A Review of Stocking Strategies in Wisconsin, With an Analysis of Projected Stocking Needs: 2010-2019

Administrative Report No. 71

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Report Summary

This report, originally written in 1999 and updated in 2010, specifically addresses the long-range stocking goals for DNR using the best available scientific information. This plan promotes the most effective use of stocking in the overall management of Wisconsin's fisheries using a goal-oriented, species- and water-specific approach that minimizes impacts to existing self-sustained populations.

Species-specific stocking guidelines were reviewed and, where needed, revised to reflect current scientific knowledge. Recommended changes include: a measurable demand for a source of adult fishes and/or species not currently propagated, which may require quarantine-type facilities, due to recent fish health concerns with field transfers; a continued shift from domestic to wild inland trout; overall reduction in bass stocking, including elimination of maintenance stocking; an increase in restorative sturgeon stocking; completion of muskellunge stocking evaluation; northern pike stocking based on suitable habitat and focused on rehabilitations and bio-manipulations; a reduced demand for small walleye fingerlings, an increased demand for extended growth walleye fingerlings, and more critical review of quota requests in waters with natural reproduction; and, no major changes to the Great Lakes trout and salmon stocking program. Overall recommendations include protection of existing naturally reproducing populations, more evaluation and use of appropriate genetic strains, long-term quota development; development of a disease free source of fish for transfer for restoration projects, and the formation of a stocking team that keeps stocking and propagation on the cutting-edge of fisheries management.

Based on the best available information, annual stocking of nearly 9.6 million fish (primarily fingerlings/yearlings) is needed to sustain and enhance the sport fishery in Wisconsin. This projected level of stocking was arrived at largely independent of current hatchery production capacity.

Summary of Projected Stocking Goals (2010-2019)

Fish Species (size)	Size	Stock/strain	Statewide Annual Stocking Goal (1999)	Statewide Annual Stocking Goal (2010)
Coolwater				
Walleye	Small fingerlings	Lake Michigan	0	492,733
Walleye	Small fingerlings	Lake Superior	0	109,994
Walleye	Small fingerlings	Mississippi Headwaters	0	1,332,361
Walleye	Small fingerlings	Mississippi Mainstem	0	41,758
Walleye	Small fingerlings	Rock/Fox	0	1,323,154
Walleye	Small fingerlings	Unspecified	6,500,000	0
		Total	6,500,000	3,300,000
Walleye	Extended growth	Lake Michigan	0	95,309
Walleye	Extended growth	Lake Superior	0	10,385
Walleye	Extended growth	Mississippi Headwaters	0	167,832
Walleye	Extended growth	Mississippi Mainstem	0	5,998
Walleye	Extended growth	Rock/Fox	0	45,475
		Total	0	325,000
Muskellunge	Large fingerlings	Great Lakes	0	65,000
Muskellunge	Large fingerlings	Upper Chippewa River	0	40,000
Muskellunge	Large fingerlings	Upper Wisconsin River	0	15,000
Muskellunge	Large fingerlings	Unspecified	140,000	85,000
		Total	140,000	205,000
Muskellunge	Yearlings	Great Lakes	0	3,000
Northern Pike	Small fingerlings	Upper Chippewa River	0	2,724
Northern Pike	Small fingerlings	Upper Wisconsin River	0	295
Northern Pike	Small fingerlings	Great Lakes	0	4,846
Northern Pike	Small fingerlings	Lower WI/Mississippi River	0	128
Northern Pike	Small fingerlings	Rock/Fox	0	46,049
Northern Pike	Small fingerlings	Unspecified	80,000	0
		Total	80,000	54,042
Northern Pike	Large fingerlings	Upper Chippewa River	0	1,115
Northern Pike	Large fingerlings	Upper Wisconsin River	0	526
Northern Pike	Large fingerlings	Great Lakes	0	13,566
Northern Pike	Large fingerlings	Lower WI/Mississippi River	0	12.024
Northern Pike	Large fingerlings	Rock/Fox	0	126,864
Northern Pike	Large fingerlings	Unspecified	70,000	0
		Total	70,000	154,095
Largemouth bass	Large fingerlings	Upper Wisconsin River	0	18,750
Largemouth bass	Large fingerlings	Lake Michigan	0	18,750
Largemouth bass	Large fingerlings	Lower WI/Mississippi River	0	18,750
Largemouth bass	Large fingerlings	Rock/Fox	0	18,750
Largemouth bass	Large fingerlings	Unspecified	175,000	0
		Total	175,000	75,000

Smallmouth bass	Large fingerlings	Rock/Fox	0	40,000
Smallmouth bass	Large fingerlings	Unspecified	35,000	0
		Total	35,000	40,000
Lake Sturgeon	Small fingerlings	Unspecified	75,000	0
Lake Sturgeon	Large fingerlings	Couderay River	0	1,500
Lake Sturgeon	Large fingerlings	Manitowish River	0	3,500
Lake Sturgeon	Large fingerlings	Menominee River	0	5,000
Lake Sturgeon	Large fingerlings	Upper Namekagon River	0	1,600
Lake Sturgeon	Large fingerlings	Upper St. Croix River	0	2,000
Lake Sturgeon	Large fingerlings	Winnebago (Streamside)	0	4,500
Lake Sturgeon	Large fingerlings	Wisconsin River	0	31,000
		Total	0	49,100
Lake Sturgeon	Yearlings	Menominee River	0	1,300
Lake Sturgeon	Yearlings	Winnebago (Water Instit.)	0	500
Lake Sturgeon	Yearlings	Wisconsin River	0	600
		Total	0	2,400
Inland Trout				
Brook Trout	Spring fingerlings	Domestic	0	20,280
Brook Trout	Fall fingerlings	Domestic	15,700	30,250
Brook Trout	Yearlings	Domestic	78,400	1,270
Brook Trout	Spring fingerlings	Wild (NE, NW, SW strains)	106,550	41,730
Brook Trout	Fall fingerlings	Wild (NE, NW, SW strains)	70,050	89,610
Brook Trout	Yearlings	Wild (NE, NW, SW strains)	91,750	58,330
Brown Trout	Spring fingerlings	Domestic	0	3,100
Brown Trout	Fall fingerlings	Domestic	91,300	144,800
Brown Trout	Yearlings	Domestic	161,900	21,580
Brown Trout	Spring fingerlings	Timber Coulee	272,030	432,460
Brown Trout	Fall fingerlings	Timber Coulee	391,810	191,220
Brown Trout	Yearlings	Timber Coulee	6,700	86,290
Rainbow Trout	Spring fingerlings	Domestic	19,200	17,100
Rainbow Trout	Fall fingerlings	Domestic	48,750	49,300
Rainbow Trout	Yearlings	Domestic	148,750	338,700
Lake Trout	Fall fingerlings	Unspecified	20,000	27,000
Lake Trout	Yearlings	Unspecified	25,000	0
Lake Trout	Fall fingerlings	Trout Lake	100,000	0
Splake	Yearlings	Unspecified	4,000	0
		Total	1,651,890	1,553,020
Great Lakes Trout and Salmon				
Brook Trout	Fingerlings	Great Lakes	109,700	0
Brook Trout	Yearlings	Great Lakes	50,380	100,000
Brown Trout	Fingerlings	Domestic	682,200	571,000
Brown Trout	Yearlings	Domestic	242,550	240,000
Brown Trout	Yearlings	Seeforellen	408,190	412,000
Rainbow Trout	Yearlings	Brule River	100,000	0
Rainbow Trout	Yearlings	Chamber’s Creek	169,900	170,000
Rainbow Trout	Yearlings	Ganaraska	160,500	170,000
Rainbow Trout	Yearlings	Skamania	169,900	170,000
Rainbow Trout	Yearlings	Arlee/Kamloops	0	120,000
Lake Trout	Yearlings	Apostle Islands	0	89,400
Lake Trout	Yearlings	Domestic	89,400	0

Splake	Yearlings	Apostle Islands x Domestic	160,000	120,000
Chinook Salmon	Spring fingerlings	Lake Michigan feral	1,867,000	1,164,000
Coho Salmon	Fingerlings	Lake Michigan feral	100,000	0
Coho Salmon	Yearlings	Lake Michigan feral	398,000	500,000
		Total	4,707,720	3,826,400
Grand Total			13,434,610	9,575,044

A Review of Stocking Strategies in Wisconsin, With an Analysis of Projected Stocking Needs

Introduction

Advances in propagation techniques, a greater understanding of the need for ecosystem management and genetic conservation, and renovations to the hatchery system have all led to revisions of management strategies for many of Wisconsin's popular fisheries. As such, management goals, and associated stocking guidelines, are periodically reviewed for many of the major fisheries in the state. A legislative audit of the department's propagation program in 1997 initially prompted a consolidated review and description of our stocking practices. A 2009-10 review of our propagation system by consulting engineers prompted this revision and update.

Updated stocking guidelines are intended to 1) provide the hatchery system with better information for production planning, 2) ensure the most efficient use of hatchery products needed for management purposes, and 3) ensure the most prudent management of Wisconsin's exploited stocks and associated communities and ecosystems. This planning effort was designed to evaluate and update, where needed, our stocking practices and to develop a statewide plan for the uses of, and demands for, stocked fish.

Clearly, stocking can not be considered in a vacuum. Central to this effort was a review and revision, where necessary, of the overall *management goals* for the various fisheries of the state. The ultimate success of any stocking activity should be judged based on its contribution to achieving those management goals. Species-specific stocking strategies can then more efficiently address where, how many, what size, and what types (e.g., strain) of fish are needed to meet overall program goals. This report suggests how many fish <u>should</u> be raised under perfect conditions to meet the overall management goals of the program, not how many <u>could</u> be raised based on the capacity or limitations of the propagation system.

The major fish species stocked by the Department of Natural Resources are addressed in this report: Inland trout (domestic and wild strains), Great Lakes trout and salmon, black bass, lake sturgeon, muskellunge, northern pike, and walleye. Existing *species management teams*, many of which include both internal and external partners, reviewed, revised and updated management goals and developed stocking strategies to ensure that the management goals are met. The teams compiled available stocking evaluations statewide, examined current scientific literature, and reviewed other available information to produce up-to-date stocking strategies. Stocking procedures for each species include suitable waters, sizes and numbers to stock, strain management, and projected changes in statewide production. This report presents the "desired state" for our stocking program and should be viewed as a working document that is open to continuous improvement and update. The recommendations contained herein should be implemented as opportunities arise.

Management Goals.- The various species-specific committees independently develop management goals for the major fisheries of the state. Many similarities existed among the species-specific goals. What follows is a consolidated list of fisheries management goals for the state that incorporates most of the goals from the species-specific groups:

I. Protect, restore and enhance fisheries habitat on Wisconsin waters

II. Protect, restore and enhance Wisconsin’s self-sustained fisheries, fish assemblages and aquatic communities

III. Provide a variety of quality fishing opportunities (e.g., trophy, action, harvest) within a flexible management system

IV. Ensure that resource managers have the necessary information on the status of Wisconsin’s fisheries and aquatic ecosystems

V. Provide technical assistance and educational opportunities to Wisconsin’s citizens and anglers, promote the value of Wisconsin’s fisheries and ensure angling opportunities for future generations

Stocking Strategies- Stocking is generally used as part of an integrated approach in the management of a waterbody which also considers habitat restoration or improvement, harvest regulations, public access, and public education and involvement. As part of a management plan, stocking should be used to accomplish specific objectives for the waterbody through one of the following strategies:

Introduction - This strategy includes instances where a species is introduced into newly created waters or to expand the range of a species. Ideally, the introduction results in the establishment of a self-sustained fishery with minimal impacts on existing fisheries. While generally not required by the department, an internal Environmental Assessment is typically requested by the Bureau of Fisheries Management before approval of new introductions.

Rehabilitation - An interim measure to re-establish formerly self-sustained populations that have been extirpated or severely reduced by catastrophic natural or intentional sources of mortality (e.g., winter kill, disease, chemical spill, mechanical removal, draw-downs, dam failures, chemical reclamation, etc.).

Research or Evaluation - Experimental stocking done in conjunction with a research or evaluation project intended to determine the effectiveness of stocking practices or other management actions.

Remediation (maintenance) - Stocking to maintain an existing fishery that has been reduced due to external impacts (e.g., loss of spawning habitat, invasion of exotic species, long-term changes in species composition) that cannot be readily corrected. This strategy would also include instances where restoration of predator/prey imbalance is sought. This type of fishery is typically dependent upon stocking for continued existence.

Recreation (maintenance) - Stocking to create or maintain a recreational fishing opportunity that did not previously exist and is not self-sustaining. This type of fishery will usually have some effect on existing fisheries and is typically dependent upon stocking for continued existence.

All of these stocking strategies are currently used on Wisconsin waters. Priority is usually given to rehabilitation stockings that promise to reestablish self-sustained fisheries, and to research or evaluation stockings that promise to improve the cost-effectiveness of stocking practices. Recreation stockings are generally a relatively costly management activity but are often needed to sustain popular fisheries in many waters. Remediation stockings are used only as a last resort after attempts to correct underlying problems have failed and the maintenance of a stocked fishery is desired. New introductions of species are generally discouraged except in newly created waters such as reservoirs or constructed ponds.

Stocking Guidelines.- Specific stocking guidelines for each species were developed to provide guidance for staff in making biologically sound stocking recommendations for a particular water and to allow for equitable and cost-effective allocation of limited hatchery production In the first set of guidelines, based on the best available biological information, stocking must:

1) Address the management goal(s) for the species of interest;

2) Minimize negative impacts on existing self-sustained fisheries, including safeguards to protect the integrity of native and naturalized stocks and consider interactions and potential impacts on other species; and

3) Be biologically sound (i.e., likely result in fishable populations) based on the best available scientific knowledge.

The second set of guidelines, based primarily on inevitable limitations in production from the hatchery system, consider allocation rules for limited production. Stocking requests should:

1) Be cost effective, as measured by cost per recruit to the populations or cost per fish returned to the creel;

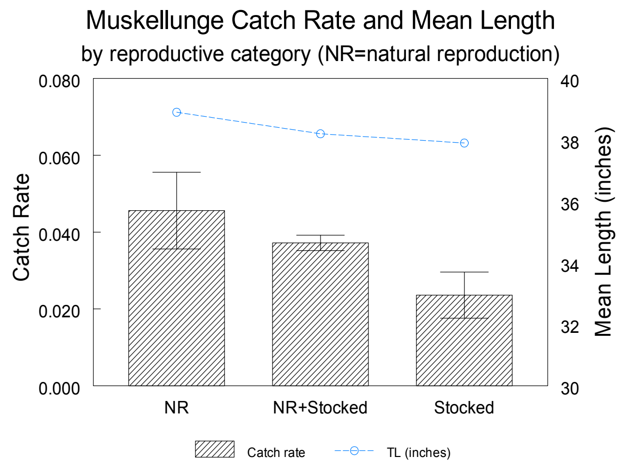
2) Ensure equitable distribution of limited hatchery production; and

3) Utilize contracts or cooperative agreements with private fish farmers and volunteer groups, where cost-effective.

The primary purpose for the first set of guidelines is to assist fisheries biologists in developing long-term management objectives for specific waters. The second set of guidelines will allow the Department hatchery system to equitably and cost-effectively allocate production for maximum benefit, as measured by return to the angler creel. The difference, if any, between long-term stocking recommendations and Department hatchery allocation represents opportunities for contract development or cooperative agreements with private businesses or volunteer groups, or for the state to consider investments in the Department hatchery system.

In this report, we present recommendations based primarily on the best available scientific information. This allows comparison of statewide need with existing facility capacity, as described in an earlier report to the legislature (DNR 1998). However, a blend of biological and production-allocation criteria have historically been used in Department stocking guidelines. In instances where scientific information is equivocal, historic practices are retained in the current recommendations. Thus, true demand for stocked fish is difficult to accurately assess because past stocking requests have been tempered by production-allocation criteria through this historic blend of guidelines.

Stock Integrity and Natural Reproduction.- A central goal for all stocking in Wisconsin should be to ensure the protection of existing self-sustained populations. Native and naturalized populations that are self-sustained through natural reproduction obviously provide some of the best fishing opportunities in the state (*see figures below*),



are the most cost-effective to manage and, if impacted or lost, can not be easily replaced. Stocking should, first and foremost, be considered an important restoration tool used to reestablish naturally reproducing populations and should never be conducted to the potential detriment of natural reproduction.

Considerable work has been done on the differentiation, fitness, and performance of individual populations within a species (Philipp et al. 1983; Gharrett et al. 1988; Beachum et al. 1989; Krueger et al. 1989; Philipp 1991). The "stock concept" (i.e., managing individual breeding populations) has been bolstered over the last decade with improved technology (ability to discern stocks; see Ryman and Utter 1987) and documentation of the superior performance of "locally adapted" populations (see, e.g., Philipp and Claussen 1995). Indiscriminate transfer and mixing of stocks negatively affects the genetic resources of a species by reducing genetic diversity among populations and by decreasing the genetic fitness of locally adapted populations through outbreeding depression (i.e., when genetically different populations interbreed to produce inferior offspring).

In an experiment conducted by Illinois researchers, bass from Florida, Illinois, Wisconsin, and Texas were stocked together in lakes in all four locations. In each location the survival, growth, and reproduction of the local fish were best; nature had already produced the best adapted fish for the local conditions. However, the few surviving transplants interbred with the locals and eventually all the bass in the lakes were hybrids with inferior performance relative to the local stock (*see* Jennings 1996 for an overview). A similar experiment was conducted at a smaller scale by transplanting bass from two different watersheds in Illinois. In this study, similar results were found: local stocks had better performance (growth and survival) and fitness (reproduction). These studies suggest that indiscriminate stocking of bass in waters with naturally reproducing populations will likely result in more harm than good.

We recommend a conservative approach that reasonably assumes that these results are applicable to other freshwater fish species, pursuant to Goal 2, above. Fields et al. (1997) also recommends this approach. As such, we recommend that no stocking take place in waters with self-sustained fisheries of the species in question.

Our recommendations for sources of stocked fish, based on the reproductive status of the population in the receiving water, are modified based on those of Fields et al. (1997):

Table of Stocking Decisions for Conservation of Native Stocks (modified from Fields et al. 1997). “NR” means natural reproduction; “Basin stock” means the brood stock originates from within the major basin

Stock Origin	Reproductive status	Recommended source of brood stock
Native to waterbody	Self-sustained through NR	Fish should not be stocked
	Some NR; not self-sustained	Basin stock
	Extirpated (rehabilitation)	Basin stock
	Dependent on stocking	Basin stock
Introduced to waterbody; native to basin	Self-sustained through NR	Fish should not be stocked
	Some NR; not self-sustained	Basin stock
	Dependent on stocking; or new introduction	Basin stock
Introduced to waterbody; not native to basin	Self-sustained through NR	Fish should not be stocked
	Some NR; not self-sustained	Any source
	Dependent on stocking; or new introduction	Any source

Stocking Plans and Quota Requests.- In developing new requests for fish from the hatchery system, fisheries biologists should evaluate the overall management goals, the specific objectives for the waterbody, determine a desired state for the fishery, select a long-term stocking strategy for the species of interest, if needed, and select stocking practices that will achieve the desired state. Generally, a 10-year stocking plan should be developed to fully evaluate whether the desired state has been reached. Recommended stocking guidelines for each of the stocking strategies, developed by teams of biologists and species-specific experts from throughout the state, are presented below to guide fisheries biologists. Evaluations of other stocking practices are also encouraged and should be supported by a research or evaluation project to ensure the most efficient use of hatchery and fiscal resources.

Species-Specific Stocking Guidelines

The stocking guidelines presented in this report address the major fish species stocked by the Department of Natural Resources: Great Lakes trout and salmon, inland trout (domestic and wild strains), black bass, lake sturgeon, muskellunge, northern pike, and walleye. This portion of the report is divided into two sections: 1) cold water species and 2) warm water species which will facilitate comparisons with DNR cold water and warm water hatchery capacity.

Within each management goal, each committee described:

1) The stocking strategy (e.g., rehabilitation, remediation, recreation, etc.), if any, recommended to achieve the goal;

2) Waters appropriate for the application of that stocking strategy;

3) The recommended stocking guidelines associated with the respective stocking strategy, including:

- a) The size of fish;
- b) Rates of stocking;
- c) Frequency (e.g., annual, biannual, etc.) of stocking; and
- d) Duration (e.g., 5 consecutive years; biannually for 10 years) of stocking;

4) Criteria recommended to evaluate the effectiveness of the strategy – including the cost-effectiveness of the strategy.

5) Projected demand for fish from the hatchery system for the next 10 years.

COLD WATER SPECIES

Great Lakes Trout and Salmon Stocking Guidelines

The Great Lakes trout and salmon stocking program can be traced back over a hundred years to the initial introductions of rainbow trout. The program has been greatly expanded in the past three decades, and now supports a vital and economically important fishery known throughout the world. Stocked trout and salmon are the backbone of a sport fishery that provides over 3,000,000 hours of relaxation and gainful entertainment to anglers each year. The program is reviewed below in three sections, an overview, a summary of the major management goals and strategies, and a discussion of the cost-effectiveness of the program.

Background - Wisconsin's Great Lakes trout and salmon program involves the stocking of six species of fish – lake trout, brook trout, rainbow trout, brown trout, chinook salmon, and coho salmon – in Lake Michigan, Lake Superior, and tributaries. The splake, a cross between lake and brook trout, has also been stocked in both lakes. This program provides sport-fishing opportunities, regulates the abundance and ecological impacts of alewives in Lake Michigan, and promotes restoration of naturally-reproducing populations of lake trout.

This complex program, which involves the annual stocking of over 4 million fish, has been developed over a period of three decades. The program is operated in cooperation with agencies in Minnesota, Ontario, Michigan, Illinois, and Indiana, and in cooperation with sport fishers who provide funding through the purchase of fishing licenses and Great Lakes Salmon and Trout Stamps.

The salmon and trout stocking program is part of a larger inter-jurisdictional fisheries management program on the Great Lakes, a program that involves sea lamprey control (funded by the Great Lakes Fishery Commission), a lake trout restoration program (funded and implemented by the USFWS subject to state and tribal oversight), regulation of sport fisheries for other species, including yellow perch, smallmouth bass, walleye, sturgeon, and northern pike, and regulation of commercial fisheries on both lakes. Because state management programs, including the salmon and trout stocking program, affect other jurisdictions, the Department is a signatory to "A Joint Strategic Plan for the Management of Great Lakes Fisheries". That agreement among all state fisheries management agencies, two tribal management organizations and several Canadian and U.S. federal agencies provides a basis for joint management of all shared fisheries resources in the Great Lakes.

Current Stocking Practices. - The Department's stocking program is summarized in the table below. The primary goal of the program is to provide sport-fishing opportunities through a put-grow-and-take stocking program, but other goals are also served. On Lake Michigan the stocking of salmon and trout by four states and the USFWS has dramatically affected the ecosystem of Lake Michigan by reducing the abundance of the alewife, a non-indigenous species that had proliferated and become a major ecological and aesthetic pest by the mid 1960's.

The salmon and trout stocking plan (excluding lake trout and brook trout stocked by the U.S. Fish and Wildlife Service), is summarized here:

Species	Lake	Number stocked
Brook trout	Superior	0

Species	Lake	Number stocked
	Michigan	100,000 -- all yearlings
Brown trout	Superior	100,000 -- all yearlings, Seeforellen strain from feral Lake Michigan brood stock
	Michigan	1,249,000 -- 571,000 fall fingerlings and 240,000 yearlings from domestic brood stock, and 312,000 Seeforellen strain yearlings from feral Lake Michigan brood stock.
Rainbow trout	Superior	0
	Michigan	630,000 -- 170,000 Chambers Creek strain yearlings, 170,000 Ganaraska strain yearlings, 170,000 Skamania strain yearlings, all from feral Lake Michigan brood stock, and 120,000 Arlee and/or Kamloops yearlings.
Lake trout	Superior	89,400 -- all yearlings, from wild Apostle Islands brood stock
	Michigan	0
Splake	Superior	80,000 -- all yearlings from wild AI stock X domestic brood stock
	Michigan	40,000 -- all yearlings from domestic brood stock
Chinook salmon	Superior	0
	Michigan	1,164,000 -- all spring fingerlings from feral Lake Michigan strain brood stock
Coho salmon	Superior	0
	Michigan	500,000 -- all yearlings from feral Lake Michigan brood stock

The Great Lakes fisheries management program benefits from extensive public involvement. For example the Department facilitated extensive public involvement in the development of the Lake Michigan Integrated Fisheries Plan, 2003-2013. In 1998 and 2005 lake-wide reviews of stocking levels for Lake Michigan involved public conferences at Benton Harbor, Michigan, and Kenosha, Wisconsin. Lake-wide conferences of that type have also been held to involve the public in management decisions related to coho salmon and yellow perch. Also, because a significant portion of the cost of obtaining, rearing, and stocking salmon and trout is covered by receipts from the sale of Great Lakes Trout and Salmon Stamps, a biennial report of those expenditures is prepared and circulated for public comment.

This report is limited to fisheries management goals directly served by the Department's stocking program. More complete reviews of the fisheries management programs on Lake Superior and Lake Michigan are provided in the Lake Superior Fisheries Management Plan, 1988-1998 and the Lake Michigan Integrated Fisheries Management Plan, 2003-2013. This discussion of stocking strategies does not include the stocking of lake trout in Lake Michigan or Lake Superior by the US Fish and Wildlife Service for the purpose of restoring naturally reproducing populations. Those programs are overseen by all the management jurisdictions on the lakes and supported by appropriate state and tribal harvest regulations. The Department does not stock lake trout in the Great Lakes except for limited stocking in the Western end of Lake Superior for the purpose of restoring naturally reproducing populations and to enhance the sport fishery.

Specific Great Lakes Trout and Salmon Goals and Strategies. - Because most Great Lakes stocking is intended for Lake Michigan, we have listed below the objectives and problems related to salmon and trout management and production that were identified in Goal II of the Lake Michigan Integrated Fisheries Management Plan 2003-2013. Omitted here is specification of the tactics developed to address those problems.

GOAL II. A diverse multi-species sport fishery within the productive capacity of the lake

This goal expresses our desire for varied sport fishing opportunities in Lake Michigan, but it also acknowledges the dependence of the sport fishery on the productive capacity of the ecosystem. The diverse sport fishery will include brook, brown, rainbow and lake trout, coho and chinook salmon, walleye, smallmouth bass, northern pike, and yellow perch. It will include fishing opportunities in tributaries, from shore and piers, and on the open lake.

Objective A. Sustain a salmon and trout species mix within ecosystem capacity that supports sport harvests within target ranges.

Sport harvest targets are listed below for the six salmon and trout species currently stocked in Lake Michigan. Harvests of salmon and trout during the last ten years were usually within acceptable ranges. The chinook salmon fishery has recovered from the low levels experienced during the early 1990s, and the lake trout harvest has remained within limitations required by the current Lakewide Management Plan for Lake Trout Rehabilitation in Lake Michigan[1]. The ten-year range was used to define targets for the next five years. This mix of six salmon and trout species provides variety in anglers' catch and fishing opportunities throughout the fishing season.

We will continue to sustain this fishery through a stocking program similar to that employed in recent years. The distribution of stocked salmon and trout other than lake trout along the Wisconsin shoreline has been determined primarily in consideration of catch data, previous stocking patterns, and the distribution of fishery access facilities (i.e., ramps, moorings, piers, shoreline, and streams)[2].

Estimated annual sport harvest of salmon and trout from Wisconsin waters of Lake Michigan during 1986 through 2008 and target ranges.

	1986– 2008 harvest average	target range	
		Low	high
brown trout	42,959	25,000	65,000
rainbow trout	70,772	70,000	120,000
chinook salmon	226,891	85,000	190,000
coho salmon	81,314	50,000	140,000
lake trout	52,876	30,000	82,000

Problem 1. The number of lake trout available for stocking in Lake Michigan is limited, and the allocation to Wisconsin waters is subject to negotiation with the other states.

Lake trout stocked into Lake Michigan are produced by the USFWS and stocked according to guidelines specified by the Lake Michigan Committee. Those guidelines are expressed in the Lakewide Management Plan for Lake Trout Rehabilitation in Lake Michigan[21] and other documents. A recent Consent Decree[3] between the federal government, the state of Michigan, and several tribes in the state of Michigan calls for increasing lake trout stocking in waters of northern Lake Michigan. This will require either moving fish from previously stocked locations to this new area or increasing the total

[1] Lake Michigan Technical Committee. 1985. A Lakewide Management Plan for Lake Trout Rehabilitation in Lake Michigan. 12 pp.
[2] Krueger, C.C. and T.R. Dehring. 1986. A procedure to allocate the annual stocking of salmonids in the Wisconsin waters of Lake Michigan. Fish Management Report 127, Bureau of Fish Management, Wisconsin Department of Natural Resources. Madison, WI.

number of fish reared and stocked, and is therefore subject to agreement by the Lake Michigan Committee.

Problem 2. The available forage in Lake Michigan can only support a limited predator population.

The salmon and trout program must recognize the limitations of the ecosystem. When salmon and trout stocking began in Lake Michigan in the 1960s, lake trout had been extirpated and burbot were very scarce. Alewife were abundant and provided plentiful forage for stocked salmon and trout. As the numbers of salmon and trout increased through the 1970s and peaked in the 1980s, forage fish populations changed. Alewife levels declined in the 1980s and remained low but stable during the 1990s. Bloater chubs proliferated and became the most abundant planktivore, but then declined substantially during the 1990s. Diet studies in our waters indicated that salmon and trout continued to feed primarily on alewife and make little use of the bloater chubs as forage populations changed. Concern developed that the high level of stocking was more than the reduced alewife populations could support. The chinook catch declined after 1987, an indication the high sport harvests of the mid-1980s could not be sustained. Bioenergetics models indicate that chinook salmon has a greater impact on alewives than any other species. In 1991 chinook salmon stocking in Wisconsin waters was reduced approximately 25% and the commercial harvest of alewife was prohibited to help stabilize the alewife population. The chinook harvest has gradually increased since then. In 1999 all four states agreed to cut annual chinook stocking by an additional 27% (from 6,000,000 to 4,400,000 fish, lakewide) because of signs of another possible crash of the chinook population. The major concern again was excessive stocking of trout and salmon exceeding the available forage, especially alewives. [Note: Since adoption of the LMIFMP, the states agreed to reduce chinook stocking lakewide by an additional 25%, starting in 2006. Project stocking numbers in this report reflect that reduction.]

Agencies on Lake Michigan have sought to monitor forage fish abundance and to understand how many salmon and trout can be safely stocked without depleting forage species. Since 1973 the abundance of the principal forage species has been assessed annually by biologists with the Great Lakes Science Center (USGS) using bottom trawls. In addition, the Department has recently worked with the USGS and other states to implement a cooperative lakewide forage survey using hydro-acoustics and trawling. Bioenergetics models have been used to estimate the amount of forage fish needed to support stocked salmon and trout and the Lake Michigan Technical Committee is working to identify warning signals of over stocking.

Problem 3. Accurate sport harvest estimates are needed.

Our knowledge of sport harvests is based on creel surveys funded largely from the sale of Great Lakes Salmon and Trout Stamps and on reports submitted by charter captains. Creel surveys provide needed information about numbers of fish harvested, movements of marked fish, growth and fitness of harvested fish, extent of natural reproduction, and angler effort. They can also be used to collect data related to special studies or management questions. Recognizing that states differ in creel survey methods, the Creel Task Group of the Lake Michigan Technical Committee compared creel surveys in the four states and issued recommendations in 1995. The Wisconsin creel survey was considered well designed. All recommendations to improve Wisconsin's survey have been implemented. The Creel Task Group recommended that all states annually provide a standardized set of data to a lakewide creel survey data base. Wisconsin has consistently submitted data to the GLFC for this purpose, but no lakewide synthesis has occurred.

The charter reporting system needs improvement. For example, during 1998, 68 charter boats were

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[3] 1836 Great Lakes Treaty Waters Consent Decree.

contacted at dock by SER fisheries staff. Data collected by DEPARTMENT personnel were used to verify the accuracy of reports submitted by those captains. Despite the fact that the captains were contacted at the dock and informed that they were being scrutinized, four of the 68 trips were not reported and data in 15 of the 64 submitted reports contained errors. During 1998 through 2000, surveys were mailed to 3,308 purchasers of two-day Outlying Waters Sport Fishing licenses in Manitowoc and Kewaunee counties. Four hundred fifty-eight survey responses related to charter trips. Non-reported or inaccurate reports were associated with 240 charter trips (i.e., over 50% of charter trips were found to be inaccurate). As a result of the investigation, citations were issued to approximately 25 captains.

Problem 4. Population dynamics of salmon and trout are not adequately understood.

Over the last decade the agencies responsible for the management of Lake Michigan have tried to improve our collective understanding of the population dynamics of the trout and salmon populations we manage. Working through the Lake Michigan Technical Committee, a Lakewide Assessment Plan (LWAP) has been developed. Through implementation of this plan, specific attempts are being made to improve our understanding of the early life history, growth, diet, mortality, health, and movement of the three main predators in the lake (chinook salmon, lake trout, and burbot). Other studies by various cooperating agencies and universities have been designed and implemented to gather additional information regarding natural reproduction, energetics, and forage demand.

To date, good progress has been made lakewide with regard to the lake trout and burbot portion of the LWAP but the state of Wisconsin has had difficulty implementing their portion of the chinook assessment because of limited sampling capability. Wisconsin has now acquired and retrofitted a used commercial fishing vessel (the Perca) capable of fishing deep gill nets for the open lake assessment of chinook salmon, and will be able to participate in the chinook assessment portion of the LWAP.

Although burbot are naturally reproducing, chinook salmon and lake trout populations in Lake Michigan are currently maintained by stocking. Over the last decade there is increasing evidence to indicate that naturalized reproduction by chinook salmon (especially in tributaries from the state of Michigan) has reached levels that will impact overall forage fish populations in Lake Michigan. The ability to quantify the contribution of naturalized reproduction by chinook salmon that is occurring in Lake Michigan is important to understanding the overall forage demand of the predator population in Lake Michigan.

The Department has been collecting biological information from chinook salmon at the Strawberry Creek spawning weir since the early 1980s. As both the Besadny Anadromous Fisheries Facility on the Kewaunee River and the Root River Steelhead Facility have come on line, biological information has also been collected from these spawning weirs. These data sets have proved invaluable in tracking chinook, coho, and steelhead age of maturity, size at age, and rate of return to the spawning weirs.

Problem 5. Pathogens and early mortality syndrome continue to threaten salmon and trout fisheries. In the late 1980’s, chinook salmon experienced large scale die-offs in Lake Michigan. Although no one factor was responsible for the disease outbreaks, several were implicated; *Renibacterium salmoninarum*, the causative agent of Bacterial Kidney Disease (BKD); *Echinorhynchus salmonis*, a parasite that caused serious intestinal hemorrhaging and anemia; bacterial gill disease; and the absence of visceral body fat. The lack of visceral fat indicated a nutritional stress was present (insufficient forage), which was thought to be the underlying stressor responsible for the conditions mentioned above. Since that time, Department hatchery staff have worked to reduce the prevalence of BKD in fish reared at state hatcheries and fisheries biologists have worked to adjust stocking quotas to reflect the amount of available forage. These efforts have reduced the prevalence of *Renibacterium salmoninarum* in spawning fish to less than 5% compared to 66% in 1988.

In the early 1990's, an early life stage mortality syndrome (EMS) was identified as the cause of seriously high mortality (up to 90% at some hatcheries) in fry of coho salmon, and to a lesser extent in the fry of chinook salmon, steelhead and seeforellen brown trout. Research studies showed that EMS resulted from a thiamine (vitamin B_1) deficiency in the eggs. There is evidence that this deficiency occurs when adult fish consume diets comprised exclusively of alewife. The intestine of alewife contains an enzyme, thiaminase, that breaks down thiamine. Based on these studies, hatchery staff now treat newly fertilized eggs in a thiamine solution which improves fry survival.

Problem 6. Steelhead runs have been erratic. Wisconsin's Lake Michigan steelhead are managed as a feral broodstock. Steelhead stocked in brood rivers (i.e., the Root and Kewaunee Rivers) are marked with a unique fin clip to allow identification to strain, and marked fish that return to the brood rivers are captured for egg collections. This is in contrast to captive broodstock management, where brood fish are maintained in ponds or raceways. Natural reproduction occurs in some Michigan streams, but not in Wisconsin streams, and is an unknown component of the Lake Michigan steelhead fishery. If this natural component is ignored, then lakewide exploitation of steelhead (number harvested divided by number stocked) averaged 15.5% during 1993 through 2000, and exploitation by Wisconsin anglers (number harvested divided by Wisconsin stockings) averaged 18.6%. Research has been conducted at Michigan State University to better understand the contribution of naturally-reproduced fish.

Since 1988, Wisconsin's Lake Michigan steelhead program has been based on a steelhead management plan[4] that established an annual harvest goal of 25,000 to 50,000 steelhead. To achieve this goal the plan recommended the stocking of three strains of steelhead, Skamania, Chambers Creek and Ganaraska, to provide lake fishing opportunities as well as up to ten months of stream fishing opportunities. The harvest goal has been surpassed every year since 1991. In the years 1993 through 1995 the number of steelhead harvested was more than twice the harvest target. This dramatic improvement in the fishery may be credited to a management plan that clearly gave direction to the steelhead program. The strains selected, improved hatchery practices, and other management activities have produced a product that anglers have utilized and once again made steelhead an important component of the Lake Michigan fishery.

Despite the success of the past decade of steelhead management, an updated Management Plan was needed to continue the successes of the past program, and to facilitate additional improvements to the steelhead fishery. The Lake Michigan Steelhead Fisheries Management Plan of 1999[5] called for the continuation of the current stocking program with an annual harvest goal of 75,000 to 100,000 steelhead. The 1999 Plan also addressed five issues that arose from the 1988 Plan. The new plan recommended 1) reallocating some of the Root River's steelhead quota to other southeast Wisconsin steelhead streams to decrease angler crowding on the Root, 2) modifying the mix of strains stocked into streams other than the Root and Kewaunee Rivers while maintaining the total number stocked into each, 3) developing and following a spawning protocol for steelhead that would maximize the genetic fitness of each strain, 4) improving near-shore fishing opportunities by stocking domestic rainbow trout, and 5) evaluating the declining steelhead return to the Besadny Anadromous Fishery Facility on the Kewaunee River.

Many anglers believe that poor steelhead runs in Wisconsin tributaries can be attributed to large

[4] Wisconsin Department of Natural Resources. 1988. Lake Michigan Steelhead Fisheries Management Plan. Bureau of Fisheries Management. Madison, WI. 18 pp.
[5] Wisconsin Department of Natural Resources. 1999. Lake Michigan Steelhead Fisheries Management Plan, 1999. Bureau of Fisheries Management and Habitat Protection Administrative Report No. 44.

harvests by trollers in the open lake. The Department has been reluctant to reduce bag limits for trollers because a) the bag limit would have to be reduced to at most two fish per day to reduce the harvest significantly, b) steelhead move throughout the lake so the harvest by trollers in Wisconsin waters may be largely composed of steelhead stocked elsewhere or produced naturally in Michigan streams, and c) other factors, especially flow rates in tributaries, may be much more important in limiting returns to our streams (see Problem 8, below).

Problem 7. Coho salmon spawning runs have been erratic. Coho salmon have been stocked in Lake Michigan by the Wisconsin Department of Natural Resources since 1968 as spring yearlings (14-16 months old) and as accelerated-growth fall fingerlings (9 months old). From 1996 to 1999, we compared coho salmon stocked as accelerated-growth fall fingerlings (9 months old) with others stocked as post-smolt spring yearlings (15 months old) to evaluate 1) return rates of jacks and adults to spawning weirs and to the sport fishery, 2) growth rates, and 3) cost/benefit ratio for each stocking strategy. Results[6] showed that return rates of adults were higher for fish stocked as yearlings than as fingerlings.

Problem 8. We lack a systematic long-term research program directed at feral brood stock management. A number of factors influence returns to spawning rivers, and hence our ability to sustain fisheries for coho salmon, chinook salmon, steelhead, and brown trout. These include factors within our control, including selection of parents for artificial propagation, age and size of fish stocked, timing of stocking relative to stream variation, location of stocking, numbers of fish stocked of all species in receiving streams, and harvest regulations.

Objective B. Improve and enhance the statewide fish production system for Lake Michigan

The current salmon and trout sport fishery in Lake Michigan, and particularly in Wisconsin's waters, is almost entirely dependent on artificial fish propagation and stocking. Since the stocking of salmon and trout was implemented on a large scale, one new hatchery (Kettle Moraine Springs) and two egg-collection facilities (one on the Kewaunee River and one on the Root River) have been added to the Department's Lake Michigan cold-water propagation system. The Department has also acquired the former USFWS hatchery at Lake Mills, which produces both coolwater fish (walleye, northern pike, smallmouth bass) for inland stocking and, currently, coho salmon for Lake Michigan. The remainder of the substantial increase in the number and pounds of trout and salmon required to meet Lake Michigan stocking quotas has been produced by the existing facilities to the point of overcrowding their rearing capacity, with a subsequent reduction in the quality of the fish produced. These problems have been compounded by increased space needs for the inland feral (wild) trout program, the evaluation of two new strains of rainbow trout for Lake Michigan and reductions in rearing capacity due to facility maintenance needs. Closures of two of the Department's hatcheries (Hayward and Crystal Springs) in the early 1980s because of funding shortfalls have added to the strain of the propagation system.

Problem 1. Production capacity remains inadequate. Most of the Department's cold-water facilities were built during the 1920s and 1930s, and most depend on a "gravity-flow" water supply, either from artesian groundwater or surface water sources. Sporadic development has occurred over the years, but nothing significant for Lake Michigan fish production since the Kettle Moraine Springs State Fish Hatchery (SFH) was renovated in the early 1980s and the lake water pipeline project was completed at the Bayfield SFH in the 1990s. Two of our primary cold-water hatcheries serving Lake Michigan, Nevin and Wild Rose, are seeing continuing erosion of their production capability because of the physical collapse of rearing units, reductions in water flow due to failing artesian wells, and

[6] Eggold, B.T. and W.H. Horns. 2001. A comparison of two methods of rearing and stocking coho salmon in Wisconsin's waters of Lake Michigan. North American Journal of Fisheries Management. 21:147-155.

environmental protection compliance issues.

Even if we had adequate, structurally sound rearing units at all of our hatcheries, waters supply limits the potential expansion of fish production. At all facilities, the available water supply is being fully utilized throughout most of the year. Most of the artesian wells that many of our facilities rely on for their fish rearing water supply do not meet current environmental protection laws. Compliance with these laws will require re-design of the fish rearing water supplies that will likely include abandoning some existing artesian well water supplies and constructing new pumped water supplies. This will mean an increase in maintenance and overhead. The Great Lakes Salmon and Trout Stamp account is not adequate to resolve all facility problems.

Problem 2. Wild Rose State Fish Hatchery is not meeting production goals. To address the concerns relating to production goals, ground water compliance issues and major facility needs at the Wild Rose SFH, a partial EMS (Environmental Management System) was developed for the Wild Rose SFH. The product from the EMS was a detailed, 16 page Scope of Work that was used to guide a conceptual engineering study that will be completed early in 2003. That study will address the ground water compliance issues and the major maintenance needs for the facility. The result of this study will be conceptual level plans for the renovation of the facility along with estimates for the work required. The next step will be the development of a funding package for the Wild Rose renovation. Once funding has been identified, a major capital development project for the renovation of the Wild Rose SFH will be submitted to the Governor and the State Building Commission.

Problem 3. Fish quality is sometimes unacceptable. Fish produced in state facilities may not always meet health or fitness standards, or may be larger or smaller than desired. In part this reflects problems with existing facilities, as described elsewhere, but there is always room for improvement in rearing procedures and strategies. The propagation system is reviewing its practices, procedures and production assignments at all facilities producing fish for stocking in Lake Michigan.

The following table summarizes the best available estimates [as of 2003] of production costs and 1997 harvests for each species in Wisconsin waters of each of the Great Lakes:

Species	Lake	No. stocked[1]	Cost[2]	Harvest[3]
Brook trout	Superior	0	0	6
	Michigan	0	0	13
Brown trout	Superior	85,000	$51,000	1,000
	Michigan	1,000,000	$608,000	23,763
Rainbow trout	Superior	0	0	no estimate
	Michigan	500,000	$180,000	41,552
Lake trout	Superior	89,400	no estimate	20,000
	Michigan	740,000[4]	0	12,763
Splake	Superior	80,000	no estimate	680
	Michigan	40,000	no estimate	no estimate
Chinook salmon	Superior	200,000	$28,000	1,100
	Michigan	1,100,000	$121,000	256,796
Coho salmon	Superior	0	0	4,000
	Michigan	500,000	$378,000	25,453

[1] Stocking numbers vary somewhat from year to year. These numbers approximate annual levels during recent years. [2] These costs are derived by multiplying species-specific production costs derived in 1985 and expanded to allow for inflation to estimate 1998 costs by the stocking numbers shown in the preceding column. [3] Estimated harvests in 1997, rounded to the nearest 1,000, except when below 10,000. These values are based on creel surveys conducted by Department biologists. These surveys are imperfect. In particular, we do not have accurate estimates of the harvest of rainbow trout, brown trout, coho salmon, and chinook salmon that return to spawn in Lake Superior tributaries. The creel surveys also miss much of the very early season brown trout fishery in Lake Michigan. [4] All lake trout stocked in Lake Michigan are stocked by the USFWS.

There are at least three cost/benefit ratios that can be computed to measure the value and effectiveness of this program. One measure of the relationship between costs and benefits is suggested above; it is the ratio of the cost of the program ($1.7 million) to the amount of direct economic activity generated (over $100 million for the Wisconsin portion of Lake Michigan alone, as estimated by COAST). Another cost/benefit ratio is the amount spent on stocking divided by the number of fish harvested. In 1997, approximately 490,000 salmon and trout were captured by anglers, at a cost per fish of a little over $3.47. This figure is somewhat ambiguous, however, because some of the harvest is attributable to naturally-reproduced fish. Also, stocked fish swim throughout each lake, so some fish stocked by Wisconsin are captured in other states and some of the fish captured in Wisconsin waters were stocked elsewhere. Finally, the overall cost of the program, divided by the amount of Great Lakes fishing each year in Wisconsin waters (approximately 3,000,000 hours) yields a cost of about $0.57 per hour. The relative cost-effectiveness of stocking different life stages of the Great Lakes trout and salmon species is still poorly understood. In the future, we need to more directly measure costs and benefits and experiment with stocking different life stages in order to improve overall cost-effectiveness of the program.

Recommended Stocking Guidelines.- No changes are recommended at this time, except that stocking of chinook salmon will be reduced by 15% to accommodate a lake-wide goal of reducing chinook salmon density. This reduction was agreed to by all the states around Lake Michigan in order to reduce the likelihood of a recurrence of bacterial kidney disease, which severely reduced chinook salmon in the 1980's. The Lake Michigan Fisheries Team and the Lake Superior Fisheries Team will review and develop requests for stocking and ensure compliance with interstate agreements and negotiate with the Propagation Coordinator to balance other requests for cold water fish species.

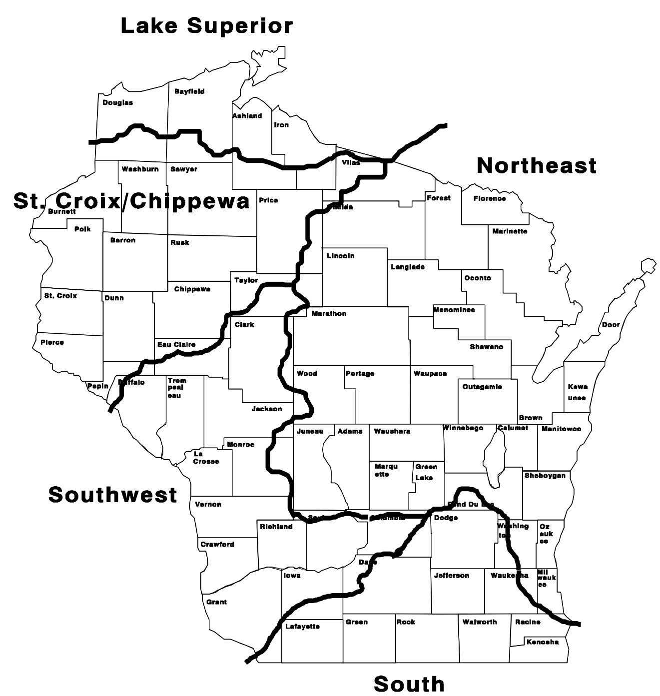
Projected Demand for Great Lakes Trout and Salmon.- We do not anticipate changes to the numbers listed in the above table over the foreseeable future. The chinook quota above does not reflect a 15% reduction that we expect to implement. This 15% reduction will be revisited annually.

Inland Trout Stocking Guidelines

Background. **–** The inland trout stocking program consists of stocking brook trout, brown trout, rainbow trout, lake trout, and splake. This program serves a number of purposes such as providing immediate fisheries, improving existing fisheries, and restoring fisheries in waters with improved habitat. The program has a long history and is well supported by the angling public. Waters stocked, species stocked, and numbers stocked are based on the local manager's request using stocking guidelines in the Fish Management Handbook, results of surveys, results of historical stocking practices, and public input.

Over the past decade, inland stocking requests for brook, brown, and rainbow trout have remained fairly stable, with total numbers ranging from 1.4 to 1.7 million. Requests were reduced by 25% in 1995-97 because of budget shortfalls. In 1994 we began experimenting with stocking trout derived from wild parents in order to improve the survival of stocked fish and create better long-term fisheries. The results of this program have been encouraging and we continue to receive requests for additional wild trout. Increased production of wild fish has been limited by hatchery space limitations, fish health concerns, and the need for a comprehensive review of trout stocking guidelines. Meeting the future demand for wild fish will be a major challenge to our current hatchery system.

***Stock Integrity*. –** Recent concerns have arisen about the effects of our past stocking practices on the genetic integrity of our native stocks. The Illinois Natural History Survey was contracted to do a genetic analysis of brook trout and brown trout. The results of the brook trout report suggest genetic management zones for conservation of genetic diversity of brook trout (Fields and Philipp 1998). We therefore recommend that transfers of wild brook trout take place from within the same watershed, where possible, or, at a minimum, take place within the basins delineated on the adjacent map.



Genetic analysis of brown trout proved difficult and is generally recognized to be of less importance than brook trout because brown trout were introduced from Europe in the late 19th century. However, stocked wild brown trout have survived better than domestic brown trout in paired stockings. Local strains of brown trout have also has also faired better than non-local strains in northeast Wisconsin. Because of the importance of source brood-stock and different rearing techniques we recommend that state hatcheries rather than private hatcheries rear wild trout.

Specific Management Goals and Objectives for the Inland Trout Fishery:

I. Protect, restore, and enhance habitat and water quality

II. Emphasize wild, naturally-reproducing trout populations

III. Provide diverse angling opportunities

IV. Use the best scientific management possible, based on population and habitat monitoring and utilizing the principles of ecosystem management

V. Have the support of an informed, educated, and involved public

Cost effectiveness of inland trout stocking.- The most recent cost information we have for trout propagation is from LAB (1997). Costs vary be type and size of trout, but are not available for wild trout or for spring fingerlings, which make up a large part of the wild trout needs. Costs include only operational costs and not capital costs such as buildings and maintenance. Costs for wild trout have been estimated to be at least twice as much as domestic trout because they can only be raised at half the density. Additional costs of wild trout are for collecting and transporting brood stock, doing fish health assessments, and buying automatic feeders. Some costs may be less, such as those related to manual feeding and maintaining a captive brood stock.

Cost effectiveness needs to be considered in terms of the type of fishery desired. In a pure put-and-take fishery, such as the urban trout ponds, legal trout are necessary to provide an immediate consumptive fishery. Historical information shows that the fish should be legal size and stocked as close as possible to the open season to maximize returns. In this type of fishery, return to the creel can be used as a direct measure of effectiveness. A recent study by Loomis and Fix (1998) in Colorado showed that if all the costs are included for put-and-take fisheries, the costs outweigh the benefits.

In put-grow-and-take fisheries, longer-term survival becomes more important than immediate return to the creel. In these fisheries, survival to a certain size or age may be a better measure of effectiveness. If survival is high, smaller fish that are cheaper to raise can be stocked in these waters. On a pure cost basis, using the 1996 cost figures, fingerlings would be more cost effective than yearlings if over-winter survival is greater than 24% for brook trout, 45% for brown and 39% for rainbow trout. This assumes that growth is similar in the hatchery and the wild, and that yearling size fish are the management goal. Although no comprehensive summary of trout survival rates is available in Wisconsin, rates over 35% would be considered high, which suggests that stocking yearlings will be more cost-effective.

Recent unpublished DNR surveys show that wild fish survive better than domestic fish in high-quality class 2 streams. Even though wild fish may be more expensive to rear than domestic fish their improved survival may make up for it. Also, wild fish may survive better at smaller sizes, so that cheaper spring fingerlings can be used. If captive brood stocks were not necessary for wild fish this would also reduce their total cost. If stocking wild fish creates self-sustaining fisheries, the long-term costs are much reduced. More studies on cost and measures of effectiveness need to be done for wild fish. Some benefits of wild fish to anglers, such as appearance, fighting ability, species preferences, and wildness are very difficult to quantify.

Recommended Stocking Guidelines. - The following stocking objectives (in priority order) are used to address goals II, III, and V:

1. Restoration or rehabilitation. Restoration applies when a water is returned to the ecological state present before degradation. Wild fish transfers are recommended over stocking hatchery fish and native brook trout should be given priority over exotic species where possible. Rehabilitation applies to an altered ecosystem that cannot be restored but can be managed in its altered state. Both restoration and rehabilitation should have a time limit of three years of stocking unless exceptions are documented.

2. Experimental management evaluations. These are active projects with approved experimental designs that are being assessed by research or management. They may have specific requests for type of fish or strain, and should have a time limit to the evaluation and stocking request.

3. Special management with demonstrated results. These are special cases that have demonstrated exceptional or unique results as measured by creel surveys, angler use surveys, exceptional growth or carry-over, or a unique fishery for that area.

4. Put, grow, and take. Put-grow-and-take fish realize significant growth before harvest. These waters are class II streams and lakes/spring ponds capable of overwintering fish on the basis of habitat. Fish stocked in this priority should be spring or fall fingerlings, unless justified in writing. Lakes or streams could be higher priority in this category based on management goals and past results; individual waters differ greatly so it is difficult to generalize.

5. Put and take. Put-and-take fish are harvested soon after stocking and have limited survival (<10% by number) the first year because of harvest or poor habitat. They will be yearlings or legal-size fish. Lakes are higher priority than streams because they generally have better return and higher use. Put-and-take waters that are regionally important or provide exceptional returns can be priority 3 if results are documented.

Projected Demand for Inland Trout – The Trout Team met and decided that domestic trout should be phased out in class 2 streams and replaced with wild fish. This reflects the widespread success of the wild trout program. Because wild fish can only be raised at half the density of domestic fish, this will result in a reduction in demand of about 150,000 trout. The Trout Team also recommended that rainbow trout be the main species stocked in put-and-take trout lakes. This may reduce the size of some domestic brood stocks. The urban fishing team requested an increase in rainbow trout yearlings of 17,500. The results of all the recommended changes are shown in the following table.

Comparison of projected stocking goals for 1999 and 2010 for inland trout stocking by species and size.

Fish Species (size)	Size	Stock/strain	Statewide Annual Stocking Goal (1999)	Statewide Annual Stocking Goal (2010)
Brook Trout	Spring fingerlings	Domestic	0	20,280
Brook Trout	Fall fingerlings	Domestic	15,700	30,250
Brook Trout	Yearlings	Domestic	78,400	1,270
Brook Trout	Spring fingerlings	Wild (NE, NW, SW strains)	106,550	41,730
Brook Trout	Fall fingerlings	Wild (NE, NW, SW strains)	70,050	89,610
Brook Trout	Yearlings	Wild (NE, NW, SW strains)	91,750	58,330
Brown Trout	Spring fingerlings	Domestic	0	3,100
Brown Trout	Fall fingerlings	Domestic	91,300	144,800
Brown Trout	Yearlings	Domestic	161,900	21,580
Brown Trout	Spring fingerlings	Timber Coulee	272,030	432,460
Brown Trout	Fall fingerlings	Timber Coulee	391,810	191,220
Brown Trout	Yearlings	Timber Coulee	6,700	86,290
Rainbow Trout	Spring fingerlings	Domestic	19,200	17,100
Rainbow Trout	Fall fingerlings	Domestic	48,750	49,300
Rainbow Trout	Yearlings	Domestic	148,750	338,700
Lake Trout	Fall fingerlings	Unspecified	20,000	27,000
Lake Trout	Yearlings	Unspecified	25,000	0
Lake Trout	Fall fingerlings	Trout Lake	100,000	0
Splake	Yearlings	Unspecified	4,000	0
		Total	1,651,890	1,553,020

COOL WATER SPECIES

Black Bass Stocking Guidelines

Background. - By the turn of the 20th century, serious habitat loss and declining water quality prompted concerns for Wisconsin's fisheries. In 1903, a hatchery was established at Minocqua to produce bass for stocking. Klingbiel (1981), described the history of stocking in Wisconsin's bass management program from 1900 to 1980: Bass stocking increased steadily until about 1940, when there were 8 state-operated bass hatcheries stocking between 1.5 and 2.5 million fry and fingerling bass each year. Maintenance stocking was widespread throughout the state and was popular with anglers. During the 1950s, results from numerous research projects showed that maintenance stocking contributed little and that natural reproduction in most waters was adequate to reach carrying capacity. As a result, stocking of bass was drastically reduced and bass production in state facilities was virtually eliminated. Almost all stocked bass then came from federal hatcheries. By the late 1960s and early 1970s, many lake reclamation projects were carried out and state facilities were again geared-up to produce bass for chemically reclaimed waters. Production during this period (about 1960 to 1980) averaged about 850,000 fry and fingerling bass annually, with almost half originating from federal hatcheries. Most bass were stocked in chemically reclaimed waters, waters experiencing winter-kills, or waters subject to some infrequent mortality events.

Stocking of bass fry or small fingerlings in waters with established populations is generally regarded as ineffective or unnecessary (Newburg 1975). However, bass have been the major beneficiary in about 65% of the more than 400 chemically treated waters prior to 1981. Many of these waters have developed outstanding, self-sustained fisheries. Stocking small bass in waters devoid of fish or where they have been significantly reduced is often an effective management practice to restore or develop a fishery.

Stocking is a minor component of the bass management program in Wisconsin. During the 1980s and 1990s an average of about 500,000 fry and fingerlings were stocked annually (374,629 to 622,416), with about 3,400 yearling and adult stock transfers each year. Most stocking is used to re-establish severely depressed (intentionally or naturally) populations. Stocking generally occurs on lakes that have had a winter-kill or have been rehabilitated using chemical fish toxicants.

Summary of Current Stocking Practices. - Department staff have historically stocked both largemouth bass and smallmouth in the waters of Wisconsin. The primary demand for black bass has been for winter kill situations or where a waterbody has undergone rehabilitation. In either case, the preferred age class is either adults or large fingerlings. At present, field transfers of adults have been deferred due to disease testing constraints. However, this size is still desirable in most situations, if disease testing requirements can be met. No stocking is recommended for the purposes of recreation or maintenance.

The tables below summarize the black bass stocking events over the past 5 years. Department hatcheries did not produce any black bass from 2005 to present, so all stocked black bass for these years were from private hatcheries.

Table 1. Historic quota requests and stocking events from 2003-2008 for largemouth bass small fingerlings.

Region		Year 2003	2004
NER	Requested		2250
	Stocked		12976
NOR	Requested	7950	17750
	Stocked	31011	20548
SCR	Requested		1175
	Stocked		1000
Total Requested		7950	21175
Total Stocked		31011	34524

Table 2. Historic quota requests and stocking events from 2003-2008 for largemouth bass large fingerlings.

				Year		
Region		2004	2005	2006	2007	2008
NOR	Requested	11575				
	Stocked	500				
SCR	Requested			175	2500	10000
	Stocked			1050	3700	2587
WCR	Requested		28775	28775		
	Stocked		100	900		
Total Requested		11575	28775	28950	2500	10000
Sum Stocked		500	100	1950	3700	2587

Table 3. Historic quota requests and stocking events from 2003-2008 for largemouth bass adult field transfers.

			Year	
Region		2004	2005	2006
NOR	Requested			1440
	Stocked			399
SCR	Requested	70	70	1570
	Stocked	78	134	15
WCR	Requested		110	
	Stocked		141	
Total Requested		70	180	3010
Total Stocked		78	275	414

Table 4. Historic quota requests and stocking events from 2003-2008 for smallmouth bass small fingerlings.

		Year	
Region		2007	2008
SCR	Requested	2667	3917
	Stocked	4400	4800
Total Requested		2667	3917
Total Stocked		4400	4800

Table 5. Historic quota requests and stocking events from 2003-2008 for smallmouth bass large fingerlings.

		Year			
Region	Data	2003	2004	2005	2006
SCR	Requested			550	5000
	Stocked			400	3376
SER	Requested	72825	42050		
	Stocked	4950	15440		
Total Requested		72825	42050	550	5000
Total Stocked		4950	15440	400	3376

There were no smallmouth bass adult field transfer requests or stocking events between 2003 and 2008.

Specific Management Goals and Objectives. – The Bass Committee developed the following specific management goals and objectives:

I. Protect, restore and enhance fisheries habitat on Wisconsin waters.

A. Locate, document and protect existing functional littoral and riparian habitat.
B. Insure that fishery concerns are incorporated into habitat alteration decisions.
C. Review and develop educational material on the value of aquatic habitats.
D. Ensure that effective, cost-efficient habitat protection, restoration and enhancement procedures are documented and used consistently throughout the state.
E. Improve enforcement of existing habitat protection regulations.

II. Protect and maintain Wisconsin's self-sustained fisheries, fish assemblages and aquatic communities.

A. Maintain and enhance existing self-sustained bass populations.
B. Rehabilitate formerly self-sustained bass populations.
C. Maintain the genetic integrity of self-sustained bass populations.
D. Review available information on the impacts and interactions of bass with other species.

III. Provide a variety of quality fishing opportunities (e.g., trophy, action, harvest) within a flexible management system.

A. Provide Fisheries Biologists with more flexibility to manage for a variety of bass fishing opportunities through a specified set of management options with established criteria.
B. Increase opportunities to catch "big" bass.
C. Endorse the concept of increasing the Department's flexibility in establishing conditions for the issuance of fishing tournament permits.
D. Endorse the development of a waters classification system for fisheries management.

IV. Ensure that sound, up-to-date technical information is available for Wisconsin's fisheries.

A. Develop cooperative efforts with external partners to obtain information on fisheries.
B. Develop a statewide strategy to ensure sufficient data are available for bass fisheries.

V. Communicate with Wisconsin anglers and promote the recreational value of Wisconsin's fisheries.

A. Increase awareness of the importance of bass to aquatic systems.
B. Increase awareness of the importance of quality bass fisheries to Wisconsin's economy.
C. Educate anglers on the differences between largemouth and smallmouth bass.

Costs and cost-effectiveness of bass stocking. - The cost to produce and stock black bass fingerlings is about $0.07 per fingerling (WDNR unpublished data); production costs vary from year to year. Due to the unique life history of black bass, stocking of fry is not recommended. Male bass guard their nests and, after the fry hatch, continue to guard fry schools until they break up (generally by about July). When bass are needed for rehabilitation stocking, either fingerlings or adult transfers are suitable choices. While we do not currently have specific estimates for survival of stocked bass and subsequent cost-effectiveness, we know that many bass populations have been successfully reestablished through stocking in reclaimed lakes throughout the state. Reestablishment of a self-sustaining population is an extremely cost-effective practice because it results in a population that is not dependent upon further stocking. Subsequent recruits to the fishery are free and, when cost-averaged, the initial stocking becomes more and more cost-effective through time as benefits continue to accrue from a relatively small one-time investment.

Currently, we have very little flexibility in our propagation program to produce the numerous strains of bass needed to protect the genetic integrity of native bass stocks. Any attempt to increase the stocking of bass without compromising their genetic integrity will be considerably more expensive than the current $0.07 / fingerling, which will affect the cost-effectiveness.

Recommended Stocking Guidelines. - The following stocking strategies, summarized in Appendix Table A, are recommended in order to achieve the black bass management goals for Wisconsin (listed in priority order).

1. Rehabilitation: Waters – Winter-kill lakes should not be stocked with bass if serious mortality occurs more frequently than 2 times in 10 years unless a plan to minimize the risk of future winter-kills is developed and implemented.

Size of Fish – Either large fingerlings (2"+) or adult transfers.
Source of fish – Same waterbody, if possible, (fingerlings), otherwise basin stock.
Stocking rate – Large fingerlings - up to 25/acre. Adults - up to 5/acre. If production is unable to meet all quota requests, a maximum of 25,000/water will be stocked.
Frequency – Three consecutive years.
Evaluation - If natural reproduction is not reestablished after 6 years from the onset of stocking, discontinue stocking until action is taken to identify and correct the reason(s) for the poor natural recruitment.

2. Evaluation: Very little need exists to conduct evaluations of bass stocking; we do not recommend development of projects or requests for evaluation quotas.

3. Remediation or Recreation: We do not recommend development or maintenance of bass fisheries dependent upon stocking due to the expense, the ubiquitous nature of bass, and availability of populations throughout the state. Other management activities should be pursued to enhance natural reproduction. Further, remediation stocking should not be conducted where the potential exists to

impact the genetic integrity of existing self-sustained bass populations.

Projected Demand for Black Bass. - Based on historic stocking occurrences, it appears the primary need for largemouth bass is approximately 30,000 small fingerlings and 30,000 large fingerings; for smallmouth bass, approximately 50,000 large fingerlings. However, since no black bass have been produced by the hatchery system since 2004, future stocking requests provide a more accurate estimate of the largemouth and smallmouth bass desired by field staff, if provided the opportunity.

The tables below represent quota requests for 2009-2011 for largemouth bass and smallmouth bass.

Table 6. Future quota requests for largemouth bass.

	2009-2010			2010-2011		
	Rehabilitation	Recreation	Total	Rehabilitation	Recreation	Total
Adult (Field Transfer)	400		400	2850		2850
Fry	529000		529000	796000		796000
Large Fingerling	49266	9597	58863	68100	18475	86575
Small Fingerling	28289		28289			
Yearling	1058	351	1409			

Table 7. Future quota requests for smallmouth bass fingerlings.

	2009-2010			2010-2011		
	Rehabilitation	Recreation	Total	Rehabilitation	Recreation	Total
Large Fingerling	36231	20720	56951	8175	57690	65865
Small Fingerling	8667		8667	2667		2667

Quota requests in Tables 6 and 7 include those for the purpose of "recreation". Because the Bass Standing Team does not recommend black bass stocking for the purpose of recreation, the estimated need maybe be somewhat lower than reflected in the future quota requests. Based on future quota requests for "rehabilitation", the estimated demand for largemouth bass is approximately 75,000 large fingerlings and the estimated demand for smallmouth bass is 40,000 large fingerlings. We suggest that these two estimates be used for planning purposes.

These estimates are substantially lower than the demand for largemouth bass fingerlings (150,000 to 200,000) and substantially higher than the demand for smallmouth bass fingerlings (none) predicted in the 1999 document titled "Evaluation of Stocking Strategies in Wisconsin, With an Analysis of Projected Stocking Needs**".**

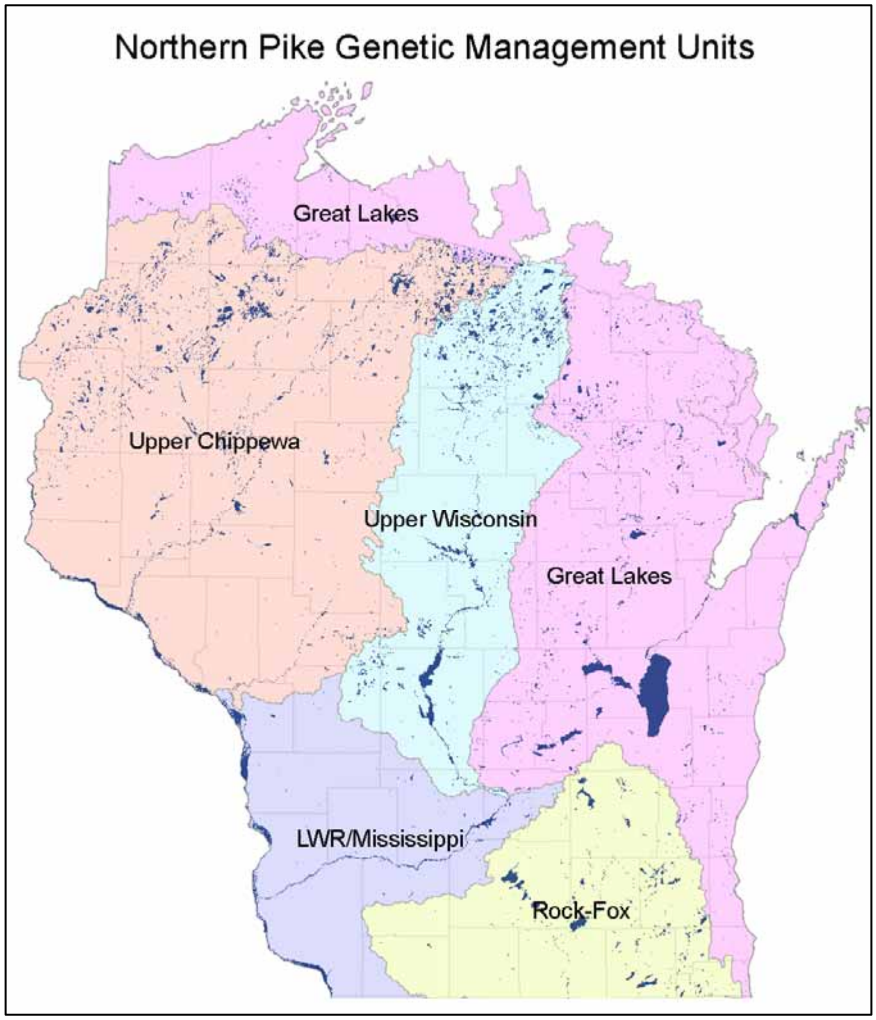
Historically, there was little consideration given to genetic management units for bass species. However, some genetic stock management would be prudent. Therefore, in the absence of specific bass management units, we recommend following the genetic management units for northern pike and suggest production requests may be similar to those outlined in Table 8, if logistically feasible.

Table 8. Projected stocking needs, by strain.

Species	Size	Strain	Number
Largemouth Bass	Large Fingerling	Upper Wisconsin	18,750
Largemouth Bass	Large Fingerling	Lake Michigan	18,750
Largemouth Bass	Large Fingerling	Rock/Fox	18,750
Largemouth Bass	Large Fingerling	Lower Wi/Mississippi	18,750
Smallmouth Bass	Large Fingerling	Rock/Fox	40,000

Also note that there is substantial demand for largemouth bass fry and adult field transfers. While these sizes are currently unavailable due to disease testing constraints, there is a clear demand for them if these testing obstacles can be overcome.

The committee recommends focusing on ways to facilitate the field transfer of adults (from within major stock boundaries) in order to rehabilitate self-sustained populations, rather than trying to retool the hatchery system to produce fry or fingerlings.



Lake Sturgeon Stocking Guidelines

Background.- Lake sturgeon propagation began only recently (late 70's) in Wisconsin and was pioneered by the hatchery staff at the Wild Rose Hatchery. The propagation of lake sturgeon from the Winnebago system in the form of eggs, fry, and fingerlings has contributed to lake sturgeon management and restoration programs throughout the Great Lakes states. Eggs, fry, and fingerlings have also been instrumental in bioenergetics, virology and cell culture, aquaculture, development and chemical registration projects.

Sturgeon stocking in Wisconsin waters is a relatively recent activity. Lake sturgeon were stocked in the Menominee River and the waters of Lake Superior in the early 80's. Since that time, there have been additional stockings in the Wisconsin, Flambeau, Namekagon, Chippewa, and Wolf rivers. *Appendix Table A* describes the current stocking guidelines for lake sturgeon. These stockings have all been conducted for restoration purposes under these assumptions: 1) The lake or stream is considered part of the original range; 2) No sturgeon exist there now or reproduction is absent or drastically reduced; and 3) There is a reasonable chance of developing a self-sustained population.

Specific Management Goals for Lake Sturgeon. - Wisconsin fisheries biologists manage lake sturgeon to:

I. Preserve and enhance existing naturally reproducing populations.

II. Re-establish populations in waters within their original range.

III. Develop harvestable surpluses through natural reproduction.

IV. Provide angling opportunities to harvest the surpluses.

V. Cooperate with other states to re-establish lake sturgeon populations in appropriate waters.

Cost-Effectiveness of Lake Sturgeon Stocking In 1998, approximately 64,000* lake sturgeon were propagated at the Wild Rose Hatchery. Propagation costs (e.g, obtaining and spawning wild stock, egg incubation and hatching, rearing and feeding), stocking costs, and administrative overhead totaled $26,500 ($15,000 donated by Sturgeons for Tomorrow, a private conservation organization). Rearing costs per thousand fish were estimated at $414 or $0.41 per fish. This estimate represents the propagation, rearing, and stocking of fish into the Menominee, Wisconsin, Flambeau, and St. Louis rivers, and propagation and rearing only from the Wolf River.

Because of the recent interest in sturgeon stocking and the lack of information on its effectiveness, biologists are incorporating stocking evaluation methodologies into their sturgeon work. For example, we currently have a cooperative project with the states of Michigan and Minnesota on stocking sturgeon obtained from the Sturgeon River in Michigan (a Lake Superior source) into the St. Louis River. All the sturgeon that are stocked in the project area receive a double micro tag. We anticipate expanding this micro-tagging statewide as we begin to evaluate our sturgeon stocking program. We also have ongoing a small study to look at tagging procedures and tag retention for fingerling sturgeon at the Wild Rose hatchery. We will be tagging the fish and holding them at the hatchery to provide some insight on the effectiveness of the tagging procedures.

Recommended Stocking Guidelines. **-** Lake sturgeon are stocked for rehabilitation purposes only, preferably using brood stock from within the same basin. Inter-basin transfer of fingerlings or other life stages is strongly discouraged, and should only occur after discussion and consensus by the Sturgeon Team and the Fish Management Board.

Stocking procedures, rates and frequencies. - Stocking procedures include scatter planting fingerlings, after acclimation, over fine sand, course gravel, or boulders. Planting in and around vegetation is discouraged. The biological characteristics of lake sturgeon (slow growing, late maturing), dictate that stocking should occur annually for 50 years to reach stable adult densities capable of natural reproduction. Males begin maturing at age 14 and are 100% mature at age 29, females begin to mature at age 21 with 100% mature at age 34. Considering the extended duration of stocking required, the following rates are recommended (see also *Appendix Table A*): large fingerling and yearling stocking (large 6"+ fall fingerlings at 80 /mile or 0.5/acre; Yearling >6" at 40/mile or 0.25/acre) or adult transfers (50 minimum). All stocked sturgeon should be PIT tagged.

Projected Demand for Lake Sturgeon. **–** From 1999-2010, lake sturgeon quotas exceeded 50,000. Quota requests may increase over the next few years as additional restoration opportunities arise and interest in improving fish passage at dams increases. The projected annual demand will range from 50,000-75,000 sturgeon. The sturgeon propagation program at Wild Rose is funded in large part by Sturgeons for Tomorrow, a private conservation organization. The Department is meeting the current quotas for all lake sturgeon restoration projects and will likely be able to meet the projected demand.

Summary of statewide stocking goals for existing and proposed lake sturgeon rehabilitation projects.

Source	Stock	Size Class	Receiving Water	Total
Hatchery	Couderay R	Fingerling	Couderay R	1500
	Manitowish R	Fingerling	Manitowish R	3500
	Menominee R	Fingerling	Menominee R	5000
	Menominee R	Yearling	Menominee R	1300
	Upper Namekagon R	Fingerling	U Namekagon	1600
	Upper St. Croix R	Fingerling	U St. Croix	2000
	Wisconsin R	Fingerling	Baraboo R	1000
	Wisconsin R	Fingerling	Wisconsin R	30000
	Wisconsin R	Yearling	Wisconsin R	600
			Hatchery Total	46500
Streamside	Winnebago	Fingerling	Kewaunee R	1500
	Winnebago	Fingerling	Milwaukee R	1500
	Winnebago	Fingerling	Sheboygan R	1500
			Streamside Total	4500
Water Inst.	Winnebago	Yearling	Upper Fox R	500
			Grand Total	51500

Muskellunge Stocking Guidelines

Background (based on Oehmcke 1969).- Little was known about the abundance of muskellunge in Wisconsin at the turn of the 20th century; at this time, native muskellunge were apparently confined to lakes and streams at the headwaters of the Chippewa, Flambeau, Black and Wisconsin Rivers. About 20 counties were believed to contain muskellunge. The artificial propagation of muskellunge in Wisconsin was initiated in 1899 at Woodruff. For over 25 years, little effort was directed toward rearing muskellunge beyond the sac fry stage. Up until about 1941, 18 seasonal hatcheries in northern Wisconsin produced from several thousand to 28 million fry annually. Nearly all muskellunge were stocked shortly after hatching from eggs incubated in jars. The rearing of muskellunge to fingerling size in ponds was attempted sporadically from 1926 to 1938 with little success.

A decline in muskellunge populations was observed concurrent with the growth of sport fishing activity following World War II. Although the exploitation of muskellunge populations by anglers was not documented, it was generally believed that the annual harvest exceeded recruitment to populations through natural reproduction. From 1940 to 1970, improvements in the propagation program helped contribute to the recovery and maintenance of fishable muskellunge populations. Systematic procedures for pond rearing of fingerlings were developed in the 1940's and the two major muskellunge hatcheries went into full production by about 1950. The shift to raising larger fingerlings (8 to 15 inches) occurred in 1954, when 2 to 6 inch fingerlings were cropped off and remaining fish were reared to a larger size and stocked by October.

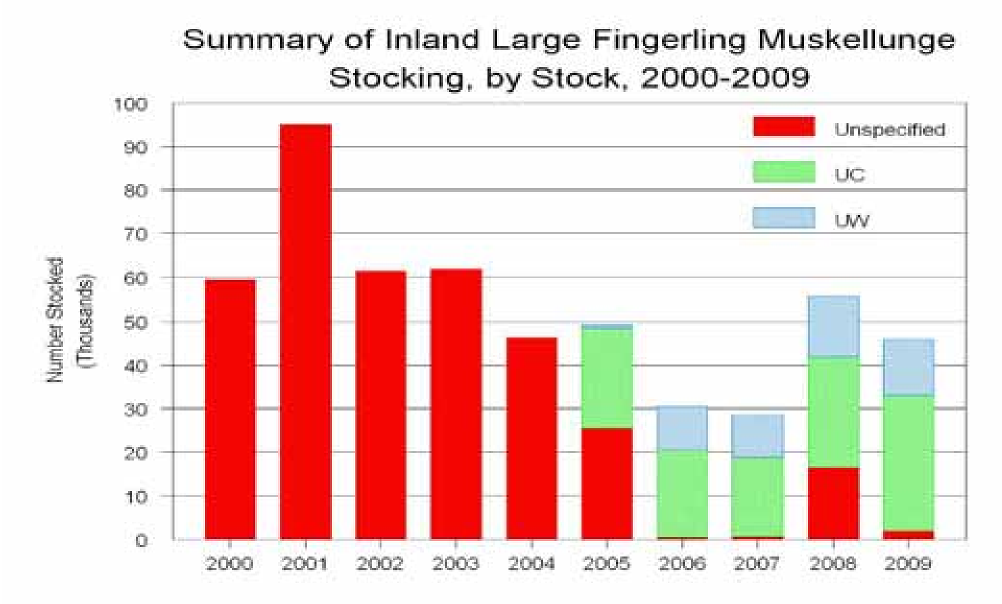
By 1970, about 30% of the muskellunge waters were stocked annually with large fingerlings. Refinements in stocking procedures resulted in targeted plantings in critical problem waters. These specialized stocking situations included waters faced with heavy depletion by angling, excessive competition with northern pike, loss of spawning areas, natural catastrophes, and stocking waters that had been reclaimed with toxicants. When actual catch from a given lake is known, a fingerling stocking of twice the annual harvest was recommended. Otherwise, a standard rate of 2 fingerlings per acre was used. A certain amount of stocking at this rate was conducted to assure adequate spawning stock in prime waters and to remediate for the loss of spawning habitat. By 1970, the species inhabited about 33 counties in all geographic areas except the extreme southwest. This expanded range was primarily a result of stocking.

Current stocking practices

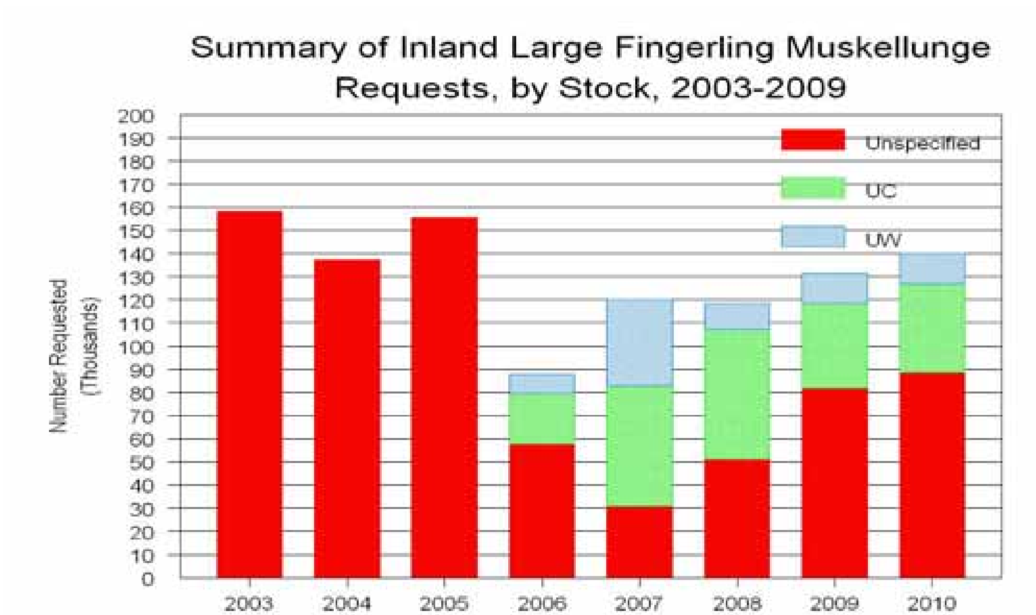
Inland Muskellunge

At present, approximately 178 waters (22% of Wisconsin's 804 muskellunge waters) are regularly stocked with muskellunge to maintain the fishery, down from 216 (27%) in 1999. From 2000 to 2009, an average of 53,326 large fingerlings were stocked annually in inland waters, compared to an average of about 72,000 from 1995-1999, following major renovations of the two primary muskellunge hatcheries. From 1970 t0 1999, an average of 128,747 muskellunge were stocked annually.

This figure shows production of muskellunge over the last decade. The completion of a brood stock management plan in 2005 resulted in the development of 2 inland stocks, aligned by watershed boundaries – the Upper Chippewa Basin (UC) and the Upper Wisconsin River Basin (UW). This initially impacted production due to minor difficulties, e.g., identifying new brood source waters, etc.



Actual requests for inland, large fingerling muskellunge from 2003 to 2010 averaged 131,228 (projected demand in 1999 was 138,000), whereas requests for muskellunge from 1995 to 1999 averaged about 141,000 annually. Requests from 1983 to 1993 averaged about 157,000. A low level demand for yearling muskellunge of about 350-400 fish has existed through recent years (not shown).



The demand for muskellunge (about 140,000 large fingerling/year) has not been met for many years. This demand is a measure of the “biological quotas” (quotas submitted without regard for limitations in production capabilities) and were not necessarily expected to be met. The demand is “tiered” to ensure that all requested waters get some fish, rather than a few large waters getting all the fish. We are closer to meeting tier I stocking levels (about 90,000 fish/year), but still typically fall short of that goal. Substantial changes in brood stock management guidelines in 2005 have undoubtedly impacted production.

The increased demand for muskellunge in recent years can largely be attributed to higher requests of "unspecified" fingerlings (outside the native range). Demand for fingerlings within the native range has remained stable and may even decline through time.

Current inland stocking practices are listed in Appendix A. Existing stocking practices under the Remediation and Recreation strategies, by far the most common strategies, are presented in the following table, along with the number of waters within each stocking strategy.

Muskellunge stocking framework for large fingerlings under the Remediation and Recreation strategies (priority 3). Note: 6 waters under the Rehabilitation and Research strategies are not included. Stocking was terminated in 28 randomly selected remediation waters (*), beginning in 2001. These waters are not included in the totals.

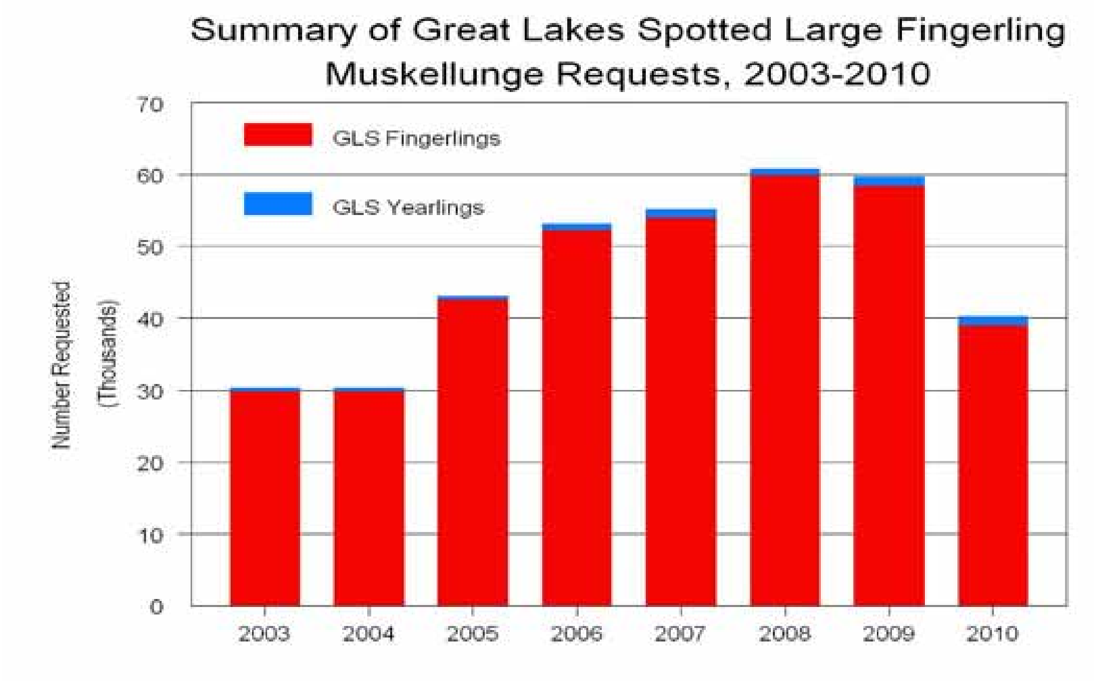
	Nominal stocking rate (number/acre)				
Strategy	0	0.5	1	2	Total
Remediation	28*	45	37	9	91
Recreation	0	28	35	18	81
Total	0*	73	72	27	172

In order to obtain the information needed to sufficiently evaluate our stocking practices, we established a management framework to allow a comprehensive evaluation of our stocking practices. We assigned each of the 220 stocked muskellunge waters to a specific stocking practice for 10 years. We are currently assessing these fisheries through existing survey efforts. This will allow us to evaluate the effectiveness of various rates (number of muskellunge per acre) and frequencies (annual, alternate years, etc.) for large fingerling stocking events in a variety of waters. This evaluation was initiated in 2001 and is scheduled to be completed by 2013. We are in the process of scheduling surveys of these populations over the next couple of years.

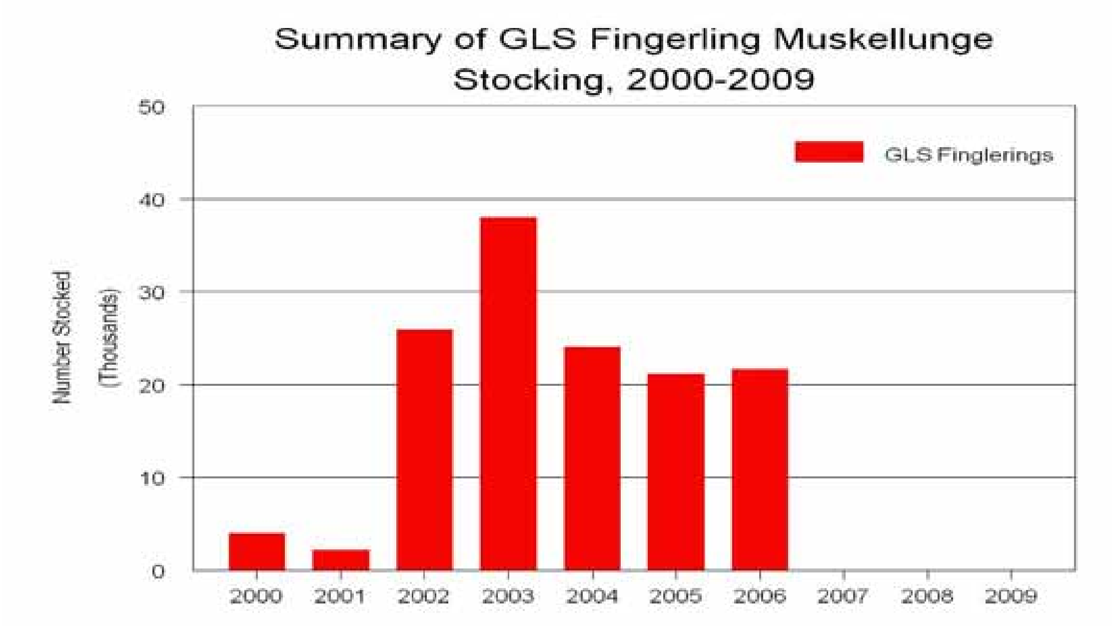
This approach was designed to: 1) allow long term, consistent application of experimental treatments, 2) provide a long-term production target for the hatchery system, 3) aid the hatchery system in development of basin-specific stocks, and 4) greatly reduce annual workload related to quota requests. Also, this framework has remained somewhat flexible so that biologists could respond to interim changes in populations with timely changes in management strategies. Serious concerns were reviewed annually and addressed prior to the spawning period.

Great Lakes Spotted Muskellunge

In 1999, we did not include the projected stocking needs for Great Lakes spotted (GLS) muskellunge. Actual requests for large fingerling GLS muskellunge from 2003 to 2010 averaged 45,816. Demand for yearling GLS muskellunge has increased from 350 in 2003 to 1,200 in 2010. An evaluation by Kapuscinski et al. (2007), found that yearlings stocked in Green Bay contributed to the adult population at a higher rate than fingerlings, suggesting higher survival and cost effectiveness.



The demand has tailed off the last couple years because these fish were not available from the hatcheries (since 2007) due to concerns over using VHS-positive waters as an egg source.



However, in the future, these concerns should be addressed by 1) approved egg disinfection; and 2) developing inland sources of brood stock. Therefore demand is expected to remain at levels consistent with the last year of production in our hatcheries (60,000 fish). Further, the Musky Team had previously recommended that all inland quotas within the Lakes Michigan and Superior basin also be stocked with GLS muskellunge. This would amount to about 5,000 additional GLS fish being produced and an equal number of an inland stock that would no longer be produced. So, overall demand for GLS muskellunge over the longer term is expect to be 65,000 fish annually.

Specific Muskellunge Management Goals and Objectives.-

I. Protect and enhance Wisconsin's naturally reproducing (category 1) populations.

A. Identify Wisconsin's self-sustained muskellunge populations.
B. Identify and protect existing spawning and nursery habitat.
C. Protect the genetic integrity of self-sustained muskellunge populations.
D. Protect adult muskellunge from harvest to full maturity.

II. Manage muskellunge for a variety of unique fishing opportunities (including trophy, quality action, and harvest) within balanced aquatic communities.

A. Trophy Fisheries - Manage Class A1 waters to increase the catch of 50" and larger muskellunge.

B. Action Fisheries - Manage Class A2 waters for a catch rate of 1 muskellunge (any size) per 25 hours of muskellunge angling.

C. Improve Existing Fisheries - Rehabilitate former muskellunge waters that have experienced substantial declines in the muskellunge population and improve class B and C fisheries, particularly in southern Wisconsin.

D. Simplify the regulations framework.

III. Improve the information available for muskellunge populations and educational efforts to inform anglers about the status and management of muskellunge fisheries.

A. Monitoring - Track muskellunge abundance, size-structure and relative abundance of the associated fish community. Conduct mail surveys every 10 years to track angler attitudes and to evaluate program goals. Pilot an Angler Diary program for possible broad-scale coverage. Update Category and Class designations.

B. Evaluation – Evaluate the comprehensive muskellunge stocking framework to determine relative contribution of stocked fish in Category 2 waters and stocking success in Category 3 waters.

C. Education - Continue to communicate the value of catch and release - provide technical assistance to partners in their efforts to educate anglers. Emphasize that muskellunge are components of aquatic ecosystems, and as such, interact with other species via predation and competition. Evaluate the reliability and adequacy of existing information from the fishery.

IV. Minimize User conflicts - provide a unique, aesthetic experience.

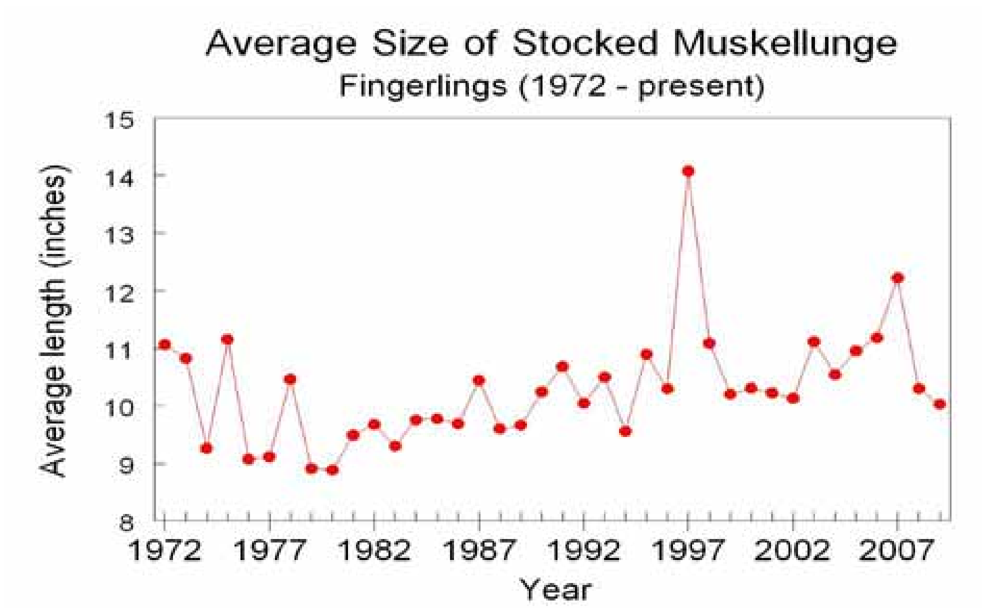
Costs and Cost-effectiveness of muskellunge stocking (from 1999 report) - The cost to produce and stock muskellunge increases considerably with size, from about $1.36/1000 fry (WLAB 1997) to about $5.20/spring yearling (Margenau 1992); production costs can also vary considerably from year to year (Margenau 1992). Cost-effectiveness is measured as the cost per stocked fish that is recruited to the fishery (i.e., of catchable size). Cost-effectiveness could also be measured as the cost per fish caught or harvested by anglers. The cost-effectiveness of stocking various sizes of muskellunge varies considerably among waters and years due to variability in survival and variability in production costs.

In general, stocking fewer large fish has been shown to be more cost-effective than stocking many small fish. For example, with muskellunge fry stocking, the costs are relatively low but the survival of fry is highly variable and the likelihood of any muskellunge surviving at all in any given year is very low (Hanson et al. 1986). Given a survival rate of 0.004% to fall (Hanson et al. 1986) and a survival rate of 4.2% from the first fall to the next fall (at 18 months of age; Margenau 1996), 588,235 fry would need to be stocked to result in 1 surviving muskellunge, at a cost of about $800.00 per muskellunge. Cost effectiveness of fall-stocked fingerlings to 18 months of age averages about $70.75 per surviving muskellunge. Cost per spring-stocked yearling muskellunge surviving to 18 months of age averages about $27.42 per muskellunge.

Estimated cost-effectiveness for stocking different sizes of muskellunge.

Size of muskellunge	Production Cost per fish	Survival rate to 18 months of age	Number stocked/ survivor	Cost per survivor to 18 months
Fry	$1.36/1000	0.00017%	588,235	$800.00
Fall fingerlings	$2.83	4%	25	$70.75
Spring yearings	$5.21	19%	5	$27.42

These estimates are based on averages: because survival and production costs vary considerably from year to year, the cost-effectiveness should be evaluated over several years on an individual water in order to get an accurate estimate. Also, WDNR Fisheries Biologists routinely use professional judgment when they determine what size of fish is most appropriate for stocking on specific waters. Their primary concern is to maximize survival of stocked fish, which obviously improves cost-effectiveness. For this reason, the department often uses fry stocking in winterkill or reclaimed lakes that are free of predators, and stocks larger sizes in waters having well established fish communities with a variety of natural predators. The reason stocking is even economical at all rests in the fact that the cost per survivor can be very inexpensive in certain years when survival of stocked fish is excellent and production costs are low, so it is cost-effective over a longer time period. A further benefit of stocking larger fish rather than smaller fish is that the variability in survival for larger fish is lower from year to year (i.e., more likely to have at least some survival; e.g., Hanson et al. 1986), providing a more consistent return on investments in stocked fish. The less time the fish is at-large when it is small and vulnerable to several sources of mortality, the higher its chances of survival and eventual contribution to the fishery.



Brood Stock Management Plan. We completed a Brood Stock Management Plan in 2005 which guides many of our spawning operations of wild brood stocks and hatchery practices based on the best available genetic principles of fish culture.

Recommended Stocking Guidelines. - To fully attain the above objectives that relate to stocking (I.C, II. A, B, C, and D), we recommended obtaining better information on the efficacy of our stocking practices (goal III.B.). This evaluation is ongoing and should be finished by 2011. One of the key goals of the 1979 management plan (WDNR 1979) was to evaluate our stocking practices (stocking rates and frequencies), yet we have very little additional information available at this time. The recommended stocking strategies and practices listed in priority order and summarized in Appendix A, are as follows:

1. Rehabilitation: *Waters* – Winter-kill lakes should not be stocked if serious mortality occurs more frequently than once in 15 years, unless a plan to minimize the risk of future winter-kills is developed and approved.

> *Size of Fish* – Fry the first year, followed by large fingerlings (> 7”) or adult transfers in subsequent years.
> *Source of fish* – Basin stock.
> *Stocking rate* – Fry – 500/acre; large fingerlings up to 2/acre. If production is unable to meet all quota requests, a maximum of 100,000 fry or 2,500 large fingerlings will be stocked per water.
> *Frequency* – Fry the first year, then large fingerlings annually for 4 years.
> *Evaluation* - If natural reproduction is not reestablished after 10 years from the onset of stocking, discontinue stocking until action is taken to identify and correct the reason(s) for the poor natural recruitment.

2. Research: Stocking sizes and frequencies as needed to realistically meet the objectives of the approved evaluation project.

3. Remediation or Recreation: *Waters* - Based on evidence provided by Fields et al. (1997), we recommend that no stocking occur in waters with adequate natural reproduction, in order to minimize the potential negative impact of stocked fish on naturally reproducing populations in the receiving or connected waters (Goal I. C). No stocking quotas should be developed for Class A2 lakes less than 200 acres in size or for Class A1, B, or C lakes less than 500 acres in size.

> *Size of Fish* – Large fingerlings (> 7”).
> *Source of fish* – Basin stock.
> *Stocking rate* – Up to 2/acre. If production is unable to meet all quota requests, a maximum of 2,500 large fingerlings will be stocked per water.
> *Frequency* – Annually or in alternate years.
> *Evaluation* - If the fishery objective (adult density, catch rate, etc.) is not met after 10 years, discontinue stocking until action is taken to identify the reason(s) for poor survival.

Suitability of Available Muskellunge Stocks

Stock	Suitable for the following inland basins	Suitable for Great Lakes/ outlying waters
Great Lakes Spotted ^ (currently unavailable)	Lake Winnebago System and downstream via the Fox River to Green Bay; Inland Brood Stock Development Waters	Green Bay, Lake Michigan and L. Superior
Upper Chippewa River	Chippewa R., St. Croix, L. Superior inland waters^, Black River; Universal Receptors*	N/A
Upper Wisconsin River	Wisconsin River and L. Michigan inland basins^; Universal Receptors*	N/A

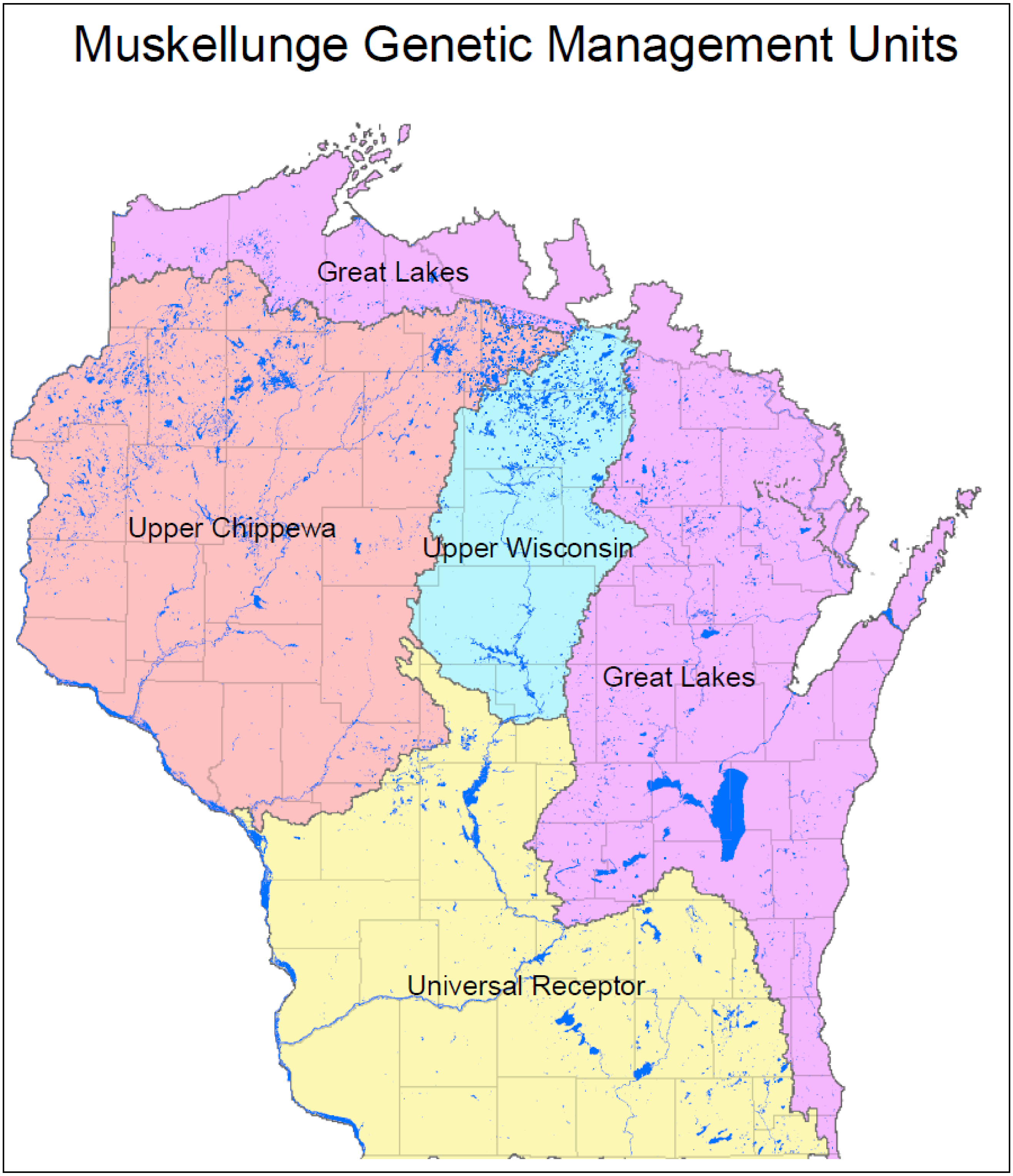
^ Once the Great Lakes Spotted muskellunge become available on a consistent basis, they should be used to fill quotas in inland waters of the Lake Michigan and Lake Superior basins.
* "Universal Receptors" are waters outside the native range of muskellunge that are dependent on stocking.
N/A = not appropriate.

Brood Stock Lakes – No stocking should occur in current or potential inland brood source lakes, except from the same waters in years when that lake is used as a brood stock. The following waters are currently identified as brood stocks, listed by basin stock:

Upper Chippewa River Basin – Chippewa Flowage, Grindstone, Lost Land/Teal, Lac Courte Oreilles, and Whitefish lakes, Sawyer County; Butternut Lake, Price County.

Upper Wisconsin River Basin – Moen Chain, Minocqua Chain, Pelican, and Squirrel Lakes, Oneida County; Big/Little Arbor Vitae, and North/South Twin Lakes, Vilas County.

No dramatic changes are recommended in the current recreational stocking practices because no compelling scientific evidence for change exists. However, this does not mean that inefficiencies do not exist or that improvements are not needed, just that we lack adequate information at this time.


Muskellunge Genetic Management Units
Great Lakes
Upper Chippewa
Upper Wisconsin
Great Lakes
Universal Receptor

Projected Demand for Muskellunge. The demand for inland muskellunge has consistently averaged about 140,000 fingerlings annually since the renovation of the two major warm water facilities. Annual demand for Great Lakes spotted muskellunge has averaged 65,000. Because we do not anticipate recommending major changes in our stocking practices, no significant changes are anticipated in the demand for muskellunge fingerlings from the hatchery system. This "biologically based" quota is unlikely to be met, given current hatchery infrastructure, staffing, and budgets.

We have observed a trend toward decreased requests within the native range and increased requests outside the native range in recent years, resulting in a slight net increase in demand. Several biologists in northern WI have requested fewer fish because higher minimum length limits and increased voluntary release of legal-sized fish by anglers has resulted in higher survival of adult muskellunge. Also, higher quality (larger) fingerlings from the hatcheries have had better survival, reducing the numbers needed to improve fishing. Therefore, we anticipate demand for muskellunge fingerlings to remain constant or decline slightly, regardless of any changes in stocking policies.

Fish Species	Size	Stock	Statewide Annual Stocking Goal (1999)	Statewide Annual Stocking Goal (2010)
Muskellunge	Large fingerlings	Great Lakes	0	65,000
Muskellunge	Large fingerlings	Upper Chippewa River	0	40,000
Muskellunge	Large fingerlings	Upper Wisconsin River	0	15,000
Muskellunge	Large fingerlings	Unspecified	140,000	85,000
		Total	140,000	205,000
Muskellunge	Yearlings	Great Lakes	0	3,000

Northern Pike Stocking Guidelines

Background.- Fishing regulations for northern pike (*Esox lucius*) have been in existence since the early 1900's. The early laws enacted by the Legislature were most likely based on the theory that fewer fish caught now will result in more available for future fishing. Size limits began in 1909 (12" minimum), bag limits in 1917 (15 daily), and closed seasons in 1935 (Jan 1st to May 15th or March 1st to May 15th). Frequent changes in the regulations in the early years were often based on economic and social considerations. There was little concern for habitat.

In the 1940's, a period of liberalized fishing regulations began for most species in the state; in 1953 the statewide minimum length limit for pike was eliminated. Prevailing ideas of the time assumed high rates of total mortality, mostly due to natural causes rather than fishing. The first experimental size limits began in the mid 1950's. Evaluations of the regulations began to show that benefits size limits will vary, depending upon exploitation rates, growth rates and structure of the fish community (Kempinger and Carline, 1978). It was found unreasonable to assume that a single length limit could produce desirable results over a wide range of lake types and fishing pressure.

***Current Stocking Practices and Priorities*.-** Current stocking practices are summarized in *Appendix Table A*. The current stocking guidelines are presented in detail below:

Current Stocking Guidelines (listed in order of priority)**. -**

1. Rehabilitation: Rehabilitation projects that involve complete chemical treatment should stock fry (1,000/ acre of habitat). Fingerling may be stocked the next year, if desired. The following equation should be used to determine fingerling stocking rates: Total number of fingerlings to be stocked= total habitat acres X desired density of fall YOY (use 10/acre of habitat; Klingbiel 1986) / (estimated proportion of fish surviving to fall YOY which is size dependent: 0.09 for pike 3.5"-5.5" in length; 0.20 for pike 5.6"-8.5" in length; and 0.40 for pike 8.6"-12" in length). These size-dependent survival estimates are taken from several studies of esocids (Hanson et al. 1986, Serns and Andrews 1986, Wahl and Stein 1989, Szendrey and Wahl 1996). Winterkill lakes that have serious mortalities no more frequently than 2 times in 10 years may be stocked. Winterkill waters should only be stocked once after a mortality, but a second year's stocking is permitted if the first survives poorly. For evaluation projects stocking sizes and frequency shall be as required to realistically meet the objectives of the evaluation project. Stocking adults (field transfer) to reproduce is also acceptable.

Note: acres of habitat are defined by estimates of total area that supported (remediation) or would support (biomanipulation and rehabitation) emergent, floating-leaf, and submergent aquatic plants.

2. Biomanipulation: Biomanipulation stocking typically involves additional actions like increased size limits for pike; stock suppression of benthivorus or planktivorus fish). Biomanipulation projects must set and objective for desired endpoint for total acres covered by aquatic plants. Fingerlings are the recommended size for stocking. The following equation should be used to determine fingerling stocking rates: Total number of fingerlings to be stocked= total habitat acres X desired density of fall YOY (use 10/acre of habitat) / (estimated proportion of fish surviving to fall YOY which is size dependent: 0.09 for pike 3.5"-5.5" in length; 0.20 for pike 5.6"-8.5" in length; and 0.40 for pike 8.6"-12" in length). Secondarily, biologists can chose to use fry instead of fingerling stocking: stock fry at a rate of 1,000/ acre of habitat.

3. Remediation: **S**tocking that seeks to remediate loss of northern pike habitat to provide a fishery, and where a decline in the northern pike population is evident. The population decline should be reasonably shown to be the result of habitat loss rather then over-exploitation. Stocking under this category is recommended to be in conjunction with other management actions (size-limits, land use and nutrient controls; wetland protection/restoration; northern pike spawning/rearing marsh construction). All remediation stocking should be for put-grow-and-take management not for put-and-take: total number of fingerlings to be stocked= total habitat acres X desired density of fall YOY (use 10/acre of habitat) / (estimated proportion of fish surviving to fall YOY which is size dependent: 0.09 for pike 3.5”-5.5” in length; 0.20 for pike 5.6”-8.5” in length; and 0.40 for pike 8.6”-12” in length) X (the proportion of spawning habitat lost or the historic proportion of stocked fish contributing to the fishery). Catchable size fish may be stocked for maintenance purposes, but only if fish become available as a byproduct of another operation through field transfer.

4. Recreational Pike Fisheries: Stockings in this category are where pike is managed to provide angling opportunities for an additional species. All stocking should be for put-grow-and-take management not for put-and-take. Fingerling stockings are recommended. For recreational pike populations, a density range of 1-3 YOY pike/habitat acre is recommended. The total number of fingerlings to be stocked= total habitat acres X desired density of fall YOY (use 1-3/acre of habitat) / (estimated proportion of fish surviving to fall YOY which is size dependent: 0.09 for pike 3.5"-5.5" in length; 0.20 for pike 5.6"-8.5" in length; and 0.40 for pike 8.6"-12" in length). Careful considerations should be taken when stocking northern pike to provide an additional fishery. Growth rates of existing piscivores and the density of larger soft-rayed forage need to be carefully considered. Stocking of northern pike has a potential for negative consequences due to inter-specific competition and predation impacts on other species. Major changes in existing fish assemblages can occur when piscivorous fishes are introduced into new locations. Several years of stocking ‘winter rescue” northern pike had negative effects on the fish community of Horseshoe Lake Minnesota. The artificially induced increase in northern pike population was followed by a sharp declines in the yellow perch, largemouth bass, and walleye populations. The Horseshoe Lake bluegill population eventually exploded and their growth rates became “stunted”, providing a very marginal fishery. Nineteen years later the Horseshoe Lake fish community has not yet recovered .

***Specific Management Goals and Objectives*.-** The overall goal of northern pike management in Wisconsin is to link the diversity of lakes and their pike populations to pike anglers’ diverse attitudes and preferences. In the past management actions primarily supported consumptive interests among anglers. Today we recognize that angler preferences and motivations for northern pike fishing are diverse. One management approach cannot meet all anglers’ expectations. To account for different demands liberal harvest regulations may be maintained on many fisheries, elsewhere, regulations other than traditional bag limits must be used to improve or maintain size-structures for larger fish.

Likewise, lakes and their pike populations are ubiquitous and diverse. Northern pike populations are found in 2,874 waters, with 795, 1,697 and 382 occurrences in water <20 acres, 20-300 acres and >300 acres, respectively. Growth rates, size-structures, and abundance of northern pike populations vary widely from lake to lake. The average standing stock and biomass reported in selected Wisconsin waters is 7.3 fish/acre and 9.2 lbs/acre, respectively. However, density and biomass estimates ranged from 0.7 to 49 fish/acre and from <1 to 59 lbs/acre, respectively. Characteristics of each lake (biological, chemical, and physical) determine each pike population’s, growth rate, size-structure and abundance. Wisconsin has a diverse spectrum of lakes that cannot be managed similarly, but require different management strategies

At one end of the spectrum are what anglers often refer to as "hammerhandle" lakes. These small, marshy lakes are loaded with aquatic plants and spawning habitat for northern pike, and are renowned for producing a lot of slow-growing, small northern pike. The pike are of an unacceptable size to many anglers. Panfish and bass are common, however larger, soft-rayed forage fish necessary for good pike growth are absent. Competition between pike for available prey is severe, growth is limited, and most deaths in the population are the result of natural causes rather than fishing. Many eutrophic lakes of Northern Wisconsin have these characteristics. Past research and evaluations of fishing regulations and stocking have shown that these actions will do little to "improve" the characteristics of northern pike in these waters. *Here the fisheries management objective is to manage populations for "consumptive" angling opportunities (i.e., to provide opportunities for anglers who value retaining a meal of fish), though the average size of pike caught will be smaller.*

At the other end of the spectrum are waters that are renowned for producing 10-25 lb. northern pike. These lakes are larger, cooler, deeper, and well oxygenated. Because of their depth, and steeper shorelines, these lakes often have fewer marshy areas and less aquatic plants for northern pike spawning. Here pike are less abundant, however they have the ability to grow to over 20 pounds. Their growth is good because larger, soft-ray forage fish (cisco, white sucker, redhorse) and yellow perch are generally abundant. Because of good growth and less competition, fewer deaths in the population are the result of natural causes. These lakes can produce large pike, however angling pressure is considered the most important factor in determining whether northern pike do well in these fisheries. That's because angler exploitation is a significant component of mortality among pike populations of low or moderate density. *Here the management objective is to manage for quality- or trophy-sized pike, though catch rates will be lower, and size limits are often quite restrictive.*

Unlike muskellunge, northern pike traditionally have not been afforded significant protection. Managing pike in Wisconsin is changing; fisheries biologists utilizing this natural diversity to manage for quality northern pike, not just on any water, but on those that are best-suited for growing large northern pike.

Biologists have witnessed a decline in the abundance and size-structure of northern pike populations through many Southern Wisconsin waters. These declines are due to: 1) losses in spawning habitat through wetland drainage, dredging, shoreline development and eutrophication; and 2) increased exploitation from angling.

In Southern Wisconsin habitat loss is often typified by high phosphorus, turbid water, dominance of algae, absent macrophytes, and dominance of benthivorus (carp and bullhead) and planktivorus (crappie) fish. The alternative and preferred conditions are typified by seasonal windows of clear water where algae are heavily grazed, dominance of macrophytes, and a dominance of fish species closely associated with macrophytes (eg. bluegill, pumpkinseed, northern pike, and bass). Restoration efforts often call for biomanipulation, water-level management, and reduced phosphorus loads in attempt to shift from the turbid condition to a clear-water condition. *Here the management objective is to rehabilitate/restore habitat and water quality through biomanipulation and other management actions (aeration; long-term water level management; drawdowns; landuse and nutrient controls; wetland protection/restoration; northern pike rearing marsh construction, boating restrictions, barrier islands, and temporary breakwaters to restore aquatic plants).* Biomanipulation and rehabilitation involves some of the following actions: protecting piscivores like pike; northern pike stocking;

chemical reclamation; stock suppression of carp using rotenone, and rough fish removal through fishing contracts.

Cost Effectiveness of Stocking Strategies for Northern Pike. - Fry survival is extremely variable and influenced by a host of factors (climate, water levels, forage, temperature, amount of refuge from predators, etc.). Fry stockings following chemical rehabilitation and winter-kill have provided excellent survival of stocked fry and established dense pike populations. A strategy of stocking fry in these “open environments” (few predators and abundant food resources) has been shown to be the most cost-effective approach. Where resident fish communities exist, we lack quantitative comparisons between fry and fingerling pike cost-effectiveness. The estimated proportion of pike surviving to the fall YOY stage is dependent upon the size of pike stocked; larger fish have significantly higher survival. Several general assumptions can be used to compare the cost-effectiveness of rearing and stocking pike at different sizes. Data taken from WLAB (1997) can be used to approximate cost-effectiveness of stocking different sizes of fingerlings. Using size-dependent survivorship described above, the cost-effectiveness of small fingerlings (4”) and large fingerlings (8”) to fall YOY stage is estimated to be $2.11/pike and $3.50/pike, respectively. Given all the assumptions and factors which influence survival of stocked fingerling pike, the difference between these two estimates is negligible. Since differences are negligible, other factors should be used to determine stocking size. Size structure, density, and growth of the resident piscivore fish community should be considered when considering stocking size for fingerling pike. If the potential for predation among the resident fish community is high (as evidenced by high CPE’s of piscivores and slow growth) large fingerling should be stocked in the fall, under lower and favorable water temperatures**.**

Proposed Stocking Guidelines (listed in order of priority)**. -**

1. Rehabilitation: Rehabilitation projects that involve complete chemical treatment should stock fry (1,000/ acre of habitat*), if requirements can be met for fish health testing. Alternatively, fingerling may be stocked the next year, if desired. Winterkill lakes that have serious mortalities no more frequently than 2 times in 10 years may be stocked. Winterkill waters should only be stocked once after a mortality, but a second year’s stocking is permitted if the first survives poorly. For evaluation projects stocking sizes and frequency shall be as required to realistically meet the objectives of the evaluation project. Stocking adults (field transfer) to reproduce is also acceptable.

***Note**: acres of habitat are defined by estimates of total area that supported (remediation) or would support (biomanipulation and rehabitation) emergent, floating-leaf, and submergent aquatic plants. **Habitat acres can be estimated = Total Lake Area * ((% lake area <3 ft deep + %<20 feet deep) /(2*100)).**

2. Biomanipulation: Biomanipulation stocking typically involves additional actions like increased size limits for pike; stock suppression of benthivorus or planktivorus fish). Biomanipulation projects must set and objective for desired endpoint for total acres covered by aquatic plants. Fingerlings are the recommended size for stocking, applied at the rates shown in the stocking rate table below. Secondarily, biologists can chose to use fry instead of fingerling stocking: stock fry at a rate of 1,000/ acre of habitat.

Pike age (length)	**Stocking rate per acre of habitat***

Fry	1,000
small fingerling (3.5-5.5")	100
large fingerling (5.6-8.5")	50
yearling (8.6-12")	25

3. Remediation: **S**tocking that seeks to remediate loss of northern pike habitat to provide a fishery, and where a decline in the northern pike population is evident. The population decline should be reasonably shown to be the result of habitat loss rather then over-exploitation. Stocking under this category is recommended to be in conjunction with other management actions (size-limits, land use and nutrient controls; wetland protection/restoration; northern pike spawning/rearing marsh construction). All remediation stocking should be for put-grow-and-take management not for put-and-take. Fingerlings are the recommended size for stocking, applied at the rates shown in the table below. Catchable size fish may be stocked for maintenance purposes, but only if fish become available as a byproduct of another operation through field transfer.

Pike age (length)	Stocking rate per acre of habitat*
Fry	1,000
small fingerling (3.5-5.5")	100
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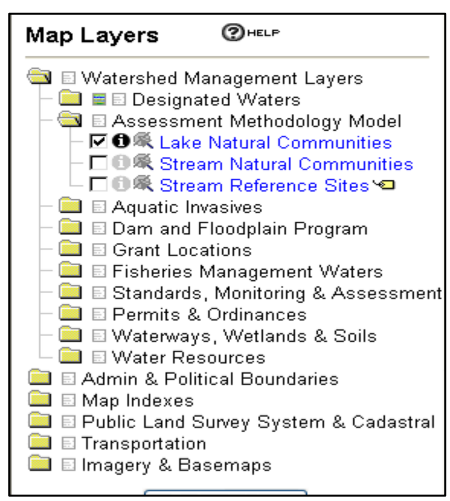
yearling (8.6-12")	25

Remediation - A waterbody can be considered for remediation stocking of northern pike if either the eutrophication or lakeshore habitat stress thresholds are met.

Eutrophication Threshold - Trophic State Index by Natural Lake Community
The WDNR recognizes that lakes may vary geographically. Spatial data are available for each of the lakes. Regional differences in soils, climate and land use may explain additional variation in the bio-indicator metrics used in the classification of lakes. However, WDNR has determined that lake size, hydrology and depth are more critical factors for initial classification of lakes, and that regional differences are secondary. The most commonly used index of lake productivity is the Carlson's Trophic State Index (TSI) which provides separate, but relatively equivalent, TSI calculations based on either chlorophyll-*a* concentration (CHL)or Secchi depth (SD, for which Wisconsin also uses satellite clarity data as a surrogate). Because TSI is a prediction of algal biomass, typically the chlorophyll-*a* value is a better predictor than Secchi or satellite data. Water clarity as measured by Secchi depth or satellite is a practical measure of algal production and water color. Algal production is known to be highly correlated with nutrient levels (especially phosphorus). High levels of nutrients can lead to eutrophication and blue-green algae blooms. This in turn limits the amount of available light to macrophytes and adversely affects northern pike spawning and nursery habitat. Proposed stocking of northern pike are eligible for remediation stocking if eutrophication of the waterbody is **significant***.
***Note:** Significant means that waterbody condition exceeds the TSI thresholds described in Table __ below.
***Note:** The waterbody cannot be an ORW Lake or ERW Stream/River

Methods - To determine if your waterbody meets the eutrophication threshold you need to know the waterbody's natural community classification and its TSI score. Lake natural community classifications are available on the Intranet Surface Water Viewer under the "Assessment Methodology Model" folder.



Wisconsin has instituted a prioritization system for selecting which TSI score to use. When more than one TSI score is available, whichever TSI score is based on the most direct measure of algal biomass will be

used, as follows:
1) TSI based on chlorophyll a will be used if available, since this is the most direct measure of trophic state.
2) TSI based on measured Secchi data is the second preference; Secchi depth readings measures clarity as a surrogate for trophic state.

Download all chlorophyll a, Secchi, and satellite data that meet minimum data requirements. These requirements are set to provide enough data to account for the average lake condition during the summer index period (when the lake responds to nutrient inputs and achieves maximum aquatic plant growth) over several years to account for unusual weather (dry, wet, hot, cold).
For chlorophyll a and Secchi data, download data that meet all of the following:

- Collected between July 15 – Sept 15
- Collected at Deep Hole or Mid-lake
- Sampled within top 2 m of water column (for chl a)
- Sampled within the last 5 years

Use the following equations to calculate CHL or Secchi based TSI's:

$$TSICHL = 9.81 \ln (CHL) + 30.6$$

$$TSISD = 60 - 14.41 \ln (SD)$$

Where:
TSI = Trophic Status Index
SD = Secchi depth (meters)
CHL = Chlorophyll-*a* concentration (µg/L)

3) TSI based on satellite data is the third preference, as it infers water clarity rather than measuring water clarity directly. A look-up menu to find TSI values from satellite data is found at:
http://mapserv.ssec.wisc.edu/research/Projects/LakesTSI/lakelookup.php

Using the TSI metric, the next step is to compare lake-specific TSI values to lake condition assessment threshold TSI values established for each of the different lake classification categories (see Table __) Lake condition assessment thresholds create four categories: Excellent, Good, Fair and Poor. Remediation Stocking TSI Thresholds were set as the mid-point in the fair category.

Lake Natural Community	***Excellent TSI***	***Good TSI***	***Fair TSI***	***Poor TSI***	***Remediation Stocking TSI Threshold***
Shallow Seepage	<45	45-57	58-70	>70	>64
Shallow Headwater	<53	53-61	62-70	>70	>66
Shallow Lowland	<53	53-61	62-70	>70	>66
Deep Seepage	<43	43-52	53-62	>62	>59
Deep Headwater	<48	48-55	56-62	>62	>59
Deep Lowland	<47	47-54	55-62	>62	>59
Spring Ponds	NA	NA	NA	NA	NA
Two Story Lakes	<43	43-47	48-52	>53	>50
Impounded Flowing Waters	NA	NA	NA	NA	Use Shallow Lowland

Note: *Shallow Lakes:* The transition between a fair and poor condition for shallow lakes was set at a TSI of 71 (corresponding to total phosphorus of 100 µg/L) because this approximates total phosphorus concentrations that lead to a switch from aquatic plant dominated to algal dominated ecosystems in shallow lakes (Jeppesen et al. 1990). This represents a major ecosystem change and once it occurs, it is very difficult to restore to the aquatic plant dominated state.
Note: *Deep Lakes:* The fair to poor transition threshold for deep lakes was set using a TSI value known to cause increased frequency of algal blooms, high amounts of blue-green algae and/or hypolimnetic oxygen depletion. A TSI of 63 (corresponding to total phosphorus of 60 µg/L) was chosen because it represents the threshold between eutrophic and hyper-eutrophic lakes (Carlson 1977).

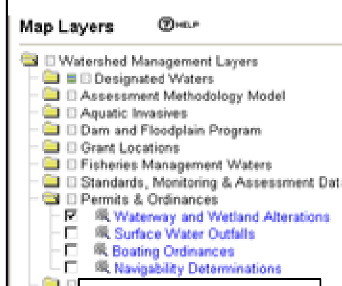
Lakeshore Habitat Stress Threshold

Activities in the riparian zone can also affect the habitat available to fish by directly eliminating overhanging cover, woody habitat, and emergent and floating-leaf plants. Ecologically, the shoreland, or riparian zone, is a living bridge between interdependent aquatic and terrestrial worlds. Shallow near-shore waters, known as the littoral zone in lakes, are the most biologically productive part of lake ecosystems. Stream, lake, and wetland ecosystems are inextricably linked to adjacent uplands through both structural habitat and food chain connections between the aquatic system and the riparian area. Riparian zones have unique physical and biological conditions that allow them to host a great variety of wildlife. The shoreland buffer is intended to protect the habitat of both species that are totally aquatic, such as fish; and those that rely on the unique habitat found in riparian areas, such as waterfowl, fish-eating birds, amphibians and reptiles, and mammals.

Lakeshore human disturbance reflects direct human alteration of the lakeshore itself. These disturbances can range from minor changes (such as the removal of trees to develop a picnic area) to major alterations (such as the construction of a large lakeshore residential complex complete with concrete retaining walls and artificial beaches). The effects of lakeshore development on the quality of lakes include excess sedimentation, loss of native plant growth, alteration of native plant communities, loss of habitat structure, and modifications to substrate types. These impacts, in turn, negatively affect northern pike spawning and nursery habitat. Proposed stocking of northern pike are eligible for remediation stocking if lakeshore habitat stress of the waterbody is **significant**. Significant means that the waterbody must contain > 3 waterway permits per shoreline mile, using the methods described below.

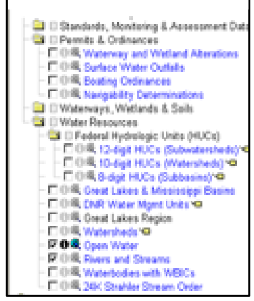
Methods - Unfortunately, the Department does not have common metrics that quantify littoral zone habitat for waters of the state. However, a useful index of physical alteration and habitat loss in the littoral zone is available on the intranet surface water data viewer – **Waterway and Wetland Alterations.** Placement of structures, dredging and similar activities in or adjacent to navigable waters are regulated under chapter 30 of Wisconsin Statutes, and often require permits from the Department of Natural Resources. The waterway and wetland alteration data indicates where such permits have been issued. This map layer can be found under the permits and ordinances folder (Figure __)

Figure __.



To determine if your waterbody meets the lakeshore habitat stress threshold you need to know the shoreline length of the waterbody and the total number of waterway and wetland alterations. These data can be readily obtained from the surface water viewer. First highlight the “open water” layer as a “selectable” layer (Figure __). Using the select tool, highlight the waterbody of interest. Open excel report and record **object perimeter** in meters. Convert this value from meters to miles and record the value.

Figure __.



Keeping the waterbody selected (should show as highlighted in yellow), next go back layers, and now highlight the “waterway and wetland alterations” layer as a “selectable” layer.

Next “hit” the select command and choose select by buffer from the waterway and wetland alterations layer (Figure __). Use a 0.5 mile buffer from 24K Open water layer.

Record the number of waterway and wetland alteration permits your selection found (Figure __); it will show up in red as the “number of features” selected. Divide the number of features found by your previously recorded shoreline length (miles) as the habitat stressor index is expressed in permits/shoreline mile.

Figure .

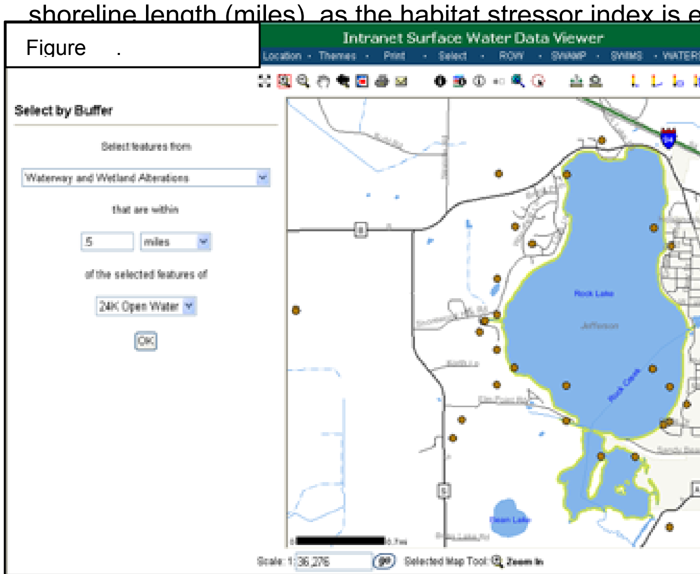
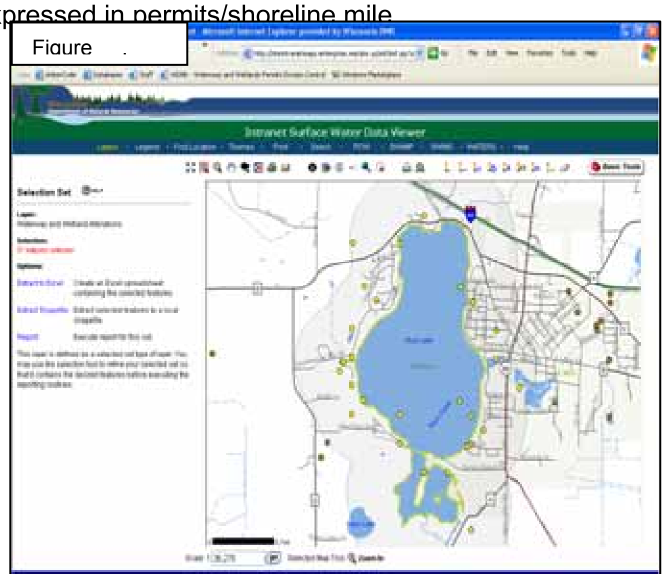


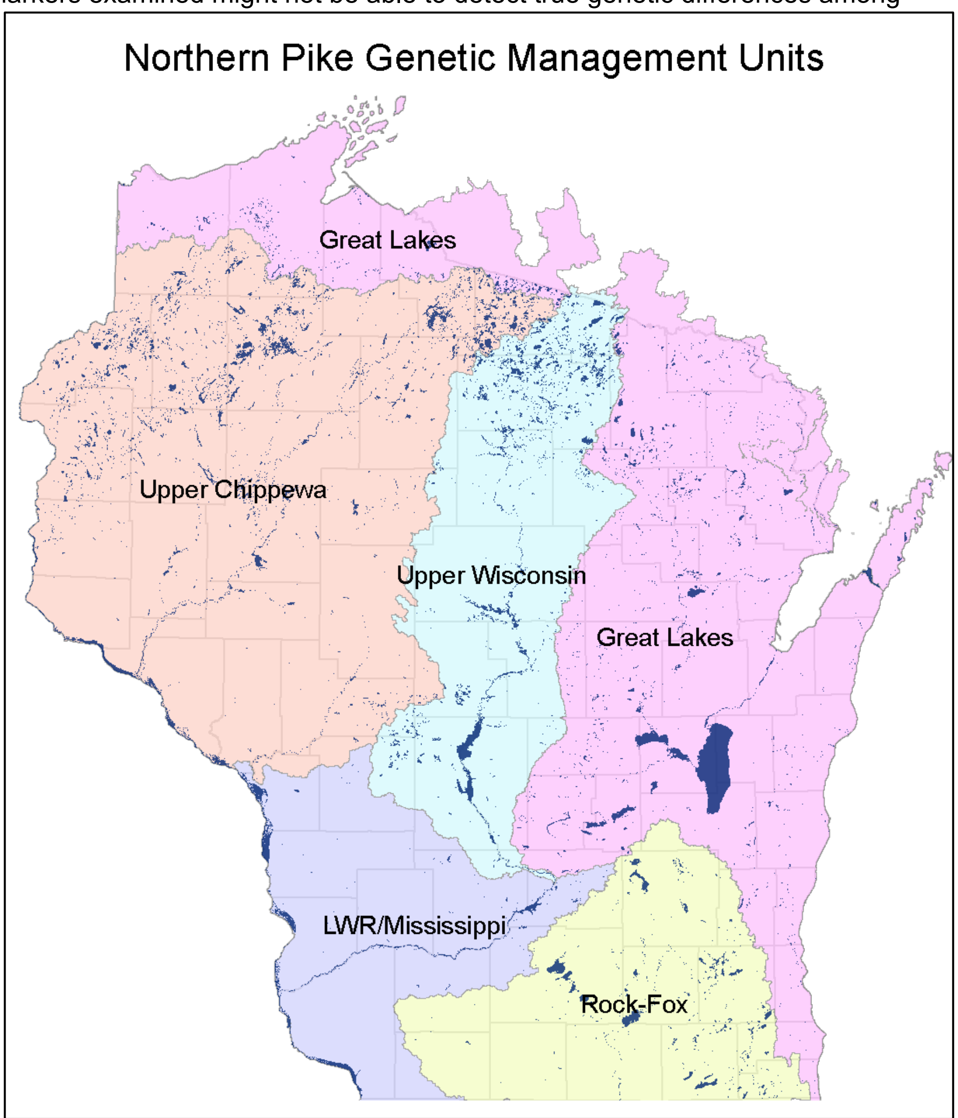
Figure .



4. Recreational Pike Fisheries: Stockings in this category are where pike is managed to provide angling opportunities for an additional species. All stocking should be for put-grow-and-take management not for put-and-take. Fingerlings are the recommended size for stocking, applied at the rates shown in the stocking rate tables above. Careful considerations should be taken when stocking northern pike to provide an additional fishery. Growth rates of existing piscivores and the density of larger soft-rayed forage need to be carefully considered. Stocking of northern pike has a potential for negative consequences due to inter-specific competition and predation impacts on other species. Major changes in existing fish assemblages can occur when piscivorous fishes are introduced into new locations. Several years of stocking 'winter rescue" northern pike had negative effects on the fish community of Horseshoe Lake Minnesota. The artificially induced increase in northern pike population was followed by a sharp declines in the yellow perch, largemouth bass, and walleye populations. The Horseshoe Lake bluegill population eventually exploded and their growth rates became "stunted", providing a very marginal fishery. Nineteen years later the Horseshoe Lake fish community has not yet recovered.

Genetic Management Units

Populations with different evolutionary pasts often develop distinct genes that are characteristic to their local environment. This genetic selection and adaptation results in increased population fitness to their local environment. Unlike other sympatric species (walleye, yellow perch, and muskellunge) northern pike in the north-central United States show low levels of genetic variation (Miller and Senanan 2003). Differences in northern pike genetic structure have been found among populations from different continents (Finland, Siberia, and Northern America), and among populations in Finland (Senanan and Kapuscinksi, 2000). Hypothesized reasons for the weak genetic structure in northern pike include (Senanan and Kapuscinki, 2000): 1) Recent divergence; 2) Microsatellite markers examined might not be able to detect true genetic differences among populations; 3) Northern pike have low genetic variation; or 4) Extensive stocking may have homogenized genetic differences among populations. Senanan and Kapuscinksi (2003) further posited a single glacial refugium for northern pike existed in the North Central United States during the last glaciation. Nonetheless geneticists recommend (Miller and Senanan 2003; personal communication - Loren Miller, University of Minnesota and Brian Sloss, University of Wisconsin Stevens Point) Genetic Management Units similar to those described in Fields et al. (1997). This conservative management approach aims to ensure northern pike's local adaptive fitness and



evolutionary potential. Major drainage basins represent likely historical barriers to gene flow and WDNR propagation operations will have many potential source populations within the proposed genetic management units for northern pike (Figure __).

Projected Demand for Northern Pike. – Due to the uncertain timing of major rehabilitation projects, quota requests for northern pike vary considerably from year to year, especially for fry. Projected demand for fry is approximately 8 million per year. Priority and policy changes now place greater biological emphasis on size dependent survival of stocked pike, quantification (actual or projected) of northern pike habitat, biomanipulation, and remediation projects.

Fish Species (size)	Size	Stock/strain	Statewide Annual Stocking Goal (1999)	Statewide Annual Stocking Goal (2010)
Northern Pike	Small fingerlings	Upper Chippewa River	0	2,724
Northern Pike	Small fingerlings	Upper Wisconsin River	0	295
Northern Pike	Small fingerlings	Great Lakes	0	4,846
Northern Pike	Small fingerlings	Lower WI/Mississippi River	0	128
Northern Pike	Small fingerlings	Rock/Fox	0	46,049
Northern Pike	Small fingerlings	Unspecified	80,000	0
		Total	80,000	54,042
Northern Pike	Large fingerlings	Upper Chippewa River	0	1,115
Northern Pike	Large fingerlings	Upper Wisconsin River	0	526
Northern Pike	Large fingerlings	Great Lakes	0	13,566
Northern Pike	Large fingerlings	Lower WI/Mississippi River	0	12.024
Northern Pike	Large fingerlings	Rock/Fox	0	126,864
Northern Pike	Large fingerlings	Unspecified	70,000	0
		Total	70,000	154,095

Walleye Stocking Guidelines

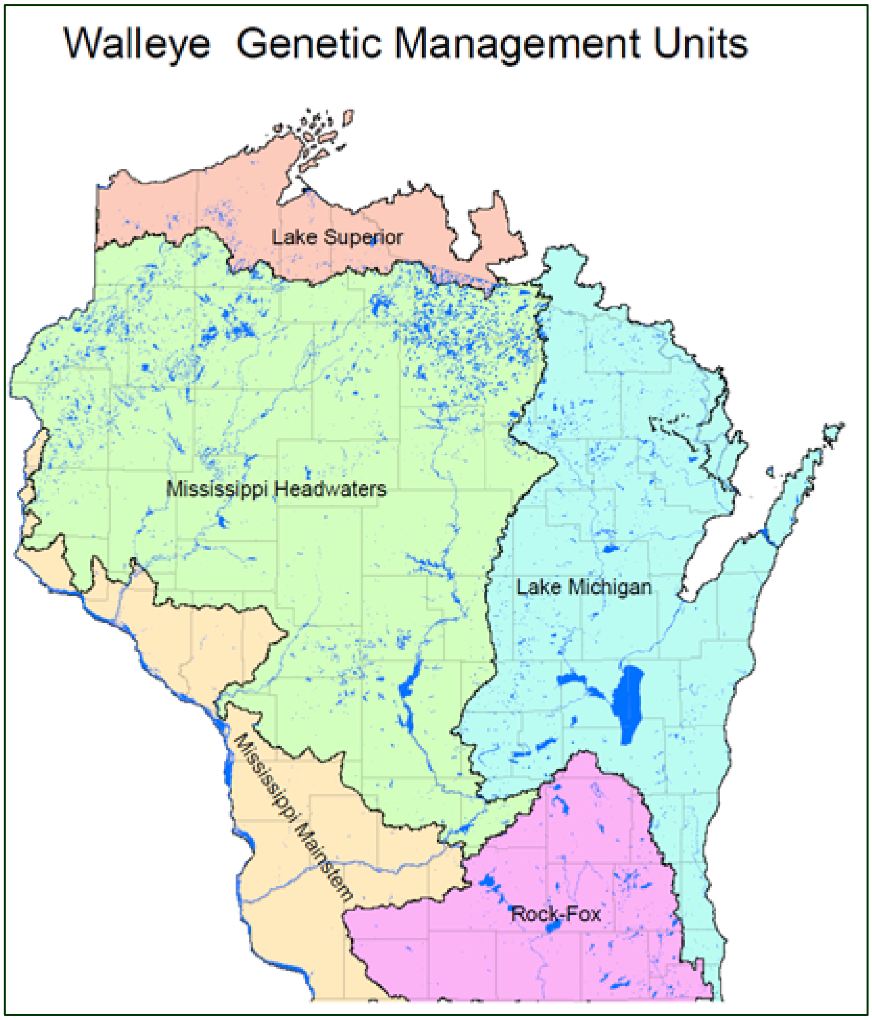
Background. - The fisheries management program has a long history of propagating and stocking walleye throughout the state. This program began in the late 1870's, with the first walleye propagated from the Lake Winnebago system. Until the early 1900's, all walleye stocked in the state were from the Winnebago system. Propagation efforts moved north and expanded to cover the entire state during the early 1900's. By the year 1910, there had been 77,904,996 walleye stocked in Wisconsin. Walleye were probably originally found in the large river systems and large drainage lakes throughout Wisconsin. Most walleye populations found in small drainage and seepage lakes were probably the result of the walleye stocking program. Some of these waters have established self-sustained walleye populations, others are maintained through continued stocking, and others contain remnant populations that are not likely to improve. Because of the long history of walleye stocking, we do not fully understand the effects of our stocking program on native walleye stocks. However, considerable regional genetic diversity still exists despite our past stocking practices.

Large numbers of fish were stocked throughout the state, with little or no evaluation of success. In the late 1950's and early 1960's, the efficacy of stocking practices were scientifically examined. Evaluations of the size at fish stocked, survival of stocked fish, and development of management goals and objectives resulted in changing emphasis from stocking all waters with fry to developing individual lake recommendations. These recommendations included the size, number and frequency of walleye stocking. Improvements at both major walleye hatcheries, increased concern about detrimental effects of walleye stocking on other species and on genetically distinct walleye stocks, as well as a need to examine the cost-effectiveness of various stocking practices, led to the recent review of walleye stocking practices.

Walleye stocking success is highly variable and is difficult to predict. There are variations in stocking success, just as there are year-to-year fluctuations in natural reproduction of walleye.
Available stocking evaluations suggest that only about 50% of new stockings are effective in creating walleye populations (reviewed in Kampa and Jennings, 1999). Maintenance and enhancement efforts generally have even lower success rates; walleye stocking to maintain populations has a lower success rate. About 85 % of fry stockings result in no measurable year class (WDNR unpublished data). Waters supported entirely by stocking have much lower walleye densities, and anglers catch walleye at a substantially lower rate than from waters supported by natural reproduction (see graph, page 5).

We have identified genetically distinct walleye populations throughout the state. Based on this information, distinct stocks are delineated on the map below. Although we are able to determine genetic differences among stocks, it is unclear whether differences in growth, fecundity, or survival have occurred. If genetically distinct walleye populations exhibit performance differences (which we suspect they do), mixing of these stocks could result in outbreeding depression and lower fitness of the population. Genetic fitness could directly affect cost-effectiveness of the propagation program. Evaluations of stock-specific performance and fitness differences among waters are underway in Wisconsin and should help to better assess benefits and risks of alternative stocking strategies.

The implications of genetically distinct stocks, along with recent research showing some negative impacts of stocking on naturally reproduced walleye year classes (Li et al. 1996), suggest that lakes with adequate natural reproduction should not be stocked. Although there have been no field evaluations on the genetics effects of stocking walleye, we could be causing more harm than good. Recent research in Minnesota suggests that stocked walleye suppress adjacent year classes, resulting in no net benefit to the fishery. Most of the scientific evidence on stocking is relatively new in comparison to our stocking program. In the future, more emphasis needs to be placed on the rigorous evaluation of the cost-effectiveness of stocking.



Walleyes are a top predator, and can have a significant impact on the structure of fish communities. While there have been few experiments on the impact of walleye stocking on fish communities, there is some anecdotal evidence that suggests negative interactions between bass and walleye. For example, after the initiation of walleye stocking, Escanaba Lake converted from a smallmouth bass-dominated fishery to a walleye dominated fishery. Conversely, the presence of bass is suspected to reduce the chances of successful walleye stocking. When walleye stocking is successful, the fish community structure is likely to change. There will likely be a change in the other predators. The net influence may be viewed as positive or negative, depending on the management objective for the specific water. Of course, the reverse is also true; other species can impact walleye populations and can seriously hinder walleye stocking efforts.

Current Stocking Practices.- During 2009, the Walleye Standing Team reviewed current stocking quotas and requests for small and extended growth walleye fingerlings, with an emphasis on determining whether requests reflected actual demand for those products or if they were an under- or over-estimate of actual demand. The team also had brief discussions regarding walleye stocking strategies and concerns.

The primary issue the team identified was that demand for large fingerlings far exceeds the current availability of that product. Extended growth fingerlings are considered a desirable product in situations where walleye populations are being maintained in the presence of predators and competitors such as centrarchids. This is true both in situations where the objective is restoration of a naturally sustained walleye population and in cases where the objective is establishment or maintenance of a secondary ("stocked") walleye population. Another reason for the increased demand for extended growth fingerlings is the decrease in average size of spring fingerlings since DNR hatchery production shifted primarily to lined ponds versus clay or outlying ponds. The team recognizes the substantial cost difference to raise extended growth fingerlings versus small fingerlings but concurs with input gathered from regional biologists that extended growth fingerlings provide a more reliable return to the fishery than small fingerlings under certain circumstances, and they are more consistent in producing year classes (Kampa and Hatzenbeler, 2009). The team will consider reviewing standards for determining when extended growth stocking is preferred, and asks if diversification of some production systems is warranted and feasible (e.g. use of outlying ponds within current fish health standards).

The team also identified a disturbing continuation of walleye stocking in waters where natural reproduction has consistently been sufficient to maintain a healthy adult walleye fishery. The practice seems to have become less common but more oversight is justifiable. Within the Ceded Territory, identification of naturally-sustained populations is easier by cross-checking quota requests with recruitment codes assigned by the Wisconsin Technical Working Group, and in cases where a quota request is made for a "natural model" lake, biologist justification should be required. There are cases where recruitment codes do not reflect present conditions (e.g. multiple years of recent reproductive failure). Outside of the Ceded Territory, oversight of this detail is more challenging and should be handled by regional supervisors. However, related to this topic, the team also perceives a need for flexibility in available responses to situations where collapsing populations are identified, including field transfer of genetically similar adults and sub-adults.

Specific Walleye Management Goals.-

I. Protect, develop, maintain, and restore critical habitats for natural walleye stocks.

II. Provide a variety of opportunities for the catch and harvest of walleye.

III. Ensure that adequate information on the status and trends of walleye populations is available.

IV. Maintain the genetic integrity of naturally reproducing walleye populations.

V. Provide educational opportunities to develop appreciation of Wisconsin's fishery resources.

Costs and cost-effectiveness of walleye stocking practices. **–** The cost to produce and stock walleye increases considerably with size: $0.56 / 1,000 fry; small fingerling at $0.04/fish; large fingerling at $0.18/fish; and extended growth fingerlings at $4.47/fish (WLAB 1997). Production costs can vary considerably from year to year for the fingerling sizes that require additional forage fishes to be provided. Cost-effectiveness is measured as the cost per stocked fish that is recruited to the fishery (i.e., of catchable size). Cost-effectiveness could also be measured as the cost per fish caught or harvested by anglers. The cost-effectiveness of stocking various sizes of walleye varies considerably among waters and years due to variability in survival and variability in production costs.

For walleye, stocking fewer large fish has not been shown unequivocally to be more effective than stocking many small fish (Kerr et al. 1996). However, some circumstances may require the stocking of larger fish to improve survive if predation by other fish on walleye fingerlings is a major limiting factor. With walleye fry stocking, the costs are relatively low but the survival of fry is highly variable and the likelihood of any walleye surviving at all in any given lake is also very low (Kampa and Jennings 1999). Given a survival rate of 0.015% for fry to fall (S. Hewett, unpublished data, 1998) 41,667 fry would need to be stocked to result in 1 surviving walleye to the creel, at a cost of about $ 23.33 per walleye. Cost effectiveness of summer-stocked fingerlings to fall averages $7.44 per surviving walleye. Cost per large fingerlings and extended growth walleye to the creel averaged higher than the small fingerlings (Kampa and Jennings 1999). We estimated 33% survival from age 0 fall to age 1 fall; and 49% survival from age 1 to age 3 (recruitment into the fishery) for fry and small fingerlings.

Estimated cost-effectiveness of stocking different sizes of walleye.

Size of walleye	Production Cost per fish	Survival rate to age 3	Number stocked/ survivor	Cost per survivor to age 3
Fry	$0.56/1000	0.0024%	41,667	$23.33
Small fingerlings	$0.06	0.81%	124	$ 7.44
Large fingerlings	$0.18	1.62%	62	$11.16
Extended growth fingerlings	$0.65	5.7%	18	$11.70

Tailoring our stocking efforts for water-specific conditions improves the cost-effectiveness of walleye stocking. On average, small fingerlings tend to be the most cost-effective size for stocking. However, many stocked waters have shown limited survival of small fingerlings in the summer. Up to 30 % of stocked waters in some areas may show no contribution to the fishery from stocking small fingerlings (Rick Cornelius, personal communication). Whether predation by other fishes or warm water temperatures are the cause, larger fingerlings or extended growth fish may be the more appropriate option in such waters. There is evidence that larger walleye survive better and return more fish to creel in certain situations. However, because it costs significantly more to raise larger fish, very selective use of these fish is warranted. Similarly, evidence from southern Wisconsin lakes indicates that stocking walleye fry is often successful in lakes with low water clarity. Even in clearer lakes in northern Wisconsin, fry stockings have been successful for rehabilitating winter-kill lakes. It can be very cost-effective to stock fry in certain situations, such as in lakes with turbid waters or in winter-kill lakes that lack predators. Water specific stocking plans and subsequent evaluations are, therefore, the most efficient means of maximizing cost-effectiveness.

Traditionally, nearly all walleye were hatched at either the Spooner or Woodruff hatchery systems. Before the renovations at these hatcheries, most walleye were raised off-site in leased ponds. Travel costs have been reduced because most walleye are now raised on hatchery grounds. However, costs to stock walleye in the southern part of the state have been high due to transportation costs from the northern hatcheries. With recent changes in the propagation system, walleye for the southern part of the state are now being hatched and raised at Lake Mills, lowering distribution costs, which should improve cost-effectiveness.

Recommended Stocking Guidelines (listed in priority order).- In general, we recommend flexibility in the size of walleye available for stocking to assure that the most cost-effective stocking techniques are used and so that we can use the latest information on stocking practices to ensure that success is not limited by stocking practices. Recommended stocking practices for walleye, summarized in Appendix A, are as follows:

1. Rehabilitation; Remediation: *Waters* - Winter-kill lakes should not be stocked if serious mortalities more frequently than twice in 10 years. Walleye are not recommended for lakes with more frequent winter-kills because walleye are sensitive to low oxygen concentrations and development of a fishable population is unlikely.

Size of fish - Fry should be stocked the first year. If investigation shows poor survival of stocked fry, 2"+ fingerlings should be stocked in subsequent years.

Source of fish - Same waterbody, if possible, otherwise basin stock.

Stocking rate - There is some concern that current stocking densities might not be adequate to develop a self-sustaining walleye population. Therefore, we recommend higher stocking rates, as follows: 1,800/acre (fry) or 100/acre (2"+ fingerlings).

Frequency - Annually for 5 years.

Evaluation criteria - Rehabilitation efforts should be evaluated within 10 years prior to further stocking. An evaluation of fingerling stocking should be done. Initial evaluations should consist of fall electrofishing subsequent to stocking or during years when stocking does not occur, to evaluate natural reproduction. Further, a survey should be done to assess survival of stocked fish to reproductive age. This survey should be completed after sufficient time has passed to allow multiple year classes to mature and be present. If adequate survival is not found, rehabilitation stocking can continue for 2 more years, after the spring survey. After this initial rehabilitation period is completed, as assessment of natural reproduction should be made. If no natural reproduction is found, and the decision is made to continue management as a stocked water, the water will be moved to the Recreation category.. Stocking should be discontinued if significant natural reproduction is found and if the management strategy for the water is changed from a rehabilitation to a natural reproduction water.

2. Research/Evaluation: Stocking practices should vary depending upon the objectives of the project. An existing or approved funded evaluation project is required.

3. Recreation (Maintenance): *Waters* – Existing waters with maintenance stocking. New maintenance quotas will be established only after investigation shows growth is satisfactory and there is little or no natural reproduction for at least 3 years. Also, in order for walleye to be introduced into new waters, an Environmental Impact Assessment will need to be prepared. If the EIA indicates no impact on existing species, then new introductions can be made.

Size of fish – Fingerlings (2”+) or fry.

Source of fish - Basin stock for drainage lakes and rivers; Basin stock for landlocked lakes, if available.

Stocking rate – Up to 1800 fry/acre; up to 100 - 2” fingerlings/acre

Frequency – Annual for fry; alternate years for fingerlings. Fingerlings may be stocked annually for 4 years in new introductions.

Evaluation - Existing maintenance stocking programs should be evaluated every 5-7 years and discontinued if not successful in developing a fishery after 4 years of stocking fingerlings. Initial introductions should be evaluated at the start of year 5 prior to further stocking. This evaluation should include an assessment of impacts to other species. If adequate survival is

found, stocking may continue for 2 more years. At that time, alternate year stocking should commence to allow for evaluation of natural reproduction. If no natural reproduction is found, stocking should follow the above strategy.
Production shortfalls - If there are shortfalls in production, cuts will be made from the bottom up. Regions should develop their own priority system for Recreation Stocking waters.

4. Additional recommendations: A) Sauger should not be stocked into waters with naturally reproducing walleye populations. "Saugeye" (walleye x sauger hybrids) should not be stocked into any Wisconsin waters. B) Develop methods and procedures to ensure that all stocked walleye are marked to allow for reliable evaluation of our stocking practices.

Projected Demand for Walleye.- A comparison of quota requests and hatchery production over the past 6 years, excluding the 2007 VHS-affected production year, shows that, on average, only 50% of extended growth fingerling quotas are met. In contrast, nearly 90% of small fingerling quotas are currently being met (independent of stocking priority). The demand for extended growth fingerlings of all strains is unmet. Further, discussions with regional biologists suggest that current quota requests are a significant under-estimate of the numbers of extended growth fingerlings biologists would prefer to stock, and they are also over-estimates of the actual demand for small fingerlings (not preferred, but all that is available, and some quota requests are made with socio-political motivation with the expectation that they will be rejected. With that, a revision of the statewide annual stocking goal is warranted:

Fish Species (size)	Size	Stock/strain	Statewide Annual Stocking Goal (1999)	Statewide Annual Stocking Goal (2010)
Walleye	Small fingerlings	Lake Michigan	0	492,733
Walleye	Small fingerlings	Lake Superior	0	109,994
Walleye	Small fingerlings	Mississippi Headwaters	0	1,332,361
Walleye	Small fingerlings	Mississippi Mainstem	0	41,758
Walleye	Small fingerlings	Rock/Fox	0	1,323,154
Walleye	Small fingerlings	Unspecified	6,500,000	0
		Total	6,500,000	3,300,000
Walleye	Extended growth	Lake Michigan	0	95,309
Walleye	Extended growth	Lake Superior	0	10,385
Walleye	Extended growth	Mississippi Headwaters	0	167,832
Walleye	Extended growth	Mississippi Mainstem	0	5,998
Walleye	Extended growth	Rock/Fox	0	45,475
		Total	0	325,000

Note that if demand for extended growth fingerlings cannot be met, there would be a companion increase in demand for small fingerlings.

Summary and Recommendations

Risks associated with projections.- The projections contained in this report are based on a combination of past stocking practices and best professional judgment. Historically, the demand for hatchery fish has been based partially on public expectations and perceptions and, to some degree, on available supply. Projections based on historic supply are constrained by past hatchery practices which, while untested, could be modified considerably to meet demand. This is the first contemporary attempt by DNR to estimate demand for hatchery fish, so there is some uncertainty associated with these projections. However, the approach taken in this report is viewed as a logical first step from which future refinements can be made.

Management Recommendations

Several recommendations were common across many of the species reviewed in this report. The most important ones are highlighted below.

Protection of existing natural reproduction. - This is a universal theme throughout the report. Populations sustained through natural reproduction provide the best fishing, and are therefore worthy of vigorous protection. Any actions we can take to reduce the risk of impacting naturally reproducing populations should be pursued, whether through the hatchery system, habitat protection, or harvest regulation.

Genetic Stock Development.- The department should continue to develop capacity to use appropriate genetic stocks. Considerable research has been completed in Wisconsin since the publication of the first version of this report, which will assist with stock boundary development and brood stock guidelines. Continued use of appropriate stocks will ensure the most efficient management of Wisconsin's fishery resources. Basin-specific stocks, as identified in this report, should be used for most stocking in the state. This approach will, in the long term, result in stocking a product that is better suited to the receiving waters and, ultimately, better fishing.

Sources of disease-free adult cool water fish. - Most of the cool water species teams identified a substantial need for adult “field transfers”. While this is outside the scope of normal hatchery operations, ideas such as 1) development of “quarantine” pond facilities, where fish can be moved in, tested, held and/or stocked out; or 2) feral populations sustained in registered fish farms (natural water bodies, e.g., Trilby Lake), where transfers could come from “surplus” production at maximum sustained yield, etc., need to be pursued, with the assistance of propagation staff.

Define "Self-sustained". - Many of the recommendations in this report use the term "self-sustained" to characterize fisheries supported by natural reproduction. We need to ensure that population characteristics indicative of self-sustained populations are identified and well defined.

Long-term quotas.- We recommend the establishment, where feasible, of stocking plans with long-term quota requests for individual waters. For the major stocked species, the demand for stocked fish is relatively constant from year to year. Development of a 5- or 10-year stocking plan for stocked waters will reduce annual planning workload and will provide the hatchery system, private fish hatcheries, and cooperators with a long-term demand. In cases where special needs arise, the system should be flexible enough to address these short-term demands from the hatcheries. Stocking plans for individual waters should clearly identify the desired outcome of the stocking regime and an evaluation of the success of the plan. <u>Attainment of that outcome should be evaluated before renewal of another long-term commitment for fish from the hatcheries or private providers</u>.

Per-Water-Maximums.- In general, the per-water-maximum numbers for stocking quotas are eliminated in deference to the best biological recommendation, regardless of limitations in production. However, due to the high variability in hatchery production from year to year, there will be inevitable shortfalls. We recommend addressing this problem by prioritizing stocking strategies statewide and, within those categories, requiring cuts in the waters that are stocked rather than spreading out fewer fish in all waters where fish were requested. This approach assumes that the likelihood for success is higher for a few waters that get adequate numbers of fish rather than for a few fish in a greater number of waters, assuming the quota requests are biologically-based.

Shortfalls in Hatchery Production.- The requested number of fish of any one species could likely be met by the hatchery system, but it would adversely affect the availability of other species from the hatcheries. For example, walleye and muskellunge are the primary species competing for space in the cool water hatcheries while Great lakes and inland salmonids compete for space in the cold water facilities. Demand for many of these species is currently not being met.

Examination of the need for stocked fish, coupled with instances where we are unable to meet that need through the state hatchery system suggests that there may be room for increased involvement from private fish hatcheries throughout the state, as suggested by WDNR (1997). Development of longer-term quotas would make it easier for private industry to plan for and provide fish for stocking. Development of more cooperative agreements would benefit both the state and private fish hatcheries.

Stocking Team.- A team of Department biologists and hatchery personnel should be formed to periodically evaluate the stocking program. This forum would provide an outlet for 1) presentations on in-state stocking evaluations; 2) review of current scientific literature related to stocking, propagation, and related issues; 3) increased communication between biologists and hatchery personnel; and 4) development of work planning guidance for future stocking evaluation projects. In short, the purpose of this team would be to maintain the state-of-the-art in our stocking program through a continuous improvement process.

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Appendix

Appendix Table A. Summary of sizes and recommended stocking guidelines for cool water fishes needed from the propagation system. Data are stocking rates per acre (maximum number per water, if production is limited).

Size	Black bass	Lake Sturgeon	Muskellunge	Northern Pike	Walleye
Fry	--	--	500/acre (100k) [1]	1000/habitat acre[1]	1800/acre[1]
Small fingerling	--	--	--	3.5" –5.5" 111/habitat acre[1,2,3]	1"+; 100/acre[1]
Large fingerling	2”+ 25/acre (25K)[1]	6”+; 80/mile or 0.5/acre[1]	7"+; up to 2/acre (2500) [1,2,3]	5.5"+ 50/habitat acre[1,2,3]	4"+; 20/acre[1]
Yearling	--	6”+; 40/mile or 0.25/acre[1]	--	--	--
Adult	Up to 5/acre[1]	50 (minimum) [1]	Yes (rates not established)[1]	Yes (rates not established)[1,2]	--

1 = Rehabilitation; 2 = Remediation; 3 =Recreation.