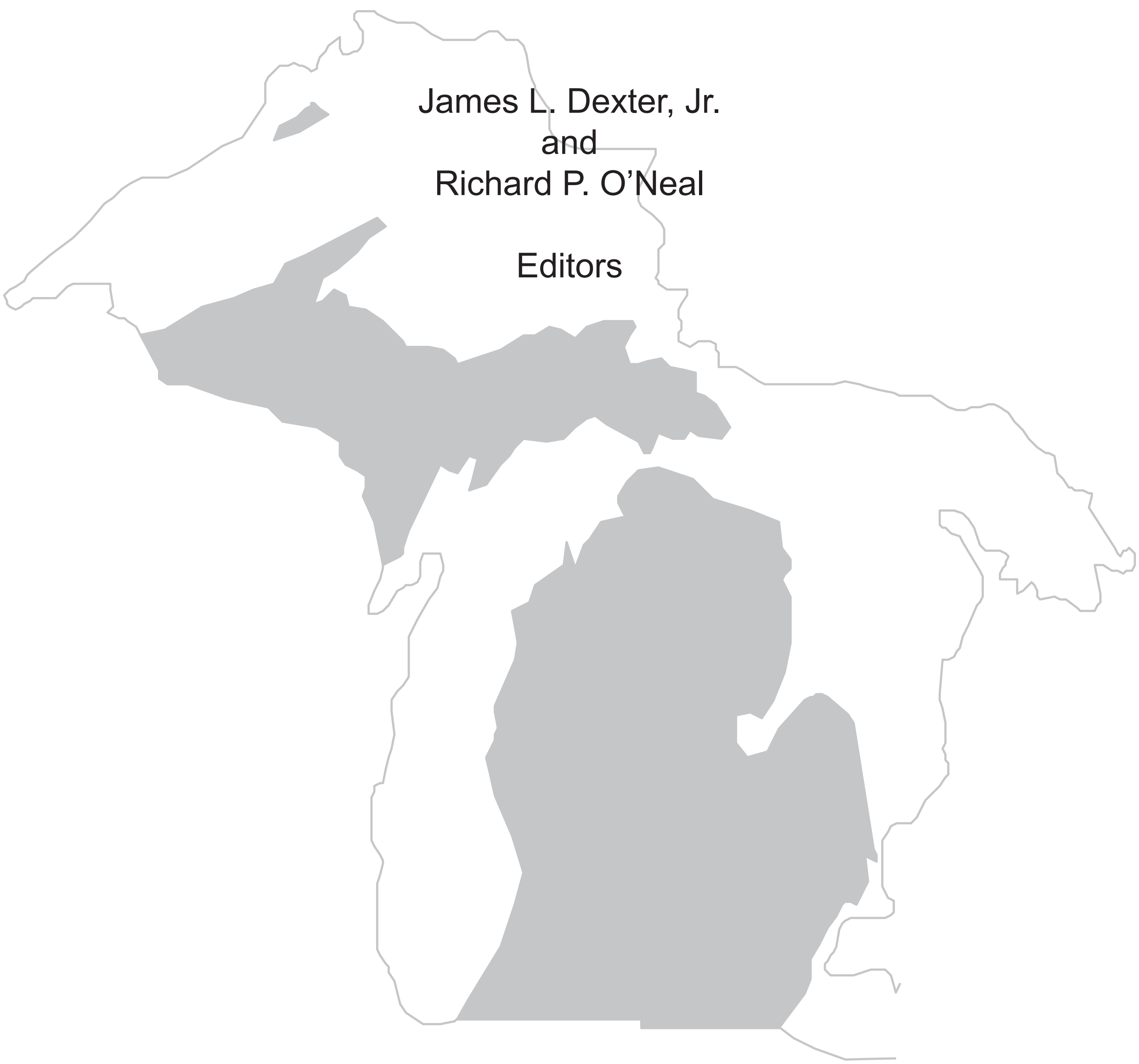
STATE OF MICHIGAN
DEPARTMENT OF NATURAL RESOURCES

Number 32 October 2004

Michigan Fish Stocking Guidelines II: with Periodic Updates



James L. Dexter, Jr.
and
Richard P. O'Neal

Editors

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FISHERIES DIVISION
SPECIAL REPORT

MICHIGAN DEPARTMENT OF NATURAL RESOURCES
FISHERIES DIVISION

Fisheries Special Report 32
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Printed under authority of Michigan Department of Natural Resources
Total number of copies printed 135 — Total cost $1,822.98 — Cost per copy $13.50

Suggested Citation Format

Dexter, J. L., Jr., and R. P. O'Neal, editors. 2004. Michigan fish stocking guidelines II: with periodic updates. Michigan Department of Natural Resources, Fisheries Special Report 32, Ann Arbor.

Acknowledgements

This report was compiled by Fisheries Division employees over a several-year period in an effort to update the Department of Natural Resource's fish stocking guidelines. Substantial effort was put forth to use Michigan research and management examples whenever possible. This is a reflection upon the quality work done by division employees to further the knowledge of these species in our own waters. References from outside of Michigan were also used to either verify our own work, or provide information where it was lacking for Michigan. Contributors to this report are listed alphabetically.

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This report will be updated periodically as new advancements in fish stocking are confirmed effective and implemented.

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Suggested citation:

MDNR (Michigan Department of Natural Resources). 2004. Introduction to Michigan fish stocking guidelines. Chapter 1 *in* Dexter, J. L., Jr., and R. P. O'Neal, editors. Michigan fish stocking guidelines II: with periodic updates. Michigan Department of Natural Resources, Fisheries Special Report 32, Ann Arbor.

Chapter 1: Introduction to Michigan Fish Stocking Guidelines

Fish stocking is an important part of fisheries management programs in Michigan. The stocking of fish in inland and Great Lakes waters has been very successful in creating many new fisheries and rehabilitating many others. Recreation fishing is the largest and highest-valued use of the state's fishery resources. Approximately two million Michigan residents and 334,000 non-resident tourists fish in Michigan each year. Approximately one-third of all recreational fishing in Michigan depends on stocked fish, including a substantial portion of Great Lakes trout and salmon fishing. In fiscal year 2003-04, fish production in Michigan cost $7,242,118, which accounted for 29.5% of the Fisheries Division's budget. Anglers spend approximately $850 million per year with effects on the tourism and fishing equipment sectors of Michigan's economy of $2.0 billion per year.

All fish found in the Great Lakes, bays of the Great Lakes, connecting waters between those lakes, and inland lakes and streams are property of the State of Michigan (Michigan Compiled Laws § 324.47301 and § 324.48702(1)). Under the public trust doctrine, Michigan holds all fish within Michigan's jurisdictional waters in trust for the benefit of the people of Michigan. Michigan's obligation to preserve and protect its resources is prescribed by Article 4, § 52 of the Michigan Constitution. The Michigan Legislature has implemented this constitutional mandate by establishing the Michigan Department of Natural Resources (MDNR, in the Natural Resources and Environmental Protection Act, 1, Act 451, Part 5, § 324.501), and established duties for the Department (in Act 451, Part 5, § 324.503): "The department shall protect and conserve the natural resources of this state; provide and develop facilities for outdoor recreation; …prevent and guard against the pollution of lakes and streams within the state and enforce all laws provided for that purpose with all authority granted by law; and foster and encourage the protection and propagation of game and fish". The department has authority to regulate the taking or killing of fish, animals, or game birds for protection or preservation purposes, and may promulgate rules and orders as necessary under Act 451, Part 411, § 324.41102. The Department has the authority to regulate stocking of spawn, fry, or fish into public waters under Act 451, Part 487; and the Department has the authority to regulate the importation of game fish and eggs under Act 451, Parts 459 and 487. The importation of Oriental weatherfish *Misgurnus anguillicaudatus*, grass carp *Ctenopharyngodon idellus*, ide *Leuciscus idus*, rudd *Cardinius erythrophthalamus*, bitterling *Rodeus sericeus*, tench *Tinca tinca*, and species in the Family *Salmonidae* are prohibited without permit, under Department of Natural Resources Administrative Rules R299.1051 et seq.

Under the authority of Part 413 of 2003 PA 270 it is unlawful to possess or transport any live transgenic (genetically engineered) organisms or the following nonnative fish: bighead carp *Hypophthalmichthys nobilis*, black carp *Mylopharyngodon piceus*, silver carp *Hypophthalmichthys molitrix*, grass carp *Ctenopharyngodon idellus*, members of the family Channidae (known as snakeheads), Japanese weatherfish, ide, rudd, bitterling, and tench. Under the authority of Part 411 of 1994 PA 451, FO-209.03, it is unlawful to possess or transport Eurasian ruffe *Gymnocephalus cernuus*, tubenose goby *Proterorhinus marmoratus*, or round goby *Neogobius melanostomus*.

The Department regulates stocking in public waters, including the Great Lakes and connecting waters, inland waters with public access, and all water bodies connected by intermittent or permanent streams and channels to public waters. Private waters are those entirely confined by private land, with no connections to public waters. A determination of whether a water body is public or private is sometimes difficult to make because of historical precedents and various legal issues. For information regarding public and private waters in Michigan, refer to "Guide to Public Rights on Michigan Waters" (Anonymous 1993).

Fisheries Division has various policies that aid in guiding fish stocking programs. Fisheries Division has specific procedures for preparing and approving fish stocking recommendations. Stocking recommendations are developed by management and research biologists for individual water bodies. These recommendations are peer reviewed and evaluated at various administration levels prior to approval for stocking. Evaluations are required to determine the effectiveness of stocking in each water body (Borgeson 1987).

There are four purposes for stocking fish. These include: restoration of fish populations; provide diverse sportfishing opportunities (introductory, continuous, and supplemental stocking), improve ecosystem balance; and aid experimental studies. Consideration of numerous factors is needed in making recommendations for each water body. Some of these include: costs, benefits, affects on the aquatic community, genetic effects on existing fish populations, biological soundness, community support, geographical need, existing regulations, and availability of fish. Protecting and restoring habitat is usually the most important method for managing self-sustaining fish communities. Stocking is usually not recommended where fish populations are self-sustaining. Stocked fish can negatively affect healthy fish communities through degradation of genetic fitness (Kapuscinski and Jacobson 1987), competition, predation, and other biological factors. Stocked fish generally demonstrate poor survival in the presence of healthy fish populations, so benefits are usually small and sometimes lacking. Expected and demonstrated benefits of stocking programs must be reasonable because these programs are expensive. To assess the success of management actions in areas of natural reproduction, hatchery stocks should be uniquely marked to distinguish hatchery and wild fish, and to assess possible hatchery-wild interactions.

The stocking of fish is one method available to fisheries mangers to assist in the management of fisheries resources. This publication is intended to be a guide for managers to assist in determining the appropriate time, place, and quantities of fish to stock in order to meet specific management objectives. These guidelines will be updated, as new information becomes available. Other information that can be consulted regarding fish stocking and management in Michigan include Fisheries Division's Broodstock Management Proposal and Manual of Fisheries Survey Methods (Schneider 2000).

1.1 Historical Stocking Perspective

Stocking of fish by the State of Michigan began in 1874 when Atlantic salmon *Salmo salar* fingerlings were released from the Crystal Springs State Fish hatchery near Niles (Anonymous 1974). Stocking was initiated to replenish perceived depletion of native stocks and to establish new species such as rainbow trout *Onchorhyncus mykiss* and brown trout *Salmo trutta.* During the following 125 years, practically every potentially useful species has been stocked.

During the early development of culture techniques in Michigan, most fish (predominantly trout and lake whitefish *Coregonus clupeaformis*) were stocked as sac-fry or fry. Soon after 1930, stockings gradually shifted away from fry stockings toward larger fingerlings and in the 1940s began to shift to sizes large enough for legal harvest. The stocking of legal-sized trout intensified in the 1950s and 1960s, and then ceased due to a change in statewide stocking policy. Since 1965, our stocking program has emphasized yearling sub-legal trout (put-grow-take), because that size optimized costs and benefits.

Rearing the youngest fish (sac-fry) is obviously cheaper than fry, fingerlings, or yearlings. However, numerous studies have shown that larger fish often survive better in the wild. Stocking catchable-fish can produce unwanted results in terms of human behavior (crowds and truck chasing). Other studies have shown that stocking fish may compete with wild fish (Bachman 1984 and Vincent 1987). While stocking large fish can be beneficial, managers must consider both the costs and benefits in determining the best size of fish to stock.

While the majority of fish stocking by the state has involved coldwater species, large numbers of coolwater and warmwater species were stocked during the first half of the 1900s. By 1947, most stocking of warmwater fish had stopped (Cooper 1948) because most lakes already contained the desired species, and most of these species reproduced well enough that additional stocking was not warranted. This may not be true for some species unable to reproduce naturally, most notably walleye *Sander vitreus.*

1.2 References

Anonymous. 1974. Michigan fisheries centennial report, 1837 - 1973. Michigan Department of Natural Resources, Fisheries Management Report 6, Lansing.

Anonymous. 1993. A guide to public rights on Michigan waters. Michigan Department of Natural Resources, Law Enforcement Report 9, Lansing.

Bachman, R. A. 1984. Foraging behavior of free-ranging wild and hatchery brown trout. Transactions of the American Fisheries Society 113:1-32.

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Cooper, G. P. 1948. Fish stocking policies in Michigan. Michigan Department of Natural Resources, Fisheries Research Report 1167, Ann Arbor.

Kapuscinski, A. R., and L. D. Jacobson. 1987. Genetic guidelines for fisheries management. University of Minnesota, Minnesota Sea Grant, Sea Grant Research Report 17, Duluth.

Schneider, J. C., editor. 2000. Manual of fisheries survey methods II: with periodic updates. Michigan Department of Natural Resources, Fisheries Special Report 25, Ann Arbor.

Vincent, E. R. 1987. Effects of stocking catchable-size rainbow trout on two wild trout species in the Madison River and O’Dell Creek, Montana. North American Journal of Fisheries Management 7:91-105.

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Chapter 2: General Guidelines

Suggested citation:

MDNR (Michigan Department of Natural Resources). 2004. General guidelines. Chapter 2 *in* Dexter, J. L., Jr., and R. P. O'Neal, editors. Michigan fish stocking guidelines II: with periodic updates. Michigan Department of Natural Resources, Fisheries Special Report 32, Ann Arbor.

Chapter 2: General Guidelines

The protection, maintenance, and creation of high quality and productive fisheries in the public waters of this state are primary fisheries management objectives of the Michigan Department of Natural Resources. The MDNR may undertake the following activities to accomplish this objective: collect fish and eggs; rear and stock fish; construct, maintain, and operate spawning areas and rearing ponds; transfer and stock wild fish; and regulate private stocking. Stocking new or existing species can be undertaken provided certain criteria are met. Consulting the American Fisheries Society guidelines (Appendix 2.1, Kohler and Courtenay 1986) for the introduction of aquatic species can assist biologists in evaluating stocking potential.

2.1 Introducing a New Species

Fish may be introduced into public waters to establish new species or reestablish extirpated species, provided these criteria is met:

- Biological expectation exists that the quality of the fishery or fish community will be improved.
- There is reasonable biological expectation the quality of the existing fishery or fish community will not be diminished.
- The species can be expected to maintain itself through natural reproduction or by continued stocking if management objectives are met.
- Specific authorization for the Department is obtained for stocking species not indigenous to Michigan.
- Consultation with neighboring fish management agencies and the Great Lakes Fish Commission must precede any action to introduce a new species.

2.2 Continuous and Supplemental Stocking

Fish may be stocked to maintain or improve fisheries, or supplement self-sustaining populations, provided at least one of these criteria is met:

- Natural reproduction and survival are inadequate to maintain the fishery.
- There is reasonable biological expectation the quality of the existing fishery or fish community will not be diminished.
- The fishery produced justifies the cost of the program.

2.3 Stocking in Public Waters

The MDNR may authorize the stocking of fish obtained from private sources into public waters. Individuals or interested groups must submit permit applications and obtain a fish stocking permit from the Department. Fish must be obtained from licensed Michigan game fish breeders, or approved out-of-state sources. Permits can be issued provided the Department is satisfied the proposed stocking program is biologically sound, it will improve public resources, it will not cause harm to existing biological communities, and stocking is consistent with existing and future management goals of the Department.

Management goals must be clearly established for private stocking into public waters. Proposals in conflict with management of public trust resources should not be approved. For example, stocking trout into streams with naturally reproducing populations is often not effective and can harm existing populations. Brown trout can affect brook trout *Salvelinus fontinalis* populations, so stocking of brown trout may not be warranted in brook trout streams. Stocking predators can affect forage species populations. In most situations, northern pike *Esox lucius*, muskellunge *Esox masquinongy*, and walleye should not be stocked in association with trout. Stocking proposals inconsistent with good management practices should be discussed with the sponsor. Consultation and withdrawal of improper stocking proposals by applicants is a better resolution than direct denial of permits.

The Department may form partnerships with communities and volunteers interested in assisting with rearing and stocking programs. Partnerships can help reduce Department stocking costs (O'Neal 1998). Partnership responsibilities should be documented with written agreements between the Department and individual partners (Appendices 2.2 and 2.3). Agreements need to establish authority of the Department for assurances of fish health in the rearing program, and the location where fish will be stocked. The agreement should also establish responsibility for program expenses, data collection, and notification of problems and program completion. For liability purposes, individual volunteers directly involved in manual labor, working on state properties, or using state equipment or vehicles, must sign the Department's volunteer agreement (Appendix 2.4). Partnerships can be established if the program provides public benefit, the Department is assured of the biological soundness of the problem, and the Department is confident the partner can complete the responsibilities outlined in the agreement.

Species that typically are reared under partnership agreements include walleye, northern pike, and various salmonids. Partners generally rear fingerling walleye in earthen ponds, and these programs have economic and management benefits to Michigan's walleye rearing and stocking program (O'Neal 1998). Northern pike rearing partnerships generally are established on lakes that have inadequate natural reproduction. Salmon and steelhead partnership programs have been established to attempt improvements in survival and imprinting of these species. Generally, partners hold salmon or steelhead *Onchorhynchus mykiss* in ponds or pens for a period of time to increase size at stocking, and to improve imprinting to the stocking location. The effectiveness of the salmon-steelhead rearing and imprinting programs is being evaluated.

2.4 Stocking in Private Waters

The Department may stock fish into private waters provided a written agreement has been acquired assuring adequate public access. Adequate public access must assure the water body will be open to public fishing long enough to utilize the stocked fish. Notification of public access must be posted at the access site. All considerations listed in the section "*Stocking in Public Waters*" must be followed.

The Department may stock fish in private waters where the Department has removed fish. This sometimes occurs when the Department conducts research studies on private lakes.

Authorization from the Department is not required for stocking fish in private waters that have no connection at any time of year to other public or private waters. This is provided such that fish are acquired by legal angling methods, by transfer from other private waters, or by purchase from licensed Michigan game breeders.

The state does not supply fish for use by private parties but telephone consultation services and literature may be provided. The publication "Managing Michigan Ponds for Sportfishing" (Schrouder et al. 1994) is a good source of information. This publication, along with other material, is available through Michigan State University, Extension Services. The U.S. Department of Agriculture, Natural Resources Conservation Service, also provides assistance to agricultural communities. Fish may be purchased from licensed Michigan game fish breeders. The Michigan Department of Agriculture annually updates a game fish breeder's list and copies are available to interested individuals. Fish taken legally from public waters may be stocked into private waters. Often, this is the easiest and least expensive way to stock bass and panfish into private ponds.

2.5 Genetic Issues

Effort should be made by managers to maintain unique local genetic integrity. Survival of wild fish can be negatively effected by interactions with hatchery stocks (Bachman 1984; Vincent 1987). Diversity among populations is adaptive in the sense that differences have accrued over time in response to local environmental regimes.

Naturalized populations have already been subjected to selection at some level and have shown themselves to be adapted to local conditions. The release of multiple strains (of a species) into the same area should be avoided if the management goal is to establish or supplement a naturalized population.

Stocking has the potential to cause a loss of genetic diversity and possible reduction in fitness due to outbreeding depression. Stocking options should be constructed according to specific needs and situations. In closed aquatic systems, maintained solely by stocking, it is recognized that stocking multiple strains will not impair natural diversity.

Genetically altered fish may be able to interbreed with natural populations. This poses a genetic hazard of losing a taxonomically distinct population of native fish. These distinct wild populations are an irreplaceable reservoir of genes. Interbreeding could reduce fitness and productivity of a wild population due to outbreeding depression. The Department will generally not issue permits to stock genetically altered fish.

2.6 Fish for Research Purposes

Fish may be provided by the Department to public or private institutions for research purposes. Formal requests for fish must be submitted to the Department.

2.7 References

Bachman, R. A. 1984. Foraging behavior of free-ranging wild and hatchery brown trout. Transactions of the American Fisheries Society 113:1-32.

Kohler, C. C., and W. R. Courtenay, Jr. 1986. American Fisheries Society position on introduction of aquatic species. Fisheries 11:39-42.

O'Neal, R. P. 1998. Costs of rearing and stocking walleye in Michigan during 1994. Michigan Department of Natural Resources, Fisheries Division, Technical Report 98-2, Ann Arbor.

Schrouder, J. D., C. M. Smith, P. J. Rusz, R. J. White, D. L. Garling, and G. R. Dudderar. 1994. Managing Michigan ponds for sports fishing. Third Edition. Michigan State University Extension, Bulletin E1554, East Lansing.

Vincent, E. R. 1987. Effects of stocking catchable-size rainbow trout on two wild trout species in the Madison River and O'Dell Creek, Montana. North American Journal of Fisheries Management 7:91-105.

2.8 Appendices

Appendix 2.1. American Fisheries Society position on introductions of aquatic species (Kohler and Courtenay 1986).

Appendix 2.2. Criteria for cooperative fish rearing projects.

Appendix 2.3. Agreement between fish rearing pond or net-pen cooperative associations and the Fisheries Division, Michigan Department of Natural Resources.

Appendix 2.4. Department volunteer agreement form.

Appendix 2.1–American Fisheries Society position on introductions of aquatic species (Kohler and Courtenay 1986).

Introduction of Aquatic Species

The increased frequency of inter- and intranational transfers of aquatic species has prompted concern relative to the potential for debasement of aquatic community integrity. Natural resource managers concur that substantially improved measures can and should be taken to increase the odds that benefits of a given introduction will exceed risks. Impacts of introduced aquatic organisms on native aquatic communities in North America can be classified into five broad categories: habitat alteration, trophic alteration, spatial alteration, gene pool deterioration, and introduction of diseases.

Habitat impacts produced by introduced plants that produce excessive growth include interference with swimming and fishing activities, disruption of predator-prey relationships by providing too much cover, and disruption in water quality by plant growth and decomposition. Fish, such as grass carp, introduced to control vegetation can overly decimate exotic as well as non-target native vegetation, which, in turn, limits fish nursery areas, causes bank erosion, and accelerates eutrophication through release of nutrients previously stored in the plants.

Introduction of any species into a novel environment may alter community trophic structure, and the nature and extent of such changes are complex and unpredictable. There is little doubt that when an introduced fish exhibits explosive population increases, substantial changes in native communities must occur. Documentation of predation by introduced species on native species serves as the most definitive example of impacts on communities. Concomitant overlap in use of space by non-native and native fishes may lead to competitive interaction if space is in limited supply or of variable quality. High densities of introduced fish have been shown to exert negative effects on native fishes.

Reduction of heterogeneity through inbreeding is clearly a threat to any species being produced in a hatchery. The risk is most acute with species of intercontinental origin because the initial broodstock invariably represent limited gene pools at the outset. The larger the stocking program, the more inbreeding among original broodstock is necessary. Thus species introduced to a novel habitat may or may not have the genetic characteristics necessary to adapt and perform as predicted. The possibility of native gene pools being altered through hybridization also exists.

Diseases caused by bacteria, viruses, and parasites are all too often conveyed along with introduced aquatic species. This aspect represents one of the most severe threats that an introduced species may pose to a native community.

The AFS policy regarding introduction of aquatic species is to:

1. Encourage fish importers, farmers, dealers, hobbyists, and shipowners to prevent the accidental or purposeful introduction of aquatic species into local ecosystems.

2. Urge that no city, county, state, province, or federal agency introduce, or allow to be introduced, any species into any waters within its jurisdiction that might contaminate any waters outside its jurisdiction without official sanction of the exposed jurisdiction.

3. Urge that only ornamental aquarium fish dealers be permitted to import such fishes for sale or

Appendix 2.1–Continued.

distribution to hobbyists. The "dealer" would be defined as a firm or person whose income derives from live ornamental aquarium fishes.

4. Urge that importation of fishes for purposes of research not involving introduction into a natural ecosystem, or for display in public aquaria by individuals or organizations, be made under agreement with responsible government agencies. Such importers should be subject to investigatory procedures currently existing or to be developed, and species so imported shall be kept under conditions preventing escape or accidental introduction. Aquarium hobbyists should be encouraged to purchase rare ornamental fishes through such importers. No fishes should be released into any natural ecosystem upon termination of research or display.

5. Urge that all species considered for release be prohibited and considered undesirable for any purposes of introduction into any ecosystem unless that species has been evaluated upon the following bases and found to be desirable:

• ***Rationale***. Reasons for seeking an import should be clearly stated and demonstrated. It should be clearly noted what qualities are sought that would make the import more desirable than native forms.

• ***Search***. Within the qualifications set forth under *Rationale*, a search of possible contenders should be made, with a list prepared of those that appear most likely to succeed, and the favorable and unfavorable aspects of each species noted.

• ***Preliminary Assessment of the Impact***. A preliminary assessment should go beyond the area of ***Rationale*** to consider impact on target aquatic ecosystems, on game and food fishes or waterfowl, on aquatic plants, and on public health. The published information on the species should be reviewed and the species should be studied in preliminary fashion in its biotype.

• ***Publicity and Review***. The subject should be entirely open and expert advice should be sought. It is at this point that thoroughness is in order. No importation is so urgent that it should not be subject to careful evaluation.

• ***Experimental Research***. If a prospective import passes the first four steps, a research program should be initiated by an appropriate agency or organization to test the import in confined waters (experimental ponds, etc.).

• ***Evaluation or Recommendation***. Complete reports should be circulated among interested scientists and presented for publication.

• ***Introduction***. With favorable evaluation, the releases should be effected and monitored, and the results should be published or circulated.

6. Urge that international, national, and regional natural resource agencies endorse and follow the above stated AFS policies.

7. Encourage international harmonization of guidelines, protocols, codes of practice, etc., as they apply to introduction of aquatic species.

8. Urge fisheries professionals and other aquatic specialists to become more aware of issues relating to introduced species.

Appendix 2.2–Criteria for cooperative fish rearing projects.

Michigan DNR

Criteria for Cooperative Fish Rearing Projects

Concern about changing fish communities in Lakes Michigan and Huron has led to increased public interest in cooperative fish imprinting projects that may improve performance of stocked salmonids. Expanded walleye fishing opportunities have been provided statewide through cooperative rearing programs with local/state participation. Many other cooperative projects involving other species (bass, pike, musky, trout, pan fish, etc.) have also been successfully conducted. The following criteria are offered to help guide development of these projects.

1. The Michigan Department of Natural Resources (MDNR), Fisheries Division supports partnership opportunities such as cooperative net pen and rearing pond facilities. Fisheries Division is involved in over 300 such partnerships statewide.

2. It is important to understand that there are legitimate risks to the fishery by employing these techniques statewide. These risks may include:

   - Fish mortality due to disease and mishandling;
   - Water quality degradation;
   - Negative impacts associated with fish distribution in the lakes and streams.

   Benefits of cooperative projects may include:

   - Expansion of fish rearing and management options;
   - Improved imprinting (anadromous stocks);
   - Provides the public an additional avenue to provide support to the management of the fishery resources of the State.

Based on the considerations discussed above, Fisheries Division will support new cooperative fish holding and other rearing projects provided the following criteria are met:

1. Local groups must assume the risks and expense involved;

2. Lakewide and statewide interests must supersede local fishery improvement desires;

3. Fisheries Division must be assured there will be no negative impacts (from current and future evaluations);

4. Water quality at the fish holding site must be maintained;

5. The planned project is compatible with the fish community objectives for the water involved; and

6. A memo of understanding (Cooperative Rearing Agreement) between each group and the MDNR Fisheries Division will be developed to protect local and statewide interest.

Local sponsors for new cooperative projects meeting these criteria are encouraged to work through the appropriate MDNR Fisheries Division Management Unit Supervisor.

10/07/03

Appendix 2.3–Agreement between fish rearing pond or net-pen cooperative associations and the Fisheries Division, Michigan Department of Natural Resources.

Michigan DNR

Agreement

Between Fish Rearing Pond and Net-Pen Cooperative Associations
and
the Michigan Department Of Natural Resources, Fisheries Division

This agreement is made and entered into between the Cooperative Association or group (named below) and the Fisheries Division, Michigan Department of Natural Resources (MDNR), herein after named the Fisheries Division.

Name of Cooperative Association: ______________________________

Purpose:

It is the mutual desire of the Cooperative Association and the Fisheries Division to maintain and improve the quality of the fisheries in the State of Michigan. It is the assumption of the parties that:

1) temporarily holding MDNR hatchery salmonids in rearing ponds or pens, prior to release, may improve the condition and survival of smolts and increase homing of adult fish to the area:
2) the rearing of species other than salmonids may assist the Division in its goal of improving inland fisheries by stocking fish that at present cannot be reared by the MDNR in sufficient quantity.

Fisheries inventories are currently underway by Fisheries Division to evaluate the effectiveness of rearing ponds and net pens. Final results of this research will not be available for several years until these marked fish are collected as adults. An evaluation of the project results will be made at that time.

Understanding:

The parties recognize that Fisheries Division is responsible for managing Michigan's fisheries resources and that fish stocked into ponds or pens *are the property of the State.* The Cooperators understand the risks inherent in this undertaking and that the Fisheries Division may not restore or restock fish lost to high water, unstable water temperatures, water quality, vandalism, mechanical failure or other natural or man-made circumstances.

The Cooperators must assume the responsibility for the care of any fish after the Fisheries Division places them in the holding facilities. The Cooperators recognize that they must bear all financial responsibility associated with the construction, operation, and maintenance of the holding facilities (with the sole exception of fish food for net pen projects). For Great Lakes stockings, all fish stocked into the holding facility must be released promptly at smolting directly to the waters designated by the Fisheries Division, or as directed by Fisheries Division (due to adverse conditions of the receiving water). For inland stockings, all fish harvested from rearing ponds will be stocked at locations decided upon mutually by the cooperator and the MDNR representative. Excess (surplus) fish to stated needs will be stocked at locations decided upon solely by the MDNR representative.

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Appendix 2.3–Continued.

Agreement:

It is mutually agreed that:

1. Fisheries Division will provide the fish as determined by each individual agreement at a specific stocking site determined by the Cooperators. Notification will be in a timely manner assuring adequate time to prepare the net pens, site, and or rearing pond.
2. Fisheries Division will require adequate facilities at the rearing site. Fish will be stocked at the site they are reared. The Cooperative Association understands replacement fish will not be available should a catastrophe occur during the project. Fish will be stocked (released from the rearing facility) within a specified time period determined by the MDNR, and within specific water temperatures in the receiving water (as written above). Occurrence of smolting will also determine time of stocking. Timing of stocking is determined by 1) water temperature of the receiving water, 2) occurrence of smolting (anadromous species), 3) size of reared fish in relation to natural foods present (particularly walleye).
3. Fisheries Division will purchase fish food and develop a feeding schedule for the project if it involves anadromous species.
4. The Cooperative Association will be responsible for maintaining the health of the fish during the rearing period. This will include maintaining proper feeding schedules based on fish size and determining health problems with the fish. Should health problems occur, the Association will be responsible for communicating and providing samples (live samples are preferred) directly to the Department of Pathobiology and Diagnostic Investigation, Dr. Mohamed Faisal, College of Veteniary Medicine, Michigan State University, A-532 Fee Hall, East Lansing, MI 48824. Telephone numbers include 517-432-8259, 517-432-8762. Alternately, the Association can contact the hatchery facility they are working with 2 days in advance to coordinate shipment of samples.
5. The Cooperative Association will be responsible for providing, maintaining and storing all equipment necessary to complete the pond or net-pen rearing project. This includes installation and removal of nets, freezers for food, measuring and sampling equipment.
6. The Cooperative Association will be responsible for providing personnel to provide arrangement and assistance to the hatchery for stocking the fish into the rearing pond or pen. Hatcheries will provide at lease two days notice to the contact before fish are transported to the rearing site. (Wolf Lake Hatchery - 269/668-2696; Platte River Hatchery - 231/325-4611, Thompson Hatchery – 906 –341-5587).
7. The Cooperative Association will be responsible for transporting the required amount of food from the hatchery to the rearing site (anadromous species).
8. The Cooperative Association will be responsible for providing a final fish stocking report to MDNR Management Unit supervisor on numbers stocked, mortalities and sizes of fish stocked, including such items as average lengths and average number of fish per pound. (Form Attached).
9. The Cooperative Association will be responsible for notifying Management Unit Fisheries Personnel at least one day prior to release of the fish.
10. This agreement may be terminated by either party upon thirty- (30) day's notice to the other of such intent or at any time by mutual consent.

In Witness whereof the parties have signed their names effective the day and year written below:

Name of Cooperative Association: ______________________________

Association Representative: ______________________ Date: ______________

Association Hatchery Contact: ______________________ Telephone Number: (___)__________

10/07/03 2

Appendix 2.4–Department volunteer agreement form.

DNR MICHIGAN DEPARTMENT OF NATURAL RESOURCES

VOLUNTEER RELEASE AND WAIVER OF LIABILITY

This information is required by authority of the Michigan Department of Natural Resources, for volunteer assignment consideration.

Please read carefully! This is a legal document that affects your legal rights!

The Michigan Department of Natural Resources (MDNR) encourages and supports volunteers. As a volunteer, I have an important role in providing services and programs to the public.

I want to work as a volunteer for the MDNR which appoints people like me to serve and to help the MDNR. While I am serving as a volunteer, I have the same immunity from civil liability under Michigan law as an employee of the MDNR. After becoming a volunteer, the MDNR will provide me with support, supervision, training, and supplies for me to accomplish my assigned tasks.

Therefore, I do freely, voluntarily, and without duress, execute this Release and acknowledge the following terms:

1. **Waiver and Release.** I hereby release, waive, discharge and covenant not to sue the State of Michigan, its departments, officers, employees and agents, from any and all liability to me, for all losses, injury, death or damage, and any claims or demands thereto, on account of injury to person or property, or resulting in my death in reference to the activities authorized in my work as a volunteer. I hereby covenant and agree to indemnify and save harmless, the State of Michigan, its departments, officers, employees and agents, from any and all claims and demands, for all loss, injury, death or damage, that any person or entity may have or make, in any manner, arising out of any occurrence related to the activities authorized in my work as a volunteer.
2. **Medical treatment.** I release and discharge MDNR from any claim that arises or may arise due to any first aid, medical treatment, or service rendered to me. I understand that I may not be entitled to workers' compensation.
3. **Assumption of risk.** I understand that my work for the MDNR may include activities that may be hazardous. I assume the risk of injury or harm in those activities I choose to do and release the MDNR from all liability for injury, illness, death, or property damage occurring from my work for the MDNR.
4. **Insurance.** MDNR does not have responsibility for providing any health, medical or disability insurance coverage for me. IT IS MY RESPONSIBILITY AS A VOLUNTEER TO INSURE I HAVE MEDICAL/HEALTH INSURANCE. As with other members of the public, I may file a claim with the State Administrative Board for personal losses that are under $1,000.
5. **Photographic release.** I grant to MDNR the right to use photographic images and video or audio recordings of me that are made by MDNR or others during my work assignment for MDNR, including royalties, proceeds or other benefits from use of the photographs or recordings.
6. **Copyright laws.** I understand that showing videos in public that are intended for home viewing is prohibited under the U.S. copyright laws.
7. **Background check.** I understand that a criminal history check may be obtained prior to my appointment as a volunteer. By signing this agreement I agree to a criminal history check and agree to provide MDNR with my birth date.
8. **Discrimination laws.** I agree to follow DNR's policy along with state and federal laws that forbid discrimination in employment, education, housing, public accommodation, law enforcement or public service based on a person's religion, race, color, national origin, age, sex, marital status, height, weight, or disability.
9. **In-kind service.** The MDNR is eligible for some grants that require us to match the dollars received from the grant. Many of these grants allow us to use in-kind services as a portion of this match instead of actual dollars. Your volunteer time may be used as an in-kind service to help us earn our match for some grants from federal or other sources. By signing this form, you consent to the use of your volunteer time as a possible in-kind match for grants received by the MDNR.
10. **Other.** I agree that this Release is intended to be as broad and inclusive as permitted by the laws of Michigan, and that this Release is governed by and will be interpreted according to the laws of Michigan. I understand that should any part of this Release be ruled invalid by a court, the other parts will remain valid and continue to be in effect.

	Volunteer From:	*To:*
Name (please print)	*Date*	*Date*
Signature	*Date of Birth*	
Signature of Parent/Guardian		

PR0511 (04/22/2004)

Appendix 2.4–Continued.

MICHIGAN DEPARTMENT OF NATURAL RESOURCES

VOLUNTEER PROJECT AGREEMENT

By authority of the Michigan Department of Natural Resources, completion is required for volunteer assignment consideration.

Group or Organization Sponsoring Activity (optional):	Group/Organization Telephone No.: ( )
Volunteer's Name (Last, First, M.I.):	Volunteer's Social Security Number:
Street Address	If Group, # of Individuals:
City, State, Zip Code	Volunteer's Telephone No.: ( )
In Case of Emergency Contact (Name):	Emergency Contact Telephone No.: ( )

How did you learn about the DNR volunteer program? ☐ News Media ☐ DNR Employee ☐ Other *(Explain)*: ____________________

Please list references from previous volunteer experiences (attach additional sheet as necessary):

____

____

Why do you want to volunteer? ____________________

____

____

Additional comments/considerations you want the DNR to be aware of: ____________________

____

____

Time Periods You Are Available: ☐ Year-Round ☐ Only During the Following Months: (*Example: From April to July, etc.)* ____________________

Days And Times Most Convenient For You: ☐ Weekdays ☐ Weekends ☐ AM ☐ PM

Maximum Time Commitment: __________ Indicate Hours: ____________________

Do you have a vehicle and/or equipment you are licensed to operate which you are willing to use in the course of your volunteer assignment? ❑ Yes ❑ No

Are you interested in donating project materials, money, etc. for DNR volunteer projects? ❑ Yes ❑ No

In accepting an assignment as a volunteer with the Michigan Department of Natural Resources, I, the Volunteer, will, to the best of my ability, perform the tasks set forth in my assignment description and abide by the same rules and regulations applicable to the conduct of state employees.

I understand that:

- I shall not receive compensation for work performed, but may be reimbursed under some circumstances for documented expenses pre-authorized and approved by the DNR.
- I may be required to prepare, complete and sign tracking sheets or reports using forms or guidelines provided by the DNR in order to document the time spent on a project and the task performed.
- I may not be entitled to workers' compensation or liability protection.
- Either the DNR or I, the Volunteer, may cancel this agreement at any time and that cancellation must be in writing.
- In accepting the services of a volunteer, the Department of Natural Resources will, to the best of its ability, provide appropriate supervision, training and supplies for the volunteer to carry out assigned tasks.

I agree to abide by Department Policy, State and Federal laws which prohibit discrimination in employment, education, housing, public accommodation, law enforcement or public service based on religion, race, color, national origin, age, sex, marital status, height, weight, arrest record, or handicap.

VOLUNTEER AGREEMENT CERTIFICATION

Volunteer's Signature (if minor, parent or guardian)	Beginning Date	DNR Supervisor's Signature	Beginning Date

Page 1 of 2 Volunteer Project Agreement (12/20/2000)

Appendix 2.4–Continued.

PROJECT INFORMATION
(To be completed by Supervisor.)

Project Location (Work Station):

Project Description:

Tasks (Duties to be performed):

Estimated Time	Hours	Day	Dates	Skills/Qualifications	Experience, Training

Orientation/Training Record:

USE THIS SECTION TO REPORT:
- Highlights about the project or volunteer(s) or noteworthy accomplishments or concerns.
- Donated use of privately owned vehicle(s) or equipment.
- Cash or project material.

COMPLETION CERTIFICATION

I have ended my volunteer assignment for the DNR. I understand that I will receive a copy of this report from my supervisor.

Volunteer's Signature | Date | DNR Supervisor's Signature | Date

Retain this completed record at the project location

Distribution:
1 Copy - Retain for Unit
1 Copy - Volunteer
1 Copy - Division Office, Personnel Liaison
1 Copy - Volunteer Coordinator

Page 2 of 2 Volunteer Project Agreement (12/20/2000)

Michigan Fish Stocking Guidelines II: with Periodic Updates

Chapter 3: Departmental Procedures

Suggested citation:

MDNR (Michigan Department of Natural Resources). 2004. Departmental procedures. Chapter 3 *in* Dexter, J. L., Jr., and R. P. O'Neal, editors. Michigan fish stocking guidelines II: with periodic updates. Michigan Department of Natural Resources, Fisheries Special Report 32, Ann Arbor.

Chapter 3

Chapter 3: Departmental Procedures

3.1 Fish Stocking Request and Review Process

Fish stocking requests are prepared by management and research biologists, peer reviewed, and approved at various administrative levels. All fish stocking requests require preparation, and approval, of a fisheries management prescription. Management prescriptions are submitted using Fisheries Division's computerized prescription program. All reviews and approvals are made electronically. Requests must be consistent with Fisheries Division's strategic plan and management policies.

Requests for stocking are usually made for a maximum period of 6 years. This helps facilitate hatchery planning and production targets for future years. Shorter-term requests typically are made for research studies or restoration of depleted populations. Requests must be made for all fish stocked into public and private waters, and administered or purchased by the state. Sources of fish may include Michigan and out-of-state public and private hatcheries, rearing ponds, and transfers of fish from wild sources. Egg and fry requests must also be submitted for rearing pond needs. The filling of approved requests depends on availability of fish and can take several years to accomplish.

3.2 Allocations, Surpluses, and Shortages of Fish

The annual stocking program balances approved requests with available fish, by species and strain. Allocations for each stocking site are provided annually to hatchery and management unit supervisors. Adjustments between stocking sites, within management units, can be made provided there is suitable justification, proper notification, and appropriate approvals have been given.

Minor surpluses and shortages occur annually for most species. Adjustments for minor variances in supply are made to each stocking site automatically by computer and by hatchery staff, within limits set by the approved stocking request.

Major surpluses and shortages (over or under 10% of request) are identified by the hatcheries as early as possible. Adjustments for substantial variances in fish supply are made with coordination between management and administrative units.

3.3 Fish Transfers

Fish may be transferred from one water body to another if certain species and sizes of fish are not available from hatcheries or specific genetic stocks are needed for reproduction. Necessary considerations include disease transfer implications, economic benefits, and potential harm to the source population by a reduction in population numbers. Transfers usually are made for restoration of depleted populations or research studies. However, continuous transfers from a population may sometimes occur.

Species like white bass *Morone chrysops*, black crappie *Promoxis nigromaculatus*, yellow perch *Perca flavescens*, bluegill *Lepomis macrochirus*, flathead catfish *Pylodictis olivaris*, and rainbow smelt *Osmerus mordax* are not produced on a regular annual basis by the hatchery system. Transfers of these species from wild populations often require only small numbers of fish to establish self-reproducing populations in stocked water bodies. Transfers of small numbers of fish from wild populations are usually more economical to fisheries management programs than purchases from private sources or establishment of hatchery rearing programs. Suitable numbers of fish must be transferred to maintain the genetic fitness of a population. Species like chinook salmon

Oncorhynchus tshawytscha, steelhead, and northern pike are sometimes transferred from one location to another to increase reproduction. This occurs when obstructions to spawning grounds are present.

Most species can be transferred successfully when water temperatures are cool and fish are not under spawning stress. Transfers of fish to establish reproduction should be made well in advance of the spawning period. Stresses caused by transfer procedures can inhibit natural reproduction in fish.

Any time fish stocks are going to be transferred from their original sources, consideration should be given to the possible fish disease consequences. Given the diversity of the fish stocks and strains, and the many waters of the state, the health considerations of any proposed transfer will likely vary from case to case. The state fish pathologist should be consulted in these situations.

Introductions of non-indigenous species to new water bodies must be avoided during fish transfers. Examples of non-indigenous species include zebra mussels, white perch *Morone americana*, Eurasian water milfoil Myriophyllum spicatum, and the zooplankter *Bythotrephes cederstroemi*.

The following precautions should be taken when fish transfers are made to water bodies:

- Fish collected from rearing ponds or the wild should be inspected prior to loading on transport units to preclude the likelihood that any life stage of a species may be present that are non-indigenous to the receiving water.
- Water used for transport should not be obtained from a source which may contain any life stage of species that are non-indigenous to the receiving water.
- Disinfection of transportation units and equipment should be done immediately after the transfer is completed (Appendix 3.1).

3.4 Permits and Inspections for Private Stocking

Permits are not required from the Department for private stocking in private waters. Private stocking into public waters requires a permit from the Department (see Appendix 3.2). Management unit personnel usually issue these permits. Permits state the Department's authority to conduct inspections for diseased fish and require stocking reports be submitted within a specific time period.

3.5 Reporting

Public and private stocking into public waters must be reported annually. Individual Management Units have the responsibility for stocking reports. Reports should be made within 1 week of the stocking date. Reporting is made through the computerized fish stocking information system.

3.6 References

Hnath, J. G. 1983. Hatchery disinfection and disposal of infected stocks. Pages 121-134 *in* F. P. Meyer, J. W. Warren, and T. G. Carey, editors. A guide to integrated fish health management in the Great Lakes basin. Great Lakes Fishery Commission Special Publication 83-2, Ann Arbor, Michigan.

Hnath, J. G., J. Timmons, and R. Martin. 1996. Michigan Hatchery Equipment and Transport Unit Disinfection. Michigan Department of Natural Resources, Fisheries Division, Hatchery Section Standard Operating Policies and Procedures, Lansing.

3.7 Appendices

Appendix 3.1. Fish transportation unit disinfection.

Appendix 3.2. Issuance of Fish Stocking Permits: Division Directive FI-120, 1998.

Appendix 3.1.–Fish Transportation Unit Disinfection (R. Martin, Michigan Department of Natural Resources, unpublished data).

Fish transport units and associated equipment must be disinfected prior to entering Harrietta, Marquette, or Oden hatcheries to prevent the introduction of disease organisms to those pathogen-free facilities (Hnath et al. 1996). Stocking units must also be disinfected *anytime* they carry water or fish from an out-of-state hatchery or from a natural body of water to prevent spreading diseases or zebra mussels to a hatchery. The stocking unit tanks and anything on the truck that is exposed to fish or rearing water should be disinfected. This includes the discharge tubes and truck exterior as well as rain gear, waders, gloves, boots, scap nets, buckets, and any other equipment used to handle fish.

It is recommended that each hatchery have a dedicated discharge tube for the occasions when fish are off-loaded at the hatchery. Discharge tubes from the stocking units that have been exposed to water sources away from the hatchery should not be used to off-load fish at a hatchery as they may be contaminated with disease organisms or zebra mussels.

Stocking units should be disinfected with a 20-ppm solution of chlorine (Cl_2) for a period of at least 30 minutes. All exterior surfaces that could have come into contact with fish or rearing water should be sprayed and scrubbed and the Cl_2 solution should be circulated through the tanks and aerators. Buckets, scaps, discharge tubes, and any other equipment used to handle fish should be scrubbed with, or immersed in, the Cl_2 solution.

A 20-ppm Cl_2 solution can be prepared by adding 3.5 g (0.12 oz) of dry HTH powder (70% active) per 100 L (26 gal) of water. This 20-ppm solution can also be made by adding 2.2 L (0.6 gal) of liquid household bleach (5.25% sodium hypochlorite) per 5,680 L (1,500 gal) of water.

The presence of organic materials will create a chlorine demand resulting in less than a 20-ppm residual with the above directions. Therefore, in the presence of significant organic contamination the solution should be tested, and if necessary more chlorine added to achieve a residual of at least 10 ppm.

After the disinfection period, the Cl_2 solution should be dumped a safe distance away from direct drainage into natural waters and where there will be no harmful effects from the chlorine. If necessary, chlorine solution can be neutralized with sodium thiosulfate at a rate of 50 g (1.8 oz) per 100 L (26 gal) of water. Circulate the neutralized water through the aerators and tanks for at least 10 minutes. The chemical orthotolidine can be used to test for residual Cl_2. To do this place, 125-ml (4.25 oz) of water from the stocking unit into each of two clean glass containers. Add one drop of orthotolidine to one of the containers. Set them aside, out of the sun, for 5 minutes and then compare the two containers. If any yellowish color forms in the sample with the orthotolidine the neutralization was not complete and additional sodium thiosulfate needs to be added. Once the neutralization process has been completed, the water can be dumped in a safe place away from direct drainage to natural waters. Sodium thiosulfate is not toxic to fish at this low level (Hnath 1983).

Appendix 3.1.–Continued.

Amount of chemical needed for 20-ppm chlorine solution.

Unit type	Vehicle capacity (gal)	HTH (70% active Cl_2) (g)	HTH (70% active Cl_2) (oz)	Household bleach (5.25% NaClO) (L)	Household bleach (5.25% NaClO) (gal)
Peterson	1,200	160	5.6	1.76	0.46
Manchester	750	100	3.5	1.1	0.29
Intermediate	2,000	265	9.3	2.9	0.76
Semi	3,500	464	16.4	5.1	1.35

Amount of sodium thiosulfate ($Na_2S_2O_3$) needed for Cl_2 neutralization.

Unit type	Tank capacity (gal)	$Na_2S_20_3$ (g)	$Na_2S_20_3$ (oz)
Peterson	1,200	2,271	80.1
Manchester	750	1,420	50.1
Intermediate	2,000	3,786	133.5
Semi	3,500	6,625	233.7

Appendix 3.2–Issuance of fish stocking permits: Division Directive FI-120, 1998.

STATE OF MICHIGAN

JENNIFER M. GRANHOLM
GOVERNOR

DEPARTMENT OF NATURAL RESOURCES
LANSING

K. L. COOL
DIRECTOR

Dear Interested Citizen:

The Departments of Natural Resources and Agriculture welcome your interest in improving fishing opportunities in public waters of Michigan. Both departments are directly involved in managing and regulating the stocking of fish by private parties into waters of the state. Department of Natural Resources (DNR) is the agency responsible for protection and management of fisheries resources throughout the state. Department of Agriculture (MDA) is the agency responsible for oversight of the private aquaculture industry in Michigan, a source from which you can obtain fish for stocking. We have worked together to develop a stocking permit process that provides you with opportunities to stock fish as a private party, yet maintains protection of the state's fisheries resources.

As a private party, you may wish to stock fish into public waters of the state. To do so requires a permit from DNR. This permit is required to ensure that fish to be stocked are:

1) healthy and will not pose a disease risk to populations in the wild;
2) a species that currently exists in the watershed and do not pose long term management problems; and
3) a species that is compatible with the overall fishery management goals in a watershed.

The permit process ensures protection of the state's fisheries resources by preventing potential long range and expensive problems before they occur, thus improving fishing opportunities for all.

The permit process is detailed in the attached materials. It requires a purchaser or their agent to first determine if the water body to be stocked is public or private. Water bodies that have permanent inlets or outlets will require a permit, as fish will escape from these waters into public waters. Waters with no permanent inlets or outlets do not require a permit. Waters that have been stocked in the past by the state require a permit along with those that have public access. If you are unsure about the status of the water body you wish to stock, please contact any of our Fisheries Management Unit offices for assistance (see Table 1).

If the water body to be stocked is public, you will need to fill out an application (attached) and specify what species and how many fish you intend to stock. This allows

STEVENS T. MASON BUILDING ● P.O. BOX 30028 ● LANSING, MICHIGAN 48909-7528
www.michigan.gov ● (517) 373-2329

Appendix 3.2–Continued.

DNR to determine if the species is permitted for stocking, and if it is compatible with management goals established for the watershed. It is also important for you to determine if the source from which you intend to obtain the fish is free of certain fish diseases (see Table 2), so be sure to enquire about the fish disease certification status of the source you intend to use. DNR recommends that any applicant obtain a copy of the disease certification from the source, as fish must be certified disease-free for stocking in waters of the state. Although providing a copy of the disease certification with your application will speed the processing of the permit, it is not a necessary step.

After you fill out the application form, submit it to the Fisheries Management Unit (see Table 1) responsible for the watershed in which you wish to stock fish. If you need help determining the right office, feel free to contact any Fisheries Management Unit Office. It is a good idea to send copies of your application form to multiple individuals in the Fisheries Management Unit to ensure that it gets processed promptly. The same is also true for follow up emails and other inquiries as our staff is frequently in the field and may not see your message. By sending emails to multiple staff, you will get a response back much quicker. Our fisheries staff will review the permit and provide you with either an approved permit or a letter detailing why the permit was denied.

Once you have an approved permit, you can stock your fish. Please be sure to contact our Fisheries Management Unit Office about the stocking at least two calendar days before it occurs. Also be sure that either an original or a copy of the Public Waters Fish Stocking Permit is on site during the stocking. After stocking, be sure to submit the Public Waters Fish Stocking Report to DNR. This data will be input into our databases and will become a permanent part of the fisheries management record for the watershed.

Both DNR and MDA are appreciative of your interest in the state's fisheries resource. We hope this process will meet your needs.

Good Fishing to All,

Kelley D. Smith, Ph.D.
Chief
Department of Natural Resources
FISHERIES DIVISION

Joan M. Arnoldi, D.V.M.
Chief
Department of Agriculture
ANIMAL INDUSTRY DIVISION

2

Appendix 3.2–Continued.

Michigan Department of Natural Resources

Fisheries Division

PUBLIC WATERS STOCKING PERMIT PROCESS

January 1, 2003 through December 31, 2003

1) It is the responsibility of the purchaser or their agent to determine if a permit is required to stock fish into a water body. If a Public Waters Stocking Permit is necessary, the purchaser or their agent must obtain the permit prior to any stocking event. A copy of the Public Waters Stocking Permit Application is in Attachment 1.
   a) If the water body to be stocked is permanently connected to public water bodies via an inlet or outlet, the purchaser or their agent must obtain a Public Waters Stocking Permit.
   b) If the water body to be stocked is not permanently connected to any other water body, it is does not require a Public Waters Stocking Permit unless it meets one of the two following conditions.
      i. If the water body has public access, the purchaser or their agent must obtain a Public Waters Stocking Permit.
      ii. If the water body has been stocked at anytime in the past by the state, the purchaser or their agent must obtain a Public Waters Stocking Permit.
   c) If unsure of the need for a permit to stock a water body, the purchaser or their agent may request assistance from any Department of Natural Resources (DNR) Fisheries Management Unit Office. The offices and fisheries biologists are listed in Table 1.

2) The purchaser or their agent can obtain an application for a Public Waters Stocking Permit from any DNR Fisheries Management Unit Office, from the DNR Internet site (www.michigan.gov/dnr) or from any private aquaculture facility.

3) The purchaser or their agent must return the completed Public Waters Stocking Permit Application to the DNR Fisheries Management Unit Office responsible for the watershed that is to be stocked. See attached Table 1 to determine which office is the appropriate location.

4) DNR Fisheries Management Unit staff will employ the following guidelines in its review of the permit application:
   a) Disease status of the private aquaculture facility. Lists of emergency fish, reportable and diseases of concern are in attached Table 2.
      i) Emergency Fish Diseases - If the facility has a valid disease free certification for emergency fish diseases, the fish can be stocked in public waters. If the facility does not have a current or valid disease-free certification for emergency fish diseases, the permit shall be denied.
      ii) Reportable Disease - If the facility has a known reportable disease, additional review shall be conducted before approving any stocking. The existence of

Appendix 3.2–Continued.

reportable diseases at a facility will not automatically cause the denial of the permit but will require additional consultation with fish health experts from DNR and MDA prior to the issuance of the permit to determine if there are potential resource impacts from stocking the fish. If there is no potential for resource impacts then the fish can be stocked in public waters. If there is the potential for resource impacts then the permit will be denied.

iii) Diseases of concern - If the facility has a known disease of concern, additional review shall be conducted before approving any stocking. The existence of diseases of concern at a facility will not automatically cause the denial of the permit but will require additional consultation with fish health experts from DNR and MDA prior to the issuance of the permit to determine if there are potential resource impacts from stocking the fish. If there is little or no potential for resource impacts then the fish can be stocked in public waters. If there is the potential for resource impacts then the permit will be denied.

b) Species analysis – If the species has been approved for stocking in waters of the state, the fish can be stocked in public waters. If the species has not been approved for stocking in waters of the state, the permit shall be denied. The list of approved species for fish stocked can be found in Table 3.

c) Management implications of the stocking – If the stocking action is consistent with DNR's management objectives for the water body and watershed to be stocked, the fish can be stocked in public waters. If the stocking action is not consistent with DNR's management objectives for the water body and watershed to be stocked, the permit shall be denied.

5) After review of the application, the Fisheries Management Unit will determine if the permit is to be approved or denied based on Sections 4 a, b and c above, taken in their entirety.

6) Within seven (7) calendar days of receipt of the permit application, the Fisheries Management Unit shall provide either an approved permit to the purchaser or their agent, or a letter of permit denial designating the rationale for denial based on Sections 4 a, b, and c above, taken in their entirety (see Attachment 2).

7) Purchaser or their agent must notify the appropriate Fisheries Management Unit of the actual date of stocking at least two (2) calendar days prior to occurrence of the stocking event. This notification can be done via letter, telephone, or e-mail. Upon receipt of notification, the Fisheries Management Unit shall provide a response to the purchaser or their agent that notification of the actual stocking date has been received.

8) The permit must be available on site when fish are stocked into public waters.

a) If a private aquaculture operation is to do the stocking, they must have the original or a copy of the valid Public Waters Stocking Permit on site during stocking.

b) If the purchaser or their agent is to do the stocking, they must have the original valid Public Waters Stocking Permit on site during stocking.

Appendix 3.2–Continued.

9) Within 14 days calendar days of the actual public waters stocking event, a signed Public Waters Stocking Report (see Attachment 2) shall be sent to the Fisheries Management Unit that issued the permit.

10) Upon receipt of the report, the Fisheries Management Unit shall:
   a) Record receiving the report.
   b) Enter the data into the DNR's Fish Stocking Information System database.
   c) Provide a response to the party that the report was received and processed.

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Appendix 3.2–Continued.

Table 1.–DNR Fisheries Management Unit Offices.

Basin/Watersheds	Staff	Office location	Telephone	E-mail
Lake Superior Basin – Coordinator	Steve Scott	Newberry	906-293-5131	scottsj@michigan.gov
Western Lake Superior – Supervisor	George Madison	Baraga	906-353-6651	madisong@michigan.gov
West of the Chocolay River to Ironwood				
Eastern Lake Superior – Supervisor	Robert Moody	Newberry	906-293-5131	moodyr@michigan.gov
Chocolay River to Sault Ste. Marie	Jim Waybrant	Newberry	906-293-5131	waybranj@michigan.gov
Lake Michigan Basin – Coordinator	James Dexter	Plainwell	616-685-6851	dexterjx@michigan.gov
Northern Lake Michigan – Supervisor	Michael Herman	Escanaba	906-786-2351	hermanm@michigan.gov
All Upper Peninsula - Lake Michigan watersheds	Darren Kramer	Escanaba	906-786-2351	madisong@michigan.gov
	Bill Ziegler	Crystal Falls	906-875-6622	zieglerw@michigan.gov
Central Lake Michigan – Supervisor	Thomas Rozich	Cadillac	231-775-9727	rozicht@michigan.gov
Mackinac Bridge to Muskegon River	Mark Tonello	Cadillac	231-775-9727	tonellom@michigan.gov
	Todd Kalish	Traverse City	231-922-5280	hayr@michigan.gov
	Rich O'Neal	Twin Lake	231-788-6798	onealr@michigan.gov
Southern Lake Michigan – Supervisor	Jay Wesley	Plainwell	616-685-6851	wesleyjk@michigan.gov
South of Muskegon River to Indiana Border	Kregg Smith	Plainwell	616-685-6851	smithkrm@michigan.gov
	Scott Hanshue	Plainwell	616-685-6851	hanshusk@michigan.gov
	Amy Harrington	Comstock Park	616-784-1808	harringa@michigan.gov
Lake Huron Basin – Coordinator	Tammy Newcomb	Lansing	517-373-3960	newcombt@michigan.gov
Northern Lake Huron – Supervisor	David Borgeson	Gaylord	989-732-3541	borgesd1@michigan.gov
St. Marys River to Au Sable River	Tim Cwalinski	Gaylord	989-732-3541	cwalinst@michigan.gov
	Neal Godby	Gaylord	989-732-3541	godbyn@michigan.gov
	Steve Sendek	Grayling	989-348-6371	sendeks@michigan.gov
Southern Lake Huron – Supervisor	James Baker	Bay City	989-684-9141	bakerjp@michigan.gov
South of Au Sable River to Port Huron	Kathrin Schrouder	Bay City	989-684-9141	schroudk@michigan.gov
	Joe Leonardi	Lapeer	810-245-1250	leonardi@michigan.gov
Lake Erie Basin – Coordinator	Kurt Newman	Lansing	517-241-3623	newmankr@michigan.gov
Lake Erie – Supervisor	Gary Towns	Livonia	734-432-1267	townsg@michigan.gov
South of Port Huron to Ohio border	Jim Francis	Livonia	734-953-1539	francisj@michigan.gov
	Jeff Braunscheidel	Livonia	734-953-1481	braunscj@michigan.gov

Baraga DNR Office 427 US 41 North Baraga, MI 49908	Comstock Park DNR Office 195 6-Mile Rd. NE Comstock Park, MI 49321	Gaylord DNR Office 1732 M-32 West Gaylord, MI 49735	Lapeer State Game Area DNR Office 3116 Vernon Road Lapeer, MI 48446	Plainwell DNR Office 621 N. 10th Street Plainwell, MI 49080
Bay City DNR Office 503 N. Euclid Ave., Suite 1 Bay City, MI 48706	Crystal Falls DNR Office 1420 US 2 West Crystal Falls, MI 49920	Grayling DNR Office R#3, 1955 N. I-75 BL Grayling, MI 49738	Livonia DNR Office 38980 Seven Mile Road Livonia, MI 48152	Traverse City DNR Office 970 Emerson Traverse City, MI 49686
Cadillac DNR Office 8015 Mackinaw Trail Cadillac, MI 49601	Escanaba DNR office 6833 Hwy. 2, 41 & M-35 Gladstone, MI 49837	Lansing-Fisheries Division P.O. Box 30446 Lansing, MI 48909	Newberry DNR Office 5100 State Highway M-123 Newberry, MI 49868	Twin Lake DNR Office 7550 E. Messenger Road Twin Lake, MI 49457

Appendix 3.2–Continued.

Table 2.–Emergency fish diseases, reportable fish diseases (Michigan Department of Agriculture Reportable Animal Diseases August 2002 – July 2003) and fish diseases of concern in the State of Michigan.

Reportable Fish Diseases

Disease agent	**Disease name**	**Approved fish species affected**
Aeromonas salmonicida	Furunculosis	Atlantic salmon, brook trout, brown trout, rainbow trout
Ceratomyxosis shastal	Ceratomyxosis	Atlantic salmon, brook trout, brown trout, lake trout, rainbow trout
EED Virus	Epizootic Epitheliotropic Disease	Lake trout
EHN Virus	Epizootic Hematopoietic Necrosis	Atlantic salmon, brook trout, brown trout, lake trout, rainbow trout
IHN Virus*	Infectious Hematapoietic Necrosis	Atlantic salmon, brook trout, brown trout, lake trout, rainbow trout
IPN Virus*	Infectious Pancreatic Necrosis Virus	Atlantic salmon, brook trout, brown trout, lake trout, rainbow trout
*Myxobolus cerebralis**	Whirling Disease	Atlantic salmon, brook trout, brown trout, lake trout, rainbow trout
Myxosporean agent PKD	Proliferative Kidney Disease	Atlantic salmon, brook trout, brown trout, lake trout, rainbow trout
Onchorhynchus masou Virus	Onchorhynchus masou Virus Disease	Atlantic salmon, brook trout, brown trout, lake trout, rainbow trout
Renibacterium salmoninarum	Bacteria Kidney Disease	Atlantic salmon, brook trout, brown trout, lake trout, rainbow trout
Rhabdovirus – Spring Viremia of Carp Agent	Spring Viremia of Carp	
VHS Virus*	Viral Hemorrhagic Septicaemia	Atlantic salmon, brook trout, brown trout, lake trout, rainbow trout
Yersinia ruckeri	Enteric Redmouth	Atlantic salmon, brook trout, brown trout, lake trout, rainbow trout

* - These shaded diseases are considered emergency fish diseases. Fish must have certified free of these diseases to be permitted for stocking in public waters.

Fish Diseases of Concern.–These are emerging diseases on the watch list for future action.

Disease Agent	**Disease Name**	**Fish Species Affected**
Ranavirus	Largemouth Bass Virus	Largemouth bass
Heterosporsis	Heterosporis	Yellow perch
Iridovirus	Sturgeon Virus	Lake sturgeon

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Appendix 3.2–Continued.

Table 3.–Approved list of species that can be stocked into public waters of the State of Michigan.

SPECIES
Atlantic salmon
Black bullhead
Black crappie
Bluegill
Bluntnose minnow
Brook trout
Brown bullhead
Brown trout
Channel catfish
Common shiner
Emerald shiner
Fathead minnow
Flathead catfish
Golden shiner
Green sunfish
Hybrid sunfish
Lake herring
Lake trout
Lake whitefish
Largemouth bass
Muskellunge
Northern pike
Northern redbelly dace
Pumpkinseed
Rainbow trout
Redear sunfish
Rock bass
Smallmouth bass
Walleye
Warmouth
White bass
White crappie
Yellow bullhead
Yellow perch

Appendix 3.2–Continued.

Attachment 1. Public Waters Stocking Permit Application

DNR Michigan Department of Natural Resources - Fisheries Division

APPLICATION TO STOCK FISH INTO MICHIGAN PUBLIC WATERS

Under authority of Section 48735 of Part 487, Sport Fishing, of Act 451, P.A. 1994, as amended, ***stocking fish into the public waters of the State of Michigan is prohibited without an approved permit****. Failure to comply with the conditions of this Act and permit shall be cause for revocation of this permit. The penalty for stocking fish into public waters of the state without a permit is a misdemeanor, punishable by imprisonment for not more than 90 days, or a fine of not more than $500.00, or both.*

PERMITTEE INFORMATION

Applicant's Name	Telephone Number ( ) –
Street Address	City, State and Zip Code

WATER TO BE STOCKED

Waterbody Name	Size (Acres)	County	Township	Range	Section(s)	Approximate Stocking Date
Name of Inlets and/or Outlets			Is Water to be Stocked Open to Public Fishing? ☐ Yes ☐ No			
Purpose of Stocking						

SOURCE OF FISH

MDA Facility Registration Number	Telephone Number ( ) –	Facility Manager's Name	Telephone Number ( ) –
Street Address		Street Address	
City, State and Zip Code		City, State and Zip Code	

FISH TO BE STOCKED

Species	Stock or Strain	Size (Inches) or Age	Number

FOR TROUT AND SALMON ONLY

The trout and salmon for stocking must come from a facility with a certificate or report of fish health designating disease free status that includes all facilities through which said fish have passed.

Aquaculture Facility has a Current Fish Health Certificate(s) or Report(s) of Fish Health? Yes ☐ No ☐

I hereby certify that all information provided above is true to the best of my knowledge.

Signature of Purchaser or Agent________________________ Date ________________

For Department Use Only

APPLICATION IS: ☐ **APPROVED** ☐ **DENIED** (see attached denial letter)

Permit Number: ________________

Issue Date: ________________

Expiration Date:

Approved Action:

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Appendix 3.2–Continued.

Attachment 2. Public Waters Fish Stocking Permit and Report Form

DNR **Michigan Department of Natural Resources - Fisheries Division**

PERMIT TO STOCK FISH INTO MICHIGAN PUBLIC WATERS

This permit is issued under the authority of Section 48735 of Part 487, Sport Fishing, of Act 451, P.A. 1994, as amended. Failure to comply with the conditions of this Act and permit shall be cause for revocation of this permit. The penalty for stocking fish into public waters of the state without a permit is a misdemeanor, punishable by imprisonment for not more than 90 days, or a fine of not more than $500.00, or both.

PERMIT TO STOCK FISH INTO PUBLIC WATERS OF THE STATE OF MICHIGAN

APPLICATION IS: ☐ **APPROVED** ☐ **DENIED** (see attached denial letter)

Permit Number: ____________________

Issue Date: ____________________

Expiration Date: ____________________

Approved Action:

By: ______________________________ ____________________ ____________________
Department Signature — Title — Date

LAWS, CODES AND PERMITS. Permittee recognizes that this permit does not obviate other requirements of federal, state, or local law. Permittee agrees to comply with all applicable laws, regulations, and codes, and shall obtain any necessary permits in connection with the activities that are the subject of this permit.

INDEMNIFICATION. Permittee shall indemnify and hold harmless the State of Michigan and all its departments, agencies, commissions, officers, employees, and agents from and against all claims, liabilities, damages, losses, penalties, and fines, and all related costs and expenses, including reasonable attorney fees, for personal injury, death, or property damage of any kind or nature, including environmental contamination, that arise in any manner from Permittee's use of the property that is the subject of this permit or from the exercise of any rights or privileges granted under this permit.

I have read the terms and conditions contained in this permit. I agree to abide by same and assume all the obligations contained herein. Approved applicants or their agent will be required to submit a report detailing the number and size of each species stocked.

______________________________ ____________________
Purchaser or Agent's Signature — Date

Return completed application to: FISHERIES MANAGEMENT UNIT OFFICE RESPONSIBLE FOR THE WATERSHED TO BE STOCKED (see Table 1)

Detach and Submit Private Fish Stocking Report within 14 days of Stocking

MDNR FISHERIES DIVISION – PUBLIC WATERS STOCKING REPORT

This report is required under the authority of Section 48735 of Part 487, Sport Fishing, of Act 451, P.A. 1994, as amended.

PERMIT INFORMATION

Purchaser or Agent's Name	Telephone Number ( ) -
Permit Number	

WATER STOCKED

Waterbody Name	County	Township	Range	Section(s)	Stocking Date

FISH STOCKED

Species	Stock or Strain	Size (Inches) or Age	Number

I hereby certify that all information reported by me is true to the best of my knowledge.

Signature of Purchaser or Agent______________________________ Date ____________________

Return completed application to: FISHERIES MANAGEMENT UNIT OFFICE RESPONSIBLE FOR THE WATERSHED TO BE STOCKED WITHIN 14 DAYS OF STOCKING (see Table 1)

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Michigan Fish Stocking Guidelines II: with Periodic Updates

Chapter 4: Stocking Guidelines for Lakes and Streams

Suggested citation:

MDNR (Michigan Department of Natural Resources). 2004. Stocking guidelines for lakes and streams. Chapter 4 *in* Dexter, J. L., Jr., and R. P. O'Neal, editors. Michigan fish stocking guidelines II: with periodic updates. Michigan Department of Natural Resources, Fisheries Special Report 32, Ann Arbor.

Chapter 4: Stocking Guidelines for Lakes and Streams

4.1 Determining the Size of Fish and Time of Year to Stock

Habitat biologists and hatchery managers should target fish stocking to coincide with optimum food and temperature conditions in the receiving waters. The varieties, sizes of fish, and dates available for stocking are shown in Tables 1 and 2. Stocking in the Great Lakes should coincide with the Great Lakes stocking windows (Table 4.3 and Figure 4.1). Hatchery truck loading capacities can be found in Appendices 4.1 and 4.2.

Fingerlings are fish beyond the egg-sac stage, but less than 1 year old. With the exception of walleye, fingerlings are classified as spring fingerlings (SF) if stocked between January 1 and June 30 and fall fingerlings (FF) if stocked between July 1 and December 31. (Walleye are spring fingerlings prior to September 1 and fall fingerlings from September 1 to December 31). Fish become yearlings (YR) on January 1 following their first summer of life.

Trout Size

Based on experiences in Michigan with stocking trout, larger trout (6–8 inches long, 5–1.5 fish/lb) should be requested where predator fish are abundant or "forage" fish competition is moderate to severe. Where rainbow trout or brook trout are the most serious fish predators and "forage" fish competition is not severe, 3–5 inch trout (25–135 fish/lb) should give good results. Unless a water body is nearly barren of competing or predator fish (as in trout–only lakes after chemical treatment), fingerlings smaller than 2 inches (300 fish/lb), should not be requested.

Trout Stocking Period

In general, the best time to stock trout from Michigan experience is from late March to early June and September through October. Stocking during this period usually allows for maximum growth and survival through the spring and summer months. When stocking later in the year, try to take advantage of as much of the good fall growing conditions as possible. Good trout growth occurs through November in large oligotrophic lakes and streams.

With fingerlings, the choice of fish sizes and numbers is generally a function of stocking date. The earlier the date the smaller the trout will be. A larger number of smaller trout will generally be needed to produce the same results as fewer, larger, fingerlings stocked later. If the fish stocked have immediate access to deep and cool waters, brook, brown, and rainbow trout can be stocked in 70º F surface water without significant mortality. However, it should not be necessary to stock in water over 70ºF if sensible precautions are taken (proper scheduling of lakes, stocking relatively warm lakes during cool spells, stocking in the morning or evening). Receiving waters should not vary more than 10°F from tank water temperature.

Fisheries managers should work with hatcheries to establish specific time periods for stocking in special situations. Comments can be made for special consideration in the fish stocking information system and in the prescription process. Stocking at night is discouraged because of safety issues.

Stocking time frames in the Great Lakes can be guided by using established stocking windows (Figure 4.1 and Table 4.3). Temperature, food, and predator conditions may be optimum for the survival of stocked fish during these periods. Steelhead stockings are typically related to smolting behaviors and historically used site stocking dates are working well, even if they are outside of the suggested stocking window. Hatcheries should continue to notify managers in advance of planned stockings so that adjustments in stocking times that could be affected by weather events, predators, rainbow smelt dippers, etc. are accounted for.

Coolwater Species

The size of coolwater species to stock is also dependent upon the competition present in the receiving water as well as food conditions. However, flexibility with coolwater species is more limited than with trout. Where walleye fry are to be stocked directly into a lake, consider stocking over several days to hedge against adverse food and weather conditions (conduct stocking a week or so apart). Stock fry before they have completely absorbed their yolk sac (true for other species as well).

Release walleye and northern pike fingerlings from rearing ponds (marshes) before food runs out and cannibalism becomes severe. For further guidance, refer to Laarman and Reynolds (1974). The Division's Walleye Evaluations Committee continually revises walleye pond operations and rearing techniques. Muskellunge fingerlings between 8 and 12 inches should produce good results depending on the availability of "forage" fish. Transfers of adult fish from stunted populations sometimes can be accomplished. These fish typically have high survival rates and perform well.

4.2 Great Lakes and Connecting Waters

Michigan has a tremendous wealth of fisheries resources on four of the five Great Lakes. Michigan tributaries support major spawning runs of Great Lakes fish. Great Lakes fish communities were severely degraded as a result of human activities in the 19th and 20th centuries. Stocking played a significant role in the rehabilitation and restoration of these fisheries. Presently, stocking continues to support some of the principal sport and commercial fisheries. Future reliance on stocked fish is expected to decrease as habitat restoration and management programs reestablish enough natural reproduction to support fisheries.

Stocking too many fish in the Great Lakes must be avoided. The 1988 collapse of the chinook salmon fishery in Lake Michigan was believed to be related to high predator levels in relation to the forage base. Biological data indicating that similar conditions were occurring in Lake Michigan in 1999 resulted in a lake-wide reduction in chinook salmon stocking.

Michigan manages portions of the fisheries resources on Lake Superior, Lake Michigan, Lake Huron, Lake Erie, and connecting waterways including the St. Mary's River, St. Clair River, Lake St. Clair, and the Detroit River. Other agencies also have fisheries management interest in these resources including state, federal, provincial, and tribal authorities. A combination of multiple agency management interests, and numerous broad-scale ecological issues and problems affecting all of the Great Lakes, led to the formation of an inter-agency Joint Strategic Plan for Management of Great Lakes Fisheries (Great Lakes Fishery Commission 1980). The Joint Strategic Plan implemented a framework of cooperative fishery management by establishing procedures for achieving a consensus approach among fisheries management agencies. The Joint Plan also recognized that the fish community in each lake must be managed as a whole. Much of the responsibility for implementing a consensus approach to fish community management was delegated to individual lake committees. Lake committees are composed of a single representative from each management agency with fishery resource jurisdiction on a Great Lake.

Lake committees developed "Fish Community Objectives" (FCO's) for each Great Lake. Stocking rates are determined by inter-agency lake committees and are driven by the FCO's. A common set of goals and guiding principals were used by lake committees to establish fish community objectives. One common goal recognized as part of the Great Lakes Water Quality Agreement of 1978 (amended 1987) was:

> "… To restore and maintain the chemical, physical, and biological integrity of the waters of the Great Lakes basin ecosystem."

The Joint Strategic Plan provided another common goal statement:

> "To secure fish communities, based on foundations of stable, self-sustaining stocks, supplemented by judicious stockings of hatchery-reared fish, and provide from these communities an optimum contribution of fish, fishing opportunities, and associated benefits to meet needs identified by society for:
>
> - wholesome food
> - recreation
> - employment and income
> - a healthy human environment."

Principals guiding development of fish community objectives were:

- Lakes must be managed as whole ecosystems.
- Management should be based on the best available scientific knowledge.
- Recognize the limits on lake-productivity.
- Preserve and restore fish habitat.

- Preserve species diversity.
- Preserve native species.
- Protect and enhance threatened and endangered species.
- Enhance natural reproduction of native and desirable introduced fishes.
- Recognize naturalized species.
- Acknowledge the role of stocked fish.
- Adopt the genetic stock concept.
- Prevent the unintentional introduction of exotic species.
- Recognize the fisheries are an important cultural heritage.

Lake Superior

The Lake Superior Committee has representatives from the state of Minnesota, Michigan, and Wisconsin, along with the Chippewa-Ottawa Regulator Authority, the Great Lakes Indian Fish and Wildlife Commission, and the Ontario Ministry of Natural Resources. Busiahn (1990) provides the Lake Superior Committee's recommended goals and objectives for Lake Superior's fish community. The committee established five primary objectives.

1. Forage: Rehabilitate lake herring *Coregonus artedi* stocks to historical levels of abundance for the purposes of lake trout *Salvelinus namaycush* rehabilitation, production of other predators, and fishery harvest historical reference period: 1916-1940.

2. Predators: Achieve a sustained annual yield of 4 million lb of lake trout from naturally reproducing stocks, and an unspecified yield of other salmonid predators, while maintaining a predator/prey balance that allows normal growth of lake trout.

3. Other Species: Manage exploitation of non-depleted stocks to maintain stable self-sustaining status. Examples: whitefish and chubs *Coregonidae*., suckers *Catostomidae*, and walleye.

   Re-establish depleted stocks of native species. Examples: lake sturgeon *Acipenser fulvescens*, brook trout, and walleye.

4. Sea Lamprey *Petromyzon marinus*: Achieve a 50% reduction in parasitic-phase sea lamprey abundance by 2000. Achieve a 90%reduction in parasitic-phase sea lamprey abundance by 2010.

5. Habitat: Achieve no net loss of the productive capacity of habitats supporting Lake Superior fisheries.

   Restore the productive capacity of habitats that have suffered damage.

   Reduce contaminants in all fish species to levels below consumption advisory levels.

Anticipated annual stocking targets for Michigan waters of Lake Superior from 2000 to 2005 include: 10,000 brook trout yearlings, 80,000 brown trout yearlings, 350,000 chinook salmon fingerlings, 150,000 lake trout fingerlings, 85,000 splake *Salvelinus fontinalis x S. namaycush*, 85,000 rainbow trout (Michigan steelhead) yearlings, and 204,500 walleye fingerlings.

Lake Michigan

The Lake Michigan Committee has representatives from the states of Illinois, Indiana, Michigan, and Wisconsin, along with the Chippewa-Ottawa Treaty Fishery Management Authority. The Lake Michigan Committee's recommended goals and objectives for Lake Michigan's fish community are provided by Eschenroder et al. (1995). The committee established seven primary objectives.

1. <u>Salmonine (salmon and trout):</u> Establish a diverse salmonine community capable of sustaining an annual harvest of 6 to 15 million lb, of which 20–25% is lake trout.

   Establish self-sustaining lake trout populations.

2. <u>Planktivore:</u> Maintain a diversity of planktivore (prey) species at population levels matched to primary production and to predator demands. Expectations are for a lakewide planktivore biomass of 1.2 to 1.7 billion lb.

3. <u>Inshore fish:</u> Maintain self-sustaining stocks of yellow perch, walleye, smallmouth bass *Micropterus dolomieui*, northern pike, catfish, and panfish. Expected annual yields should be 2 to 4 million lb for yellow perch and 0.2 to 0.4 million lb for walleye.

4. <u>Benthivore:</u> Maintain self-sustaining stocks of lake whitefish, round whitefish *Prosopium cylindraceum*, lake sturgeon, suckers, and burbot *Lota lota*.

   The expected annual yield of lake whitefish should be 4 to 6 million lb.

5. <u>Sea lamprey:</u> Suppress sea lamprey to allow the achievement of other fish community objectives.

6. <u>Other species:</u> Protect and sustain a diverse community of native fishes, including other species not specifically mentioned earlier (i.e., minnows *Cyprinidae*, gars *Lepisosteidae*, bowfin *Amia calva*, brook trout, and sculpins *Cottidae*). These species contribute to the biological integrity of the fish community. They should be recognized and protected for their ecological significance and cultural and economic values.

7. <u>Physical/chemical habitat:</u> Protect and enhance fish habitat and rehabilitate degraded habitats.

   Achieve no net loss of the productive capacity of habitat supporting Lake Michigan fish communities.

   High priority should be given to the restoration and enhancement of historic riverine spawning and nursery areas for potamodromous species.

Stocking levels in Lake Michigan do not vary greatly from year-to-year. However, overall stocking is currently at peak levels. Predator biomass levels now match or exceed those prior to the chinook salmon collapse in 1988. Various models, such as the Connect Model (Rutherford 1997), indicate biomass is too high to be supported by the existing forage base, and most agencies agree with this scenario. This information indicates stocking levels should be reduced in future years to balance predator and prey populations.

Anticipated annual stocking targets for Michigan waters of Lake Michigan from 2000 to 2005 include: 420,000 brown trout yearlings, 2,270,000 chinook salmon fingerlings, 1,700,000 coho salmon *Oncorhynchus kisutch* yearlings, 2,188,000 lake trout yearlings, 75,000 splake yearlings, 10,000 rainbow trout yearlings, 486,000 rainbow trout (Michigan steelhead) yearlings, and 1,550,000 walleye fingerlings.

<u>Lake Huron</u>

The Lake Huron Committee has representatives for the state of Michigan, the Ontario Ministry of Natural Resources, and the Chippewa-Ottawa Treaty Fishery Management Authority. The Lake Huron Committee's recommended goals and objectives for Lake Huron's fish community are provided by DesJardine et al. (1995). The committee established nine primary objectives.

1. Overall: Over the next two decades, restore an ecologically balanced fish community dominated by top predators, and consisting largely of self-sustaining indigenous and naturalized species capable of sustaining annual harvests of 19.6 million lb.

2. Salmonine: Establish a diverse salmonine community that can sustain an annual harvest of 5.3 million lb, with lake trout the dominant species and potamodromous (stream spawning) species also having a prominent place.

3. Walleye: Reestablish and/or maintain walleye as the dominant coolwater predator over its traditional range with populations capable of sustaining a harvest of 1.54 million lb.

4. Esocid (northern pike and muskellunge): Maintain northern pike as a prominent predator throughout its natural range. Maintain muskellunge in numbers and sizes that will safeguard and embrace its special status and appeal. Sustain a harvestable annual surplus of 220,000 lb.

5. Channel catfish *Ictalurus punctatus*: Maintain channel catfish as a prominent predator throughout its natural range while sustaining a harvestable annual surplus of 440,000 million lb.

6. Coregonine (lake whitefish and cisco): Maintain the present diversity of coregonines. Manage lake whitefish and cisco at levels capable of sustaining annual harvests of 8.4 million lb. Restore lake herring to a significant level and protect, where possible, rare deepwater cisco *Coregonus johannae*.

7. Species diversity: Recognize and protect the array of other indigenous fish species because they contribute to the richness of the fish community. These fish—cyprinids, rare cisco, suckers, burbot, gar, and sculpins—are important because of their ecological significance; intrinsic value; and social, cultural, and economic benefits.

8. Genetic diversity: Maintain and promote genetic diversity by conserving locally adapted strains. Ensure that strains of fish being stocked are matched to the environments they are to inhabit.

9. Habitat: Protect and enhance fish habitat and rehabilitate degraded habitats. Achieve no net loss of the productive capacity of habitat supporting Lake Huron fish communities and restore damaged habitats. Support the reduction or elimination of contaminants.

Anticipated annual stocking targets for Michigan waters of Lake Huron from 2000 to 2005 include: 65,000 Atlantic salmon yearlings, 335,000 brown trout yearlings, 3,550,000 chinook salmon fingerlings, 2,957,000 lake trout yearlings, 30,000 splake yearlings, 180,000 rainbow trout yearlings, 357,000 rainbow trout (Michigan steelhead) yearlings, and 1,137,500 walleye fingerlings.

Lake Erie

The Lake Erie Committee has representatives from the states of Michigan, New York, Ohio, Pennsylvania, and the Ontario Ministry of Natural Resources. The Lake Erie Committee's recommended goals and objectives for Lake Erie's fish community are provided by Ryan et al. (2003). The committee established 13 primary objectives.

1. Trophic conditions: Maintain a range of trophic conditions that accommodate a diverse fish community consisting largely of coolwater organisms (i.e., mesotrophic conditions [10–20 ug/l phosphorous]) in the western basin, central basin, and nearshore waters of the eastern basin of Lake Erie, following the natural gradient in productivity from west to east. Optimal summer transparencies for walleye should be 3–5 m in most areas of Lake Erie.

2. Lake Erie ecosystem: Manage the Lake Erie ecosystem to ensure high-quality mesotrophic environments in the western basin, central basin, and near-shore waters of the eastern basin, capable of supporting potential sustainable harvest of 50–60 million lb of high-valued fish species each year.

3. Near-shore habitat: Manage near-shore habitat to support high-quality fisheries for smallmouth bass, northern pike, muskellunge, and walleye.

4. Riverine and estuarine habitat: Protect and restore self-sustaining, stream spawning stocks of walleye, white bass, lake sturgeon, and rainbow trout. Restoration of stream spawning stocks of walleye would provide some added protection from wide fluctuations in year-class strength.

5. Western basin: Manage the western basin ecosystem to provide sustainable harvests of valued fish species, including walleye and yellow perch.

6. Central basin: Manage the central basin ecosystem to provide sustainable harvests of valued fish species, including walleye and yellow perch, rainbow smelt, and rainbow trout.

7. Eastern Basin: Manage the eastern basin ecosystem to provide sustainable harvests of valued fish species; including walleye, rainbow smelt, yellow perch, whitefish, lake trout, rainbow trout, and other salmonids. Continue efforts to restore a self-sustaining population of lake trout to the modest levels of abundance observed historically that would serve as an integrating, terminal predator in the cold, profundal waters of the eastern basin.

8. Contaminants: Reduce contaminants in all fish species to levels that require no advisory for human consumption and no detrimental effect on fish eating wildlife, fish behavior/productivity and fish reproduction.

9. Fish habitat: Protect, enhance, and restore fish habitat throughout the watershed to ensure that the Lake Erie fish community is not degraded and that the fisheries it supports are not diminished.

10. Genetic diversity: Maintain and promote genetic diversity by conserving locally adapted strains and by ensuring that if strains of fish are introduced, they are matched to the environments they are to inhabit. The ecological or genetic impacts of proposed new strains on native strains or populations will be considered by the Lake Erie Committee members prior to their introduction into Lake Erie.

11. Rare, threatened, and endangered species: Manage rare, threatened, and endangered fish species (i.e. lake sturgeon, lake herring) in Lake Erie by reducing exploitation and protecting habitat to ensure that no more species become extinct.

12. Forage: Manage a diverse base of forage species to maintain abundance levels necessary to sustain use by predators with the fish community and to sustain human use (i.e., exploitation of rainbow smelt, harvest of bait fish.)

13. Food web structure: Manage the food web structure of Lake Erie to optimize production of high valued fish species. Recognize the importance of *Diporeia* and *Hexagenia* as key species of the food web and important indicators of habitat suitability.

Anticipated annual stocking targets for Michigan waters of Lake Erie (and Lake St. Clair) from 2000 to 2005 include: 20,000 brown trout yearlings and 102,000 rainbow trout (Michigan steelhead) yearlings.

4.3 Inland Lakes

Michigan inland lakes vary considerably in habitat and productivity and, consequently, in the fish species, communities, and biomass they support. Habitat characteristics related to the success of a fish species include lake size, temperature, dissolved oxygen, pH, depth, clarity, vegetation, and substrate. The distribution and abundance of Michigan fishes in relation to these characteristics, and their response to perturbations, were summarized recently by Schneider (2002) and should be reviewed when stocking is being considered.

Basic knowledge of a lake's productivity and fish community status should be acquired before stocking. The numbers or weight of fish a lake can produce can be estimated and should serve as a rough guide for stocking strategy and expected success. Basic limnological productivity can be adequately predicted from Secchi disk transparency (an index of plankton production), relative abundance of vegetation (an index of macrophyte and epibenthos production), and climate (an index of growing season and turnover rate). When combined with indices of fish community composition, useful predictions of relative sportfishing yield and fish standing crop biomass can be made. See Schneider (1975, 1978) for methods.

Typical Michigan warmwater lakes, with average productivity and fish communities, have fish standing crops of approximately 100 lb/acre (Schneider 1975,1978). Fertile southern lakes dominated by carp or stunted bluegills can have considerably more, and infertile northern lakes with few species can have much less. Typical sport fishing yield is about 30 lb/acre, again with wide variation. Well-managed trout-only lakes can produce (weight harvested minus weight stocked) about 10 lb/acre of trout.

The average fish community of a warmwater lake in the Lower Peninsula consists (by weight) of 38% bluegill, 18% largemouth bass, 7% white sucker *Catostomus commersoni*, 9% yellow perch, 6% northern pike, 5% pumpkinseed *Lepomis gibbosus*, 7% carp, and a lesser percentage of other species (Schneider 1981). Generally, better sportfishing is experienced in deeper, clearer, moderately vegetated lakes that have a layer of cool, oxygenated water in summer (Schneider 1981). Indices favorable to good fishing are relatively high proportions of piscivores (especially largemouth bass) and low proportions of bluegill, carp, and white sucker; fast growth of bluegill; and a high percentage of large-sized bluegill and pumpkinseed.

The species composition of a Michigan fish community depends on the relative amounts of cold-, cool-, and warm-water habitats. These proportions are strongly related to climate, depth, area, and balance between oxygen production and oxygen consumption (Schneider 1975). Trout, whitefish, and cisco can survive in temperature-stratified lakes that maintain a layer of cool, well-oxygenated water in the thermocline or hypolimnion. At the other extreme, bluegill, largemouth bass, and black crappie are most abundant in lakes with a high proportion of warm water (epilimnion). Yellow perch, walleye, and smallmouth bass thrive best in lakes with intermediate or diverse thermal conditions.

Habitat quality is most predictable for trout because trout distribution and productivity are so strongly linked to cold temperature and high dissolved oxygen. The most tolerant trout (rainbow) can survive in lakes with a minimum of a 5-foot layer in the thermocline containing at least 2-ppm oxygen (Schneider 1975). Relatively cold lakes (more northerly or spring-fed) need not be deep enough to stratify to support trout. Lake pH should also be considered when stocking trout. Brook trout have been found in waters with pH as low as 4.4; the minimum for rainbow, brown and lake trout is about 5.4 (Schneider 2002).

Inland lakes are protected by Michigan Surface Water Quality Standards (Michigan Department of Natural Resources and Environmental Protection Act, Public Act 451, 1994, Surface Water Quality Standards, Part 31 – Part 4 rules). These should be consulted for specifics. Minimum dissolved oxygen concentrations of 7 mg/l are required for designated trout lakes. All other inland lakes have minimum dissolved oxygen concentrations of 5 mg/1. Water temperatures should not exceed 69°F for optimum growth and survival of trout. Inland lake Surface Water Quality Standards for temperature do not allow the following: 1) an increase in the temperature of the thermocline or hypolimnion, 2) an increase in the temperature of the receiving waters at the edge of the mixing zone more than 3°F above the existing natural water temperature, and 3) an increase in the actual temperature of the receiving water at the edge of the mixing zone greater than 45 to 85°F, depending on month. Impoundments have different standards.

Trout survive and grow best in the absence of predators (such as pike) and competitors (any type), and in lakes where large *Daphnia* exceed 150 organisms/sample (Galbraith 1975; Galbraith and Schneider 2000). Large *Daphnia* are useful indicators of habitat and food conditions for both bluegill and rainbow trout. Galbraith and Schneider (2000) found that poor trout lakes had less than 100 large daphnids per plankton net haul. Best success is obtained in "two-story lakes" (containing a mixture of species) when the volume of open water habitat is relatively large and it is underutilized by resident pelagic plankton feeders such as bluegill and cisco. Underutilization is indicated by fast growth. After a century of trout stocking experience, Michigan waters capable of supporting trout and providing the best returns should be well known. Therefore, there is no justification for continued stocking of waters that have demonstrated poor returns.

The Director of the Department has the authority to list specific lakes as Designated Trout Lakes (FO-200). These lakes are intensively managed for trout fisheries, have special regulations listed in the order, and are protected by Surface Water Quality Regulations for coldwater lakes. Special regulations may limit fishing activity to the regular trout season and include restrictions on baits, legal sizes, creel limits, and use of minnows (live or dead). Typically, chemicals (rotenone or antimycin) are used to reduce or remove all other fish species from these lakes on a periodic basis. Species stocked include brook trout, brown trout, rainbow trout, and Atlantic salmon. Typical annual stocking rates of yearlings are 25–100 fish/acre, depending on lake size and fish extraction rate (Table 4.4).

Two-story trout lakes are lakes stocked with trout and managed in conjunction with the existing fish community. Typically, trout are not stocked when northern pike and walleye are present in moderate to high densities. In large (>500 acres) oligotrophic lakes, trout stocking sometimes can be effective in the presence of these predators. In smaller lakes, northern pike densities sometimes are reduced by netting prior to trout stocking. Two-story trout lakes are typically open to fishing all year. Species stocked include rainbow trout, brown trout, brook trout, splake, and Atlantic salmon. Typical annual stocking rates of yearlings average 50 fish/acre, depending on lake size and extraction rate (Table 4.4). Isolated lakes and lakes over 500 acres in size typically have lower fishing pressure and are stocked at lower densities.

Walleye survival is less constrained by temperature and dissolved oxygen than trout survival. Although they prefer cool waters, stocked walleyes can survive in warm and cold inland lakes and rivers that provide suitable forage. Soft-rayed fish such as gizzard shad *Dorosoma cepidianum*, and small spiny fish such as yellow perch and bluegill, are suitable forage provided the walleyes are stocked at a large enough size to utilize the available prey. However, small fingerling walleyes will not survive well in stunted panfish lakes if they have to compete for sparse supplies of invertebrate foods. Walleye predation on yellow perch and bluegill can be substantial enough to improve stunted panfish populations (Schneider 1995; Schneider and Lockwood 1997).

Some coolwater and warmwater lakes are stocked every 1 to 3 years to maintain put-grow-take fisheries. Species typically stocked for this purpose include walleye, muskellunge, channel catfish, and much less frequently, northern pike and redear sunfish *Lepomis microlophus.* Almost any other species may be stocked occasionally for special purposes such as introductions of new species, re-introductions after fish kills, and experimental studies. Other species that have been stocked in Michigan include largemouth bass, smallmouth bass, bluegill, hybrid sunfish *Lepomis* spp., lake sturgeon, flathead catfish, yellow perch, and rainbow smelt.

Fish kills occur in lakes due to natural causes, pollutants, and fisheries management reclamation programs. Natural fish kills are widespread and usually of minor importance. The most important natural fish kills occur in small, shallow lakes that lose nearly all dissolved oxygen during periods of ice cover ("winterkill"). Winterkills are usually not complete and require no stocking. If significant fish mortality occurs, stocking should be conducted only if historical information indicates kills are so infrequent that a satisfactory return from the stocked fish can be expected. Lakes that winterkill frequently may be used for rearing small walleyes or northern pike.

Pollutant-caused fish kills may occur from spills of toxic chemicals or wastewater into lakes. Stocking may be warranted if mortalities are extensive and natural re-colonization is not expected. In most cases, stocking should be directed at restoring the original fish community.

Fisheries managers sometimes use piscicides to reclaim lakes, reservoirs, and rivers that do not support acceptable sport fisheries. (This practice has declined in recent years due to public opposition.) Typically, these waters have unbalanced fish communities because of an overabundance of carp, suckers, bluegills, bullheads, or yellow perch. As a rule of thumb, carp and suckers may have a significant negative effect on sport fish when they comprise more than 50% of the total weight of fish (Schneider 1981). Communities in which bluegills and pumpkinseeds combine for more than 78% of the total fish weight are usually poor due to slow growth. A similar guideline (>75%) probably applies to yellow perch.

Lakes and reservoirs with high carp populations often have poor water quality conditions that favor the more tolerant carp. Even if water quality improves, a large carp population may persist for many years because carp are long-lived. The need for total reclamation projects has declined in recent decades because water quality conditions have improved in many Michigan waters. Attempts to remove carp by netting rarely catch enough fish to improve the community and are impractical. Reclaimed carp waters are usually restocked with appropriate mixes of panfish and piscivores (see individual species recommendations). Under suitable environmental conditions, a diet of small carp can help produce large muskellunge and northern pike.

Overabundance of suckers is a problem in some reservoirs, rivers, and northern lakes. A manual removal program with trap nets may be a feasible alternative to piscicides in waters where suckers concentrate at shoals or inlets for spawning. However, to effectively reduce a sucker population for several years, netting must be efficient enough to remove approximately 80% or more of the adults in the first year (Schneider and Crowe 1980). Restocking, if needed, should emphasize large predators.

Overabundance of stunted bluegills or yellow perch can be alleviated by total reclamation, partial reclamation with antimycin or rotenone, or stocking of walleyes (Schneider and Lockwood 1997). Manual removal with nets is too inefficient to be practical except, perhaps, in very small waters. The benefits of chemical reclamation in warmwater lakes tend to be short lived (1–5 years—Hooper et al. 1964) unless predators such as walleye and bass can be enhanced either by stocking or protection from exploitation. Stunted bluegill lakes often have excess cover in the form of higher aquatic plants. Stocked walleyes can be especially effective at improving stunted yellow perch populations. Northern pike are rarely effective predators on bluegills and can have a negative effect by feeding on the larger more desirable sizes of yellow perch. For total reclamation, some options for restocking are given in Table 4.5 (simplified warmwater fish stocking guide).

4.4 Inland Streams

From 1965 to 1968 the Fisheries Division reclassified all streams in the state (Tanner 1965; Tody 1965; Shapton 1967; Anonymous 2000). Each management unit should have a set of the original color-coded 1968 county maps. These should be updated periodically as new classification information is obtained. This classification scheme defined eight types of streams (four coldwater and four warmwater). Primarily, it has been used to legally define trout streams for the purpose of trout angling regulations and to guide assignment of water quality standards to individual streams. Consequently, only four of the eight classifications—top-quality coldwater, top-quality warmwater, second-quality coldwater, and second-quality warmwater—have been important. Surface Water Quality Division, Department of Environmental Quality (Water Quality Standards, rule 323.110 Part 4) uses warm and coldwater classifications for enforcing water quality standards.

Michigan has over 36,000 miles of streams (Brown 1944), of which roughly 25% are classified as coldwater systems (Seelbach et al. 1997). Before any management takes places on a trout stream, basic knowledge of the fish community structure, watershed characteristics, and water quality information should be obtained.

Information on water temperatures is of primary importance because it will have an overriding effect on the ability of the stream to support adequate growth and survival of trout. The maximum-weekly-mean temperature tolerance for salmonid species stocked into Michigan streams can be found in Table 4.6 (Eaton et al. 1995). Salmonids are not expected to be present if mean temperature (average of weekly maximum and minimum) during any week exceeds the values shown in Table 4.6. In Michigan, water temperatures are usually highest during July. The optimal daily temperature range (fluctuation) for the species will generally be approximately 5°C (9°F).

Recording thermometers should be used to determine if mean weekly temperature thresholds (hottest week of the year, usually July) are exceeded in stocked streams if there is reason to believe that water temperatures are limiting survival. Research conducted in Michigan streams by Wehrly et al. (1998) suggested that July monthly mean temperatures that can be tolerated by brook, brown, or rainbow trout are about 2°C (3.6°F) lower than the values shown in the Table 4.6. This number represents a 4-week average maximum, which diminishes the extreme values. For example, brook rout are rarely abundant in waters having mean July temperatures greater than 19.0°C (66.2 °F, Figure 4.2), and brown or rainbow trout are rare in waters with mean July temperatures exceeding 22.0°C (71.6°F, Figures 4.3 and 4.4).

Figure 4.5 presents a similar relationship using total numbers per acre rather than pounds per acre for these three species. The recommendations in Table 4.7 are based on the information presented in Figures 4.2–4.5. Large rivers and streams with coldwater refuges such as small tributaries and springs may support trout even if the recommended temperatures are exceeded.

<u>Coldwater Streams and General Stocking Rates</u>

Coldwater streams (maximum daily mean temperature usually <22°C or 71.6°F) generally are small-to medium-sized with only salmonid and cottid species predominating (Gowing and Alexander 1980; Lyons et al. 1996; Zorn et al. 2002). However, stocked trout may survive and grow well in portions of larger rivers such as the Muskegon and lower Au Sable which have suitable temperature regimes but complex communities containing 2–3 dozen species of fish (O'Neal 1997; Zorn and Sendek 2001).

Standing crop and production of trout varies greatly between streams and stream segments depending upon factors such as temperature, fertility, channel morphology, and flow regime. Fall standing crops of trout in 14 Michigan streams examined by Gowing and Alexander (1980) ranged from 22 to 160 lb/acre and averaged 75 lb/acre. Standing crops of all salmonid species in the Michigan Rivers

Inventory (MRI) database ranged from 0.01 to 184 lb/acre. There is some evidence that standing crops are greater in streams supporting more than one salmonid species (Gowing and Alexander 1980; Kwak and Waters 1997). Kwak and Waters (1997) also found some indications that nutrient enrichment boosted natural trout production in some Minnesota waters to as high as 352 lb/acre.

When deciding whether to initiate or continue stocking trout into a stream the following items should be considered:

1. Are water temperatures suitable?

   Conditions are usually not suitable for stocking if the values in Tables 6 and 7 are exceeded. Further refinement of predicted stocking success and standing socks can be made with temperature monitoring. Wehrly et al. (1999) has developed thermal distributions for trout species in cold, cool, and warm thermal regimes. Biologists can calculate the temperature fluctuation of a stream (the average weekly July fluctuation is the difference between the weekly maximum and minimum stream temperature) and compare the information to the relationships developed by Wehrly et al. (1999). Mortality of stocked trout may be high due to extreme winter conditions (Leonard and Shetter 1936).

2. What growth and survival are likely?

   Both survival and growth rates need to be considered. Generally, most trout are stocked into streams as spring yearlings. Most will have grown to 8 inches by the time they are 2 years old. In streams with 12-15 inch minimum size limits, trout may need to survive to age-3 or age-4 to become legal sized. Thus, if survival or growth rates are too low, few stocked fish will reach legal size for harvest.

   Table 4.8 illustrates how a manager might reasonable project the numbers of brown trout surviving to older ages based on two survival rates known to occur in Michigan streams. The upper part of the table, based on data for 13 streams (Gowing and Alexander 1980), shows average numbers of wild brown trout (first row) and their average survival from spring-to-spring (second row). Those data were standardized to numbers per acre at the time of spring annulus formation. Based on those survival rates, 100 stocked spring fingerlings might produce the age structure computed in the third row. However, it is not realistic to expect hatchery brown trout to survive as well as wild fish.

   The last two rows of Table 4.8 show survival of hatchery brown trout in Newton Creek (Alexander and Peterson 1981), and numbers at age that would result if stocked trout (100 spring yearlings/acre) survived at that rate. First-year survival of brown trout stocked into Newton Creek may be higher than in other stocked streams because a 10-inch minimum size limit was in effect when the study was conducted.

   Both hatchery and wild brook trout in streams exhibit lower survival than brown trout. Table 4.9 shows annual survival rates of wild brook trout in four streams. As time permits, data from additional streams will be added. Geographically extensive data on survival rates of brook trout is not available at this time. However, brook trout older than age-2 (fall samples) are extremely rare in virtually all streams in the state that are open to angling with an 8-inch minimum size limit. They are also rare in sections of the Au Sable River where “flies-only-no-kill” regulations are in effect.

3. Is natural reproduction adequate to generate the desired population of legal-sized fish?

   Managers must consider the quality of the habitat, stream productivity, genetic integrity, and temperature regime before considering supplemental stocking. Based on Michigan field data collections, desirable fisheries can be maintained by natural reproduction if densities of fall young-of-the-year are more than 150 fish/acre or if densities of spring yearlings are more than 75 fish/acre. Streams providing this level or higher of natural reproduction should not be stocked.

If there is significant natural reproduction, stocked trout will usually not result in a significant improvement in the fishery. Alexander and Peterson (1981) found that wild brown trout comprised 83% of the population by weight and 90% by number over a 10-year period at Newton Creek, Clare County. Standing crops ranged from 24 to 44 lb/acre during a period when the stream was stocked with 115 yearling brown trout/acre each year. The stocking program resulted in relatively insignificant increases in trout abundance and anglers harvested only 1.9% of the stocked brown trout.

4. Does the stocking generate sufficient angling activity to justify the cost of stocking?

   Widespread differences in capture rates of stocked trout should be expected due to differences in habitat, angling pressure, and the suitability and quality of the stocked fish. The latter includes the genetic lineage and health of fish delivered by the hatcheries (Shetter et al. 1964).

It was recognized in Michigan as far back as 1944 (Hazzard 1944) that stocking trout at any time of the year does not add appreciably to the trout catch in streams that had suitable spawning habitat and sufficient wild trout to saturate that habitat. A study conducted in the Pigeon River (Otsego County) during 1949 revealed that few of the legal-sized trout stocked into the Pigeon River survived to the next year (Institute for Fisheries Research 1953). Less than 3% of brook trout survived to the next year, and less than 10% of brown or rainbow trout survived for 1 year. However, during the first year anglers harvested 40% of the brook trout stocked as legal-sized fish, 45% of the rainbow trout, and 26% of the brown trout. Few marked, sub-legal brown trout stocked into the Pere Marquette and Manistee Rivers during the 1990s were collected 1 year later during either electrofishing or angler surveys. Wagner et al. (1994) found that stocking yearling brook trout in Upper Peninsula streams increased the number of legal-sized brook trout to a level similar to that of the natural population in the Iron River; however overwinter survival of the stocked fish was very low.

The most common objective of salmonid stockings is to generate angling effort and catch. Stockings can be considered successful even if they do not result in significant harvest because many anglers place high value on catch and release. This, for example, stocking to create or maintain a fishery subject to high size limits or no-kill regulations can be successful when they generate significant angling effort and catch, but little or no harvest. In these instances, the cost effectiveness of stockings can be assessed using the methods illustrated below.

The U.S. Department of Interior et al. (1996) estimated that a Great Lakes angler-day had an economic value of $36.00. If we accept the premise that a stocking is cost effective if it generates angler day values greater than the cost of stocking, then the success of a stocking can be assessed by estimating the amount of angling activity directed at catching the stocked species. In other words: If [(annual angler days* angler-day value in dollars) ≥ (annual cost of stocking)], then the stocking program is successful and may be continued. Because this criterion is a departure from more traditional criteria for evaluating the success of stockings, we recommend that a more conservative angler day value of $25.00 be used to determine annual angler day values and benchmarks for success. Table 4.10 shows how this method could be used to determine if the angler days generated by stockings of yearling trout justify the cost of stocking. The same approach can be used to evaluate the cost effectiveness of stockings of species such as walleye that are less costly to rear.

A major advantage of using angler-day values to assess the cost effectiveness of stockings is that relatively little survey effort is required to obtain sufficient data to assess the success of inexpensive stockings. For example, stocking could be justified in approximately 40% of the trout lakes stocked in the state if anglers made 2 dozen or fewer trips/lake/year. Inexpensive methods such as postcard creel surveys or low intensity creel surveys conducted during peak angling periods can determine this level of angling effort (Lockwood 2000).

Top-quality Trout Streams and General Stocking Rates

A key feature of top-quality trout streams is that natural reproduction and survival in these streams is generally adequate to support an acceptable angler fishery. These streams usually will not require stocking as a management procedure. Growth rates of trout in top-quality streams may range from well below state average to above state average depending on water temperature and fertility. For example, brook trout in Hunt Creek grow slower than average yet the stream is clearly top-quality as it supports one of the densest populations in the state. Top-quality trout streams have stable to moderately stable flow regimes (indicating high groundwater inputs). They are usually the least perturbed by man and should receive the highest level of habitat protection.

Some top-quality streams, however, may be stocked to provide a desired, or historical, level of fishing activity. Those streams should not be stocked if they contain multiple species of wild trout totaling more than 25 lb/acre. Brown trout should not be stocked into streams supporting more than 20 lb/acre of wild brown trout, and brook trout should not be stocked into streams supporting more than 10 lb/acre of wild brook trout. Top-quality streams with lower than the noted standing stocks may be candidates for stocking. Unstocked streams supporting fewer than 75 wild or naturalized spring yearling trout per acre may be considered for stocking. If evaluations show that overfishing is causing low standing stocks, then the manager has the option of using either stocking or regulations to maintain the level of fishery. However, managers should note that stocking hatchery trout might decrease the fitness of native or naturalized populations. Supplemental stocking rates for trout on top-quality streams in Michigan are generally 100 yearlings/acre or less.

If surveys on stocked streams detect significant numbers of young-of-the-year trout, then efforts should be made to determine the ratio of natural to stocked fish through population analysis or marking projects (Appendix 4.3). The easiest way to determine if a stocked stream can maintain adequate trout stocks without stocking is to compare standing stock and size structure between years when the stream is stocked and not stocked (Dexter 1991a).

Top-quality Potamodromous Streams

Some potamodromous streams are similar to top-quality trout streams in that they support healthy runs of salmon and steelhead through natural reproduction. They are managed to protect and foster wild runs and should usually not be stocked. The quality of a potamodromous stream can be partially assessed by determining if it supports higher-than-average amounts of natural reproduction. The average density of rainbow trout (mostly steelhead) was 391 fish/acre at 62 MRI sites where at least one rainbow trout was found. If you assume that 75% of these were steelhead young-of-the-year, then streams supporting more than 300 young/acre in late summer are better than average. Some reaches of excellent-quality streams—such as the Little Manistee River, or Bigelow Creek (Muskegon River watershed) and Pine Creek (Manistee River watershed)—support up to 2,000 young steelhead/acre during fall surveys.

Stocking top-quality potamodromous streams can increase angling opportunities. However, these stockings also may incur costs that need to be evaluated in terms of cost and benefits. Stocking on top of locally adapted stocks may decrease the genetic fitness of subsequent generations of fish. Stocking may cause loss of diversity due to inter-strain hybridization or competition. Many studies indicate outbreeding depression may occur in salmonid populations where the phenotypic traits of offspring are less adapted for growth or survival than are characteristics of the parental strains. Further, species- and strain-specific differences in demography and life history can result in competitive exclusion of a strain or species, contrary to management prescriptions or to public desires.

Second-Quality Trout Streams and General Stocking Rates

Streams in this category lack adequate natural reproduction to sustain desirable fisheries. These stream types are generally stocked with brook, brown, or rainbow trout yearlings at rates of 50–300/acre. Numbers stocked will vary greatly across the state primarily due to either the productivity, or stream size. Smaller streams generally are stocked more heavily on a per acre basis. Certain large rivers (e.g., Muskegon, Manistee, and the Au Sable rivers) where trout reproduction is limited but trout growth and angler uses are high are also stocked at high rates. Managers should expect trout densities of 30 lb/acre or less in these situations.

In the past, some second-quality streams were chemically treated with rotenone to remove populations of non-trout species. This practice has been used less frequently in recent years because it is expensive, non-trout species recolonize the treated waters within a few years, and there is substantial public opposition to the use of toxicants. When chemical treatments are conducted on streams, they should be restocked as soon as possible after detoxification to take advantage of increased opportunities for growth due to the paucity of food competitors. Fall treatments generally require a doubling of the standard stocking rate to compensate for high overwinter mortalities of fingerlings. Fall fingerlings are stocked immediately after treatment and in subsequent years yearlings should be stocked at normal levels.

Second-quality potamodromous streams

Large potamodromous streams may produce insignificant numbers of natural recruits. However, stocking these streams can produce significant runs of potamodromous salmonids from the Great Lakes. Generally, recruitment is naturally limited by water temperature. Large streams in this category offer great flexibility for salmon and steelhead management.

- Their stockings can support the open lake salmon fishery.
- They support intensive fall and spring fisheries for salmon and steelhead.
- They stimulate visitor and spectator interest and activity (such as the Grand River's 6th Street Dam) near urban areas.

Most southern Michigan streams fall into this category primarily because stocking efforts support them.

Smaller second-quality potamodromous streams generally are not stocked unless they are strategically located to produce stream-mouth harbor, or open-water Great Lakes fisheries (Harrisville and Lexington harbors on Lake Huron are two such examples).

Warmwater streams

These streams presently support sportfishing for a variety of fishes, including common carp, various suckers, channel and flathead catfish, northern pike and muskellunge, rock and smallmouth bass, yellow perch, and walleye. Warmwater streams biologically support lower numbers and overall weight of sportfish in comparison to coolwater streams in Michigan. Larger warmwater rivers (usually top-quality) such as the Grand or the St. Joseph rivers offer the best fisheries. Access is generally good and angling opportunities for a number of species of fish exist. Such top-quality warmwater streams generally have good fish populations and typically do not need stocking (O'Neal 1997). The exception is when there is a niche available to introduce a new species for anglers, such as muskellunge (Seelbach 1988).

Some warmwater impoundments have been chemically treated with rotenone for complete fish community removal as part of a broader lake or reservoir reclamation project. This is often done to remove high densities of common carp (Spitler 1978). The best stocking success has been initially after reclamation with yearling channel catfish and spring fingerling walleyes, and typical warmwater species (bass, bluegill, pike, etc., see individual species for stocking rates). In some river systems, stocked channel catfish have become self-sustaining, and some walleye populations are also showing increasing levels of natural reproduction.

Other species that have been stocked in warmwater rivers include smallmouth bass, northern pike, and muskellunge. Some species, such as smallmouth bass, are typically not available through the hatchery production program on an annual basis. Special planning will be required to accommodate non-programmed species.

Smaller warmwater streams (typically designated as second-quality) are very common in southern Michigan, but generally do not support sport fisheries other than seasonal fisheries for spawning suckers. They are typically highly variable in temperatures and flow regimes making them unsuitable for coolwater species. Small warmwater streams typically are not stocked.

Potamodromous fish streams general notes

Potamodromous species can be managed in all three of the above stream categories. Streams in this class support potamodromous runs of trout and salmon from the Great Lakes of either wild or stocked populations. Managers are faced with the primary problem of trying to determine stocking locations within the potamodromous reach. Management goals such as size of stream, fishing interest, access, etc. should dictate this decision.

Fish stocked upstream imprint better and return to the river better than fish stocked in river mouth areas. Total catch from upstream stockings may be similar or higher than returns from downstream stockings if there are intensive angler fisheries in the river. Fish stocked near river mouth areas provide high survival and return to the Great Lakes fisheries, but very poor returns to the upstream stream fisheries.

Several studies have been conducted in recent years to determine the best stocking locations to achieve desired management results. Seelbach et al. (1994) determined that steelhead stocked in the upper St. Joseph River (above five dams) had much lower post-stocking survival than those stocked below the dams. Steelhead that imprinted to a spring pond below the dams returned to the river at the highest rate. Steelhead stocked at the mouth or in downstream tributaries of the Grand River did not return upstream to the first dam, but contributed substantially to the open-lake fishery. Preliminary data show similar results for chinook salmon.

In streams that support natural reproduction, stocking can be reduced when new spawning habitat becomes available. New areas may become available by fish ladder construction and weir or dam removal. Potential reproduction for individual stream reaches can be estimated using known recruitment estimates from similar streams with similar water quality and physical characteristics. Increasing natural reproduction can increase survival rates of a species as wild fish are generally more genetically fit. Managing for increased natural reproduction of chinook salmon would reduce hatchery costs and could increase the overall survival of chinook salmon by reducing the occurrence of BKD (Hesse 1994).

Competition between species and between wild and stocked fish can be a problem (Bachman 1984; Vincent 1987). Studies are ongoing at this time to further examine interactions between steelhead and resident trout (Nuhfer 1997). Concerns at this time include redd superimposition, density-dependant interactions between potamodromous and resident salmonids, and competition for food and space (Ziegler 1988; Kocik 1992). These factors need to be considered by managers when weighing the possibility of extending runs into new areas to promote natural reproduction.

4.5 Figures

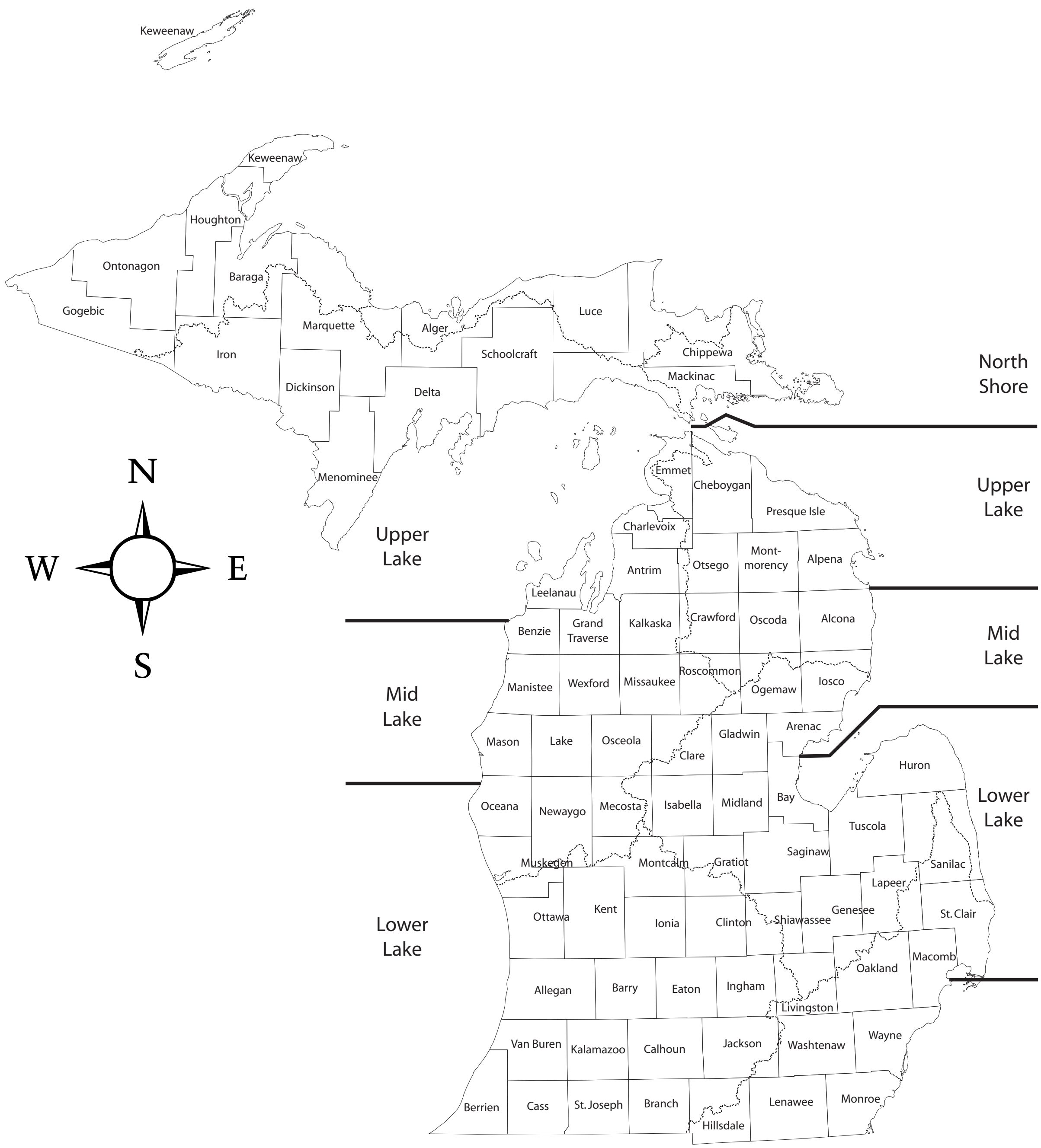

Figure 4.1.–Great Lakes stocking windows.

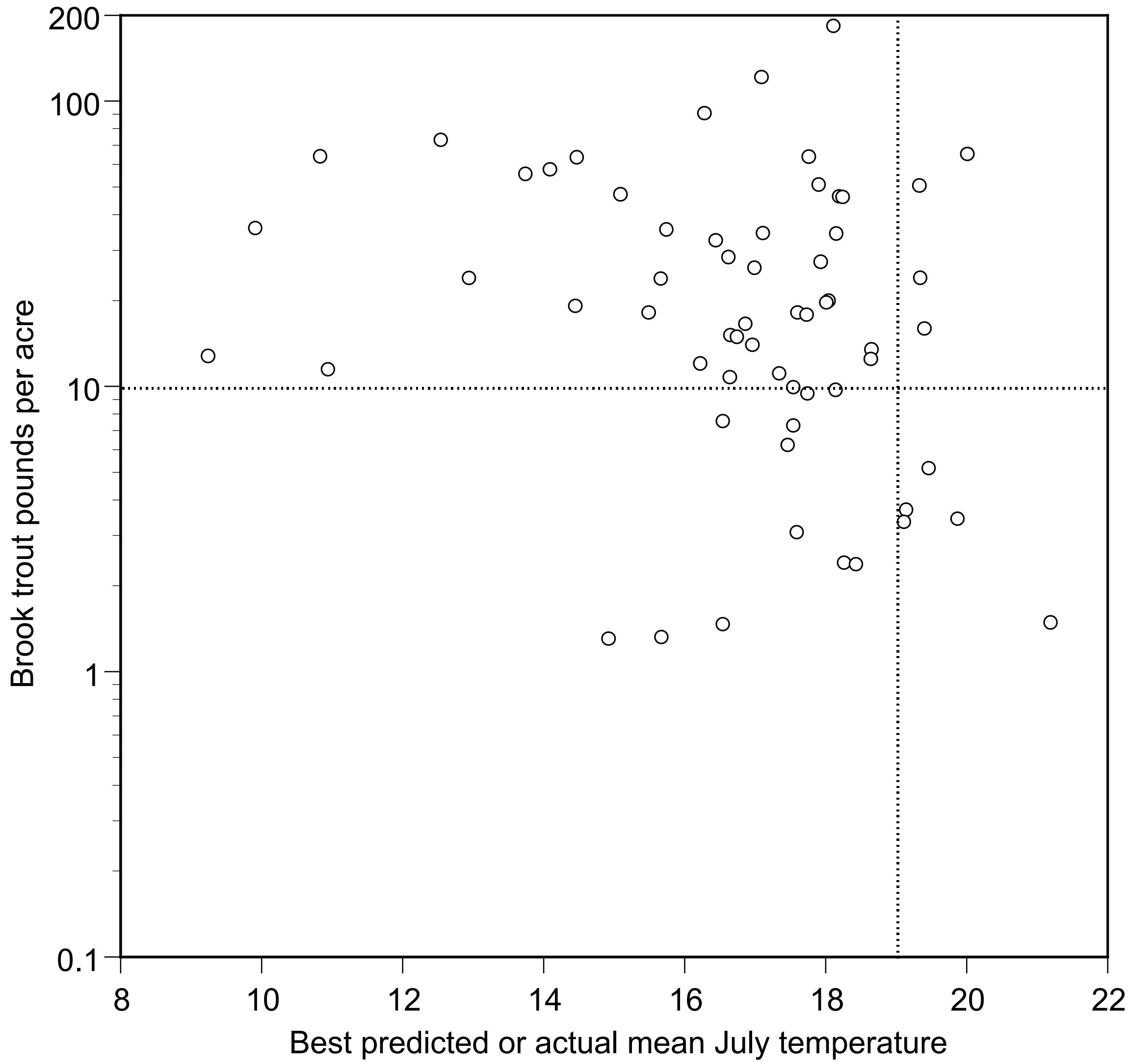

Figure 4.2.–Relationship between pounds per acre of brook trout and predicted or actual mean July water temperatures for sites in the Michigan Resource Inventory database.

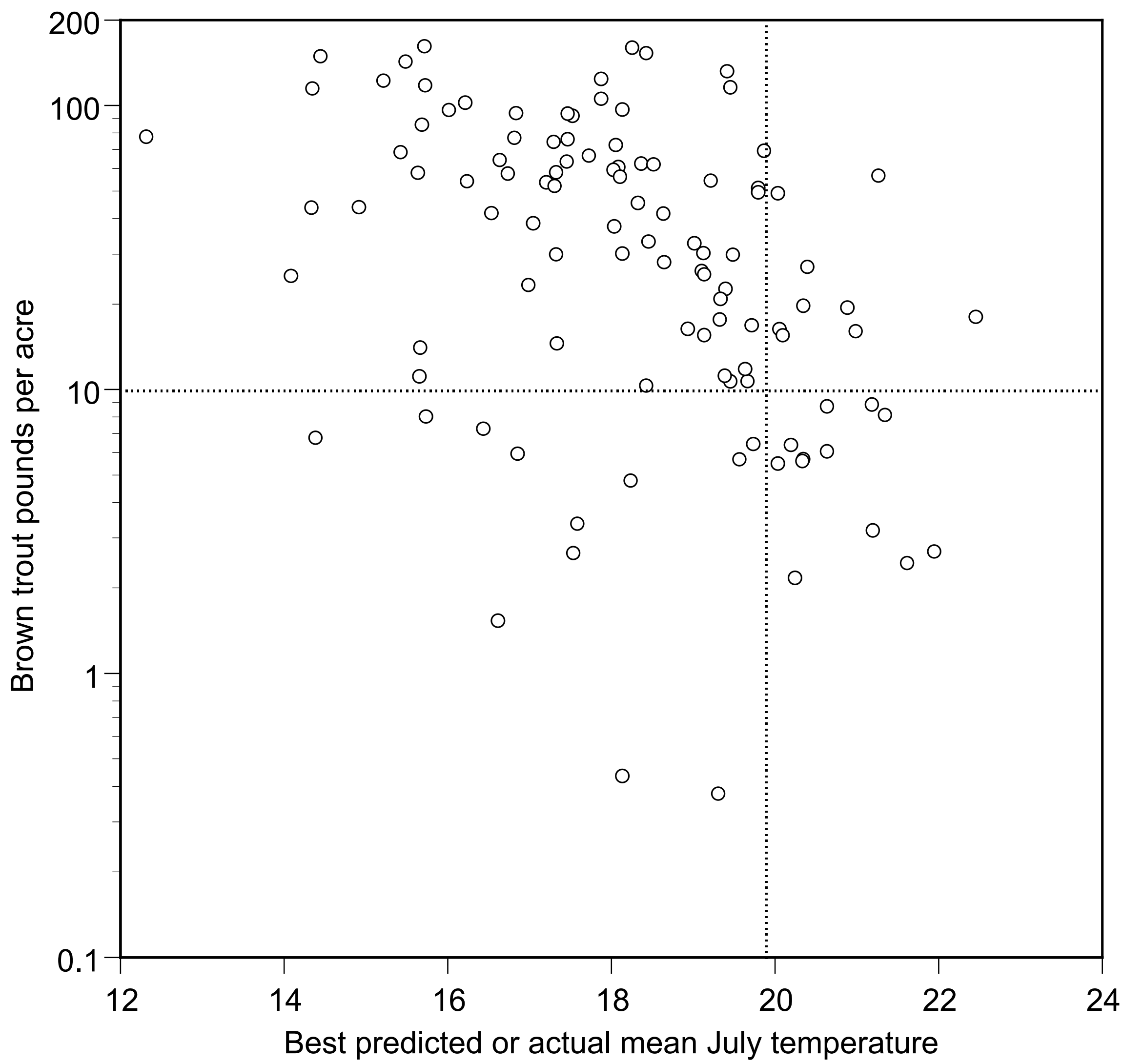

Figure 4.3.–Relationship between pounds per acre of brown trout and predicted or actual mean July water temperatures for sites in the Michigan Resource Inventory database.

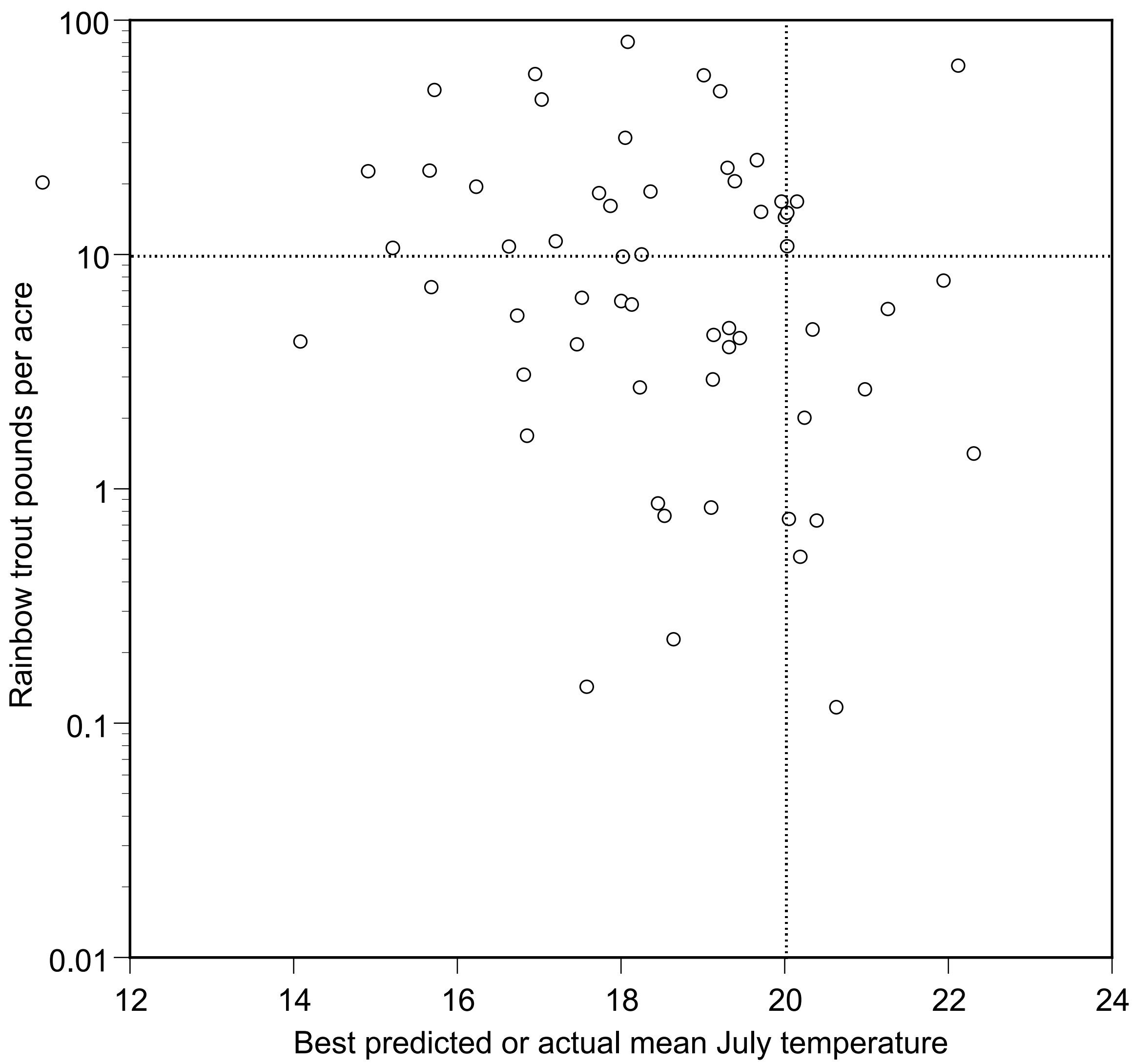

Figure 4.4.–Relationship between pounds per acre of rainbow trout and predicted or actual mean July water temperatures for sites in the Michigan Resource Inventory database.

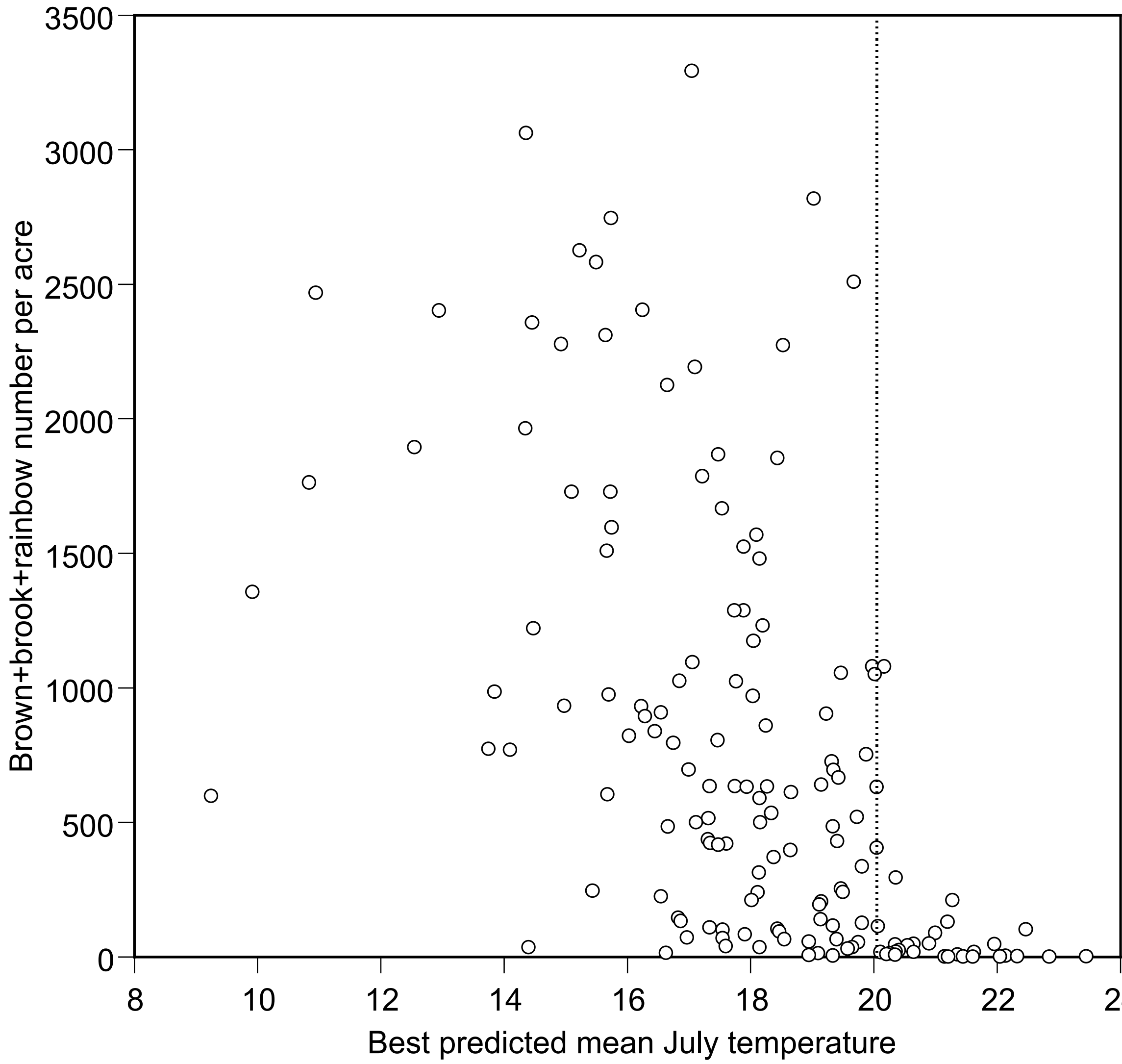

Figure 4.5.–Relationship between total numbers per acre of brown, brook, and rainbow trout and predicted or actual mean July water temperatures for sites in the Michigan Resource Inventory database.

4.6 Tables

Table 4.1.–Coldwater species reared by the Michigan Department of Natural Resources. YR = yearling, SF = spring fingerling, FF = fall fingerling.

Stocking period and Species	Strain	Age	Target size range: Inches	Number/lb
Late March-early June				
Atlantic salmon	Landlocked	YR	6.0-8.0	13.0-5.5
Brook trout	Assinica	SF	1.5-2.0	735.0-315
	Assinica	YR		
	Iron River	YR	6.0-8.0	11.5-5.0
Brown trout	Gilchrist Creek	YR	6.0-8.0	11.5-5.0
	Seeforellen	YR	6.0-8.0	11.5-5.0
	Wild Rose	YR	6.0-8.0	11.5-5.0
Chinook salmon	Michigan	SF	3.0-4.0	52.0
Coho salmon	Michigan	YR	4.0-5.0	45.0-23.0
Lake trout	Marquette	YR	6.0-8.0	18.5-7.5
Rainbow trout	Eagle Lake	YR	6.0-8.0	11.5-5.0
	Shasta	YR		
Splake		YR	6.0-8.0	11.5-5.0
Steelhead	Michigan	YR	7.0-8.0	7.2-4.8
	Skamania	YR	7.0-8.0	7.2-4.8
September-October				
Rainbow trout	Various	FF	3.0-3.0	120-35
Brown trout		FF	4.0-5.0	56-20
Brook trout		FF	3.5-5.5	54-15

Table 4.2.–Coolwater and warmwater fish reared by the Michigan Department of Natural Resources. YR = yearling, SF = spring fingerling, FF = fall fingerling.

Species	Age	Length (inches)	Number/lb	Time of year
Largemouth bass [a]	FF	1.7-3.0	92-450	Aug-Oct
Smallmouth bass [a]	SF	1.7-3.0	92-450	Aug-Oct
Channel catfish [a]	FF	7.0-9.5	4-10	Aug-Sep
	SF	6.0-7.5	8-15	May-Jun
	YR	7.0-10.0	3-10	Sep-Oct
Northern muskellunge	FF	8.0-12.0	4-13	Sep-Oct
	Fry	0.7	19,000	May-June
Northern pike [b]	FF	7.0-13.0	3-20	Jul-Oct
	Fry	0.5	40,000	Apr-May
	SF	2.0-40	100-1,000	May-June
Lake sturgeon	FF	4.0-6.0	15-50	Sep-Oct
Walleye [bc]	FF	5.0-9-0	4-26	Sep-Nov
	Fry	0.2	70,000	Apr-May
	SF	1.0-4.9	28-3,333	May-Aug

[a] Bass and catfish are not currently raised in Michigan hatcheries. Contact the Fish Production Manager for special requests.

[b] Most pike and walleye fingerlings are raised in watershed management unit rearing ponds. Limited number pike are available as SF from the production unit.

[c] Includes several strains.

Table 4.3.–Great Lakes stocking windows (See also Figure 4.1). All species stocked in Lake Superior are stocked after ice-out and before smolting.

Location	Species (strain)							
	Atlantic salmon	Brown trout	Chinook salmon [a]	Coho salmon [a]	Lake trout	Rainbow trout	Rainbow trout (MI) [a]	Splake
Lakes Huron and Erie								
Port Huron to state line		5/10-5/25	4/15-5/15		4/15-5/15	4/15-5/15	4/15-5/15	4/15-5/15
Au Gres to Lexington		5/10-5/25	5/15-5/30		5/01-6/30	5/01-5/30	4/25-5/15	5/10-5/25
Tawas to Harrisville	5/10-5/20	6/01-6/15	5/15-6/10		5/01-6/30	5/15-5/30	5/10-5/25	6/01-6/15
Black River to Mackinaw	5/10-5/20	6/01-6/15	5/15-6/10		5/01-6/30	6/01-6/30	5/10-5/30	6/01-6/15
St. Ignace to Sault Ste. Marie	6/01-6/10	6/01-6/15	6/01-6/10		5/01-6/30	6/01-6/30	5/10-5/30	6/01-6/15
Lake Michigan								
Pentwater South		5/10-6/15	5/15-5/30	4/25-5/10	5/01-6/30	5/01-5/30	4/25-5/15	
Ludington to Frankfort		5/15-6/15	5/15-6/10	5/01-5/15	5/01-6/30		5/10-5/25	
Platte River North		5/15-6/15	5/15-6/10		5/01-6/30		5/10-5/30	5/15-6/15

[a] Stock before smolting.

Table 4.4.–Numbers of trout stocked per acre, by lake size, 1995-96.

	Lake size (acres)			
Species (life stage)	<20	21-99	100-500	>500
Brook trout (fall fingerling)				
Range	23-200	11-143		
Mean	109	59		
Median	100	53		
Brook trout (yearling)				
Range	25-147	6-100		
Mean	69	66		
Median	69	76		
Rainbow trout (yearling)				
Range	29-175	13-320	5-83	2-21
Mean	86	63	35	8.4
Median	79	53	36	5.7
Splake (yearling)				
Range		15-114	4-68	1-15
Mean	35	51	35	6
Median		44	34	3.5
Brown trout (yearling)				
Range	29-500	10-99	7-43	0.6-8.5
Mean	119	46	28	4.7
Median	91	42	30	4.2

Table 4.5.–Simplified warmwater and coolwater fish stocking guide[a] (no competing fishes present initially).

Water body type and Species combination	Target composition (%)[b]	Stocking rate[c] Life stage	Number/acre	Size (inches)	Notes
Ponds or specially managed small lakes[d]					
Bluegill	75	fingerling	640	1 - 3	
Largemouth bass	25	fingerling	40	2 - 6	
		adult	5	10+	Give bass head start.
Hybrid sunfish	100		400-800/ 1-2 yrs	1 - 3	No reproduction; restock.
Largemouth bass	50	fingerling	40	2 - 6	Allow minnows to spawn
Golden shiner	50		500	2 - 7	first.
Walleye	30	fingerling	10/yr	3 - 6	No walleye reproduction
Perch	20	eggs		0	expected. Best for
Bluegill	50	fingerling	500	1 - 3	northern lakes with low
		adults	5	7+	bluegill reproduction.
Walleye	50	fingerling	10/yr	3 - 6	No walleye reproduction
Golden shiner	50		500	2 - 7	expected.
Typical warmwater lakes					
Bluegill	50	fingerling	400	1 - 3	If history of stunted bluegill
Largemouth bass	15	fingerling	30	2 - 6	or perch, maintain high
Pike[e]	5	fry	200	fry	densities of predators
Perch	10	any		any	with protective regulations
Channel catfish	10	fingerling	30/yr	3 - 6	or supplemental stocking
Crappie	5	adults	5	7+	of walleye or channel
					catfish. Minnows may
Minnows	5	adults	100	1 - 7	re-colonize on own.
Coolwater lakes					
Perch	50	any		any	
Bluegill	20	fingerling	200	1 - 3	
Walleye	10	fingerling	30/yr	1 - 3	Walleye and bluegill
Smallmouth bass	20	fingerling	30	2 - 6	optional and may or may
		adults	5	10+	not reproduce.

[a] General advice: select species based on habitat suitability and predator-prey balance; construct simpler fish communities in small or unproductive northern lakes; avoid restocking species that created problems there before.
[b] Refers to the resulting fish community.
[c] Stocking rates refer to one-time events, unless followed by /yr, indicating a need for maintenance stocking.
[d] See also Schrouder et al. (1989).
[e] May substitute walleye, but annual or semi-annual maintenance stocking of fingerlings required.

Table 4.6.–The maximum weekly mean temperature for salmonid species stocked in Michigan (Eaton et al. 1996).

Species	Centigrade	Fahrenheit	Sample size
Brook trout	22.3	72.1	180
Brown trout	24.1	75.4	53
Chinook salmon	24.0	75.2	282
Coho salmon	23.4	74.1	193
Rainbow trout	24.0	75.2	442

Table 4.7.–Average July water temperatures that should not be exceeded in stocked coldwater streams. Data from Wehrly et al. (1998)

Species	Centigrade	Fahrenheit
Brook trout	19.0	66.2
Brown trout	20.0	68.0
Chinook salmon	20.0	68.0
Coho salmon	20.0	68.0
Rainbow trout	20.0	68.0

Table 4.8.–Measured trout survival rates from 13 wild streams and Newton Creek.

	Age				
Stream type and statistics	1	2	3	4	5
13 wild brown trout streams					
Average number/acre	226.0	114.0	53.0	13.0	1.5
Average survival rate	0.50	0.46	0.25	0.11	0.13
Projected population/100 wild	100.0	50.0	23.0	6.0	0.6
Newton Creek					
10-year average number/acre (hatchery brown trout)	115.0	17.0	3.0	0.6	0.3
Average survival rate	0.14	0.18	0.20	0.41	
Projected population/100 stocked	100.0	14.0	2.5	0.5	0.21

Table 4.9.–Brook trout annual survival rates from four Michigan streams.

		Survival (%) by age (fall to fall)			
Wild brook trout stream	Regulation	0	1	2	3
Hunt Creek Section B, 1974-94	No fishing	31	32	15	32
Mainstream Au Sable at Stephan Bridge	No-kill, flies only	20	7	N/A	N/A
Mainstream Au Sable at Wa Wa Sum	No-kill, flies only	37	10	4	N/A
North Branch Au Sable at Dam 4	8-in minimum, flies only	15	6	2	N/A

Table 4.10.–Angler-day equivalents needed to provide cost-benefit justification for salmonid stockings.

Number of yearling salmonids stocked	Annual cost of stocking ($0.73/yearling)	Angler-day equivalents ($25.00/angler-day)
20,000	$14,600	584
10,000	$7,300	292
5,000	$3,650	146
1,000	$730	29

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4.8 Appendices

Appendix 4.1. Fish stocking truck information.

Appendix 4.2. Loading capacities for standard 250-gallon compartment for several species.

Appendix 4.3. Fish marking policy: Division Directive FI-122 with proposal form.

Appendix 4.1.–Fish stocking truck information.

DNR

STATEWIDE FISH STOCKING FLEET INFORMATION

(Updated September 2004)

Unit I.D.	No. of Units	Total Tank Size m3	No. of Compartments	Load Capacity (kg) Yr.=Yearling Fing.= 2” Fingerling	Vehicle Wt. Empty (lbs)	Vehicle Wt. Full (lbs)
4 x 4						
SV-0176	1	1.1m3 (300 gal)	3 (100 gal/ea)	Total Load: 244 kg - Yr., or 77 kg - 2” Fing.	8,080	10,480
Manchester:						
SV-0016 SV-0100	2	2.8m3 (750 gal)	3 (250 gal/ea)	Total Load: 620 kg – Yr., or 196 kg – 2” Fing.	12,940	19,480
Cadillac:						
SV-0095 SV-0096 SV-0097 SV-0098 SV-0102 SV-0179 SV-0319 SV-0320 SV-0473 SV-0474	10	4.5m3 (1,200 gal)	4 (300 gal/ea)	Total Load: 1,000 kg - Yr., or 315 kg - 2” Fing.	15,640	25,640
Intermediate:						
SV-0101	1	7.8m3 (2,000 gal)	1 (2,000 gal/ea)	Total Load: 1,529 kg – Yr.	19,780	36,340
Intermediate:						
SV-0178 SV-0321	2	7.8m3 (2,000 gal)	4 (500 gal/ea)	Total Load: 1,529 kg - Yr.	23,720	40,900
Cadillac: Semirep						
SV-0177	1	13.2m3 (3,500 gal)	1 (3,500 gal/ea)	Total Load: 2,480 kg – Yr.	42,490	72,650
Semi Unit						
SV-0380	1	15.1m3 (4,000 gal)	1 (4,000 gal/ea)	Total Load: 2,840 kg - Yr.	46,000	78,400

CONVERSION NOTES:

- (m^3)(35.31476) = $ft.^3$
- ($ft.^3$)(7.48052) = U.S. Gallons
- (U.S. Gallons)(1.7 lbs.) = Maximum carrying capacity for yearling Trout
- (U.S. Gallon)(1.2 lbs.) = Maximum carrying capacity for 4” trout

(Typical walleye planting units are the older Peterson Cabover Style and the New Cadillac Units, which are both 1,200-gallon units)

- Fish Stocking – 1998: 400,000 KGS/year (882,000 lbs.) Salmonids from 6 hatcheries statewide, 300,000 KLM (180,000 miles) 600 truck trips/year

Appendix 4.2.–Loading capacities for standard 250-gallon compartment for several species.

Species	Temperature	Number/pound	Size (in)	Lbs/gal.	Max lbs.	# Fish/125 Gallon Compartment
Walleye	55-65 F	1000	1	0.55	69	69,000
		500	2	0.66	83	41,500
		60	3	1.3	163	9,780
Redear Sunfish	65-85 F	1000	1	0.33	41.25	41,250
		400	2	0.5	62.5	25,000
		100	3	0.66	125	12,500
Channel Catfish	65 F	1000	1.5	1.25	156	156,000
		500	1.9	1.75	219	109,500
		125	3	2.95	369	46,125
		50	4.1	3.45	431	21,000
		4	9.4	5	625	2,500

Appendix 4.3.–Fish marking policy: Division Directive FI-122 with proposal form.

DNR
MICHIGAN DEPARTMENT OF NATURAL RESOURCES

INTEROFFICE COMMUNICATION

Number: _FI-122___________
Effective Date: _Immediate______
Expiration Date: _Onoing_________

April 12, 2000

DIVISION DIRECTIVE

TO: All Biologists
Gary Whelan, Hatchery Operations Manager

FROM: Kelley Smith, Chief

Action to be taken:

Implement revised Fish Marking Policy and Procedures for hatchery reared stock.

Description of Action (Revised Policy and Procedure):

Fish marking studies are conducted for many management purposes including strain evaluation, estimation of survival rates, abundance, migration patterns, age and growth, diet studies, etc. In order to avoid duplication of effort, confusion, budgetary problems, rearing space problems, and scheduling conflicts, all fish marking projects will be coordinated through the Fish Marking Review Committee (FMRC). Membership of this committee includes the Fish Stocking Biologist, a representative from each Basin, two representatives from Research, and the Staff Specialist. This will ensure that the proposed program adheres to policy, will contribute to statewide fish management programs, and not conflict with previously established programs.

The FMRC will review all marking and tagging projects and will 1) return the project to the writer for revision or clarification, or 2) place the project into one of the following four categories (Tiers):

Tier I: Tier I projects are those that:
1) will not require hatchery personnel/resources for marking.
2) may require on-site marking by field personnel or an outside agency
3) will need to be reviewed by FMRC for mark coordination purposes
4) will be handled through the prescription process.

Tier II: Tier II projects are those that:
1) will require hatchery personnel/resources for marking
2) will be funded under existing hatchery budget for marking*
3) will be considered "small" projects

Appendix 4.3.–Continued.

4) will need to be reviewed by FMRC for mark coordination purposes
5) will be handled through the prescription process

Tier III: Tier III projects are those that:
1) will require hatchery personnel/resources for marking
2) will be funded under existing hatchery budget for marking*
3) will be considered "large" projects
4) will need to be reviewed by FMRC for mark coordination purposes
5) may or may not be handled through the prescription process

Tier IV: Tier IV projects** are those that:
1) will require substantial hatchery resources (personnel, funding, etc).
2) may exceed existing budgets for marking
3) may require special funding, personnel or equipment
4) may or may not be handled through the prescription process

*The Hatchery Section will be operating under an annual fish marking budget. Any projects recommended by the FMRC must fall within existing budgetary constraints.

**Tier IV projects will be subject to further review and recommendations of the FMRC and will not necessarily fall under the same time frame as those in Tiers I-III. All Tier IV projects will be evaluated and prioritized by the FMRC, which will forward a list of recommended projects to the Management Team for final approval.

Timeline for Submittal, Review and Approval of Marking Proposals

July 1: Deadline for submitting all marking and tagging proposals to the FMRC.

July 15: Deadline for review of all proposals by the FMRC.

January 15: Deadline for submission of Fishery Management Prescription (FMP) with approved marking proposal attached.

January 31: Deadline for Unit Supervisor approval of all FMP and associated Fish Stocking Requests.

March 15: Hatchery stock allocations finalized.

Submittal of Fish Marking and Tagging Study Proposal

All fish marking and tagging project proposals shall be submitted on a Fish Marking and Tagging Study Proposal form. Marking proposals will include project goals and objectives, the number, age, species, strain of fish involved, and the type of mark desired. The duration of the project is to be included, **as is a description of the evaluation procedures and assignment of project responsibility**. Costs for marking/tagging and evaluation are to be included.

Proposal Evaluation

All proposals will be evaluated by the FMRC using a standardized set of criteria.

Coordination with the Fishery Management Prescription (FMP) process

Appendix 4.3.–Continued.

A Fishery Management Prescription (FMP) must be submitted for all Tier I, II and III marking and tagging proposals that 1) pertain to inland waters and 2) have been approved by the FMRC. When a FMP is completed, the author will include a description of the marking proposal and attach a "Fish Marking and Tagging Study Proposal" form to the FMP. The FMP must be submitted by January 15 and approved by the Unit Supervisor by January 31. **Projects not submitted in this fashion may not be accomplished the first year.**

Marking projects on the Great Lakes

Fish Stocking Requests (FSR) for Great Lakes stockings do not require associated prescriptions. Likewise, any Tier III or Tier IV marking and tagging project for Great Lakes waters will not require a FMP. However, for Great Lakes marking proposals, a Fish Marking and Tagging Study Proposal must be written and submitted to the FMRC by the July 1 deadline in order to be considered for the next fiscal year.

Project Evaluations

It is recognized that marking projects are of utmost importance to proper evaluation. However, because fish marking can be both expensive to the Division and time consuming, **project leaders will commit to proper and timely evaluations of marked stockings, with appropriate documentation** (minimum Status of the Fishery Report, more often a Technical or Research Report). **Units with proposed marking projects will make those required evaluations the highest priority fieldwork on work plans.**

All on-going marking projects will be made a high priority for field evaluation. These projects should show up in your work plan for evaluation on schedules you devise for evaluation. Project leaders will prepare annual interim reports until completion of the project (a short summary of accomplishments), to be submitted to the Staff Specialist and Basin Coordinator. Projects that lack timely evaluation must be considered by the Basin Team for dropping off work plans entirely.

Coordination:

The Fish Stocking Biologist will be responsible for coordinating all marking projects with the hatchery system. The Staff Specialist will serve as the liaison between the hatcheries and field. Statewide marking needs will be distributed yearly by the Staff Specialist to biologist so that you are aware of all projects. Basin Coordinators will be responsible for (1) determining which marking project(s) are of highest priority for the next fiscal year, (2) ensuring that project proposals are submitted by July 1, and (3) ensuring that marking evaluations are scheduled and completed on work plans.

Allotment and Accounting:

No special allotment. Expenses to be paid from Management Unit/Hatchery/Research operating funds.

Approved by: ____
Kelley Smith, Chief
FISHERIES DIVISION

Attachments

Michigan Fish Stocking Guidelines II: with Periodic Updates

Chapter 5: Stocking Guidelines for Various Species of Fish

Suggested citation:

MDNR (Michigan Department of Natural Resources). 2004. Stocking guidelines for various species of fish. Chapter 5 *in* Dexter, J. L., Jr., and R. P. O'Neal, editors. Michigan fish stocking guidelines II: with periodic updates. Michigan Department of Natural Resources, Fisheries Special Report 32, Ann Arbor.

Chapter 5: Stocking Guidelines for Various Species of Fish

5.1 Brown Trout

Brown trout *Salmo trutta* were first introduced to North America in 1884 when the Michigan Fish Commission released fish of German origin into the Pere Marquette River (Anonymous 1974; Johnson 1995). Today they are highly regarded as a sport fish, both as the premier species of inland trout fishing and as an inshore, small boat element of angling in the Great Lakes.

The vast majority of brown trout currently stocked in Michigan waters are spring yearlings. Yearlings produce far better returns to the creel than fall fingerlings (Shetter 1939; Shetter et al. 1964). Shetter et al. (1948) also investigated the efficiency and results of bridge stocking versus boat (scatter) stocking and found no significant benefit derived from the extra work involved with scatter stocking. Based on experience gained on Michigan trout stream reclamation projects, fall fingerling brown trout are best used for stocking smaller streams after competing species are removed.

Ongoing evaluations of hatchery brown trout stocked into some streams suggest that most do not survive beyond fall of the year they are stocked and even fewer survive to the next year. Survival and growth are highly variable among streams. For example, in marginal streams where growth and survival may be poor, stocking large trout could provide better fisheries. In streams with good growth and survival, smaller trout typically suffice. Research on Michigan's three strains of brown trout is continuing. Managers need to carefully consider and evaluate survival and growth when stocking trout, especially in waters subject to larger minimum size limits.

Brown trout should not be stocked into streams managed for brook trout (Waters 1983; Zorn et al. 2002). If habitat is suitable for both species, brown trout usually reduce the abundance of brook trout through competition.

Brown trout may be stocked in lakes in conjunction with rainbow trout or as the sole species. Brown trout are much more difficult to catch in lakes than rainbow or brook trout, and hence are more likely to survive to grow to a larger size (Alexander and Nuhfer 1994). In heavily fished lakes where most rainbow trout are harvested during the year stocked, mangers may also consider stocking brown trout to provide angling opportunities for larger fish. Fewer brown trout need to be stocked because they survive better (Shetter 1940; Gowing 1974). Managers and anglers in these situations must be aware that brown trout will provide lower catch rates, but bigger fish.

Brown trout are more piscivorous than rainbow trout. Based on experience, mangers can stock them successfully in two-story lakes that have undergone plankton declines and associated poor survival rates of rainbow trout. The majority of lakes stocked with brown trout are less than 100 acres in size. These lakes are stocked at an average rate of 46 yearlings/acre (Table 5.1). Brown trout may be better suited to stocking into larger lakes (>1000 acres), but these stockings have been poorly evaluated. Some stockings of brown trout into Lake Charlevoix produced good fisheries during the late 1980s whereas more recent stockings have not. More evaluation of brown trout stockings in large lakes needs to be done. Great lakes stocking of certain strains of yearling brown trout have produced excellent results (Keller et al. 1990; Johnson 1997).

Returns of brown trout have diminished significantly in Lake Huron, presumably from an increase in predation by walleyes. Jim Johnson (MDNR, personal communication) found survival and success of brown trout stockings in Lake Huron's Thunder Bay were highly variable, most likely due to fluctuations in alewife abundance. It is thought that alewife availability buffers yearling brown trout from predation by walleye. Because of this, larger sized brown trout are now being stocked at different times to avoid predation. Evaluations are underway. Lake Michigan brown trout fisheries continue to be good. Stocking rates vary from 10,000 to 120,000 spring yearlings per port in lakes

Michigan and Huron. About 40% of the yearling brown trout presently reared in state hatcheries are stocked in the Great Lakes. These stockings produce fisheries in shallow, in-shore waters by long-line trollers and pier anglers. These lake-fed fish also provide added excitement to stream anglers when they ascend large rivers in the fall to spawn.

Brown trout strains presently stocked exhibit different survival and growth characteristics in a variety of habitats. Information available to date does not give a clear indication as to which strain performs best in certain waters. Managers presently may chose from three strains of brown trout for stocking. Most strain evaluations to date have been conducted in lake environments, but there is on-going research in streams. The following is a brief description of the characteristics of the three strains presently reared in the hatchery system.

Wild Rose is a long-domesticated strain of brown trout originally obtained from Wisconsin. Wild Rose usually contributes more heavily to the nearshore spring fishery on the Great Lakes. They are the largest of the three strains of brown trout at stocking in the spring. Some managers report very poor survival of this strain when stocked in streams, but there are also some streams where they appear to be performing well. They are generally not a well-colored fish (steel gray with washed out spot coloring) and experience high rates of fin erosion in the hatcheries. Due to their large size at stocking, Wild Rose may be a good choice for stockings into streams with low angling size limits where few fish survive beyond the year they are stocked.

New York State originally imported Seeforellen brown trout from West Germany's larger oligotrophic lakes in the early 1980s. Seeforellen stocked into Lake Huron provided better return to the creel at a slightly greater age and size than Wild Rose (Johnson 1997). They are more frequently caught later in the summer and farther offshore than Wild Rose. In inland lakes, Seeforellen attain a larger size than Wild Rose due to later maturity. They show similar survival characteristics to Wild Rose over a 2-year period (Nuhfer 1996). In the short period that Michigan has been stocking this strain, it appears to survive better than Wild Rose in stream environments and is more naturally colored. They are generally smaller than Wild Rose when stocked.

Naturalized brown trout from Gilchrist Creek Montmorency County were used to develop a broodstock in 1991. Their origin is believed to have been from Lake Huron brown trout migrating up the Thunder Bay River system prior to 1940 (Alexander and Nuhfer 1994). This strain was selected specifically for stream stockings. Alexander (1987) showed that trout transferred from naturally reproducing populations survived twice as well as domestic brown trout in four study lakes. This strain was found to be 2–4 times more vulnerable to angling than wild Au Sable River brown trout (Alexander and Nuhfer 1994). Gilchrist Creek strain brown trout are typically much smaller when stocked than Wild Rose or Seeforellen strain fish because the broodstock ripen much later in the fall and juveniles appear less adapted to the hatchery environment. Gilchrist Creek brown trout have more natural coloration than the other strains and have excellent fin quality. A definitive comparison of the survival and growth of this strain to Wild Rose and Seeforellen strain brown trout in streams will be available after 2002 when the ongoing evaluation is completed.

Experience shows that appropriate supplemental stocking rates for trout in top-quality streams in Michigan are generally 100 yearlings/acre or less. Second-quality streams are generally stocked at rates of 50–300 yearlings/acre (see Chapter 4 page 16).

5.2 Brook Trout

Brook trout *Salvelinus fontinalis* are indigenous to the Great Lakes region and have been stocked since the late 1870s (Anonymous 1974). They are stocked primarily in streams and small inland lakes. Great Lakes brook trout (coasters) are presently being enhanced in certain areas by stocking tributary streams. Brook trout are the primary trout species sought by anglers in the Upper Peninsula. In recent years, almost all of the Michigan brook trout stockings have been made in the Upper Peninsula. Yearling brook trout are used to supplement resident stream trout populations where there is inadequate natural recruitment. Brook trout stockings should be restricted to coldwater streams where summer temperatures rarely exceed 70˚F. Brook trout should not be stocked into waters containing significant brown trout populations (Stazo and Rahel 1994; Waters 1983; Wehrly et al. 1999).

Yearling brook trout should be used for most inland stream stockings. Shetter et al. (1964) found much better returns from stocked yearling brook trout than from fall fingerlings, when summarizing data for over 40 stream stockings. Since Upper Peninsula waters are generally less productive than Lower Peninsula waters, stocking rates are usually reduced. After chemical reclamation, designated trout lakes are stocked initially with yearlings and in subsequent years primarily with fall fingerlings. Smaller lakes are typically stocked with approximately 100 fall fingerlings/acre (Table 5.2).

Brook trout are not usually stocked into coldwater lakes with significant populations of non-salmonid species or in combination with other trout species. Survival of brook trout with other species is very poor. In 1999, Nipigon-strain brook trout were stocked as fall fingerlings into coastal Lake Superior streams in an attempt to reestablish or enhance native coaster brook trout populations.

Michigan presently rears three brook trout strains, each used in different types of waters. The Assinica strain of brook trout is well suited for stocking into small inland lakes. The State of New York originally obtained it from Assinica Lake of the Broadback River watershed in Quebec, Canada. This lake drains into James Bay (Alexander et al. 1990). Several studies have shown that the Assinica strain grows and survives better than domestic stocks normally used in management (Gowing 1978, 1986; Flick and Webster 1976). Assinicas are stocked as either fall fingerlings or as yearlings. We presently are stocking relatively more Assinicas as fall fingerlings because the strain is susceptible to furunculosis infections in the hatchery if they are reared to larger size. These fall fingerling stockings have produced good to excellent fisheries in inland lakes in the Upper Peninsula. Assinicas average 6–8 fish/lb as yearlings, and about 23 fish/lb as fall fingerlings. Fin quality is fair to good and they have good natural colors.

The Iron River strain was selected specifically for river stockings. The Iron River has never been stocked and the brook trout there are considered to be a pure native strain. In fall 1994, 1,600 wild young-of-the year brook trout from Iron River in the Upper Peninsula of Michigan were transferred to isolation at the Marquette State Fish Hatchery (Driver 1995). This strain is not in full production and is providing 35% of the total brook trout stocking needs for the state. Limited investigations into the success of this strain began in 1998 and no results are available yet. Iron River brook trout grow to a large size in their natal river. They ripen very late in the hatchery system, are very slow growing because of their wild characteristics, and are stocked as small spring yearlings (23 fish/lb).

Nipigon and Tobin Harbor strains are being used to restore coaster brook trout populations along Michigan's Lake Superior watershed. Evaluations of these strains are underway, and no decision has been made as to which strain may be used for long-term management, if any. Current plans prescribe stockings of fall fingerlings into the Gratiot and Little Carp rivers for 5–6 years, which began in fall 1999. Other stockings will be in accordance with coaster brook trout restoration plans that have not been finalized.

Supplemental stocking rates for brook trout in top-quality Michigan are generally 100 yearlings/acre or less. Second-quality streams are generally stocked at rates of 50-300 yearlings/acre (see Chapter4 page 16).

5.3 Rainbow Trout and Steelhead

In 1876, Daniel C. Fitzhugh Jr., of Bay City, is believed to have brought the first rainbow trout *Onchorhynchus mykiss* into Michigan (Anonymous 1974; Keller et al 1990). They were imported as eggs from Campbells Creek, a tributary to the McCloud River, which is a tributary to the Sacramento River, California. Fry from these eggs were released into the Au Sable River. In 1878, Frank N. Clark purchased 125 yearling McCloud River rainbow trout and raised them to maturity at the hatchery in Northville, Michigan. He released their progeny into the Au Sable River.

The Michigan Fish Commission first introduced rainbow trout in 1880. The eggs that they brought into Michigan originated from Crooks Creek, also a tributary to the McCloud River. These were incubated and hatched at the Crystal Springs State Fish Hatchery at Pokagon. The 2,000 eggs produced 1,200 fry, of which one-third were stocked into the North Branch of the Paw Paw River and one-third into the Boyne River, both tributaries to Lake Michigan. The remaining one-third was retained for production of future broodstock.

Rainbow trout are presently stocked in inland lakes, streams, and the Great Lakes. Three strains of rainbow trout are now used by managers, depending on management objectives. These strains include Eagle Lake, winter-run steelhead (Little Manistee River), and summer-run steelhead (Skamania). Use of Shasta and Arlee strains was discontinued due to poor performance. Rainbow trout are the trout species most frequently stocked into inland lakes. They are generally easier for anglers to catch than brown trout. Rainbows are now stocked almost exclusively as spring yearlings. In large oligotrophic lakes, stocking rates are usually fewer than 10 fish/acre. Smaller lakes are typically stocked around 50 fish/acre (Table 5.1). Fall fingerlings can be requested for some circumstances, such as reclamation projects. Sometimes rainbow trout fisheries fail, apparently related to declines in abundance of large *Daphnia*. Galbraith and Schneider (2000) found that poor trout lakes had less than 100 large daphnids per plankton net haul. Many two-story lakes in southern Michigan have experienced this. On lakes experiencing poor returns from stocking, managers should discontinue stocking efforts for up to 3 years to allow daphnid populations to rebuild. Stocking can then resume. Managers should consider reducing historical stocking rates of trout at this point to prevent future declines in zooplankton populations.

Experience has shown that domesticated rainbows stocked into river systems frequently emigrate from the managed area. Young rainbow trout (age-1 to age-2) rarely reside in streams long enough to grow to a size attractive to anglers. Thus, stocking of rainbow trout in streams currently has limited application in management of in-stream fisheries as compared to brown trout. Exceptions include the larger coolwater rivers, such as the lower Muskegon and Au Sable. These produce the best fisheries when stocked with spring yearling rainbows. Excellent growth rates are observed at these streams, and angler harvest and effort is intense. For most of Michigan's smaller trout streams, brook and brown trout should generally be used to enhance the fisheries.

The Great Lakes rainbow trout program is similar to the brown trout program in that it is designed to provide increased nearshore, harbor, and pier fishing opportunities during periods when potamodromous salmonids are offshore. Domestic strains seem to remain closer to the release sites than steelhead strains, but angler harvest of the domestics has generally been poorer than for steelhead (Richard O'Neal, MDNR, personal communication). In recent years, up to 20% of the yearling domestic rainbows reared in state hatcheries have been stocked in the Great Lakes, with the majority going to ports on Lake Huron. Stocking rates range from 10,000 to 65,000 yearlings per port. This practice has been discontinued. No domestic rainbow trout are stocked into Lake Superior (Peck 1992).

There are currently two recognized strains of steelhead in Michigan. Winter-run steelhead (naturalized Little Manistee River fish) migrate into streams during fall, winter, and spring. Fall migrations begin in September, increase in late October, and probably peak in early November. Migrations continue to an unknown extent through the winter, but direct observations are lacking.

Spawning runs typically peak in late March and early April. In some areas of the state runs continue as late as June. The Little Manistee River is used as the state's primary source of broodstock for this strain.

Observations at the Little Manistee River weir suggest that fall run winter-strain fish spawn in late winter. During March and early April, post-spawning adults are observed migrating downstream at the same time spring run fish are moving upstream to spawn. Spring run fish spawn in April and May. State hatcheries use eggs collected during April.

Skamania (summer-run) strain fish begin migrating into streams as early as May and continue through the summer and early fall. These fish also spawn in late winter and early spring. Eggs for the hatchery program are collected in January and February from broodstock obtained the previous summer from the St. Joseph River by the State of Indiana.

Wild steelhead juveniles spend from 1 to 3 years in the stream before emigrating to the lake. Emigrants include both smolts and pre-smolts. Smolts are juveniles, ages 1–3, which have undergone a physiological transformation and are actively migrating downstream to the lake (Seelbach 1985b and 1986). This typically occurs during spring (mid-May peak). Emigrant parr are age-1 juveniles that have not yet undergone smolting transformation but are actively migrating downstream, presumably due to habitat limitations.

Most adult steelhead return to the river to spawn after 2–4 years of lake life. There are very few fish age-6 or older. Steelhead can spawn more than once. Survival to second spawning has been reported to be 18–63% for a Lake Michigan population (Seelbach 1993).

Steelhead stocking rates are determined by inter-agency Lake Committees and are driven by fish community objectives (see below). They are managed primarily for stream fisheries (Keller et al. 1990). In streams with limited natural reproduction steelhead are stocked to enhance stream and open-water fisheries. In recent years, anglers have discovered steelhead concentrations far offshore in cold surface water zones. Tagging data from sport-caught fish in Lake Michigan during this seasonal fishery suggests that these fish are from many different locations around the lake. It is in essence a mixing zone for most rainbow trout in the lake.

The winter-run fish provide not only open-water fisheries, but primarily are stocked for fall/winter and spring fisheries in large tributary rivers to the Great Lakes. The Skamania strain is stocked specifically to provide river fishing opportunities during the summer months when opportunities for large salmonids are non-existent, especially for the angler that does not own or have access to boats.

Lake Michigan

Fisheries managers have agreed that the desirable annual yield for rainbow trout should be 0.7 million lb (Eschenroder et al. 1995). Stockings (by all agencies) of rainbow trout in Lake Michigan since 1998 has ranged from 1.7 to 2.1 million fish. Average annual stockings were 1.8 million fish. Most of these fish were yearling steelhead. During this same period, MDNR stocked an average of 550,000 yearling steelhead. Of this number, nearly 85% were the Michigan strain of steelhead; the remaining fish were the Skamania strain.

Michigan currently stocks a total of nearly 475,000 Michigan and 35,000 Skamania strain steelhead annually. Individual streams are stocked with as few as 3,500 yearlings up to 60,000 yearlings. Stocking target dates were developed to coincide with wild smolt emigrations (Seelbach 1993). In general, stocking begins in April in southern Michigan and should conclude by mid-May in northern waters.

Many steelhead smolts are naturally produced in Lake Michigan tributaries. In the late 1980s and early 1990s, Rand et al. (1993) estimated that the lake supported a total of 1 million smolts, of which approximately 825,000 were hatchery smolt equivalents and an average of 200,000 were wild smolts.

Wild smolt numbers fluctuated to as high as 400,000 fish, depending on winter severity. In an attempt to reduce natural steelhead harvest and to determine the amount of natural recruitment, all steelhead stocked by Michigan in the lake have been fin clipped (right pectoral) since 1995. Ongoing creel surveys in Michigan provide information on the total number of steelhead harvested and the percentage of hatchery (clipped) versus natural (non-clipped) fish.

Some research has been done on select rivers to determine the extent of natural recruitment. Seelbach (1993) showed that the rivers of northwestern Lower Michigan produced large numbers of wild fish, including up to 80,000 recruits in the Little Manistee River. Natural recruits were verified using scale analysis (Seelbach and Whelan 1988). Woldt (1998) estimated less than 2,000 age-2 pre-smolts in the Big Manistee River and approximately 30,000 in the Little Manistee River in March 1988. Newcomb (1998) estimated annual natural recruitment of less than 3,000 smolts from the Betsie River in 1993-96. Research continues today to evaluate the strength of recruitment in Lake Michigan tributaries using new techniques. Both high and low water temperatures were found to be critical in determining survival of young steelhead. Using landscape parameters in a regression analysis, Rutherford et al. (MDNR, personal communication) recently obtained whole lake wild recruit estimates very similar to those obtained earlier by Rand et al. (1993). The Pere Marquette River produces the highest number of smolts, an estimated 56,000 fish.

From 1985 to 1996, the estimated average lake-wide sport catch of steelhead in Lake Michigan was approximately 800,000 lb/year (Francis 1997), which is slightly above stated FCO's. Assuming a 6-lb per fish average weight, the lake-wide catch would be 133,000 steelheads. The estimated annual catch of steelheads from Michigan waters alone was 52,000 fish during the same period (Gerald Rakoczy, MDNR, personal communication).

Creel surveys for the Betsie River in 1986 and 1988 showed a harvest of 1,000 to 3,000 steelheads between April and November (Rakoczy and Rogers 1987, 1990). Prior stocking rates averaged 15,000 yearlings/year. There are no estimates of naturally produced rainbows for that period, but Newcomb (1998) estimated that fewer than 3,000 smolts were produced per year in the mid 1990s. For the mid 1980s, annual emigrations of wild and stocked steelhead combined numbered at least 15,000 fish, minimum stream harvest was 1,000 to 3,000 fish, and the calculated combined return rate was 7–20%. Return rates for stocked fish were also calculated for the Manistee River in the late 1990s. There, average annual stockings resulted in a harvest from March through December of 16,000 steelheads (Gerald Rakoczy, MDNR, personal communication), for a return of 19%.

Survival of wild fish appears to be better than stocked fish. Most steelhead in the Little Manistee River are naturally produced (Seelbach and Whelan 1988). Seelbach (1993) found that survival in Lake Michigan was variable but high. Survival to spring maiden spawners averaged 16%, while survival to autumn plus survival to spring maiden spawners averaged at least 24%. Estimated smolt production in the Little Manistee River ranged from 12,000 to 86,000 during 1982-84 (Seelbach 1993). Assuming an average of 45,000 smolts emigrating per year and an average return of 8,000 adults (30-year average weir return), the calculated survival from smolting to spawning is 17%.

Lake Huron

There is no specific FCO for steelhead harvest in Lake Huron (see the Great Lakes section). Michigan stocks nearly 360,000 (Michigan strain) steelhead annually. Smaller streams receive 6,000–50,000 yearlings and the Au Sable River receives 150,000.

Minimal natural reproduction is believed to occur in western Lake Huron tributaries. Most of those are blocked by dams that prevent potamodromous fish from reaching suitable spawning habitat. An unknown number of wild steelhead are produced in streams of the eastern Upper Peninsula and Canada. Beginning in 1996, all steelhead stocked in Lake Huron by Michigan have been fin clipped. Canada presently marks only a portion of their stocked steelhead. This makes estimation of natural reproduction difficult.

Eagle Lake strain rainbow trout were stocked into Lake Huron prior to 1993 and during 1998–2001. Stockings of this strain at Lake Huron thumb port sites without streams were discontinued after the 2001 stocking due to extremely poor returns (Jim Baker, MDNR, personal communication). Michigan strain steelhead have been stocked since. In 1986, a creel survey on the lower Au Sable River estimated a harvest of less than 2,000 rainbow trout (domestic rainbows, not steelhead) from April through November (Rakoczy and Rogers 1987). Rainbow stockings in the river in 1981–85 averaged 95,000 yearlings. Assuming limited natural reproduction from the Au Sable, the return of stocked domestic rainbows to the Au Sable was 2%. A current study on natural reproduction in the Au Sable should provide additional information.

Lake Superior

Steelhead were introduced around 1900 to Lake Superior and are now a permanent but small component of the fish community. There is no specific FCO for steelhead harvest in Lake Superior. Michigan distributes nearly 79,000 Michigan-strain steelhead yearlings among five streams. Smaller streams are stocked with less than 2,000; larger streams are stocked with 30,000 or more.

Actual estimates of emigrants from tributary streams in Lake Superior are lacking. However, Seelbach and Miller (1993) estimated less than 10,000 wild steelhead smolts in the Huron River in 1987 and 1988. This is probably indicative of many smaller streams across the Lake Superior watershed. They estimated the survival of emigrant smolts to maiden adult at 11–51%. In the same study, they found that the survival of hatchery smolts stocked in the river was less than 1%. There is currently concern among managers regarding the use of the Michigan winter strain (Little Manistee River strain) for stocking into Lake Superior because of their poor survival after stocking. Naturalized stains in the western Upper Peninsula might be more adapted to the harsh environments of this region.

Creel surveys on Michigan waters of Lake Superior from 1987–97 estimated the average annual harvest at less than 1,000 steelheads (Gerald Rakoczy, MDNR, personal communication). The estimated annual sport-catch of spring steelheads from the Huron River from 1988–92 was generally less than 400 fish (Seelbach and Miller 1993). This catch represents less than 2% of stocked (16,000-20,000) and naturally produced (less than 10,000) fish.

Lake St. Clair

There is no known natural reproduction to this system because warm temperatures occur in mainstem tributaries and dams block migrations to coldwater tributaries. Annual stockings into tributaries of the St. Clair River and Lake St. Clair averaged 40,000 yearlings from 1989 to 1998. Three streams were stocked with 10,000 to 17,000 yearlings. Excess fall fingerlings are also stocked every other year. All stockings have been the Michigan strain. It is unclear where steelhead smolts go to grow and mature. Creel survey information on this system is sparse.

Lake Erie

Annual steelhead stockings into the Huron River have averaged 60,000 yearlings in recent years. Experimental (excess) fall fingerling stockings have occurred every other year. All stockings have been the Michigan strain steelhead. The majority of returning steelhead are age-1.2, which is one year earlier than the other Great Lake waters (Seelbach et al. 1994). Seelbach also estimated returns to the Huron River at only 3.5%. Several Michigan stocked fish have been taken by anglers in New York and Ontario streams that are tributary to the eastern Lake Erie basin (Gary Towns, MDNR, personal communication).

Strain Characteristics

Managers presently have only two strains of rainbow trout to choose from (year 2002). Note however that while Little Manistee River steelhead stocks are listed as a strain, they are generally not available for production stockings into inland waters at this time.

Michigan hatcheries obtained the Eagle Lake strain from a large, highly alkaline lake in California. The strain may have originated from stocked fish obtained from a West Coast potamodromous system. They live a relatively long time (5–6 years) and grow larger than 10 pounds in lightly exploited fisheries. They are known for their tendency to inhabit near shore waters. They rely primarily on zooplankton and insects for food (Schnicke 1995). For the most part, they have survived and grown well in Michigan inland lake environments. Eagle Lake rainbows were significantly heavier than steelhead (or Shasta strain) 30 months after they were stocked into small inland lakes (Nuhfer 1996).

Winter run steelhead (Little Manistee River) have not been reared for routine inland stocking. They have been stocked experimentally and occasionally when availability of Shasta (since dropped) and Eagle Lake strains were low. A study by Nuhfer (1996) suggested that survival and standing crop in small trout lakes was higher for steelhead than for Eagle Lake and Shasta strains. Overall results indicated no significant difference ($P>0.05$) in growth of steelhead compared to Shasta. (Sentence not clear) There was little evidence that any rainbow strain tested was more likely to emigrate from lakes with outlets.

Summer run steelhead (Skamania) have been stocked by the Department since 1984. This unique strain was developed in 1956 with 153 fish from the Wasougal River in the State of Washington. Stocking emphasis in the past has been on large tributary rivers to the Great Lakes. This strain contributes to both lake and river fisheries, and migrates up rivers starting in May and continuing through early fall. This unique characteristic can allow for year-round steelhead angling, such as occurs on the St. Joseph River (stocked by Indiana). Spawning takes place at similar times as winter runs. Skamania typically mature 1 year later than winter run steelhead. Size at age of the two strains is similar (Seelbach et al. 1994). Currently only the Manistee and the St. Joseph Rivers receive Skamania. These fish are reared by the State of Indiana and traded to Michigan.

Presently there is not sufficient rearing capacity at Wolf Lake State Fish Hatchery to rear any additional steelhead for inland stockings. Water temperatures are too cold at the other state hatcheries to provide a large enough yearling steelhead for inland lake stockings.

5.4 Splake

Splake *Salvelinus fontinalis x S. namaycush* are a hybrid cross between male brook trout and female lake trout *Salvelinus namaycush*. They are stocked as yearlings in inland lakes that meet the temperature and oxygen requirements for coldwater species, and in the Great lakes where they inhabit shallower water than lake trout. In the Great Lakes, they tend to stay close to stocking sites (Miller 1973). Splake are omnivorous (utilizing aquatic insects and small fish for forage), show better growth than either parent, live longer than brook trout, and potentially contribute to a fishery for a long period of time (Scott and Crossman 1973) If management objectives favor daylight fisheries, splake should be used instead of rainbow trout. Splake may be reared to yearling size more cost effectively (John Driver, MDNR, personal communication.) than brook, brown, or rainbow trout. Yearling stocking rates are similar to brown and rainbow trout (Table 5.1). Fall fingerlings are generally requested only in lakes where competing species have been removed or reduced.

The only significant evaluations of splake stockings (fall fingerlings) were conducted during the 1960s. Biologist William Bullen (1970) summarized findings of fingerling stockings in Michigan. Of inland lakes that failed to produce splake fisheries, 96% contained significant yellow perch populations. Nearly 60% of the successful waters were either partially reclaimed with rotenone or did not contain any predators. Splake did not provide better fisheries than rainbow trout, and they are generally perceived to be more difficult to catch than brook or rainbow trout.

Consider the following when stocking yearling splake:

- Select waters that do not contain significant yellow perch, pike, or walleye populations.
- Lakes smaller than 100 acres offer a much better return to creel.
- Lakes containing lake trout populations generally provide good survival of splake in spite of the presence of predators.

5.5 Atlantic Salmon

Michigan has made several attempts to introduce Atlantic salmon *Salmo salar* in state waters. Landlocked salmon were stocked as early as 1873 in Oakland County lakes and in 1874 in Dowagiac Creek, Cass County (Jerome 1875). Although these early introduction attempts failed, the appeal of the Atlantic salmon's sporting qualities and recent successes with landlocked strains have rekindled angler interest for more experimental management.

In 1972, Michigan renewed efforts to establish Atlantic salmon in its waters. During this period, release of salmon smolts from the Quebec-Grand Cascapedia strain where encouraging (showing fair to good survival, primarily stream releases). Emphasis later switched to landlocked (Sebago Lake strain) fisheries in large oligotrophic lakes, and a cooperative rearing program with Lake Superior State University to develop a potamodromous fishery on the St. Mary's River.

Based on our long experience with Atlantic salmon, their role will be limited to special fishing opportunities (inland) and experimental releases (Great Lakes) as described below:

For inland waters, fall fingerling or yearling landlocked strain may be stocked annually. Large and deep lakes with suitable forage such as rainbow smelt are preferred for stocking in order to create unique fisheries with special regulations. Atlantic salmon should not be stocked where brown trout fisheries exist or vice versa, due to identification problems.

In the Great Lakes, Atlantic salmon may only be stocked under controlled experimental conditions designed to better define the species role (Schrouder 1996). To date, they have provided a unique summer fishing opportunity in the St. Mary's River system. This use of this species is not intended to replace currently available species such as chinook or coho, but rather to provide a rare angling opportunity in the Great Lakes.

Based on recent stocking experiments with several large and deep inland lakes in the Lower Peninsula, it appears feasible to maintain a few quality Atlantic salmon fisheries where there is sufficient support for the special regulations needed to maintain fisheries. Stocking recommendations for inland waters are for yearlings (or advanced fall fingerlings) be stocked at 1–2/acre for normal sport fisheries. Any inland waters that may be used as a broodsource should be stocked at 2–4 yearlings/acre. Gull Lake (Kalamazoo County) was stocked at 6–13 yearlings/acre from 1986-1990, which subsequently was determined to be much too high of a rate (Dexter 1991b). New Hampshire (Seamans and Newell 1973) and Maine (Warner and Havey 1985) both stock at the rate of 2 spring yearlings/acre, even in waters that are classified as having a large number of predators.

Yearling (Sebago strain) Atlantic salmon are available on very limited basis. This species has been very susceptible to bacterial kidney disease and furunculosis in Michigan's hatcheries. If predator numbers in stocked waters are low, it is recommended that fall fingerlings be stocked instead of yearlings (Warner and Havey 1985). An evaluation of survival between fall fingerling and yearling stockings is currently take place at Torch Lake (Antrim County).

5.6 Chinook Salmon

In 1967 Michigan made the first successful introduction of chinook salmon *Oncorhynchus tshawytscha* with the stocking of spring fingerling smolts in two tributary streams of Lake Michigan. After 3 years of successful introductions of smolts from eggs, Michigan became self-sufficient in the collection of eggs and was also able to supply other states with eggs. Fall chinook salmon, the West Coast strain chosen for introduction, migrate up streams and spawn in the autumn. They return with high fidelity to the stream in which they were either stocked or spawned. They usually return to spawn after 3–4 years in the Great Lakes, although a few return as precocious males (jacks) at age-1 and a few at age-5 (Keller et al. 1990). After spawning they die.

The young chinook salmon smolts leave natal rivers in May and June. Migrations peak with an increase in flow and water temperature (Carl 1980). Stocking rates are determined by interagency Lake Committees and are driven by fish community objectives. Within Michigan, stocking sites are determined by various factors including natural reproduction, site-specific survival, movement, size of river, and previous success. Chinook salmon are released from hatcheries as spring fingerlings during May and June when they are about 100 fish/pound. In large rivers that warm quickly, they should be stocked before stream temperatures reach 70˚F. Seelbach (1985a) reported that mortality of hatchery-reared chinook salmon from stocking to smolting ranged from 0–32% in the Little Manistee River (a top-quality trout stream). Seelbach also found that smolts (advanced or not) will emigrate immediately regardless of date. Thus stocking times should mirror natural timing of smolts in order to take advantage of available food in the Great Lakes.

Lake Michigan

Since 1990, stockings in Lake Michigan by all agencies have averaged about 6 million smolts/year. Recent studies seem to show that fish stocked in the northern portion of Lake Michigan seemed to scatter throughout the lake, and contribute to lake-wide fisheries more than fish stocked in the south.

The number of naturally produced chinook salmon smolts in Lake Michigan has gradually increased. Carl (1982) estimated that natural reproduction from major tributaries in lower Michigan contributed a minimum of 23% to lake-wide smolt production (630,000 natural smolts) in the late 1970s. Research biologists (Clark 1996) estimated the natural reproduction of chinook salmon during the 1980s at 1.5 to 2.0 million fish. Hesse (1994) sampled the sport harvest to determine the proportion of marked versus unmarked fish for the 1990-93 year-classes. Hesse (1994) and later Clark (1996) estimated that in the 1990s nearly 2 million smolts were produced annually. Most of these smolts are thought to come from Michigan streams since the eastern shore of the basin is where most of the streams suitable for natural reproduction occur. Preliminary results of marking studies from Michigan rivers support this (David Clapp, MDNR, personal communication).

In recent years, the estimated average lake-wide catch of chinook salmon in Lake Michigan was about 1,750,000 pounds (Francis 1997). If average weight ranges from 8–10 pounds, then 175,000 to 222,000 chinook salmon were caught. This translates into a return of 2.2–2.7% to the creel. Michigan anglers catch about 2.4% of the fish stocked by Michigan (3.4 million).

During the 1990's the return rate for stocked chinook salmon has averaged 2.1% to the Little Manistee River (Janice Sapak, MDNR, personal communication) and 1.4% to the Boardman River (Ralph Hay, MDNR personal communication). Not all chinook salmon mature at the same age. For the 1986-91 year-classes sampled at the Little Manistee River weir, less than 0.1% returned after one summer in the lake as age-0.0 mini-jacks, 29% after two summers in the lake as age-0.1 jacks, 34% as age-0.2, 33% as age-0.3, 5% as age-0.4, and less than 0.1% as age-0.5 (Ralph Hay, MDNR, personal communication). (In aging potamodromous fish, the number preceding the decimal denotes age at smolting and the number following the decimal represents the number of annuli formed in the Great

Lakes.) Total survival (lake harvest plus spawning runs tabulated at the weir) approaches 5%. This is considerably less than the survival rate of 15–20% observed in the 1970s and early 1980s (Hay 1986).

Beginning in 1990, hatchery parr were held in net pens for 3 to 6 weeks in an effort to improve survival and return to the stocking site. In the Grand River, from 1990-93, marked (coded-wire-tagged) chinook salmon were reared in net pens (Clark 1996). Tag return rates suggested that net-pen stockings contributed to the fishery as well as, or slightly better than, direct stream stockings. It was not determined if net-pen stockings improved imprinting to the local spawning stream.

During this same period, similarly marked fish were stocked in the lower and upper Grand River to evaluate survival and return (Clark 1996). Tag return rates suggested that downstream stockings contribute more to the lake fishery than upstream stockings. The favorite hypothesis for explaining this was that upstream stockings have greater exposure to predators. Direct-lake beach stockings might provide even better return rates to the fisher, because stocked fish would not be exposed to predators that may be concentrated at river mouths. However, the trade-off would be that beach-stocked fish would probably have a lesser tendency to imprint on the stocking site and could stray all over the lake at spawning time (Jim Johnson, MDNR, personal communication).

When selecting locations and stocking levels, consideration must be given as to the goals for both the open water fishery and the stream fisheries that will develop. Because large numbers of fish are caught in streams and at river mouths, large streams with adequate public access receive most of our chinook salmon plants. Also important are the impacts of both anglers and observers on the environment, availability of parking, boat launching and other amenities.

Generally, stockings are made in very large rivers, or smaller streams with blocking weirs or egg take stations. Stockings are in the range of 100,000 to 800,000 smolts annually. Larger stockings are made in rivers with egg-take stations which have the ability to harvest surplus fish. Number of chinook salmon returning annually to the egg-take facilities on the Little Manistee River have been around 15,000 adults.

Lake Huron

Since 1990, stockings in Lake Huron have averaged about 3.4 million smolts. Recent studies suggest that fish stocked in the northern portions of Lake Huron scatter throughout the lake and contribute to lake-wide fisheries more than fish stocked in the southern portion.

The number of naturally produced chinook salmon smolts in Lake Huron has increased since they were first stocked. Based on annual gill-net sampling of young-of-year chinook salmon done by Alpena Research Station personnel in the early 1990s, natural reproduction varied by year, contributing 6–31% (average 15%) of the chinook salmon in Michigan waters in Lake Huron (Clark 1996). This translates into an estimate of 500–700 thousand natural smolts produced per year in Michigan waters during the early 1990s. Most likely, natural reproduction is much higher in Canadian waters because more spawning streams without dams are present there. Shoal spawning in Lake Huron was also identified in Ontario waters (Powell and Miller 1990), but is believed to be limited.

Average open-water catch for 1992–97 was nearly 80,000 chinook salmon at nine index ports. This represents a return of about 2.0% of the chinook salmon stocked by Michigan (3.4 million) plus naturally produced salmon (500–700 thousand). This is probably only a minimum percentage since estimated catch does not include all Michigan ports or the Canadian waters. The total return may be closer to 4%.

During the 1990s returns to Swan River have averaged 28,000 chinook salmon. This represents an average return of 3.2% of the fish stocked from 1989–94. Age composition for the 1986–91 year-classes was about 18% as age-0.1 jacks (two summers in the lake), 31% as age-0.2, 40% as age-0.3, 11% as age-0.4, and 0% as age-0.0 or age-0.5 fish (John Clevenger Jr., MDNR, personal communication, unpublished data.). Angler harvest plus Swan River weir returns total 5–7% of the annual stocking. Current return rates appear to be better than in Lake Michigan (Clapp 1999).

Beginning in 1991, hatchery smolts were held in net-pens in effort to improve survival and return to the stocking site. In the Au Sable River, from 1991 to 1993, marked (coded-wire-tagged) chinook salmon were reared in net-pens (Clark 1996). During this same time period, similarly marked fish were stocked directly in the stream to compare survival with net-pen fish. Tag return rates from the open-water catch in Lake Huron yielded conflicting results (Clark 1996). The Alpena Fisheries Research staff is collecting additional information regarding net-pen returns. Early indications are that pen-reared fish returned at least three times better than conventionally reared and stocked fish. It was noted that sea lamprey predation and commercial fishing are two causes for mortality in adult chinook salmon.

In the last few years, stocking locations and numbers have stabilized. The largest stocking (about 900,000 chinook salmon) is at Swan River, the only egg-take and harvest station on Lake Huron. A few stockings in the range of 300,000–500,000 are made in large rivers, or shoreline sites near marinas. The remaining stockings are about 100,000 each and are scattered along the shoreline.

Lake Superior

During the 1990s, stockings in Lake Superior by all agencies have averaged about 1.5 million smolts/year. Since 1994, only four Lake Superior tributaries in Michigan have been stocked with chinook salmon. Each stocking is less than 100,000 fish, and they provide only local fisheries. Wisconsin, Minnesota, and Ontario all stock chinook salmon. Chinook salmon appear to move extensively throughout Lake Superior.

The number of naturally produced chinook salmon smolts in Lake Superior is very significant. Most chinook salmon captured in Michigan's sport fishery during 1990-94 were naturally produced. Wild fish made up 69–85% of the Michigan open water catch in those years, and the hatchery portion was mostly fish stocked by other agencies (Clark 1996). Wild fish made up about 90% of the sport catch in Ontario waters and about 50–60% in Wisconsin and Minnesota waters. There is evidence of natural reproduction in at least 10 Michigan tributaries as spawning redds have been observed (Peck 1996). Peck further reported that contribution of wild fish as a total of each jurisdiction's stock was 44% in Minnesota, 68% in Wisconsin, 76% in Michigan, and 91% in Ontario.

From 1990 to 1994, the chinook salmon sport catch averaged 4,000 fish from Minnesota and Wisconsin and 3,000 fish from Michigan. No information on the sport catch from Ontario is available. Michigan anglers catch is only about 1% of what is stocked.

In streams where there is minimal natural reproduction, returning stocked fish provide a good fishery. In the Dead River, the catch, effort, and catch-per-hour statistics decreased 2 years after chinook salmon stocking was reduced 50% (Clark 1996).

A few chinook salmon enter the sport catch at age-0.0 in the fall, but their first major contribution is at age-0.1 (jacks) in the late winter-early spring fishery (Clark 1996). Chinook salmon age-0.2 and age-0.3 predominate in the Lake Superior fishery. Very few fish live to age-0.5 or age-0.6.

Chinook salmon in Lake Superior are not fully vulnerable to the sport fishery until the summer of their second year of life (Clark 1996). Faster growing individuals grow from 3-inch fingerlings at stocking to 12 inches the following spring (age-0.1), then they grow 5–6 inches each year during ages 0.2–0.4. There has been no apparent change in chinook salmon length-at-age over the past 10 years. Overall growth rates in Lake Superior are slower than in the lower lakes.

5.7 Coho Salmon

Coho salmon *Oncorhynchus kisutch* were introduced to Lake Michigan in 1966, when 395,000 yearlings were stocked in Bear Creek, a tributary to the Manistee River, and 264,000 were stocked in the Platte River (Borgeson 1970). Since these initial introductions, they have been stocked in the other Great Lakes and have colonized many other streams. They have a 3-year life cycle. They spawn in streams during the fall of the year, hatch the following spring, and live as juveniles in the stream for one additional year. They migrate to the Great Lakes in the spring of the second year of life (18 months old) when smolting occurs. Smolting is a physiological change that enables the fish to survive in their native saltwater habitat. After spending about 18 months or two growing seasons in Lake Michigan, most adult coho salmon return to their natal streams (there is considerable straying to other streams) to spawn and die, as do all Pacific salmon. A few also return to spawn after only one summer in the lake (precocious males called jacks) and a few may spend three growing seasons in the lake.

Stocking rates are determined by inter-agency Lake Committees and are driven by fish community objectives. The primary objective of the coho salmon program is to provide open-water fishing in the Great Lakes. Fish are in prime condition when caught from the Great Lakes. The offshore coho salmon fishery is of high quality but is overshadowed by the tremendous chinook salmon fishery.

Coho salmon have a well-defined migration pattern in Lake Michigan. In April and May, they support an important early-season trolling fishery in southern waters, and large numbers of Michigan fish are caught in Indiana, Illinois, and southern Wisconsin. As the lake warms in June and July, the coho salmon migrate north along Wisconsin's shore and reach mid lake. By late July or early August, coho salmon begin to appear off Grand Haven, Manistee, and Frankfort. By Labor Day, concentrations are centered near the mouths of parent streams. It is during this time that Platte Bay provides some spectacular fishing due to its deep water and sheltered location, and to the high rate of stocking in the Platte River. The Grand River also receives a substantial run all the way to Lansing. Coho salmon remain in better condition on these long migrations than chinook salmon. By October, coho salmon are in the spawning streams. Spawning activity peaks in mid-October.

If a good open-water fishery is to be maintained, large schools of adult coho salmon must be present. The current Lake Michigan stocking target is about 1.6 million coho salmon yearlings annually; about one-half of these are stocked in Platte River. Stocking in various rivers helps distribute the fish along the Lake Michigan shoreline. It must be kept in mind that, even with a significant open-water fishery, up to 25% of the fish stocked may enter the stream during the fall spawning run (5% is closer to normal).

Estimated annual lake harvest in Michigan waters of Lake Michigan has averaged about 43,000 coho salmon since 1990 (Jerry Rakoczy, MDNR, personal communication). This harvest represents about 3.3% of the coho salmon stocked by Michigan. In recent years, return rates to the Platte River weir have ranged from 3.9% to 9.2% of the number stocked (Chuck Pecor, MDNR, personal communication). Similar rates were observed in the Little Manistee River (Janice Sapak, MDNR, personal communication) prior to eliminating that stocking site in 1993. Thus, survival of coho salmon from stocking to returning adult is in the range of 7% to 13% in recent years.

Coho salmon smolts are stocked mid-April to early May at a target size of 15 fish per pound (5–7 inches). Seelbach (1985a) reported that hatchery-reared coho salmon stocked in the Little Manistee River (a top-quality trout stream) had a survival to smolting rate of nearly 70%. Stockings in trout streams generally have a better survival rate than those stocked in marginal or non-trout streams, apparently due primarily to fish predation. A study on the Platte River (a trout stream) in the late 1980s suggested that upstream stockings provide better returns to the stream than stockings near the lake. The return ratio (at the lower weir) for fish stocked upstream versus downstream was 2.6:1 (unpublished data). Stocking has been discontinued in some streams where returns have been poor

(Muskegon and White rivers). Coho salmon performance in Lake Huron was not been reliable and stockings were discontinued in 1990.

Patriarche (1980) found natural reproduction of coho salmon was of a low magnitude compared to the numbers stocked in Lake Michigan (<10%). In 1979, Lake Michigan anglers caught a total of 213,000 coho salmon, of which approximately 20,000 were naturally produced (in Michigan streams). From the 20,000 wild coho salmon, Michigan anglers caught 7,000 and anglers in other states caught 13,000. Many good-quality streams support wild populations of coho salmon. Evidence strongly indicates that most (90%) of the coho salmon produced in Lake Superior are wild fish (Peck 1992, 2001). Stockings (of Lake Michigan progeny) in Lake Superior were discontinued in 1994.

An intensive creel survey on the Platte River in 1990 found that anglers harvested nearly 50% of the 23,178 coho salmon released above the lower weir (James Ryckman, MDNR, unpublished data). This fishery generated nearly 50,000 angler hours or 14,000 angler days of activity. This level of activity could create problems, especially on smaller streams with considerable private property.

In providing an open-water coho salmon fishery, these elements are desirable:

- Good nearshore fishing grounds with deep water and drop-offs, and preferably with some protection from the wind.
- A safe harbor facility nearby that provides boat launching and mooring, generous parking, lodging, a restaurant, and camping, and that is readily accessible by car.

5.8 Lake Trout

Lake trout *Salvelinus namaycush* are currently stocked into the Great Lakes and large oligotrophic lakes. Historically it was the major salmonid inhabiting the Great Lakes, being very abundant and the dominant predator. They were nearly extirpated by sea lamprey predation but have rebounded to become the mainstay of Great Lakes sport fishing. Nearly the entire lake trout fishery is the result of yearling stockings by Michigan and federal hatcheries. Lake Superior is not stocked and presently has sufficient natural reproduction to maintain populations.

Annual lake trout stockings represent a major segment of a continuing management commitment to rehabilitate the fisheries of the Great Lakes. Rehabilitation efforts, which include lamprey control, are coordinated between the United States and Canada through the Great Lakes Fishery Commission. Through coordination by this Commission and various Lake Committees, available lake trout are allocated to the various states by lake and stocking site. Stocking rates are determined by inter-agency Lake Committees and are driven by fish community objectives. Michigan's internal lake committees and research biologists work together to formulate lake trout stocking schedules. Generally speaking, the number of acres of suitable habitat roughly determines the numbers of lake trout stocked by lake (or site). Annual target stocking rates are usually never met due to insufficient hatchery production. Other factors used to arrive at the number include available spawning habitat and lamprey abundance.

Juvenile lake trout (age-1 to age-3) occupy depths of 150 to 250 feet. At these depths, they are less subject to predation by walleyes, piscivorous birds, and other trout and salmon. Shallower waters are probably not suitable for lake trout stocking. Lake trout are stocked in the Great Lakes by transporting them offshore using a specially equipped stocking vessel. Offshore release minimizes exposure of young lake trout to predation and places them close to natural nursery habitats.

Where the objective of stocking is to rehabilitate or establish self-sustaining populations, lake trout total mortality rates should not exceed 40% (Healy 1978). To manage within this target mortality rate, annual exploitation rates are kept relatively low. Lake trout are exceptionally vulnerable to large-mesh gillnets and sea lampreys. Consequently, they should not be stocked in areas where these mortality sources are not carefully controlled.

Several oligotrophic inland lakes are currently being managed for lake trout. These inland waters may present the best opportunities for stocked populations to become self-sustaining. Presently there are only a handful of waters that receive annual yearling stockings. Stocking rates generally are 2–8 yearlings/acre, depending on lake size, productivity, and food source. Lakes with large rainbow smelt populations are good candidates for higher stocking rates that approach 8 yearlings/acre. In waters where lake trout are introduced they must be stocked for at least 1 decade before attempting an assessment of natural reproduction, due to their late maturation.

5.9 Rainbow Smelt

Rainbow smelt *Osmerus mordax* eggs were first stocked in Michigan waters in the St. Mary's River in 1906 (Fukano et al. 1964) and Crystal Lake in 1912. Since that time, they have spread throughout the Great Lakes and provide for important commercial and sport fisheries, and serve as an important component of the Great Lakes food chain. Introductions (through transfers) of rainbow smelt have been made periodically over the last 75 years into larger inland lakes that are capable of supporting good rainbow smelt populations.

Hubbs (1930) hypothesized that rainbow smelt introductions may adversely affect yellow perch and lake herring populations, and Latta (1995) suggested that predation or competition from rainbow smelt extirpated three inland natural populations of lake herring. However, there are waters that have long held sympatric populations of yellow perch, lake herring, and rainbow smelt (e.g., Higgins Lake).

There is no hatchery production program for rainbow smelt. All stockings have been the result of egg or adult transfers from the wild. Adult transfers from the Great Lakes to inland waters are not encouraged due to the possibility of transmitting non-indigenous species into uncontaminated inland waters.

Successful rainbow smelt introductions were made in the past with adult fish stocked at the low rate of 3.5 adults/acre (Gull Lake 1950–1953). Adult stocking rates in other waters have averaged 6–63 fish/acre.

Several introductions across the state were unsuccessful at establishing populations. Recent introductions have been accomplished through egg transfers. The easiest way to introduce rainbow smelt is to collect eggs from a breeding stream and stock them directly into a receiving stream. This may be accomplished easily from select inland runs of rainbow smelt. Rainbow smelt eggs have been collected on cut cedar boughs (Shetter and Reynolds 1942), screens, burlap bags (untreated for moths), and fine mesh net material (James Dexter, MDNR, personal communication). The receiving material is anchored to a breeding area prior to spawning. After spawning takes place, the material is taken out, moved to the receiving water, and anchored to the bed of a stream or lake until the eggs hatch.

5.10 Whitefish and Cisco

Lake whitefish *Coregonus clupeaformis* and cisco *Coregonus artedi* (lake herring) have been extirpated from several waters in their historical range. Historically, whitefish occurred in only a few Michigan inland lakes, but were abundant in all of the Great Lakes. They have become rare in western Lake Erie and Walnut Lake (Oakland County), and perhaps elsewhere. The cisco, once abundant in many inland waters and the Great Lakes, is now classified as a threatened species. It is, or was, present in at least 153 Michigan lakes (Latta 1995). Almost half of these waters are found in the southern portion of the Lower Peninsula).

Reintroduction of these species should be considered for those waters where they were indigenous and which now have suitable limnological parameters. They require cool, well-oxygenated water where the temperature is 20˚C (68˚F) or less and the dissolved oxygen is 2.0 mg/l or more. It is important to note that Latta (1995) suggested that exotic fish introductions (rainbow smelt) may have caused extirpation of native cisco from some waters.

Lake whitefish were widely stocked in inland and Great Lakes waters during the early years of fish culture, over a hundred years ago. Some experimental whitefish introductions and reintroductions have been made in recent years. So far, the only successful case of lake whitefish stocking has been in North Lake Leelanau, where a lake whitefish population was established where none previously existed. In that case, 27,182 spring fingerlings (92/acre, 2-inches in length) were stocked in 1995. A 2000 survey using Great Lakes gill nets collected 28 lake whitefish ranging from 12 to 19 inches.

Although the North Lake Leelanau case proves that stocking hatchery-reared lake whitefish can be successful, any proposed rearing and stocking program should be considered experimental. No stocking rates have been established for whitefish.

5.11 Lake Sturgeon

Lake sturgeon *Acipenser fulvescens* are potamodromous fish found in many large rivers and lakes across North America. Michigan is in the center of their historic range. Populations in and around Michigan were estimated to number in the hundreds of thousands. Since the mid-nineteenth century, exploitation and habitat degradation have resulted in substantial decline. Today, these populations are believed to be at 1% of their former size. As a result, the Michigan Department of Natural Resources listed lake sturgeon as a state threatened species (section 36505(1a), Part 324, Endangered Species Protection, of Act No. 451 of the public Acts of 1994) (Hay-Chmielewski and Whelan 1997).

The goal of stocking lake sturgeon is to conserve and rehabilitate self-sustaining populations of lake sturgeon to a level that will permit delisting as a threatened species (Hay-Chmielewski and Whelan 1997). The objectives are to:

- Conserve and rehabilitate existing self-sustaining populations.
- Where populations have been extirpated, reestablish self-sustaining populations.
- When the first two objectives are near completion, establish new self-sustaining populations in waters within lake sturgeon's suspected historic range.

Individual populations of lake sturgeon are considered discreet stocks (genetically) and stocking should maintain the genetic identity of each population. Waters to be stocked should receive only progeny from adults in those same waters or from stocks in systems with similar genetic characteristics.

The criteria used to evaluate rivers and inland lakes for stocking can be found in Hay-Chmielewski and Whelan (1997). Stockings should occur first in rivers and lakes listed in Table 5.3 and Table 5.4 of the above-listed report. The population goal should be a minimum of 500 breeding fish per population in order to have a self-sustaining population. Management plans do not recommend allowing fisheries on populations of less than 500 breeding fish. The stocking rates to achieve this utilizing fall fingerlings should be 80 lake sturgeon fingerlings (5-inch) per mile for rivers or one fish per 2 acres for inland lakes. If yearling fish (12-inch) are stocked, the rate should be 40 lake sturgeon per mile of river or one fish per 4 acres of inland lake. Stocking should occur annually for 25 consecutive years (Ron Bruch, Wisconsin Department of Natural Resources, personal communication). Monitor population size and structure every 5 years to monitor the success of population building, then every 10 years once sustainability is achieved.

5.12 Walleye

Walleye *Sander vitreus* were first stocked in Michigan waters in 1882 (Anonymous 1974). Walleye are stocked in Great Lakes waters and some of the larger tributaries for restoration or preservation of indigenous populations. Principal populations in Michigan's Great Lakes waters where walleye occurred include: Black River, Ontonagon River, Huron Bay, and Whitefish Bay (Lake Superior); northern Green Bay and Muskegon River (Lake Michigan); lower St. Mary's River, Thunder Bay and Saginaw Bay (Lake Huron); St. Clair River, Lake St. Clair and Detroit River; and western Lake Erie. This is only a partial list of the distribution of this species in Great Lake waters. Smaller numbers were present in other tributary and bay locations. For example, the presence of walleye has been documented in at least 24 locations in Michigan Lake Superior waters (Hoff 1996).

Most Great Lakes populations suffered substantial declines during the 1960s and 1970s for various reasons (Schneider and Leach 1979). Important exceptions were populations in the lower St. Mary's River, Lake St. Clair, and the St. Clair River. The western Lake Erie population declined but then returned to historical levels without stocking. Success there was likely due to restrictions on harvest coupled with improvements in water quality. In other depleted areas, those remedial measures have not been sufficient and stocking has been used to partially restore walleye populations. Stocking continues in most waters today because recruitment is not believed to be sufficient to sustain historic levels of abundance or there is not enough information to determine natural recruitment levels. Presently, approximately 2.9 million walleye fingerlings are stocked into Great Lake waters annually by the Fisheries Division. Nearly 1 million of these fingerlings are stocked into Saginaw Bay. Still, Saginaw Bay is under-stocked in relation to the amount of forage and habitat available. In contrast, stocking in the Muskegon River was recently cut in half (½ million annually to ½ million every other year) because growth and survival rates were decreasing, approaching historical rates when natural reproduction sustained high population levels.

Inland waters are stocked for creation of new fisheries, rehabilitation, or enhancement of small natural fisheries. The intent of this program is to provide fisheries distributed throughout the interior of Michigan, and this program is often supported by partner organizations. Another purpose is to add predators to lakes that have an overabundance of panfish with slow growth rates. The majority of walleye fisheries in inland lakes are dependant on stocking to support fisheries. In 1994, nearly 93,000 acres of inland waters were managed for walleyes using stocked fish. Presently, approximately 3–4 million fingerling walleyes are annually stocked into inland lakes.

Michigan's walleye sport fisheries are substantial. The harvest of walleyes from Saginaw Bay during the 1990s ranged from 45,000 to 125,000 fish annually. Recent annual harvest for Michigan waters of Lake Erie has ranged from 100,000 to 1 million fish. Catch per hour estimates of walleye in Great Lakes waters range from 0.03 to 0.46, and are comparable to salmonid catch rates. Walleye catch rates in Michigan inland lakes are similar (0.01–0.21/hr) to those in the Great Lakes. Walleye catch rates generally increase as population density increases (Beard et al. 1997).

Walleye population levels in Michigan waters vary considerably. Abundance of age-2 and older walleye in Lake Erie has ranged from 5.6 to 24.0/acre. Muskegon Lake historically had adult population levels ranging from 23 to 27/acre and presently contains about 8/acre (although densities may be somewhat lower due to migration into Lake Michigan). Michigan managers ranked inland populations with more than 2 adults/acre as good to excellent fisheries. Populations with 1 adult/acre or less were ranked from poor to fair. For inland lakes in general, adult walleye densities of at least 2/acre are needed to maintain adequate fishing and justify continuation of stocking programs. Lower densities can be acceptable if walleyes are used to manage over-abundant panfish populations.

The effects of stocking walleyes on fish communities are important considerations in developing management strategies. Walleyes affect other species—both positively and negatively from a management perspective—through predation and competition. Walleyes feed heavily on salmonids. Stocking walleye in water bodies that contain salmonids is generally not recommended. In western states, walleye introductions have caused significant harm to salmonid populations and walleye predation on stocked salmonids in Lake Huron has been noted. In Lake Huron, however, most of the walleye stocks are indigenous and predation has been minimized using "stocking windows." Stocking windows are designed to buffer predation by stocking within seasonal periods of high natural forage abundance. Certain waters in Michigan are able to support both walleye and salmonids. Generally, these are large lakes or rivers where temporal distribution or habitat characteristics allow sufficient segregation of the two species. Rivers usually have substantial densities of walleyes only during spring walleye spawning runs, so effects on salmonid populations are minimized. Large lakes can have extensive shoal and profundal zones that provide adequate habitat separation. Largemouth bass and smallmouth bass populations can be significantly reduced by walleye introduction. This usually is most severe in lakes with low productivity and little vegetative habitat. Bass populations have been reduced in several northern Michigan lakes as a result of walleye stocking. For example, at one time walleye replaced smallmouth bass as the dominant fish in Lake Gogebic.

Walleyes can be very effective predators on yellow perch and bluegill. The introduction of walleyes into unbalanced fish communities sometimes improves growth and size structure of panfish populations (Schneider 1995; Schneider and Lockwood 1997). Bluegill populations have been improved for angling at adult walleye densities as low as 0.3/acre. However, overstocking can occur when managing yellow perch populations and fast-growing bluegill populations. If walleye densities are too high, their predation can significantly reduce abundance of both small and large panfish. Walleye stocking levels should be conservative initially, then increased after several years if needed. Measurable improvements in growth rates and size structure of panfish populations generally become visible 5 or 6 years after initial walleye stocking.

Protecting the genetic health of wild walleye populations is also an important consideration in formulating stocking strategies for both inland and Great Lake waters. Walleyes stocked in inland waters with outlet streams are likely to migrate and may reduce the fitness of Great Lakes stocks. Managing naturally reproducing stocks maintains the genetic health of fish populations. If stocking is necessary, introduction of fish from other stocks (even within the Great Lakes basin) is not recommended. Migration studies of various Great Lakes wild stocks—including the Muskegon River, northern Green Bay, St. Mary's River, Saginaw Bay, Lake St. Clair, and Lake Erie—indicate good homing behavior to natal streams, with extensive mixing of stocks during non-spawning periods.

Presently, collecting fish from all local broodstocks in Michigan is not feasible. However, stocking can be maintained through the principal broodstocks in broad regional areas of the state. The principal broodstocks currently used in the state are Bay De Noc, Saginaw Bay, and the Muskegon River.

Walleyes are stocked at various life stages in Michigan, including sac-fry, spring fingerling, fall fingerling, and adult. Prior to 1950, walleye stocking in Michigan waters was limited to the use of fry. Eggs were collected from Saginaw Bay and other stocks, incubated in hatcheries, and distributed as fry to innumerable inland lakes as well as the Great Lakes. Approximately 3 billion fry were stocked during this period. Fry stocking rates varied through the 1980s, and stabilized near 20 million annually during the 1990s (O'Neal 1998). Sac fry are stocked only for specific habitat or management conditions because success is sporadic in most situations (Laarman 1978; Laarman and Schneider 1986). Presently, fry stocking is generally limited to turbid waters were survival tends to be higher. Occasionally, fry are stocked into waters following chemical reclamation projects designed to remove all fish from entire lake or river systems. In 1994, the cost/fish of rearing and stocking sac fry into public waters was $0.00091 (O'Neal 1998). The recommended rate for stocking fry is 2,000/acre (Borgeson 1987). At these rates, the average stocking cost for sac-fry is $1.82/acre. This low cost would indicate fry stocking is a favorable walleye management practice for Michigan lakes. However, fry stocking is generally limited to lakes where they are likely to have good survival rates (noted above). In additional, at the recommended stocking rate, fry stocking for all managed Michigan waters could not be supported by collection of eggs from wild populations (O'Neal 1998), and increasing fry production from the three principal wild stocks is not recommended by biologists (O'Neal and Siler 1995). There is potential to collect eggs from the St. Mary's River, but it is unlikely the addition of this stock could support fry stocking in all desired waters.

Fingerling rearing programs began in the 1950s and remained at low levels until the late 1970s (O'Neal 1998). Fingerling production increased during the 1970s as rearing techniques improved and restoration of severely depressed wild populations began. Production stabilized during the 1990s, at 6-8 million annually, and similar production is expected in the near future. Spring fingerlings are the primary size now used by the Fisheries Division in public waters. Larger fall fingerlings, reared in private hatcheries, are widely stocked in private lakes. In 1994, total public and private stocking of walleye fingerlings was 8,165,213, of which Fisheries Division stocked 96.2% and private parties stocked 3.8%**.**

Fingerling walleyes stocked prior to September 1 are called spring fingerlings. Michigan data (1988-1995, n=143) indicated survival of these 1–5-inch fish to the first fall (age-0) averaged 5%, and ranged from 2% to 8%. Survival from stocking to the second fall (age-1) averaged 2%. Recommend stocking rates for spring-fingerling walleyes are 25–100/acre. The average cost of rearing and stocking spring-fingerling walleyes in 1994 was $0.044/fish. Rates may vary regionally dependent upon survival and productivity. Using these rates, the average cost of stocking spring fingerlings is $1.10–$4.40/acre (O'Neal 1998).

Walleyes stocked on September 1 or later are called fall fingerlings. Generally, fall fingerlings are larger than 5 inches, a length representative of wild fall fingerlings in Michigan. Studies are presently underway to evaluate their survival. Prior studies generally indicate larger sizes have better survival, but this advantage may be offset by their higher cost (Schneider 1969; Laarman 1978; Laarman and Schneider 1986). Recommended stocking rates for fall-fingerling walleyes are 10–40/acre. The average cost of rearing and stocking a 5.0" fall-fingerling walleyes in 1994 was $1.23/fish. Using these rates, the average cost of stocking fall fingerlings is $12.30–$49.20/acre (O'Neal 1998).

Historically, adult walleyes were stocked (transferred) to create fisheries in some inland lakes (e.g., the "Newaygo transfer"); however, this management practice is not currently considered economical or appropriate. Transfers of adults occasionally occur for establishing brood stock or special studies.

Significant evidence from Michigan and other states indicate strong year-classes of walleyes suppress survival of young the following year (Laarman 1978; Schneider 1969). Annual fry and fingerling stocking should be conducted based on the previous year's reproductive success (recruitment), if possible. Reproductive success can be measured using shoreline fall electrofishing surveys for individual water bodies (Serns 1982, 1983). If measured reproductive success is relatively good, additional stocking should not be conducted until the second or third year following. If annual recruitment cannot be measured in individual water bodies, stocking should be made on a 2- or 3-year schedule. An exception to this schedule can be made when first introducing walleyes to a new water body, when stocking can be made for the first 3 consecutive years. In this situation, evaluations should be conducted in the fourth year using standard gill and trap net methods.

Stocking rates should be adjusted based on measurements of survival and growth. This is most easily accomplished by collecting young-of-the-year and yearling fish during fall. Observed growth rates can be compared to average growth rates for Michigan walleyes. Generally, survival and growth rates decline within several years after initial stocking of new waters and where stocking is too intense. Low growth rates indicate high walleye densities (relative to food supply), and stocking can be adjusted to achieve the optimum growth rate for each water body.

5.13 Muskellunge

Muskellunge *Esox masquinongy* are considered by many to be the "trophy" fish of freshwater angling (McClay 1981). They are generally sedentary fish of solitary habit. Preferred hiding areas include vegetation near channels, drop offs, or shoals. Muskellunge can tolerate water temperatures up to 90ºF for short periods, but prefer temperatures cooler than 78ºF. They typically are found in water depths of less than 20 feet, but may be found as deep as 40 feet. Relatively large, shallow, fertile lakes and reservoirs are generally the preferred habitat (Schrouder 1973). In the mid-1950s, there were about 15 inland lakes and streams where muskellunge (all strains) provided a fishery. Since then this number has increased substantially due to increased hatchery production and stocking.

Survival of stocked muskellunge has been shown to be positively related to length at stocking (Beyerle 1984; Hanson et al. 1986). Mortalities due to predation are generally believed to decrease with increased length at stocking. Muskellunge stocked in lakes nearly always contribute significantly to the population. Stocking in new waters should be conducted with caution, as there is a distinct history of negative public perception when muskellunge are stocked (Siler and Beyerle 1984). Anglers will often attribute any decline in any fishery to introduced muskellunge.

Stocked fish are believed to have contributed significantly to the muskellunge population in the Tahquamenon River. There is not, however, any other published Michigan information on the contribution of fish in river systems (Seelbach 1988). Seelbach, however, does provide additional information regarding the potential of stocking muskellunge into river systems.

The management objectives for northern muskellunge include:

- Manage waters to preserve the natural range of native species.
- Rehabilitate or establish populations where natural reproduction is likely.
- Establish populations in waters where stocked fish have been shown to provide a trophy fishery.

Since the inception of the program, muskellunge were stocked into strategically located larger lakes on the premise that these fish would add variety, quality, and excitement to the states' fisheries program. Future expectations for the program include:

- More consistent hatchery production.
- Stocking higher quality fish.
- Stocking only the most suitable waters.

Stocking of muskellunge in lakes managed for trout and salmon is not recommended. The use of northern muskellunge to control panfish or other forage fish is not justification for stocking (Schrouder et al. 1994). Research has shown repeatedly that esocids do not control stunted panfish populations because they prefer soft-rayed species.

Stocking should occur in lakes that are 100–2,000 acres in size. Stocking of muskellunge should not occur in lakes that are less than 100 acres in size. Some eutrophic lakes may support trophy populations (e.g., Emily, Paint, and Crystal Falls Impoundment in Iron County). The forage base should consist primarily of large-sized, soft-rayed fishes (e.g., suckers, cisco, alewife and gizzard shad). Northern muskellunge should not be stocked in lakes where there are healthy northern pike or largemouth bass populations. If stocking to establish a population that will be self sustaining, there should be sufficient spawning areas available (marshy areas in water less than 3-feet deep with abundant cattails and sedges). Fallen logs, stumps, and other woody material in spawning areas may increase egg survival. Wisconsin studies have also noted that 3–6 foot deep offshore areas with soft substrates and a dominance of *Chara* are well-used spawning areas (Zorn 1996).

The population goal should be one adult fish (>30inches) per 3 surface acres. The stocking rate to achieve this is two–four, 10-inch fingerlings/acre; or one–two, 12-inch fingerlings/acre (or 0.15–0.6 lb/acre). Stocking should occur for 3 consecutive years, then every other year if fall fingerling index standards of 2–6 fall fingerlings/mile of shoreline are met using the protocol for muskellunge evaluation (Schneider 2000). Broodstock lakes have priorities for stocking.

Currently the Division does not rear tiger muskellunge (Dexter and Wolgamood 1998). However this information is provided should be program be revived. The management objective for tiger muskellunge was to manage a few waters in strategic geographic areas to provide a trophy fishery. Tiger muskellunge should only be stocked in waters where northern muskellunge cannot reproduce.

Great Lakes muskellunge were once abundant enough in Michigan to support a limited commercial fishery (Schrouder 1973). The natural range of Great Lakes muskellunge includes: Brevoort and Indian lakes; the Burt, Black, and Mullet Lake chain; the Intermediate chain of lakes including Elk, Skegemog, and Torch lakes; the St. Mary's River; the lower Menominee River; Green Bay and its tributaries; Saginaw Bay; the Detroit River; the St. Clair River and Lake St. Clair. Stocking rates and sizes in waters other than these should be the same as northern muskellunge. There is not an annual production program for the Great Lakes strain at this time.

5.14 Northern Pike

Northern pike *Esox lucius* are important predators in the fish community and a popular game fish in many North American lakes. Northern pike are much more widespread than muskellunge, but in recent history, their populations have declined dramatically, most likely due to spawning habitat loss. Fisheries managers consider them to be valuable in maintaining desirable game fish populations. The objectives for management of northern pike are to:

- Manage waters to preserve, enhance, or restore critical habitat.
- Use stocked fish to rehabilitate depleted stocks or to establish new populations.

Stocking of pike in lakes managed for trout and salmon is not recommended. The use of northern pike to control panfish or other forage fish is not justification for stocking (Schrouder et al. 1994). Research has shown repeatedly that esocids do not control stunted panfish populations.

The quantity and quality of spawning habitat (marshes) often limit pike populations. Michigan managers have had success raising pike in man-made, spawning-rearing marshes connected to local lakes. The marshes should be stocked with northern pike fry at a rate of approximately 10,000 fry/acre (Beyerle 1980) or, if fry are not available, with 5 pounds of adult females and 2–4 pounds of adult males per acre. To discourage the spread of red sore (Lymphosarcoma, Allison et al. 1977) northern pike should not be transferred from waters suspected of harboring this disease.

Beyerle and Williams (1972) and Beyerle (1980) found that a stocking of 40 spring fingerlings (3–6 inch) per acre, reared in a spawning marsh, had a survival of 10% through early fall. An additional study found that a stocking of 17 spring fingerlings (2.9-inch average) per acre from the same marsh had a survival of 27% through early fall. Both stocking rates accomplished the same result: 4-5 young-of-the-year per acre.

The population goal should be 2–4 adult (>20-inch) fish/acre. The stocking rate to achieve this is 10 (4-inch) spring fingerlings/acre, or 20 (2–3-inch) spring fingerlings/acre. Stocking should occur for 2–3 consecutive years, then in alternate years if fall recruitment standards are met.

5.15 Bluegill

Bluegills *Lepomis macrochirus* are often the most abundant game fish in Michigan lakes (Schneider 1981). This species is very prolific and is able to maintain self-sustaining populations in a great variety of habitats. While primarily a lake and pond species, they are also found in large, slow-moving rivers. Once bluegills have been established, it is extremely rare that any new stocking is warranted.

Lakes with established bluegill populations should not be stocked with bluegills in an effort to increase bluegill size. A common misconception is that bluegills in heavily fished lakes become stunted due to poor genes. Scientific evidence does not suggest that panfish populations in lakes become genetically deficient and predisposed to smaller fish due to angler harvest over time. Rather, likely causes of chronically small panfish are related to habitat, limited food supply, and possibly a higher percentage of cuckholders (small mature spawning males) (Ehlinger 1997). There have been many instances where slow-growing panfish have excelled in growth after transfer to waters with better habitat and food conditions.

Fisheries in newly created waters or chemically reclaimed waters may benefit from bluegill stocking. Since generally the best fishing occurs within the first 3 or 4 years following initial impoundment or chemical reclamation, it is important to stock adequate numbers of bluegill or hybrids (Table 5.2). A strong initial sunfish year class may also serve to repress its own succeeding year classes.

Bluegill stocking should be geared to the productivity of the water of be stocked. For example, when bass and bluegills are introduced after a typical reclamation, a reasonable goal would be to establish a standing crop of 100 lb/acre, 80 of which would be panfish. If these fish are to be harvested at 0.25 pounds each and 50% of the stocked fingerlings survive, then 640 fingerlings need to be stocked per acre. However, as more species are added to the above combination, it will be necessary to adjust the poundage of all species and hence the stocking rates (Borgeson 1987).

Schrouder et al. (1994) warned against stocking ponds in Michigan’s climate with just bluegills, or with just bass and bluegills. Generally, bass alone do not control bluegill populations very well in small ponds unless they are very well protected by size limits and controls on harvest. Consideration should be given to introducing walleye or channel catfish to provide additional predatory control.

5.16 Hybrid Sunfish

Hybrid sunfish *Lepomis* spp. seem to excel only in formerly treated waters, or waters otherwise made void of fish, where purebreds do not reenter (small landlocked waters). These work especially well in farm ponds. However, they show no real advantage in combination with other sunfish. If stocked in a lake with an existing panfish population, hybrids seem to quickly disappear—either through natural mortality or rapid angler harvest. Schrouder et al. (1994) reported that hybrid fingerlings are of little or no value when stocked with existing panfish populations or in shallow weedy ponds. In the vast majority of cases, purebred sunfish should be used where sunfish stocking is desirable. Where hybrids are needed, the bluegill-green sunfish cross should be requested. There is some evidence that hybrids are more resistant to winterkill and so might be considered for those lakes that occasionally lose all or part of their fish populations during the winter (Borgeson 1987).

5.17 Pumpkinseed

Pumpkinseed *Lepomis gibbosus* (Linnaeus) generally do not get very large or abundant; consequently they comprise only a small fraction of sport fishery. This species is rarely stocked in new waters, but seems to find its way into most fish populations. Pumpkinseeds eat snails more than any other native sunfish and so are most adapted to marl-bottom and sand-bottom lakes and ponds. This species is a direct competitor with redear sunfish, but seems to coexist in low numbers with that species. Pumpkinseed stocking is not recommended in most cases because they rarely attain large size and compete for food with bluegill and some other more preferred species. Pumpkinseeds are one of the most easily caught native panfish on hook-and-line and can offer much enjoyment to anglers fishing the shallow edges of warm-water lakes and ponds.

5.18 Largemouth and Smallmouth Bass

The stocking of largemouth bass *Micropterus salmoides* and smallmouth bass *Micropterus dolomieui* is done very infrequently. By the mid-1900s, biologists in Michigan (and other states) realized that bass and other warmwater species reproduce very prolifically, and that stocking adds little to their populations (Cooper 1948; Latta 1975; Newburg 1975). Stocking of largemouth and smallmouth bass should be limited to those waters devoid (or nearly so) of fish. They should not be requested for waters where panfish have been thinned. The thinning process itself should stimulate bass reproduction. The goal of these stocking efforts should be to establish self-supporting bass fisheries. Smallmouth and largemouth bass have been successfully reared in management unit rearing ponds and are available for use.

Stocking rates should be geared to the productivity of the receiving water (Table 5.2). Combination stockings of adults and fingerlings are preferable to establish reproduction quickly (Schrouder et al. 1994). Adult-only stockings should be avoided when fingerlings are available. In reclamation projects involving lakes of moderate productivity (100 lb/acre), two stockings of bass fingerlings at 40/acre (one immediately following detoxification and one the next year) will suffice to reestablish the fishery. When fingerlings are not available, adults may be introduced at a rate of no more than one pair per 10 acres. (Female bass produced about 4,000 eggs/lb of which about 50% hatch, perhaps more. In treated situations, a high proportion of these fry reach fingerling size. Therefore, a single 2-lb female could produce 4,000 fingerlings in a treated situation, enough to seed 100 acres of lake.)

5.19 Redear Sunfish

Redear sunfish *Lepomis microlophus* often attain large sizes in heavily fished lakes. This species grows rapidly while being rather difficult to catch on hook and line. It therefore has the ability to supply a large, even "trophy-sized" panfish in lakes that are under intensive fishing pressure and are known for small panfish. Redear sunfish should not be used as a replacement for bluegill or other sunfishes (Towns 2003). Rather, the primary emphasis should be to provide anglers with the opportunity for catching a few very large panfish.

Michigan waters are north of the natural range of this species; however, several reproducing populations have thrived in the extreme southern part of Michigan's Lower Peninsula since redears were stocked in the mid-1950s. Since 1984, several more lakes have been stocked and reproducing populations as far north as Eaton County have been documented (Saubee Lake–MDNR, Fisheries Division, unpublished data).

Redear sunfish grow quickly and reach large size when compared to bluegill and pumpkinseed. In some southern lower Michigan lakes, redear sunfish have attained lengths of 8 inches in three growing seasons. Trap net catches indicate that redear sunfish generally average from 1.5 to 3 inches larger than bluegills or pumpkinseeds in the same lake (Towns 2003). A similar relationship is evident when comparing state average length-at-age of these three species (Schneider 2000). Individuals as large as 10 to 11 inches should be expected within 5 years of introduction. After diligent stocking efforts, many lakes in southern Lower Michigan now have significant redear sunfish populations. Surveys have found many redear sunfish in these lakes that exceed 11 inches in length and a few larger than 12 inches.

Larger redear sunfish feed primarily on snails, but also eat midges, mayflies, dragonflies, small clams, and other invertebrates (Twomey et al. 1984). There has been some speculation that redear sunfish may benefit from recent introductions of zebra mussels and help to control mussel populations. A recent study by French (1993a) demonstrated that redear sunfish preyed on zebra mussels in aquarium experiments, but preferred native snails. Another report suggests that both pumpkinseed and redear sunfish will probably prey heavily on zebra mussels in shallow vegetated habitats (French 1993b). More study is needed to determine if redear sunfish can detach and consume zebra mussels once they are firmly attached to hard substrates.

Redear sunfish seem to do best in typical Michigan warmwater lakes that are high in marl, low in turbidity, and are not heavily influenced by rivers or riverine species. Trautman (1957) reported that wherever the redear sunfish has been introduced into waters north of its original range, it has essentially adapted to non-flowing waters that were relatively clear and that contained some aquatic vegetation. Lakes that have good pumpkinseed populations have proven to be good candidates for redear sunfish introductions. However, a redear sunfish introduction is likely to reduce pumpkinseed populations because these species complete for similar food items. Both species eat snails, but Huckins (1996) found that the greater crushing strength of redear sunfish allowed them to shift from a diet of soft-bodied insects to a diet of snails at an earlier age than pumpkinseed. However, this study also suggests that pumpkinseed may be better able to eat soft-body prey items, such as aquatic insects. While the superior snail crushing ability provides an advantage to redear sunfish, it is not so overwhelming that pumpkinseed will likely be extirpated after redear sunfish introductions. Michigan fishery surveys have found pumpkinseed populations co-existing (although at much lower densities) with redear sunfish in lakes that have had large redear sunfish populations for several decades.

In lakes with established fisheries where an eventual reproducing redear sunfish population is desired, fall fingerling redear sunfish (1.5-inch) should be stocked at 100 fish/acre for 3 years in succession (Towns 2003). This method assumes that at least two of the three-year classes will survive in high enough numbers to establish a breeding population. In some cases, new introductions have resulted in very large redear sunfish populations, with redear sunfish comprising somewhat smaller numbers, but similar total biomass as bluegills in trap net catches (MDNR, Fisheries Division, unpublished data). Newly established populations should be surveyed in the forth or fifth year to ascertain survival, and determine if successful natural reproduction has occurred. Subsequent stocking may not be necessary, but if survival to adult size has been low, alternate-year stocking may be used to maintain the fishery.

5.20 Yellow Perch

Yellow perch *Perca flavescens* are valuable for table fair, angling, and forage for predators. In addition as a part-time piscivore, yellow perch can beneficially reduce over-abundant small bluegills (Schneider and Breck 1997). They adapt to all types of habitats, are winterkill-tolerant, and are very prolific and invasive. They tend to over-populate and stunt at a small size unless adequate populations of piscivores such as walleye and bass are maintained, and are a nuisance to the management of trout-only lakes. Consequently, it is rarely necessary to stock yellow perch except following total reclamation or complete winterkill.

5.21 Black Crappie

Black crappies *Promoxis nigromaculatus* often become the dominant panfish in reservoirs and highly productive lakes and occasionally exhibit slow growth rates. Although of widespread distribution in Michigan, it has rarely been stocked and actively managed. The role of crappies in fisheries management is poorly understood. As a combination of mid-water planktivore and piscivore, they potentially effect the growth and survival of fry and juveniles of many species of fish. The effects could be either beneficial or harmful to the quality of those populations. In New York lakes, presence of crappies is considered to be detrimental to survival of stocked walleye fry. In Michigan ponds, Schrouder et al. (1994) recommended crappies not be stocked due to stunting tendencies. In Michigan lakes, stocking to reestablish crappie populations after total fish kills can be considered. This can be accomplished by transferring adults from other waters.

5.22 Channel Catfish

Currently the Department does not rear channel catfish *Ictalurus punctatus*. Fish have been secured for public stockings via negotiations with nearby states that have active catfish programs. Furthermore, after conversations with several private fish breeders, it appears that few if any, channel catfish are reared in private Michigan hatcheries. Michigan fish breeders act as brokers for catfish stocks reared in southern states.

The native range of channel catfish extends from the southern portions of the prairie provinces of Canada, south through the Great Lakes and Mississippi Valley, and includes all Gulf of Mexico states and Mexico – but not the Atlantic coastal plain (Trautman 1957). This species has been widely introduced in other areas and now forms a substantial portion of the game fish populations in the midwestern, southern, and southwestern United States. The species is native to Michigan, but few waters contain large populations of them.

Channel catfish can add a new dimension to the game fish communities in typical warmwater bass-bluegill lakes. Catfish can reach 8 to 10 lb, and even larger, and become the largest game fish in such systems. Once they grow to 16 inches, they become piscivorous (O'Neal 1988). Growth in inland waters of southern Michigan indicates that catfish reach this size by age-4.

Possibly, they may help improve growth and size structure of stunted panfish populations, but good evidence of this is currently lacking.

This species requires high water temperatures for reasonable growth. Because of this catfish stocking will normally be limited to southern Michigan waters and select northern impoundments. This species occupies a large segment of the game fish fisheries of several southern, Lower Peninsula rivers and impoundments (Dexter 1991c). Many of these populations are now self-sustaining. Also, some experimental public and private stockings have proven successful in typical southern Michigan warmwater lakes that are low in turbidity.

The size of fingerlings when stocked seems to be of critical importance in lakes and ponds with existing fish populations. Largemouth bass have been well recognized as a potential predator of stocked catfish (Krummrich and Heidinger 1973). Crance and McBay (1966) found that the survival and harvest of catfish stocked in ponds varied depending on the size of the channel catfish. They observed largemouth bass consuming channel catfish immediately after catfish were stocked. This predation factor is the likely explanation for the lack of successful reproduction in Michigan lakes and ponds that have significant populations of predators such as largemouth bass. Several studies have attempted to determine the best catfish fingerling size for stocking in warm waters with existing fish populations (Storck and Newman 1988; Spinelli et al. 1985; Krummrich and Heidinger 1973). This research indicates that the greatest return on investment would be obtained by stocking large fingerlings (8-inch and larger) in waters which hold significant populations of largemouth bass. Smaller catfish fingerlings may survive to fishable numbers, if stocked in large quantities, when stocked in newly renovated (treated) systems, or in large rivers and impoundments that have low largemouth bass populations.

To establish a catfish fishery in small to medium-sized lakes (20 to 300 acres) with established predator populations and low to moderate catfish fishing pressure, 25 yearlings/acre of 8-inch or larger fish should be stocked (State of Indiana, Division of Fish and Wildlife, unpublished data). Higher densities can be used for smaller lakes and ponds where more emphasis is to be placed on catfish as a primary game fish. In larger lakes, where a small percentage of the lake surface covers shallow productive area, lower stocking rates can be used (up to 10 large fingerlings/acre). In Michigan, we suggest stocking for 3 years in succession, and every other year thereafter. This method assumes that at least two of the first three year-classes of fish will survive in large enough numbers to establish a fishery. Subsequent stocking should maintain the fishery. Rivers and impoundments, new lakes and renovated (treated) lakes should be stocked with large fingerlings if they are available. However, 4-inch or larger fingerling catfish stocked at 50/acre may create a fishable population. Again, stocking should be for 3 years in succession and every-other-year thereafter. In rivers and impoundments reproducing populations may eventually develop. Therefore, it is important to survey regularly to determine the need for continued stocking.

5.23 Flathead Catfish

Flathead catfish *Pylodictis olivaris* are indigenous to Michigan and are most frequently found in large warmwater rivers. Their distribution is generally limited to the southern portion of the Lower Peninsula. Introductions have been made into a few inland lakes and impoundments for experimental purposes. They are usually found in rivers with channel catfish, but are less abundant. Habitat preferences for young are rubble-bottomed riffles; older fish become solitary in deep holes with large woody structure (Minchly and Deacon 1959).

Flathead catfish grow quickly and attain large sizes. A length of 16 inches is attained in the third or fourth year of life and 40–50 inches in 11–15 years. They are highly piscivorous and their diet is often dominated by fish by the time they reach 4–5 inches long (Turner and Summerfelt 1971). Preferred foods are bottom-feeding fish including bullhead, carp, and suckers. Many other species are also eaten, including crappie, bluegill, and sunfish.

Stocking of flathead catfish is limited in Michigan and throughout the United States. This is the result of limited availability and because they are difficult to culture. Only a few states (e.g., Texas) have limited rearing programs, and most management studies have been conducted using adults transferred from natural populations. Michigan made several unsuccessful attempts to rear flathead catfish during the 1990s at the Wolf Lake Hatchery.

Michigan stocked flathead catfish in five inland waters during the 1990s. Goals of the introductions were to enhance the size structure of panfish populations, reduce sucker abundance in a small impoundment, and make more attractive recreational fisheries. All of the experimental lakes had a history of abundant, slow-growing panfish with few bluegill or sunfish reaching 6 inches in length. Flathead catfish were introduced to feed on the panfish and reduce population densities, hopefully resulting in increased growth rates and ultimately larger panfish.

All but one lake was stocked by transferring adults from natural river populations (Grand River, Maple River, and Kalamazoo River). One lake was stocked with spring yearlings for a single year with fish obtained from another state. Additional yearlings could not be obtained and surveys indicated no survival from that stocking. The yearlings were small and only in fair condition when stocked, and that may have been the cause of poor survival. Larger fingerlings may have survived better.

Lakes stocked with adult flatheads showed varying results. One small impoundment showed no difference in sucker abundance, but the flatheads may have migrated from the impoundment to the river.

Sand Lake (Newaygo County) was stocked at a rate of 7–11 lb/acre between 1990 and 1996 (cumulative stocking rate). (Why is thre A series of trap bet surveys were conducted before and after the introduction. For bluegill, the proportion of fish over 6 inches increased from 0.0-7.3% to 4.8-43.3%. For pumpkinseed, the proportion of fish over 6 inches increased from 4.6-46.7% to 20.0-77.8%. The bullhead population was significantly reduced, similar to findings by Davis (1985). Black crappie sizes increased substantially. Yellow perch sizes also increased. Largemouth bass and northern pike appeared to be unaffected. The flathead catfish population fluctuated during the study period because some were added after the initial stocking and some died from natural mortality (harvest was prohibited). Bluegill sizes and catch per unit effort seem to reflect flathead abundance.

Baptist Lake (Newaygo County) was stocked with flathead catfish at approximately 3 lb/acre in 1992. The proportion of bluegills larger than 6 inches during preceding trap net surveys in 1985, 1987, and 1989 were 8%, 7%, and 1%, respectively. The proportion of bluegill larger than 6 inches in 1994, 1995, and 1996 improved to 43%, 50%, and 21%. Note, however, the 1996 survey indicated smaller sizes and increasing catch per unit effort for bluegills. Additional flathead catfish were not added to this lake and management was changed to stocking adult walleyes in 1997.

Brush Lake (Newaygo County) was stocked with adult flathead catfish at the rate of 5 pounds/acre in 1996. The proportion of bluegill larger than 6 inches in 1971 was only 13.3 %. Bluegill numbers were reduced with an antimycin treatment in 1974 and size structure improved for a few years, but by 1994, only 7% were larger than 6 inches. In 1999, 3 years after flathead stocking, bluegills larger than 6 inches had increased to 76%.

Flathead catfish introductions were discontinued because they could not be readily cultured, yearlings could not be purchased, transferring adults was expensive, and there was concern about possibly depleting the indigenous populations. The experimental stocking studies discussed above indicate introduced flathead catfish can cause significant changes in fish community structure in some in inland lakes. Generally, crappie, pumpkinseed, bluegill, and yellow perch numbers can be reduced and larger sizes will result. Bullhead populations will be reduced to very low levels, but largemouth bass and northern pike appear to be unaffected. It takes 4 years before the size structure of prey populations becomes more favorable for angling. Stocking flathead catfish has potential as a management technique to improve size structure of overabundant panfish populations, but only if improved culture techniques can produce sufficient numbers of fish.

5.24 Tables

Table 5.1.–Numbers of trout stocked per acre, by lake size, 1995-96.

	Lake size (acres)			
Species (life stage)	<20	21-99	100-500	>500
Brook trout (fall fingerling)				
Range	23-200	11-143		
Mean	109	59		
Median	100	53		
Brook trout (yearling)				
Range	25-147	6-100		
Mean	69	66		
Median	69	76		
Rainbow trout (yearling)				
Range	29-175	13-320	5-83	2-21
Mean	86	63	35	8.4
Median	79	53	36	5.7
Splake (yearling)				
Range		15-114	4-68	1-15
Mean	35	51	35	6
Median		44	34	3.5
Brown trout (yearling)				
Range	29-500	10-99	7-43	0.6-8.5
Mean	119	46	28	4.7
Median	91	42	30	4.2

Table 5.2.–Simplified warmwater and coolwater fish stocking guide[a] (no competing fishes present initially).

Water body type Species combination	Target composition (%)[b]	Stocking rate[c] life stage	 number/acre	Size (inches)	Notes
Ponds or specially-managed small lakes[d]					
Bluegill	75	fingerling	640	1 - 3	
Largemouth bass	25	fingerling	40	2 - 6	
		adult	5	10+	Give bass head start.
Hybrid sunfish	100		400-800/ 1-2 yrs	1 - 3	No reproduction; restock.
Largemouth bass	50	fingerling	40	2 - 6	Allow minnows to spawn
Golden shiner	50		500	2 - 7	first.
Walleye	30	fingerling	10/yr	3 - 6	No walleye reproduction
Perch	20	eggs		0	expected. Best for
Bluegill	50	fingerling	500	1 - 3	northern lakes with low
		adults	5	7+	bluegill reproduction.
Walleye	50	fingerling	10/yr	3 - 6	No walleye reproduction
Golden shiner	50		500	2 - 7	expected.
Typical warmwater lakes					
Bluegill	50	fingerling	400	1 - 3	If history of stunted bluegill
Largemouth bass	15	fingerling	30	2 - 6	or perch, maintain high
Pike[e]	5	fry	200	fry	densities of predators
Perch	10	any		any	with protective regulations
Channel catfish	10	fingerling	30/yr	3 - 6	or supplemental stocking
Crappie	5	adults	5	7+	of walleye or channel catfish. Minnows may
Minnows	5	adults	100	1 - 7	re-colonize on own.
Coolwater lakes					
Perch	50	any		any	
Bluegill	20	fingerling	200	1 - 3	
Walleye	10	fingerling	30/yr	1 - 3	Walleye and bluegill
Smallmouth bass	20	fingerling	30	2 - 6	optional and may or may
		adults	5	10+	not reproduce.

[a] General advice: select species based on habitat suitability and predator-prey balance; construct simpler fish communities in small or unproductive northern lakes; avoid restocking species that created problems there before.
[b] Refers to the resulting fish community.
[c] Stocking rates refer to one-time events, unless followed by /yr, indicating a need for maintenance stocking.
[d] See also Schrouder et al. (1989).
[e] May substitute walleye, but annual or semi-annual maintenance stocking of fingerlings required.

Table 5.3.–Average July water temperatures that should not be exceeded in stocked coldwater streams. Data from Wehrly et al. (1998)

Species	Centigrade	Fahrenheit
Brook trout	19.0	66.2
Brown trout	20.0	68.0
Chinook salmon	20.0	68.0
Coho salmon	20.0	68.0
Rainbow trout	20.0	68.0

Table 5.4.–Brook trout annual survival rates from four Michigan streams.

		Survival (%) by age (fall to fall)			
Wild brook trout stream	Regulation	0	1	2	3
Hunt Creek Section B 1974-94	No fishing	31	32	15	32
Mainstream Au Sable at Stephan Bridge	No-kill flies only	20	7	N/A	N/A
Mainstream Au Sable at Wa Wa Sum	No-kill flies only	37	10	4	N/A
North Branch Au Sable at Dam 4	8” minimum flies only	15	6	2	N/A

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