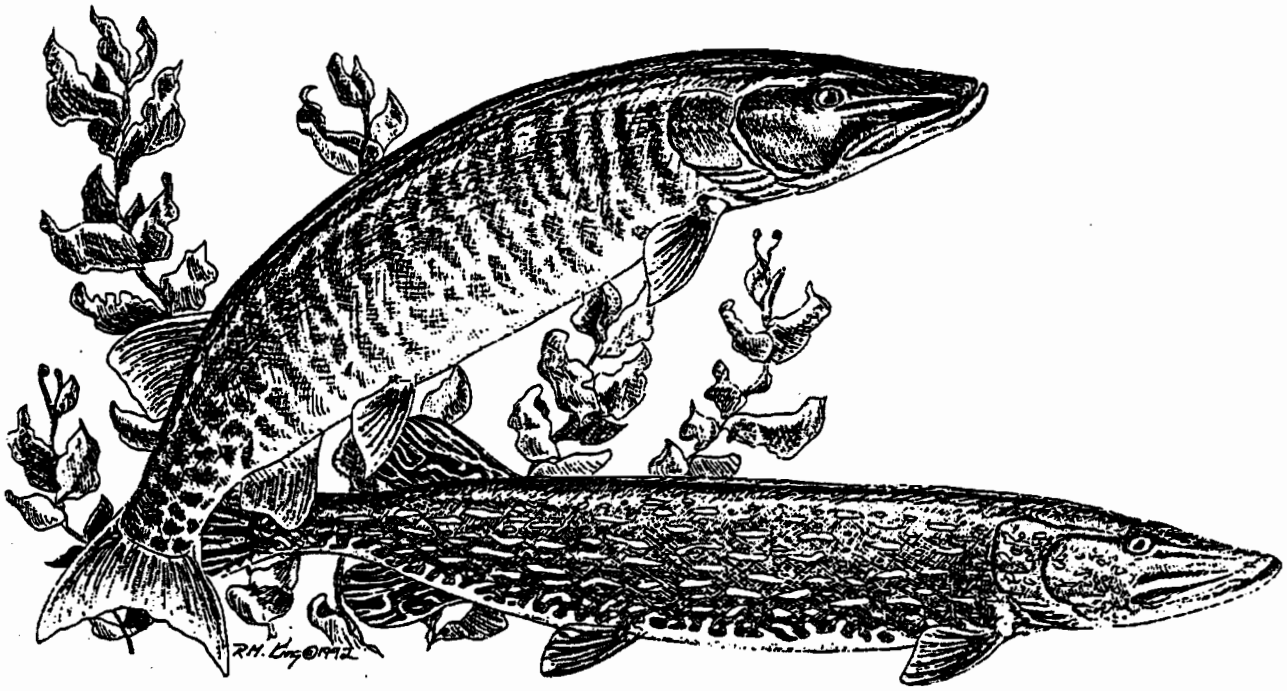
Esocid Technical Committee

The Introductory, Maintenance, and Restoration Stocking of Esocids



North Central Division American Fisheries Society

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THE INTRODUCTORY, MAINTENANCE, AND RESTORATION STOCKING OF ESOCIDS

PROCEEDINGS OF A WORKSHOP SPONSORED BY THE
ESOCID TECHNICAL COMMITTEE
NORTH CENTRAL DIVISION
AMERICAN FISHERIES SOCIETY

JULY 24-25, 1996

THE RADISSON HOTEL
LACROSSE, WISCONSIN

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INTRODUCTION

A workshop on the introductory, maintenance, and restoration stocking of esocids was held July 24-25, 1996, in LaCrosse, Wisconsin, as part of the summer meeting of the Esocid Technical Committee of the North Central Division, American Fisheries Society. The workshop was loosely modeled after the 1995 American Fisheries Society symposium in New Mexico, "Uses and Effects of Cultured Fishes in Aquatic Ecosystems" (Schramm and Piper 1995), and was intended to bring together esocid managers and researchers from throughout the Midwest. Twenty-four people attended the workshop, to discuss the major goals and objectives of esocid management, stocking strategies employed by state and provincial agencies to meet these goals, and considerations and constraints in implementing these strategies.

The workshop began with seven presentations describing general aspects of esocid management and stocking programs in 14 states and provinces. Presenters included Richard Day (Ohio Department of Natural Resources), Dave Clapp (Illinois Natural History Survey), Dave Neuswanger (Missouri Department of Conservation), Joe Larscheid (Iowa Department of Natural Resources), John Lott (South Dakota Department of Game, Fish, and Parks), Jerry Younk (Minnesota Department of Natural Resources), and Terry Margenau (Wisconsin Department of Natural Resources). Special thanks go to Dave Neuswanger who developed the workshop format and made initial contact with the presenters. Presentations focused on goals and objectives of each management program, stocking strategies (including stocking rates, periodicity, size of fish at stocking, rearing history, criteria for receiving waters, and other considerations), and program limitations. The specific charges to each presenter were:

1) To describe the main goals/objectives for each species of stocked esocid in their area of concern and to describe the process used in evaluating the success of stocking strategies and other management efforts.

2) To describe the specific stocking strategies used by each state or province to achieve the stated goals and objectives for each esocid species stocked. Details of these strategies included the following criteria:

- Presence or absence of natural recruitment
- Stocking density
- Stocking periodicity
- Size of fish at stocking
- Rearing history
- Physical requirements of receiving waters
- Social criteria
- Strain considerations
- Brood stock sources

3) To describe the biggest factors limiting the ability of each state or province to effectively implement these strategies, and to discuss what could be done to make things better.

The majority of the presentations during this first half of the workshop focused on the stocking of muskellunge, with some discussion of hybrid (tiger) muskellunge and a few presentations dealing with northern pike. These general presentations were followed by presentations concerning special topics in esocid management, including genetics and fish production procedures. Thanks go to Marc Desjardins, Martha Wolgamood, and Konrad Dabrowski for their contributions to this section of the workshop. Finally, a roundtable discussion among workshop participants addressed "the appropriate role of stocking in esocid management."

The organization of this document follows that of the workshop. The first section contains summaries of presentations concerning individual state and province stocking programs. These presentations are somewhat weighted towards the presenter's area of interest and expertise, as well the amount of assistance the presenter received from the agencies contacted. For example, if a research biologist from one state presented information on the muskellunge programs in their state plus two other states, the presentation may have focused more on the program in the presenter's state, and may have dealt more with research into stocking options

than with management applications in that state. However, the information presented in all cases provides a good starting point from which to address the future applications of stocking in esocid management. Summaries of individual state and province stocking programs are followed by information on technical subjects related to esocid stocking, including production techniques and genetics. Finally, a summary of the roundtable discussion is presented, and some conclusions are drawn (where appropriate). It is hoped that the workshop and this document will add constructively to an important ongoing dialogue (see Smith 1996) concerning the importance of stocking, and will help in determining the most appropriate future uses of stocked esocids.

ESOCID STOCKING STRATEGIES IN THE MIDWEST AND NORTH AMERICA

MUSKELLUNGE STOCKING STRATEGIES IN OHIO, INDIANA, AND PENNSYLVANIA

Presenter -- Richard Day, Ohio Department of Natural Resources

GOALS/OBJECTIVES:

Indiana

- To improve fishing quality and diversity
- To provide trophy fishing opportunities
- To provide adults for brood stock

Ohio

- To maintain high quality muskellunge fisheries at selected water areas
- To provide muskellunge fishing opportunities commensurate with angler use and demand, in areas with suitable habitat
  - sustain an average of 150,000 angler-hours of effort
  - sustain an average annual catch of 1,700, 30"+ muskellunge
- To provide trophy muskellunge fishing opportunities
  - sustain an average annual catch of 317, 42"+ muskellunge

Pennsylvania

- To provide trophy fishing opportunities

OF WATERS STOCKED:

Indiana

- 8 reservoirs (2 muskellunge and 6 hybrid)

Ohio

- 8 reservoirs

Pennsylvania

- 6 brood stock lakes
- Annual or biennial stocking of a variable number of lakes and rivers

ANNUAL PROGRAM COST / FISH PRODUCTION:

Indiana

- Approximately $20,000 annually, to produce 15,000, 8"+ fish

Ohio
- Approximately $100,000 (Production cap - approximately 20,000 fish)

Pennsylvania
- Approximately 20 cents per fish

STOCKING DENSITY:

Indiana
- 0.5 to 8.0 fish/acre

Ohio
- 0.7 to 2.0 fish/acre

Pennsylvania
- (Muskellunge) 10/acre in brood stock lakes, 1/acre in others
- (Hybrid Muskellunge) 5/acre in all water bodies

STOCKING PERIODICITY:

Indiana
- Annual

Ohio
- Annual

Pennsylvania
- Alternate year or annual

SIZE AT STOCKING:

Indiana
- 8" average total length (range - 7.3" to 12.5")

Ohio
- 8"+ average total length (range in averages - 8.5" to 10.3")

Pennsylvania
- (Muskellunge) 6" minimum total length
- (Hybrid Muskellunge) 10" average total length

REARING HISTORY:

Indiana
- 5 reservoirs on artificial diet
- 3 reservoirs finished on forage fish

Ohio
- Started on pellets, finished on forage fish in ponds

Pennsylvania
- Started on brine shrimp, followed by artificial diet, and finished on minnows

CRITERIA FOR RECEIVING WATERS:

SIZE:

Indiana
- None stated (Range - 17 to 5,300 acres)

Ohio
- None stated (Range - 600 to 3,000 acres)

Pennsylvania
- None stated

SPECIES COMPOSITION:

Indiana
- Abundant prey fish
- No northern pike

Ohio
- Abundant gizzard shad
- Low densities of predators other than muskellunge

Pennsylvania
- Purebred muskellunge and hybrids may be stocked into the same system

TEMPERATURE:

Indiana
- None stated

Ohio
- None stated

Pennsylvania
- None stated

OTHER:

Indiana
- None stated

Ohio

- Good potential for survival (based on habitat)
- Distribution in state to maximize angler utilization and access
- Average growth rate in system
- Previous angler effort
- Previous angler catch and catch rate

Pennsylvania

- Suitable habitat and forage

SOURCE STOCK /GENETICS:

Indiana

- Wisconsin, Pennsylvania

Ohio

- Clear Fork Reservoir (OH)

Pennsylvania

- Clear Fork Reservoir (OH)

OTHER CONSIDERATIONS:

Indiana

- None stated

Ohio

- None stated

Pennsylvania

- None stated

RESULTS OF STOCKING:

Indiana

- Creel data indicates a limited fishery in Webster Lake (pure muskellunge) and Skinner Lake (tiger muskellunge) – established from stocking

Ohio

- 50% survival from stocking to Age 1 (in reservoirs where estimates were obtained)
- Average annual catch of greater than 1,200, 30"+ muskellunge
- Average annual catch of greater than 150, 42"+ muskellunge

Pennsylvania

- Not provided

FACTORS LIMITING SUCCESS OF PROGRAM:

Indiana

- Erratic production
- Poor survival of fish raised intensively (pellet)

Ohio

- Limited escapement
- Potential disease problems ("red spot") at certain reservoirs

Pennsylvania

- Potential disease problems ("red spot") at certain reservoirs
- Loss of stocked fish to predators
- Low first year survival

SUGGESTIONS FOR IMPROVEMENT:

Indiana

- Increase proportion of pond-reared, minnow-fed fish stocked in state waters

Ohio

- Meet new 6 year program goals

Pennsylvania

- Develop a better system for prioritizing stocking
- Develop a strategy for complete minnow-reared fish production

MUSKELLUNGE STOCKING STRATEGIES IN ILLINOIS AND KENTUCKY

Presenters -- Dave Clapp, Illinois Natural History Survey, and Benjy Kinman, Kentucky Department of Fish and Wildlife Resources

GOALS/OBJECTIVES:

Illinois

- To provide diversified sport fishing opportunities
- To control forage fish and overabundant panfish
- To increase the quantity and quality of cool-water sport fish angling days

Kentucky

Reservoirs

- To provide a high quality, put-grow-take fishery, part of which includes trophy fish
- To add an additional 1 pound per acre or 10% of harvest

Streams

- To maintain the fishery within naturally occurring native muskellunge streams to near carrying capacity

OF WATERS STOCKED:

Illinois

- (Muskellunge) Approximately 15 impoundments
- (Hybrid Muskellunge) Approximately 12 impoundments

Kentucky

- 3 reservoirs and 14-23 streams

ANNUAL PROGRAM COST / FISH PRODUCTION:

Illinois

- (Muskellunge) 20,000 to 25,000 fish produced
- (Hybrid Muskellunge) 30,000 to 40,000 fish produced

Kentucky

- Approximately $105,000 annually; 13,000 to 22,000 fish are produced

STOCKING DENSITY:

Illinois
- 0.5 to 2.0 fish/acre

Kentucky
- 0.5 to 1.0 fish /acre

STOCKING PERIODICITY:

Illinois
- Annual

Kentucky
- (Reservoirs) Annual
- (Streams) Annual or Biennial

SIZE AT STOCKING:

Illinois
- (Muskellunge) 8" to 12"
- (Hybrid Muskellunge) 10"

Kentucky
- (Reservoirs) 9"-13"
- (Streams) 9"

REARING HISTORY:

Illinois
- Pellet followed by forage fish

Kentucky
- Not provided

CRITERIA FOR RECEIVING WATERS:

SIZE:

Illinois
- None stated (Range of lakes stocked - 25 to 25,000 acres)

Kentucky
- None stated (Range of lakes stocked - 1,200 to 8,300 acres)

SPECIES COMPOSITION:

Illinois
- None stated

Kentucky
- None stated

TEMPERATURE:

Illinois
- None stated

Kentucky
- Fall stocking preferred

OTHER:

Illinois
- None stated

Kentucky
- Extent of natural reproduction in streams

SOURCE STOCK /GENETICS:

Illinois
- Variety of sources, but primarily Spring Lake (IL)

Kentucky
- Not provided

OTHER CONSIDERATIONS:

Illinois
- None stated

Kentucky
- None stated

RESULTS OF STOCKING:

Illinois
- Initial survival of 10", minnow-finished muskellunge approximately 30% to first fall (range 0-50%)
- Angler catch and harvest - generally less than 0.001 fish/hour
- Abundance in surveys - 0.1 to 1.2 fish per trap net night (average)
- Approximately 4 years to reach 30"
- Annual reported catch of 30"+ fish is approximately 200 fish
- Annual reported catch of 40"+ fish is approximately 30 fish

- Average release rate is approximately 75%

Kentucky

- Approximately 2-3 years to reach 30"
- Average annual harvest is approximately 500 fish (Average size = 35", 11 pounds)

FACTORS LIMITING SUCCESS OF PROGRAM:

Illinois

- Demand for esocids exceeds supply
- Production is limited by lack of approval of therapeutic chemicals
- Optimum stocking rates need to be determined, relative to reservoir forage conditions and other factors
- Biological information is inadequate
- Demand resulting from the presence of non-native fish could result in pressure to stock these fish before impacts on native fish are evaluated

Kentucky

- Loss of habitat
- Dam construction
- Poaching
- Reservoir drawdown and flushing rate

SUGGESTIONS FOR IMPROVEMENT:

Illinois

- Conduct research to address stocking rate and success questions
- Conduct research to address food habits and competition and predator/prey relationships and questions
- Increase state fish hatchery production of esocids
- Develop better fish population assessment methods and tools
- Stock additional impoundments which are capable of supporting esocids to increase supply of opportunities
- Investigate impacts of "trophy fish" stocking

Kentucky

- Currently investigating effects of stocking density

MUSKELLUNGE STOCKING STRATEGIES IN MISSOURI

Presenter -- Dave Neuswanger, Missouri Department of Conservation

GOALS/OBJECTIVES:

- To efficiently produce and manage muskellunge in order to provide special, high-quality angling opportunities in suitable, well-distributed impoundments where more traditional Missouri fisheries will not be adversely affected and may be enhanced
- To annually stock up to 3,000 large muskellunge fingerlings into small impoundments scheduled to receive introductory or maintenance stockings according to a prioritized list of eligible impoundments
- To ensure that the average Missouri muskellunge angler can catch one 36"+ muskellunge per 20 to 40 hours of effort

OF WATERS STOCKED:

- 5 reservoirs

ANNUAL PROGRAM COST / FISH PRODUCTION:

- Approximately $58,000 per year (direct costs)
- $14.95 per fish
- Cost:Benefit = 1:4.5

STOCKING DENSITY:

- Lake Pomme de Terre - 0.5 fish/acre
- Small Impoundment Program - 1 to 3 fish/acre

STOCKING PERIODICITY:

- Lake Pomme de Terre - Annual
- Small Impoundment Program - Every three years

SIZE AT STOCKING:

- 10"-12" (Largest that can be produced in one season)

REARING HISTORY:

- Dry diet indoors to 3.0", then pond-reared on fathead minnows

CRITERIA FOR RECEIVING WATERS:

SIZE:

- Lake Pomme de Terre
  - 7,820 acres
- Small Impoundment Program
  - Average size = 300 acres
  - Range = 158-530 acres

SPECIES COMPOSITION:

- Gizzard shad must be present
- Presence of additional forage (brook silversides, "shiners", common carp) is preferred

TEMPERATURE:

- No temperature or dissolved oxygen problems

OTHER:

Minimum criteria

- Not subject to flooding
- Water transparency ≥ 24"
- Macrophytes or dense flooded timber present
- Emigration barriers in place
- No concurrent specialty fisheries
- No watershed development problems
- Open to fishing all year

Ranking criteria

- Proximity to metro areas
- Distant from other muskellunge fishing opportunities
- Availability of camping facilities
- Availability of mid-water structure

SOURCE STOCK /GENETICS:

- Lake Pomme de Terre
  - Lake Pymatuning (PA)
  - Various other sources
- Small Impoundment Program
  - Hazel Creek Lake (MO) 1983 year class broodstock (originally from Linesville Culture Station - PA)

OTHER CONSIDERATIONS:

- Cost:Benefit ratio of muskellunge program
- Length limit options (36" versus 42")
- Public relations considerations

RESULTS OF STOCKING:

- Tremendous survival from original stocking events in Hazel Creek Lake (7% annual mortality)
- Lots of catch and release
- Currently evaluating stocking density and length limits

FACTORS LIMITING SUCCESS OF PROGRAM:

- Lack of suitable evaluation of program
- Insufficient information on stock differences and suitability under Missouri's environmental conditions

SUGGESTIONS FOR IMPROVEMENT:

- Recognize our limited ability to age muskellunge accurately
- Designate a liaison to public on muskellunge management
- Enlist public assistance in evaluating muskellunge stocking program success

MUSKELLUNGE STOCKING STRATEGIES IN IOWA

Presenter -- Joe Larscheid, Iowa Department of Natural Resources

GOALS/OBJECTIVES:

- To provide a unique opportunity to catch a trophy fish in the context of a larger, multi-species fishery
- To maintain densities at 1 adult muskellunge per 7 to 10 acres of water
- To maintain a catch rate by anglers of 1 fish per 70 to 100 hours of effort

OF WATERS STOCKED:

- 7 lakes

ANNUAL PROGRAM COST / FISH PRODUCTION:

Fall fingerlings
- Pellet-reared; $2.04 per fish
- Pellet-reared, minnow-finished; $2.81 per fish

Spring yearlings
- Pellet-reared, minnow-finished; $9.75 per fish

STOCKING DENSITY:

Fall fingerlings
- 1 fish per 3 acres

Spring yearlings
- 1 fish per 6 acres

STOCKING PERIODICITY:

Fall fingerlings
- Annual

Spring yearlings
- Alternate year

SIZE AT STOCKING:

- 6" to 14"

REARING HISTORY:

- Mixture of pellet-reared and pellet/minnow-reared fish

CRITERIA FOR RECEIVING WATERS:

SIZE:
- None stated

SPECIES COMPOSITION:
- None stated

TEMPERATURE:
- None stated

OTHER:
- 6 lakes distributed throughout state

SOURCE STOCK /GENETICS:

- Iowa Great Lakes (Spirit Lake strain)

OTHER CONSIDERATIONS:

- Public relations considerations: non-muskellunge anglers are against introductions and are worried about potential effect on panfish (primarily yellow perch) populations

RESULTS OF STOCKING:

- Poor survival of pellet-reared fish stocked from 1982 to present
- Relatively few, large fingerlings stocked in spring of a single year were primary contributors to Lake Okoboji muskellunge population, and provided the only significant recruitment from 1981-1997

FACTORS LIMITING SUCCESS OF PROGRAM:

- Poor survival of pellet-reared muskellunge
- Limited pond production space
- Intensive sampling necessary to gather information on muskellunge populations due to low density
- Lack of information

SUGGESTIONS FOR IMPROVEMENT:

- Utilize spring stocking of larger fingerlings
- Implement results of energetic analyses in managing muskellunge populations

NORTHERN PIKE AND MUSKELLUNGE STOCKING STRATEGIES IN NORTH AND SOUTH DAKOTA

Presenter -- John Lott, South Dakota Department of Game, Fish, and Parks

GOALS/OBJECTIVES:

Northern Pike

- To create or re-establish northern pike fisheries in marginal (subject to winterkill) or newly flooded waters
- To maintain northern pike population status during periods when environmental conditions do not favor natural reproduction
- To increase northern pike density and biomass to levels where northern pike serve as biological control mechanisms on overabundant panfish and rough fish populations (not a primary objective)

Muskellunge

- To provide anglers with a unique opportunity to catch a trophy fish

OF WATERS STOCKED:

Northern Pike

- Variable (100-200), depending on environmental conditions
- Approximately 340 lakes contain northern pike

Muskellunge

- 10 to 15 lakes

ANNUAL PROGRAM COST / FISH PRODUCTION:

Northern Pike

- Up to 10,000,000 fish stocked annually

Muskellunge

- 20,000 to 30,000 fish stocked annually

STOCKING DENSITY:

Northern Pike

- 50 to 500 fish/acre (50 to 100 fish/acre supplemental)

Muskellunge

- 0.5 to 4.25 fish/acre

STOCKING PERIODICITY:

Northern Pike
- Annual to Triennial

Muskellunge
- Annual to Sporadic

SIZE AT STOCKING:

Northern Pike
- 1,200 to 1,700 fish per pound

Muskellunge
- 120 fish per pound (1,200 to 2,500 fish/lb - Hybrid Muskellunge)

REARING HISTORY:

Northern Pike
- Pond-reared on zooplankton

Muskellunge
- Purchased as fingerlings (Hybrid Muskellunge are pond-reared on zooplankton)

CRITERIA FOR RECEIVING WATERS:

Northern Pike

SIZE:
- 100 acres to 400,000 acres

SPECIES COMPOSITION:
- Varies, depending on lake classification

TEMPERATURE:
- Winterkill is considered in stocking decisions

OTHER:
- Lake classification / type - Missouri River reservoirs, prairie pothole lakes, glacial lakes, and high plains reservoirs
- Water level - related to northern pike year class strength
- Availability of spawning and rearing habitat
- Water quality (see "Temperature" - winterkill, above)
- Lake trophic state

Muskellunge

SIZE:

- None stated

SPECIES COMPOSITION:

- None stated

TEMPERATURE:

- None stated

OTHER:

- None stated

SOURCE STOCK /GENETICS:

Northern pike

- Eastern natural lakes or Missouri River reservoirs

Muskellunge

- Pennsylvania, Minnesota, or Iowa

OTHER CONSIDERATIONS:

Northern Pike

- Growth is good to excellent
- Availability of hatchery fish is not a limiting factor

Muskellunge

- None stated

RESULTS OF STOCKING:

- Limited evaluations of northern pike and muskellunge stocking have been conducted

FACTORS LIMITING SUCCESS OF PROGRAM:

Northern Pike

- Greatly fluctuating water levels leading to "boom and bust" reproduction in Missouri River reservoirs
- Requests greater than supply

- Lack of evaluation of stocking, including
  - Lack of age structure information to confirm stocked northern pike contribution to population
  - Fish population survey data often unavailable for stocked waters
  - Creel surveys are rare and only conducted on primary walleye lakes
  - Lack of information on contribution of stocked northern pike to year class strength

Muskellunge

- Stocking justifications and evaluation procedures are lacking
- Lack of standardized indices of stocking and reproductive success
- Lack of information on contribution of stocked muskellunge to the fishery
- Anglers have problems with identification of fish - overharvest of small fish
- Poor survival

SUGGESTIONS FOR IMPROVEMENT:

- Require written stocking justifications and detailed descriptions of proposed stocking evaluation procedures before stocking is approved for a given body of water
- Improve biologists northern pike aging abilities, and require age and growth information to be a standard component of fish population surveys
- Initiate fall electrofishing surveys to index both esocid and walleye reproduction and / or recruitment
- Investigate the use of mass marking techniques as a means of determining the contribution of stocked northern pike to a year class
- Identify public interest in muskellunge fisheries and identify potential muskellunge waters
- Determine optimum sizes and densities of muskellunge and tiger muskellunge to stock to maximize contribution of stockings to the fishery

MUSKELLUNGE AND NORTHERN PIKE STOCKING STRATEGIES IN MINNESOTA

Presenter -- Jerry Younk, Minnesota Department of Natural Resources

GOALS/OBJECTIVES:

Northern Pike
- To increase the diversity of recreational opportunities

Muskellunge
- To manage natural and introduced populations for a range of angling experiences (including trophy opportunities)
- To maintain genetic integrity of populations

OF WATERS STOCKED:

Northern Pike
- Not provided

Muskellunge
- Approximately 50

ANNUAL PROGRAM COST / FISH PRODUCTION:

Northern Pike
- Not provided

Muskellunge
- 30,000 to 40,000 fish per year (cap)

STOCKING DENSITY:

Northern Pike
- Not provided

Muskellunge
- Average 1 fish per littoral acre
- Range = 0.3 to 4 fish per littoral acre (depending on hatchery production and specific lake management plans)

STOCKING PERIODICITY:

Northern Pike
- Not provided

Muskellunge
- Annual to Biennial (Investigations are ongoing)

SIZE AT STOCKING:

Northern Pike
- Not provided

Muskellunge
- Approximately 11" average total length

REARING HISTORY:

Northern Pike
- Fry stocked into managed spawning marshes or winter rescue lakes

Muskellunge
- Variety of methods (trough with live feed, ponds with live feed, experimenting with dry diet in troughs)

CRITERIA FOR RECEIVING WATERS:

Northern Pike

SIZE:
- None stated

SPECIES COMPOSITION:
- None stated

TEMPERATURE:
- None stated

OTHER:
- Winterkill lakes
- Management reclamation efforts
- Maintenance stocking in areas with limited reproduction due to habitat degradation
- Limited use as predator on undesired fish

Muskellunge

SIZE:

- Area greater than 500 acres

SPECIES COMPOSITION:

- Appropriate forage species, including Coregonids, suckers, yellow perch, and in some cases bullheads

TEMPERATURE:

- Not indicated

OTHER:

- Demonstrated biological, social, and / or economic need
- Distribution of angling pressure
- Stocking may be reduced or eliminated if natural reproduction is demonstrated

SOURCE STOCK /GENETICS:

Northern Pike

- Not provided

Muskellunge

- Historically; Shoepack / Mantrap strain
- Present; Leech Lake / Mississippi strain

OTHER CONSIDERATIONS:

Northern Pike

- Lake management plans

Muskellunge

- Lake management plans

RESULTS OF STOCKING:

Northern Pike

- Spring gill net or trap net CPUE (specialized sampling) used in evaluation

Muskellunge

- Spring trap net (specialized sampling) primarily technique used in evaluation (CPUE, population estimates, growth)
- Fall electrofishing, creel survey, and angler diary programs are also used on a limited basis.

FACTORS LIMITING SUCCESS OF PROGRAM:

Northern Pike

- Size and diversity of resource can be overwhelming in some areas
- Population assessment methods need to be refined

Muskellunge

- Process of proposing lakes for stocking may be too informal
- Public concerns about impacts on fish communities (walleye) and lake property values
- Public concerns about northern pike spearing season closures with introduction of muskellunge
- Lack of information on muskellunge (hard to catch, small numbers of fish are sampled)
- Lack of information on critical habitat

SUGGESTIONS FOR IMPROVEMENT:

- Not provided

MUSKELLUNGE STOCKING STRATEGIES IN WISCONSIN, MICHIGAN, AND ONTARIO

Presenter -- Terry Margenau, Wisconsin Department of Natural Resources

GOALS/OBJECTIVES:

Michigan
- To preserve the natural range of native species
- To rehabilitate or establish populations where natural reproduction is likely
- To provide trophy fisheries

Wisconsin
- To provide trophy fisheries

Ontario
- To protect and rehabilitate muskellunge populations and habitats
- To provide quality angling opportunities
- To provide for trophy angling opportunities in selected waters
- All of above based on natural reproduction (no muskellunge culture or stocking program)

OF WATERS STOCKED:

Michigan
- 10 to 30

Wisconsin
- Greater than 500

Ontario
- None

ANNUAL PROGRAM COST / FISH PRODUCTION:

Michigan
- 1,000 to 30,000 fingerlings stocked annually

Wisconsin
- Approximately 150,000 large fingerlings produced annually
- Cost is approximately $500,000

Ontario
- $0 (No stocking program)

STOCKING DENSITY:

Michigan
- 2-4, 10" fish per acre *or* 1-2, 12" fish per acre
- To produce a density of 1 fish > 30" per five surface acres

Wisconsin
- Not provided

STOCKING PERIODICITY:

Michigan
- (Brood stock lake) As necessary to maintain population of 1 adult per acre
- (Non-brood stock lakes) 3 consecutive years, then alternate year stocking, depending on results of fall fingerling index sampling

Wisconsin
- Not provided

SIZE AT STOCKING:

Michigan
- 5-14" (variable)

Wisconsin
- Primary hatchery product is 9" to 12" fall fingerlings
- Some experimental production of spring yearlings (14") and fall yearlings (21")

REARING HISTORY:

Michigan
- Pellet-raised to 4", then pond raised on minnows
- Experimenting with intensive pellet culture

Wisconsin
- Pond-reared on forage fish

CRITERIA FOR RECEIVING WATERS:

SIZE:

Michigan
- 100-2,000 acres (but larger lakes may be considered)

Wisconsin
- None stated

SPECIES COMPOSITION:

Michigan
- Forage base should consist primarily of large, soft-rayed fishes (e.g., suckers and cisco)
- Muskellunge should not be stocked into lakes with healthy northern pike or largemouth bass populations
- Panfish control not a justification for stocking

Wisconsin
- None stated

TEMPERATURE:

Michigan
- None stated

Wisconsin
- None stated

OTHER:

Michigan
- Generally not stocked into highly eutrophic or heavily vegetated lakes
- Presence of spawning habitat (flooded wooded debris in 1-4' of water) if stocking is for purpose of re-establishing a self-sustaining population
- Light shoreline development
- Suitable for future evaluation

Wisconsin
- None stated

SOURCE STOCK /GENETICS:

Michigan
- State brood stock lake(s)
- "Great Lakes" muskellunge from Wisconsin
- "Northern" muskellunge are not stocked in "Great Lakes" muskellunge waters

Wisconsin
- Not provided

OTHER CONSIDERATIONS:

Michigan
- None stated

Wisconsin
- None stated

Ontario
- Can systems be sustained through natural recruitment levels?

RESULTS OF STOCKING:

Michigan
- Evaluation of stocking program based on Sern's fall fingerling index
- Target index value is 2-6 fall fingerlings per mile of shoreline
- Target survival of 10" stocked fish is 40% (year 1), 60% (year 2), and 70% (year 3) – Cumulative 15.8% alive after 3 years
- Results to date have been variable

Wisconsin
- 80% mortality of fall fingerlings, primarily resulting from predation

FACTORS LIMITING SUCCESS OF PROGRAM:

Michigan
- Past and present rearing capabilities have been inadequate to meet approved requests and recommended stocking criteria (produce about one-third of 80,000 fish requested)
- Most muskellunge are not stocked at the recommended size (10") or preferred time of year (late fall)
- Overharvest of stocked fish
- Competition with northern pike

Wisconsin
- Overharvest
- Poor survival of stocked fish
- Loss of quality habitat for early survival of stocked fish
- Competition with northern pike

SUGGESTIONS FOR IMPROVEMENT:

Michigan

- Renovate production facilities
- Shift emphasis from tiger muskellunge to pure muskellunge program

Wisconsin

- Focus on natural reproduction with state research efforts
- Consider "quality" of fish stocked (translating to survival) rather than quantity (#) of fish stocked
- Make decisions concerning appropriate uses of hatchery produced fish and appropriate density of muskellunge in Wisconsin lakes

HYBRID MUSKELLUNGE STOCKING CONSIDERATIONS IN COLORADO

Presenters -- Dave Neuswanger, Missouri Department of Conservation, and Keith Koupal, Colorado Division of Wildlife

GOALS/OBJECTIVES:

- To provide new and trophy angling opportunities and
- To control rough fish populations (white sucker and common carp) while
- Protecting the existing aquatic wildlife resource

OF WATERS STOCKED:

- 22

ANNUAL PROGRAM COST / FISH PRODUCTION:

- 38,000 fingerlings

STOCKING DENSITY:

- 5 fish per acre

STOCKING PERIODICITY:

- Annual or Biennial

SIZE AT STOCKING:

- 8"

REARING HISTORY:

- Not provided

CRITERIA FOR RECEIVING WATERS:

SIZE:

- None stated

SPECIES COMPOSITION:

- Abundance of white suckers and common carp
- No endangered species present

TEMPERATURE:

- None stated

OTHER:

- West slope versus east slope
- Escapement potential and flushing rates

SOURCE STOCK /GENETICS:

- Not provided

OTHER CONSIDERATIONS:

- None stated

RESULTS OF STOCKING:

- Observed decrease in percentage of total catch comprised of white suckers and common carp in four lakes over a five year period
- Survival rate following stocking is highly variable
- 4-6 years to reach harvestable size (30")
- Evaluation mainly from angler reports

FACTORS LIMITING SUCCESS OF PROGRAM:

- High temperatures in lower elevation reservoirs
- Need to obtain fry from out-of-state sources for fingerling rearing program

SUGGESTIONS FOR IMPROVEMENT:

- Determine factors influencing stocking success, including post-stocking mortality and predation
- Determine potential for and possible impacts of west slope hybrid muskellunge stocking
- Devise appropriate stocking strategies
- Develop post-stocking assessment system

SPECIAL TOPICS IN ESOCID STOCKING

PRODUCTION OF FUNCTIONAL SEX-REVERSED MALE MUSKELLUNGE

(Konrad Dabrowski, from Ohio State University, could not attend the meeting but provided several papers he had published related to specialized muskellunge production techniques)

Lin, F., and K. Dabrowski. 1996. Effects of sperm irradiation and heat shock on induction of gynogenesis in muskellunge (*Esox masquinongy*). Canadian Journal of Fisheries and Aquatic Sciences 53:2067-2075.

Lin, F., A. Ciereszko, and K. Dabrowski. 1996. Sperm production and cryopreservation in muskellunge after carp pituitary extract and human chorionic gonadotropin injection. The Progressive Fish-Culturist 58:32-37.

Lin, F., L. Liu, and K. Dabrowski. 1996. Characteristics of muskellunge spermatozoa I: ultrastructure of spermatozoa and biochemical composition of semen. Transactions of the American Fisheries Society 125:187-194.

Lin, F., and K. Dabrowski. XXXX. Induction of androgenesis by UV irradiation in muskellunge, *Esox masquinongy*. In preparation.

HATCHERY PRODUCTION OF MUSKELLUNGE ON DRY DIETS

(Martha Wolgamood, from the Michigan Department of Natural Resources, could not attend the meeting but provided copies of a paper describing recent research into production of muskellunge on dry diets)

Abstract:

A request for 50,000, 25.4 cm fall fingerling muskellunge for stocking in the state of Michigan has never been met by extensive production in earthen ponds. For this reason, the Fish Quality Lab, Michigan Department of Natural Resources (MDNR), has attempted to develop intensive culture techniques and find a pelleted diet that will produce a 25.4 cm muskellunge by October 1 with few or no deformities. Eggs were collected by MDNR field personnel and transferred to Wolf Lake Hatchery in April 1995. Feeding began on day 14 post-hatch, and muskellunge fry were reared on either the federal formulation of Atlantic Salmon Diet (ASD) or on a "musky-maker diet" (MM) from the Fish Technology Lab in Bozeman, Montana. Muskellunge raised on the MM diet regime had lower daily growth rates (0.15 cm/day versus 0.17 cm/day) and lower temperature unit growth rates (TUGR; 0.007 cm/temperature unit versus 0.008 cm/temperature unit) than fish raised on ASD. Muskellunge raised on ASD were stocked in September 1995 at an average total length of 20.7 cm, short of the goal of 25.4 cm. However, incidence of deformities was only 3.4%, much lower than the 28.2% incidence observed in 1994. In addition, the severity of deformities was much less extreme than in other years and for muskellunge raised on other diets. Additional improvements in rearing protocol – including changes in temperature regime, rearing density, prophylactic treatments, and date of egg take – should allow us to achieve our goal of producing a 25.4 cm muskellunge on dry diet for fall stocking.

THE ROLE OF GENETICS IN ESOCID STOCKING AND MANAGEMENT:

Presenter -- Marc Desjardins, Illinois Natural History Survey

I. Comparison of Techniques

Abstract:

Little comparative work has been done to assess the relative effectiveness of various molecular techniques to detect genetic variation among populations. The objective of this study was to investigate the utility of three molecular techniques (allozymes, Restriction Fragment Length Polymorphism (RFLP) analysis of mtDNA, and Random Amplified Polymorphic DNA (RAPD) analysis of genomic DNA) in assessing genetic variation in two related species, muskellunge (*Esox masquinongy*) and northern pike (*E. lucius*). Fifteen individuals were collected from each of four muskellunge and four northern pike populations distributed across a wide geographic area. Genetic variation was quantified by assaying the protein loci encoded in 32 enzyme systems, the mtDNA restriction sites generated by 18 restriction enzymes, and the RAPD bands amplified with 20 primers. For both species, a greater percentage of variable characters were revealed with allozymes, followed by RAPD analysis of genomic DNA, and then RFLP analysis of mtDNA. Genetic clustering of populations generated from the allozyme and RAPD analyses were in agreement for both species, indicating potential future use of RAPD's for population genetic analysis. Due to the almost unlimited number of RAPD primers available for population studies, the RAPD technique could be an important tool in the genetic assessment of species characterized by low genetic variability.

II. Population Surveys

Abstract:

Historically, fisheries have been managed as single panmictic units; however, it is more likely that fish species are composed of multiple genetically distinct groups. As a result, management programs should be designed to incorporate this concept of multiple stocks.

Although muskellunge (*Esox masquinongy*) possess morphological and genetic variation among populations, their stock structure remains unknown. Our goal was to investigate the relationship between population genetic structure of muskellunge and geographic distance using a sampling design based on watershed hierarchies. Protein electrophoresis and RFLP analysis of mitochondrial DNA were used to examine population genetic variation within and among watersheds of Minnesota and Wisconsin. Up to 30 individuals from 21 populations (18 populations from Minnesota and Wisconsin and 3 outgroup populations) were assessed for variation at four protein loci (*sIDHP-A**, *GPI-B**, *G3PDH-1**, and *PGDH-1**) and in the mtDNA using two restriction endonucleases (*Pst-I* and *Sca-I*). Both techniques were successful in detecting population structuring, however, only the allozyme analysis detected significant geographic patterning in the dispersal of the observed genetic variation. Furthermore, there was little congruence between the resulting mtDNA-based and allozyme-based dendrograms; correlation analyses also indicated the absence of a relationship between mtDNA-based and allozyme-based genetic distance matrices. These were combined to describe the genetic subdivision (stocks) among upper midwest populations of muskellunge.

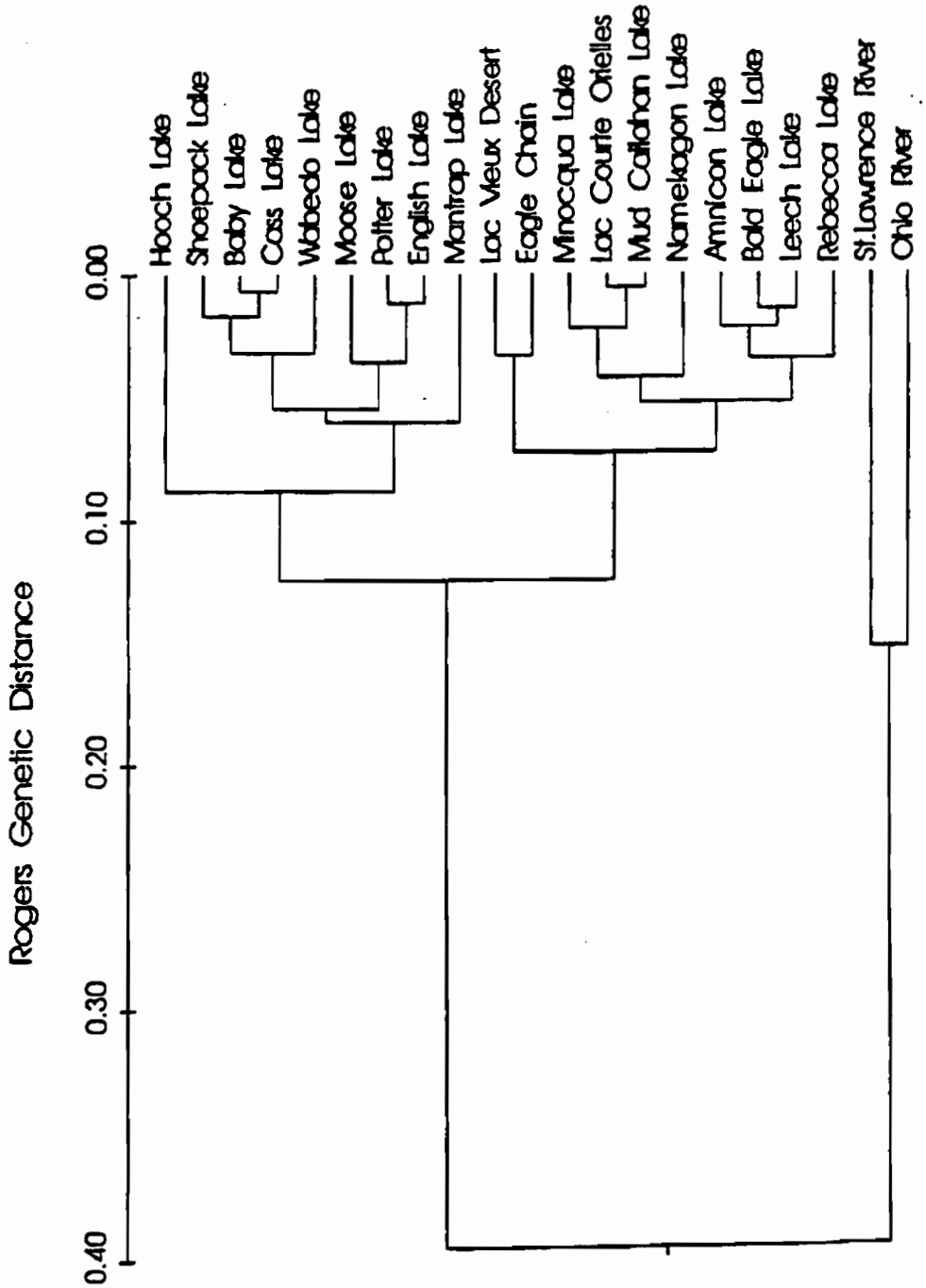

Figure 1. UPGMA phenogram generated from Rogers genetic distance matrix, based on allozyme analysis of muskellunge.

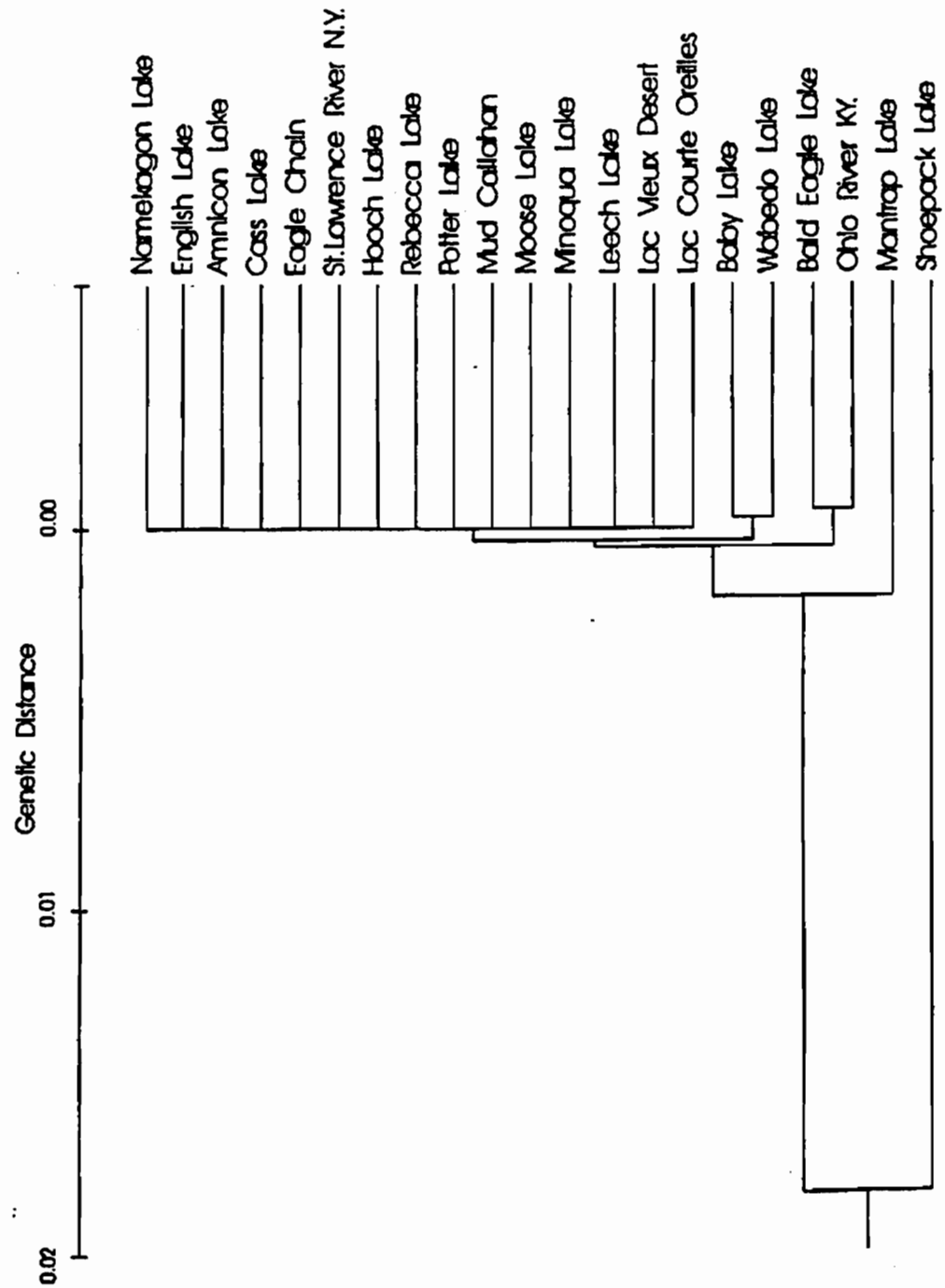

Figure 2. Dendrogram showing relatedness of muskellunge populations, based on mtDNA analysis.

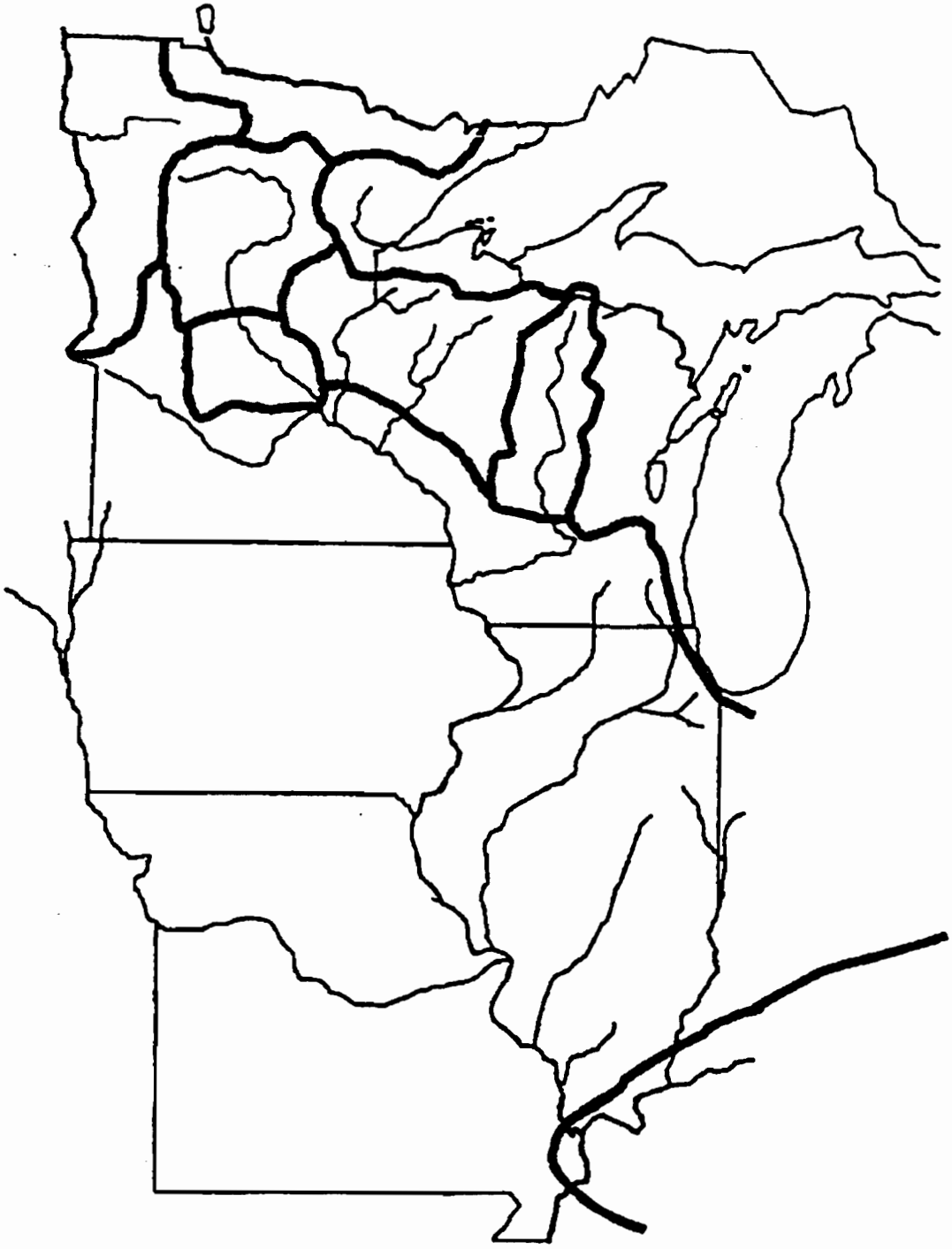

Figure 3. Proposed genetic stocks of muskellunge, based on both mtDNA and protein analysis. Not shown is the proposed stock based on the St. Lawrence strain.

THE APPROPRIATE ROLE OF STOCKING IN ESOCID MANAGEMENT – A ROUNDTABLE DISCUSSION

The discussion began by looking at the possible roles of esocids and esocid stocking in management. These included *enhancement, maintenance, supplemental, and introductory stocking*. We then began a discussion of additional considerations in stocking, including habitat, lake criteria, production capacity, genetics, and density. While we didn't have time to cover all of these topics, the items we were able to discuss generally fell into one of five basic areas – the need for stocking, community manipulations and potential impacts of esocids on other fish populations, criteria for stocking and evaluation, and research and management needs. Discussions within each of these areas are outlined below.

I. The Need for Stocking

- Should we stock esocids wherever they will survive and grow?
- Are the same stocking rates begun during periods of high exploitation (pre-"catch and release") needed at present?
- Are we teaching our children that fish come from hatcheries?
- Are hatcheries "monuments to our failure"?

II. Community Manipulations / Potential Impacts on Other Fisheries / Predation

- Influences of stocked esocids may be huge to non-existent, depending upon who you talk to.
- Influences may depend on complexity of fish community (i.e., 40+ lake classifications in MN). Do we have information to predict effects in all of these systems? Do results from one apply to another?
- It's probably hard to achieve high enough rates of predation to control stunting (i.e., panfish), although there may be evidence of control of overabundant small bass.
- Are fish stocked at high enough densities to exert control?
- Are we sending a mixed message to the public concerning the potential influences of stocked esocids?
- Are community manipulations more effective when there are already habitat limits on recruitment?
- Indirect effects – on species other than target, as well as behavioral effects – haven't been measured.
- We don't allow for compensatory mortality among prey populations when we stock predators, but we do when we look at predation by humans (i.e., fishing mortality).

- Effects of year classes often swamp manipulations / treatments

III. Criteria for Stocking / Stocking Rate Questions / Evaluation of Stocking

- Some type of objective process is necessary before stocking should take place.
- Some states have point systems and distinct criteria, but many don't.
- Use of esocids in "highly altered" versus "pristine" systems.
- Which criteria are specific to muskellunge? Esocids? Universal?
- Should we re-examine our standards concerning size and growth rate? Is a 20-year old, 30" fish necessarily a bad thing?
- Quality of experience and satisfaction may be defined simply by big fish potential. Size limits can change people's perception, as can "word of mouth".
- Should we be trying to meet our (biologist's) expectations or anglers?
- How would decreasing number of fish stocked but increasing quality (i.e., size) mesh with current hatchery objectives?

IV. Research Needs

- Conduct additional bioenergetic studies and model tests aimed at community manipulation by esocids
- Conduct side-by-side diet comparisons among esocid species
- Investigate potential for control of overabundant small bass
- Investigate indirect effects of esocid stocking
- Coordinate projects among states and provinces
- Obtain better information on what constitutes a "natural population" (historically or at present) or "good" recruitment, adult density, or year class strength
- Gather more information about how extreme muskellunge growth rate variation is driven by stocking rate, density, and prey abundance
- Gather more information on subtle effects of habitat degradation

V. Management needs

- Access to summaries (i.e., diet studies) and case histories
- Better ways to educate the public concerning quality of fishing experience (beyond pounds of fish)
- More information concerning the need for "supplementing" populations (i.e., What would happen if we quit stocking the 80% of Wisconsin lakes currently stocked?)
- Better ways of articulating goals and reasons for stocking
- More creel and angler surveys

ESOCID STOCKING IN NORTH AMERICA - A SUMMARY

In summarizing the workshop, Terry Margenau identified three basic stocking philosophies;

1 - Manage by natural recruitment (No stocking)

2 - Manage through a mixture of natural recruitment and stocking

3 - Manage entirely through stocking

While most people in attendance agreed that the first philosophy was the ideal to strive for, the third philosophy was most prevalent among the states represented (Figure 4). Several states in this category (e.g., Ohio) had a strict limit on the number of lakes that could be stocked and criteria to determine whether or not a lake could be included. This is the best situation and should be emulated by states involved in stocking esocids for management purposes. While there was some consensus within the group concerning the appropriate use of esocids in artificial systems, and concerning situations in which stocking was unnecessary, there was much debate about the question of supplemental stocking -- when it is appropriate and how many fish are necessary. This debate is reflected in our discussion of needs for additional research. In addition, specific goals, strategies and criteria for evaluation are needed. While 100% of the agencies represented indicated some type of angling quality or diversity goal (Figure 5), less than 30% had some specific "quantity" objectives by which to gauge progress. While many angling quality goals involved creation of "trophy" fisheries, 30" size limits in many states probably fall below what most muskellunge anglers would consider to be a real "trophy" fish (Dave Neuswanger, Missouri Department of Conservation, personal communication).

While only one state representative explicitly stated a goal of preserving genetic integrity, fisheries managers appear to be increasingly concerned with genetic integrity and the mixing of stocks of muskellunge when conducting management activities. A great deal of research has been conducted in the past 10 years, but we haven't reached the point where we are completely

implementing this knowledge. From seven state representatives providing information, only two indicated that their agencies were using broodstock solely from within the state borders. We still don't have definitive answers – for example, we still need to conduct tests of the fitness of identified stocks under different environmental conditions. Most people agreed that, for the present, we should take a conservative approach in making stocking and stock transfer decisions.

The number of waters stocked with muskellunge within each state or province ranged from zero to approximately 500; on average, about 10-15 lakes are managed for muskellunge by each agency represented. Number of fish produced ranges from 5,000 to 150,000, and cost of stocking programs ranged from $58,000 to $500,000. Cost estimates were only provided by four of the management agencies represented at the workshop. These estimates, along with estimates of cost:benefit ratios for culture programs, will be increasingly important and useful in gauging the relative success of different esocid stocking programs.

Stocking density ranged widely (from 0.3 to 10 fish per acre) among states and provinces involved in stocking esocids. Average stocking densities were about 1 fish per acre. Managers in Minnesota in some cases stock on a "per littoral acre" basis -- densities using this measure ranged from 0.3 to 4 muskellunge (per littoral acre). Almost all state agencies stocked on an annual basis, although a few were experimenting with biennial and triennial stocking. In a few additional states, stocking was labeled "sporadic", probably due to insufficient production of esocids in any given year.

Many different rearing procedures were used, but the most common product is a 6" to 12" fall fingerling. Most state agencies are moving towards rearing fish in ponds on various forage fish, although some are still experimenting with intensive, dry diet procedures. The use of spring yearlings is being experimented with in several states, and appears to have some real potential. Government fish production programs were initiated with the idea of stocking large numbers of fish. However, based on the presentations at this workshop, there seems to be good evidence that in many cases relatively few, "high-quality" fish can carry a fishery for many years. We now

have the technology to raise large numbers of fish -- we might do better to use this technology in producing a higher quality product (in terms of size).

Criteria used in deciding where and when fish are stocked are shown in Figure 6. The most frequently cited criteria was abundance (or overabundance) of forage fish in a given body of water. Many managers also have some criteria for geographic distribution of muskellunge fishing opportunities, either to provide equal coverage throughout the state or to locate muskellunge fisheries near human population centers. Other criteria not shown in Figure 6 included historic muskellunge growth rates in a given system, historic catch or effort, water quality, habitat considerations, or presence of endangered species. Only one state representative stated "need" (biological, social, or economic) as a criteria used in judging the advisability of stocking a given system.

Results and success of stocking programs were mixed, and it was hard to come up with a summary of stocking results. Some state and provincial agencies have good data concerning catch of adult muskellunge but little information on early life history of esocids stocked in their waters. The opposite is the case for other agencies. Lack of information was cited as one of the most important factors limiting the success of muskellunge stocking programs (Figure 7). Much of this lack of information stems from the fact that esocids are typically present at low densities, and as such are difficult to sample effectively. While this is the case, we probably have better data on muskellunge stocking than we have for many other species. This data provides us with a base from which to build, and should allow us to make better decisions when new management situations arise.

Factors identified as limiting the success of esocid stocking programs (in addition to lack of information) included insufficient production, poor survival following stocking, loss of habitat, and lack of justification and evaluation procedures (Figure 7). The importance of decision criteria for stocking was a recurring theme at this workshop, and most people in attendance agreed that some system of stocking criteria and evaluation procedures should be implemented by any state agency involved in stocking esocids for management purposes.

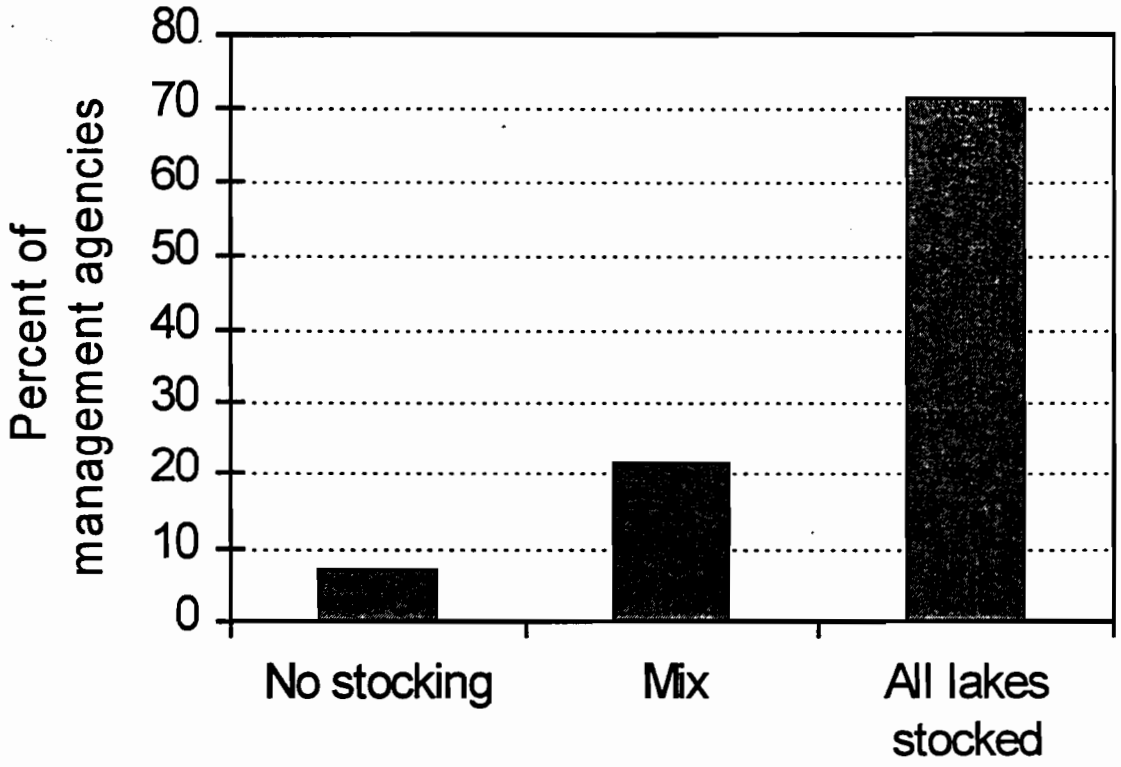

Figure 4. Prevalence of three stocking "philosophies" among states and provinces represented at the Esocid Technical Committee stocking workshop.

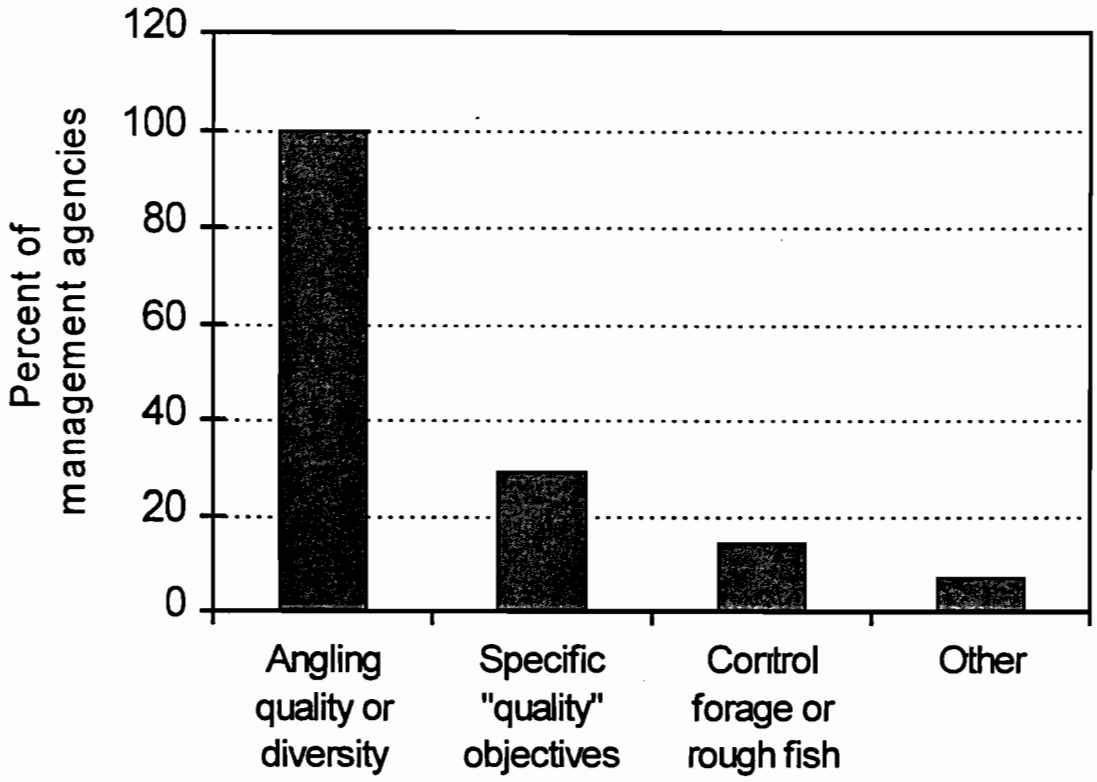

Figure 5. Goals of muskellunge stocking programs in states and provinces represented at the Esocid Technical Committee stocking workshop.

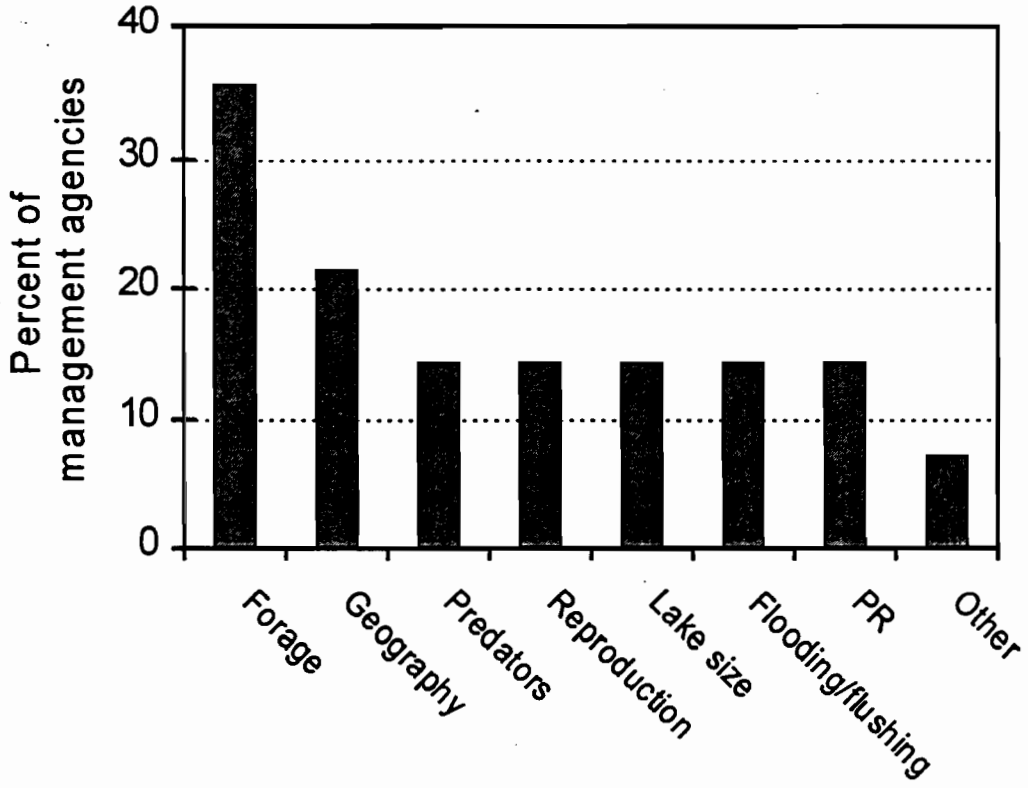

Figure 6. Criteria used by management agencies in evaluating water bodies for muskellunge stocking potential.

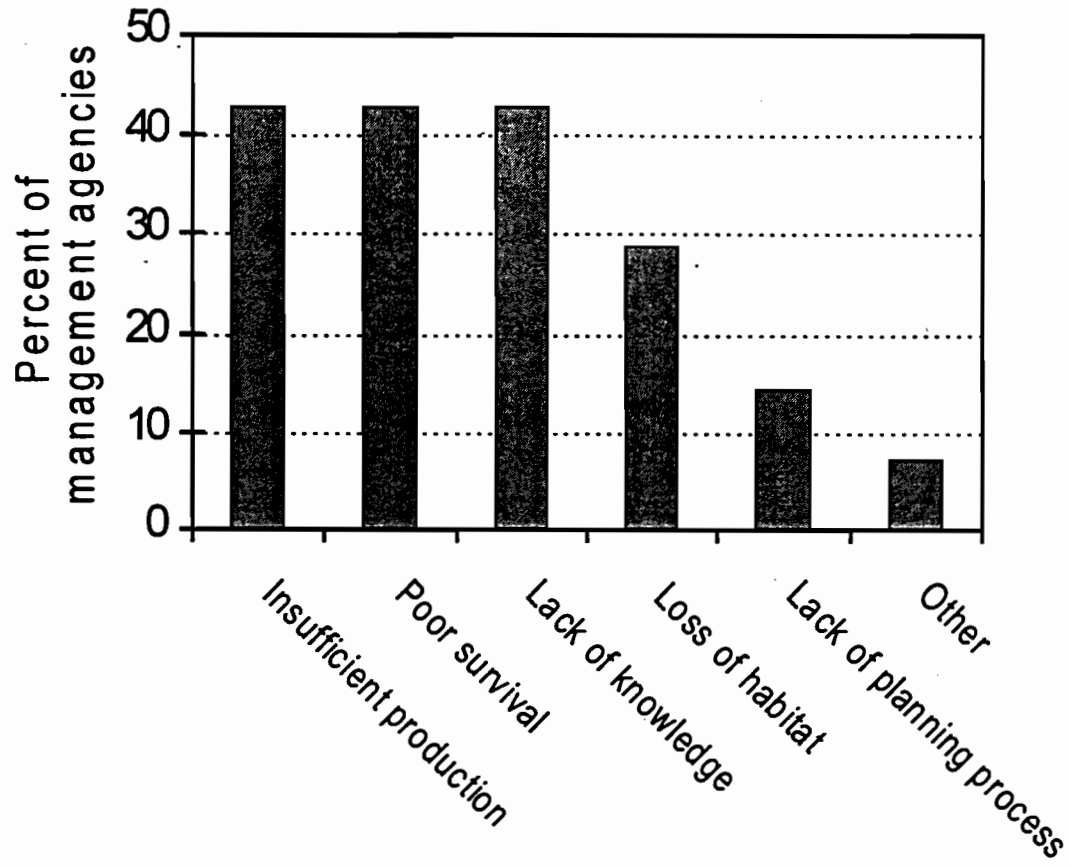

Figure 7. Factors identified by management agencies as limiting to the success of a muskellunge stocking program.

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