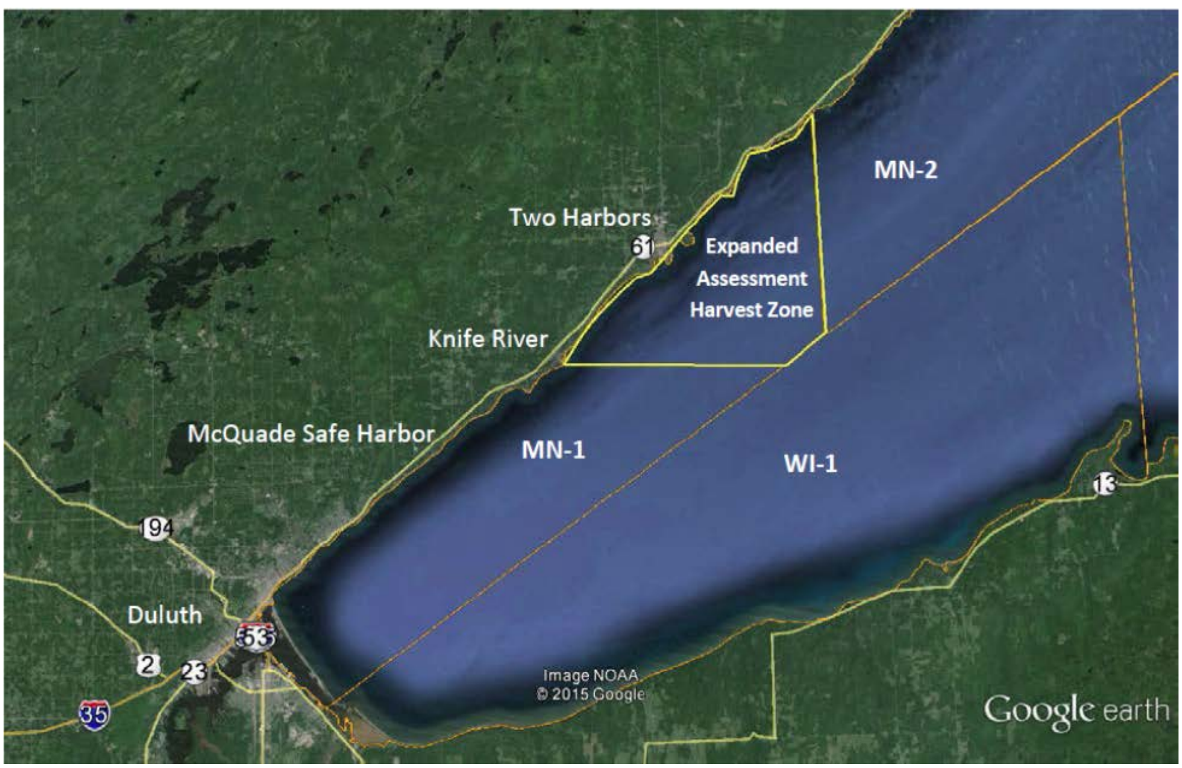

FIGURE 6.6: Map of Expanded Assessment Harvest Zone for Lake Trout in MN-1 (quota = 500 Lake Trout).

Objective 6: Support Sea Lamprey control efforts by the Great Lakes Fishery Commission and the U.S. Fish and Wildlife Service with a goal of maintaining wounding rates below five percent.

The Great Lakes Fishery Commission, pursuant to the Convention on Great Lakes Fisheries, delivers a Sea Lamprey Control Program (Program) in partnership with the U.S. Fish and Wildlife Service, Fisheries and Oceans Canada, and the U.S. Army Corps of Engineers. The U.S. Geological Survey conducts critical Sea Lamprey research to aid in control. The Program has reduced the Sea Lamprey population in Lake Superior by 90%. Wounding rates have regularly remained above target rates in Minnesota waters (Figure 6.7) despite limited Sea Lamprey production in Minnesota tributaries, which indicates Sea Lamprey production and movement from other jurisdictions is a significant contributor to Lake Trout mortality.

A variety of methods are used to control Sea Lampreys in Lake Superior (Adair and Sullivan 2015). The lampricide TFM and granular Bayluscide are the primary tools used to reduce Sea Lamprey populations. Barriers also play a critical role in the Program by preventing Sea Lampreys from reaching suitable spawning and nursery habitat. The Program further recognizes the need to remain innovative in its approaches to controlling Sea Lamprey to diversify the toolbox. Understanding how pheromones and alarm cues influence Sea Lamprey migration behavior is critical to increasing the efficiency of traps and barriers. Pheromones could be used to pull Sea Lampreys to locations that can either be trapped or treated with lampricide more effectively. Alarm cues could be used to push Sea Lampreys away from locations that can't be trapped or treated with lampricide effectively. These two novel approaches could be used in concert to manipulate migration behaviors in a way that enhances the effectiveness of the Program by reducing the number of parasitic Sea Lampreys in Lake Superior. Although streams in Minnesota produce very few lampreys, wounding rates in Minnesota waters remain among the highest in Lake Superior. A reduction in lamprey-induced Lake Trout mortality to less than 5% would increase the biomass of Lake Trout available for harvest and increase the rate of rehabilitation. If reductions in Sea Lamprey abundance are to occur, funding for alternative control methods must remain available.

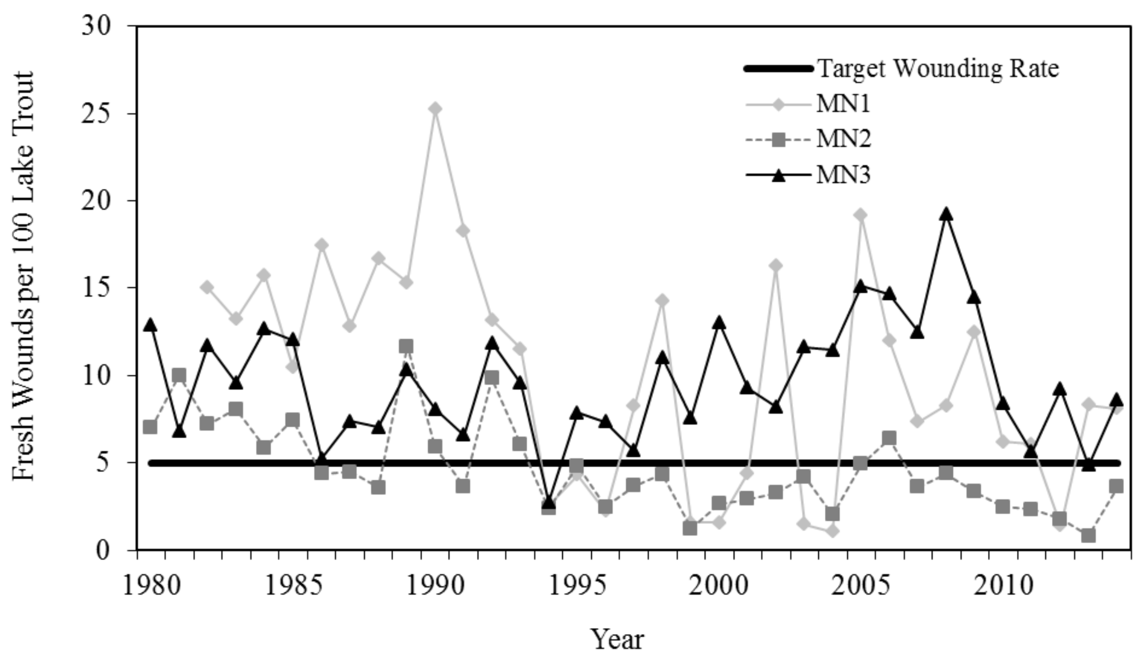

FIGURE 6.7: Percent of fresh Sea lamprey wounds by management zone from 1980 to 2014. The Great Lakes Fishery Commission target wounding rate is indicated by the black line.

Objective 7: Locate and protect areas where Lake Trout spawn successfully.

Most information on historical Lake Trout spawning areas in Minnesota has come from interviews with commercial operators. Presently, there is little documentation of the exact locations of Lake Trout spawning or of the extent to which historical spawning reefs are currently being utilized. The substrate of much of the nearshore water of Minnesota has been mapped, and the quality for Lake Trout spawning has been estimated (Richards et al. 1999), but identifying discrete spawning areas has not progressed. Riley et al. (2014) found Lake Trout in Lake Huron use submerged drumlins as primary spawning habitat. Light Detection and Ranging (LIDAR) technology provides high-resolution three-dimensional information about the shape and surface characteristics of the Earth. Combining LIDAR data to identify drumlin features with on-the-ground fisheries assessments may provide an efficient and effective method of identifying Lake Trout spawning areas and assist with assessment and protection of critical spawning areas.

Objective 8: Maintain the current fishery closure during the spawning season to limit mortality of spawning Lake Trout.

Among interested angling groups, support was mixed for instituting a length-based size restriction for Lake Trout, despite lack of evidence that one was needed. Most lean Lake Trout greater than 25 inches are at least ten years old and the oldest fish can approach 40 years old. Over-exploitation of long-lived species can have negative impacts to long-term population abundance that may not be fully realized for many years. For instance, most Lake Trout reach sexual maturity at six or seven years old. For those fish to reach sexual maturity and be replaced in the population by another spawning Lake Trout could take 12 to 14 years.

Objective 9: Work with other management jurisdictions on ecosystem modeling efforts to better understand predator-prey dynamics and bioenergetic demands in Lake Superior.

The Lake Superior Technical Committee is engaged in an Ecopath with Ecosim modeling effort to better understand fine-scale bioenergetic demands in the Lake Superior food web. This effort will compile data on the lower trophic food web and the inter-relations between predator and prey fish populations.

6.6 INFORMATION NEEDS

Lake Trout population response to discontinuing stocking in MN-1 will not be fully realized for some time. Recent growth rates suggest most stocked Lake Trout become vulnerable to the sport fishery around age 7. The 2015 year class will be stocked in the spring of 2016, which means those fish will reach age 7 in 2022, only two years before the management plan revision process begins again. Management of Lake Trout populations will benefit from continued monitoring of hatchery-reared and wild Lake Trout abundance, establishing a sport fishery age and diet pilot program, and continued monitoring of prey fish biomass and diet overlap among predators.

Ecosystem-based modeling of energy inputs and consumption in Lake Superior can provide valuable insight into mechanisms limiting prey, sport, and commercial fish production as well as help predict ecosystem changes in the event of invasion by non-native organisms. The Lake Superior Technical Committee is building an ecosystem model for Lake Superior and MN DNR will continue to assist in these efforts when resources are available.

The best ways to sustain productivity of Lake Trout and other species in Lake Superior are to improve existing methods and develop new methods for controlling Sea Lamprey. Although Sea Lampreys in the Great Lakes prefer large Lake Trout, they do attack other species when Lake Trout abundance is low. Examples are Chinook Salmon in northern Lake Huron and Lake Whitefish and steelhead in Lake Superior. The frequency of lampricide treatment on streams and in lentic areas that consistently produce large numbers of Sea Lamprey larvae should be increased. The mechanism of larval survival from lampricide treatment should be investigated, and the knowledge obtained should be used to eliminate residual larval production. The contribution of lamprey from different potential sources (stream, lentic, migratory, etc.) should be determined and these sources should be appropriately treated. New control technologies, such as the use of pheromones, should be implemented as soon as practical.

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CHAPTER 7: BROOK TROUT

7.1 BACKGROUND

Brook Trout and Lake Trout are the only native trout species in Lake Superior; however, Smith and Moyle (1944) claimed it was unlikely Brook Trout existed above barrier falls until they were stocked there in the late 1800s. Brook Trout can utilize both stream and lake habitat during different life stages. In streams, they prefer cool, spring-fed reaches with vegetated banks, abundant instream cover, stable flows, and stable banks (Raleigh 1982). Brook Trout that spend part of their life in Lake Superior are referred to as "coasters" because of their preference for rocky, coastal habitat. Coasters were once abundant and widely distributed among Lake Superior tributaries below the natural barriers (Newman and Dubois 1996; Waters 1987).

During the 1880s, many coaster Brook Trout populations were extirpated due to habitat degradation and overfishing (Newman et al. 2003). Intensive logging operations cleared forests and opened riparian canopies, causing rapid snowmelt and increased runoff. It is likely that as streams adjusted to the inputs from their newly impacted watershed, they became unstable, changed form (dimension, pattern, and profile), and lost the ability to effectively transport their sediment load. Excess sediment filled in spawning and rearing habitats and increased water temperatures, the single most important factor limiting Brook Trout distribution and production (Raleigh 1982). In 1922, Thaddeus Surber, a biologist with the Minnesota Game and Fish Department, began reconnaissance of the tributaries to Lake Superior in Cook and Lake Counties (*Fins, Feathers, and Fur 1923)*. From Mr. Surber's report:

> *"Because of changed conditions brought about by the deforestation of great areas of this region some of the once-famous Brook Trout streams are no longer tenable as such and will have to be re-stocked with Brown Trout, or other species, more suitable for the changed conditions. These radical changes have come within the past 35 years, occasioned in the first place by lumbering operations and followed later by forest fires which destroyed immense areas of swampland along with second growth in the slashings, giving the powerful rays of the sun access to the cold sphagnum swamps. Fires have actually destroyed many of these sphagnum swamps. This rise in water temperature has been so marked as to prohibit the presence of Brook Trout in certain parts of the streams during long periods in the summer, the colder upper water have been destroyed, so that trout in their search for cold waters have been compelled to descend many of the streams to Lake Superior."*

Furthermore, Mr. Surber discusses the heavy exploitation of stream trout along the North Shore:

> *"The influx of summer tourists and trout anglers along the North Shore, which is made more accessible by good roads, has caused a tremendous drain on the trout streams, and the problem of maintaining the fishing in these streams now assumes great importance and was one of the problems confronting us when this survey was undertaken. The planting of Brown Trout or smallmouthed bass in unduly-heated streams, thereby diverting greater number of Brook Trout to streams still suited to their habitat, is apparently about the only solution of this problem."*

Contrary to Mr. Surber's prediction, stocking Brown Trout and Smallmouth Bass was not the only solution to providing fishable populations in warming stream temperatures. Today, many North Shore streams support wild Brook Trout populations and the cold waters that are needed to sustain them, perhaps a fair reminder to the resilience of natural systems despite their perceived limitations at a specific point in time.

Intensive logging and the damaging fires that followed also impacted wildlife, including beaver *Castor canadensis*. The conversion of a pine-dominated landscape to an aspen-dominated landscape greatly favored beaver and beaver abundance increased substantially (Breckenridge 1949; Figure 7.1).

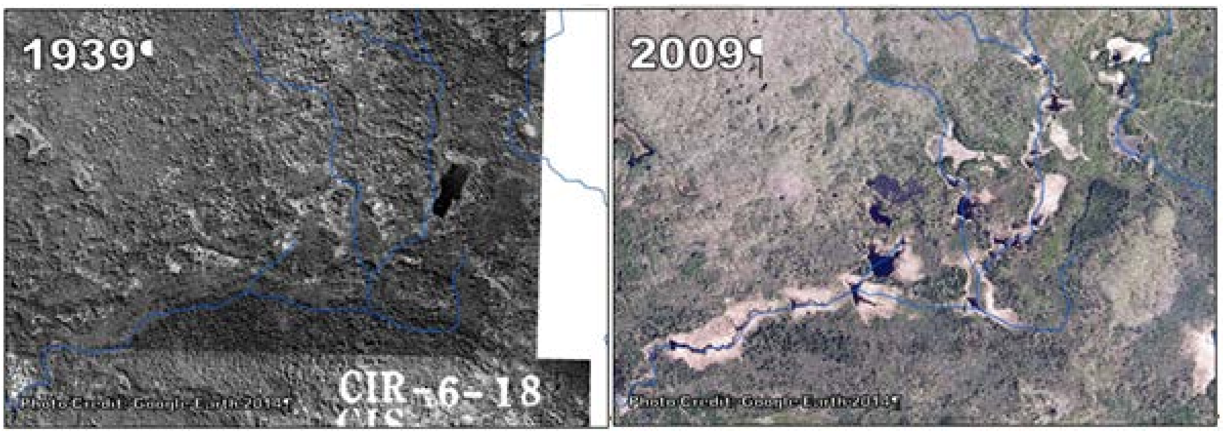

FIGURE 7.1: Aerial photographs showing beaver activity in the headwaters of the West Branch Knife River in 1939 (left) and 2009 (right).

A Brook Trout Rehabilitation Plan for Lake Superior (Newman et al. 2003) identifies the need for controlling beaver activity in key stream sections in order to achieve rehabilitation goals. Negative impacts of beaver dams on water temperatures preferable to Brook Trout have been documented on the North Shore. Over a three-year period, summer hourly water temperature was recorded above and below a series of six beaver dams on the Little East Branch of the Knife River near Two Harbors, Minnesota. On average, water temperature above the beaver dams was within the range of growth for Brook Trout 98% of the time. Below the beaver dams, water temperatures were within the range of growth for Brook Trout 48% of the time, within the stressful range for Brook Trout 41% of the time, and above the lethal threshold 11% of the time (Peterson 2012). Higher percentages of hours within the stressful range for Brook Trout below beaver dams were also found in tributaries to the West Branch Knife River and Stanley Creek in the Knife River watershed and a tributary to the Sucker River. Repeated field observations in the Lake Superior watershed conclude that increases in water temperatures below beaver dams is positively related to the surface area of the water that is impounded by the beaver dam; dams that retain riparian shade cover and do not impound water produce no increase in water temperature below the dam. However, these dams likely still disrupt stable river process and health (connectivity, geomorphology, water quality, biology, and hydrology) and may prevent fish movement.

Management agencies have attempted to rehabilitate the coaster Brook Trout fishery in Minnesota by stocking different strains and sizes. Although stocking records before 1970 are incomplete, fish managers did stock many hatchery-reared Brook Trout in lakes and streams above barriers to provide inland fishing for Brook Trout. At various times since 1970, domestic Brook Trout were stocked in Lake Superior harbors and bays to create put-grow-take fisheries. Results were mostly limited to returns within the first month of stocking and the programs were deemed unsuccessful (Halpern 1995). In the mid-1980s Nipigon strain Brook Trout were stocked in the French River for three years and only three fish returned to the trap. After 1987, Brook Trout have not been stocked by the MN DNR in the Minnesota waters of Lake Superior.

The Grand Portage Band of Chippewa, assisted by the U.S. Fish and Wildlife Service, stocked three reservation area streams with eyed eggs and/or fry from Nipigon strain Brook Trout from 1992 through 2002, with stocking gaps in 1997 and 2001 to allow assessment of natural reproduction (Grand Portage Band of Lake Superior Chippewa 2005). There is evidence of at least some adults returning to spawn and natural reproduction occurring in stocked streams (Newman 2000). Grand Portage Band of Chippewa has maintained a stocking program by annually stocking various life stages of Brook Trout (mainly Isle Royal strain) from 2003 through 2015 in reservation waters.

The *Fish Community Objectives for Lake Superior* (Horns et al. 2003) called for rehabilitating Brook Trout populations. A resurgence of interest in coaster Brook Trout led to the development of a Brook Trout rehabilitation plan for Lake Superior supported by the Great Lakes Fishery Commission (Newman et al. 2003). Recent research has focused on filling information needs identified therein. Genetic investigations support the idea that coaster Brook Trout are ecological variants of stream resident Brook Trout that adapt to Lake Superior and return to tributaries or nearshore areas to spawn and are genetically similar to stream resident populations (D'Amelio 2002; Burnham-Curtis 1996, 2000). Ground water is important in spawning site selection for Brook Trout (Curry and Noakes 1995). A regional assessment of ground water resources on Minnesota's North Shore and tributaries found only two ground water locations, indicating that ground water is a limiting resource in Minnesota (Ostazeski and Schreiner 2004). The University of Minnesota-Duluth's Natural Resource Research Institute is investigating ground water inputs to North Shore tributaries at finer spatial scales, which could refine results from Ostazeski and Schreiner (2004).

Brook Trout are highly susceptible to angling pressure and overfishing is one of the primary causes for the decline of coaster Brook Trout (Newman et al. 2003). To protect and potentially enhance coaster Brook Trout production in Minnesota, restrictive regulations below the posted boundaries were implemented in 1997. They included a closed season from the day after Labor Day until the inland trout opener in April, a 20-inch minimum length limit, and a possession limit of one fish. Agencies basin-wide have imposed similar restrictive regulations in the lake. Surveys conducted in 1997, 2002, 2007-2008, and 2013 in Minnesota tributaries to Lake Superior to assess the impact of the regulations detected increases in the age-structure of Brook Trout populations, and to a lesser extent size structure, after regulation changes (Figure 7.2; Schreiner et al. 2015, *in review*).

Environmental degradation and changes in the fish community have occurred in the Lake Superior basin since Brook Trout were abundant. The original logging of the basin watershed increased water temperatures and the range of flows, removed instream cover, and increased sedimentation. Introductions and naturalization of non-native species and dramatic changes in the Lake Superior fish community since the early 1900s may have also adversely affected Brook Trout. Non-native salmonids, especially Rainbow Trout, now frequently dominate stream habitat previously available to Brook Trout. There have been very few studies on biotic interactions between Brook Trout and Rainbow Trout in the Lake Superior basin. However, Rose (1986) found that young Brook Trout had reduced growth after the emergence of Rainbow Trout in a tributary to Lake Superior. Similarly, in the Appalachian Mountains, Larson and Moore (1985) concluded that non-native Rainbow Trout displaced Brook Trout from lower stream reaches, confining them to the headwaters of streams where both species existed. Yet in laboratory experiments, Brook Trout have been shown to be more aggressive and out-compete Rainbow Trout at various temperatures (Magoulick and Wilzbach1998; Cunjak and Green 1986), and dominate Rainbow Trout in slower water habitats (Cunjak and Green 1984). The watershed degradation and fish community changes may also have led to a loss of local adaptation and genetic diversity where Brook Trout have been extirpated.

Loss of genetic diversity, habitat degradation, and changes in the Lake Superior fish community are all obstacles to successfully rehabilitating Brook Trout. Management agencies on Lake Superior are working to protect remaining Brook Trout stocks in Lake Superior and gather information to address problems facing Brook Trout rehabilitation. The Coaster Brook Trout Scientific Synthesis Meeting held in October 2003 at the University of Minnesota Cloquet Forestry Center compiled existing information, identified information needs, and helped form a common understanding of how coaster Brook Trout rehabilitation may proceed in Lake Superior (Schreiner et al. 2004). Successful rehabilitation may take 10 to 100 years depending on habitat, the status of remnant stocks, and interactions with other species. Agencies, stakeholders, and researchers must work together to ensure the continued maintenance and enhancement of Brook Trout habitat. Agencies realize that coaster Brook Trout rehabilitation requires continuing the restrictive regulations that appear to be improving size structure and may require limiting fishing opportunity for other species. Coaster Brook Trout are unlikely to support a harvest fishery and expectations need to focus on "existence" value. Biologists agreed that the presence of remnant stocks, suitable habitat, and appropriate strain all need to be addressed before stocking programs are implemented. Furthermore, any future stocking should be done in an adaptive management context with well-framed plans for evaluation and criteria for success (Schreiner et al. 2008).

7.2 MANAGEMENT HISTORY (1996-2015)

7.2.1 REGULATION HISTORY

The Brook Trout season has been from the Saturday nearest April 15 through Labor Day in Lake Superior and tributaries below the posted barriers. In 1997, the regulation was changed to a possession limit of one with a minimum size of 20 inches. This may be in combination with Brown Trout and Rainbow Trout for an aggregated limit of five. Above the posted boundaries the season is from the Saturday nearest April 15 through September 30. In the 2006 revision, the regulation above posted boundaries was revised from a bag limit of ten to a bag limit of five to match statewide Brook Trout limits and reduce confusion related to upstream posted boundaries. This regulation change was implemented in 2014.

7.2.2 STOCKING HISTORY

Brook Trout have not been stocked below barriers by MN DNR since 1987.

7.2.3 ASSESSMENT HISTORY

Brook Trout have been assessed in Minnesota through creel surveys, returns to the French River and Knife River traps, summer electrofishing surveys, and through special fall electrofishing surveys targeting coaster Brook Trout. The spring fishery averaged catches of 191 Brook Trout per year from 2005 through 2014. Very few Brook Trout are caught in the Lake Superior summer creel survey. Fall spawning assessments specifically targeting below-barrier populations of Brook Trout using electrofishing were conducted in 1997, 2002, 2007-2008, and 2013 to assess effects of the regulation changes. Very few Brook Trout greater than 12 inches were caught (Figure 7.2). A regional groundwater survey using remote thermal infrared imaging occurred in 2003 and 2004 and found very limited ground water accessible to migratory Brook Trout in tributaries or the Lake Superior shoreline in Minnesota. A stream-crossing survey to assess and prioritize impediments affecting fall-run anadromous fish was completed in 2004.

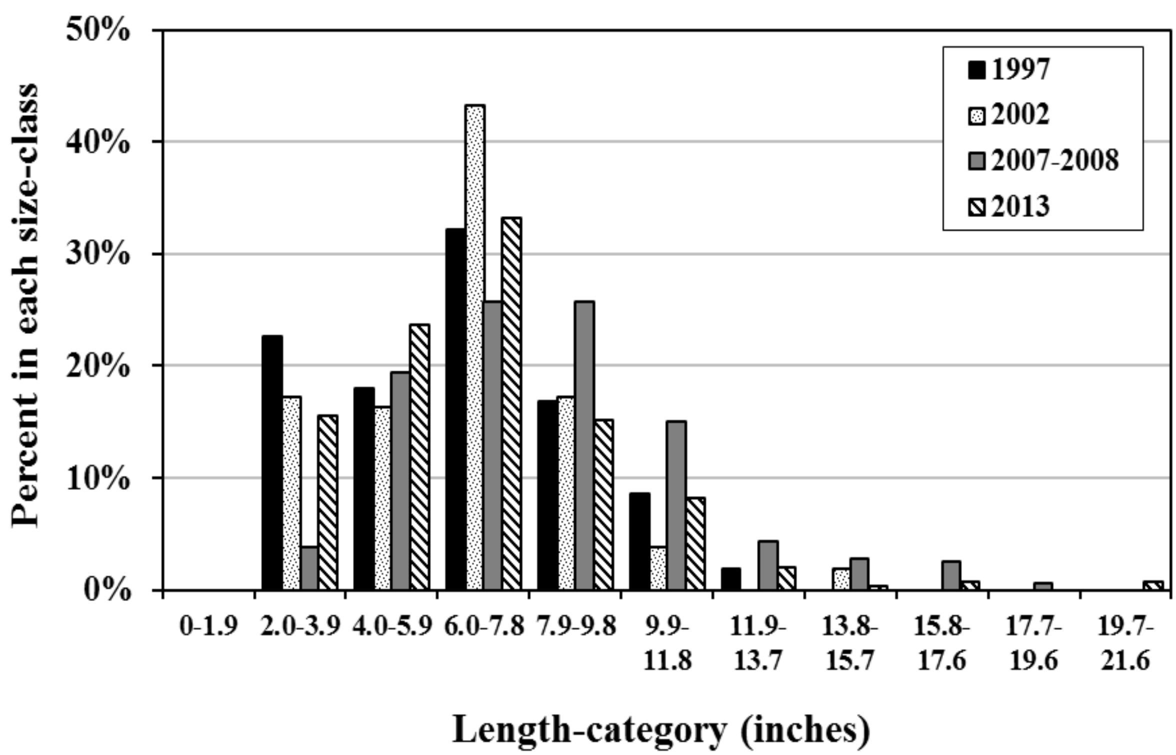

FIGURE 7.2: Length frequencies of Brook Trout sampled in fall electrofishing surveys below barriers in 1997, 2002, 2007-2008, and 2013.

7.3 GOALS AND OBJECTIVES (2016-2025)

Goal: Protect and maintain self-sustaining coaster Brook Trout stocks in the Minnesota waters of Lake Superior where practical.

Objectives:

1. Manage for a trophy Brook Trout fishery in below-barrier reaches.
2. Work with partners to protect, rehabilitate, and restore habitat on high priority streams that will promote natural stream function while enhancing fish habitat, where practical.
3. Coordinate with other agencies and support research on coaster Brook Trout management and apply successful techniques.
4. Work cooperatively with the Grand Portage Band of Chippewa to monitor results of various coaster Brook Trout stocking strategies.
5. Investigate the feasibility of adopting the Lake Superior Technical Committee's protocols for coaster Brook Trout sampling.

7.4 MANAGEMENT STRATEGIES (2016- 2025)

7.4.1 REGULATIONS

Maintain current regulations. The below-barrier possession limit is one Brook Trout greater than 20 inches with an aggregate number of Brook, Splake, Brown Trout, and Kamloops Rainbow Trout of five. The above barrier possession limit is five Brook and Brown Trout combined with not more than one over 16 inches.

7.4.2 STOCKING

No stocking.

7.4.3. ASSESSMENT

Continue spring and summer creel surveys. Monitor the French River and Knife River traps to determine the number of adults entering and juveniles leaving these two rivers. Conduct a fall survey to assess spawning Brook Trout every three years to determine impact of restrictive regulations. Gather tissue samples from creel surveys and special assessments for comparison to the developing basin-wide genetic database. Assess whether Lake Superior Technical Committee standardized sampling protocol for Brook Trout is an adequate replacement to the current MN DNR long-term sampling design.

7.5 JUSTIFICATION

Objective 1: Manage for a trophy Brook Trout fishery in below-barrier reaches.

Restrictive harvest regulations, which are in place in the lake basin-wide, are designed to protect spawning-size coaster Brook Trout. In recent years, the fall electrofishing surveys in Minnesota tributaries have shown a modest increase in the age and size structure of below-barrier Brook Trout populations, suggesting the restrictive regulations are beneficial. Spawning Brook Trout populations should continue to be surveyed at least every five years to assess the impact of restrictive regulations and to determine the impact of experimental stocking by other agencies on populations of coaster Brook Trout in Minnesota. Given the low abundance of coaster Brook Trout and the many obstacles faced to fully recover coaster Brook Trout populations, exploitation of this resource should be minimal. Coaster Brook Trout should be considered a "heritage fishery" that allows anglers the unique opportunity to catch a coaster Brook Trout and, in rare instances, keep a trophy fish.

Objective 2: Work with partners to protect, rehabilitate, and restore habitat on high priority streams that will promote natural stream function while enhancing fish habitat, where practical.

In Minnesota waters of Lake Superior, spawning habitat for coaster Brook Trout is extremely limited due to the abundant natural barriers close to the lake. Many of these barriers prevent or restrict upstream spawning movements. Of the 29 rivers that are sampled every five years as part of the coaster Brook Trout survey, coaster Brook Trout can only reach 12 miles or 3% of the 427 miles of total main stem length in these streams, and the longest stretch stream below barriers is only 1.4 miles. Because habitat below barriers is so limited, any additional loss of this habitat may impede rehabilitation efforts, especially if successful reproduction is negatively impacted. In a synthesis of coaster Brook Trout sampling in Minnesota tributaries to Lake Superior, Schreiner et al. (2015) noted age-0 Brook Trout were found in 16 of 29 streams in at least one year, but in only three streams were ten or more Brook Trout sampled in a single year.

Stream habitat assessments should be undertaken to identify the streams with the greatest potential for Brook Trout reproduction. Because consistent groundwater flows are critical for Brook Trout, groundwater intrusion sources should be identified and protected or enhanced where possible. Habitats should be connected, as funding becomes available, where habitats are separated by suboptimal road crossings that impede fish passage (Ostazeski 2004).

Due to the relatively high number of streams along the North Shore, habitat projects for coaster Brook Trout should be conducted on rivers that are considered high priority, and the five components of riverine systems (hydrology, geomorphology, water quality, connectivity, and biology) should all be considered when implementing habitat projects. Strategically selecting streams on which to implement projects and utilizing a systems-based approach to habitat restoration will provide the most benefits to coaster Brook Trout.

Objective 3: Coordinate with other agencies and support research on coaster Brook Trout management and apply successful techniques.

Although much has been learned about coaster Brook Trout life history and genetics in recent years, further research into the factors limiting coaster Brook Trout rehabilitation is needed. Most jurisdictions have enacted conservative harvest regulations for coaster Brook Trout and evaluation of those regulations will be critical to determining their effectiveness.

Objective 4: Work cooperatively with the Grand Portage Band of Chippewa to monitor results of various coaster Brook Trout stocking strategies.

In the early 2000s a renewed interest in coaster Brook Trout rehabilitation led to the writing of *A Brook Trout Rehabilitation Plan for Lake Superior* with the goal of "maintaining widely distributed, self-sustaining populations in as many of the original habitats as is practical"

(Newman et al. 2003). Several agencies stocked coaster Brook Trout; however, concern exists over the potential for Brook Trout stocked in neighboring jurisdictions to emigrate and negatively compromise the genetic integrity of remnant coaster Brook Trout populations through a variety of genetic means (Utter 2003). Close coordination with agencies conducting stocking experiments is needed as stocking is implemented and results become available. Given the likelihood of remnant coaster Brook Trout populations using Minnesota tributaries, stocking is not recommended at this time.

Objective 5: Investigate the feasibility of adopting the Lake Superior Technical Committee's protocols for coaster Brook Trout sampling.

In 2014, the Lake Superior Technical Committee established a standardized protocol for sampling coaster Brook Trout populations. The sampling protocol establishes one-kilometer-long sampling stations along the Lake Superior coast. Minnesota's coaster Brook Trout sampling began 17 years prior and additional assessments will need to occur to determine whether implementation of the LSTC protocol is justifiable.

7.6 INFORMATION NEEDS

Identifying critical habitat and limiting factors for all life stages of coaster Brook Trout is needed (Newman et al. 2003). Genetic analysis should be done to identify and describe existing coaster Brook Trout stocks and to compare with resident stream populations. This will provide insight into whether anadromy is a genetic characteristic in coaster Brook Trout stocks or whether coasters are a function of source/sink population dynamics. Quantifying competition effects with non-native salmonids, especially Rainbow Trout, is needed to better understand the potential consequences of managing heavily for Rainbow Trout. Continued genetic monitoring to assess introgression with hatchery reared Brook Trout is also suggested.

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CHAPTER 8: RAINBOW TROUT

8.1 BACKGROUND

Rainbow Trout were first introduced to tributaries in eastern Ontario of Lake Superior in 1883 from the McCloud River system in northern California, which likely consisted of a combination of anadromous (migratory) and resident life-history forms (Needham and Behnke 1962). Soon after, Rainbow Trout were introduced from the west-coast (exact origins unclear) into Wisconsin waters (1889) and Minnesota waters (1895; MacCrimmon and Gots 1972). Additional imports from other west-coast populations to Lake Superior occurred between 1895 and 1920. By 1920, spawning populations were established in tributaries throughout Lake Superior (MacCrimmon and Gots 1972). Steelhead, Rainbow Trout with a migratory life-history form, quickly became naturalized and provided a sought-after sport fishery in Minnesota waters (O'Donnell 1944; Hassinger et al. 1974; MacCrimmon and Gots 1972).

Minnesota waters supported an abundant steelhead fishery from the 1940s through the 1960s (Smith and Moyle 1944; Hassinger et al. 1974). Steelhead abundance sharply declined throughout the 1970s and 1980s and corresponded with changes in the Lake Superior fish community, habitat degradation, increased fishing pressure, and unregulated harvest. In response, the MN DNR initiated a number of programs which included alteration of natural barriers to allow fish passage, installation of habitat structures to provide additional spawning and rearing habitat, and construction of a hatchery production and rearing facility for supplemental stocking. Adult and juvenile fish traps were also constructed at a number of rivers to monitor spawning runs and progress of steelhead rehabilitation (Hassinger et al. 1974).

Initial efforts to rehabilitate the steelhead fishery were only partially successful and the number of wild steelhead continued to decline over time. The decline was documented through returns to the French River trap and low numbers of steelhead caught in spring creel surveys. Between 1960 and 1990, angler-hours in the spring fishery in tributaries increased 5-8 times and effort to catch one fish increased from 12 to about 65 angler-hours (Hassinger et al. 1974; Schreiner 1992). In 1992, the MN DNR developed the North Shore Steelhead Plan (NSSP) to address the consistent decline of steelhead in the Minnesota waters (Schreiner 1992). A series of public meetings were held in the winter of 1991/1992, and public input from these meetings was then used to form the NSSP. Management strategies for Rainbow Trout included the following actions: more restrictive angling regulations, revised stocking strategies, beaver management, construction of additional migratory fish traps, delineation of long-term stream-monitoring stations, a shorewide genetics study, an economics study, and a variety of other projects. The 1992 NSSP was reformed and incorporated in the 1996 LSMP (Schreiner 1995), the 2003 Rainbow Trout Management Plan for Minnesota Waters of Lake Superior (Schreiner 2003), and the 2006 LSMP (Schreiner 2006).

The original goal from the 1992 NSSP and all subsequent guiding documents, *"to stop the decline of adult steelhead and gather the necessary information to rehabilitate wild steelhead stocks,"* has largely been accomplished. Minnesota DNR creel surveys and trap reports show that adult and juvenile steelhead catch, catch-rates, and abundances have steadily increased over the past two decades (Blankenheim and Peterson 2014; Peterson 2015a; Peterson 2015b). The NSSP and subsequent LSMPs have provided a better understanding of population dynamics of steelhead. However, not all rehabilitation goals defined in previous LSMPs have been met. Information gaps still exist that, if answered, could greatly improve progress in steelhead rehabilitation and increase the potential for providing sustainable steelhead harvest in Minnesota waters. Continued management and research effort will be necessary to achieve complete rehabilitation of steelhead stocks in Minnesota waters.

8.2 MANAGEMENT HISTORY (1953-2015)

8.2.1 REGULATIONS

The first regulation for unclipped (wild produced) steelhead in the Minnesota waters of Lake Superior and in tributaries below posted boundaries was implemented in 1953 as a shorewide bag limit of 10. The regulations were changed in 1966 to allow a bag limit of 5, only 3 greater than 16 inches, and a minimum length limit of 10 inches. These regulations were in place from the mid-1960s through the early 1990s, except in 1985 when regulations at the Knife River were changed to a bag of 1 over 16 inches. More restrictive regulations were adopted as steelhead populations continued to decline. In the early 1990s, concerned anglers campaigned for more restrictive regulations. The MN DNR responded with a regulation change to a bag of 1 over 28 inches in 1992. A catch-and-release only regulation was implemented in 1997 and continued through 2016.

The catch-and-release regulation appeared to have a significant influence on the rehabilitation of steelhead in Minnesota waters. The 2006 LSMP called for discussions about allowing limited steelhead harvest if the shorewide catch rate of unclipped steelhead exceeded 0.1 fish per angler-hour for three consecutive years; this occurred from 2006 through 2010 (Peterson 2015b). In 2010, the MN DNR met with stakeholders to discuss potential harvest options for unclipped steelhead and the consensus was to maintain the catch-and-release regulation.

The regulations for clipped Rainbow Trout (both adipose fin-clipped steelhead and Kamloops) have remained unchanged since first implemented in 1976 as a bag limit of 3 with a minimum size limit of 16 inches. The Rainbow Trout angling season remained open year round below posted boundaries. Regulations for tributaries to Lake Superior above the posted boundaries remained closed to harvest for any Rainbow Trout.

Several changes to fish sanctuaries went into effect in 2014. The Lester River became permanently closed to fishing from the Superior Street Bridge downstream to the bottom of the first falls. The seasonal closure between the cables at the Second Falls on the Knife River was replaced with a permanent closure to fishing. The fish sanctuary above County Road 9 on the Knife River system and the sanctuary on the Little Knife River were eliminated.

8.2.2 HATCHERY PRODUCTION AND STOCKING

Experimental stocking of hatchery-strain Rainbow Trout yearlings began in Minnesota in the 1970s to supplement efforts to rehabilitate naturalized steelhead. In 1972 and 1973, the MN DNR stocked three domestic strains of Rainbow Trout (Donaldson, Madison, and Kamloops) and evaluated their performance in Lake Superior (Close and Hassinger 1981). The Kamloops strain was deemed best suited to provide a put-grow-and-take fishery and reduce pressure and harvest on naturalized steelhead populations.

In 1976, a Kamloops stocking program was implemented by the MN DNR to provide harvest opportunities for Rainbow Trout until steelhead populations recovered to a level that would allow sustainable harvest. Approximately 125 pairs of adult Kamloops that returned to the French River each spring were used as the egg source for subsequent production and stocking. Kamloops were stocked annually as yearlings, grew to adult size in Lake Superior, and then returned to spawn as adults (primarily at ages 4 and 5). All Kamloops were given an adipose fin clip to differentiate them from steelhead. Some changes were made to Kamloops stocking locations over time. In 2003, Kamloops stocking was eliminated in Chester Creek and its quota was added to the Lester River. Since 2003, the annual quotas of 92,500 Kamloops were distributed among the Lester River, McQuade Harbor/Talmadge River, and the French River.

From 1981 through 1992, natural reproduction of steelhead was supplemented by stocking large numbers of steelhead fry, usually in tributaries upstream of the first natural fish barrier to Lake Superior. At this time, the majority of eggs used for fry production came from steelhead captured in the Little Manistee River, a tributary to Lake Michigan. However, a portion of the stocked fry came from eggs that were collected from adult steelhead captured at the French River. In the mid-1990s, the MN DNR began to gather only locally sourced steelhead gametes for fry production after a genetics evaluation found low genetic diversity in rivers stocked with Lake Michigan strain offspring (Krueger et al. 1994). Thereafter, eggs were primarily collected from adults returning to the French and Knife rivers.

A multi-phase yearling steelhead stocking program was implemented in 1990 to evaluate the returns of stocked steelhead smolts to the French and Knife rivers. Phase 1 examined the cost and feasibility of rearing steelhead to smolt size (≥ 5 inches) at the FRCWH. Approximately 20,000 adipose-clipped yearling steelhead were stocked annually from 1990 through 1993 in the French River (Tureson 1994). In phase 2, approximately 40,000 adipose-clipped yearlings were produced annually from 1997 through 2002. The Knife River was stocked in odd years and the French River in even years, and a smaller portion of the quota went to short-run streams each year (i.e., Silver Creek and the Gooseberry River). The adult returns from Phases 1 and 2 provided additional harvest opportunities for Rainbow Trout in Minnesota waters. Phase 3 evaluated how stocking location influenced juvenile steelhead survival. Approximately 40,000 steelhead yearlings were given a non-harvest fin clip and were stocked annually into the Knife River from 2003 through 2007 (Ward et al. 2013). In 2007, the MN DNR met with constituents to reevaluate the yearling stocking program and a decision was made to discontinue all steelhead yearling stocking. The main reasons for this decision were poor returns, high program costs, and genetic concerns (Caroffino et al. 2008).

In an attempt to produce a dependable source of steelhead eggs, a captive broodstock program was initiated in 2003. Since this time, a captive broodstock has been maintained by collecting emigrating juvenile steelhead at the Knife River fish trap and rearing them to adults in the French River Coldwater Hatchery (FRCWH). The FRCWH maintained approximately 500 pairs of broodstock (distributed among 5 year classes) and spawned approximately 250-280 pairs annually to produce fry. None of the offspring of the captive broodstock were used for future broodstock. Although domestication selection of hatchery-propagated steelhead could negatively impact efforts to rehabilitate wild steelhead stocks, replenishing the captive broodstock with wild juveniles from the Knife River reduces hatchery influence while also contributing to adult returns (Caroffino et al. 2008).

As suggested in the 2006 LSMP, an experimental steelhead fryling stocking program was developed in 2008. Frylings are fry that are held in the hatchery for several more weeks to increase their size at stocking. From 2009 through 2013, approximately 55,000 frylings were stocked annually in the French River, except in 2010 when the fish were stocked into the Knife River (Negus 2013). The French River was stocked with frylings from the captive broodstock rather than fry produced from feral stocks that returned to the French River before reverting to fry stocking in 2014. The adult returns from fryling stocking are still being evaluated and will be realized in coming years.

During the yearling steelhead stocking program, interested citizens observed that stocked fish were concentrated at the mouth of the Knife River and were being preyed upon by double-crested cormorants *Phalacrocorax auritus*. The Lake Superior Steelhead Association hired the U.S. Department of Agriculture to harass the birds at the stocking site and to reduce the cormorant population. Cormorant harassment was unnecessary after 2007 when yearling steelhead were no longer stocked.

Prior to 2010, all Kamloops were produced at FRCWH. In 2010, the discovery of Viral Hemorrhagic Septicemia (VHS) in Lake Superior forced changes to both Kamloops and steelhead fry stocking and production protocols. Due to the concern that VHS could be transmitted from the FRCWH to above-barrier reaches, no fish hatched at the FRCWH were allowed to be stocked above upstream posted boundaries. Beginning in 2010, approximately 70% of Kamloops eggs collected at French River were shipped to the Spire Valley Coldwater Hatchery (SVCWH), near Remer, Minnesota. Kamloops and steelhead eggs were water hardened immediately after fertilization, brought to the FRCWH where they were surface disinfected, and then incubated to the eyed stage. Once all the eggs were cleaned, sorted, and rated, they were then transported to the SVCWH on ice in coolers. At SVCWH, the eggs were disinfected again in an iodophor solution before being brought into the hatchery and hatched. With the new protocol, steelhead fry were then able to be transported from SVCWH and stocked directly into North Shore streams, upstream of natural barriers. Kamloops were reared at SVCWH for approximately ten months and then trucked back to the FRCWH where they were reared for approximately three months before stocking.

Steelhead fry stocking schedules and quotas have changed over time. Excluding the French River, which is stocked primarily with offspring from feral returns, the steelhead fry quota was increased from 350,000 fry per year in the 1996 plan to 500,000 fry per year in the 2006 plan (Schreiner 1995, 2006). In the summer of 2012, Lake Superior's nearshore waters that feed the FRCWH intake pipe were uncharacteristically warm. This resulted in the loss of a large portion of Knife River captive broodstock held at the FRCWH, which drastically reduced steelhead fry production for a number of years during the 2006 LSMP. The goal of producing and stocking 500,000 fry annually was never met between 2006 and 2015.

Following the shift of production to SVCWH, there were some concerns from anglers and MN DNR that Kamloops raised outside the Lake Superior basin would not survive as well due to their smaller size at stocking and/or the lack of imprinting to local water sources. Negus et al. (2012) found that return rates of Kamloops were largely dependent on size at stocking and season of stocking, where Kamloops yearlings benefitted from summer stocking at larger sizes.

Between 2013 and 2015, catch and catch-rates of Kamloops raised at SVCWH and stocked at the mouth of the Lester River were significantly lower than in years prior to the production shift (Peterson 2015a). Several more year classes of Kamloops that were produced using the new hatchery protocols will be necessary to fully evaluate this program change.

The FRCWH was built in 1974-1975 and needed significant repair and upgrades to meet MN DNR statewide energy efficiency and fish production goals. The MN DNR hired an engineering and consulting firm, HDR, Inc., to evaluate the FRCWH and provide details on the repairs and upgrades necessary for energy efficient fish production at the facility. The consultant produced the French River Rehabilitation Study, which projected the cost of renovation at $7.6 million (in 2013 dollars) to extend the life of the facility by 25 years (HDR 2013).

An angler-use survey was completed to gauge angler use of Minnesota's coldwater resources, with an emphasis on the Rainbow Trout (Kamloops and steelhead) fishery in Lake Superior and its tributaries (Schroeder 2013). Of the 85,825 anglers who purchased a trout stamp during the study period (between October 1, 2011 and September 30, 2012), 30.5% (26,177) fished Lake Superior and its tributaries and 14.6% (12,530) participated in the Lake Superior Rainbow Trout fishery. Of the 12,530 anglers who targeted Rainbow Trout in Lake Superior and its tributaries, 20.4% (2,575) targeted only Kamloops, 34.0% (4,291) targeted only steelhead, and 45.6% (5,664) targeted both Kamloops and steelhead. Trout anglers fishing Lake Superior and its tributaries contributed $261,766 through purchase of trout stamps. Lake Superior Rainbow Trout anglers contributed $125,300, anglers who exclusively targeted steelhead contributed $42,910, anglers exclusively targeting Kamloops contributed $25,750, and anglers fishing for both strains contributed $56,640 (Schroeder 2013).

8.2.3 ASSESSMENTS

Several assessments have been developed to monitor rehabilitation efforts for steelhead, which included annual electrofishing at designated index stations, annual spring and summer angler creel surveys, and monitoring via migratory fish traps. Stream population assessments have been conducted annually within specific stream stretches on a subset of North Shore tributaries to provide an index of reproduction and juvenile Rainbow Trout abundance (Morse 2000). The number of index stations has changed through time and the stations are spread throughout the Duluth, Finland, and Grand Marais management areas. The number of age-0 steelhead sampled at index stations shorewide has generally increased since the 1970s, while the number of age-1 and older steelhead has remained fairly consistent (Ward and Schreiner 2011).

An annual spring creel survey has been conducted on 17 tributaries and along the shoreline near river mouths to estimate the fishing pressure, catch, and catch rate of Rainbow Trout (Figure 8.1). McQuade Harbor/Talmadge River was added as an 18^{th} station in 2010. A summer creel survey targeting boat anglers fishing the Minnesota waters of Lake Superior has also been conducted annually. Fall and winter creels have been conducted less frequently. Fall creels were conducted in 1998, 2003, and 2005, while winter creels were conducted in 1997 and 2001.

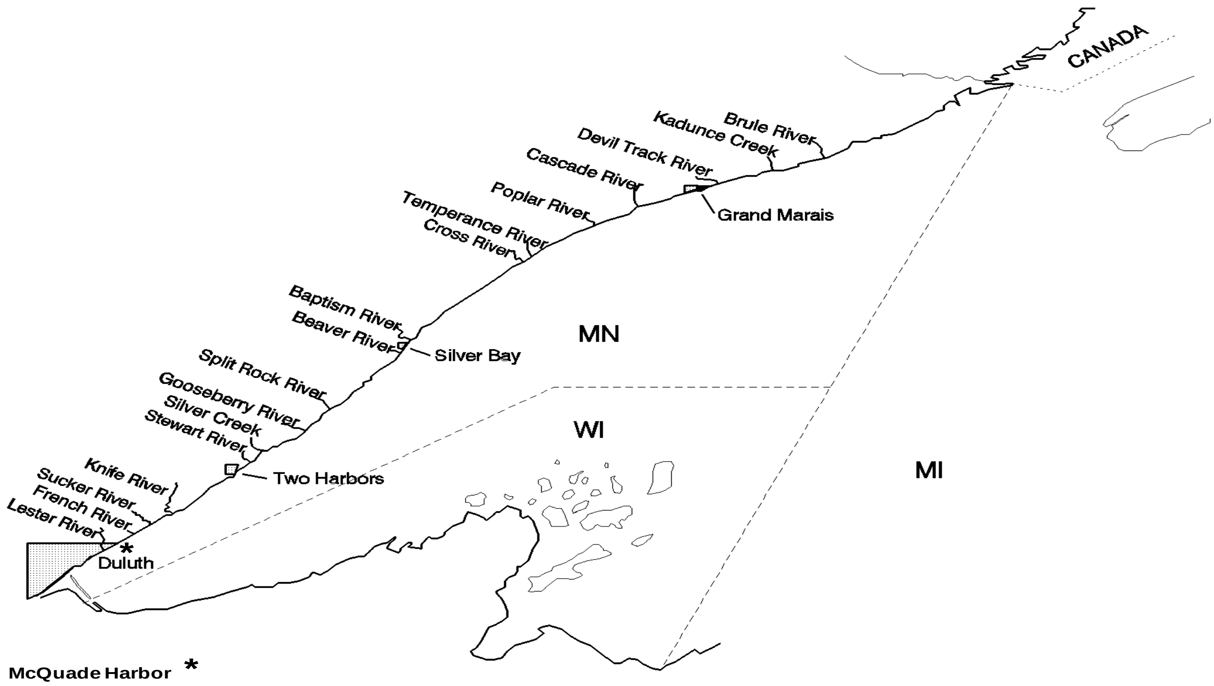

FIGURE 8.1: The location of sampling stations in the MN DNR Lake Superior spring creel survey.

Fish traps have played a vital role in Rainbow Trout management. The Little Knife River fish trap was operated from 1988 through 2003, and was removed in 2006. The French River fish trap has been in place since the mid-1970s and is used primarily to collect feral broodstock as a gamete source for both Kamloops and steelhead. The French River juvenile trap was constructed in 1994 and has provided much information on juvenile steelhead as well as the effectiveness of various stocking programs. The Knife River fish trap was built in 1995-1996, has been used to collect fish for numerous special projects and genetics studies, and has provided a wealth of information on both wild and hatchery-produced steelhead. The French and Knife River fish traps have been operated annually since being constructed, with one exception. The Knife River fish trap was inoperable from fall of 2012 through fall of 2013 due to damage sustained in the June 2012 flood. Completion reports from both traps are produced annually and provide more detailed information than provided in this management plan (Peterson 2015a).

8.3 GOALS AND OBJECTIVES (2016-2025)

Goal: Rehabilitate naturalized steelhead stocks to achieve a level that will allow limited angler harvest supported by naturally reproducing populations.

Objectives:

1. Work with partnering agencies and groups to protect, maintain, and improve steelhead habitat in North Shore streams by addressing issues with hydrology, geomorphology, connectivity, water chemistry, and biology.

2. Continue to locate and contact willing landowners to acquire easements and angler access to North Shore streams, and develop a map depicting locations where angler access is currently available.
3. Expand the zone where steelhead are maintained solely through natural reproduction and evaluate catch rates in the absence of supplemental stocking.
4. Continue to monitor steelhead catch rates in the spring creel and meet with stakeholders in 2020 to discuss potential steelhead harvest regulations, which may include maintaining the catch-and-release fishery.
5. If feasible, determine the contribution of steelhead stocked as fry to the spring fishery.
6. Evaluate the effectiveness of partial rearing of Kamloops at Spire Valley Hatchery.
7. Develop a genetic monitoring plan to evaluate the potential hybridization between wild steelhead and Kamloops.
8. If funding is available, conduct a winter creel survey targeting shore anglers.
9. Work with partnering agencies and stakeholder groups involved with habitat improvement projects towards a long-term goal of 7,500 age-2 or older smolts emigrating from the Knife River annually.
10. Coordinate with MN DNR Division of Ecological and Water Resources, U.S. Department of Agriculture, and interested citizens to monitor the cormorant population on Knife Island and if necessary, reduce negative impacts on emigrating Knife River juvenile steelhead.

8.4 MANAGEMENT STRATEGIES (2016-2025)

8.4.1 REGULATIONS

No regulation changes are proposed at this time. Current regulations require the release of all unclipped Rainbow Trout, and a bag limit of three clipped Rainbow Trout with a minimum size restriction of 16 inches. Law enforcement activities during the spring Rainbow Trout run will remain a high priority for the MN DNR Division of Enforcement.

8.4.2 HATCHERY PRODUCTION AND STOCKING

In November 2016, the MN DNR made the decision to terminate all fish production at the FRCWH and decommission the facility. The decision was made based on the high annual operating costs and energy usage required by the facility. The total annual stocking quota for Kamloops yearlings (92,500) will remain the same as in previous years. Production of 25,000 Kamloops that were raised exclusively at French River will now be raised at Spire Valley Coldwater Hatchery (SVCWH) in Remer, Minnesota. Eggs will continue to be taken from adult Kamloops returning to French River in the spring. The eggs will also continue to be fertilized, tested for disease, and developed to the eyed-egg stage at French River and then shipped on ice to Spire Valley prior to hatching (same protocol used from 2010 through 2016). All Kamloops will be hatched and grown at SVCWH to an average size of 5 inches (pre-imprint size is approx. 5.91 inches/150 mm; Negus 2003). All Kamloops will then be brought from SVCWH and stocked directly into the Lester and French Rivers, upstream of the natural barriers, to allow them time and space to imprint on local water sources. The new stocking protocol will allow the Kamloops raised at SVCWH to finish their final growth and imprint period in the Lester and French rivers. The new Kamloops production and stocking protocol will be evaluated over the duration of the 2016 LSMP.

A strategic assessment of the entire coldwater hatchery production program in the State of Minnesota will be finalized in 2017. This strategic assessment is designed to evaluate all coldwater stocking programs and determine where efficiencies and cost savings can be made while continuing to provide and enhance coldwater angling opportunities around the state. The strategic assessment of coldwater hatchery programs will be separate from the LSMP revision process. Steelhead and Kamloops production will continue at levels defined in the 2016 Lake Superior Fishery Management Plan until the strategic assessment is complete. The fate of the Knife River captive broodstock will be determined following the completion of the strategic assessment of the coldwater hatchery production program. Results from both the statewide evaluation of the hatchery production program and steelhead genetic assessments will guide future production and stocking strategies for Kamloops and steelhead.

The numbers of steelhead fry that are available to stock each year is nearly impossible to predict. Annual fry availability is determined by irrepressible factors including: 1) the number of eggs provided by adult female steelhead that return to French River (French River wild brood source), 2) the number of eggs provided by captive adult steelhead held at the FRCWH (Knife River captive brood source), 3) green-egg-to-fry survival at FRCWH and Spire Valley Coldwater Hatchery, 4) the number of wild and captive steelhead adults that test positive for bacteria kidney disease, and 5) the timing of adult steelhead returns to French River relative to stream conditions in the spring.

The steelhead fry stocking program will continue at this time but at a marginally reduced quota that more accurately reflects the annual availability over the past decade and progress made in steelhead rehabilitation. Stocking will be limited to streams located south of the Split Rock River to Amity Creek, and suspended in the Cascade, Temperance, Cross, Baptism, and Beaver rivers (Table 8.1). A detailed justification for the stocking change is provided in Section 8.5-Objective 3. The lack of quota needed to stock upper-shore rivers, rehabilitation of the Knife River captive broodstock, and/or above-average returns of adult steelhead at the French River may provide surplus fry in some years. In this scenario, the following stocking strategies were developed:

Surplus Knife River captive broodstock fry:
All available surpluses will be stocked in equal proportions (based on total annual surplus) in Amity Creek, Stewart River, Silver Creek, and East Branch-Split Rock River, or as determined after discussions with the Area Fisheries Supervisor. The Gooseberry River will not receive surplus fry because it experiences relatively lower angling pressure for steelhead than other streams in the middle shore and currently provides a sought-after Brook Trout fishery.

Surplus French River wild broodstock fry:
The MN DNR will attempt to evaluate the contribution of fry stocking to the spring fishery by genotyping the captive Knife River broodstock and using genetic monitoring of anglers' catch to identify whether those offspring are being caught by anglers. To prevent potential confounding factors, all available surplus fry from French River wild broodstock will only be stocked into the French River.

From 2009 and 2014, steelhead fry stocking in the French River was half or less of the proposed quota, which resulted in low numbers of age-2 emigrants in subsequent years. Adult returns from these year classes cannot be evaluated at this time because not all adults from these year classes have completely returned to French River. Stocking surplus fry in French River should help sustain adult steelhead returns to French River (the egg source for future stocking). The MN DNR has rarely stocked more than 150,000 fry in French River, so stocking surplus fry would also help to refine the smolt-adult relationship at French River and to examine factors that influence juvenile steelhead migration patterns and survival (Blankenheim and Peterson 2014).

TABLE 8.1: Steelhead fry stocking quotas, frequencies, and locations in Minnesota waters to Lake Superior.

MN DNR Management Area	Stream	MN DNR Tributary ID	Stocking Quota	Stocking Frequency[1]	Stocking Location(s)[2]
Duluth Area	Amity Creek	S-005-001	50,000	O	E. Skyline Parkway - 6th Bridge (mile 2.3)
	French River[3]	S-011	150,000	A	McQuade Road (mile 2.2)
					Can't Road (mile 4.4)
					Lakewood Road (mile 6.2)
					Private Drive (mile 6.9)
					Pioneer Road (mile 9.4)
Finland Area	Gooseberry River	S-026	100,000	E	County Road 3 (mile 8.8)
					E. Algier Grade (mile 10.7)
	Silver Creek	S-021	100,000	O	County Road 3 (mile 1.2)
					Gun Club Road (mile 4.3)
					Country Road 2 - 1st Crossing (mile 5.4)
					Country Road 2 - 2nd Crossing (mile 7.0)
	Stewart River	S-019	100,000	E	Waldo Road (mile 4.8)
					Big Rock Road, 1st Crossing (mile 6.0)
					Big Rock Road, 2nd Crossing (mile 7.0)
					Big Rock Road, 3rd Crossing (mile 8.0)
	Split Rock River (E. Branch)	S-029-001	150,000	O	County Road 3 (mile 2.7)

[1]A-annual, E-even years, O-odd years; [2]Mile numbers approximated; [3]Fry from adult steelhead that return to French River

A total of 92,500 Kamloops yearlings will continue to be stocked per year with modifications to the hatchery production and stocking protocols (Table 8.2). Kamloops stocking will continue to be limited to the Lester and French rivers to minimize impacts on naturalized steelhead and to address shared concerns by the MN DNR and LSAG of decreased catch-rates and increased straying of Kamloops in recent years. Modifications to the Kamloops production and stocking protocols include:

1. ***Fill the annual Kamloops stocking quotas for the Lester River (32,500) and French River (60,000) by stocking all fish directly from Spire Valley Coldwater Hatchery into suitable locations upstream of natural barriers:***
   Negus (2003) recommended that stocking larger Kamloops in the French River in early summer and smaller individuals in other streams in May and June could maximize survival and homing to stocking locations. In early spring, pre-smolt-sized Kamloops (not to exceed 5.91 inches total length; Negus 2003) will be brought from SVCWH and stocked directly into the Lester and French rivers, upstream of the natural barriers (Table 8.2). This will allow time for the stocked fish to imprint on local water sources and finish their final growth and imprint period in the river. Stocking Kamloops upstream in early spring is preferred over stocking the same amount of larger fish upstream in July/August when water temperatures are higher. The French River Juvenile Fish Trap may be used to evaluate the age and time of emigration of Kamloops stocked at the French River.
2. ***Modify fin clip schedule to evaluate adult returns and straying rates of the Kamloops produced at Spire Valley Coldwater Hatchery:***
   The MN DNR and LSAG recognize that stocking Kamloops upstream in the Lester River should improve imprinting to the local water source and that the survival of juvenile Kamloops to return as adults will depend on many factors (e.g., the size and timing that the Kamloops emigrate from French River, stream rearing conditions, Lake Superior conditions). The Kamloops fin clip schedule will be modified to provide a more detailed evaluation of the new stocking and production protocols. Kamloops stocked in Lester River and French River will have unique clips to indicate where they were stocked. Used in the spring creel survey and trap operations, the clip schedule should provide straying rates for each group among North Shore rivers.

If the shorewide catch rate of Kamloops in the spring creel is less than 0.04 fish per angler-hour for three consecutive years, the MN DNR will reevaluate hatchery production and stocking protocols. In relation to wild steelhead rehabilitation, the Kamloops program will be reevaluated and possibly phased out if:

1. Genetic introgression is demonstrated by the occurrence of steelhead x Kamloops hybrids in wild populations.
2. Steelhead abundance rebounds to produce an acceptable fishery where Kamloops are not stocked.
3. Steelhead decline only in areas with a heavy Kamloops presence.
4. Straying of Kamloops beyond the Lester and French rivers increases, as indicated by creel and trap data (Knife River, MN and Brule River, WI).
5. The program becomes cost-prohibitive.

A phase-out of the Kamloops program will not occur without discussions between the MN DNR and the LSAG.

TABLE 8.2: Annual Kamloops stocking quotas and locations in Minnesota waters of Lake Superior.

Stream	MNDNR Tributary ID	Stocking Quota	Stocking Frequency	Stocking Location(s)[1]
Lester River	S-005	32,500	Annual	Strand Road (mile 5.2)
				N. Tischer Road (mile 8.1)
				Jean Duluth Road (mile 12.0)
French River	S-011	60,000	Annual	McQuade Road (mile 2.2)
				Can't Road (mile 4.4)
				Lakewood Road (mile 6.2)
				Private Drive (mile 6.9)
				Pioneer Road (mile 9.4)

[1] *Mile numbers approximated*

8.4.3 ASSESSMENT

To the extent practical, assist partnering agencies and groups on site selection, design, implementation, and evaluation of habitat projects on North Shore streams. Continue the annual spring and summer creel surveys to monitor fishing pressure, catch, and catch rate of both steelhead and Kamloops. Add a periodic winter creel or expand the spring creel to include the time period prior to ice-out when there can be substantial angling pressure targeted at Kamloops. Continue to monitor returns of steelhead and Kamloops to the Knife and French River traps and evaluate options to reduce time of fish handling, data collection, and processing. Evaluate the life-history-specific population parameters (growth, survival, movement) of important Lake Superior migratory fish species, particularly coaster Brook Trout and Rainbow Trout, and use to refine population assessment and monitoring protocols for migratory fish in Lake Superior tributaries. The juvenile fish trap at the Knife River will be extremely valuable to monitor abundances of both juvenile and adult Brook Trout, Brown Trout, and Rainbow Trout following habitat improvement projects within this watershed. If funding is available, tag and track migration patterns of fish in the Knife River and its tributaries to identify critical habitats for juveniles and adults. Maintain annual sampling at steelhead index stations to monitor juvenile steelhead abundance. Assist the MN DNR Division of Ecological and Water Resources staff during their survey of the cormorant population on Knife Island every five years.

8.5. JUSTIFICATION

Objective 1: Work with partnering agencies and groups to protect, maintain, and improve steelhead habitat in North Shore streams by addressing issues with hydrology, geomorphology, connectivity, water chemistry, and biology.

Poor spawning and rearing habitat in North Shore streams has long been a limitation to steelhead production (Smith and Moyle 1944). Unlike many other limiting factors, such as forage availability or environmental conditions, stream habitat is something that can, to an extent, be addressed. The passage of the Clean Water, Land & Legacy Amendment in 2008 provided a dedicated funding source through the Lessard-Sams Outdoor Heritage Fund (LSOHF) starting in 2009. This funding source is mandated to last for 25 years, which will provide long-term effort and benefits for habitat improvements including stream restoration. Agencies and constituent groups are now able to form partnerships and utilize dedicating funding from the LSOHF to complete habitat projects. Projects that consider all five components of riverine systems (hydrology, geomorphology, connectivity, water chemistry, and biology) stand the best chance of improving habitat for steelhead and thus potentially increasing their numbers. The Knife River will remain a priority river for habitat projects given how much of the river is available to migratory fish.

Objective 2: Continue to locate and contact willing landowners to acquire easements and angler access to North Shore streams, and develop a map depicting locations where angler access is currently available.

Trout stream easements ensure protection of the riparian corridor from detrimental activities, enhance water quality, authorize MN DNR personnel to conduct habitat improvement projects within the easement boundaries, and provide angler access. Acquiring and preserving riparian easements helps ensure that future generations of anglers have access to North Shore streams. A riparian easement acquisition program was initiated in 2011 with a $200,000 grant obtained by MN DNR from the National Fish Habitat Initiative-Great Lakes Partnership and with approximately one million dollars from the LSOHF. The MN DNR purchased easement rights in the riparian corridors of trout streams in the Lake Superior watershed from private landowners. The project, which ended in 2014, mapped land ownership on 60 Lake Superior tributaries spanning 764 miles of stream along the North Shore. Of the 764 river miles, 246 are under private ownership. The program has agreements with 31 landowners to purchase 12.04 river miles that will protect 232 riparian acres and adds 21 new angler access points at an estimated cost of $812,004.85. The easements will also connect over 95 miles of currently unconnected public river miles. If funding is available, easement acquisition in Lake Superior tributary watersheds should continue.

Objective 3: Expand the zone where steelhead are maintained solely through natural reproduction and evaluate catch rates in the absence of supplemental stocking.

Fry stocking above the natural barriers has likely contributed to the increased catch rate in the steelhead fishery by essentially expanding the amount of rearing habitat for juvenile steelhead. The goal in the 2006 LSMP for fry production was 500,000 fry per year from the Knife River captive broodstock, plus 150,000 per year for the French River from feral returns. However, even with the establishment of the Knife River captive broodstock, fry production failed to reach the total annual quota. Fry production from 2006-2014 averaged 454,317 fry per year, and ranged from a high of 644,931 in 2006 to a low of 233,989 in 2014. In 2012, a large portion of the captive broodstock died due to high summer water temperatures in Lake Superior, which further hampered fry production.

The failure to reach fry production goals warrants adjustments to annual quotas. Adjusting the annual quota to a more realistic goal of 400,000 total fry per year will be accomplished by eliminating the Cascade, Temperance, Cross, Baptism, and Beaver rivers from supplemental fry stocking. Adjusting the annual quota will allow the remaining rivers to receive more robust numbers of fry. Additionally, eliminating these five rivers from supplemental fry stocking will expand the area that is maintained through natural reproduction to include all rivers north of the Split Rock River to the Canadian border. Expansion of this zone will further demonstrate the capacity of naturalized steelhead to maintain their populations independent of stocking.

Objective 4: Continue to monitor steelhead catch rates in the spring creel and meet with stakeholders in 2020 to discuss potential steelhead harvest regulations, which may include maintaining the catch-and-release fishery.

The catch rate of steelhead has improved significantly compared to when the LSMP process started in the 1990s (Figure 8.2). Recently, the shorewide catch rate for steelhead has regularly been above 0.10 fish/angler-hour due in part to the catch-and-release regulation for unclipped steelhead that was implemented in 1997. The catch rate has remained relatively stable over the past decade, suggesting limitations may exist that prevent further rehabilitation of the steelhead population. Feedback from the LSAG included both the desire to maintain the catch-and-release regulation, and to establish new criteria that would initiate discussions on changes to harvest regulations. Based on this feedback, the MN DNR has developed the following criteria:

Lower Shore (Lester River to Split Rock River):
The catch-and-release regulation and steelhead fry stocking will continue for streams south of Split Rock River (identified in Table 8.1). The MN DNR will monitor catch rates over time in the spring creel survey and meet with stakeholders in 2020 to discuss suspension of stocking at rivers where catch rates have been at least 0.2 fish per angler hour for three of five years.

Upper Shore (North of Split Rock River):
The MN DNR will continue to monitor catch rates over time in the spring creel survey to evaluate how populations respond to the suspension of steelhead fry stocking. If catch rates remain consistent or increase, MN DNR will meet with stakeholders in 2020 to discuss acceptable harvest regulations which could include maintaining the catch-and-release fishery.

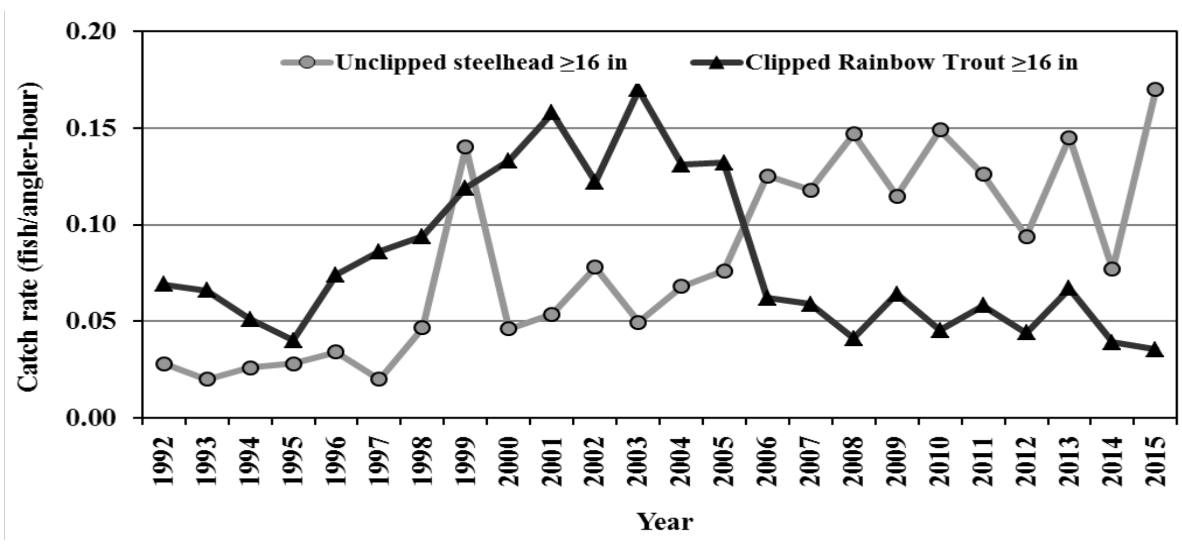

FIGURE 8.2: Shorewide catch rate (fish/angler-hour) of unclipped steelhead and clipped Rainbow Trout greater than or equal to 16 inches from the Lake Superior spring creel survey by year.

Objective 5: If feasible, determine the contribution of steelhead stocked as fry to the spring fishery.

The contribution of fry stocking to the spring steelhead fishery has been estimated from return rates of fry-stocked year classes as adults to the French River (Blankenheim and Peterson 2014). The juvenile and adult fish trap operations at French River found that adult returns from fry stocking have been highly variable and largely dependent on the environmental conditions (in stream and in Lake Superior). Since 1990, the survival of individual fry-stocked year classes has ranged from 0.01 to 0.15% (Blankenheim and Peterson 2014). Members of the LSAG questioned if the data collected from the fry stocking program at the French River were representative of other North Shore tributaries, where there is more habitat available below barriers compared to the very limited below-barrier habitat in the French River. Additionally, they questioned if a significant portion of the steelhead run at the French River could result from sources other than fry stocking, namely, steelhead straying from other rivers. The extent to which stray steelhead from other rivers contribute to the run size at the French River is not well understood and may influence fry stocking results at the French River. The actual contribution of steelhead fry stocking to the spring steelhead fishery is not known and should be pursued.

A steelhead genetics study will be completed to gain a better understanding of the contribution of fry stocking among North Shore streams. The genetics study will evaluate the parentage of steelhead that return and are caught by anglers to delineate if they were products of natural reproduction or from fry stocking efforts. The fry stocking program will be reevaluated if genetic research indicates that fry stocking provides minimal contribution to the fishery. Other reasons that will lead to reevaluation of the broodstock fry program include:

1. Genetics study indicates wild steelhead stocks are negatively impacted by the stocking of broodstock fry,
2. Survival from green egg to swim-up fry averages less than 50% for three consecutive years,
3. The annual quota of 250,000-300,000 broodstock-produced fry is not met for three consecutive years despite a full complement of broodstock,
4. The program becomes too cost prohibitive,
5. An unmanageable disease outbreak occurs in the captive broodstock.

Objective 6: Evaluate the effectiveness of partial rearing of Kamloops at Spire Valley Hatchery.

Increased straying of Kamloops beyond the Lester and French rivers is a concern of MN DNR, local anglers, and other jurisdictions. Adipose-clipped Rainbow Trout have been caught in the St. Mary's River in Michigan, the Brule River in Wisconsin, and rivers both on the upper North Shore of Minnesota and into Canada. Creel surveys suggest catch rates of Kamloops have decreased considerably in the Lester River in recent years, suggesting either increased straying or decreased survival of stocked fish. In response, the MN DNR has changed the Kamloops stocking protocols from the Spire Valley Coldwater Hatchery. Full details of these changes are described in Section 8.4.2. The changes to the program should increase returns to the angler at the Lester River and decrease straying. The use of differentiating clips will allow biologists to better assess the efficacy of the different stocking strategies.

Objective 7: Develop a genetic monitoring plan to evaluate the potential hybridization between wild steelhead and Kamloops.

Definite reproductive and genetic risks come with maintaining the Kamloops program. The major risk is that Kamloops can spawn and hybridize with steelhead. Negus (1999) found poorer survival of eggs from Kamloops x steelhead crosses compared to steelhead x steelhead crosses. If male Kamloops spawn unsuccessfully with female steelhead, then steelhead gametes are wasted. Kamloops have been shown to successfully spawn with steelhead in the wild and produce juvenile hybrids (Close 1999). Juvenile hybrids survive significantly less well compared to juvenile steelhead in the stream environment (Miller et al. 2004), which is another way that gametes are wasted. If hybrids did survive to reproduce, genetic introgression could occur which would decrease the fitness of wild steelhead. More recently, Page et al. (2011) modeled the effects of Kamloops stocking on wild steelhead populations and concluded that continual stocking of Kamloops greatly increases the risk of extinction of wild steelhead through non-introgressive hybridization. Due to the risks associated with the Kamloops program, Kamloops stocking will continue to be confined to the area between the Lester River and the French River to minimize the potential effects on wild steelhead populations. At the time of the 2006 LSMP, a genetic diagnostic marker for Kamloops had yet to be discovered which restricted the identification of hybrids in the wild. However, recent advances in genetic techniques now allow delineation of Kamloops x steelhead hybrids in the wild. The MN DNR will investigate the potential presence of hybrids in the wild and the effects of Kamloops on steelhead genetics in coming years.

Objective 8: If funding is available, conduct a winter creel survey targeting shore anglers.

The Kamloops program currently provides the harvest component of the Rainbow Trout fishery. Interest in the fishery remains fairly high despite relatively poor return rates to anglers over the past decade (Figure 8.2). At times there is considerable fishing pressure targeted at Kamloops by shore anglers during the winter and prior to ice-out on rivers, which is not captured in the spring creel survey. For this reason we recommend adding a periodic winter creel or expanding the spring creel to include the late winter time period, which will increase understanding of fishing pressure, catch, and catch rates of Kamloops.

Objective 9: Work with partnering agencies and stakeholder groups involved with habitat improvement projects towards a long-term goal of 7,500 age-2 or older smolts emigrating from the Knife River annually.

The Knife River is considered a high-priority stream by both biologists and anglers because it does not have a significant waterfall barrier and it contains approximately 43% of the spawning and nursery habitat for anadromous fish along the entire North Shore (Hassinger et al. 1974). Since the juvenile portion of Knife River fish trap became operational in 1997, the estimated number of emigrating juvenile steelhead has averaged 14,017 per year. However, only 2,858 of the total annual emigrants per year were age-2 or age-3 smolts. Age-2 smolts have been shown to contribute to adult returns at a rate 30 times greater than juvenile steelhead that emigrate early at age-1 (Blankenheim and Peterson 2014). The high number of age-1 emigrants suggests that stream habitat may be a limiting factor for retaining juvenile steelhead until age-2. The population of adult steelhead that returns to spawn in the Knife River could potentially be increased if a greater number of juvenile steelhead remain in the river for an additional year and then emigrate as age-2 smolts. Working collaboratively with constituent groups that have secured LSOHF grants for habitat projects will be of vital importance to reach the long-term goal for smolt production.

Objective 10: Coordinate with MN DNR Division of Ecological and Water Resources, U.S Department of Agriculture, and interested citizens to monitor the cormorant population on Knife Island and if necessary, reduce negative impacts on emigrating Knife River juvenile steelhead.

Juvenile steelhead must survive the stream and lake environments and avoid predators to become adults available to anglers. At one particular location, the Knife River, and in the right conditions, emigrating juveniles may be exposed to potentially high mortality upon entering Lake Superior near Knife Island. The island supports a rookery for cormorants, which eat mostly fish. Other such rookeries do not exist nearby and the emigrating steelhead are generally not highly concentrated near the island, which limits the predation on steelhead. However, significant increases in cormorant abundance at Knife Island could lead to enhanced predation on emigrating steelhead at the Knife River. The MN DNR Section of Fisheries will cooperate with the MN DNR Division of Ecological and Water Resources to survey the island every five years and to monitor the cormorant population.

8.6 INFORMATION NEEDS

Continue to examine adult-smolt, smolt-adult, and other important relationships pertinent to steelhead management with trap operations. Continue to document characteristics of the steelhead and Kamloops fisheries through annual spring and summer creel surveys, and include winter creels when possible. Evaluate how stream restoration influences natural reproduction and recruitment of steelhead. Investigate the utility of stable isotope analysis, genetics, and tagging technology to depict community ecology and interactions among steelhead, Kamloops, and other Lake Superior fishes. Continue surveys and research on the life-history dynamics and interactions of steelhead and Brook Trout, and relate to current management approaches (e.g., managing some rivers primarily for Rainbow Trout).

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CHAPTER 9: CHINOOK SALMON

9.1 BACKGROUND

Chinook Salmon were first introduced into Lake Superior by the Michigan Department of Natural Resources in 1967 (Peck et al. 1994). Minnesota first stocked spring-run Chinook Salmon in 1974 and converted to fall-run Chinook Salmon in 1979 after disease-free spring-run eggs were unavailable (Close et al. 1984). The original goal of the Chinook Salmon program was to create a put-grow-take fishery under the assumption that natural reproduction would not support the population. However, natural reproduction is now responsible for the majority of the Chinook Salmon landed lake-wide (Peck et al. 1999).

Minnesota stocked an average of 302,599 fingerlings (mid-quartile range: 194,013-412,403) annually in Minnesota from 1974 through 2002 and less than 56,000 per year in 2003-2006, after which stocking ceased. In order to determine the contribution from stocking and the extent of natural reproduction, Peck et al. (1999) examined stocking success from three year classes (1988-1990) of stocked Chinook Salmon. Returns to the summer sport fishery in Minnesota from 1990 to 1994 indicated that natural reproduction accounted for 43% of the Chinook Salmon caught. Stocked fish contributed 57% to the Minnesota summer fishery, with 31% of the stocked fish originating from Minnesota. The results were encouraging enough to justify continued stocking. Fall creel surveys were conducted in the 1990s to evaluate the Chinook Salmon fishery. The surveys indicated a declining return to the creel of stocked fish.

9.2 MANAGEMENT HISTORY (1996-2015)

9.2.1 REGULATION HISTORY

The fishing season has remained open year-round for all salmon, including Chinook Salmon. The possession limit is five when combined with Coho, Pink, and Atlantic Salmon. The minimum size limit was 10 inches.

9.2.2 STOCKING HISTORY

The contribution of Minnesota-stocked fish to the summer angling harvest plummeted from more than 31% in 1988-1990 to less than 5% during 1995-2004 (Schreiner et al. 2006). After a series of public input meetings in 1998, the Section of Fisheries extended the stocking program using an outside source of gametes for four years, 1999-2002, after which adult fish that returned to the French River trap would be used as a brood source. Minimum criteria were established to discontinue the Chinook Salmon stocking program if annual returns of mature Chinook Salmon to the French River trap fell below 75 BKD-free pairs for three consecutive years starting in 2003. Only 13, 20, and 9 pairs of fish were spawned in 2003, 2004, and 2005, respectively. Angler catches of Chinook Salmon in the fall stream fishery declined to 52 fish in 2003 and 292 fish in 2005, despite four years of stocking with at least 350,000 fingerlings in 1999-2002 (Ostazeski 2006). The low catch and effort by anglers in the fall, combined with low returns to the fish traps during spawning, prompted the re-evaluation of the program. As a result, Minnesota stopped stocking Chinook Salmon in 2006. Wisconsin also evaluated its stocking program and stopped stocking Chinook Salmon into Lake Superior in 2007. Michigan and Ontario have continued to stock Chinook Salmon into Lake Superior.

9.2.3 ASSESSMENT HISTORY

Chinook Salmon are assessed by two methods in Minnesota: creel surveys and charter captain reports. The summer creel survey monitors the catch and harvest of Chinook Salmon in the boat fishery. Very few Chinook Salmon are taken incidentally in assessment nets. Stream electrofishing surveys that target juvenile steelhead have sampled a very small number of naturally reproduced Chinook Salmon. Harvest and catch rates for all Chinook Salmon in the summer creel have varied among years; however, the harvest and catch rates in 2005-2014 were similar to previous years (Figure 9.1). During 1995-2004, anglers harvested 3,814 Chinook Salmon per summer at an average catch rate of 0.024 fish per angler-hour (Figure 9.1). Anglers harvested a similar number of Chinook Salmon during 2005-2014, at 3,607 fish per summer and 0.022 fish per angler-hour (Figure 9.1). Given that Chinook Salmon have not been stocked in Minnesota since 2006, the continued angling harvest indicates that abundance is largely dependent on natural reproduction and migration from other jurisdictions in Lake Superior.

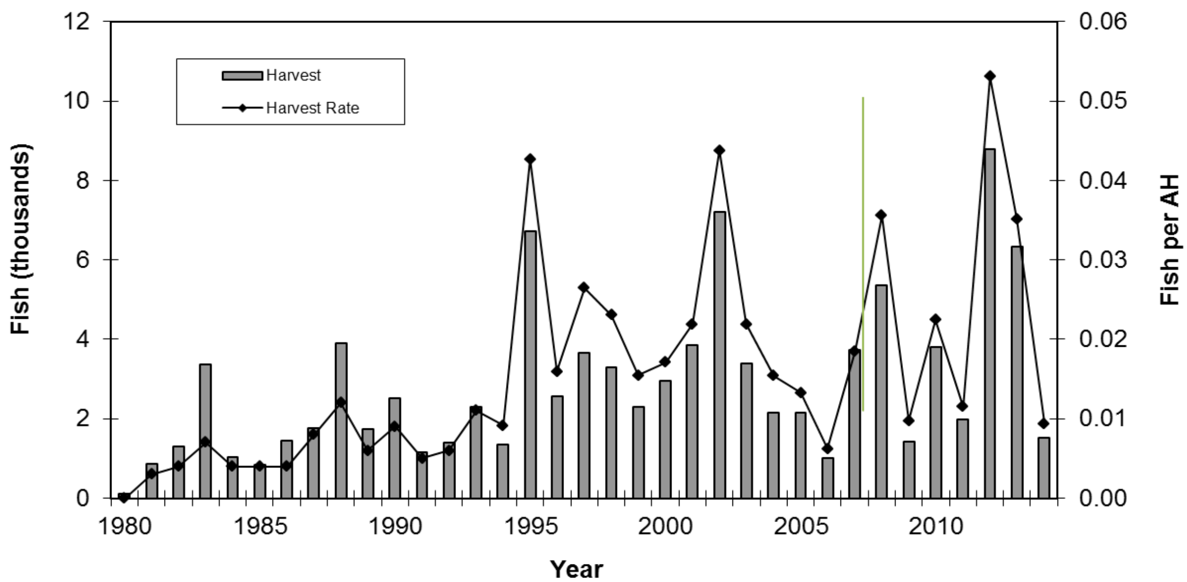

FIGURE 9.1: Harvest-per-unit-effort (fish per angler-hour (AH)) and harvest of Chinook Salmon in the summer creel survey, 1980-2014.

9.3 GOALS AND OBJECTIVES (2016-2025)

Goal: Manage for self-sustaining Chinook Salmon populations that provide diverse sport fishing opportunities.

Objectives:

1. Maintain an average annual catch of 2,500 Chinook Salmon from the summer boat fishery, realizing that there will be large annual fluctuations.
2. Coordinate with other jurisdictions involved in wild Chinook Salmon management since very little natural reproduction takes place in Minnesota streams.

9.4 MANAGEMENT STRATEGIES (2016-2025)

9.4.1 REGULATIONS

Maintain a possession limit of five when combined with Coho, Pink, and Atlantic Salmon. Remove the restriction on a bag limit of only 1 Atlantic Salmon. Eliminate the 10-inch minimum length limit.

9.4.2 STOCKING

No stocking.

9.4.3 ASSESSMENT

Conduct a lake-based summer creel survey annually to monitor angler harvest. Monitor and summarize charter captain reports annually. Conduct diet and growth analyses of angler-caught Chinook Salmon at least every five years to update growth-rate estimates and to evaluate prey consumption during intense predator demand on prey populations. Review ongoing research by Michigan regarding stocking success and movement of Chinook Salmon across jurisdictions in Lake Superior.

9.5 JUSTIFICATION

Objective 1: Maintain an average annual catch of 2,500 Chinook Salmon from the summer boat fishery, realizing that there will be large annual fluctuations.

Chinook Salmon were last stocked into Minnesota waters in 2006. Since then, angler harvest in summer has fluctuated; however, the mean annual harvest for the periods 1995-2004 and 2005-2014 were similar and harvest peaked in 2012. Maintenance of summer and fall fisheries for Chinook Salmon is desirable from the perspective of providing diverse fishing opportunities to Lake Superior anglers. Fish that migrated from other jurisdictions into Minnesota have enabled harvest objectives to be met for the summer boat fishery. Minnesota lacks sufficient spawning habitat to sustain significant runs of naturalized Chinook Salmon. Predators may be at carrying capacity in the west end of Lake Superior (Negus et al. 2008) and possibly even in all of the lake (Kitchell et al. 2000). Chinook Salmon consume more forage per individual than any other Lake Superior species (Negus 1995) and an enhanced Chinook Salmon population would presumably have a substantial negative impact on prey resources. Rainbow Smelt abundance is very low and stocks of Lake Herring have not yet rebounded to historic levels (see Chapter 4). The primary prey species for Chinook Salmon are now coregonines (Ostazeski et al. 1999). With the restoration of Lake Trout, establishment of naturalized Chinook Salmon populations, and concerns over the forage base, stocking Chinook Salmon is no longer necessary or prudent. The cost-effectiveness of stocking Chinook Salmon was deemed by Minnesota and Wisconsin to be too low and stocking by these two jurisdictions ended before 2008. Chinook Salmon have migrated into the Minnesota waters enough to yield at least 2,500 adults on average per year since 2006. This level provides periodic excitement and enthusiasm for anglers and should be sustained by maintaining the current harvest regulations and by encouraging other jurisdictions to protect their natural spawning habitat. Additional efforts to increase the harvest are likely to be inefficient and ineffective.

Objective 2: Coordinate with other jurisdictions involved in wild Chinook Salmon management since very little natural reproduction takes place in Minnesota streams.

Most North Shore streams below major fish barriers are too short for successful spawning and rearing for salmonids, thus most of the salmon that are caught in Minnesota are produced elsewhere. The MN DNR should work with other jurisdictions to protect the most productive natal streams and thus protect the Chinook Salmon that swim into and are caught in the Minnesota waters of Lake Superior.

9.6 INFORMATION NEEDS

More information is necessary regarding the interaction between Chinook Salmon and their prey, and between Chinook Salmon and other predators in Lake Superior. Diet and growth studies of Chinook Salmon should be conducted at least once every five years to monitor changes. The samples should come from summer angling, which is much more productive than at other times and methods. Seasonal and juvenile diet studies also need to be conducted. The diet and growth information for all salmonids should be included in an updated bioenergetics model to evaluate changes to the fish community in the Minnesota waters of Lake Superior. Movement of Chinook Salmon throughout the lake is poorly understood and abundance estimates need further work. Natal origins of Chinook Salmon may be identified by examining otolith chemistry, as has been done in Lake Huron (Marklevitz et al. 2011).

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CHAPTER 10: COHO SALMON

10.1 BACKGROUND

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, and high cost of the hatchery product. The stocking program was discontinued in 1972 after failing to meet management goals.

Coho Salmon are naturalized throughout Lake Superior. Coho Salmon fluctuate with Chinook Salmon as the second or third most frequently caught salmonine behind Lake Trout in the summer fishery (Halpern 2005). Among summer anglers surveyed in 2012-2014, 20% targeted Coho Salmon (unpublished document). Coho Salmon is also a secondary target species in the winter and early spring shore fisheries (Ostazeski and Morse 2001). Spawning occurs in Minnesota tributaries, but reproductive success is low due to limited habitat. Natural reproduction in other jurisdictions and migration to Minnesota waters account for the success of the fishery. Coho Salmon have a three-year life cycle with anglers catching primarily two-year-old fish (Bronte et al. 2003). As a result, fluctuations in year-class strength strongly impact catch and harvest in the fisheries. From 1980 to 2004, the harvest of Coho Salmon ranged from 229 to 11,652 fish (Figure 10.1). The average summer harvest of Coho Salmon in Minnesota waters from 1995-2004 was 3,261. The average summer Coho Salmon harvest was nearly the same, 3,281 fish, from 2005-2014. The fall fishery for Coho Salmon in Minnesota is very limited. Because Coho Salmon naturally reproduce in sufficient numbers, past contributions of hatchery-reared Coho Salmon to the sport fishery were low, and historically high catch rates have occurred without stocking, a hatchery program for Coho Salmon is not needed.

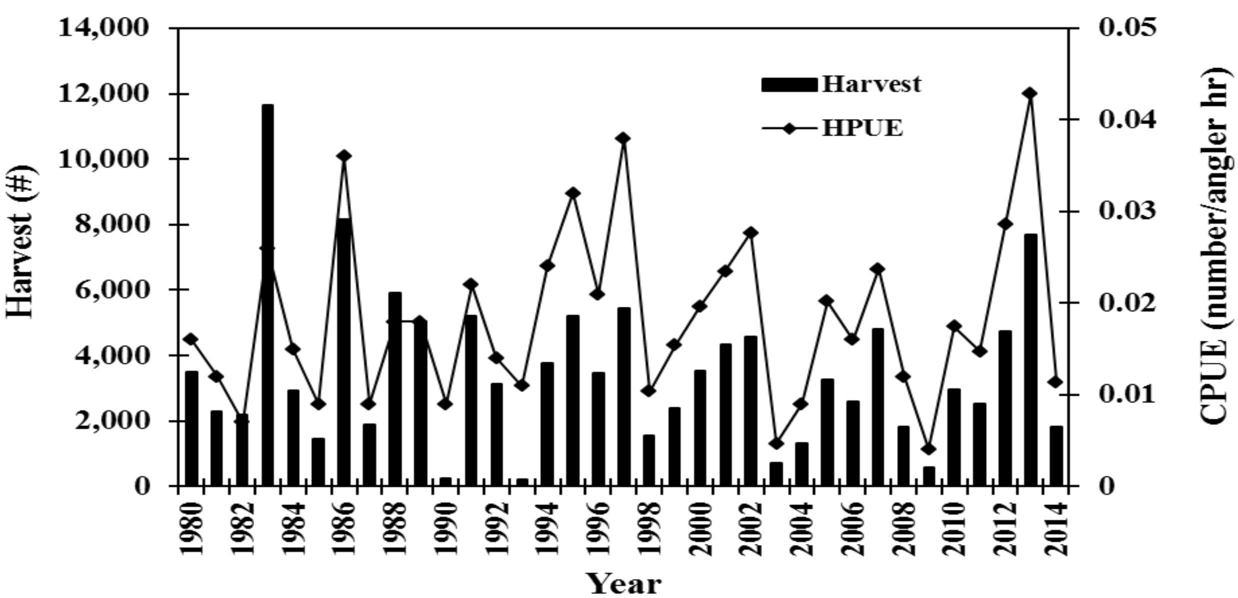

FIGURE 10.1: Harvest (number of fish) and harvest rates (number per angler hour) of Coho Salmon in summer boat fishery in the Minnesota waters of Lake Superior, 1980-2014.

10.2 MANAGEMENT HISTORY (1996-2015)

<u>10.2.1 REGULATION HISTORY</u>

The fishing season has remained open year-round for all salmon, including Coho Salmon. The possession limit is five when combined with Chinook, Pink, and Atlantic Salmon. The minimum size limit was 10 inches.

<u>10.2.2 STOCKING HISTORY</u>

No Stocking. Coho Salmon stocking has not occurred in Minnesota waters since 1974.

<u>10.2.3 ASSESSMENT HISTORY</u>

Coho Salmon have been assessed by three methods: creel surveys, charter captain reports, and returns to the Knife and French river traps.

10.3 GOALS AND OBJECTIVES (2016-2025)

Goal: Manage for a self-sustaining Coho Salmon population that provides diverse sport fishing opportunities.

Objectives:

1. Maintain an average annual catch of 3,000 Coho Salmon from the summer fishery based on natural reproduction, realizing that there will be large annual fluctuations.
2. Coordinate with neighboring jurisdictions on wild Coho Salmon management since very little production of Coho Salmon occurs in Minnesota tributaries.

10.4 MANAGEMENT STRATEGIES (2016-2025)

<u>10.4.1 REGULATIONS</u>

Maintain a possession limit of five when combined with Chinook, Pink, and Atlantic Salmon. Remove the restriction on a bag limit of only 1 Atlantic Salmon. Eliminate the 10-inch minimum size limit.

<u>10.4.2 STOCKING</u>

No stocking.

<u>10.4.3 ASSESSMENT</u>

Conduct winter creel survey in years with sufficient ice cover. Continue to conduct annual Lake Superior summer creel surveys. Monitor and summarize charter captain reports annually.

10.5 JUSTIFICATION

<u>**Objective 1:** Maintain an average annual catch of 3,000 Coho Salmon from the summer fishery based on natural reproduction, realizing that there will be large annual fluctuations</u>.

Coho Salmon have provided a high-quality fishery based on natural reproduction in other jurisdictions. Coho Salmon may compete for spawning habitat with other migratory species during fall spawning runs into tributaries. They use some of the same spawning areas and food items as Brook, Brown, and Rainbow Trout (Fausch and White 1986). In the lake, Coho Salmon may compete for forage with Chinook Salmon and sub-adult Lake Trout (Harvey and Kitchell 2000).

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 climate, fishing mortality, and predation. Fluctuating year-class strength relates directly to harvest and catch rates since the fisheries are predominantly based on a single year class. Overall, the fishery has yielded at least 3,000 Coho Salmon per year on average since 2005 and is likely to continue to do so as long as the natal spawning habitat is protected.

Objective 2: Coordinate with neighboring jurisdictions on wild Coho Salmon management since very little production of Coho Salmon occurs in Minnesota tributaries.

As is true for Chinook Salmon, most North Shore streams below major fish barriers are too short for successful spawning and rearing for Coho Salmon, thus most of the Coho Salmon that are caught in Minnesota are produced elsewhere. The MN DNR should work with other jurisdictions to protect the most productive natal streams and thus protect the Coho Salmon that swim into and are caught the Minnesota waters of Lake Superior.

10.6 INFORMATION NEEDS

More information about predator-prey interactions and competition from other predators is needed to better understand the sources of pressure on prey fish populations. Diet surveys are needed to identify overlaps between Coho Salmon and other Lake Superior species at all life stages. Isotope analyses of muscle tissue may be useful to identify the primary nutrient sources for Coho Salmon over time. A winter creel survey is needed during years of sufficient ice cover to document the variability in the Coho Salmon fishery in Minnesota.

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CHAPTER 11: PINK SALMON

11.1 BACKGROUND

Approximately 21,000 Pink Salmon fry were accidentally introduced into the Current River in Ontario in 1956 (Nunan 1967), became established, and are now naturalized in Lake Superior. In Minnesota, the first Pink Salmon were caught in 1959 by anglers fishing in the Sucker and Cross rivers (Eddy and Underhill 1974). Based on creel survey results and angler reports, Pink Salmon have never attained the abundance in the summer boat fishery that Chinook and Coho Salmon have, but have provided a significant fall stream fishery in some years. In Lake Superior, Pink Salmon abundance increased from the 1960s through the 1970s, then declined to extremely low levels during the late 1980s (Peck et al. 1994). From 1984-1995, the annual harvest by summer lake anglers averaged less than 200 in Minnesota. However, since the mid-1990s Pink Salmon abundance has again started to increase as indicated by higher harvest levels (Figure 11.1) and number of spawning adults reported by anglers in the fall fishery. Given that Pink Salmon normally live for only two years, harvest of Pink Salmon is extremely variable because anglers are fishing only one year class.

Pink Salmon normally enter Minnesota streams in mid-September to spawn. After eggs are deposited in gravel redds, the fish die. Little is known about the specific life history of Pink Salmon in Minnesota streams but in British Columbia, where Pink Salmon are native, the eggs hatch in about 125 days where they remain as sac fry. In April and May, the sac fry emerge and almost immediately migrate downstream to the ocean. Juvenile Pink Salmon are rarely observed in tributary streams after mid-July. Pink Salmon normally mature in two years, but may occasionally live to three years in Lake Superior. Pink Salmon are the smallest of the Pacific salmon in Lake Superior and average less than two pounds. In Minnesota waters, there is no targeted management program for Pink Salmon; however, they are included in the combined Pacific salmon possession limit of five fish and have been protected with a 10-inch minimum length limit.

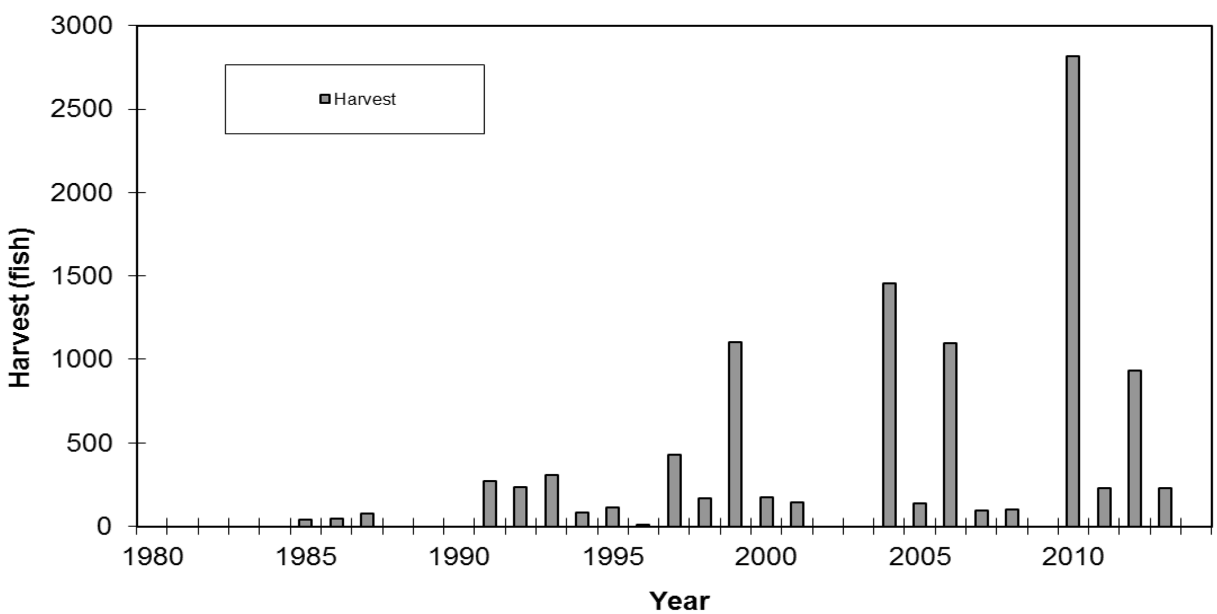

FIGURE 11.1: Number of Pink Salmon harvested in the summer Lake Superior creel survey, 1980-2014.

11.2 MANAGEMENT HISTORY (1996-2015)

11.2.1 REGULATION HISTORY

The fishing season has remained open year-round for all salmon, including Pink Salmon. The possession limit is five when combined with Chinook, Coho and Atlantic Salmon. The minimum size limit was 10 inches.

11.2.2 STOCKING HISTORY

No stocking.

11.2.3 ASSESSMENT HISTORY

Pink Salmon have been assessed by three methods: creel surveys, charter captain reports, and returns to the Knife and French river traps.

11.3 GOALS AND OBJECTIVES

Goal: Manage for self-sustaining Pink Salmon populations that provide diverse sport fishing opportunities.

Objective: Allow angler harvest of Pink Salmon in Lake Superior and tributary streams.

11.4 MANAGEMENT STRATEGIES (2016-2025)

11.4.1 REGULATIONS

Maintain the possession limit of five in combination with Chinook, Coho, and Atlantic Salmon. Remove the restriction on a bag limit of only 1 Atlantic Salmon. Eliminate the 10-inch minimum length limit for Salmon.

11.4.2 STOCKING

No stocking.

11.4.3 ASSESSMENT

Continue with present assessment program and also record presence of Pink Salmon in coaster Brook Trout assessments conducted once every five years.

11.5 JUSTIFICATION

Objective: Allow angler harvest of Pink Salmon in Lake Superior and tributary streams.

Pink Salmon have become established as part of the Lake Superior fish community. Pink Salmon are not stocked by any management agency on Lake Superior. They provide a limited summer and fall sport fishery. Their impact on other species in the Lake Superior fish community is unknown, but at this time appears to be minimal.

North Shore streams are relatively unproductive and can support only a limited number of fish (Waters et al. 1990). Juvenile Pink Salmon are reported to leave the stream as fry immediately after swim-up. This behavior results in little competition between Pink Salmon and juveniles of other migratory species. Spawning Pink Salmon adults do have the potential to impact other Pacific salmon and coaster Brook Trout for a short period of time as they compete for spawning areas. There is one reported observation of spawning male Pink Salmon attacking male Brook Trout and displacing them from females in spawning condition in a Lake Huron tributary (Kocik and Jones 1999). However, since Pink Salmon spawn relatively early in Minnesota (mid-September) compared to coaster Brook Trout (mid-October), their impact may be limited. Spawning habitat in tributaries below major barriers should be protected from in-shore disruption and from sedimentation to ensure continued production of Pink Salmon year classes that provide a minor recreational fishery in early fall along the North Shore.

11.6 INFORMATION NEEDS

Interactions between Pink Salmon and other migratory species in Lake Superior and tributary streams need to be determined. More research should be conducted on the life history and food habits of Pink Salmon to determine their impact on the Lake Superior fish community.

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CHAPTER 12: BROWN TROUT

12.1 BACKGROUND

Since introduction into Lake Superior in the 1890s, Brown Trout have established naturalized anadromous populations in tributaries, primarily in Wisconsin. The Brule River in Wisconsin supports the largest known run of Brown Trout in Lake Superior (Bronte et al. 2003). In Minnesota, attempts to establish anadromous populations in a number of streams provided very limited success. Brown Trout are rarely caught in tributary streams below the barrier and are only occasionally caught during the summer boat fishery, as reported in summer creel surveys.

Experimental stocking of 63,000 yearling and 170,000 fingerling Brown Trout in the St. Louis River from 1985 to 1987 failed to significantly increase the catch in the summer boat fishery from 1988 to 1992. Fish caught in Minnesota are the result of limited natural reproduction below the barriers, fish migrating down to the lake from above the first barrier, and fish originating from other states and in particular from Wisconsin, which stocked about 100,000 age-1 Brown Trout per year from 2006 to 2014. Habitat for Brown Trout along Minnesota's shoreline and tributaries below the first barrier is marginal, as it is for other fall-spawning anadromous species.

12.2 MANAGEMENT HISTORY (1996-2015)

12.2.1 REGULATION HISTORY

There has been no closed season in Lake Superior and in tributaries below posted boundaries. The possession limit is five in combination with Rainbow Trout, Brook Trout, and splake with a minimum size of 10 inches, with not more than one over 16 inches.

12.2.2 STOCKING HISTORY

Brown Trout have not been stocked below barriers on Lake Superior tributaries in Minnesota since 1987; however, Brown Trout have been stocked above barriers in North Shore tributary streams.

12.2.3 ASSESSMENT HISTORY

Brown Trout catches were recorded in summer creel surveys, on charter trip reports, in periodic coaster Brook Trout surveys along tributaries to the North Shore, in Knife and French River Trap reports, and in various netting surveys in Lake Superior for MN DNR. Brown Trout have been caught only rarely in any one survey in the past couple of decades.

12.3 GOALS AND OBJECTIVES

Goal: Maintain the opportunity to harvest naturalized Brown Trout in Minnesota waters of Lake Superior.

Objective: Allow angler harvest of Brown Trout in Lake Superior and tributary streams.

12.4 MANAGEMENT STRATEGIES (2016-2025)

12.4.1 REGULATIONS

Maintain present regulations. There has been no closed season in Lake Superior and in tributaries below posted boundaries. The possession limit is five in combination with Rainbow Trout, Brook Trout, and splake with a minimum size of 10 inches, with not more than one over 16 inches.

12.4.2 STOCKING

No stocking below barriers. For stocking above barriers, refer to MN DNR fisheries stream management plans.

12.4.3 ASSESSMENT

Continue with present assessment program.

12.5 JUSTIFICATION

Objective: Allow angler harvest of Brown Trout in Lake Superior and tributary streams.

North Shore streams are relatively unproductive and can support only a limited number of anadromous salmonids (Waters et al. 1990). When the carrying capacity of a stream is exceeded, juveniles tend to leave the stream or die. If young fish are forced to leave early at a small size, very few survive to return as adults. There is some evidence that Brown Trout in streams may prey on steelhead fry and displace Brook Trout stocks (Fausch and White 1981; DeWald and Wilzbach 1992; Sorenson et al. 1995). If the priority for anadromous trout in Minnesota is steelhead, then Brown Trout should not be stocked. Therefore, augmenting anadromous Brown Trout populations in Minnesota tributaries may interfere with the goal of restoring coaster Brook Trout.

12.6 INFORMATION NEEDS

Interactions between Brown Trout and other anadromous species in Lake Superior and tributary streams need to be determined.

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CHAPTER 13: LAKE STURGEON AND OTHER SPECIES

13.1 BACKGROUND

Several other game fish species occur in the Minnesota waters of Lake Superior, including Walleye, Lake Sturgeon, and Muskellunge. Anglers catch other species incidentally while pursuing other game fish; however, these fish are unlikely to produce viable targeted fisheries in Lake Superior. Walleye, Lake Sturgeon, and Muskellunge reproduce and spend considerably more time in the St. Louis River Estuary (SLRE) than Lake Superior. Fisheries exist for these three species (and others) in the SLRE, and fisheries management duties are carried out by the MN DNR Duluth Area Fisheries Office. The Duluth office uses the Lake Management Plan for the St. Louis River Estuary as its guide, which includes stocking and management history. The Plan can be found on the Duluth Area Fisheries webpage of the MN DNR website (http://www.dnr.state.mn.us/areas/fisheries/lakesuperior/index.html), or by request from the Duluth Area Fisheries Office.

The Duluth Area Fisheries Office manages Lake Sturgeon in the SLRE. A total of 82,291 Lake Sturgeon fry and 61,053 fingerlings were stocked in the SLRE from 1985 through 2000. Lake Winnebago strain (Wisconsin) was stocked from 1985 through 1991, and Sturgeon River strain (Michigan) fingerlings were stocked from 1998 through 2000. Stocking of Lake Sturgeon was discontinued after 2000 to evaluate natural recruitment, which is an ongoing effort. A Lake Sturgeon spawning habitat improvement project was implemented in the late summer of 2009. The goal of the project was to remove an old MN DNR Walleye collection weir from the channel and replace it with three boulder riffles. The project was successfully completed and now provides greatly improved spawning habitat for Lake Sturgeon over a wider range of flow conditions. A majority of the past effort to capture sturgeon during the spring spawning run has been focused around the constructed riffles.

The Lake Superior Area Fisheries Office manages Lake Sturgeon in Lake Superior. The Lake Superior office has and will continue to work with the Great Lakes Fishery Commission (GLFC) to rehabilitate the once-thriving Lake Sturgeon populations in the lake. The MN DNR and GLFC use *A Lake Sturgeon rehabilitation plan for Lake Superior* (Auer 2003) to guide their efforts toward the goals of maintaining, enhancing, and rehabilitating self-sustaining populations where the species historically occurred basin-wide. The lack of information on the biological characteristics and population abundance of Lake Sturgeon has constrained management lake-wide. These limitations are being addressed in part through the Great Lakes Cooperative Science and Monitoring Initiative (CSMI), which is a binational effort that coordinates scientific monitoring and research to better understand the Great Lakes ecosystem.

13.2 MANAGEMENT HISTORY (1996-2015)

In 2011, as part of the Great Lakes CSMI, the first coordinated Lake Sturgeon Index Survey was conducted and plans call for repeating the survey during the next Great Lakes CSMI sampling on Lake Superior in 2016. Goals of the survey included: 1) describing the current status, 2) establishing an index of relative abundance, and 3) describing the biological characteristics of Lake Sturgeon in Lake Superior. The 2011 survey sampled 34 Lake Sturgeon outside the St. Louis River Estuary with 80% of those being 12 years old or older, which coincides with stocking events.

Without stocked fish, very few sturgeon would have been sampled during the survey (Schloesser 2014). Concern regarding bycatch prevented targeted netting in the SLRE despite the assumed higher densities of Lake Sturgeon.

13.3 GOALS AND OBJECTIVES (2016-2025)

Goal: Maintain, enhance, and rehabilitate self-sustaining populations of Lake Sturgeon where they historically occurred.

Objectives:

1. Coordinate Lake Sturgeon sampling efforts as part of the Great Lakes CSMI.
2. Adopt strategies and objectives from *A Lake Sturgeon rehabilitation plan for Lake Superior* where feasible.

13.4 MANAGEMENT STRATEGIES (2016-2025)

13.4.1 REGULATIONS

Catch and release only. No tag needed. See regulation book for specific season dates.

13.4.2 STOCKING

No stocking.

13.4.3 ASSESSMENT

Continue Lake Sturgeon Assessment netting as part of the Great Lakes CSMI. Coordinate with Fisheries Research and other agencies to assess Lake Sturgeon movement between the SLRE and Lake Superior.

13.5 JUSTIFICATION

Objective 1: Coordinate Lake Sturgeon sampling efforts as part of the Great Lakes CSMI.

As signatory to the Joint Strategic Plan for Management of Great Lake Fisheries (GLFC 2007), MN DNR has an obligation to other signatories of the plan to work towards the goals and objectives outlined in the *Fish Community Objectives for Lake Superior* (Horns et al. 2003) and the various species rehabilitation plans that exist.

Objective 2: Adopt strategies and objectives from *A Lake Sturgeon rehabilitation plan for Lake Superior* where feasible.

The St. Louis River is the largest tributary to Lake Superior on the U.S. side and rehabilitation of Lake Sturgeon began with a stocking program from 1983-1994 and 1998-2000. By addressing the issues and implementing the strategies outlined in the Lake Sturgeon rehabilitation plan (Auer 2003) where feasible, MN DNR can continue to assess the success of the stocking program and obtain additional data on progress made towards Lake Sturgeon rehabilitation.

13.6 INFORMATION NEEDS

13.6.1 IDENTIFIED IN LAKE-WIDE REHABILITATION PLAN

Many of the research and management needs identified in *A Lake Sturgeon rehabilitation plan for Lake Superior* (Auer 2003) apply for the informational needs on Lake Sturgeon in Minnesota waters of Lake Superior including:

1. Determine habitat requirements and movement and dispersal patterns of all life stages.
2. Identify genetic variability within and among populations in Lake Superior.
3. Estimate historic and present status of Lake Sturgeon populations in Lake Superior and determine if spawning occurs in lake environments.
4. Determine the impact of stocked Lake Sturgeons on remnant populations; quantify and document the results of larvae and fingerling stocking.
5. Determine if Lake Sturgeon imprint on spawning tributaries and, if so, at what life stage.
6. Identify suitable techniques for capturing juveniles that limit mortality of non-target fishes.
7. Quantify predation on drifting larvae.
8. Evaluate the effects of contaminants on growth, reproduction, survival, and body burden.
9. Continue to evaluate the effect of lampricides on Lake Sturgeon larvae and the effect of lamprey predation on sub-adult and adult Lake Sturgeons.
10. Determine if there are any levels of harvest that do not affect rehabilitation and if there are strategies that allow sustainable harvests both during and after rehabilitation.

13.6.2 IDENTIFIED FOR MINNESOTA WATERS OF LAKE SUPERIOR

Information needs not identified in *A Lake Sturgeon rehabilitation plan for Lake Superior*, but important for the rehabilitation of Lake Sturgeon in Minnesota waters, include:

1. Evaluate delayed mortality of Lake Sturgeon in the catch-and-release Lake Sturgeon fishery established in 2015
2. Evaluate juvenile Lake Sturgeon population within the St. Louis River Estuary and investigate sampling strategies to minimize bycatch
3. Evaluate movement of Lake Sturgeon between the St. Louis River Estuary and Lake Superior using acoustic tag and receiver technologies.

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APPENDIX A: BEAVER MANAGEMENT ON TROUT STREAMS

Deserae Hendrickson, MN DNR Duluth Area Fisheries Supervisor

The determination of benefit to fishery resources is made by the Area Fisheries Supervisor with the support of the public as identified in individual stream management plans, long-range plans, and discussions with angling groups and individual anglers. Selection of streams for beaver dam removal is largely based on the potential benefits to the stream fishery resource, angler use, and return on investment. Intended control activities are typically outlined in stream management plans, which are announced by news release and can be commented on by the public prior to finalization. In the case of the Knife River system, beaver control is identified as a strategy to help address the decline of wild steelhead in the MN waters of Lake Superior as well as to remove blockages to fish migration. These are identified in the Fisheries Management Plan for the Minnesota Waters of Lake Superior (MN DNR, Section of Fisheries Special Publication No. 163, 2006), which underwent an intensive public input process and public comment period. Many angling and natural resource constituent groups participated in the development of these plans. This document is available on the MN DNR website at the Lake Superior Area Fisheries Management website.

There are a limited number of trout streams that are targeted for beaver dam and beaver removal. For example, in the Lake Superior watershed, there are a total of 2,093 miles of designated trout streams and tributaries. Of these, 122.5 miles or about 6% have active control of beaver by DNR Fisheries. There are an additional 3,989 miles of warmwater streams in this watershed where no control is taking place by Fisheries. Of the total stream miles in the watershed, only 1.7% are being managed to control beaver to benefit trout resources. The trout streams selected for control are the highest priority, most productive, and receive the highest angling effort directed at trout. All funding for beaver control has come from either trout stamp or fishing license revenues. These projects are not funded from general tax revenues.

Beavers, according to early reports in the literature, were scarce on the streams of the North Shore of Lake Superior during the era of the fur trade. The forest was then largely coniferous. However, logging, fires, and predator control since settlement have produced forest stands and habitats much more suitable for beaver. Our Wildlife Division has conducted aerial censuses to index beaver abundance from 1958 to 2001 (Figure 1). These also indicate an increase in populations in recent years in northeast MN.

There are numerous aspects of stream function which are disrupted or negatively impacted by beaver impoundments. These include: increasing water temperature, disrupting sediment transport, reducing stream stability, limiting or blocking fish movement and access to critical habitats, and alteration of invertebrate communities which influence food availability for trout. Hydrology impacts for this region are as yet undetermined. While there are some stream conditions where some fishery benefit may be derived from a beaver impoundment, these have only been shown to occur in systems with large quantities of continuous cold groundwater input. Unfortunately, these conditions do not exist in northeastern MN, which makes trout streams in this area much more susceptible to temperature impacts from beaver dams. The majority of flow in trout streams in northeastern MN originates from wetlands, shallow groundwater seepage, and storm water runoff. This does not provide buffering capacity for stream temperatures. Figure 2 shows typical impacts to temperature above and below a beaver impoundment on a northeast Minnesota stream. It is not uncommon to see temperature increases of 10 to 15 degrees Fahrenheit from beaver dams during the summer.

As a result of limited groundwater input, trout streams in northeast MN often are on the margin of having suitable temperatures for trout. The Knife River system is a good example. Figure 3 shows how temperature increases as flow continues downstream on the Knife River. For much of the summer, water temperatures are already in the range of thermal stress for trout, especially in the lower portions of the river. Much of this increase is due to thermal energy as sunlight hits the water (radiant transfer), as well as exchange of energy at the water/air interface. Beaver dams increase temperature in several ways: 1) increasing the amount of water/air interface within the impoundment and speeding up heat transfer to the water, 2) slowing the water and exposing it to a much larger area of sunlight (increasing radiant warming), and 3) beaver remove a significant portion of the riparian tree cover in adjacent stream reaches, increasing even further the amount of radiant warming from sunlight. The more dams that are present on the stream, the greater the temperature impact. In the case of dams on the headwaters, the impacts occur along the entire stream length. Many of the streams on the North Shore have portions that become too warm to support trout, depending on temperature conditions in a given year. Beaver dams can increase the frequency of lethal temperature conditions, as well as the amount of the stream impacted.

Beaver dam removal and beaver trapping is an on-going management activity also directed at restoring the connectivity of a stream. The loss of access to areas by all the species that inhabit the stream, including both native and non-native fish species, can reduce reproductive capacity, prevent emigration of anadromous smolts during periods of thermal stress, and reduce survival in both winter and summer by restricting fish from access to seasonal refuges.

The Knife River has always historically been accessible to anadromous fish, and does not have a complete barrier falls. This is part of what makes this river unique, compared to many of the other North Shore streams which have complete barrier falls not far from their mouth. There are approximately 95 miles of stream with suitable spawning and rearing habitat accessible to trout in the Knife River watershed. On the entire North Shore of MN, there are only 180 miles of river habitat accessible to anadromous trout and salmon, including the native coaster Brook Trout. This is why the Knife system is considered to be so critical to steelhead recovery and survival, and why it is imperative to maintain connectivity within this system.

Beaver dams create an area where fine sediments settle out and create habitat that is different and less suitable to the aquatic organisms normally found in trout streams. In addition, the disruption of the sediment transport process often results in accelerated erosion downstream of the dam, which is similar to impacts seen at sites with man-made impoundments. When dams fail after they are abandoned, they then contribute large flushes of sediment all at once, which can overwhelm the streams ability to move it, and clog up fish spawning and invertebrate habitat downstream. It may take several years for these stream functions to be restored.

Evaluation of project areas include assessment of trout populations, continuous temperature monitoring during the summer, angler reports, and, in the case of the Knife River, monitoring of the anadromous fishery through a migratory fish trap. On the Knife River, past assessments have shown that fish have routinely been blocked from spawning areas in years when dams are present.

On the Knife River, trapping occurs mainly in the fall starting in late October and is typically finished by late spring (May). Every effort is made to do the majority of trapping when the pelts can be utilized, and for the period of 2010 through 2015, 81% of beaver taken from the Knife have been salvaged for their fur. Additionally, nearly 100% of beaver castors have been salvaged, and some trapped beaver have also been used to feed captive wildlife at non-profit wildlife centers. For the first two years of expanded trapping on the Knife, a larger number of beaver were trapped outside the normal season in June, to increase the number of accessible stream reaches. We are currently more in a maintenance trapping mode at this time, trapping when needed to keep the main stems open. Figure 4 shows the number of beaver that have been removed in recent years for the Knife River. An inventory of visible dams on recent high-resolution 2015 aerial photography of the Knife watershed indicates that 187 dams are still present on the designated tributaries, with a number of dams also present on the designated trout streams. This should help to identify that this project is in no way eliminating beaver from the Knife River watershed. While it would likely be most beneficial to the trout resource to do so, we recognize the need to balance fishery benefits with other benefits to wildlife. As such, beaver are only removed on the major designated trout stream tributaries that flow directly into the Knife River.

Beaver control will likely continue as long as there is funding and it continues to show a benefit to the trout fishery resource. Statewide, beaver harvest by licensed trapping averages 61,500 beaver per year. In comparison, the Knife River removal by DNR amounts to the equivalent of 0.2 % of this harvest, even in the year of highest removal.

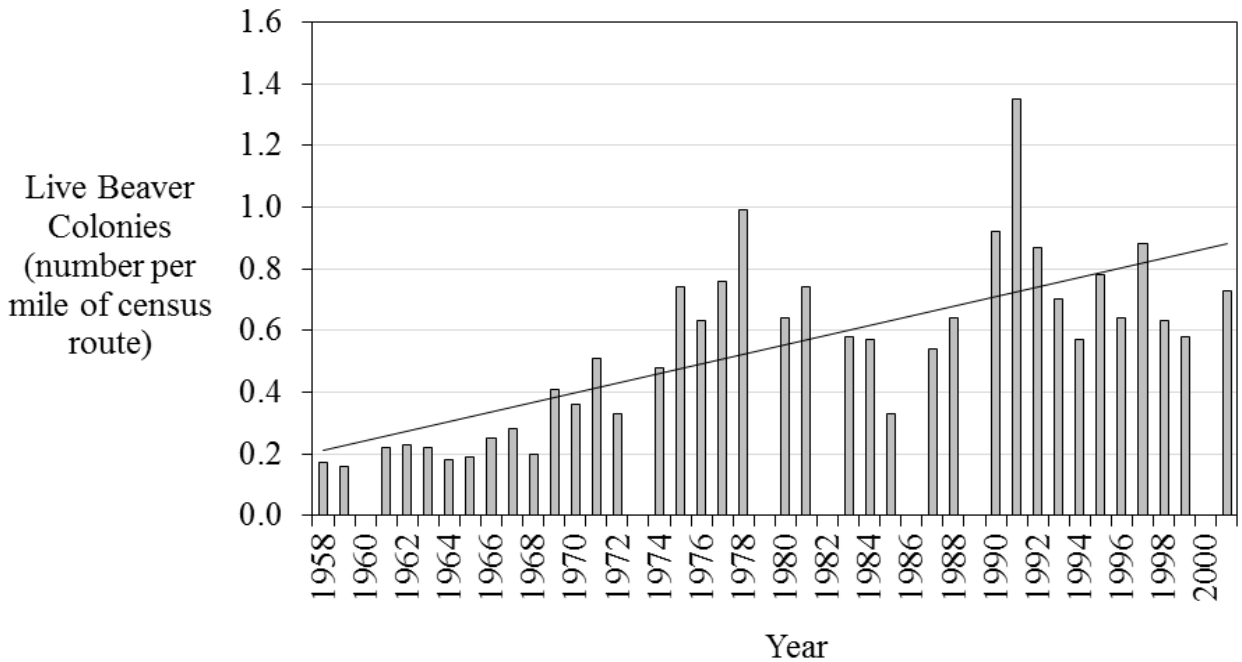

FIGURE A1. Live beaver colonies per mile of census route, South St. Louis County, 1958-2001.

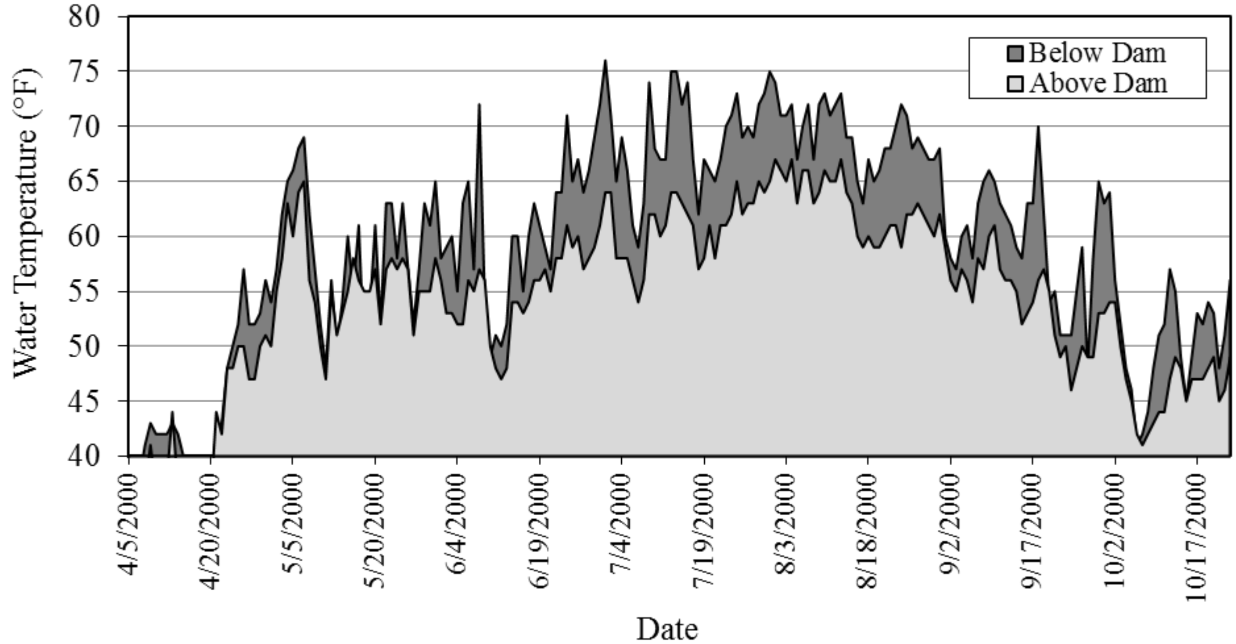

FIGURE A2. Water temperatures above and below a beaver impoundment, Stewart Creek.

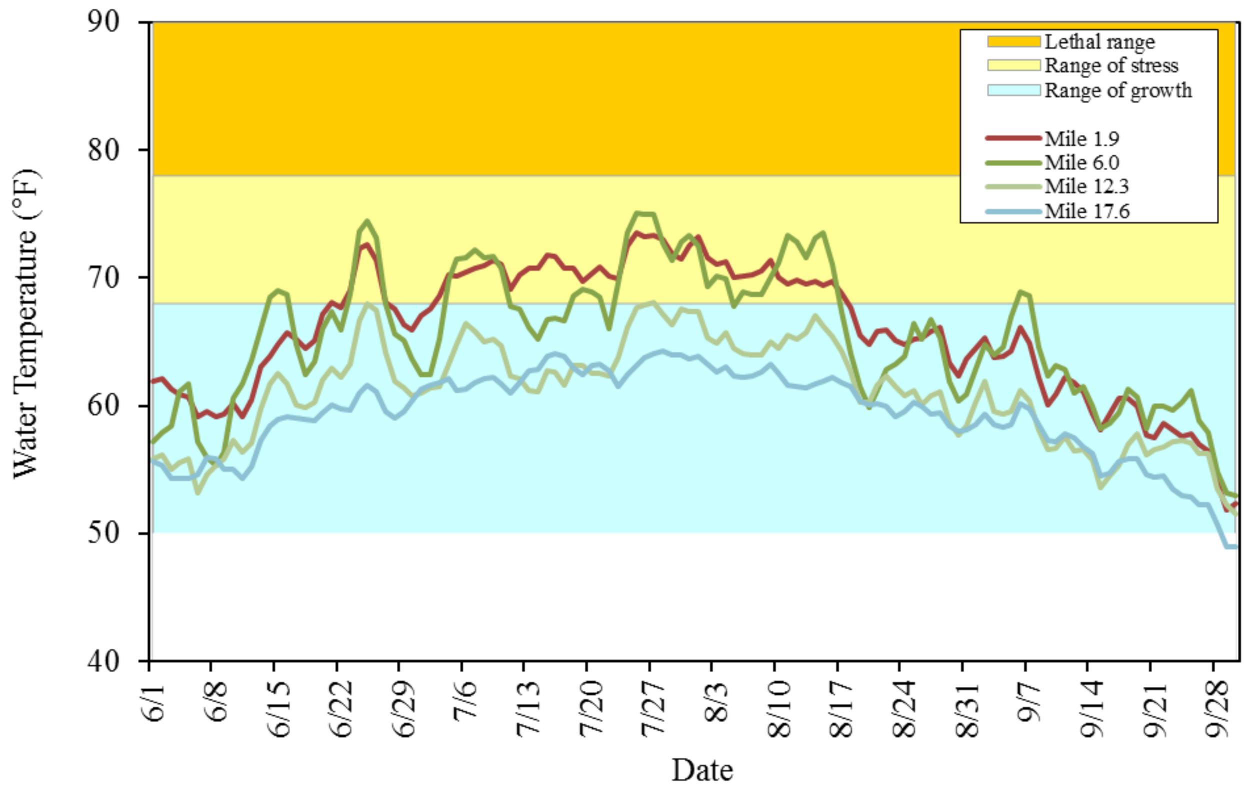

FIGURE A3. Knife River average daily water temperature at mile 1.9, 6.0, 12.3, and 17.6. Temperature ranges indicated are for juvenile steelhead.

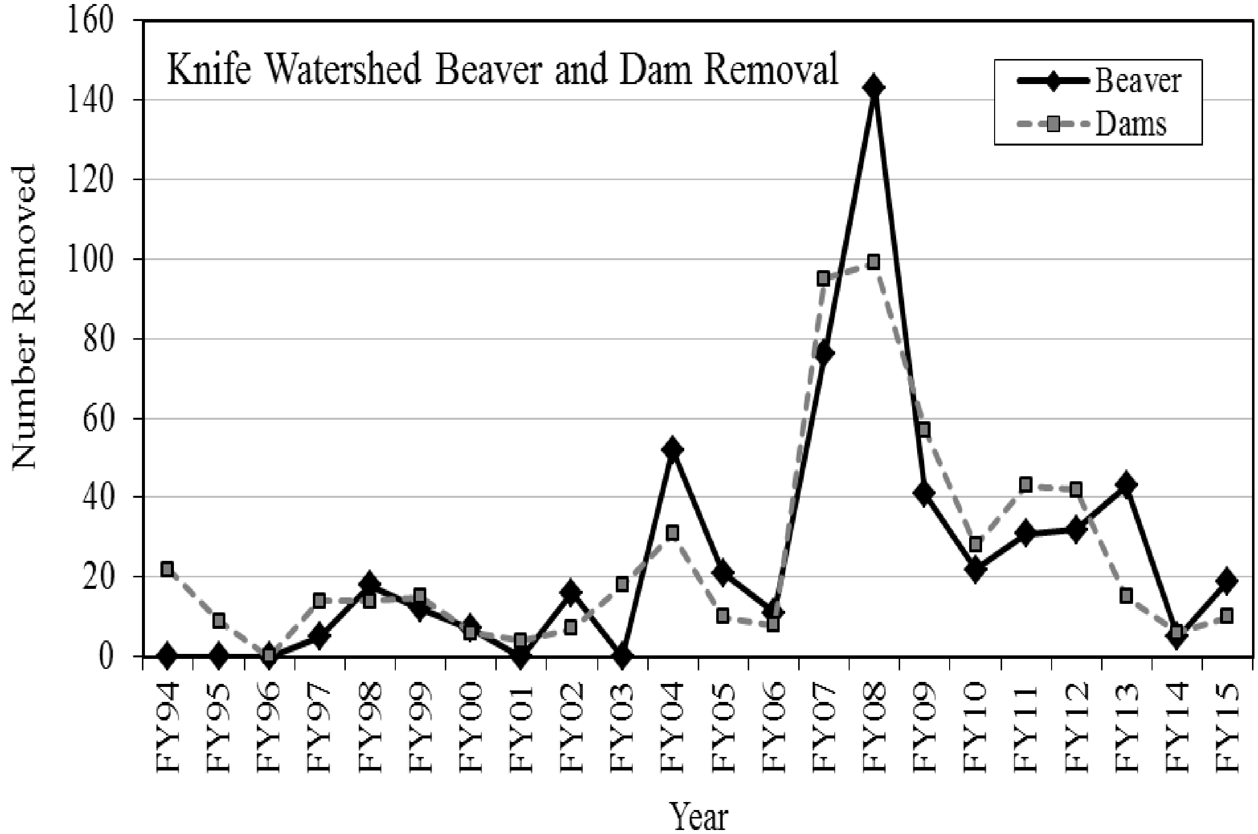

FIGURE A4. Beaver removed on the Knife River, 1994-2015.

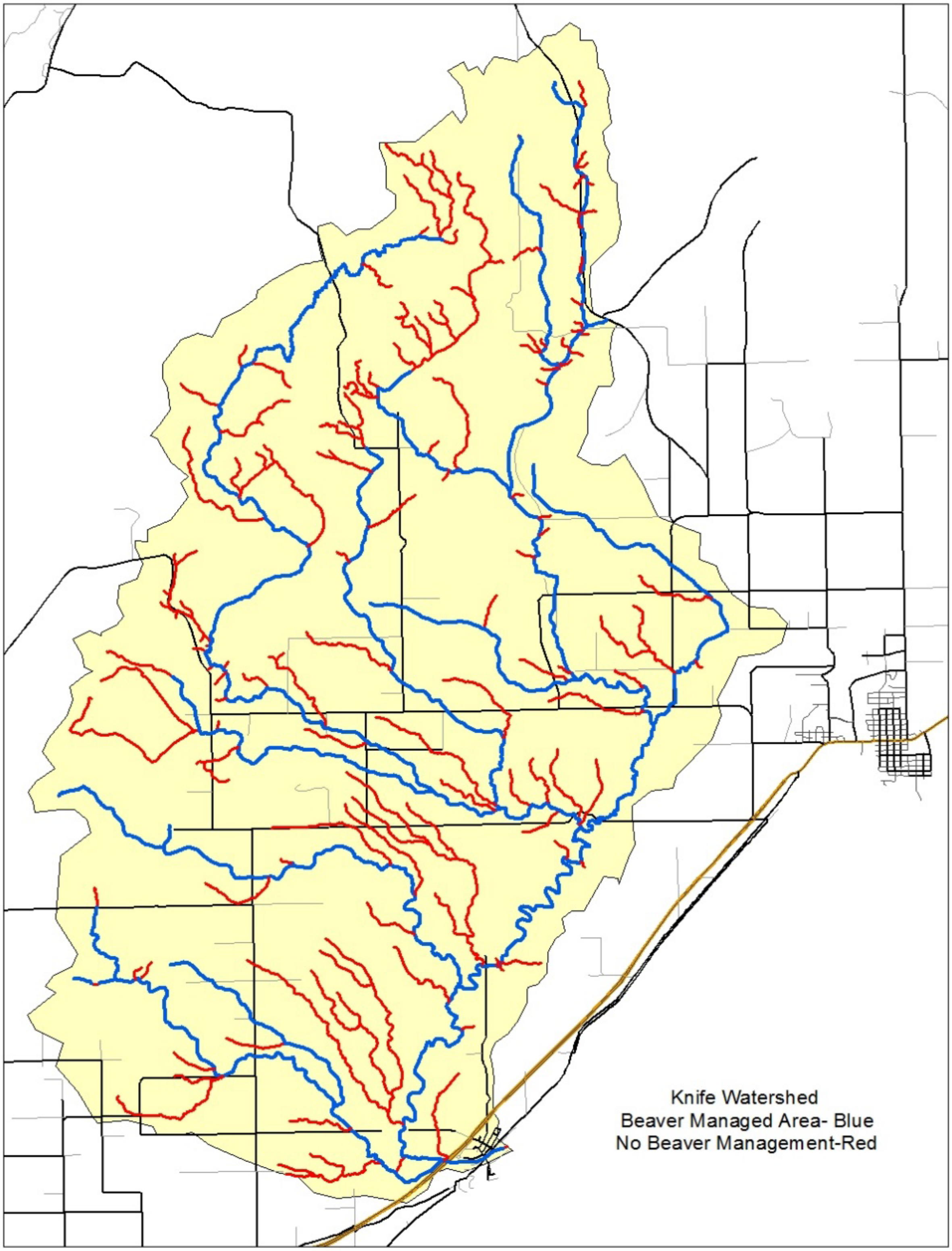

FIGURE A5. Map of beaver management activities in the Knife River system. Blue lines are streams where beaver management occurs and red lines are streams where no beaver management occurs.

APPENDIX B: SUPPORTING DATA TO DISCONTINUE STEELHEAD FRY STOCKING ON THE UPPER SHORE

Steve Persons, MN DNR Grand Marais Area Fisheries Supervisor

There are fairly strong reasons to reduce or eliminate steelhead stocking in some streams. Chief among those, in the Grand Marais area, is poor success of stocking in the two streams we still stock (Temperance and Cascade rivers).

The Temperance River is stocked above the barrier falls, at about mile 1.0. That section of the stream supports only a very limited resident trout population, mainly due to marginal water temperatures. Grand Marais has a long history of stocking steelhead fry in inland reaches of many of our North Shore streams. In 188 assessments of those reaches through 2012, mean catches of age-0 and age-1+ steelhead from stocking were 78.5 (SE=10.1) and 19.8 (SE=2.2) fish per 1000 feet, respectively. In our limited assessments of the stocked reach of the Temperance River, mean catches have been 14.7 age-0 per 1000 feet (SE=14.7) and 9.2 1+ per 1000 feet (SE=5.1), when we have seen any steelhead at all. These low catches, coupled with the short stretch of stream supporting stocked steelhead, suggest the stocking effort on the Temperance River contributes almost nothing to the fishery at the mouth of the river. We have only one assessment from the below-barrier reach on the Temperance – no age-0 steelhead were taken and only one or two age-1+ fish. I suspect the fishery at the Temperance is driven almost entirely by strays, with little or no contribution from stocking or natural reproduction in the stream itself.

The Cascade River is also stocked above the barrier, at about mile 3.7. That section of the stream supports a resident Brook Trout population, and Brook Trout are found throughout the reach from the stocking site down to the barrier falls. Stocking has been more effective on the Cascade River; mean catches of age-0 and age-1+ Rainbow Trout at mile 3.7 in seven assessments of that reach were 55.7 (SE=39.5) and 7.7 (SE=3.5) fish per 1000 feet, respectively. Although the Cascade River is a short-run stream, it provides more spawning and nursery habitat in its anadromous reach than does the Temperance, and that is reflected in higher catches of juvenile Rainbow Trout. At mile 0.0, mean catches of age-0 and age-1+ Rainbow Trout in four assessments were 52.5 (SE=35.8) and 4.0 (SE=2.7) fish per 1000 feet. Although I'll not repeat the analysis here, we did once look at these catches, and determined that catches of juvenile Rainbow Trout at mile 0.0 of the Cascade River were not affected by stocking done at mile 3.7. The fishery in the Cascade is probably supported by a mix of natural reproduction, stocking, and strays.

Production of juvenile, and particularly age-1+, Rainbow Trout in stocked reaches of the Cascade and Temperance rivers has been lower than production we used to see in our other stocked inland reaches. Even that production was considerably lower than we saw in our anadromous below-barrier reaches. Mean catches of age-0 and age-1+ Rainbow Trout in 389 assessments of below-barrier reaches were 231.8 (SE=34.4) and 35.6 (SE=2.1) fish per 1000 feet, respectively, compared to mean catches of 78.5 and 19.8 fish per 1000, respectively, seen in stocked above-barrier reaches.

I am also concerned about the effects of stocking Rainbow Trout fry on top of resident trout populations. Those concerns, shared by other managers, were one reason Rainbow Trout fry stocking was eliminated from several of our inland reaches. Along the North Shore, in anadromous reaches that it seems should be capable of supporting Brook Trout, streams seem to be dominated by juvenile Rainbow Trout. We see fewer Brook Trout in those reaches than we do in our inland waters. Catches of age-1+ Brook Trout in inland reaches in this area averaged 37.9 fish per 1000 feet (SE=2.6; 605 assessments), compared to an average of 10.2 fish per 1000 feet (SE=1.1; 151 assessments) in below-barrier anadromous reaches. While other factors may contribute to this difference, it suggests we should be very cautious about stocking Rainbow Trout into reaches supporting (or capable of supporting) significant Brook Trout populations.

In the Grand Marais area, I recommend discontinuing steelhead fry stocking in the Temperance River because it has not been successful or effective. I also recommend discontinuing fry stocking in the Cascade River, because the fishery there can probably be supported by natural reproduction and strays, and because I am concerned about the effects of steelhead fry stocking on resident Brook Trout in the stream below mile 3.7.

APPENDIX C: PROPOSED MODIFICATIONS TO KAMLOOPS STOCKING PROTOCOL

The Lester River traditionally provided one of the most sought-after harvestable Rainbow Trout (Kamloops) fisheries in Minnesota waters of Lake Superior. Annual catch and catch rates for Kamloops and non-harvestable Rainbow Trout (steelhead) in the annual spring creel increased from the mid-1990s to 2004. Rainbow trout catch increased substantially between 1996 and 1997, was relatively stable in 1997-2010, and has been sporadic since 2011. Beginning in 2006, Kamloops catch and catch rates have continually declined over time and two of the lowest catch and catch rates for Kamloops were observed in 2014 and 2015 (Figures 1 and 2). However, steelhead catch and catch rates have generally increased over the same time period (Figure 2). The discordances in returns between Rainbow Trout strains make it unlikely that environmental conditions alone explain the decline in Kamloops returns at this location. Lake Superior Area fisheries staff question if poor Kamloops returns in recent years are caused by shifts in hatchery production and stocking protocols, and if changes to stocking locations have reduced time to imprint to the Lester River waters and (potentially) increased straying.

Under the current Kamloops program, approximately 32,500 Kamloops are raised exclusively at French River and 67,500 are partially raised at Spire Valley Hatchery. Spire Valley receives eyed eggs from French River Hatchery each spring, raises them to pre-smolt size (4-5 inches mean TL), and then transports them back to the French River Hatchery in May. All Spire Valley Kamloops are then fed at French River Hatchery as long as possible before hatchery source water temperatures from Lake Superior become inadequate for trout. French River Kamloops reach a larger size more quickly (because the French River Hatchery has the ability to heat the water) and are stocked much earlier than Spire Valley Kamloops (typically in June; mean TL = 9.5 inches). Spire Valley Kamloops are stocked at a smaller size in July (mean TL = 7.7 inches).

On average, 34,645 Kamloops have been stocked annually in the Lester River since 1986. All Kamloops stocked in the Lester River between 1986 and 1998 were stocked downstream of the first natural barrier, with most being stocked near the confluence of the Lester River and Lake Superior. From 2000 to 2010, all Kamloops were stocked upstream in the Lester River at Strand Road (mile 5.2), Atkinson Road, and/or in Amity Creek below the first natural barrier (mile 0.4 in Amity Creek). The stocking location at the Lester River was modified once again in 2010 due to concerns with VHS and others (e.g., stream and weather conditions at time of stocking), and all Kamloops have been stocked at the mouth of the Lester River since 2010. Kamloops reared at Spire Valley Hatchery currently undergo VHS testing prior to stocking (Table 1; Figure 3).

Straying of stocked Kamloops is a major concern with resource managers and anglers because it increases the potential for hybridization between hatchery Kamloops and naturalized steelhead. In recent years, there have been more reports of Kamloops caught or observed at rivers in Michigan, Ontario, and Wisconsin, including in the Brule River system, which is likely the most popular steelhead fishery in Western Lake Superior. The increased straying could be a product of failed imprinting to stocked rivers under the current stocking scheme. Stocked Kamloops typically spend very little (or no) time in or near the mouth of the Lester River prior to migrating to Lake Superior (MN DNR pers. comm.). Short stream lengths limit the ability to maximize imprinting and partially imprinted fish stray more, increasing the likelihood of spawning overlap between the strains (Negus 2003). Stocking into a river significantly increases ATPase activity levels for Kamloops, and the size threshold to determine the onset of possible smoltification for Kamloops is 150 mm (about 6.0 inches; Negus 2003). Therefore, it is highly unlikely that many of these fish successfully imprint and return to the Lester River under the current stocking protocol (stock 32,500 SVH/FRH Kamloops that average 7.7 inches near the mouth of the river). Regardless of what has led to the negative long-term trends in catch and catch rates for Kamloops at the Lester River, it is clear that the current protocols need to be reevaluated.

Proposed Changes

1) **Fill the annual Lester River Kamloops stoking quota (32,500) by stocking all fish directly from SVH in April (4-5" mean TL) at two locations upstream in the Lester River**.

   Stocking the larger Kamloops in French River and smaller individuals in other streams in May and June may maximize survival of the stock and homing to desired locations (Negus 2003). Fish stocked upstream of the natural barrier are exposed to Lester River water for a longer period of time prior to their migration to Lake Superior than fish stocked at the mouth. The Lester River quota (32,500 of 4-5-inch fish) would be brought from Spire Valley and stocked directly into the Lester River. Upstream stocking will be split evenly at 2 locations to spread out stocked fish and provide a better opportunity for them to imprint on Lester River water source: 1) downstream of North Tischer Road CR293 (mile 8.1), and 2) downstream of Strand Road (mile 5.2). Stocking upstream in April would be much less stressful than stocking the same amount of larger fish upstream in later months. The combined stress of stocking larger fish in less than ideal water temperatures in summer months could result in higher mortality.

2) **Eliminate the steelhead stocking from the Lester River to account for stocking Kamloops upstream.**

   The MN DNR will eliminate stocking of steelhead at Lester River to reduce the competition between steelhead, Kamloops, and other trout. This would also provide additional steelhead fry to stock at other North Shore steelhead streams at the Area Supervisors' discretion.

3) **Modify the Kamloops clip schedule so that the new stocking scheme and straying from Lester River can be evaluated in annual spring creel survey and Knife River and French River trap operations.**

   All fish stocked in the Lester River will be given an adipose-only clip so they can be identified by creel clerks and anglers in the annual spring creel survey. This will allow the MN DNR to determine straying rates from the new protocol (raising offsite and stocking directly into stream) and distinguish fish stocked at Lester River or French River. Since only Spire Valley fish will be stocked at Lester River (all with Adipose-only clips), the MN DNR will still be able to evaluate returns of SVH and FRH Kamloops at the Knife River and French River traps.

4) **Stock all remaining SVH Kamloops (partially-reared at French River Hatchery) at the mouth of the French River.**

   The MN DNR managers and anglers have been concerned with straying and small size-at-stocking of SVH Kamloops. With this proposal, Spire Valley Kamloops should be a larger size at stocking than in previous years due to the added space at the French River Hatchery, and more similar to the size of Kamloops that are raised entirely at the French River Hatchery.

Stocking SVH/FRH Kamloops at the French River at a larger size should insure the maximum return to the French River when they are adults. This will allow the MN DNR to better evaluate returns from fish raised entirely at French River, fish partially raised at SVH/FRH, and SVH Kamloops that were stocked directly into the Lester River because each group will have unique clips, regardless of where they are stocked. For example: anything with an Adipose-only clip would denote a small SVH fish stocked in the Lester River, anything with an ALF or ALR clip would be Kamloops that was partially raised at Spire Valley/French River, and anything with an ARF or ARR would be a Kamloops completely raised at French River. The adipose-only fish that return to the French River would have to be strays from the Lester River, which would provide a 'straying-rate' for Kamloops using the alternative stocking protocol. Used in the spring creel survey, this approach could provide straying rates among the three groups at other North Shore rivers.

Potential Benefits

1) **Reduce cost of the Kamloops Program**: Stocking 32,500 SVH Kamloops directly into the Lester River in May will reduce the number of SVH Kamloops that need to be partially raised at the French River Hatchery by 48%, on average (based on the Lester River quota of Spire Valley fish that would be directly stocked into the Lester River [32,500] from the total raised at Spire Valley and brought back for partial rearing at French River [67,500]). This could reduce costs of the Kamloops program (Mark Gottwald pers. comm.).

2) **Ability to improve growth rates and size at stocking for Spire Valley Kamloops**: Less SVH Kamloops will need to be partially raised at the French River Hatchery. This will provide more hatchery space and allow MN DNR to improve growth rates and size for SVH Kamloops that are brought to French River Hatchery (Mark Gottwald pers. comm.). This should reduce costs for the Kamloops program, help to reduce the differences of size at stocking between Kamloops raised exclusively at French River and Kamloops partially raised at Spire Valley and French River, and tailor to concerns about straying (imprinting) and differences in size at stocking between FRH and SVH hatchery products.

3) **Provide more opportunity for stocked Kamloops to imprint to the Lester River waters and not stray to other rivers**: Stocking Kamloops directly into the stream should allow more acclimation time to Lester River waters and reduce straying to other rivers. Return rates from fish stocked upstream will be evaluated with catch and catch-rates in the spring creel over time. The unique clips at the Lester River will allow MN DNR to identify any strays from the Lester River in the annual spring creel survey, and at the Knife and French River fish traps. The unique clips should provide much needed information about straying rates using the offsite rearing and direct stocking Kamloops production method, and will be vital information for those making decisions about the future of the Kamloops program.

4) **Reduce confounding factor in steelheadfry stocking evaluation:** Before this proposal, both Lester River and Amity Creek were listed to be stocked with steelhead fry on alternating years. Genetics of adult steelhead returning to the Lester River are going to be evaluated to determine what proportion of the adult steelhead catch were of hatchery origin (stocked as fry) and what were products of natural reproduction. In the old protocol, it would be impossible to distinguish a Lester River adult fry-stocked steelhead from an Amity Creek fry-stocked steelhead. The

proposed stocking changes would alleviate this potentially confounding issue. It would also provide a 'non-stocked' steelhead river and creel location in the lower shore that would add to ongoing evaluation of how catch and catch rates of steelhead in the annual spring creel survey respond to the suspension of fry stocking.

Tradeoffs

The MN DNR will be stocking Kamloops in the same areas as existing, but limited, trout populations in Lester River. However, fish stocking has occurred nearly every year the past century. The Lester River has historically been managed for steelhead and Kamloops given its close proximity to Duluth and the limited/marginal habitat for other trout species. Steelhead and Brown Trout stocking has occurred in past years regardless of other trout populations, and the Duluth Area is currently stocking and managing the stream for non-native Brown Trout. The new protocol will greatly reduce the cost of production at the French River Coldwater Hatchery, allow the MN DNR to evaluate the new stocking program (via adult Kamloops catch and catch rates in the spring creel), and could reduce straying while (potentially) improving catch and catch rates of the only harvestable Rainbow Trout strain in Minnesota waters of Lake Superior.

Reference

Negus, M. T. 2003. Determination of smoltification status in juvenile migratory Rainbow Trout and Chinook Salmon in Minnesota. North American Journal of Fisheries Management 23:913-927.

TABLE C1. Stocking history for Kamloops Rainbow Trout in the Lester River.

Year stocked	Total Stocked	Upstream of Barrier	Downstream of Barrier	Unknown Location
1968	11,600			11,600
1969	600			600
1970				
1971				
1972				
1973				
1974				
1975				
1976				
1977				
1978				
1979				
1980				
1981	5,250	5,250		
1982				
1983	37,070	37,070		
1984	10,788		10,788	
1985				
1986	35,041		35,041	
1987	34,997		34,997	
1988	31,998		31,998	
1989	37,570		37,570	
1990	32,424		32,424	
1991	36,847		36,847	
1992	16,044		16,044	
1993	59,234		59,234	
1994	35,005		35,005	
1995	35,007		35,007	
1996	30,765		30,765	
1997	35,010		35,010	
1998	35,005		35,005	
1999	35,020	17,510	17,510	
2000	35,002	35,002		
2001	36,223	36,223		
2002	35,001	35,001		
2003	42,504	42,504		
2004	42,517	42,517		
2005	42,504	42,504		
2006	42,514	42,514		
2007	30,012	30,012		
2008	32,502	32,502		
2009	32,499	32,499		
2010	28,521		28,521	
2011	32,513		32,513	
2012	32,112		32,112	
2013	32,507		32,507	
2014	32,707		32,707	
2015	19,730		19,730	
Sum	1,104,643	431,108	661,335	12,200
Avg	31,561	33,162	31,492	6,100
Min	59,234	42,517	59,234	11,600
Max	600	5,250	10,788	600
N	35	13	21	2
Avg (Pre-1990)	22,768	21,160	30,079	6,100
Avg (1990-1999)	35,036	17,510	33,285	---
Avg (2000-2009)	37,128	37,128	---	---
Avg (2010-2015)	29,682	---	29,682	---

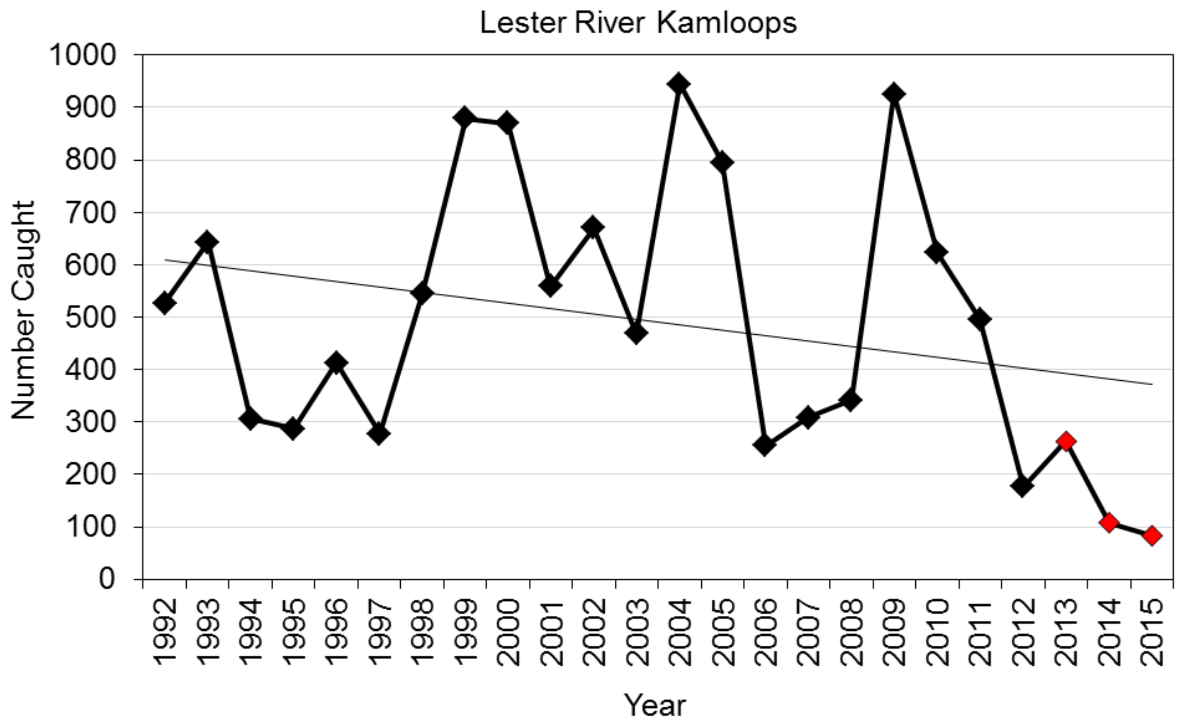

FIGURE C1. Number of Kamloops Rainbow Trout caught per year at the Lester River.

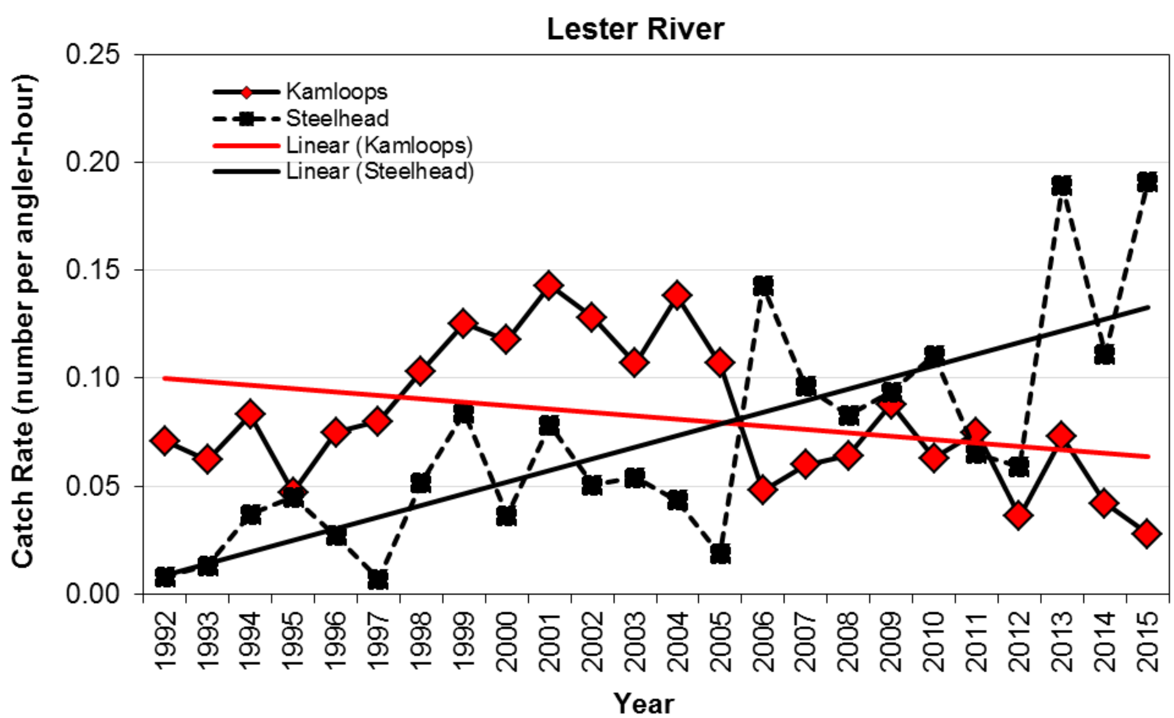

FIGURE C2. Catch rate (number per angler hour) of Kamloops Rainbow Trout by year at the Lester River.

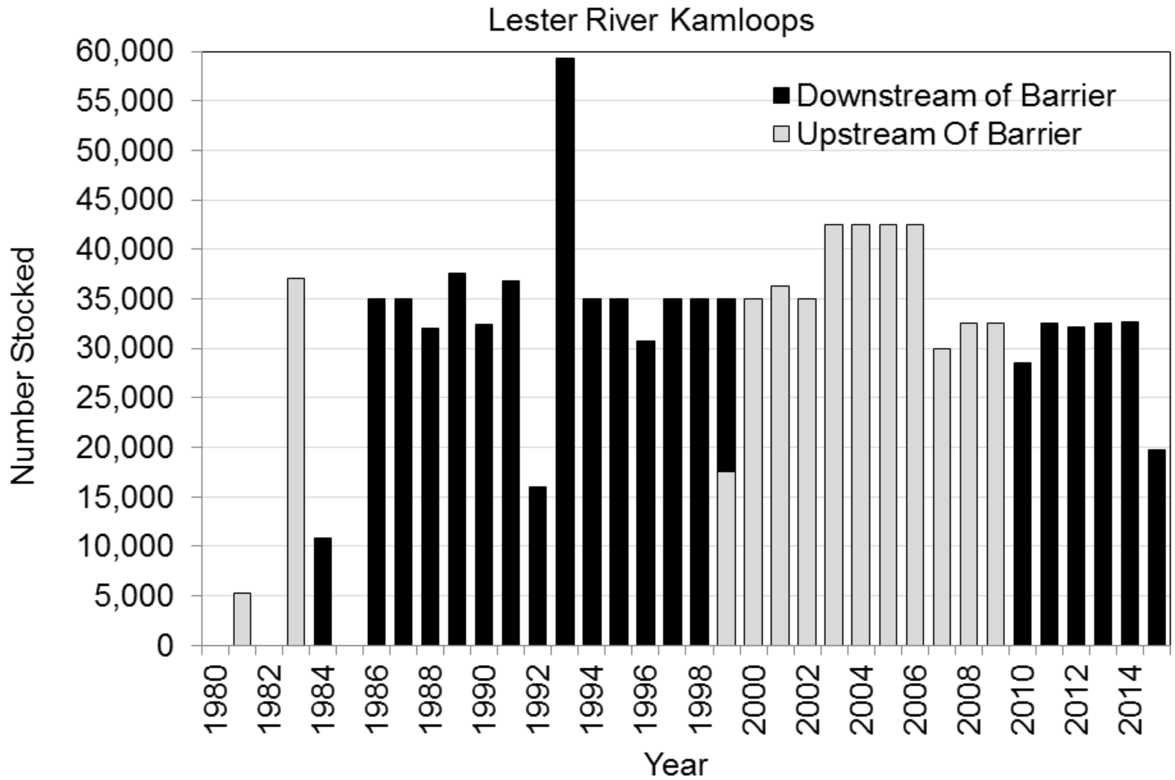

FIGURE C3. Number of Kamloops Rainbow Trout stocked per year in the Lester River.