1974 INTERSTATE MUSKELLUNGE PRODUCTION

An informal survey of 1974 workshop participants showed 12 states producing muskellunge fingerlings. A total of about 283,000 pure muskellunge fingerlings were produced during 1974; an additional 117,500 tiger muskellunge (male northern pike X female muskellunge) were produced. Total pure muskellunge + tiger muskellunge production was about 410,500 fingerlings. A moderate but steady increase in total muskellunge fingerling production appears to be occurring over recent years. Tiger muskellunge fingerling production appears to be showing a more marked increase and now tiger muskellunge fingerling production represents nearly 29% of the total pure musky and tiger musky production. Increases in tiger musky production are surely related to the adaptability of this fish to a dry diet program. Increases in pure musky fingerling production are still limited by the continuing problem of providing a sufficient number and correct size of forage minnows. Some data from the 1974 workshop indicates that the pure muskellunge may yet be adapted to a dry diet program.

Individual state production figures are listed below. Some 1973 production figures had to be used and perhaps the listing contains minor mistakes due to the way in which the information was gathered. The listing is only presented here for providing background information on general production figures and for general trends. Some states listed have only recently begun producing musky fingerlings and at least two states present at the meeting indicated they also would soon be producing musky fingerlings.

FINGERLINGS PRODUCED

STATE	PURE MUSKELLUNGE		TIGER MUSKELLUNGE	
Iowa*	2,000	Fingerlings	---	
Kentucky	12,500	5" - 8"	---	
Michigan	1,255	8" - 10"	28,600	8" - 10"
Minnesota (1973)	26,500	8" - 12"	---	
New York	18,000	6"+	5,100	6" - 12"
North Carolina	1,700	6"	1,900	5.5"
Ohio	10,400	Fingerlings	450	
	7,450	Advanced fingerlings		
Pennsylvania	61,500	6" - 12"	81,500	6" - 12"
Tennessee*	Fewer than 1,000		---	
Virginia	18,000	Fingerlings	---	
West Virginia	1,900	5" - 8"	---	
	(9,000 in 1973 according to SFI report)			
Wisconsin	121,000		---	
Total	About 283,000		About 117,500	
GRAND TOTAL	410,500			

* According to Sport Fishing Institute records supplied by Carl Sullivan of SFI.

R.B.

SIXTH INTERSTATE MUSKELLUNGE WORKSHOP

Held At

MOREHEAD, KENTUCKY

September 25-26, 1974

MINUTES OF MUSKY WORKSHOP STEERING COMMITTEE CO-CHAIRMEN MEETING

SEPTEMBER 26, 1974

I. This year's workshop theme of muskellunge and other cool water fishes was discussed. It was apparent from the results of the vote of all workshop participants, requested by chairman Trandahl on the morning of the 26th, that the inclusion of papers on other cool water fishes was quite popular. There was also a strong desire expressed by many to retain the traditional musky only theme. It was the consensus of the co-chairmen that the traditional musky theme should be retained and when pertinent information on other cool water fishes, which is applicable to musky management, become available, a limited amount of this information could also be presented. If the title of the musky workshop were changed to include all cool water fishes, it is believed that muskellunge management would be rapidly diluted by the rapidly expanding bass-walleye groups.

II. Another feature of this year's workshop, the abstracts required of each speaker, was also discussed. Again, the general consensus of the co-chairmen was that this requirement was beneficial to audience understanding and will certainly be valuable in preparing the workshop minutes. Some criticism was expressed that the abstract requirement made the 1974 session too formal. The co-chairmen, to the contrary, felt that the abstract would help maintain the workshop's high professional standards and would thus attract more top administration, field and hatchery personnel nationwide.

III. Because of the relatively high interest in other cool water fishes, (namely walleyes), it was decided that a walleye workshop should be planned for 1975. The content of this workshop would include artificial diet work with walleyes and any new survival information that may be available by then.

Arden Trandahl (or one of the Bureau's biologists working out of the Minneapolis office) would be program chairman for this workshop.

The Bureau's La Crosse, Wisconsin, facility was offered as a tentative site for this workshop.

IV. The year 1976 and State of Pennsylvania were tentatively approved as the date and location of the next Interstate Musky Workshop. The co-chairmen agreed that the every-other-year scheduling of the workshop seems to work out best.

V. The final recommendation of the group was to incorporate the minutes of this co-chairmen meeting in the minutes of the 1974 workshop.

CO-CHAIRMEN

Arden Trandahl, U.S. Fish and Wildlife Service	John Klingbiel, Wisconsin
Shyrl Hood, Pennsylvania	John Schrouder, Michigan

List of Participants
INTERSTATE MUSKELLUNGE WORKSHOP

GEORGIA

Kim Primmer
Georgia Department of Natural Resources
Calhoun, Georgia

Harry E. Hottell
Georgia Cooperative Fish Unit
School of Forestry
University of Georgia
Athens, Georgia 30602

INDIANA

Gary Hudson
Indiana Department of Natural Resources
607 State Office Building
Indianapolis, Indiana 46204

William D. James
Indiana Department of Natural Resources
607 State Office Building
Indianapolis, Indiana 46204

Steven Huffaker
Cikana Fish Hatchery
Route 4
Martinsville, Indiana 46151

IOWA

Wallace D. Jorgenson
Spirit Lake Fish Hatchery
Spirit Lake, Iowa 51360

Vernon Spykerman
Big Spring Hatchery
Elkader, Iowa 52043

KENTUCKY

Charles Bowers
Pete Pfeiffer
James R. Charles
James R. Axon
Charles Gorham

Kentucky Department of Fish and Wildlife
Capital Plaza Tower
Frankfort, Kentucky 40601

Dan Brewer
Mike Hearn
Al Surmont

Minor Clark Fish Hatchery
Route 4
Morehead, Kentucky 40351

Bernie Carter
204 Montgomery Drive
Frankfort, Kentucky 40601

MICHIGAN

John Schrouder
Fisheries Division
Michigan Department of Natural Resources
Stevens T. Mason Building
Lansing, Michigan 48926

MINNESOTA

Stan Daley
Minnesota Section of Fisheries
390 Centennial Building
St. Paul, Minnesota 55105

Richard L. Trombley
Department of Natural Resources
Section of Fisheries
Area Fisheries Headquarters
Stacey, Minnesota 55079

NEW YORK

Richard T. Colesante
New York State Conservation Department
Debruce Fisheries Lab
Livingston Manor, New York

Norman B. Youmans
New York State Environmental Department
Mayville, New York 14757

NORTH CAROLINA

Mike Quick
North Carolina Wildlife Resources Comm.
Route 6, Box 685
Marion, North Carolina 28752

Lawrence L. Kearson
North Carolina Wildlife Resources Comm.
Route 6, Box 685
Marion, North Carolina 28752

Leroy Beck
North Carolina Wildlife Resources Commission
Route 5, Box 348
Morgantown, North Carolina 28655

OHIO

Ray Riethmiller
Ohio Division of Wildlife
1500 Dublin Road
Columbus, Ohio 43212

Tom Goettke
Ohio Division of Wildlife
1500 Dublin Road
Columbus, Ohio 43212

Tim Nagel
Ohio Division of Wildlife
2470 Roberts Mill Road
London, Ohio 43140

Jim Gall
Ohio Division of Wildlife
360 East State Street
Athens, Ohio 45701

PENNSYLVANIA

Del Graff
Pennsylvania Fish Commission
Box 70, R.D. 1
Bellefonte, Pennsylvania 16823

Shyrl Hood
Pennsylvania Fish Commission
Box 127
Linesville, Pennsylvania 16424

Tom Clark
Pennsylvania Fish Commission
Linesville Fish Cultural Station
Linesville, Pennsylvania 16424

Charles Sanderson
Pleasant Mount Fish Cultural Station
Pleasant Mount, Pennsylvania 18453

SPORT FISHING INSTITUTE

Carl R. Sullivan
Executive Secretary
Sport Fishing Institute
608 13th Street
Washington, D.C. 20005

TENNESSEE

Danny G. Scott
Tennessee Wildlife Resources Agency
Russellville, Tennessee

TEXAS

Bill Rutledge
Texas Parks and Wildlife Department
Junction Star Route, Box 62
Ingram, Texas 78025

U.S. FISH AND WILDLIFE SERVICE

Arden Trandahl
Fish and Wildlife Service
Federal Building, Fort Snelling
Twin Cities, Minnesota 55111

Joe Webster
Fish and Wildlife Service
Federal Building, Fort Snelling
Twin Cities, Minnesota 55111

Ray Phillips
National Fish Hatchery
Valley City, North Dakota

Dave Ostergaard
National Fish Hatchery
Genoa, Wisconsin 53711

John Hawkinson
National Fish Hatchery
Senecaville, Ohio 43780

Mayo Martin
Fish Farming Experiment Station
Box 860
Stuttgart, Arkansas

George Hanson
U.S. Fish and Wildlife Service
Elkins, West Virginia

John W. Quam
Hatchery Manager
Frankfort National Fish Hatchery
Frankfort, Kentucky

Chuck Stearns
Fish and Wildlife Service
17 Executive Park Drive, Northeast
Atlanta, Georgia 30329

Fred A. Downs
National Fish Hatchery
Tupelo, Mississippi

John Breland
National Fish Hatchery
Carbon Hill, Alabama 35549

O. L. Green
Southeast Cultural Laboratory
Route 3
Marion, Alabama

Chuck Hockstetler
National Fish Hatchery
Senecaville, Ohio 43780

Doug Baumgartner
National Fish Hatchery
Frankfort, Kentucky

Charlie Wright
National Fish Hatchery
Frankfort, Kentucky

VIRGINIA

Joe Gray
Route 4, Box 194
Boonesboro Road
Lynchburg, Virginia 24503

Carl Ramsey
Virginia Commission of Game and
Inland Fisheries

Stuart Currin
Virginia Commission of Game and
Inland Fisheries
Sugar Grove, Virginia 24375

Robert Brooks
Fort Valley Route
Strasburg, Virginia 22657

Virginia (cont.)

William E. Neal
Farfields Drive
Lynchburg, Virginia

C. Odell Whisman
P.O. Box 32
Sugar Grove, Virginia 24375

WEST VIRGINIA

Bob Miles
West Virginia Department
of Natural Resources
Route 2
Belleville, West Virginia 26133

Robert D. Ross
West Virginia Department
of Natural Resources
Charleston, West Virginia 25305

Neil Stalnaker
Palestine Fish Hatchery
Elizabeth, West Virginia 26143

WISCONSIN

John H. Klingbiel
Wisconsin Department of
Natural Resources
Madison, Wisconsin 53701

Dr. David Stuiber
Department of Food Science
University of Wisconsin
Madison, Wisconsin 53706

Chuck Gahler
Wisconsin Department of
Natural Resources
Woodruff, Wisconsin 54568

Leon Johnson
Wisconsin Department of
Natural Resources
P.O. Box 309
Spooner, Wisconsin 54801

Kenneth Walker
Wisconsin Department of Natural Resources
Spooner, Wisconsin 54801

WELCOME:

Remarks by Charles Bowers, Director, Kentucky Division of Fisheries.

INTRODUCTION:

By Dan Brewer, Kentucky Division of Fisheries.

JOHN SCHROUDER, Michigan, Program Chairman:

Commented that this year's workshop would be somewhat different from those held in the past (1967, 1969, 1970, 1971, 1972). This year's theme would be altered somewhat to include presentations on other "coolwater" fishes such as walleye, sauger and northern pike. This somewhat expanded workshop was a "trial balloon" to test the degree of interest in the other "coolwater" fishes. It was also noted that for the first time informal abstracts of presentations were required primarily in the interest of supplying the new information immediately to the participants.

A show of hands revealed that 30 percent of the participants were "supervisory personnel" (supervise hatchery and field managements operations); 48 percent were hatchery biologists or hatchery technicians; 12 percent were "research biologists"; and 10 percent were "field management biologists".

WORKSHOP PROGRAM

September 25, 1974

WELCOME - Charles C. Bowers, Jr., Kentucky, Director of Division of Fisheries.

INTRODUCTIONS - Dan Brewer, Kentucky

GENERAL PROGRAM CHAIRMAN: JOHN SCHROUDER, MICHIGAN

MORNING CHAIRMAN: SHYRL HOOD, PENNSYLVANIA

A. Artificial Diets

1. 1974 Dry Diet Trials - Valley City, North Dakota, National Fish Hatchery (R. Phillips).

2. Artificial Diets for Esocids and Walleye Culture - Pennsylvania. (C.H. Sanderson).
   Tiger Muskellunge Culture, Artificial Diet - Concrete Rearing Units (C.H. Sanderson).

3. Summary of Attempts to Raise Walleye Fry and Fingerlings on Artificial Diets, With Suggestions on Needed Research and Procedures to be used in Future Tests - Michigan (J. Schrouder).

   Dry Diet Test Results on Walleye Fry and Fingerlings (J. Schrouder).

4. Formulated Dry Diet Feeding - 1974 - USFWS (A. Trandahl).

B. Forage

1. Musky Production in Kentucky Hatchery Ponds Using Various Musky Fry Stocking Rates and Adding Fathead Minnows as Supplemental Forage - Kentucky (D. Brewer).

2. Muskellunge Forage - Minnesota (S. Daley).

3. Forage Production in Municipal Waste Water Treatment Lagoons - Michigan (J. Schrouder).

4. Minnow Forage Supplied by a Waste Treatment Lagoon - Ohio (J. Gall).

C. Survival

1. Muskellunge Survival in Wisconsin Lakes - Wisconsin (L. Johnson).

2. Summary of 1974 Muskellunge Fry Studies in New York State - New York (R. Colesante).

AFTERNOON CHAIRMAN: JOHN KLINGBIEL, WISCONSIN

D. Nursery Ponds

1. Muskellunge Nursery Ponds in Pennsylvania - Pennsylvania (T.L. Clark).

2. Report of Muskellunge Management in Minnesota - 1973 - Minnesota (S. Daley).

E. Disease

1. A Summary of Disease and Treatments Administered in the Cool Water Diet Testing Program - Michigan (J. Schrouder).

2. Gill Rot of Pike - USFWS (J. Webster).

F. Broodstocks

1. Muskellunge Fry Production by Pond Spawning - Kentucky (M. Hearn).

2. A Domestic Muskellunge Broodstock - USFWS (R. Phillips).

September 26, 1974

MORNING CHAIRMAN: ARDEN TRANDAHL, USFWS

G. Intensive Culture

1. Intensive Culture of Muskellunge in Pennsylvania - Pennsylvania (T.L. Clark)

H. New Pertinent Studies

1. Collecting, Spawning, Incubation and Shipping of Sauger Eggs - USFWS (D. Ostergaard).

2. Sauger Fingerling Production at the Senecaville NFH - USFWS (J. Hawkinson).

3. Northern Pike Fry Mortalities Attributed to P.C.B.'s - Michigan (J. Schrouder)

   Walleye Fry Feeding with Infusoria (J. Schrouder).

4. Feeding of Smallmouth Bass on Formulated Diet - USFWS (C. Hockstetler).

5. Raising Yellow Perch and Walleye Pike for Human Food Use - University of Wisconsin (Dr. D. Stuiber).

I. General Discussion

Additional Information Submitted but not Presented

1. Use of Tannic Acid to Reduce Adhesiveness of Walleye Eggs - Pennsylvania (T.L. Clark).

2. Hatchery Design - Kentucky (D. Brewer).

3. Propagation of Muskellunge in Virginia During 1963 Through 1974 - Virginia (J. Gray).

4. Summary of 1974 Interstate Muskellunge Production - Kentucky (D. Brewer).

1974 Dry Diet Trials

By: Ray Phillips
National Fish Hatchery
Valley City, North Dakota

I. Introduction

A. Species of fish used for testing include NOP, WAE & Musky.
B. 296 NOP which remained from 1973 Dry Diet Trial were used in 1974. They averaged 8.15/lb.
C. 41 WAE at 12.06/lb. from 1973 trials were used in 1974.
D. Walleye from production ponds running 3950, 1850, & 1520/lb. were also used in trials.
E. 145 Muskies which had been raised to 1" in intensive culture with brine shrimp, plankton & sucker fry were used from 1" on with dry diets.

II. Diets

A. W-7 Spearfish Diet used in all trials.
B. A highly fortified diet with an increased vitamin pack was used in the latter stages of the NOP & Musky trials.

III. Troughs & Tank Used

A. Circular tanks 2 at 5' diameters (34 cu. ft.) with 4gpm H_2O used for NOP. 1 - 4' diameter tank (22 cu. ft.) with 2 gpm H_2O for NOP, and later Musky.
B. 10' x 20" x 8" deep aluminum troughs (11.1 cu. ft.) used for walleye with 8-9 gpm H_2O.
C. 10' x 20" x 8" aluminum troughs for Musky with 3-4 gpm H_2O.
D. Concrete tanks (20" pipe) = 85.9 cu. ft.

IV. Feeders

A. Clock type feeders with windshield wire blades & electronic Nielson controls used for walleye & musky.
B. NOP hand fed until feeder was formulated from a wood bit & electric can opener.

V. Feeding

A. Northern Pike fed 3% of body weight 3/16" pellets by hand 3 times/day. Automatic feeder formulated was used with a timer to feed once per hour/ 12 times daily.
B. Carryover Walleye fed 4.5% body weight with #4 crumbles after pellets had been refused. Tank had to be covered and feed moving for fish to feed.
C. SM Walleye fed plankton and then #2 dry diet crumbles later #3 crumbles used. .6 lb. fish cu. ft./H_2O. Later reduced to .3 lb. cu. ft./H_2O. Fed 24 hours a day with clock feeder.
D. 1" Musky Confined to 1 cu. ft. of H_2O and fed #2 crumbles-first week fed 165% body weight; after 2 weeks feed reduced to 50% body weight; after 4 weeks 20% body weight; after 8 weeks 10% body weight. Clock type feeder used all the time. When fish reached 1.5 grams in weight they became very nervous and refused to feed. Fish oriented themselves in clusters and were very nervous. Crumbles would be followed downward and caught before they reached the tank's bottom. Fish were moved to the 26" deep, 4' diameter tank where they fed well, were less nervous and re-oriented themselves in H_2O flow pattern.

VI. Care

A. Troughs cleaned daily (3 times/day for small walleye).
B. Musky troughs needed to be cleaned several times/day because of the excess feed fed.
C. Every 4th day fish were removed from tanks and troughs and these units were scrubbed with either Hyamine 3500 or a detergent.
D. Mortality rates were less if units were cleaned more than once.

VII. Chemical Treatments

A. Hyamine 3500 at 1-2 ppm/hr. was used every 4th day (because of bacterial gill disease problems in 1973).
B. Formalin at 1:6000/hr. used for external parasites.
C. Acriflavin at 5 ppm used for fin rot.
D. H_2O temps. ranging from 81 - 84°F, when coupled with Hyamine 3500, 2 ppm treatments were given to WAE which showed stress signs within 20 minutes. The chemical was flushed out. However, the fish turned dark in color and became listless and died in one hour.
E. WAE treated at 1ppm Hyamine and 85°F died 6 hours after treating. No problems when using the same treatment on Musky, Northern and Smallmouth Bass.
F. 69% of NOP treated with 1:6000 Formalin in the morning & 2 ppm Hyamine in the late afternoon died.
G. No pathogens found on the fish by Bozeman Fish Cultural Development Center. They recommended that we treat with Terramycin in food at 4 gms/100 lbs. fish per day for 10 days. This reduced fish death rates but did not stop it entirely.
H. Several weeks later the NOP developed a spinal curvature, constriction of caudal area plus hemorrhaging by the caudal area. A fortified diet was fed. This increased the growth rate and curbed mortality.

VIII. Mortality

A. 92 NOP remained from the original 296. Half were lost because of faulty tank covers and most of the remaining fish were lost after disease treatments.
B. WAE- Almost all of the fish were lost after treatments.
C. MUE- 60 remained from 145. Most of the fish were lost when water pressure was increased to the tank, gill covers were ripped off with the increased H_2O pressure.

IX. Results and Conclusions

A. NOP - Feed conversions from 2.9 - 6.0 on W-7 Diet.
   2.63 on highly fortified diet.
B. WAE - Small fingerlings feed conversion 1.0 - 1.67
C. MUE - Conversion 4.6 for 54 days on W-7 Diet
   2.0 conversion of fortified diet.
D. Chemical treatments need to be rearranged with high H_2O temperatures.
E. Visitors should be kept from trial area.
F. Walleye require much attention during first weeks of feeding trial.
G. Northern pike in circular tank requires as little as 1 hour per day if automatic feeders are working. This includes weighing fish, treatments, tank cleaning, daily checks and food measurement. Hand feeding would increase time spent up to 2 hours/day.

-COMMENTS AND QUESTIONS -

<u>1974 Dry Diet Trials</u> by Ray Phillips, USFWS

Much of the work involved was done by Dale Bast, Moorhead State University (Minnesota) under the Work-Study Program.

The northern pike and the larger walleyes used in the study were fed a dry diet during May - September, 1973 and were overwintered in 1973-74 on forage minnows.

The highly fortified diet referred to contained a double vitamin-pack content.

The water supplied to the circular tanks was jetted in under pressure.

Musky were reared in aluminum troughs to a size of one inch on a diet of brine shrimp to graded plankton to ungraded plankton to sucker fry back to plankton and then to dry diet.

Many of the northern pike were lost when the northerns jumped from the tank during automatic feeding. An improved cover made of 1/4 inch hardware cloth reduced such losses.

<u>Lanier Green</u> (USFWS)

Were there problems involved with the changeover from pond rearing to artificial feeding?

<u>Phillips</u>

Small walleye from the ponds did not convert directly to dry feed so well. When small walleye were fed plankton first then dry feed the results were better.

The musky which had been fed plankton converted over to the dry diet in about three days.

<u>Tom Clark</u> (Pennsylvania)

Was the water velocity into the circular tanks sufficient to carry unused [redacted] food, fecal matter, etc. down the center drain or was it necessary to clean by pulling the drain?

<u>Phillips</u>

As the northern pike were fed 3/16" pellets there was a problem with clogged holes at the bottom; to remedy this we made larger openings in the drain. Otherwise the tanks were fairly well self cleaning and saved lots of time.

<u>Carl Sullivan</u> (SFI)

You said the tanks were cleaned every four days and the fish were removed. How were they removed?

Phillips
They were dipped out and quickly put into another tank.

Shyrl Hood (Pennsylvania)
Did such moving disturb feeding?

Phillips
Just for a short time, then they were right back feeding as before.

Tom Clark (Pennsylvania)
Were your walleyes kept under total darkness?

Phillips
We covered 3/4ths of the tank.

Carl Sullivan (SFI)
You said some of your fish were fed 3% of body weight three times a day. Was this 3% a day or 3% per feeding?

Phillips
3% per day.

Artificial Diets for Esocids and Walleye Culture

By: Charles H. Sanderson
Fisheries Technician II
(Diet Coordinator)

During the past several years Pennsylvania has been conducting dry diet testing programs in co-operation with other state and federal fishery agencies. The results from these tests provided enough favorable information to encourage us to initiate full production programs on artificial diets. Programs designed to produce maximum numbers of tiger muskellunge, walleye and northern pike were initiated in 1974. The results of the 1973 diet testing program indicated that we could expect good results with tiger muskellunge on dry feed and moderate success with walleye and northern pike. The results with pure muskellunge revealed limited success and should be continued on an experimental basis only in 1974.

Diet

One diet formulated at Spearfish Diet Testing Center, South Dakota, under the direction of Leo Orme, referred to as the W7 diet was used in all programs. Feed sizes required for fingerling from 1 1/2" to 8"-9" included #3 and #4 crumbles, 3/32", 1/8", 5/32" and 3/16" pellets. It appears that feed sizes smaller than #3 crumbles are not required to start 1 1/2" fingerling. However, future programs will possibly be designed to start smaller fish on dry feed and will require feed in starter sizes. The crumble and pellet consistency could be termed very soft by most standards. This posed minor problems due to the fine particles, as a result of crumbling. We found it necessary to screen the feed, as the fine particles sometimes plugged the holes in the feeders. The "soft" consistency appears to be very desirable, as the fish seem more willing to accept a soft feed than a hard pellet.

Feeding Procedures

Tiger muskellunge, muskellunge and northern pike were reared on brine shrimp and daphnia to approximately 1.5". Supplemental feeding of shrimp or daphnia during the initial day or two on dry feed appears to be beneficial. Several days are required before the majority of fish are accepting the artificial diet. Individuals that do not accept the diet immediately, benefit from supplemental live feed and many will accept the dry diet after being exposed to it for several days.

Walleye are stocked in nursery ponds as fry and removed at 1 1/2" - 2" in length.

Automatic feeders and electronic timers were used on all rearing units. Feeding schedules are started feeding every five (5) minutes for a fifteen (15) second duration, twenty-four (24) hours a day. This schedule was maintained until all fish in a particular lot had been trained to accept the dry diet. In many instances this schedule was maintained throughout the entire rearing period. Changes in feeding schedules and feed amounts may be made as required, i.e., fish size, density, species, etc.

Rearing Units

During the training period all fingerling are crowded into a small area directly under the feeders until they have been converted to the artificial diet.

Crowding devices may be removed or extended as fish densities increase. There appears to be a definite advantage in using dark tank covers, especially on walleye units. These darkened areas provide a secluded area that attracts most of the fish and minimizes disturbances from outside activities. Locating the feeders just outside the covered area works well, as the fish can feed at will and return to the darkened area.

Training tigers in small confined tank type units, then transferring into outside concrete type rearing units produced good results. The concrete type rearing units were partially covered to provide a secluded area, with the feeders located just outside the covered area. The tigers took several days to adapt to this situation, but were soon feeding well on pelleted feed and growth rate was better than fish reared inside in a more confined area. Feed conversions were very good in two lots reared in raceway type units, with conversions of 1.71 and 1.55 recorded. During the initial training period, it is necessary to waste feed to assure adequate amounts of feed available at frequent intervals. After training has been accomplished good feed conversion may be expected with proper feeding schedules. There is no evidence of preference related to unit color. Tanks painted black did not result in any better results than light aluminum colored units.

Tanks were cleaned daily to remove feed waste and fecal material. Flow rates were regulated to provide approximately two (2) exchanges per hour.

Temperatures varied from station to station with a low of 58° F. at one station, to highs of 75° - 80° F. We attempted to maintain water temperatures between 68° F. - 70° F., if possible. This appears to be ideal for good growth rate and is not as difficult to maintain desirable dissolved oxygen levels as the higher temperatures. The fish (tigers) did well in 58° F. water but growth rate was significantly retarded.

Rearing Techniques

It is of utmost importance to have healthy fish to start a dry diet program. Any condition that puts added stress on the fish such as parasites or disease problems will make it difficult to achieve maximum acceptance of dry feed. Feeding frequencies are very important during the transition from live feed to dry feed. The fish should be exposed to feed at very frequent intervals until the acceptance of feed has been established. The five minute intervals used in this years program accomplished this very well.

Cannibalism can be controlled by frequent grading during the initial feeding period. There is little evidence of cannibalism after the feeders and non-feeders have been separated. Uneven growth patterns do not necessarily create cannibalism, if all fish are accepting the dry diet and sufficient amounts of feed are available at frequent intervals.

Tiger muskellunge have been successfully converted from a minnow diet to pelleted feed. One reports 64% acceptance converting 4.5" tigers; another relates 87% success with 3" tigers. Pelleted feed and minnows were fed to one lot on alternate days, with good acceptance of dry feed under this condition.

Disease Problems and Controls

The major problems encountered during the 1974 artificial diet program have been disease or parasite related. A wide range of treatments have been used in an attempt to control these outbreaks. While the effectiveness of these treatments cannot always be positively verified, we feel that they have been effective in preventing mass mortalities. Quite a bit of effort has been concentrated to try and establish effective treatments to control parasite and bacterial disease problems in walleye. Trichodina and Schyphidia have been controlled, treating with Postassium Permanganate, 5 ppm, 30 minutes flow treatment. Columnaris bacteria and Saprolegnia fungus were controlled treating with Diquat (35% active) 16ppm for 60 minutes flow treatment. Hyamine 3500 was also used on walleye. Tiger muskellunge, muskellunge and northern pike have been treated with Formalin, Formalin-Malachite Green combination, Hyamine 3500, Roccal and Diquat. One advantage to feeding dry feed to these species is the ability to administer antibiotic fortified feed for the treatment of internal bacterial problems. Terramycin fortified feed has been used on tigers with good results when this type treatment was necessary.

Advantages Rearing Predator Fish on Artificial Diets

The results of a full scale production program on artificial diets have conclusively substantiated that tiger muskellunge can be produced in large numbers on dry feed. The acceptable results with northern pike and walleye are substantial enough to indicate that desired numbers of these species may also be produced on artificial diets. Limited success with pure muskellunge indicate that they will accept dry feed and acceptable growth rates can be expected. Future dry diet production programs will likely include pure muskellunge.

The accomplishments in 1974 pave the way for dramatic changes in the whole concept of producing these species at full production levels. Hatchery capabilities and production levels will increase greatly, economic advantages are obvious considering the manpower and water area required to produce these species on live forage fish. Feed conversions compare favorably with any species of fish being produced on dry feed. As rearing techniques and diets continue to improve, it would be reasonable to expect that future production programs for esocids and walleye will not include a forage program.

Combined Results at Six Fish Cultural Stations Feeding Artificial Diets

Species	No. Fish Start	Size Start	No. Fish Finish	Size Range Finish	Weight Fish	% Survival
Muskellunge	2,832	1"-1.5"	278	6"	11#	9.8%
Tiger Muskellunge	104,525	1.2"-4"	71,214	5.5"-8"	3,419 #	68.13%
Northern Pike	10,000	1.14"	1,525	6"	68#	15.25%
Walleye	21,000	1.5"	6,740	4"-5"	202 #	32%
Totals all Species	138,357		79,757		3,700	57.6

Total Amount Feed	9,100 lbs.
Pounds Fish Produced	3,700
Conversion	2.46

- COMMENTS AND QUESTIONS -

Artificial Diets for Musky and Walleye Culture - by Charles Sanderson, Pennsylvania

Pennsylvania has been trying to feed artificial diets to walleyes and esocids for five to six years. This year artificial feeding of walleye, northern pike and tiger muskellunge went into full production scale at four Pennsylvania hatcheries. Chuck stressed the real importance of dry feed to their program in regards to these species.

During training the fish are concentrated directly beneath the feeders at a rate of 300-500 fish per cubic foot of water.

The fish were not removed from the tanks during tank cleaning. As fish were small, extra feed and fecal matter was siphoned out; when the fish were larger, the water level in the tanks was drawn down and the tanks were scrubbed.

In general, there were not a large number of northern pike to work with because Pennsylvania has had some mass mortalities of northern pike after swim-up. The mortalities are probably of bacterial origin. The lower survival rates of northern pike on dry diet were probably not so much related to the dry diet since such survival was comparable to survival of northern pike which were on a minnow diet. The survival rates were due to other problems and not due to the dry diet.

Chuck stressed that the maintenance of feeding schedules was very important, especially at the start. He thought feeding at regular five-minute intervals was very important at the start. Supplemental live feed (brine shrimp, daphnia) during initial training appears to be beneficial; but isn't necessary.
BOB MILES - Do you have cost figures for rearing these fish? SANDERSON - No.
BOB MILES (West Virginia) - Using the same cost, could you rear more on a dry diet than on minnows?
SANDERSON - Definitely.
SHYRL HOOD (Pennsylvania) - Labor-saving is significant. For example, you eliminate the labor in harvesting minnows. The dry diet cost was $.43 per pound during 1974.
SANDERSON - At one time during 1974, one man was caring for 70,000 fish on dry feed.
CARL SULLIVAN (S.F.I.) - What situations are you stocking into?
DEL GRAFF (Pennsylvania) - Musky fingerlings are stocked primarily to sustain populations. We do not get much musky recruitment in lakes, except in northwest Pennsylvania lakes. The general management feeling is that we might as well stock tigers quite a bit since we don't get much recruitment on straight musky. So far, lakes stocked every two to three years with tigers have been very successful. We do get straight musky recruitment in our river systems and we can stock musky fry in a river system and develop musky fishing (like in the Delaware River).

CARL SULLIVAN (S.F.I.) What are your future plans for musky rearing in Pennsylvania?
DEL GRAFF (Pennsylvania) - We have two hatchery renovations planned (both are currently trout operations). Both will include warmwater operations on an intensive basis - no forage ponds to any great extent. Management doesn't call much for northern stocking; about 10,000 per year. They want musky and tiger muskellunge stocking.

CARL SULLIVAN (S.F.I.) - Do you plan on expanding your program?
DEL GRAFF - Yes. For example, we did expand during 1974. During 1974, we reared a total of about 140,000 musky and tiger muskellunge. Our previous best year was about 88,000.
SANDERSON - When dry diet fed fish were transferred to a larger tank or were allowed a larger feeding area, it usually took several days for the fish to adapt to the larger feeding area. In general, the fish stayed under the covered area and the feeder was placed right at the edge of the covered area.
QUESTION - (Unidentified) - When the 3" to 4" tiger muskellunge were brought in for feeding, were the tanks covered?
SANDERSON - Yes, and they were put right on dry feed.

Sanderson showed slides of feeders, timers, graders, cleaning of tanks and representative fish which had been fed the dry diet.

Source of the feeders is: Allen Feeders, Rancho Cordova, California.

Sixteen feeders can be run off of one timer. As far as grading, some of their hatcherymen grade every day or every other day during the training period; some grade hardly at all. Chuck believes only minimal grading is necessary and that the time of feeding is more important than the grading to reduce cannibalism. He advises against hand-feeding. Musky were grown to six (6) inches during three months on dry feed.

Sanderson discussed water temperature in the tanks. The optimum appeared to be 68-70°F. Tiger muskellunge were held at 58°F. at one station; there were no difficulties other than growth rate retardation. At 75°F. they had some problems: there was no problem if well water was used once the fish were cleared of external parasites; but, when lake water was used they had more problems with columnaris on walleye. He felt that northerns, walleye and musky wouldn't do well under this culture technique at 80°F. water temperature. Perhaps if good quality water was available, then 80°F. water could be used.

JOHN KLINGBIEL (Wisconsin) - Have you conducted any post-stocking survival studies of dry diet fish as compared to fish reared on minnows?
SANDERSON - No, because 1974 was the first year of substantial production on dry diet.

Tiger Muskellunge Culture
Artificial Diet - Concrete Rearing Units

By: Charles H. Sanderson
Fisheries Technician II (Diet Coordinator)
and
Zenas Bean
Hatchery Superintendent, Pleasant Mount

Introduction

It has been established that tiger muskellunge will accept an artificial diet and can be produced on a production level in intensive type rearing units. The purpose of this project was to determine the practicality of training tigers to accept pelleted feed, then transferring to larger concrete raceway type units. In an attempt to obtain information required to produce predator species on artificial diets at production levels, this project was undertaken to establish basic guidelines and provide the following information:

1. Will tigers accept dry diet in a less confining area.
2. Growth rate.
3. Survival rate.
4. Feeding schedules.
5. Feed conversions.

Methods

All tiger muskellunge used in this project were reared from swim-up fry to 1 1/2" - 2" on brine shrimp and daphnia. Training to accept dry feed was accomplished by crowding the fish in an area 1.5 x 1.5 x 3'. Feed was administered every five (5) minutes for a fifteen (15) second duration twenty-four (24) hours a day. Fish were graded frequently during the initial ten (10) days to remove non-feeders and/or cannibals. After approximately twenty (20) days on artificial feed the fingerling averaged four (4) inches in length, at this time they were transferred into outside concrete raceway units. Unit A received 1,500 fingerlings and Unit B 2,000 fingerlings. Unit size was reduced from 8' x 60' to 8' x 25' x 1.5' (300 cu.ft.) by inserting a screen to confine the fingerling in close proximity to the feeders. A portion of the rearing area was covered with black plastic to afford a secluded area. About seven (7) days were required for the fingerling to acclimate to this situation. After this period almost all fish were observed resting under the shaded area, coming out only to feed.

Two automatic feeders were installed over the rearing units, close to the edge of the shaded area. Electronic timers actuated the feeders for forty (40) seconds every fifteen (15) minutes, twenty-four (24) hours a day. Feed amounts were regulated in an effort to keep feed accumulation on the bottom at a very minimum. Fecal matter and feed wastes were pumped out at least once a week. Daily treatments of Formalin 1:4000 for thirty (30) minutes were administered to control parasites and fungus. Water flow was started at seventeen (17) gpm and increased to thirty-four (34) gpm by the termination of this project. Water temperature averaged 67° during the rearing period.

Results

	Unit A	Unit B
Size	8'x25'x1.5' (300 cu.ft.)	8'x25'x1.5'(300 cu.ft.)
Fish Size Start	4"	4"
No. Fish Start	1,500	2,000
Weight Fish Start	12 lbs.(.8lbs/c)	24 lbs.(1.2 lbs/c)
Length Feeding Period	69 days	57 days
No. Fish Remove	1,470	1,984
Fish Size Range	8"-9"	7"-8"
Average Size	8.75"	7.75"
Weight Fish Removed	162 lbs. (11 lb/c)	163 lbs. (8.2 lb/c)
Percent Survival	98%	99%
Pound Fish/Cu. Ft.	.5	.46
No. Fish/Cu. Ft.	4.9	6.6
Pounds Feed Used	264 lbs.	216 lbs.
Pounds Gain	150 lbs.	139 lbs.
Food Conversion	1.76	1.55

Conclusions

Results obtained from these two production lots of tiger muskellunge reared on an artificial diet, in concrete raceway type units show that this species can be produced to advanced fingerlings at full production levels. Fingerling produced in this type rearing unit on artificial feed compare favorably to minnow fed fish reared in these units.

SUMMARY OF ATTEMPTS TO RAISE WALLEYE FRY AND FINGERLINGS ON ARTIFICIAL DIETS, WITH SUGGESTIONS ON NEEDED RESEARCH AND PROCEDURES TO BE USED IN FUTURE TESTS

By: George B. Beyerle
Michigan Department of Natural Resources
Fisheries Division

Introduction

During the past several years, a number of attempts have been made to raise walleye fry and fingerlings on artificial diets at various state, federal, university, and provincial hatcheries and testing centers. Reports are available from the Gavins Point (South Dakota), New London (Minnesota), Senecaville (Ohio), and Valley City (North Dakota) National Fish Hatcheries, Linesville (Pennsylvania) and Wolf Lake (Michigan) State Fish Hatcheries, University of Wisconsin at Madison, and White Lake Rearing Station (Ontario).

This paper is a summary of the methods and procedures used in the various diet trials, the many problems that have beset the investigators, and the results (or lack of results) obtained. Based on these past experiences, some suggestions are made for improving testing procedures. Areas that require more testing are proposed.

Walleye Fry

As in 1972, the attempts to raise walleye fry on various "artificial" diets in 1973 were uniformly unsuccessful (1, 2, 6, 10).[1] Essentially, no fry being fed on artificial diet survived beyond 17 days after yolk sac absorption. Diets presented to the walleye fry in 1973 included the W-4 and W-5 (Spearfish) formulation dry pellets, Oregon Moist pellets, a pelleted Atlantic salmon diet, a liver slurry, egg yolk, and an egg yolk and Farina slurry.

In most tests automatic feeders periodically dispensed various amounts of feed into troughs, tanks, or aquaria containing the walleye fry. In some cases, hand feeding at frequent intervals was attempted. Typically, many of the walleye fry never showed any interest in the food. The more aggressive fry would sometimes grab a pellet, spit it out, then "eye" another pellet. Much cannibalism occurred, in the form of "tail grabbing." None of the artificial diets which have been tried to date have been accepted by walleye fry.

At Wolf Lake State Fish Hatchery, Michigan (2), walleye fry were raised in fiberglass troughs; in 32 days they grew from an average length of 0.28 inch to an average of 0.90 inch, on a combination of brine shrimp and daphnians, but survival from 48,000 sac fry was only 3.9%. In 1974 at Wolf Lake, infusorians will be added to the diet of walleye fry in hopes of increasing the early survival rate.

Walleye Fingerlings

Artificial diets presented to walleye fingerlings have included PR-6 trout granules (8), Oregon Moist Pellets (4, 9), and the W-3, W-4, W-5, and W-6 dry diets developed at the federal Diet Testing Development Center in Spearfish, South Dakota (1, 3, 4, 5, 7, 9). Generally, walleye fingerlings have accepted to some degree all of the tested artificial diets. However, many problems concerning factors such as rearing containers, water quality, fish diseases, light intensity and periodicity, intensity and periodicity of food dispensation, control of cannibalism, etc., must be resolved in order to make meaningful evaluations

[1] See Literature Cited, at end of this paper. Reports which are summarized here are cited by numbers.

of the artificial diets and achieve maximum growth and survival of walleye fingerlings.

Rearing Containers

Attempts to raise walleye fingerlings have been made in aquaria, troughs, tanks, and raceways of various capacities, designs (including circular), and construction (including glass, aluminum, steel, and concrete). To date, no particular rearing container has proved to be significantly better than another. Ideally, the container should provide screening for crowding the walleyes into a section of the container with minimal turbulence, to enhance feeding. Obviously, water flow through the container should be adjusted to provide a relatively quiet section. Covers may be necessary to prevent fish from jumping out of the container. Walleyes are very excitable, and tend to flee from any outside activity, including hand-feeding operations. Screens or plastic curtains may be installed to isolate the walleyes from disturbing activities.

Water and Fish Diseases

Here it should be repeated that the flow of water must be regulated so that the rearing container has a quiet section where walleyes can feed without having to swim continually against a current. In one test (5) the optimum water temperature for maximum growth of walleye fingerlings was 22°C (71.6°F.). Fingerlings grew nearly as fast at 26°C, but almost one third less at 18°C. Poor water quality and/or problems with various fish diseases have caused disruptions in practically all of the walleye feeding tests. How much of the abnormally high incidence of diseases is related to attempts to feed pelleted food is hard to determine. It often takes some 10 days to condition the walleyes to accept pelleted food. Somewhat starved, weakened fingerlings would obviously be more susceptible to diseases than more healthy fish. Since meaningful feeding tests cannot be conducted with diseased fish, much effort must be made to keep experimental fish free of disease organisms. Rearing containers should be cleaned several times a day if necessary to remove excess food, feces, and dead fish.

Light Intensity and Periodicity

More research is needed on both light intensity and periodicity in relation to walleye feeding. In one test (5), light periodicity (8-hour period vs. 16-hour period) seemed to have little influence on feeding intensity, but fingerlings ate and swam more actively when light from a 15-W aquarium light was "reduced". In another test (2), walleye fingerlings in fiberglass troughs fed more intensively when a 100-W incandescent lamp was suspended over the trough and lit for a 9-hour period.

Food and Feeding

It has been suggested (3) that walleyes should be at least two inches in length before starting on a dry diet. However, very little diet testing has been done with walleyes in the one to two-inch size range. Possibly walleye fry could be raised to one-inch size in troughs on brine shrimp and plankton; then switched to pelleted food.

It usually takes about ten days for fingerlings to adapt to pelleted food. Acceptance of pellets may be hastened by first introducing a natural food such as daphnids, and finally by hand-feeding the pellets while the walleyes are consuming the daphnids. There is some disagreement on the quantity of food to be fed, and on the frequency of feeding. In one test (5) better efficiency in conversion, and in weight gain, was obtained by feeding at three percent of body weight per day, rather than at five or seven percent (fish were fed twice per day). Another investigator (4) suggests feeding "large amounts" of food at one time, and feeding only a few times a day. In yet another test (3) the most successful method was hand-feeding a few particles at a time, as many as 24 times per day.

Obviously more testing is needed to determine the amount and periodicity of feeding pelleted food.

The use of automatic feeders seemingly is a much more practical method of feeding pelleted food, than is hand-feeding. It permits feeding on a 24-hour basis, and eliminates much of the disturbance to the walleyes caused by periodic hand-feeding. One major problem with automatic feeders has been a tendency to plug up, especially with the smaller-sized pellets and with starter mash. The feeders should be protected as much as possible from splashing water, and from moisture condensation. A plastic cover is handy in keeping the food fairly dry.

The limited information available suggests that there is relatively little difference in acceptability to walleye fingerlings, of the W-4, W-5, and W-6 diets (3). No one compared these diets with the W-3 diet. In two tests (4, 9), walleyes seemed to prefer OMP pellets to the dry W-3 and W-4 pellets. In Ontario (8), walleye fingerlings are raised successfully on No. 4 trout granules. It is suggested that future feeding tests include direct comparisons between "trout crumbles", OMP, and the cool water fish dry diets, so an evaluation can be made of the comparative merits of each type of artificial diet. For instance, the W-4 diet should be tested along with the trout granules and/or the OMP diet, using walleyes of the same size and condition.

When raising walleyes with artificial food, either on a production basis or during extended food tests, frequent grading of walleyes by size is necessary to minimize cannibalism.

Because of the many differences encountered from test to test (such as with size of fish, diets, water temperatures, diseases, length of tests) it seems pointless to compare test results as far as growth and survival are concerned. It is safe to say, however, that walleye fingerlings can be raised to a length of 4 inches on artificial diets, with survival proportional to the success of the fish-culturist in controlling water quality, diseases, outside disturbances, light intensity, water flow commensurate with rearing container size, and the other limiting factors mentioned in this summary.

LITERATURE CITED

1. White, Warren, and Roger Cooper. 1973. Feed test on walleye (Stizostedion vitreum) at Gavins Point National Fish Hatchery, Yankton, South Dakota 57078. Mimeo. Report. 2 pp.
2. Byerle, G. B. 1973. Letter reporting results of attempts to raise walleye fry at Wolf Lake State Fish Hatchery (Michigan) in 1973. Michigan Department of Natural Resources, Wolf Lake State Fish Hatchery, R#1, Mattawan, Mich. 49071. Mimeo. Letter. 3 pp.
3. Sanderson, C. H. 1974. Dry diet testing results - 1974. Pennsylvania Fish Commission. Linesville Fish Cultural Station, Linesville, Pa. 16424. Mimeo. Report. 11 pp.
4. Bast, Dale R. 1973. Dry diet research at Valley City National Fish Hatchery. Valley City National Fish Hatchery, Valley City, North Dakota 58072. Mimeo. Report. 39 pp.

5. Calbert, H. E., D. A. Stuiber, and H. T. Huh. 1973. Raising yellow perch and walleye pike for human food, Progress Report: September 1, 1972 - August 31, 1973. Dept. of Food Science, College of Agricultural and Life Sciences, University of Wisconsin, Madison, Wisconsin 53706. Mimeo. Report. 10 pp.

6. Cernohous, Len. 1973. Dry diet test results on walleye fry. New London Fish Hatchery, New London, Minnesota 56273. Mimeo. Report. 2 pp.

7. Cernohous, Len. 1973. Progress report on dry diet tests - walleye fingerlings. New London National Fish Hatchery, New London, Minnesota. Mimeo. Report. 2 pp.

8. Cheshire, W. F., and K. L. Steele. 1972. Hatchery rearing of walleyes using artificial feed. Progressive Fish-Culturist 34(2): 96-99.

9. Copeland, J. A., and R. M. Poynter. 1972. Warm-water development report, Experimental Series A, Test 2, smallmouth bass, walleye, tiger muskie. Michigan Department of Natural Resources, Wolf Lake State Fish Hatchery, R#1, Mattawan, Michigan 49071. Typewritten report. 14 pp.

10. Hochstetler, Charles. 1973. Cool water diet testing program - 1973. United States Government Memorandum, Senecaville National Fish Hatchery, Senecaville, Ohio 43780. 2 pp.

Dry Diet Tests Results on Walleye Fry and Fingerlings

By: Roger Martin*
Michigan Department of Natural Resources
Fisheries Division

Introduction

It is considered very important to the advancement in walleye rearing techniques to succeed in having this species accept artificial diets.

For this reason a series of experiments have again been initiated this year (1974) at the Thompson State Fish Hatchery. These experiments were conducted by trial and error rather than by the scientific method due to a lack of reliable information on such parameters as temperature, density, diet, disease control, etc. During these "experiments" numerous changes were made as ideas arose and situations dictated.

Methods

A. Feeding Trial I

On May 14, 1974, walleye fry, two days old, with a mean total length of 9.3 mm were stocked in eight circular rearing tanks. The eight tanks were divided into two groups (I and II), thus each group occupying four tanks. Two tanks were stocked with 8,500 fry resulting in a density of 100 fry per cubic foot and two tanks were stocked with 850 fry or a density of 10 fry per cubic foot. Water flow and temperature were maintained at 2 gm and 64°F respectively. The walleye in group I were fed smelt fry while group II received W-3 warmwater fish pelleted diet ground to very fine particles.

The group I walleyes were introduced to smelt fry on May 15, but were not observed feeding until May 18. After May 18 they fed readily without having trouble ingesting the smelt fry. When large amounts of smelt fry were introduced, the walleye would attack several smelt before eating any. This phenomenon did not occur when only relatively small numbers of smelt were offered to the walleyes. On May 27, as the smelt supply became exhausted, the walleyes were fed sucker fry, until June 4 when the experiment was terminated.

The group II walleyes were fed only token amounts of the pellets until May 18, the date when the smelt fed walleyes were first observed feeding. At this time the fish were hand fed every fifteen minutes throughout the day. On May 19, automatic feeders were placed on the tanks and programmed to feed every fifteen minutes. Several walleyes were observed feeding on the dry pellets. Examination for stomach contents by means of a microscope confirmed this observation.

At about 11:00 P.M. on May 19 a red fluorescent light was placed directly over one of the pellet fed tanks to observe feeding activity while being hand fed. When the light was switched on, all the fish in the tank positioned themselves under the light within two minutes, became very active and appeared to be feeding aggressively. During the week of May 27 the experiment had to be terminated due to a severe and rapid mortality.

*Fish Culturist, Marquette State Fish Hatchery, Department of Natural Resources, Marquette, Michigan

B. Feeding Trial II

On June 9, 1974, an attempt was made to switch 4,000 of the smelt fed walleyes to pelleted food. Two tanks were set up with 2,000 walleyes in each one. The mean total length of the fish was 26.4 mm. Water flow was set at 2 gpm and a temperature of 64° was maintained. Air was bubbled into the tanks for oxygenation and gas exchange. Automatic feeders were used to feed 3/64 inch OMP pellets every half hour.

Results and Discussion

Feeding trial I, group I, the group of walleyes which were fed natural food (smelt) in a confined area, succeeded. The walleye needed very little care other than placing the forage into the tanks. It seems advisable to keep forage levels low to prevent waste.

At the termination of the experiment, necessitated by the exhaustion of the forage supply, 12,150 walleyes with a mean total length of 21mm were harvested. Their length gain was 12 mm over a 20 day period or 0.6 mm per day (average). Accountable mortality was 50 fish. However, 6,500 fish could not be accounted for. Due to the method used for cleaning the tanks (syphon hose) and the size of the fry, mortality record keeping was very inaccurate and cannot be relied upon as an indicator. There appeared to be no difference in growth rate or mortality between the two densities of group I.

Feeding trial I, group II, representing the walleye fry fed an artificial diet, also produced some positive results. The fact that the walleye fry did start feeding is, in itself, a very encouraging observation.

Here, too, a precise record of mortalities was virtually impossible, if not more difficult. Much more intensive cleaning of the tanks was required. As a matter of fact, the inability to keep the outlet screens from plugging up and thus interferring with good water exchanges resulted in a fouling of the water which may have caused a near total mortality during the week of May 27. At the termination of the trial only 26 pellet fed fry had survived. These had a mean total length of only 12.0 mm. Their length gain was only 2.7 mm for a 20 day period. Again, no difference in growth rate or survival could be established between the two densities of walleyes represented in group II.

Water chemistry analyses were not conducted, thus we were unable to determine whether the mortalities were caused by a water quality related problem. However, the water in tanks where artificial diets were fed was very turbid and particles of fungus and organic debris were suspended indicating definitely a degradation of the environment. This problem, I believe, can be eliminated by using coarse mesh drain screens, increased water flow, and, if necessary, a tank filter system similar to those used on aquaria.

It is of interest to make a few comments about the red fluorescent light I suspended directly over the tank about six inches from the water surface. When lighted it triggered a very significant change in behavior. Without the light, during the day as well as at night, the fry were scattered throughout the tank and/or swimming around at the perimeter. When the light was turned on, all the fish converged to the lighted area in less than two minutes and became very active and appeared to be feeding aggressively. I feel that this behavioral phenomenon is significant, and I recommend that a light and feeder system be developed for experimentation next spring. This system should include a light that would switch on about two minutes before activation of the automatic feeder. It should remain on for about five minutes after feeding started.

Feeding trial II was a complete failure in the sense that the walleyes all perished without ever starting to feed.

It appears to be very difficult to make the switch from live forage fish to an artificial pellet, at least under our experimental design. However, walleyes reared in natural rearing ponds on plankton and insects etc. have been, at least to a degree, successfully switched to an artificial diet under intensive rearing conditions. Either the change in rearing environment may have been conducive to conversion to artificial diets, or possibly the fact that the fish may not have become piscivorous in their feeding behavior may have resulted in maintaining enough flexibility to switch from a plankton type diet to pellets. There may have been, of course, other reasons.

Conclusion

It is encouraging that some walleye fry accepted an artificial food. Further studies are needed to determine tha optimum conditions for the walleyes to accept such food, to improve methodology and to develop proper diets.

This is no small task and a united, coordinated effort can do much to shorten the time in achieving our goal of successful, intensive walleye culture.

The state of Michigan intends to continue to do its share in attaining this goal.

-COMMENTS BY JOHN SCHROUDER OF MICHIGAN-

John called attention to another report by Martin which was not yet available: it regarded 1974 work on walleye; two lots (1,000 each) of 2" walleye were fed the W-3 diet and two lots (1,000 each) of 2" walleye were fed the Oregon Moist Pellet. The Oregon Moist Pellet was rolled into the cigar-shape prior to feeding. Overall, there was a 64-65% conversion to the dry diet and the walleye were up to 3" in length at the end of the experiment.

Formulated Dry Diet Feeding - 1974

By: Arden J. Trandahl

Prepared from reports submitted to Leo Orme, Diet Development Center, Spearfish, South Dakota.

Five Locations responded with written results from formulated dry diet feeding in 1974. The locations were Senecaville, Ohio National Fish Hatchery, Valley City, North Dakota National Fish Hatchery, New London, Minnesota National Fish Hatchery, State of Pennsylvania and State of New York.

Working species this year were walleye, sauger, northern pike, muskellunge, muskellunge/northern pike hybrid, largemouth bass and smallmouth bass.

Walleye

Walleye trials were attempted at Senecaville, Valley City, New London and State of Pennsylvania.

Senecaville - Both walleye fry and fingerlings were fed at Senecaville. Fry started on brine shrimp fed well but failed to convert to the dry diet. Pond-reared walleye fingerlings ranging from 1.5 to 2.5 inches were used in the fingerling trial. The trial ended with limited success. The uneven size of fingerlings in the starting lot and an external bacterial infection were factors limiting success. A treatment of formalin and malachite green was not an effective treatment. However, acriflavin treatments at 2ppm were deemed effective.

Valley City - One year old walleye were fed dry food after wintering in a pond with poor results. Small young-of-the-year walleye were used in other trials with varying results. One lot increased almost four times in size and had almost 75% survival.

New London - Walleye fry were fed Oregon Moist Pellet mash with poor results. No fry appeared to feed readily on this diet. A trial using pond started fingerlings fed W-7 dry feed was initiated. It was terminated early due to mechanical problems. However, some fingerlings started well and fed until the trial was terminated.

Pennsylvania - Walleye fingerlings were fed on dry feed and grew from 1.5 inches to 4 and 5 inches with a survival of 32.8%. The W-7 dry diet was used. Fish were successfully treated with Potassium Permanganate and Diquat.

Sauger

Senecaville - A small lot of sauger fry were started on brine shrimp and then fed Oregon moist pellet. The fry fed well on brine shrimp but never converted to the OMP. Sauger responded to brine shrimp feeding similar to walleye. It is theorized sauger fingerlings could be fed on dry feed in the same manner as walleye.

Northern Pike

Valley City - Overwintered northern pike reared the previous season on dry feed were again fed this season on a dry diet. The fish were overwintered with live forage but readily converted back to dry feeding. However, in general, the lot did not do well.

Pennsylvania - Northern pike fingerlings were reared successfully on a dry diet from a 1.1 inch size to 4.8 inch. Survival was much lower than musky hybrid.

Muskellunge

Valley City - Muskies were reared from fry to one inch on live food and then converted to dry feed. A successful program on a limited number was conducted this year.

Pennsylvania - Muskies were reared from a small fingerling 1 - 1.5 inch to 4.3 inch size on dry feed. Survival was in the area of 10%.

Muskellunge Hybrid

Pennsylvania - Hybrid muskellunge were successfully started as small fingerlings on dry feed. Large fingerlings of 6-8 inches were obtained. One lot was changed from minnows to dry feed, one lot fed on minnows and dry feed on alternate days, others only on a dry diet. Excellent success was noted on all program phases. Confidence in the program was to the degree that it will likely become part of a regular program routine. Automatic feeders and regular frequent feeding schedules are thought to contribute to the program.

New York - Hybrid muskellunge were successfully reared. Fry were started on zooplankton and brine shrimp and converted to dry feed. The original project goal of 1,500 fingerlings was exceeded. A deterioration of the lower jaw and isthmus was noted and treated with Roccal. The effectiveness of the Roccal treatment was not positive. The trial was termed successful.

Largemouth Bass

Pennsylvania - Largemouth bass were successfully fed on dry feed up to a 4" size with a 70% survival. Small pond reared fingerlings 1.5 to 2.0" size were used for the trial.

Smallmouth Bass

Senecaville has successfully fed OMP to smallmouth bass from small fingerlings up to 5 inches in length for several years. In the past, small pond started fingerlings were used as starting stock. This year, fry were started on brine shrimp and grew rapidly. The trial was terminated prior to conversion to dry feed because of space requirements. It appeared little difficulty would be experienced in converting smallmouth to dry feed from brine shrimp.

It should be emphasized the interest in dry diet feeding is widespread. It will be the next big breakthrough in fish culture. One has only to think about the broad range of species reviewed in this short paper to grasp the interest and potential of this program. I have watched the interest and program grow from a foundling to many agency involvement. Michigan, Pennsylvania, New York and others have done excellent work and have made good progress. I am very enthused and think we have only begun.

Note: This summary is from reports submitted to Leo Orme early in the season. Final results may vary somewhat from what is presented here.

- COMMENTS AND QUESTIONS -

Formulated Dry Diet Feeding - 1974 - by Arden J. Trandahl

Diet Testing Development Center

Arden expressed the real interest of Leo Orme, Director of the Diet Testing Center, in the development of dry diet feeding for "cool water" fishes. Leo's address is as follows: Leo Orme, Director
Diet Testing Development Center
U.S. Fish and Wildlife Service
Spearfish, South Dakota 57783

The contents of the W-7 diet are as follows:

Herring Meal	50%	Protein	53.5%
Blood Flour	5%	Fat	15.5%
Soy Flour	10%	Moisture	7.5%
Brewers Yeast	5%	Ash	10.0%
Whey	5%		
Fish Soluble	10%		
Fish Oil	9%		
Vitamin PR Mix 25	6%		

Arden said this was the first year that one diet produced relatively consistant results under the cool water diet testing program.

RAY PHILLIPS - (U.S.F.W.S.) - Has Leo indicated any changes in the W-7 diet for 1975?

TRANDAHL - Not at this time. This subject will be discussed at the winter meeting of the Cool Water Diet Committee Meeting.

SANDERSON (Pennsylvania) - The only major change in the 1974 diet over the 1973 diet was that the Vitamin content was increased from 4% to 6%.

Musky Production in Kentucky Hatchery Ponds Using Various Musky Fry Stocking Rates and Adding Fathead Minnows as Supplemental Forage

During 1973-1974, we have used pond spawning to obtain native musky fry. To date, we have been able to obtain 40,000-60,000 native musky fry per year. Our operating premise has been to stock musky fry into one-acre ponds on top of a reproducing minnow population and to add supplemental forage as needed from one-acre minnow ponds. Our problem, to date, has been as follows: at lower musky stocking rates (2,000/acre) we do not harvest enough musky fingerlings numbers-wise to fulfill our stocking program; but at higher musky fry stocking rates (10,000/acre) we have a difficult time supplying enough forage to obtain a suitable musky survival rate from fry to fingerling. Our results during 1974 are shown on the attached table.

During 1974, the 10,300 musky fry stocked into Pond 74 quickly decimated the minnows already present in the pond. We then added goldfish eggs on mats and the musky almost completely decimated the goldfish fry as the goldfish swam off the mats. We then added minnows, but apparently in insufficient poundage - we were only obtaining about 500,000 minnows (5,000/lb.) from each minnow pond (fathead minnow broodstock were placed in minnow ponds about April 10 at rates of 2,000-15,000/acre and the minnow ponds were harvested about mid-June).

Our present plans are to gradually increase our musky fry stocking rates from 3,000-5,000/acre and then upwards while at the same time improving our forage program. Plans for 1975 will probably be about as follows: 1) use about 12 ponds for musky fingerling production, 2) stock the musky fingerling ponds with 5,000-10,000 broodstock minnows on April 10 or earlier (our minnow ponds seemed to be more productive at the higher broodstock stocking rates - and we seemed to get better minnow production from ponds stocked early with fathead broodstock), 3) stock 3,000 to 5,000 musky fry per acre, 4) when suitable, add about 600,000 goldfish eggs to each musky production pond (we have hopes of producing 5,000,000 to 10,000,000 goldfish eggs from a one-acre pond), 5) when suitable, add 200,000 minnows (3,000-5,000/lb.) to each musky production pond (we will probably need 5 one-acre minnow ponds to accomplish this). We have hopes of stocking 5,000 musky fry per acre by this method and obtaining 2,000 fingerlings at a survival rate of 40% which would supposedly supply us with about 24,000 fingerling musky. At present stocking program policy, we need a minimum of 13,000 musky fingerlings per year (which we approximately produced during 1974 by also using some out-of-state fry); would really like about 22,000 fingerlings per year, and could probably stock 32,000 per year.

Under the present plan, we basically need more forage of all sizes. I presently think it is too expensive for us to purchase commercial minnows. Next year, we hope to feed our minnows more both in the minnow production ponds and in the musky production ponds - this year, we usually fed only about 5 pounds of wheat middlings or soybean meal per pond per day, but we only fed about 1/3 to 1/2 of the total days period (such feeding also seemed to reduce our algae proglems). We also hope to rear minnows in ponds from June through March on a second crop basis to achieve a high poundage of minnows for use in the subsequent season - to date, we have not been able to do this at the hatchery since we have been using up all our minnows as fast as we can rear them. We also would like to start feeding minnows in our raceways.

Under next year's plan, we would probably only need about 60,000 musky fry.

Musky Production in Eight Ponds at Minor Clark Fish Hatchery (Kentucky) during 1974

- All ponds received 2,000 broodstock fathead minnows on April 10, 1974. -

Pond Number (1-acre ponds)	Number musky fry stocked	Forage added	Number musky harvested	Size musky harvested	% Return fry to fingerling	Average number stocked (2 pond average)	Average number harvested (2 pond average)	Average % return (2 pond average
74	10,300	190,000 gold-fish eggs ------------- 350,000 fat-head minnows (5,000/lb.)	2,340	5"	22.7	9,573	1,770	18.5
54	8,845	450,000 fat-head minnows (5,000/lb.)	1,200	5"	13.5			
53	4,645	225,000 (5,000/lb.)	1,300	5"	27.9	4,310	1,368	31.7
35	3,975	100,000 (5,000/lb.)	1,435	5"	36.0			
60	3,140	220,000 (5,000/lb.)	1,560	5"	49.6	3,056	1,230	40.9
51	2,871	100,000 (5,000/lb.)	899	6"	31.0			
41	2,000	110,000 (5,000/lb.)	850	6"	42.5	2,000	782	39.1
47	2,000	110,000 (5,000/lb.)	715	6"	35.0			

- COMMENTS AND QUESTIONS -

Forage Ponds for Musky Production, Dan Brewer, Kentucky

CARL SULLIVAN (S.F.I.) - What was the size range for musky in report listed as 5" to 6"?

BREWER - 4" to 8".

OHIO - Ohio stocks 5,000 ten-day-old musky per acre with broodstock minnows present and obtain a yeild of 2,000 6" to 8" musky without adding supplemental forage. Some of the 6" to 8" musky are then transferred to other ponds for advanced rearing; these ponds do receive supplemental forage.

BOB MILES - West Virginia - West Virginia stocks 2,000 to 3,500 ten-day-old musky per acre. In a good year, the percent return on musky is 35%. Brood-stock minnows are added, but supplemental additions of forage are not. The state is generally satisfied with this method because of cost involved and needs of about 10,000 to 15,000 musky per year.

CHUCK GAHLER (Wisconsin) - Wisconsin stocks about 100,000 musky fry per acre for rearing to 3". Forage is added to these ponds. The 3" musky are then transferred to other ponds for rearing to 11".

MUSKELLUNGE FORAGE

By: Richard L. Trombley
Area Fisheries Manager
State of Minnesota Department of Natural Resources

A. Early Forage (Nursery Ponds).

1. Plankton. In the past, our northern hatching stations at Park Rapids and Grand Rapids have had poor success in raising muskellunge fry. The major reason for this has been the absence of or very low plankton pulses.

We now try to raise most fry at the Hinckley station and return small size fingerlings to the northern stations.

2. Sucker Fry. All sucker eggs are taken from northern runs and are transported to various hatcheries for hatching. Early and late runs plus some water temperature controls give us good flexibility in adapting to needed changes.

B. Fingerling Forage (Expansion Ponds).

1. Fathead Minnow Reproduction. Fisheries crews acquire adult fathead minnows for all expansion ponds and we stock them as early as possible in the spring. Reproduction from these minnows usually provides sufficient fry of varying sizes to feed the muskellunge fingerlings until they can take larger sized minnows.

We start to purchase minnows around the middle of July as the muskellunge fingerlings have reached four to four and one half inches and will bypass the fathead minnow reproduction for larger food.

Cost for minnows went up from $2.00 per gallon in 1973 to $2.50 per gallon in 1974. Minnows were harder to get in 1974 because larger bait dealers paid a higher price to the smaller bait dealers.

C. Other Forage.

1. Stickleback Minnows. Stickleback minnows are utilized and seem to be choice in the later part of the season. They might be easier to catch than the fathead.

2. Yellow Perch. We have had little success as in most cases the perch are too large for the muskellunge. They can be a good forage species if the perch hatch is late.

3. Buffalo and Carp. We have considered the use of these species as fry and will attempt to coordinate the seasonal differences with some of our hatcheries in southern Minnesota.

Carp or buffalo could possibly take the place of sucker fry or fill the gap for needed small size food after we run out of sucker fry.

- COMMENTS AND QUESTIONS -

Muskellunge Forage - Stan Daley, Minnesota

We have tried artificial diets for walleye although we lack facilities for feeding on a production basis. During 1974, the walleye had external parasites when brought in from the ponds and subsequent formalin treatments killed most of the walleye. We never got started on feeding trials as a result.

We work strictly with the pure musky. During 1968, we more or less got into substantial musky production. Minnesota has muskellunge nursery ponds at two locations; the ponds mostly are 4-7 acres but some range up to 20 acres -all are drainable. During 1973, 196,000 musky fry were stocked into nursery ponds and 106,000 small fingerlings were harvested (harvest began when musky reached 1.1 inches). Sucker fry were stocked into the nursery ponds; Minnesota has about a six-week period for taking sucker eggs running up to about June 6.

The small musky fingerling are stocked into expansion ponds at a rate of 2500-5000 per acre (expansion ponds are similar in size to the nursery ponds). Expansion ponds are stocked with 45-50 pounds of breeder minnows per acre - more if possible. Minnow reproduction carries the musky up into July at which time purchased minnows are added to the ponds. The commercial minnow business is large in Minnesota with 35 large dealers alone exporting 3 million pounds of minnows from the state each year.

Mayo Martin (USFWS) - Is the sucker minnow farming business growing?

Daley - No. It has stayed about the same during the last 10 years. They take 6,000 to 10,000 quarts of eggs each year and produce about 75,000 gallons of suckers per year. They cannot export sucker minnows from the state.

Minnesota has an active program to remove suckers from some softwater walleye lakes. Suckers can be knocked back in two years just by trapping.

Mayo Martin (USFWS) - Mr. Martin indicated that buffalo, especially the large-mouth buffalo, might be an excellent source for forage for musky, etc. He stated that the buffalo could be spawned by using injections, by pond spawning, and by mat-spawning. [A quick check of the literature showed that bigmouth buffalo spawn at about 60°-65°F. and have about 50,000 eggs per pound of broodfish; males have pearl organs and incubation is about 9 days at 62°F. and 1 day at 75°F.].

Forage Production in Municipal Waste Water Treatment Lagoons

By: John D. Schrouder
Michigan Department of Natural Resources, Fisheries Division

Background

The Michigan Department of Natural Resources Fisheries Division and several municipalities have participated in an experimental forage minnow rearing program in selected waste water lagoons since 1971. The practice of rearing minnows in these lagoons for muskellunge forage appears to be economically attractive, but certain human health questions need to be answered before this technique can become universally accepted. Current Fisheries Division policy prohibits use of lagoons for the production of forage or gamefish for stocking purposes.

Michigan's first experimental attempt at rearing minnows began in May of 1971 at the City of Belding's Waste Water Treatment Plant as part of a walleye rearing attempt. Belding's waste water lagoon system consists of a series of 5 oxidation ponds totaling 51 acres. Pond #1 receives domestic sewage and is anerobic. From pond #1 the effluent flows into pond #2 which is aerobic most of the year and then into ponds #3 (13 acres), #4 (7acres) and #5 (7 acres). Effluent from the final treatment ponds (#3, 4 and 5) is discharged to the Flat River semi-annually following chlorination.

Adult fatheads were stocked in June, 1971 in ponds #3, 4 and 5 at an initial stocking rate of 0.4 - 0.76 pounds/acre as forage for walleye fry which had been introduced a month earlier. Dissolved oxygen (D.O.) is monitored routinely by sewage treatment personnel during open water months. D.O.'s ranged from a low of 2.0 mg/l to a high of 25.9 mg/l in ponds #3-5 during 1971. Seining, visual observations and electro fishing from mid-July through August of 1971 indicated heavy populations of fatheads, but no walleyes.

In November of 1971, 8 "mini-fyke" nets with 3/8" mesh were constructed to harvest minnows from the Belding ponds. The frames of these nets are 2 ft. x 4 ft. Two hoops (2 ft. diameter) follow the frames.

A total of 107 "mini-fyke" lifts in Belding ponds #3, 4 and 5 yielded 4,762 pounds of fathead between November 2 and December 24, 1971. This effort represented a harvest of 378 pounds per acre from introductions of 0.4 - 0.76 pounds of brood stock per acre.

The minnows were harvested and transported to Wolf Lake Hatchery, about 60 miles away, at a cost of 14.7 cents/pound. Compared to the $0.50 per pound we paid commercial minnow dealers, the minnow production from Belding could represent a significant savings. More recent cost figures indicate the lagoon forage cost to be even less, 12.5 cents/lb. In relation to our total muskellunge forage needs, these minnows could represent a savings in excess of $11,000 based on 1972 cost figures.

In 1972, six additional municipal waste water systems (Bangor, Carson City, Coopersville, Cassopolis, Eau Claire, and Lawton) were stocked with combinations of fatheads (5 systems) and golden shiners and golden shiner and tiger musky (1 system). Brood stock plantings of fatheads at 0.5 pounds/acre were successful in 2 of the 5 new lagoon systems checked. The plants of golden shiner and tiger musky and shiners were successful. Approximately 200 tigers were collected in mid-November of 1972 from the 1.25 inch fingerlings stocked in June of 1972. The tigers grew to 5.5 inches by August 1st and 13.8 inches by November 1st with some reaching 18 inches. Sampling during August indicated a much larger population than the November harvest figures indicated. If harvest had been completed in September, a much larger number of 8-10 inch muskies may have been available.

Harvest Problems

The most serious harvest problem encountered in sewage lagoons was winterkill of the brood stock, and heavy summer weed growth. Because of the heavy nutrient load these lagoons receive, the D.O. usually drops to 0.5 ppm or less by March. In June and July when large quantities of minnows are required for muskellunge production, the minnow populations have recovered to permit some harvest but rather dense mats of filamentous algae and higher aquatics (*Ceratophyllum sp.*) make netting difficult. But by fall, from mid-August on, minnows are numerous and weed problems have subsided.

If the minnow crop is harvested in the fall and over-wintered in other ponds (hatchery) which have adequate D.O. concentrations, we believe our entire forage needs for muskies could be satisfied economically.

Human Health Implications

Fisheries Division and the Michigan Department of Public Health are currently studying the human health implications of rearing forage and gamefish in waste water lagoons. The accumulation of toxic materials and pesticides in fish reared in sewage lagoons is being checked.

Although much research is needed before all disease questions can be answered, the preliminary data we have collected appears encouraging. Fatheads and golden shiners from 2 sewage lagoon systems were analyzed in 1972 and were found to contain heavy metal (As, Cd, Hg, Pb, Zn, Cu, TCr, Ni), P.C.B. (polychlorinated biphenyls) and D.D.T. concentrations well within natural background levels. Of the tiger muskies sampled from one system, however, rather high concentrations (2.0-2.2 ppm wet weight) of mercury were detected.

This year (1974), additional samples of lagoon reared fatheads, and muskellunge fry and fingerlings, before and after feeding with lagoon reared minnows, have been collected for analysis. Unfortunately, laboratory backlogs have delayed analysis of these samples. When the tests are completed the fish samples will be analyzed for heavy metals (Cu, Ni, Hg, Pb, Cd, Cr, As, Se and Zn), pesticides (D.D.T., Dieldrin, Heptachlor, Chlordane), organo phosphates (2, 4-D, and 2, 4, 5-T) and various industrial compounds including PCB's and phthalates.

- COMMENTS AND QUESTIONS -

Use of Sewage Lagoons for Forage Production, by John Schrouder, Michigan

Our survey shows there are 371 such lagoon systems in Michigan; probably 100 of these would be suitable for forage production. Acreages of the systems range from 20 to 75 acres and average about 50 acres. The systems receive either or both municipal and industrial wastes. (For the record, Michigan does not believe extensive musky rearing with heavy reliance on forage is the way to go in the future but rather is planning for intensive rearing).

Nets are set in the afternoon and are not baited. A two-man crew can run a dozen nets in an afternoon. On harvesting, the minnows are about 100/lb. and up to 50-100 pounds of minnows are harvested from one set fished overnight. There are no abrasion problems with the minnows since netting material is used and consequently the minnows were not treated with malachite green, etc.

At the beginning, it was necessary to use antimycin to get rid of centrarchids. Winterkill reduced the forage population in the lagoon by about one-half.

It is hoped with further checking that the Department of Public Health will allow the use of lagoon facilities for forage production; clearance for rearing gamefish probably will not be achieved. One selling point is that the fish assimilate nutrients and in a sense help the sewage control system. The ponds used were of secondary treatment systems; tertiary treatment ponds would probably be better in several ways.

No one at this time is checking the bacterial and viral problems. Even with chlorination, not all viruses are killed; many viruses go right through such sewage treatment plants. No studies to date show that fishes will pick up and transmit viruses to humans (although this can occur with some shellfish).

<u>Tom Clark</u> (Pennsylvania) - Could production go up with higher initial broodstock minnow stocking rate?

<u>Schrouder</u> - We just used what happened to be available and perhaps a better harvest would be achieved with higher stocking rates. It was obvious that we did not harvest nearly all of the minnows in the lagoon.

Minnow Forage Supplied by a Waste Treatment Lagoon

By: James Gall, Ohio

The rearing costs of Ohio's muskellunge has been sharply reduced as a result of the utilization of a lagoon controlled by an industrial waste treatment plant near Wellston, Ohio. From March until September of 1974, almost five tons of minnows have been trapped by Kincaid Hatchery personnel and used as a source of forage for both the fingerling and advanced muskie fingerling program in Ohio. Considering a "good" price of $1.50 per pound of minnows bought commercially, this lagoon has provided $15,000 worth of minnows to Ohio's muskie program this year.

In 1973, Kincaid Hatchery advanced 5,819 muskie fingerlings to a 10 inch size. The muskie raised on commercial bought minnows were $1.53 per fingerling as compared to $0.67 per fingerling from the Wellston minnow operation.

The Wellston Sewage Treatment Plant is a secondary treatment operation designed to process waste products from the Banquet foods industry. The treatment plant consists of mechanical operations for grease removal and a series of three lagoons for aeration and bacterial action.

The first lagoon is considered an air flotation system whereby six 10 horsepower aerators are utilized to increase the oxidation of the suspended solids.

The second lagoon consists of approximately 31 1/2 acres with an average depth of six feet. This lagoon is considered a non-aerated 30-day retention lagoon. This second lagoon has been our prime source of minnow production. The minimum oxygen is approximately 4.2 ppm when all systems are in proper working order. This permits a desirable quality of water which produced 312 pounds of minnows per acre in 1974.

The third lagoon is a reaeration lagoon. This permits the effluent into the stream to meet the minimum dissolved oxygen standards and B.O.D. load set forth by the Ohio Environmental Protection Agency.

-COMMENTS and QUESTIONS-

Ohio started minnow production in the lagoon on a limited scale during 1972. During 1973, 6,000 pounds of minnows were harvested from the lagoon; during 1974, 9,800 pounds of minnows were harvested (312 pounds of minnows per acre). The 1974 production was most useful since the administration provided no funds for purchasing minnows during 1974.

Carl Sullivan (S.F.I.) - Any aeration in the 31.5-acre lagoon?

Gall - No. Effluent into the receiving stream is designed for 5-6 ppm oxygen and 5-10 ppm B.O.D. load.

Gall - Minnow traps have a funnel on one end and a trap-door like structure on the other end for dumping the minnows. Six traps were used in the lagoon from about March 1 through September 1. The traps were baited with a couple of handfuls of Purina Trout Chow. Traps were checked every other day. Trapping was not too successful until water temperatures reached 52°F.; following that, minnow harvests showed pulses coinciding with the warmer days.

COMMENTS AND QUESTIONS (cont.)

John Schrouder (Michigan) - What does Ohio Department of Public Health think of the operation?

Gall - Not sure. Effluents do meet EPA standards.

John Schrouder (Michigan) - Is the effluent mostly a B.O.D. problem?

Gall - The operation is for industrial food wastes; human fecal material is not involved. The water in the lagoon does irritate the skin so full length rubber gloves are worn. The lagoon has heavy algae growths but not higher aquatics. The minnows are treated at Kincaid Fish Hatchery before placement into the ponds. Treatment consists of malachite green at one part per 15,000 for 15 seconds.

Shyrl Hood (Pennsylvania) - Any mortality in handling?

Gall - At the cooler water temperatures there is low mortality, but at higher temperatures there is some scraping on wire traps resulting in columnaris problems and some mortality.

Charles Sanderson (Pennsylvania) - Why do you trap so early in the year?

Gall - For minnow broodstock in musky ponds. During 1974, we stockpiled 1600 pounds of minnows for broodstock. Minnow broodstock rates were about 175 pounds of minnows per acre (100 minnows to the pound). These ponds are for rearing musky to 5" - 6"; any minnows left in the ponds at harvest are are salvaged and used in rearing musky to an advanced size.

Shyrl Hood (Pennsylvania) - Did the costs per fingerling musky cited in your paper involve only the cost for food or was it the total cost of the fingerling?

Gall - Those costs included food, labor, and chemical treatments. Labor also included costs of collecting eggs, draining ponds, etc.

Shyrl Hood (Pennsylvania) - Has the retention pond ever been drained?

Gall - Not yet. It could be though. We do not have a whole lot of control over the pond, for example someone could stock wild fish in the pond. The agreement for the use of the pond is verbal and there is no contract.

Mayo Martin (USFWS) - If bluegills or other centrarchids become a problem, a selective kill could be accomplished with 1/2 ppm malathion.

Muskellunge Survival in Wisconsin Lakes

By: Leon D. Johnson
Wisconsin Department of Natural Resources

Studies were conducted on 14 northern Wisconsin lakes during a three year period, 1971-73, to determine factors that influence survival of stocked muskellunge fingerlings. Fish collections were made with electrofishing gear three to four weeks after the fingerlings were stocked and data were examined by means of least square computations and Chi-square.

Fingerling survival was significantly higher with higher levels of aquatic vegetation for the combined three year data. Survival was variable for cover less than 0.20 acres vegetation per acre of lake and only attained significantly higher levels above 0.30 to 0.40 acres of vegetation per acre of lake.

Differential finclips were used to distinguish the smaller from larger fingerling stocked within the same lake. There was no significant difference in survival between two groups of fingerling, 7 to 8.5 inches, compared to those, 9 to 13 inches in total length.

There was also no significant relationship of muskellunge survival to (1) pounds per acre seined of small forage fishes (averaging under 4 inches) or (2) pounds per acre of large forage (4-7 inches) of size edible only by large predators.

The number of predators in a lake capable of preying on the stocked muskies has been considered as a main contributing factor to lowered muskellunge fingerling survival. Two lakes with zero predators had high survival, 74 percent for Lund Lake in 1971 and 85 percent for Perch Lake in 1972. In 1973, however, survival in Little Sand Lake, Sawyer County, was only 37 percent, a far lower figure than would be expected for a lake with no predators. In contrast, Island Lake, in 1972, had the highest predator index of any lake studied and the highest, 96 percent, survival of stocked fingerling. Very heavy aquatic vegetation cover in Island Lake appeared to outweigh fingerling mortalities caused by predation.

Other factors present in a lake were expected to have adverse affects on survival of stocked muskellunge fingerling. No significant correlations were found, however, for survival plotted against number of predators, size of predators, or number of days (14 to 30) that fingerlings were present in the lake. Higher water temperatures at time of stocking tended toward lower survival at temperatures approaching 20°C. but the effect was not statistically demonstrable.

It is unlikely that stocked fingerling survival, or mortalities can be attributed to any single factor acting alone. A number of variables and combination of variables were explored for the combined three year data, 1971-73, by the Technical Services Section using the University of Wisconsin Computer Center. In order of importance, for factors influencing survival, aquatic vegetation was first, followed by length of fingerlings stocked, water temperature of the receiving water and length of predators in the lake.

It was considered that different water chemistries where fingerlings were stocked might differ from the hatchery where they were reared, to the extent that the fish might not be able to adjust. Methyl purple alkalinity (MPA) was recorded for all waters. Muskellunge fingerlings were required to adjust downward from the hatchery 85 ppm MPA to alkalinities, sometimes as low as 6 ppm. There was no significant relationship to survival.

-Comments and Questions-

Muskellunge Survival in Wisconsin Lakes, by Leon Johnson, Wisconsin

A 5,000 acre lake was stocked with 1,000 musky fingerlings (9" to 10" average size) per year over a period of years since 1955. During better years, stocking survival through the first year was about 150 musky (150/1000). The better part of the first year mortality evidently occurred within the first four weeks after stocking. The surviving musky past the first year maintained a fairly constant population level with limited mortality until age five. At age five, these musky generally achieved their first spawn. Past age 5, the stocked musky experienced a steady annual decline of about 45% per year, i.e. 45% mortality of the previous year's population. Stocked musky were tagged and/or fin-clipped. Rather comprehensive fishermen checks showed that fishing pressure took about 10% of the musky per year - those age five and older. The 10% fishermen creel was viewed as a minumum figure. Marking was not considered as a significant source of mortality since similar results were obtained from unmarked musky stocked into lakes without existing populations. At the same lake, survival of stocked musky was only about 50 (50/1,000)through the first year during poorer survival years.

Over a three-year period, fourteen study lakes were annually stocked with six (6) musky fingerlings per acre (much higher than normal stocking rate). The study lakes were checked 3-4 weeks after fingerling stockings and fingerling survival generally was 25% to 95%; the 95% survival was unusual and survival was more apt to be 35-40%. Fingerlings were stocked into both established and non-established musky lakes - without much difference in fingerling survival. Survival as related to different variables is described in the abstract. Predators referred to include pike, walleye and bass. In regards to methyl purple alkalinity, tiger muskellunge survived very well when stocked into southern Wisconsin waters having alkalinities up to 350 ppm (tiger muskellunge came from hatchery waters having 85 ppm methyl purple alkalinity).

It is thought that predators are the cause of the immediate (14 to 30 day) post-stocking fingerling mortality. Such mortality does not occur when musky are held in holding nets at the lakes for 2 to 3 days. Studies showed a quick dispersal of stocked musky - some fingerlings were to the other side of the lake within hours and traveled up to 10 miles in two days. Studies showed that predators did not actively congregate at the stocking sites. Apparently what happens is general widespread predation over much of the lake within the first few weeks. One experience occurred as follows: 2 loads of musky were hauled to a lake, the second load arriving three hours later; after three weeks, the second load showed a better survival.

Question (Ohio) - Would stocking musky over 7" be beneficial?

Johnson - I can't say it would be beneficial. Dr. Miles (University of Wisconsin) reported at a previous workshop that smaller fish recovered from physiological stress more quickly than larger fish. Conceivably smaller fish might give better results. I would like to evaluate 5" fish as compared to a larger one. We have some data showing that some of these smaller fish don't do so well as far as survival but on the other hand do well in regards to the money spent on them.

[Insert: At a previous workshop, stocking size was discussed and several states reported their results. Pennsylvania's report regarded Union City Reservoir which has a large population of bluegills and shiners and the results were as follows:

(See table on next page)

STOCKING SIZE	SURVIVAL
swim-up fry	none
2" fish	2.41%
3" fish	none
4" fish	1.20%
5" fish	3.61%
6" fish	9.64%
7" fish	13.25%
9" fish	69.88%

Several states agreed that 6" is about the minimum size for a successful contribution.]

Jim Axon (Kentucky)-Is scatter stocking more beneficial than concentrated stocking?

Johnson - We have scatter planted and have found not much difference. Most of the time, stocking is done along the shoreline, but we have also tried open water stocking, again without much difference.

Carl Sullivan (SFI) - Is only 10% of the adult mortality a result of fishing?

Johnson - That is a minimum figure which comes from a result of angler returns with a comprehensive effort on these returns. [Note: from the notes it would appear that each year the remaining adult population suffers a 45% mortality, 10% from fishermen and the remaining 35% from other causes or unchecked fishermen - so of the annual mortality a minimum of 10%/45% or 22.2% is a result of fishing.]

James Gall (Ohio) - In the past, Ohio stocked a smaller sized musky. Starting in 1961, Piedmont Lake was stocked with 5 1/2" musky each year. A pattern developed, similar to a pulse, in which every other year the musky experienced a higher percent survival. The pulse was broken in 1968 when 7" fingerlings were stocked for the first time - the "pattern" normally would have shown a down year but instead good survival resulted. Would you say managers should concentrate on stocking 7" fish rather than any other size?

Johnson - I don't have adequate data to say that, but what appears to be true is that a smaller musky like 7" would survive nearly as well and would be cheaper to produce.

Question (unidentified) - What about under 7 inches?

Johnson - It is somewhat hypothetical depending upon survival rates for the various sized fish against the cost of producing and stocking that fish. For example, if 1,000 10-inch fish cost the same to produce as 20,000 5-inch fish and each yielded 100 survived musky after the first year then it would make little difference.

John Klingbiel (Wisconsin) - One point is that when we stock the larger fish the receiving waters are cool whereas if we stocked 7" fish the waters and weather are warmer and not so conducive to fish harvesting, hauling and stocking. If artificial feeding could prolong the smaller size into cooler weather then that might be an advantage.

Johnson - The two sizes of fish that we evaluated were both stocked during the fall.

Carl Sullivan (SFI) - Have you ever considered stocking under the ice in winter?

Johnson - We have stocked a limited number of northern pike this way but without good success; we had high mortality afterwards.

Del Graff (Pennsylvania) - You mentioned the 45% annual mortality - is this true for wild fish also?

Johnson - Yes, at least for northern pike, bluegill and most other fish that we have studied.

Question (unidentified) - How do you make population estimates?

Johnson - We use a lake shocker (A.C.) with a transformer to vary voltage. We mark and recapture until we catch so many fish that it is statistically significant. The fish are marked immediately on acetate sheets and released. We generally shock every 2 or 3 nights.

Bob Miles (West Virginia) - What do you consider a good population of adult muskies?

Johnson - Regarding two lakes: one hasn't been stocked since 1952 and has a population of 300-400 musky ranging from 22" to 52" (1,000 acre lake); the other lake (200 acres) was stocked very heavily and then let go for 5-6 years, it had 45 musky (same size range?). Another lake which has a very high population had 6,000 musky ranging from 23" to 54" (700 acres) - it is an extremely fertile lake.

Bob Miles (West Virginia) - Then, two legal muskies (30") per acre can be considered a good lake?

Johnson - Yes, a very good population.

James Gall (Ohio) - Do you think that the 1974 stocking is perhaps "bite size" for the 1973 stocking?

Johnson - We don't have the rapid growth in northern Wisconsin and this probably is not likely.

James Gall (Ohio) - I was thinking that an every-other-year stocking program would probably help alleviate any such problem.

Summary of 1974 Muskellunge Fry Studies in New York State

By: Richard Colesante

Complete or near-complete loss of muskellunge sac-fry at the Chautauqua Lake Fish Hatchery has occurred in seven out of the last ten years. Losses occur in both lake and well water systems and are characterized by massive die-offs of sac-fry near the end of their yolk absorption period.

The Hatchery was operated on an experimental basis during the 1974 production year. Investigations centered around the following variables with reference to fry survival of known egg lots:

1. Size and age of parent muskellunge.
2. Date of egg take, trap location, and water temperature at time of egg take.
3. Trough-loading of sac-fry and slow turnover of water.
4. Possible changes in water quality at various times during egg taking, egg incubation, and fry swim-up.
5. Heavy metal contamination in the Hatchery.
6. Sudden temperature decreases during yolk absorption.
7. Possible pathogens in the water supplies.

Results of the 1974 sac-fry mortality studies, although incomplete at this time, are given below:

a. Mortality of sac-fry began in lake and well water on 5-26-74, and on 6-1-74 all sac-fry in the experimental lots were dead. Death ocurred regardless of age and size of male or female parent, trap location, date of egg take, or temperature at trap site on day of egg take.

b. Death occurred initially in lots just prior to swim-up, but then progressed to lots regardless of the stage in their life cycle.

c. There was no significant correlation between percent hatch and age or size of male muskellunge contributing to egg lots, date of egg take, temperature at the trap site, and location of egg take. There was a significant correlation between percent hatch and age of female muskellunge, with the following regression line calculated:

$$y = 2.54x + 13.9$$

y = percent hatch
x = age of female muskellunge

d. Trough loading of sac-fry with slow turnover of water (1-2 gpm) did not effect fry survival in 1974. Fry died regardless of trough density or water flow.

e. There were no changes in water quality during the 1974 production season that outwardly could have contributed to the sac-fry losses.

Complete analysis were done on 4-16, 5-8, 5-26, and 5-28 in both lake and well water. A comparison of these water qualities with those at stations able to rear sac-fry showed no obvious differences.

f. Heavy metals are present in the Chautauqua Lake Hatchery, but preliminary analysis of water samples indicate amounts are very low:

Cu = less than 10 ppb
Zn - less than .1 ppm
Pb = unknown as yet

Analysis of eggs and fry for pesticides and heavy metals (Zn and Cu) were generally negative and not deemed significant. Analyses of water, egg, and fry samples for lead are pending.

g. Bioassays of sac-fry with heavy metals yielded the following results:

1. Lead by itself must be present at a .5 ppm-1.0 ppm to affect fry survival.

2. Zinc (by itself) had no adverse effect of survival at 4 ppm.

3. Toxicity of copper to fry is markedly increased by the presence of zinc in a 4:1 zinc to copper ratio.

4. Copper was markedly more toxic in simulated Chautauqua Lake water than in simulated Chautauqua well water.

5. Forty three ppb of copper with 172 ppb zinc prevented muskellunge fry swim-up in water intermediate in water chemistry between Chautauqua's well and lake water. 238 and 338 ppb copper prevented swim-up in simulated lake and well water respectively.

6. Heavy metal poisoning at the Hatchery was not a likely cause of fry die-offs during 1974, but could have contributed through stress on the fry.

h. Sudden temperature decreases, 10°F during 15 minutes, at different stages through yolk absorption, had no affect on fry survival.

i. Pathological work by Neil Ehlinger of the Rome Pathology Unit resulted in the isolation of a suspected bacterial pathogen Pseudomas sp. from diseased muskellunge. It may be the cause of the fry die-offs. Infection of healthy sac-fry with this bacterium resulted in a die-off pattern similar to that occurring at Chautauqua. Control fish swam up normally. Work will be repeated in 1975.

- COMMENTS AND QUESTIONS -

Summary of 1974 Muskellunge Fry Studies in New York State
Richard Colesante, New York

Tests were conducted to determine if the size and age of parent muskellunge had an affect on survival of subsequent fry. Such tests involved the use of 32 different female musky of known age and size. Egg lots were fertilized with milt from four different males (results are given in paper). Results indicated that the use of older fish resulted in a higher per cent hatch but 1974 seemed to be an atypical year in that total per cent hatch was about 30%, which is very low compared to past results.

Parameters measured for possible changes in water quality included: DO, BOD, pH, CO_2, total alkalinity, dissolved solids, ammonia, suspended solids, silica, hardness, calcium, magnesium, potassium, sodium, chlorides, nitrates, sulphates, copper, zinc, iron and manganese. Checks were made for possible accumulation of heavy metals during the yolk absorption stage. Results showed no accumulation of zinc or copper with a possible lead accumulation - to date, have not been able to find lead in the water supply. The bioassay work with heavy metals showed that affected fry could go to the surface of the hatching jars and take air but the fish could not fill their swim bladders.

Neil Ehlinger of the pathology unit was sent moribund fry and he isolated seven bacterial colonies. He injected bacteria from each of the seven colonies into brook trout and three of the injected bacteria killed brook trout. All three bacteria had similar chemistry and qualities and were of the pseudomanid bacteria group.

One conclusion was that the origin of the problem was definitely in the water supply.

JOHN SCHROUDER (Michigan) - What pestidides did you monitor?

COLESANTE - I haven't got that report. I know they did [redacted] do DDT.

JOHN SCHROUDER - We did an analysis on pike fry that had died shortly after hatching at Wolf Lake Hatchery and we found PCB's to be the cause of mortality.

COLESANTE - The group which did our report felt that DDT and PCB's were not a factor at Chatauqua. At least, the prevalent levels would not be important for trout (trout levels were used for evaluation of prevalent levels).

QUESTION (Unidentified) - Does natural reproduction of Musky occur at Chatauqua Lake?

COLESANTE - Yes, a small amount. During the last two years we've handled 1100 adult musky; of these, about 75% were of hatchery origin.

MAYO MARTIN (USFWS) - Did you get a better survival with well water?

COLESANTE - No difference.

QUESTION (Unidentified) - What were the water temperatures during incubation?

COLESANTE - Between 48°F and 55°F. Some eggs were incubated with well water at a constant temperature and those fry also died.

Muskellunge Nursery Ponds in Pennsylvania

By: T. L. Clark, Superintendent
Linesville Fish Cultural Station

The term nursery ponds for muskellunge in Pennsylvania pertains to those ponds, regardless of size, which are stocked with fathead minnows each spring for brood, receives 2" or larger muskellunge in early July, are drained and harvested of advanced muskellunge fingerling in the fall. During this rearing period no fingerling are cropped, sample seining gives an indication of survival and abundance of forage. It is not uncommon to "feed" these ponds supplemental forage in the form of fathead minnows or emerald shiners in late summer. Major concern with nursery ponds has been to determine the most desirable physical features which lend themselves to higher fathead production and ease of harvesting muskellunge fingerling.

Observations of fathead production in ponds indicate that total volume of water throughout the growing season, accessable either by actual size of the pond or high flow of water, produce the most pounds. Nineteen ponds varying in size from .5 acre to 5.5 acres are used for fathead production; five of these are usually stocked with muskellunge fingerling. Total acreage for fathead production is 22.7 acres. Historically, two ponds have consistently produced more than the other seventeen. One of these ponds is a 3.5 acre having an average depth of 4' with 16' at the drain. The shoreline is relatively even and riprapped with broken pieces of concrete to afford ample spawning areas; total volume of water is approximately 531,676 cubic feet. Actual weighing of fathead forage is not feasible due to injury and loss due to handling, but observations through the years indicate approximately two tons of fatheads averaging .75/m are harvested annually. Approximately 250 G.P.M. flow through this pond during the rearing season.

The other exceptionally high producing pond is a .5 acre having approximately 50,000 cubic feet of water. This pond has a flow of 150 G.P.M. of fertile lake water. There does not appear to be an overabundance of spawning devices but stones from 1" to 3" in diameter are profuse and are used extensively. During the rearing period approximately 3.5 million cubic feet of water run through this small pond most likely supplying tremendous amounts of food.

All muskellunge rearing ponds are stocked with 7,500 brood fatheads per acre in early May. Spawning devices in the form of broken concrete and terra-cotta tile are spread along the shore under 6" to 8" of water. These ponds are one acre with an oblong shape and very regular shoreline. The bottoms are clay and gently sloped to the center which slopes into a concrete bulkhead having a 12" diameter drain. Water is supplied directly from a 2,500 acre lake through a 2" pipe.

The 12" drain runs into a concrete fish catch 12' x 8' x 3' deep which is equipped with sloped grates to allow water to flow through but cause the fish to slide into the fish catch. This type of construction allows easy seining if desired to partially harvest the muskellunge or total harvest by draining into the fish catch. The fish catch can be supplied with fresh water if necessary during harvest.

Each of these one acre ponds has a .5 acre pond within 30' at a higher elevation; each of these .5 acre ponds are also stocked with brood fathead minnows and are constructed to drain into one of the one acre muskellunge rearing ponds. This allows supplemental feeding of the one acre pond at any time during the rearing period.

Each one acre rearing pond is stocked with 1,500 2" muskellunge in early July. Harvest records show that these particular ponds have a higher percent of survival of muskellunge at this rate, generally exceeding 70 percent, harvested fingerling average 110 pounds per 1,000 fish. Stocking with 1,750, 1,800 and 2,000 muskellunge resulted in 50 percent or less survival. One other larger pond of 5.5 acres is stocked at the same rate and percent of survival is usually similar to one acre ponds.

Summary

Those ponds having high volume of flow consistently produce more pounds of fathead forage than those of equal size with less flow.

New design of pond draining facilities including a catch basin and separate forage rearing ponds for supplemental feed have reduced amount of time required to harvest muskellunge fingerling.

- COMMENTS AND QUESTIONS -

CLARK - Less than 30 percent of Pennsylvania's musky fingerlings are produced in nursery ponds; over 70 percent are reared intensively in various-sized tanks.

JOHN KLINGBIEL (Wisconsin) - Why does more flow through the pond result in a better minnow production?

CLARK - The water supply comes from a 2500-acre lake which has a real good plankton population; the higher flow supplies more plankton from the lake to the minnows. We also feed the minnows at a rate of about 1/2 pound per pond per day. Ponds generally are not fertilized. When they are, sheep manure is used.

QUESTION (Unidentified) - How long are the musky kept in the ponds?

CLARK - About 110 to 120 days, unless the forage runs out earlier. The musky are stocked into the ponds at a size of two inches. They are reared to two inches on brine shrimp and daphnia (we may or may not feed minnows or small suckers in the building before the musky go to the ponds). The time period from musky swim-up to two inches is about four to five weeks.

KENNETH WALKER (Wisconsin) - At the Spooner Hatchery, we stock 10 pounds of brood fathead minnows to the acre. The minnows are 100 to 110/pound. In the past, we have stocked five pounds to the acre and production seemed to be just as good. We don't fertilize the ponds anymore. Also, at Spooner, the musky are selective as to the size of minnow wanted - they will not utilize the very small minnows until the others are gone.

Report of Muskellunge Management in Minnesota - 1973

By: Stanley A. Daley
Fish Production Coordinator
Minnesota Department of Natural Resources
Division of Game and Fish
Section of Fisheries

1973 MUSKELLUNGE PROGRAM

Spawning Operation

Muskellunge were spawned at seven locations in 1973. Stripping crews handled 822 adult fish. There were 98 productive females that yielded 33 3/4 quarts (2,169,200) of eggs. Egg production, by location, is summarized in Table I.

Rush Lake, Chisago County, is now established as a major source of eggs in south central Minnesota. In 1973, Rush Lake produced 921,700 muskellunge eggs.

Hatching

In 1973, muskellunge eggs were hatched at Park Rapids, Cut Foot, and St. Paul. Total production from these hatcheries was 730,200 fry (Table II).

Overall hatching success was 34 percent and ranged from 11 percent to 49 percent on individual egg lots.

Rearing

Three state drainable ponds were used as nursery ponds to produce 1 1/2 inch fingerlings for transfer to expansion ponds for advanced rearing. Nursery ponds were stocked with a total of 448,500 fry (Table III).

Ten expansion ponds were used for muskellunge rearing. Altogether, 65,363 fingerlings were cropped from nursery ponds and transferred to expansion ponds for rearing to 8-inch to 12-inch size (Table IV).

In addition to nursery ponds, fry were also stocked in four ponds (Deer Lake, Tent, Muskies Inc., Ten Section) with the intention of rearing fish to yearling[1] size to be harvested in the fall.

For a description of rearing methods, refer to the 1972 "Report of Muskellunge Management in Minnesota".

Production

Table V summarizes yearling production. The total harvest from all ponds was 26,496 fish that weighed 4,838 pounds.

Stocking

Yearlings were stocked in 33 lakes in 13 counties, and at several locations on the St. Croix and Mississippi Rivers. Balsam Lake and North Star Lake in Itasca County were stocked with surplus fry. See Table VI for a detailed list of 1973 muskellunge distribution.

[1] Yearling are fish that have spent a growing season (summer) in a pond.

No new lakes were designated for muskellunge management in 1973.

Cost Analysis

Muskellunge program operational costs for 1973 were as follows:

Muskellunge Spawning	$ 5,198
Sucker Spawning	3,066
Muskellunge & Sucker Hatching	2,676
Muskellunge Pond Operation	14,258
Miscellaneous Costs	650
	$25,848

It costs $5.35 a pound to produce muskellunge this year compared to $7.80 per pound in 1972 and $11.26 per pound in 1971. These costs are comparable to other agencies that have musky rearing programs similar to Minnesota's.

Discussion

An experimental egg fertilization method using lake water heated to 49° or 50° was tried at Rush Lake. First year results were inconclusive and this method should be tried again.

A new water temperature control system on the St. Paul hatching battery worked good. After the hatching season, a separate musky battery was installed at St. Paul. This will prevent the build-up of sucker egg shells in musky fry trays, which causes fungus to form.

It was again apparent that it would be desirable to have some late hatched sucker fry for nursery ponds, as the early stocked sucker fry are usually depleted before fingerlings are ready to be moved to expansion ponds.

Fathead reproduction in expansion ponds was adequate to provide early forage, and few problems were experienced in obtaining minnows from bait dealers when required.

At Park Rapids we installed a water temperature control system on the hatching battery that utilizes a 50 gallon gas water heater with a solenoid valve that supplies heated water on demand. This is an inexpensive system that is easy to install and works very well within a 2 degree temperature range. In 1974, a second system will be installed so that separate temperatures can be maintained on the sucker battery.

After the 1973 hatching season, a new well was drilled at Park Rapids. This will provide chilling water on the hatching batteries when it is desired to retard the hatch.

An outlet should be constructed on Pond #2 at Park Rapids so this pond can be filled and drained independent of Pond #1. Presently, there is a combination inlet-outlet that serves both ponds. The outlet system on Ponds 1 and 3 at Hinckley also needs attention.

TABLE I
1973 Muskellunge Stripping Locations and Egg Production

Lake	Adults	Females Stripped	Quarts	Eggs
Rush Lake	279	39	13 1/2	921,700
Big Mantrap	338	28	10 3/4	666,500
Deer Lake	-0-	-0-	-0-	-0-
Little Moose	6	1	3/4	39,200
Little Long	184	30	8 3/4	541,800
Moccasin	12	-0-	-0-	-0-
Wabedo	3	-0-	-0-	-0-
Total	822	98	33 3/4	2,169,200

TABLE II
Muskellunge Hatching

Hatchery	Egg Source	Eggs	Hatch	Fry
Park Rapids	Big Mantrap	666,500	19%	124,000
St. Paul	Rush Lake	991,700	49%	447,500
Cut Foot	Little Moose	39,200	11%	3,900
	Little Long	541,800	29%	154,800
Total		2,169,200	34%	730,200

TABLE III
Muskellunge Fry Stocking in Ponds

Pond	No. of Fry Stocked	Production
St. Croix Pond (Nursery Pond)	169,500	17,220 fgl.
Hinckley Pond #1 (Nursery Pond)	169,500	41,300 fgl.
Hinckley Pond #1		2,670 yrl.
Park Rapids Pond #1 (Nursery Pond)	109,500	6,843 fgl.
Deer Lake Pond	3,900	-0-
Tent Pond	5,000	603 yrl.
Muskies, Inc.	62,000	1,778 yrl.
Ten Section	62,000	50 yrl.
Total	581,400	65,363 fgl. 5,101 yrl.

TABLE IV

Muskellunge Fingerling Stocking In Expansion Ponds

Pond	Fingerlings Stocked	Yearlings Harvested
Hinckley #2	15,000	6,280 (41.9%)
Hinckley #3	15,000	6,996 (46.6%)
Park Rapids #2	5,498	1,400 (25.5%)
Park Rapids #3	5,175	2,495 (48.2%)
Straight Lake #3	6,870	1,952 (28.4%)
Winnie #2	4,160	255 (6.1%)
Winnie #4	1,560	290 (18.6%)
Grassy Lake	5,200	699 (13.4%)
Cub Lake	1,900	370 (19.5%)
Carlos Avery	5,000	375 (7.5%)
Total	65,363	21,112 (32.3%)

TABLE V

Muskellunge Yearling Production 1973

Pond	Number	Pounds	Rate
Hinckley #1	2,670	445	6/lb.
Hinckley #2	6,280	1,256	5/lb.
Hinckley #3	6,996	1,166	6/lb.
Carlos Avery	375	75	5/lb.
Park Rapids #1	275	46	6/lb.
Park Rapids #2	1,400	232	6/lb.
Park Rapids #3	2,495	311	8/lb.
Straight Lake #2	1,952	244	8/lb.
Cub Lake	366*	263	3/4 lb. ea.
Cub Lake	12	1.5	8/lb.
Grassy Lake	699	232	3/lb.
Tent Pond	603	51	11.8 /lb.
Winnie #2	255	51	5/lb.
Winnie #4	290	58	5/lb.
Muskies, Inc.	1,778	356	5/lb.
Ten Section	50**	50	1 lb. ea.
Total	26,496	4,837.5	5.5/ lb. Av.

* Apparent carry-over from 1972

** Estimated number released into Pike Bay of Cass Lake

TABLE VI
Muskellunge Distribution 1973

Lake/Stream	County	Size	Fish Number	Weight	Source of Fish (Pond)
Baby	Cass	yrl.	707	176.5	10(57);9(50);2(600)
Balsam	Itasca	Fry	48,810		
West Battle	Otter Tail	yrl.	1,328	194	7(950);15(378)
Big	Beltrami	yrl.	800	160	2(400);8(400)
Little Boy	Cass	yrl.	710	170	15(200);10(210);2(300)
Cass	Beltrami	yrl.	850	210	2(400);8(400);11(50)
Child	Cass	yrl.	400	50	8(400)
Deer (nr. Effie)	Itasca	yrl.	900	180	2(900)
Deer (nr. Deer R.)	Itasca	yrl.	1,043	176	3(978);13(65)
Dumbell	Lake	yrl.	603	51	14(603)
Howard	Cass	yrl.	360	245	9(300);10(60)
Independence	Hennepin	yrl.	1,002	167	1(1002)
Inguadona	Cass	yrl.	630	127.5	8(320);9(20);10(130);15(160)
Island	St. Louis	yrl.	498	83	3(498)
Island	Itasca	yrl.	105	21	12(105)
Latoka	Douglas	yrl.	175	58	15(175)
Lobster	Douglas	yrl.	375	62.5	3(375)
Long	Itasca	yrl.	254	44	3(204);13(50)
Mann	Cass	yrl.	160	32	15(160)
Big Mantrap	Hubbard	yrl.	1,675	224	6(375);7(1300)
Mississippi R.	Benton	yrl.	700	133	2(500);3(200)
Mississippi R.	Crow Wing	yrl.	900	166	2(500);3(400)
Mississippi R.	Itasca	yrl.	300	60	2(300)
Mississippi R.	Stearns	yrl.	375	62.5	3(375)
Moose	Itasca	yrl.	498	83	3(498)
Little Moose	Itasca	yrl.	240	48	12(150);13(90)
North Star	Itasca	Fry	100,000		
Norway	Kandiyohi	yrl.	400	80	15(400)
Portage	Cass	yrl.	18	6	10(18)
Pughole	Itasca	yrl.	85	17	13(85)
West Rush	Chisago	yrl.	2,976	496	1(1668);3(1308)
Big Sand	Hubbard	yrl.	920	148	6(800);7(120)
Little Sand	Hubbard	yrl.	625	99	5(275);6(225);7(125)
Spider	Itasca	yrl.	798	143	2(300);3(498)
St. Croix R.	Pine-Chisago	yrl.	1,038	173	3(1038)
St. Croix R.	Washington	yrl.	780	156	2(789)
Big Swan	Todd	yrl.	100	20	15(100)
Sugar	Wright	yrl.	999	179	3(624);4(375)
South Twin	Beltrami	yrl.	200	40	2(200)
Wabedo	Cass	yrl.	676	145	2(600);10(76)
Woman	Cass	yrl.	1,132	194	2(500);8(432);15(200)
Total yearlings stocked			26,335	4,880	
Total fry stocked			148,810		

Pond Key

1. Hinckley #1
2. Hinckley #2
3. Hinckley #3
4. Carlos Avery
5. Park Rapids #1
6. Park Rapids #2
7. Park Rapids #3
8. Straight Lake #2
9. Cub Lake
10. Grassy Lake
11. Ten Section
12. Winnie #2
13. Winnie #4
14. Tent Pond
15. Muskies, Inc.

A Summary of the Diseases and Treatments Administered
In The Cool Water Diet Testing Program

By: John G. Hnath
Michigan Department of Natural Resources
Fisheries Division

Dr. Leo E. Orme has been directing for the past four years a program for testing and evaluation of artificial diets for the culturing of traditional cool water fishes. With direction and coordination from Dr. Orme's Diet Testing Development Center at Spearfish, South Dakota, workers in various areas of the United States have been involved in segments of the diet testing program.

One of the most predictable results of such a program has been the realization that intensive culturing and artificial feeds in warm waters sets the scene for some rather serious, often catastrophic, fish disease problems. These problems are in many ways similar to those encountered in the rearing of salmonids on artificial diets. But the problems are also unique in that the elevated temperatures used for cool water species (as opposed to salmonids) provide an optimum environment for the growth and rapid multiplication of most of the microorganisms causing disease in fish. The problems are also compounded by the lack of experience and basic information on just what treatments can be used successfully and under what circumstances. The excellent compendium by Drs. Hoffman and Meyer published earlier this year[1] provides a well-organized and extremely valuable starting point for the application of "standard" treatments to intensively-reared cool water species. However, as one tries to apply treatments to these situations, he soon finds that no one has ever reported the successful treatment of fungus on walleye fry, or bacterial gill disease on northern pike X muskellunge hybrid fry. This summary, then, proposes nothing more than to indicate to others some treatments that have been applied, and the results. No attempt has been made to be dogmatic in saying that some particular method will or will not work under other circumstances. And in most cases the rigors of scientific experimentation with replicates and controls have not been applied. Let this serve, if it may, as an introduction to the subject. My appreciation is gratefully extended to all the contributors as listed in the reference key for permission to include their work in this summary.

Summary

The disease problems attendant with intensive culture and artificial feeding of cool water fishes may be catastrophic, but many problems can be eliminated or greatly reduced by appropriate prophylactic measures. Summarized here are the problems and remedies tried in various segments of the above diet testing program, and at Wolf Lake Hatchery in 1972:

Species - Walleye

PROBLEM	TREATMENT	RESULTS	REFERENCE
Egg disinfection	Wescodyne 1:150 for 10 minutes	no adverse affects	1
Columnaris (84°F water)	Formalin at 1:6000 for 20 minutes & cooler water	no apparent affect	2

[1] Hoffman, G.L., and F.P. Meyer, 1974. Parasites of Freshwater Fishes; A Review of Their Control and Treatment, TFH Publications, Neptune City, N.J.

PROBLEM	TREATMENT	RESULTS	REFERENCE
Columnaris	Hyamine 3500 used at 2ppm for 45 minutes on 3 consecutive days	no new cases appeared	2
ICH	Formalin at 1:4000 for 1 hour	killed all fish	4, 5
ICH	Formalin at 1:6000 for 1 hour	ineffective	4
Bacterial gill disease	Roccal at 2ppm for 1 hour (must be rinsed well)	effective	4
Bacterial gill disease	Hyamine 3500 at 2 ppm active	effective	4, 5
Unnamed external parasites	Formalin at 1:6000	effective	5
Furunculosis	Terramycin at 4% in diet	controlled symptoms, mortality continued	5
Fin rot	Acriflavine 5 ppm for 1 hour	effective	4
Fin rot	Hyamine 3500 used 1 time weekly prophylactically	prevented disease	4
Unnamed external parasites	2% salt dip	effective	6
NORTHERN PIKE			
Egg disinfection	Wescodyne 1:150 for 10 minutes	no adverse affects	1
Bacterial gill disease	Acriflavine 5 ppm for 1 hour	inconsistent	4
Bacterial gill disease	Hyamine 3500 at 2ppm 1 hour on 2 consecutive days	effective	4
NORTHERN PIKE X MUSKELLUNGE			
Prophylactic	Formalin at 1:2000 for 1 hour daily	prevented any disease problems	3
Costia	Formalin at 1:3000 for 1 hour daily	ineffective	6

PROBLEM	TREATMENT	RESULTS	REFERENCE
Fungus	Formalin at 1:4000 for 1 hour daily	ineffective	5
External protozoans	Formalin at 1:4000 for 1 hour	effective	5
Gill Bacteria	Hyamine 3500 at 2ppm	effective	5
Furunculosis	Terramycin at 4% in diet	ineffective	5
Lernaea	Dylox at 0.25 ppm static	lethal to fish	7
SMALLMOUTH BASS			
ICH	Formalin at 1:4000 for 3 weeks continuous	effective	5
Fungus	Formalin at 1:4000 for 3 weeks continuous	ineffective	5
Bacterial gill diesease	Hymine 3500 or Roccal at 2 ppm active for 1 hour	effective	4, 5
External parasites	Formalin 1:4000 or 1:6000 for 1 hour (use 1:6000 in water over 65°F)	effective	4, 6
Unnamed parasites	2% salt dip	effective	6
PADDLEFISH			
Fungus on eggs	Formalin at 1:6000 for 15 minutes daily until hatch	effective	1

Reference Key

1. Feed Test on Walleye (Stizostedion vitreum) at Gavins Point NFH
2. Dry Diet Test Results on Walleye Fry - Len Cernohous, New London Nat'l Fish Hatchery, New London, Minn. August 8, 1973
3. Report on the Artificial Diet Feeding Trial on Northern Pike x Muskellunge Hybrids at Chautauqua Hatchery, June 18, 1973
4. Dry-Diet Research at Valley City NFH by Dale R. Bast
5. Warm-water Development Report, Experimental Series A, Test 2, Smallmouth bass, walleye, tiger muskie, November 13, 1972, by James A. Copeland, Richard M. Poynter, Wolf Lake Fish Hatchery
6. Dry Diet Testing Results - 1974 Pennsylvania Fish Commission
7. Toxicity of Dipterex to Muskellunge 1972, by James A. Copeland, Wolf Lake Fish Hathcery, October 18, 1972

- COMMENTS AND QUESTIONS -

A Summary of the Diseases and Treatments Administered in the Cool Water Diet Testing Program

John Schrouder, Michigan

TIM NAGEL (Ohio) - We had a problem with Lernaea on some muskellunge broodstock. A static treatment with Dylox in aquaria did no good. Outside ponds were treated with 1/4 ppm Dylox for five consecutive weeks and we got control of Lernaea without ill effects to the musky.

O.L. GREEN (USFWS) - It is better not to use dylox on fish which have both a Lernaea infection and a bacterial infection - fish kills can result, based on our experience.

[Insert: It was reported at a past workshop by Tennessee that dylox can be very toxic to muskellunge broodstock.]

IOWA - We use treatments of Furacin on muskellunge at a rate of 5 ppm for one hour for three consecutive days (the notes didn't show whether this was a prophylactic treatment or for a specific type of disease).

Gill Rot of Pike

By: James W. Warren
Hatchery Biology Laboratory
Genoa, Wisconsin

A serious fungal infection of the gills of fish has been reported in Europe since the early days of organized fish disease investigations. The disease has been named "Branchiomycosis" which is derived from the terms "branchial", which pertains to the gills, and "mycosis", which pertains to fungal infections. Since the disease was first identified in Europe, and has been reported most frequently there, it has been given the common name of "European Gill Rot". This has been more recently split into two diseases based upon the species of fish involved and the fact that two different species of fungus have been identified. Thus we have Gill Rot of Carp (which is not restricted to carp, by the way) and Gill Rot of Pike. Fred Meyer and Jordan Robinson, at Stuttgart, Arkansas (PFC, Vol. 35, #2) diagnosed cases of Gill Rot of Carp in striped bass and largemouth bass. Several other species have also been reported as being infected. These fish were infected with Branchiomyces sanguinis, the etiological agent of Gill Rot of Carp. This disease has yet to be encountered in more of the northern states. A very closely related form, caused by Branchiomyces demigrans, has caused a serious loss of wild, 2 year-old northern pike in Wisconsin and has been diagnosed in a Missouri hatchery in young-of-the-year northern pike of Michigan origin. Whether the disease was introduced to Missouri from Michigan or was of local origin is unknown.

Gill Rot of Pike is not difficult to diagnose. Early symptoms are those typical of an oxygen deficiency. In support of this preliminary diagnosis would be the virtual absence of disease signs indicating an infectious disease. There are no lesions on the body surface and no hemorrhagic areas or inflammations internally. The fish, except for being dead, are in apparent good condition. The course of the disease is acute and mortalities mount rapidly with little development of secondary infections or symtoms. Routine examination of the gills, however, illustrates immediately that gill damage is the cause of death. Columnaris might logically be expected, but instead of well defined, whitish necrotic areas in the gills commonly found with Columnaris, one encounters denuded gill filaments and greenish or brownish masses of debris. This debris is composed of necrotic tissue, mucus, fungal hyphae and miscellaneous algae trapped in the affected areas. The distal portions of the filaments are often matted with this material but appear more normal at the base. Microscopic examination of affected northern pike gill tissue, in a simple wet mount under a cover slip, will reveal non-septate hyphae filled with round spores. These spore-filled hyphae appear in tangled masses which penetrate the gill tissue and resemble BB-filled tubes which immediately catch ones attention. This observation, when made on samples from several fish, is sufficient for a presumptive diagnosis of Gill Rot of Pike. Tissue samples should be preserved in 10 percent formalin for histological confirmation of the disease.

Gill Rot of Pike is commonly associated with hot summer weather even though water temperatures have not risen drastically. In July 1973, an outbreak involving 20,000 to 25,000 northern pike ranging in size from 16 to 24 inches occurred in the lower reaches of the Fox River in Eastern Wisconsin near Oshkosh. The on-set of the mortality was rather abrupt with most of the losses occurring within a three-day period. This mortality followed a spell of hot weather with afternoon air temperatures in excess of 90°F for more than two weeks. Erwin Amlacher, in his "Textbook of Fish Diseases", report that "the disease appears in summer with no apparent relation to the prevailing temperature, although in the majority of cases following a period of heat. It is occasionally observed in May, with low water temperatures (14°C.). Its course is very rapid (2 to 4 days), so much so that the fish pathologist is usually unable to find any fungi"... for the first few days after the onset. Waters rich in nutritive organic matter have also been found to favor the appearance of the disease. Dense phytoplankton blooms, dense fish populations and temperatures in excess of 20°C are other important factors reported.

The real threat of Gill Rot of Pike is yet to be determined. We have seen its affects in valuable pike populations both in the wild and in the hatchery. There is no therapy known at present. Sanitation and prevention are our only tools of disease control. At the recent Fish Health Section Workshop in Denver, Colorado, gill rot was one of the four parasitic diseases singled out for attention during the drafting of tentative standard diagnostic procedures. Whirling disease, Ceratomyxa shasta, and Ichthyophonus were the others. Close observation of pike for the presence of Branchiomyces demigrans should be established as an on-going portion of pike management. The Genoa Laboratory will provide any assistance possible to aid in the diagnosis, confirmation and control of this problem.

- COMMENTS AND QUESTIONS -

Joe Webster, USFWS

JOHN KLINGBIEL (Wisconsin) - This mortality occurred in a 2,000-acre lake (flowage-type lake). Prior to the kill, there was a drastic increase of northern pike in the lake, partially due to a movement of northern pike downstream into the lake. We don't think all the northern pike were killed.

MAYO MARTIN (USFWS) - Meyer and Robinson were able to control this disease but not eliminate it in hatchery ponds (Mayo couldn't recall the chemical, but a check of the literature showed it was formalin). Thorough drying or sterilization of ponds seems to eliminate the disease.

OHIO - We had a fish kill at Piedmont Lake last summer after a period of hot weather. The agent was Aeromonas liquefaciens and the kill seemed to be somewhat selective towards 14" to 16" musky.

Muskellunge Fry Production By Pond Spawning
At The
Minor E. Clark Hatchery, Kentucky

Introduction

The Minor E. Clark Hatchery, designed for the artificial propagation of muskellunge, has been in production for two years. During this period, there has not been sufficient water pressure to operate the hatching jars, so muskellunge fry could not be produced artificially. Due to this problem, pond spawning by native broodstock was utilized to produce muskellunge fry.

A literature review indicated that several researchers have tried to produce muskellunge fry by this method with little success. Ohio researchers seem to have been the most prominent in their attempts. From 1949 through 1951, they introduced muskellunge brood fish into ponds and created conditions thought to be inducive to spawning. The results were so poor that they concluded that this was not a practical method of muskellunge fry production. Later, Clark (1964) reported limited success at the Kincaid Hatchery in Ohio from 1960 to 1962. Muskellunge spawning activities were noted several times and a high of 530 fingerlings were produced in 1961.

Methods

Spawning Ponds

Four one-acre ponds were used for production in 1973 and five ponds in 1974. Each of the ponds ranged in depth from 4.5 feet to 2.2 feet, had a bottom composition of sandy loam, and the banks completely rip-rapped with large crushed limestone rock. Each of the ponds could be filled from either the shallow or deep end. Certain precautions were taken to enhance muskellunge reproduction.

Predation on muskellunge eggs and fry by other fish and invertebrates is known to limit muskellunge reproduction. To eliminate this factor, the spawning ponds were filled approximately one month before broodstock introduction, and as the ponds were filled a saran bag filter (0.25mm) was placed over the inflow pipe to prohibit wild fish from entering the pond. As soon as fry were evident within a pond, the brood fish were removed to reduce cannibalism. Predacious insects were controlled by a four gallon treatment of diesel fuel every two weeks.

Another limiting factor to successful reproduction is the quantity and size of live zooplankton and forage fish available for fry. We developed a good zooplankton bloom in each of our ponds by the addition of 20 bales of hay. Eight to ten bales were added to each pond just before broodstock introduction and the remainder was added two weeks later. As soon as the fry reached 1/2 to 3/4 inches long, they were transferred to rearing ponds containing fathead minnows and goldfish. This assured an ample supply of forage. Water level fluctuation, another detrimental factor to successful reproduction was eliminated by periodically backfilling the ponds.

Successful spawning can also be correlated with the presence of a suitable spawning site. Brewer (1970) found that muskellunge in Kentucky spawn best in shallow water where there is an abundance of organic matter along the bank. Apparently in most streams, these shallow water spawning sites are associated with low gradient pools and have substrates dominated by large gravel and rubble, although some suspected sites have considerable sand deposits. As was mentioned previously, hay was added to the ponds for zooplankton production, but it also simulated the organic vegetation that is usually associated with typical spawning sites. The crushed rock along the banks and the bottom composition of sandy loam also helped to create a favorable spawning site. In order to create a small current within some of the ponds, water was piped from the shallow end of the pond and allowed to run over the spillway of the kettle. Each pond was checked daily to determine spawning activity, fry occurence, and water temperature.

Broodstock

We have been collecting native muskellunge broodstock from the streams of northeastern Kentucky since 1970. By the spring of 1973, there were 41 brood fish to use for the pond spawning and in 1974, there were 49 muskellunge available.

Each year, 9 to 11 fish were introduced into a one-acre spawning pond. An attempt was made to place the fish into separate ponds according to the year they were captured, although some integration occured. They were placed into the ponds around the latter part of March and the first half of April, just as the water temperature approached 50°F. They were given ample time to spawn and usually removed the second and third weeks of May, after fry production was evident. Even though most of the brood fish were in the ponds a month or longer without food, they all seemed to be in good shape when removed. None showed signs of ripeness at the time of removal.

Results

Spawning

Spawning activities were observed three times in two ponds in 1973. These ponds contained fish that were captured in late 1972 and early 1973. Water temperature at the time of spawning ranged from 52°-60°F. In 1974, only 1 pair of fish were seen spawning and this was in the pond containing brood fish captured in 1971. Water temperature at this time was 66°F.

Fry

Both years, fry were initially noted in the spawning ponds approximately 30-40 days after broodstock introduction. Soon after they were evident, they were removed from the spawning ponds and transferred to rearing ponds, containing fathead minnows and goldfish.

In 1973, fry transfer from the spawning ponds to rearing ponds was incomplete. A total of 45,000 fry were removed by using a sealed beam light at night for attraction. The fry were then dipped with an aquarium net and stocked at a rate of 2,000 per acre in 15 one-acre rearing ponds and one 7.5-acre pond. An approximate 20,000 to 25,000 fry were left in four spawning ponds. Total fry production for 1973 was estimated at 60,000 to 65,000 fish.

In 1974, the fry were completely removed from the five spawning ponds. A total of 37,800 fry were stocked at rates varying from 2,000 to 10,000 fish per acre into the fingerling rearing ponds. Most of the fry were removed from the spawning pond by glass V traps.

TWO YEAR PRODUCTION FIGURES

Pond No.	Year Fish Collected	No. Present in Pond	No. Fry Produced	No. Fingerlings Produced in Spawning Ponds
1973				
37	1970	11	4,450	638
38	1972, 1973	10	19,500	12
43	1970, 1971	10	6,000	1,044
44	1973	10	15,000	560
			44,950	2,254
1974				
37	1970	9	4,173	
38	1973	10	4,612	
43	1970, 1971	10	9,261	
44	1973, 1974	10	150	
45	1973, 1974	10	19,580	
			37,776	

Fingerling Production

In 1973, 2,980 fingerlings (6 to 12 inches) were produced from the 45,000 fry originally stocked into the rearing ponds. This represented a 6.6% return. Another 2,270 fingerlings (6 to 12 inches) were raised in the original spawning ponds. This brought total fingerling production for 1973 to 5,250 fish.

In 1974, fingerling production was increased by continuously adding small goldfish or fathead minnows to the rearing ponds. A total of 10,300 muskellunge (5 inches) were raised from the 37,800 fry stocked into the rearing ponds. This represented a 27% return. The ponds that were stocked at the lower rates were those with the highest percent yield.

LITERATURE CITED

Brewer, Daniel L. 1970. Muskies Studies. Annual Job Progress Report, Kentucky Department of Fish and Wildlife. 38 pp.

Clark, Clarence F. 1964. Muskellunge in Ohio and Its Management. Ohio Department of Natural Resources. Publication W-329: 1-13

A Domestic Muskellunge Broodstock

By: Ray Phillips
U. S. Fish and Wildlife Service

The Valley City National Fish Hatchery maintains two generations of muskellunge broodstock - a nine-year old and four-year old population. These fish are held in .78 and .87 acre ponds. At the present time, there are 35 nine-year old first generation fish with an average weight of 11.2 lbs. and an average length of 31.1 inches. There are 46 four-year old second generation muskies. These have an average weight of 5.6 lbs. and an average length of 28.0 inches.

The second generation muskellunge appear to be deeper bodied than were the first generation muskies when they were five years old. The second generation females were apparently sexually mature at four years of age. Eggs from the four-year old fish hatched out. However, the estimated 92,500 eggs from these fish had many cripples when the eggs hatched. These fry died within a few days. Length in inches of four-year old fish compares favorably with wild stream populations of fish both in Tennessee and Wisconsin.

Forage fish for both year classes of muskellunge consists of fathead minnows and white suckers either bought commercially or else trapped locally.

Seven hundred and two pounds of combined four and nine-year old muskies held in a .78 acre pond consumed approximately 700 pounds of forage over a 3 month period between May 21, 1974 and August 26, 1974.

Brood ponds are pulled down in the spring when water temperatures in the ponds are about 50°F. In 1973, when the first generation fish were checked, we found that three to four fish were partially spawned out. Only two fish ripened naturally for egg taking. The remainder of the fish, except for five females and three males were injected with 2 mg. of carp pituitary per pound of body weight. Over 500,000 eggs were taken. However, the eggs were of poor quality. Only a small percent of these eggs hatched. Fish which had started to absorb their eggs were also injected at the standard rate. There was a heavy loss of these fish. This reaffirmed our previous work which had shown that when there is any evidence of egg reabsorbtion, the fish should not be injected.

Egg and fry production in 1974 was much better, with 551,250 eggs taken from all but one female which had been injected with pituitary. There was an approximate 30% eye up of these eggs with a percent hatch of 22.3%. Four-year old muskellunge females produced 2 1/3 quarts of eggs; however as mentioned earlier most of the fry were deformed and died within a few days.

Five female nine-year old muskies and three males were again stocked in a grassy 1 acre pond for natural spawning. When this pond was drained in July only 25 three to four inch fish were removed.

1975 should show a good supply of eggs produced from the second generation broodstock. Some of the fry from these fish will be held to produce a third generation broodstock.

- COMMENTS -

A Domestic Muskellunge Broodstock
Ray Phillips, USFWS

During 1965, the U.S. Fish and Wildlife Service decided to rear musky to a broodstock size. Musky fingerlings were obtained from the state of Wisconsin. During October, 1966, Valley City National Fish Hatchery received 75 of these musky.

The second generation musky seem easier to handle.

During 1973, the per cent egg hatch was about 10% (range 2% to 50%). During 1974, a total of 552,000 eggs were taken from 15 female musky and per cent hatch was about 22% (range 8% to 60%).

In the past, muskellunge were hauled from the pond in 2 ppm Acriflavine and then anesthetized with a combination of MS-222 and Quinaldine Sulphate. Apparently, the combination of acriflavine and anesthetic was too much for the fish and some died (gill filaments were ruptured). Presently, the eggs are taken without the use of anesthetics. Hyamine 3500 at 2 ppm is used for prophylactic treatment of the broodstock.

IOWA - All our musky are injected.

Intensive Culture of Muskellunge in Pennsylvania

By: T.L. Clark, Superintendent
Linesville Fish Cultural Station

Intensive culture of muskellunge in Pennsylvania has remained basically the same since 1965. Some changes in feeding, treating and rearing units have taken place and will be discussed. Statistical data on production varies from one station to the other primarily due to water quality and physical structure.

Hatching and Fry Care

Just prior to hatching, the eggs are thoroughly cleaned and placed in pans to hatch. After hatching, the sac fry are rinsed of shells and placed in tanks varying in sizes from 1.5' x 1.5' x 8' to 2.0' x 2.5' x 30'. Average water temperature at this time at most stations is in the low 50°'s. Two stations have temperature control units and begin to warm the water on the sac fry during the first few days. One station had an excellent sac fry to swim up survival by hatching in 51° and warming to 68° in approximately 100 hours. The fry swim up in 11 to 12 days.

All stations rearing muskellunge are now equipped to hatch brine shrimp in sufficient amounts to sustain large numbers of fry until stocking, retaining a predetermined number for rearing to fingerling size. If possible, the fry retained for rearing are the same age but not from the same brood fish; this is done to elimate possible genetic problems. It appears there is a good possibility the brine shrimp may completely replace daphnia as a food for muskellunge fry as there are cases where the muskellunge have been grown to 2" on shrimp. This replacement would eliminate the need for the numerous daphnia units now required and give total control of food requirements. Depending on water source, the fry may or may not be treated with formalin.

Fingerling Rearing

Over 70 percent of Pennsylvania's muskellunge fingerling are reared in tanks the size aforementioned. Availability of forage species, usually suckers and fathead minnows and size of the muskellunge are the determining factors in timing when changing from shrimp or daphnia to live forage. Use of water temperature control units has made it possible to incubate and hold sucker fry in 50° well water while advancing the muskellunge as rapidly as possible on the heated water and thereby utilize all available suckers for muskellunge forage. Until these temperature control units were used, the sucker fry were too far advanced to use as feed for muskellunge in Pennsylvania. The amounts of forage available also determines the numbers of muskellunge to be changed from crustacean to forage fish within 8 to 10 days when they are approximately 1 1/2 inches. When the fish are approximately 2" most stations using heated water change the supply to a natural source of ponds or lakes. Usually during the first week in July another inventory is conducted. The number to be retained on the hatchery proper are either stocked in rearing ponds or set up in tanks; any surplus is stocked in public fishing waters.

The numbers set up to rear intensively varies from station to station, but generally the end result will produce approximately .75 pounds of fish per cubic foot of available space. To date one of the more practical and cost saving methods produced only .25 pounds per cubic foot. In this instance 2" fingerling were set up in seven concrete races 8' x 3' x 60'. Rearing fingerling in these outside races produced a larger fish at less expense since daily cleaning was eliminated but allowed continual observation, treating and ease of harvesting. The better growth rate may be due to lower densities. During the rearing period, usually July 10th to October 1st, the muskellunge are fed any available forage, usually fathead minnows. Depending on the locale they are treated four to seven times weekly with formalin 1:4000 flow for one hour for external parasites and Hyamine 3500 at varying dosages for bacterial gill disease.

Statistical data for the three major rearing units are:

	Concrete Races	Concrete Tank	Steel Tank
Dimension	8' x 3' x 60'	2.5'x 2' x 30'	20" x 20" x 10'
Flow	17-34	12	6
Exc./Hr.	.4/hr.	1.02/hr.	2/hr.
D.O.	8 p.p.m. Maximum	4-7 p.p.m.	4-8 p.p.m.
No./Ft.^{3}	2.5	10	23
Lbs./Ft.^{3}	.25	.65	1.1
Temperature	60-75°	60-75°	60-75°
Fing. Size	8-10"	6-9"	6-9"
Weight	9.6/c	6.2/c	5.2/c
Lbs./G.P.M.	5.0	6.0	9.0

Intensive culture of the tiger muskellunge (northern pike crossed with muskellunge) follows the same method during fry and early fingerling stage. Instead of changing from crustacean to minnows these fish are confined under automatic feeders which are timed to dispense proper size pellets at fifteen minute intervals. During the training period both daphnia and dry feed are administered gradually declining amounts of daphnia. Ten to fourteen days are usually required to make this transition on 1 1/2" to 2" fish. During the training period approximately 5,000 fish were confined in a 2' x 2' x 4' section of tank. When the fish "outgrow" this area they are transferred to larger units of various size, depending on locale. If necessary, the fish are graded during transfer to remove the possibility of canabalism which does not appear to be a major problem if all the fish are feeding on the dry diet and they are relatively the same size. During the initial period after transfer to larger units, the fish are confined in order to be kept in close proximity to the feed which is/remains timed to dispense every fifteen minutes. At one station the tanks were partially covered with black plastic stretched over lightweight frames to afford cover. Amounts of feed were regulated so only a small amount would pile on the tank bottom; tanks were cleaned daily and daily losses recorded. Size of feed was increased to match growth rate. Statistics for eight rearing units at Linesville are as follows:

		UNIT
Dimension	-	2.5' x 1.5' x 30' (confined to 20')
Flow	-	12 G.P.M.
Exc./Hr.	-	1.0
D.O.	-	8 p.p.m. maximum
No. /Ft.^{3}	-	33
Lbs. / Ft.^{3}	-	1.48
Temperature	-	68-70° - controlled
Fing. Size	-	6.54"
Weight	-	4.8/c
Lbs./G.P.M.	-	7.5

These fish did not exhibit excessive active feeding except when the feeders were shut off for a period of five to six hours then reactivated. The rearing period was from June 15th to September 6th with a 97.2 percent starting with a 2" fish.

Summary

Muskellunge are cultured intensively at six stations in Pennsylvania, all of which use the same basic method. State figures show 1,052,000 fry and 69,185 fingerling over 6" were stocked in the period July 1973 to June 1974. Installation of temperature control units which warm well water and widespread use of brine shrimp have given considerably more control to the fish culturist intensively culturing muskellunge to fingerling size. For the most part, the majority of losses are attributed to disease rather than poor technique.

- COMMENTS AND QUESTIONS -

Small musky are generally fed brine shrimp for 10 to 12 days. The musky are well supplied with brine shrimp and high amounts of brine shrimp are needed. Currently, brine shrimp eggs cost $20.00 to $22.00 per gallon. Brine shrimp are fed to musky five times a day; three times from 7:00 A.M. to 5:00 P.M. and two times at night.

Fathead minnows are seined from forage ponds. Seining is conducted around feeding stations. The feeding station consists of a screen cylinder (1/4 inch mesh) whose base is stuck into the pond bottom; 3/16 inch pellets are placed into the cylinder.

QUESTION - (Unidentified) - How long do brine shrimp live in fresh water?

CLARK - We feel that they can live at least 48 hours in fresh water.

Collecting, Spawning, Incubation, and Shipping of Sauger Eggs

By: David E. Ostergaard
Genoa, Wisconsin National Fish Hatchery

In the spring of 1974, adult sauger (Stizostedion canadense) were trapped in the Mississippi River by Genoa National Fish Hatchery personnel. All sauger captured were brought to the hatchery. Ripe fish were spawned immediately while green fish were held for several days in a 0.1 acre pond and periodically checked for ripeness. 1.8 million eggs were collected and 1,019,000 eggs were stocked or shipped at 6 to 12 days of age. Overall survival was 57% to "eye-up" including eggs from green fish that were held until ripening. Eye-up of eggs from river ripe fish was approximately 75%.

Collection was accomplished with the use of buffalo nets (hoop net-no lead line-7 hoops-2 throats). Seining with a 700 foot commercial seine resulted in poor catch per unit of effort. Buffalo nets were set in 6-20 feet of water in swift current and checked daily. Although sauger were found in waters traditionally trapped during the walleye run, optimum trapping return was in deeper water of sloughs or channels.

All sauger were brought to the holding house and sorted into ripe or green fish and ripe fish were spawned immediately. Green males and females were placed in a 0.1 acre pond for ripening and checked for ripeness once per day. Eggs were stripped into dry pans. A ratio of 2 males per female was used for fertilization with some reuse of the males. Water was added to the egg-sperm mixture and the eggs were allowed to water harden for 3-12 hours. No mud was used to prevent clumping. All eggs were sieved through fine mesh seine material to break up clumps. After separation, the eggs were set up in jars with a gentle roll. Eggs "eyed-up" in 9 days in 50-51 degree water. Sauger eggs appeared to be more adhesive during water hardening than walleye, however, clumps easily separated during the 3-12 hours after fertilization. Water hardened eggs averaged 210,000 per quart.

No difficulty in shipping or handling of eggs after "eye-up" occurred. Shipment was in plastic bags containing 3 gallons of water, 100,000 eggs, and oxygen.

Conclusions reached were:

1. Sauger spawning started before and continued after the conclusion of walleye spawning.

2. At no time did the sauger catch indicate a "peak" time of spawning activity as do walleye and northern pike. However, not enough trapping information was collected to conclusively demonstrate this.

3. Poor results were obtained with eggs spawned from sauger held in a pond until ready to spawn. This also correlates with previous walleye experience at Genoa NFH.

4. The sauger appeared to ripen on their own, although the eggs from fish in ponds until ripe were of poor quality. Induced spawning from pituitary should enhance eye-up from eggs spawned from penned fish. A future trial using pituitary is recommended.

5. As would be expected, the spawning habits of the sauger are similar to the walleye. Capture, spawning, incubation and shipping techniques were all similar to methods used with walleye.

- COMMENTS AND QUESTIONS -

Collecting, Spawning, Incubation, and Shipping of Sauger Eggs

By: David E. Ostergaard
Genoa, Wisconsin National Fish Hatchery

Water Hardening*	"Eye-Up"
3 Hours	79%
4 Hours	69%
12 Hours	75%

*For eggs where adults were mature at time of capture.

There were 610,000 eggs taken from "green" fish which were ripened at the hatchery - for these eggs there was a 21% survival to "eye-up".

JOHN SHROUDER (Michigan) - Why was this project carried out?

OSTERGAARD - It is part of the Great Lakes' program; we had a commitment to stock Lake Erie.

CHARLES BOWERS (Kentucky) - What were the water temperatures during capture of the adults?

OSTERGAARD - 50°F. to 58°F.

QUESTION (Unidentified) - What was the size range of the adults?

OSTERGAARD - One to three pounds.

QUESTION (Unidentified) - What was the ratio of "green" fish to "ripe" fish?

OSTERGAARD - Somewhere between 2:1 and 3:1 green to ripe. We were still getting "green" females when we stopped netting but the "bucks" had run out.

STAN DALEY (Minnesota) - We also did some sauger collecting in the Mississippi River, about 120 miles farther up the river than Ostergaard's collections. We used an A.C. shocker and ended up with about 4 to 5 quarts of "eyed" sauger eggs plus about 100 quarts of walleye eggs (this was the only place in the state where we used a shocker to collect either walleye or sauger eggs). There was no apparent damage to the fish or eggs as a result of electrofishing.

Sauger Fingerling Production at the Senecaville NFH

By: John S. Hawkinson and Charles W. Hochstetler
Senecaville, Ohio National Fish Hatchery

In April of 1974, the Senecaville Hatchery received eyed sauger eggs from the Genoa, Wisconsin National Fish Hatchery and the State of Minnesota. The eggs were tempered to hatchery water conditions for two hours and set up on the hatchery hatching battery.

Dead eggs were removed daily and a 15 minute 1:6000 formalin treatment was administered daily for control of fungus. No adverse effect on the eggs was noted.

As reported by Nelson, Hines and Beckman (1965), sauger eggs do not develop an easily distinguishable eyed stage before hatching. Hatching was similar to that of walleyes in that the fry leave the hatching jar and are collected in a collection tank. Approximately 1,069, 000 sauger fry were hatched. The fry were estimated at approximately 11,000 per ounce, somewhat smaller than walleye fry, normally about 8,000 per ounce.

Fry shipments included 365,000 to the Hebron National Fish Hatchery for fingerling rearing and 495,000 to Lake Erie for stocking by the State of Ohio. The fry were shipped in oxygen inflated plastic bags packed in insulated cardboard boxes with approximately two pounds of ice. Three gallons of water was used in each box to hold 75,000 fry.

The 209,000 fry retained for fingerling production at the Senecaville Hatchery were held for approximately 10 days in rearing troughs until the yolk sac was absorbed.

A 1.2 acre pond and a .85 acre pond were utilized to raise the sauger fingerlings. Two weeks prior to stocking, the ponds were fertilized with 1,000 pounds of clover hay and 8 pounds of phosphate per acre. One week prior to stocking, ponds were fertilized with an additional 500 pounds of hay and 8 pounds of phosphate per acre.

The sauger fry were stocked on May 6th at a rate of 100,000 per acre. An excellent bloom was maintained throughout the rearing period with supplemental applications of hay and 8-8-0 as needed. The sauger were seine checked periodically to establish a draining date.

On June 10th, after 34 days in the pond, the sauger fingerlings were harvested. One hundred sixty-eight thousand, 1 to 2 inch fingerlings weighing 168 pounds were removed. This was an 80 percent return of the fry stocked.

The harvesting method was similar to that used at this hatchery for walleyes except for one behavioral difference. With walleyes, 90 percent of the fingerlings can be dipped in front of the screen before the pond is drained down to the catch basin. This minimizes the tadpole problem normally encountered at this time of year. However, the sauger fingerlings did not gather in front of the screen and most of the fingerlings were not removed until the pond had completely drained into the catch basin.

The fingerlings were transferred to the holding house and held overnight. Mortality was limited to those few fish injured mechanically during the harvest operation. The sauger were then transported to Lake Erie for stocking under the Lake Erie Sauger restoration program.

- QUESTIONS AND COMMENTS -

Sauger Fingerling Production at the Senecaville NFH, by John Hawkinson

The annual commercial sauger catch from Lake Erie for the state of Ohio has been as follows:

1936 ----	1,700,000 pounds
1947 ----	300,000 pounds
1956 ----	12,000 pounds
1960 ----	Catch was gone

During 1970-1971, water quality projects and water quality regulations were implemented around Lake Erie. This resulted in an improved walleye "picture" and also brought about requests for sauger stockings.

Brine shrimp can be used to hold walleye or sauger an additional 10 to 14 days inside before pond stocking. This can be helpful in manipulating pond stockings so that fry are stocked on top of a zooplankton pulse.

QUESTION (Unidentified) - How did you achieve a 100% return from pond stocking to pond harvest?

HAWKINSON - Three to four weeks after fry are stocked we use inorganic fertilizers in an effort to get phytoplankton blooms. This maintains our over-all "bloom" and also reduces cannibalism by increasing turbidity. If we achieve a phytoplankton bloom by the time the sauger are 1" in length then we carry the sauger on to 1 1/2" to 2"; if the bloom doesn't materialize, then we harvest the sauger at 1" to 1 1/4".

DAN BREWER (Kentucky) - What is the age of the fry at pond-stocking?

HAWKINSON - 5 to 8 days old from hatching (after the yolk-sac is absorbed) and usually at a water temperature of 58°F.

DAN BREWER (Kentucky) - What is your method of placing fry into the pond?

HAWKINSON - We put a boat in the pond and then we siphon the sauger out around the edge of the pond.

DAN BREWER (Kentucky) - What type of zooplankton is in the pond at fry-stocking?

HAWKINSON - We start out mostly with rotifers and this changes to mostly copepods with some daphnia. This hasn't been checked out real well.

JOE GRAY (Virginia) - Are there any reports of natural hybridization between sauger and walleye?

ARDEN TRANDAHL (USFWS) - Benson said there was some evidence of that below Gavins Point Dam.

OSTERGAARD - There probably is some natural hybridization in the Mississippi River, but I'm not sure. (Stan Daley felt the same way).

BOB MILES (West Virginia) - What are the results of stocking sauger on top of walleye populations - is there competition between the two?

(Comments and Questions, continued)

TOM GOETTKE (Ohio) - The two were compatible in the past in Lake Erie.

JOE GRAY (Virginia) - What are the results from stocking small-sized fingerlings (walleye or sauger)?

TOM GOETTKE (Ohio) - We have tried limited walleye fry stockings and we feel that where we have an established reproducing walleye population, fry stockings might augment that population. We have had pretty good success with stocking 1 1/2" walleye fingerlings.

Northern Pike Fry Mortalities Attributed To
P.C.B.'s - Polychlorinated Biphenyls

By: Ronald Waybrant, Aquatic Biologist
Michigan Department of Natural Resources
Bureau of Water Management

Background

The Michigan Department of Natural Resources Fisheries Division collects from 12 to 14 million northern pike eggs each year from wild sources for its northern pike stocking program. Pike in spawning condition are trapped in southwestern Michigan streams and transported to the Wolf Lake Hatchery near Kalamazoo for spawning. Survival of the fertilized eggs to swim-up averages about 60%. Swim-up fry are then stocked in extensive rearing marshes adjacent to lakes or in chemically reclaimed waters.

Mortality

By April 10, 1974, more than 1 million fry had died at Wolf Lake and the mortalities were brought to the attention of the D.N.R.'s Toxic Materials and Bioassay Group. Nearly all fry were dying about 6 days after hatching at the swim-up stage.

The installation of new PVC pipe at the hatchery was first suspected as a source of phthalates or other vinyl chloride compounds which may have caused the mortality. The death of fry at swim-up is characteristic of mortalities caused by chlorinated hydrocarborn compounds and other lipid soluble toxicants. Water and fry samples were taken to check this possibility, while the plumbing at Wolf Lake was converted back to iron pipe on April 11, 1974.

Phthalate leaching from the new PVC pipe was ruled out as a cause of the mortality after water samples taken during plastic pipe use were analyzed, and pike fry reared with iron piping continued to die six days after hatching on April 18th.

Thirty-nine ppb phthalate were found in the water sample taken when PVC pipe was in use. Although somewhat elevated, the available 96 hour LC50's for phthalates range from 0.7 to 6.5 ppm, much higher than the observed level. An important consideration is that very hard PVC pipe was used which has less phthalate than softer plastics, and after adequate flushing little or no phthalate should leach from the pipe.

Analysis of the fry and eggs did indicate, however, that PCB levels in the fry were sufficient to cause fry mortalities. Total PCB levels in the fry were 1.65 ppm of Arochlor 1254 and 1.41 ppm of Arochlor 1248 in one sample and 0.44 ppm as 1254 and 1.21 ppm as 1248 in the other. The eggs contained 1.58 ppm as 1254 and 1.80 ppm as 1248. According to Jensen et.al. (1970), when PCB residues in groups of salmon eggs ranged from 0.4 to 1.9 ppm on a whole weight basis, mortalities ranged from 16 to 100 percent. Jensen et.al. (1970) suggested that 0.5 ppm PCB in whole salmon eggs may be near the threshold for mortality. This value may approximate the threshold level for other species, such as the northern pike.

The swim-up stage of fry may be a susceptible stage for PCB poisoning as it is with DDT.

According to Cuerrier et. al. (1967), DDT related mortality tends to occur in the swim-up stage of fry development. This can be attributed to the fact that most of the DDT in the egg will remain with the oils, which are absorbed during the swim-up stage. Like DDT, PCB's are chlorinated hydrocarborns and are very lipid soluble.

Because the PCB levels found in the fry and eggs were high and fry died in the swim-up stage, the presence of PCB's are considered to be the likely cause of the northern pike fry mortalities experienced at the Wolf Lake Hatchery.

The source of PCB's did not appear to be in the hatchery water. The basic water supply was tested and found to be free of chlorinated hydrocarbons. Pesticides and PCB's were found, however, in the water samples from the third rearing trough. These may have originated from the fry which lost them to the water, particularly after they started dying. Since PCB's were not found in the water supply entering the troughs, the PCB's in the eggs and fry probably originated with the adult fish.

To test this hypothesis, adults were collected from Lake Macatawa near Holland. Six adults ranging in size from 17.4 to 34.7 inches were collected on two separate collection attempts, May 22 and 29, 1974. The following table lists the lengths and ages of these northern pike with the concentrations (ppm) of two PCB residues found in the flesh.

Northern Pike		Arochlor (ppm)		
Length (Inches)	Age Group	1254	1248	Total PCB
34.7	V	5.5	4.2	9.7
30.0	IV	1.5	1.7	3.2
29.5	III	1.6	1.3	2.9
26.0	III	3.8	2.6	6.4
23.0	II	1.1	0.6	1.7
17.4	---	0.43	0.53	0.96

As you will note, total PCB appeared to increase with the age and size of pike. This is probably significant in light of the tendency of most fish culturists to select the largest females for spawn taking.

Past (1972) PCB data of the Michigan Water Resources Commission (MWRC) on fish collected from the Black River above Lake Macatawa also corroborates the relatively high PCB concentrations noted in 1974. An 11-inch smallmouth bass contained 4.35 ppm PCB in a portion of edible flesh. This is well above what the MWRC considers background levels.

The discovery of relatively high PCB concentrations in brood stock collected from Lake Macatawa and associated fry mortalities indicates that alternative broodstock collection sites should be explored for 1975.

Jensen, S., N. Johansson, M. Olsson. (1970) "PCB-indications of Effects on Salmon." PCB Conference. Stockholm, Sept. 29, 1970. (Swedish Salmon Research Institute). Rept. LFIMEDD 7/19/70

Cuerrier, J. P; J. A. Keigh, E. Stone, (1967) Problems with DDT in Fish Culture Operations. Naturaliste Can. 94; 315-320

- COMMENTS AND QUESTIONS -
John Schrouder, Michigan
Northern Pike Fry Mortalities Attributed to P.B.C.'s - Polychlorinated Biphenyls, by Ronald Waybrant

The source of P.C.B.'s into Lake Macatawa is from industrial discharges (spillages). We have had a DDT problem with salmon in Lake Michigan, etc. and tests show that DDT levels are going down and P.C.B. levels are holding steady. The FDA level for DDT is 5 ppm; but, no level has been set for P.C.B.'s as far as known.

MAYO MARTIN (USFWS) - We have had much the same problem with PCB's and chlorinated hydrocarbons in channel catfish broodstock in the south. In some cases it has been necessary to switch pumping from bayou water to well water.

1974 Cool Water Fish Diet Testing
Walleye Fry Rearing Using Infusoria

By: George Beyerle
Michigan Department of Natural Resources
Fisheries Division

Introduction

It has been very difficult, thus far, to successfully rear walleye fry artificially; a requirement for the intensive rearing technique.

Attempts with artificial diets, offered during this early stage of the walleye, have failed to produce the sought after results.

A Russian study by Korniyenko entitled: "The role of protozoa in pond plankton", drew attention to the importance of free living protozoa, especially infusorians, as a direct food for the larval stages of phytophagous fishes. Such protozoans accounted for 23.0 to 94.4 percent in terms of quantity and 0.1 - 11.7 percent in terms of weight in the food bolus of such fishes during their early development.

This information prompted us to investigate the possible role of infusoria in the early life of the walleye and/or the practicality of producing infusoria in large numbers for intensive walleye culture. The following is a brief report of this experiment.

Preliminary to the test we experienced an unusually heavy mortality of walleye sac fry when the water temperature was raised from 51°F (hatching trough) to 65°F (stock aquarium) at a rate of less than 1°F per hour. The reason for the mortality was undetermined. Walleye sac fry surviving the temperature rise were stocked in six 15-gallon aquaria (100 fry per aquarium) on May 2. An abundance of brine shrimp was stocked and maintained in two aquaria. Two other aquaria were stocked with an abundance of infusoria. The final two aquaria were stocked with a 50-50 mix of brine shrimp and infusoria. The larger, more abundant infusorians, primarily *Paramecium* sp. and *Stylonychia* sp., ranged from 0.1 to 0.3 mm in length, while the newly hatched brine shrimp were 0.5 mm in length. The first feeding by the walleye fry was observed on May 5. The experiment was ended on May 14. The following table shows the results:

Aquarium Number		Walleye fry alive Start	Walleye fry alive Finish	Percent Survival Per Aquarium	Percent Survival Mean
1	shrimp	100	36	36	
2	shrimp	100	59	59	47.5
3	shrimp plus infusoria	100	48	48	
4	shrimp plus infusoria	100	50	50	49
5	infusoria	100	0	0	
6	infusoria	100	17	17	8.5

Notes: On May 14 and estimated 10 percent of the fry in aquaria 1 through 4 appeared to be strong and healthy. The remaining 90 percent, although they contained food, appeared weaker and unable to easily escape the plastic tube used to collect the fry. All fry in aquarium 6 were emaciated and lying on the bottom of the aquarium.

From observations made throughout the experiment, as many as 75 percent of the walleye fry in aquaria 1 through 4 fed on brine shrimp at one time or another. Conversely, there was no evidence that walleye fed to any extent, if at all, on the infusoria. The fry in aquaria 5 and 6 became weaker and more emaciated as the days passed. They tended to lie on the bottom of the aquaria. Coincidentally, the largest concentrations of infusoria were also on the bottom. The reason the infusorians were not utilized as food by the walleye fry is open to speculation. Walleye fry, like other fishes, usually seem to be most attracted to the largest of the food items available to them. Evidently, newly hatched brine shrimp are just about the largest food item that young walleyes can devour. Thus the infusorians in aquaria 3 and 4 may have been ignored on the basis of size alone. The absence of feeding by walleyes in aquaria 5 and 6 may indicate a size (infusoria too small to be noticed) and/or a taste factor (infusoria not palatable) associated with the infusoria used.

Feeding of Smallmouth Bass on Formulated Diet

By: Charles E. Hochstetler and John S. Hawkinson and Arthur E. Murrey
United States Fish and Wildlife Service
Senecaville National Fish Hatchery
Senecaville, Ohio

SMALLMOUTH BASS

Introduction

The use of a pelleted formulated diet in artificial propagation of smallmouth bass (Micropterus dolomieu) would significantly increase the value and flexibility of a bass production program. Snow (2, 3, 4, 5, 6) has demonstrated considerable success in using a formulated diet in the production of largemouth bass. This study was an attempt to adapt Snow's methodology to a smallmouth bass production program at the Senecaville, Ohio National Fish Hatchery.

Advantages of this program at Senecaville would be:

1. A more efficient and controlled program of advanced fingerling production for management purposes.
2. The development of a bass broodstock program without the cost, space requirements and disease potential of forage fish production.
3. A reliable and timely source of fish for bioassay and other research purposes.

Methods

This study consisted of a series of three feeding trials conducted during 1971, 1972 and 1973 using fingerling smallmouth bass from the F_2generation of the Senecaville reference strain. The fish were reared to the desired test size in a standard rearing pond utilizing natural food. They were then transferred to a concrete hatchery tank (2.5' x 2.5' x 21') for training to accept the formulated diet. Water flow was set at 30 gpm. Water temperature during training averaged 70°F. The tank was cleaned daily and a 1/2 ppm copper sulfate prophylactic treatment was administered every other day for the duration of the training period.

The Oregon Moist Pellet (OMP) was used, as recommended by Snow (3). Initially, pellets were rolled into worm shaped particles to make them appear more inviting to the bass. This was discontinued when the fish were actively feeding. A supplemental feeding of ground fish was included in 1971, but was determined to be unnecessary and was eliminated in 1972 and 1973. Feed was offered hourly during working hours. No specific feeding rate was used during training and obvious cannibals were removed. Training period varied from 15 days in 1971 to 5 days in 1973.

When most of the bass were actively feeding, they were transferred to a hatchery pond. Initially, they were confined in a screen cage to establish a feeding station. After five days, they were released and feeding frequency was reduced to four times a day. Feeding rate through the remainder of each trial was based on consumption at each feeding. Use of an automatic feeder was attempted in 1971, however, it was abandoned when the feed was found unsuitable for the feeder. All subsequent feeding was done by hand. Sample counting was done by hook and line using barbless hooks.

(Methods - cont.)

The bass from the 1971 feeding trial were retained at the hatchery for broodstock replacements. Two hundred fifty typical bass types were selected from the total lot. The bass were fed on OMP the second year of life and then converted to goldfish forage the third year. Also, twenty-five additional bass were selected for broodstock replacement and remained on OMP through the third year.

Results

The bass were harvested in October at the conclusion of each trial. Stocking and harvest data is summarized in the following table:

Stocking	1971	1972	1973
Numbers	935	1328	20,000
Weight	8.5	7.1	38.2
No./lb.	110	375	523
No./acre	2805	3984	40,000
Harvest			
Numbers	701*	1122	6,844
Weight	77	92	449
Average Length	6.0"	5.5"	5.0"
No./lb.	9	12	15
No./acre	2103	2244	13,688
Percent Recovery	86	85	34
Days on Feed	110	125	113
Lbs. of Food Fed	170.8	204.6	753.0
Lbs. Gain	68.5	84.9	410.8
Conversion	2.49	2.41	1.83

*Does not include 100 cannibals removed.

In each trial, feed consumption as percent body weight per day ranged from 7-8% at the beginning to 2-3% at the conclusion. This was computed using food fed per day versus the estimated standing crop based on sample counts.

The 275 bass retained as broodstock spawned in 1974 as 3 year old fish. The following table indicates the smallmouth bass fry production at Senecaville over the last 9 years. The production for 1974 is from the 250 bass fed the OMP diet through their second year. A significant increase in fry production per pair of bass was realized in 1974.

Year	Pairs	Fry	Fry/Pair
1966	155	179,000	1151
1967	164	218,000	1329
1968	420	439,000	1045
1969	111	175,000	1516
1970	105	117,000	1114
1971	115	175,000	1521
1972	117	227,000	1940
1973	145	142,000	979
1974	125	437,000	3200

The 25 bass retained on OMP diet through their third year did not demonstrate any spawning success. From 10 pair of bass, no viable fry were produced.

Discussion

The results of these trials indicate the feasibility of producing smallmouth bass on a formulated diet. Comparison with past hatchery records indicates that 5-6 inch fingerlings can be grown on OMP as quickly and at lower cost than comparable size fingerlings utilizing natural forage. In addition, comparable numbers can be produced using considerably less rearing space.

Stocking and harvest data offers preliminary estimates on optimum stocking rates. Data on the 1973 trial indicates optimum stocking rate was exceeded, resulting in a much lower percent recovery. Snow (6) recommends that optimum stocking rate for production of 6" bass is 25-30,000 per acre. Based on the results of these trials, optimum smallmouth stocking rate for artificial feeding at this hatchery is estimated at 15,000 per acre.

Feeding results indicate an estimated feeding rate of 8% for 1-2" fish decreasing to 2% for 6" fish. It appeared from observation that consumption may be somewhat dependent on feeding frequency. The bass would accept food every half hour if it was offered to them, so consumption and resultant growth may have been higher if the feeding frequency had been increased. The rates determined in this study offer a reasonably suitable feeding rate until more information is obtained on optimum feeding rates under various conditions.

Disease was not a problem during this study. However, artificial feeding will provide opportunities for disease treatment not previously feasible in centrachid production. Systemic infections previously treatable only by drug injection of individual fish can be treated on a fish lot basis by incorporation of the drug in the food.

Artificial feeding lends itself well to the bass broodstock program at Senecaville. A larger number of future broodstock can be maintained without increased forage production and increased opportunity for broodstock selection under an artificial feeding program should result in better broodstock. Forage production previously required to maintain one and two year old future broodstock can now be utilized by the three year old spawning fish. The increase in fry production per pair of bass in 1974 is probably the result of a combination of increased forage availability and broodstock selection. Another advantage of the feeding program is the availability of the formulated diet during periods of the year when forage fish are in short supply. It was found that the bass will readily switch from OMP to forage and back to OMP with no problem.

The spawning failure of the bass fed OMP through 3 years indicates further studies need to be carried out on the feeding of a formulated diet through spawning. The limited number of bass included in this group precludes any definite conclusions on the dietary requirements necessary for successful spawning. Also, other environmental stresses experienced by these fish may have contributed to spawning failure.

References

1. Lennon, Robert E.

   1967. Selected strains of fish as bioassay animals. Progressive Fish-Culturist, Vol. 29 No. 3 P. 129-32

2. Snow, J. R.

   1968a. Production of six to eight-inch bass for special purposes. Progressive Fish-Culturist, Vol. 30., No. 3,P. 144-52

References - cont.

3. Snow, J. R.

1968b. The Oregon Moist Pellet as a diet for largemouth bass. Progressive Fish-Culturist, Vol. 30, No. 4, P. 235

4. Snow, J. R.

1970. Fecundity of largemouth bass, Micropterus salmoides (Lacepede) receiving artificial food. Proceedings of the 24th Annual Meeting of the Southeastern Association of Game and Fish Commissioners. September 28-30, 1970

5. Snow, J. R. and J. I. Maxwell

1970. Oregon Moist Pellet as a production ration for largemouth bass. Progressive Fish-Culturist, Vol. 32, No. 2, P. 101-2

6. Snow, J. R.

1971. Culture of large bass fingerlings with artificial food. Paper presented to Tennessee Fish Farmers Conference, Montgomery Bell State Park, Burns, Tennessee, November 4-5, 1971

- COMMENTS AND QUESTIONS -

During the training period, the bass were crowded into one-half of the 21-foot long tank.

DAN BREWER (Kentucky) - Why do you raise 5" to 6" smallmouth bass?

HOCHSTETLER - For the last three to four years, we have stocked such fish into lakes at veterans' hospitals and Air Force bases.

DAN BREWER (Kentucky) - Is there any difference in survival of handling and hauling between pellet-fed fish and forage-fed fish?

HOCHSTETLER - No difference.

Raising Yellow Perch (Perca flavescens) and Walleye Pike (Stizostedion vitreum vitreum) for Human Food Use

By: Harold E. Calbert, David A. Stuiber and Hyung T. Huh
Department of Food Science
University of Wisconsin-Madison

The market demand for yellow perch and walleye pike has been increasing, while the supply of these fish from natural sources has been dwindling. An aquaculture research program was initiated with the following objectives: to determine if yellow perch and walleye pike could survive in man-made systems on prepared diets; to determine the conditions that maximize growth rate and meat quality; and to produce pike and perch with retail market demands.

All fish used in this research work were obtained as fingerlings from the Wisconsin Department of Natural Resources. The yellow perch fingerlings averaged 4.0 cm in length and 1.4 g in weight. The walleye fingerlings averaged 4.1 g, and had an average length of 6.7 cm. The prepared diet used in all of the experiments reported in this paper, except where noted, was the W-3 diet developed at the Spearfish Fisheries Center, Spearfish, South Dakota. In some instances the diet was modified as to protein content. It was fed either as a meal in 1/16 in pellets or 3/16 in pellets depending upon the size of the fish.

During preliminary feeding trials the walleye and the yellow perch responded differently to the W-3 diet. During the first week the perch quickly adjusted to the diet. The walleyes showed no interest in the prepared diet. However, when cultured Daphnia was mixed with the prepared diet, the walleyes would eat the Daphnia and at the same time ingest some of the prepared feed. After about two weeks the walleyes were accepting the prepared diet.

Fish were held in a combination of 16° and 22°C water and photoperiods of 8 and 16 hours of light. With yellow perch, lengthening of the photoperiod had a greater response than did the increase in water temperature on the growth of the fish. With walleye pike the increase in the water temperature exhibited a greater effect on growth response than did the increase in the photoperiod. However, the best growth conditions observed to date for both species have been 16 hours of light and a water temperature of 22°C.

The perch fingerlings were fed either a 50, 40, or 27 percent protein isocaloric diet for 120 days. The difference in the average population weight was only 0.545 g between the group fed the 50 percent and the 40 percent diets (11.85 vs. 11.40 g). There was a rather large difference from the 50 percent fed group and the 27 percent group. This difference amounted to 3.3 g (11.85 vs. 8.55 g).

Fingerlings of both species were fed at the rate of 3 percent of body weight (wet basis) per day for a period of 42 weeks. Gross feed conversions and conversion efficiencies were determined. During the early part of the experiments the walleyes exhibited a lower conversion rate and a higher conversion efficiency than the perch. As the fish grew, the trend reversed. The conversion rates ranged from 1.13 to 4.35 in the walleye, and from 3.15 to 1.27 in the perch. The walleyes showed as high as 89 percent efficiency of conversion during the first two weeks of the trial, while the perch were experiencing a conversion efficiency of approximately 32 percent. However, by the end of the 42 weeks, the conversion efficiency of the walleyes had dropped to 33 percent, and that of the perch had risen to 55 percent.

Raising Yellow Perch (Perca flavescens) and Walleye Pike (Stizostedion vitreum vitreum) for Human Food Use

Dr. David Stuiber, University of Wisconsin

The present funding for this project is only $15,000 per year.

Presently, walleye costs $1.05 per pound "in the round". Yellow perch costs $1.60 to $2.67 per pound for fillets. At present, Lake Erie is the primary source for yellow perch.

All feed was formatized by a local feed dealer. We made our own pellets. At the start, hand-feeding was carried out with the fish in 30-gallon aquaria. Later, fish were kept in a 200-gallon confined area with one-quarter of the surface covered to provide a hiding area. The fish were fed continously on a 24-hour basis by means of clock-type feeders. This kept "pigs" from dominating the feeding.

We had no cannibalism problem. The first-year mortality for walleye was about 30% (500 fish to 350 fish). Losses were due primarily to mechanical handling. Perch mortality over the first year was 10 to 12%.

At 8°C. the fish maintained themselves but showed no appreciable growth. At 30°C. the fish exhibited stress and were weak at the end of a week. Optimum temperature was 22°C.

The light present for photoperiod studies was muted light, just one fluorescent light in the room. This light was further muted by hanging a thin, tan plastic bag over the fixture. After the light was so muted, then, walleye stratified throughout the tank.

Of the fish, 25% were fast growers, 50% were medium growers, and 25% were slow growers. Some of the fast growers were fed a 50% protein diet for eight weeks, then a 40% protein diet for eight weeks and finally a 27% protein diet thereafter; these fish maintained the same growth rate all the way along-they apparently only needed the large amount of protein on an initial basis.

Most of the protein in the diet was fish meal. For the lower protein level diets, oat flour was substituted (a little bit of lipid material was also added as a binder).

The intestinal tract of the fish was not as well developed as in wild fish. The stomach was small since it hadn't had to stretch during the feeding regime. The stomach wall was also less thick than in wild fish. On one occasion, a 3" perch jumped from its tank into a walleye tank and a 12" to 13" walleye ate it-the walleye died and the examination showed the spines of the perch had punctured the stomach wall of the walleye. For this reason, it is thought that such intensively fed fish would not survive well if stocked directly into the wild without a conditioning period.

We now have walleye at 15" and about 3/4 pound. The per cent protein of fish is 16% to 20%, with 80% being water and 2% to 3%, at most, being lipid and/or fat. Wild perch dress out to 45% to 50% as fillet, whereas our tank-reared perch dress out to 47% to 53% as fillet.

BOB MILES (West Virginia) - What are your cost figures?

STUIBER - I only have rough figures which depend upon the per cent of protein in the diet, for example, the 50% protein diet cost $525 to $550 per ton and the 27% protein diet cost $225 per ton. The cost per pound of fish was about 29 1/2 cents, which includes 3 to 4 cents cost per fingerling. This cost does not include labor.

QUESTION (Unidentified) - Why wouldn't these fish do well if stocked into the wild?

STUIBER - They are not capable of handling many wild fish in their diet. They would have to have a prior conditioning period.

NOTE: There was a lengthy discussion over this point, pro and con, most of it involving other fish species which are fed pellets but which apparently are not fed so intensively and for as long as the fish in question.

JOHN KLINGBIEL (Wisconsin) - We have made arrangements to stock some of these fish into the wild and to evaluate their survival.

STUIBER - We have tried feeding rates varying from 1% to 7% of body weight per day. Our walleye are mid-water feeders. The fish don't feed during the dark photoperiod so we probably are wasting some feed. At present, we have two-year-old perch at 8" to 10" (1/2 lb.) and two-year-old walleye at 16" to 18" (3/4 lb.). The market wants a 1/3 lb. fish - nothing more than 7"-1/3 lb. for perch which we can do in 8 to 11 months.

GENERAL DISCUSSION PERIOD

DICK COLESANTE (New York) - A questionnaire was sent to several states and Canada regarding the naming of the "hybrid muskellunge" (male northern pike X female muskellunge) and the majority opinion was that it should be called the Tiger Muskellunge. This name will be recommended to the Naming Committee of the AFS.

CARL SULLIVAN (S.F.I.) - (Carl passed out paper requesting that everyone list his category [i.e., administrator, hatchery biologist, field biologist, or research biologist] and personal view of the two major problems to overcome in achieving an "ideal" musky program; perhaps this information can be given at the next meeting or presented in the SFI bulletin.)

Within the last year, I have served on the National Task Force for Public Fish Hatchery Policy. The task force was appointed by the Secretary of Interior and included private, state and federal representatives. The goal was to look at the federal fish hatchery program and to make suggestions as to what the future role of the federal fish hatcheries should be. Detailed production questionnaires were sent out to the 90 federal and 425 state fish hatcheries.

I am passing out production results for 1973 for northern pike, walleye and musky. The final report of the task force is yet to come out (the rough draft has been readied).

I would like to mention the possibility of utilizing the heated waters of power plants for fish production. This has been done somewhat with channel catfish and I wonder if there are any possibilities along that line with musky or other species in the north. The utility company representatives are generally eager to work with people along these lines.

I would like to question what the federal role should be in assistance with the musky program. For example, it has been mentioned that sometimes milt becomes short in supply during the spawning season. Perhaps the federal government could supply research in the means of milt storage.

JOHN KLINGBIEL (Wisconsin) - We could use help in the means of bird control. At present, we have a hard time controlling predation by birds, due to existing laws. We estimate that 5,000 pounds of musky fingerlings are lost each year due to birds at our hatcheries.

ARDEN TRANDAHL - I would like to mention the Fish Cultural Section of the AFS. It was formalized in 1974, has elected officers, has established committee, plans to publish a quarterly newsletter, and presently has 325 to 340 members.

GENERAL - There was a discussion as to what direction future meetings should take. Some thought the meetings should not become too large. Others thought the meetings should return to the more informal format with no abstracts presented, etc., while others believed the abstracts, etc. lended quality to the meetings and made the information more immediately available to the participants. Some thought the meetings should remain special-interest oriented with emphasis only on musky or esocids, while others thought the meetings should expand to include "coolwater" fishes. The matter was appropriately left in the hands of the Workshop Steering Committee.

At the 1974 Interstate Musky Workshop in Morehead, Kentucky, Carl Sullivan, Executive Secretary, Sport Fishing Institute, requested each workshop participant to indicate which professional area they represented and to list two problems they considered most limiting to the development of muskellunge culture. I have tabulated the responses from that survey and they are as follows:

Response	No.	Response	No.
1. Cost/Benefit Analysis of Overall Program	4	9. Broodstock, Egg Supply and Development of Domesticated Broodstock	2
2. Develop Artificial Diet Techniques	17	10. Disease Control in Hatcheries	3
3. Research to Determine Survival of Various Sized Fingerlings; No. and Size to Stock per acre.	17	11. Communication Between Fisheries Workers and Lack of Public Information Releases	4
4. Control of Predatory Birds in Hatcheries	1	12. Lack of Live Forage	4
5. Lack of Facilities	7	13. Attitude of Top Administrators	4
6. Improve Natural Reproduction	1	14. Catchability	2
7. Program Funding	24	15. Other	6
8. Water Quality Problems in Waters to be Managed	6		

The list of responses represented the ideas of 52 individuals who commented on Mr. Sullivan's question. According to their responses, 14 indicated they held administrative positions, 24 were from hatcheries, 8 from field management areas and 6 were researchers.

Use of Tannic Acid to Reduce Adhesiveness of Walleye Eggs

By: T. L. Clark, Superintendent
Linesville Fish Cultural Station

Abstract

Adhesiveness of freshly taken walleye eggs has caused fish culturists to spend considerable hours stirring and caring for these eggs as they water hardened. Various substances including clay, liquid detergent, instant pudding and tannic acid have been used to reduce this adhesiveness. After three years of experiments, excellent results were obtained using a tannic acid mixture to rinse the eggs.

Procedure

Tannic acid had been used with limited success reducing adhesiveness of carp eggs in New York (personal conversation with R. Dumas, May 1970). During the walleye spawning season in April 1971 small lots of freshly taken walleye eggs were subjected to rinsing and/or soaking in water to which had been added various amounts of tannic acid powder ranging in strength of solution from .25 gram per gallon of water to 2.0 grams per gallon. Walleye were spawned as described by Shyrl Hood (Walleye Culture in Pennsylvania) then rinsed in the acid solutions for varying periods of time and placed directly into standard trout hatching jars leaving a flow of 1,000 milliliters per minute. Results of these experiments were as follows:

Solution of Acid	Method	Results
1-.25 grams/gallon	Rinsed 5 minutes	Eggs clumped in jar within six hours.
2- .5 grams/gallon	Rinsed 5 minutes	Eggs remained loose but turned very dark. Hatching fry could not escape from egg shell; 50 percent loss at hatch.
3-1.0 grams/gallon	Rinsed 2 minutes	Same as No. 2, except only 10 percent escaped from shell.
4-2.0 grams/gallon	Rinsed 2 minutes	Eggs remained loose, very dark but failed to hatch.

In each case the eye up was over 75 percent and it appeared the .5 gram per gallon solution showed more promise possibly with less exposure time. An exposure time of two to three minutes was felt to be ideal to fit in with the spawning operation.

During the 1972 spawning season, efforts were concentrated on using the .5 gram per gallon solution. Approximately one quart of eggs were spawned into a pan; the eggs were rinsed in the solution for one to two minutes and placed directly into the incubation jars. In each case the eggs remained loose and water hardened normally. The eggs exposed for longer periods of time were darker. Eye up and hatch was better than control lots, probably due to less injury from constant stirring used with the usual method.

This method was directly incorporated into the spawning procedure in 1973 with one minor change. The eggs were placed in a wooden keg immediately after rinsing and allowed to water harden before being placed into the incubation jars.

Two men spawned approximately one quart of walleye eggs into a shallow pan, fresh water was added and the spawn gently stirred for approximately 30 seconds. Thirty gallons of .5 gram per gallon solution had been premixed for use and put in a container with a small hose. The eggs were given to the third man in the spawning crew who washed the eggs clean using the tannic acid solution, usually two to three rinses were sufficient. Timing of this rinsing operation was never less than one minute nor more than two which was about the time required for the spawners to have another pan of eggs ready for rinsing. The eggs were then placed into a wooden keg 18"in diameter and 30" deep. This keg had water supplied through a hose of such size to flow 10 G.P.M. The hose was situated in a manner which caused the water to flow in a circular motion starting at the bottom. The eggs were allowed to water harden for an hour after spawning was completed, then strained through hardware cloth of eight meshes per inch to remove any small clumps, then placed in jars at four quarts per jar.

The eggs handled in this manner consistently hatched 5 to 10 percent better than their control lots. Loss of newly hatched fry unable to escape from the shell was minor. This method was used again in 1974 on approximately 20 percent of the total production with the same results.

The tannic acid used was manufactured by Merck Chemical Division, Merck and Company, Inc., Rahway, New Jersey, 07065, labeled "Tannic Acid Merck" N.F.XII- powder and sold for approximately $5.00 per pound.

HATCHERY DESIGN

Submitted by: Dan Brewer

A hatchery design questionnaire was sent to eleven agencies during July 1973, and by September 1, 1973, returns were received from ten agencies.

It is my personal opinion that a lot of work needs to be done in regard to hatchery design for muskellunge production. Besides the usual hatchery production problems, muskellunge rearing has the additional problem of providing a large number of sufficient-sized forage. Most hatcheries raising musky are used for multi-species culture. These facilities tend to be of more or less standard design with little innovation in regard to supplying the forage to the musky. In the near future, probably only two states, Wisconsin and New York, will be able to use a given hatchery primarily for musky production.

Missouri completed a new hatchery during 1971 and Kentucky will complete one during 1973-1974. Both hatcheries are intended for multi-species culture and I believe have a design intended for adaptability. Both are basically earthen pond hatcheries having several sizes of ponds plus a fair amount (6,000 - 6,500 square feet) of concrete raceways. Both have egg incubation facilities plus concrete and/or fiberglass tanks.

Three states, Michigan, Iowa and Tennessee, are in some stage of planning for a new hatchery. Each plans for multi-species culture often with an emphasis on fish other than musky such as catfish, striped bass or walleye. Probably all three will have some earthen ponds, but each plans to place some degree of emphasis on concrete ponds either rectangular or square or circular or swedish-type. This is probably a sign of the shift towards more intensive culture for the warmwater fishes with a greater degree of control during production.

New York and Pennsylvania are planning for or in the process of renovating existing facilities. In general, the renovations call for a new hatchery building and/or additional ponds. Pennsylvania, to date, has probably done the most work on intensive culture for muskellunge. They've utilized steel tanks, concrete raceways, etc. for rearing fingerlings. They also use earthen ponds both for forage and for musky fingerling production. One of their design methods which appeals to me is the use of small forage ponds which can be drained directly into musky fingerling ponds.

As for new equipment, several hatcheries have installed boilers and/or temperature control units for egg incubation. Also, several have installed filters for incubation. One state has added facilities for the jar culture of brine shrimp. Several states have purchased circular or rectangular fiberglass tanks.

Most hatchery water supplies were either a creek/river or a lake. Eight hatcheries used a creek/river; seven used a lake (either natural or impounded). Six hatcheries used well water, but generally wells were not the sole water supply. Five hatcheries used springs to some degree. Several hatcheries used reservoir ponds to hold their pumped water.

About eight hatcheries had a water supply of 150-500 gpm. A couple were in the range of 500-1,000 gpm. The rest generally had a water supply of 2,000-10,000 gpm. Those hatcheries with a larger supply also were generally able to use 300-700 gpm for jar hatching. In general, most of the newer hatcheries have large water supplies and are having to go to lakes and rivers to get that quantity of water.

Most hatcheries (10) had the ability to heat their water for egg incubation. Over one-half (9) had some type of filter system for hatching. Filtration systems varied considerably and included: microstrainers (openings down to the 15-28 micron size); strainers (down to the 125 micron size); sand filters; activated carbon filters; and a screened enclosure of small rock. A few hatcheries used settling ponds to improve their water quality. In a few cases, filtration or heating was not necessary since well or spring water of a suitable temperature was available.

Most hatcheries had facilities for holding fry and/or small fingerlings. These facilities were variable and included concrete tanks, steel tanks, fiberglass tanks, wooden tanks and aluminum troughs. Eight hatcheries had either circular or rectangular fiberglass tanks on hand. Three states had what they called nursery ponds. An additional five states had some ponds in the 1/10-1/3-acre size range which could probably be used as nursery ponds. For larger fingerlings, all states had some earthen ponds available, although a few hatcheries used earthen ponds only for forage production as the muskies were kept in some type of raceway structure. Most hatcheries had several sizes of earthen ponds: most ponds were in the size range 3/4 - 2-acres with a sizeable number being 3/4-1 1/4 acres; seven hatcheries had at least one pond 3 acres or larger which was being used for musky culture.

The large majority of hatcheries had standard earthen ponds with grass banks. Three hatcheries had some of their ponds with rip-rapped slopes. Two hatcheries had all of their ponds with rip-rapped banks.

Either outside or inside catch basins were present at most hatcheries: five hatcheries had inside catch basins; four hatcheries had outside catch basins. Five hatcheries had no catch basins at all. One hatchery had a common outside catch basin for each ten ponds.

Twelve hatcheries had at least some capability to drain some ponds into other ponds. In many cases, this capability was not generally used. In other cases, this capability was a disadvantage since it was more of a function of an old hatchery design whereby ponds had to be drained into other ponds. Two cases where the ability was used effectively was at Pennsylvania where forage ponds were drained into musky fingerling ponds and at New York where fry ponds (I assume musky fry) were drained directly into other ponds.

Four hatcheries had muskellunge broodstock ponds. Broodstock pond sizes were as follows: 1-2 acres; 0.8 acre, 2.2-8.0 acres; and 7.5-10.0 acres. One state mentioned that their largest broodstock pond (8 acres) was their most successful. Generally, those agencies having broodstock ponds were agencies which did not have a ready access to abundant natural musky populations.

As a rule, the musky hatcheries had their effluent running directly into a stream or lake. Three hatcheries could hold part of their effluent in some sort of a settling pond. An additional two hatcheries had all their wastewater running through settling ponds. At the Linesville (Pennsylvania) Hatchery, all waste water returns to a lake via three settling basins.

The most common hatchery problems were 1) inadequate forage, 2) water supply or water quality difficulties, and 3) inadequately built ponds. The most mentioned single major problem was insufficient quantities of suitable-size forage. A correlated problem was insufficient pond rearing space. Water supply or quality was some kind of problem at nearly all hatcheries, but the individual problems were variable. At some, water quantity was too low; one hatchery had a past problem of supersaturation on heating their water plus a zinc problem; some were carrying diseases and parasites in with their water supply; others had problems because they lacked temperature and filtration control; one hatchery could heat their water, but had the additional problem that their water supply became too warm for incubating; some had a problem with fluctuating pond temperatures; a few were using water from trout raceways and had the attendant water quality problems, and some just listed water quality in general. (I presume oxygen problems, silt problems, etc.). Leaking and/or seeping ponds were a problem at a minimum of five hatcheries. Poorly designed or old hatcheries were a problem in some states in that ponds were too large, or didn't have catch basins, or ponds were slow to drain or wouldn't drain at all, etc.

Broodstock availability was a problem for some agencies. Those who had tried broodstock ponds had sometimes found that they had an undesirable amount of handling involved. The problem of predation by kingfishers, etc. was sometimes a problem. Several states had algae problems, but were generally able to control it. As intensive culture has progressed, disease and parasite problems have arisen as well as a need to better know the behavior of muskellunge. Lack of money for new hatcheries, renovation, equipment, research, etc. also seems to be a widespread problem.

The questionnaire basically provided only background information on topics familiar to most participants. If this is done again, I think the logical next step would be to question each participant on his ideas to improve hatchery design in regards to musky production.

Propagation of Muskellunge
1963 through 1974

By: Joe Gray, Supervisor
Warm Water Hatcheries
Virginia Commission of Game and Inland Fisheries

ABSTRACT

Virginia is endowed with numerous lakes and streams that support muskellunge (Esox masquinony). The specie was initially introduced in 1963. Eggs and fry were obtained from Tennessee, West Virginia and Pennsylvania. The muskellunge have grown rapidly, a six year old specimen, 48 inches in length and others in excess of 30 pounds has been documented.

From the obtained eggs and fry, limited advanced fingerling were produced annually. The annual production was released in selected small lakes, occasionally large impoundments and main stem streams. Each year a number of selected fingerling were retained in the hatchery system for the purpose of becoming domesticated brood stock.

When domesticated specimens reached maturity, attempts to collect eggs met with little success and limited attempts to collect eggs from an eligible wild stock did not reach desired levels. The hatcheries were successful in the annual propagation of some muskellunge fingerling by using selected rearing ponds as nurse ponds and allowing the mature specimens to reproduce under natural conditions. The nurse ponds were stocked with a ratio of two males to one female and when free swimming fry were observed, they were removed by fine mesh dip nets and transferred either to troughs or rearing ponds where they were fed zoo-plankton and as many small minnows as could be obtained. Nurse ponds varied in size from .22 to 1.2 surface acres and all were not successful, but enough to merit continued use of this technique. Annual production varied from 3,000 to 8,000 advanced fingerling.

In 1974, an accelerated muskellunge propagation program was attempted. The domesticated hatchery brood stock were released in nurse ponds the second and third weeks of March. The water temperatures had reached a mean of approximately 50°F. Nine nurse ponds were used and all except one had terrestrial vegetation. The stocking ratio was varied. Approximately two weeks after the adults had been released in the nurse ponds hatchery personnel observed spawning activities. Tests in early April revealed egg deposits in all ponds. A decline in water temperatures resulted in the loss of numerous eggs in the nurse ponds. Although temperature declines resulted in considerable loss of eggs there were seven ponds that yielded a total of 36,000 swim-up fry and subsequent draining yielded another 14,000 advanced fry. Two nurse ponds were not utilized for fry dipping. Dipped fry were released in rearing ponds and reared to fingerling.

The last week in March, attempts to collect mature muskellunge from a 29 acre state owned lake was initiated. The lake water temperature was 49°F. Four gill nets 100 feet in length with 2" bar mesh and one North Dakota style trap net were used. The nets were set at 1930 hours. Nets were initially checked at 2100 hours and every hour thereafter until 0100 hours the following morning. The trap net was not disturbed during the night but was removed the following morning. Three nights of netting resulted in the collecting of three ripe female and six ripe male muskellunge and 112,669 or 2 1/4 quarts of eggs were collected and transferred to the Front Royal Hatchery for incubation. The trap net yielded two females and two males and the gill nets one female and four males.

The ripe muskellunge were anesthetized and wiped free of moisture before stripping. The males were not stripped directly into the egg collecting pan but had urine free sperm collected in a spoon and deposited into egg mass.

On April 1, the collection of adult muskellunge was attempted in a 218 acre state owned lake. Three nights of netting resulted in the collection of three ripe females but only one male. One 20 pound female yielded 1,860cc of eggs, numbering 106,020 or 1.96 quarts.

A total of 218,689 muskellunge eggs were collected from the two lakes, however, only 210,097 were incubated with 75.6 percent hatch. The eggs collected from one 20 pound female and fertilized with 2 drops of sperm from a single male yielded a 91.5 percent hatch. The total of 159,000 fry were incubated at 55°F.

The muskellunge fry were released in troughs containing mats of Spanish moss and excelsior. The fry remained in the troughs until they were free swimming or starting to feed before being released in rearing ponds.

The artificially hatched muskellunge were stocked in seven ponds, four ponds at the Front Royal Hatchery, two ponds at the Buller Hatchery and one pond at the Stevensville Hatchery. In addition, there were some 44,000 dipped fry released in four rearing ponds at the Buller unit. The Buller unit also had four nurse ponds that had not had the fry completely removed.

All rearing ponds were fertilized with 400 to 800 pounds of baled hay per surface acre and were inoculated with zoo-plankton. All ponds were furnished fathead, golden shiner and goldfish minnow fry via a shuttle method. Fathead minnows were allowed to spawn in and on sewer tile, golden shiner and goldfish on mats. Fathead eggs were moved twice weekly, golden shiner daily and goldfish were spastic, resulting in frequent egg deposits.

None of the fry stocked rearing ponds at the three units contained terrestrial vegetation in the littoral zones and the behavior pattern of the muskellunge left them open to predation from each other and fish eating birds, animals and snakes.

There were 15,034 fingerling muskellunge reared from 203,727 stocked fry for a 7.3 percent recovery. In addition, there were 2,889 fingerling recovered from the four undipped nurse ponds. The total number of fingerling produced in 1974 was 17,923.

It is concluded the fingerling muskellunge production in 1974 was not as successful as desired, however, the techniques appear to have considerable merit. Future production techniques should consist of increased fathead and golden shiner brood stock. Hatching of white sucker eggs should be exploited. A terrestrial type cover crop should be seeded in the rearing ponds littoral zones as soon as possible after the fingerling have been removed and the recovery and stocking of fingerling should coincide with the hatch of forage species in the various waters.