Combined North Central and Ninth Annual Minnesota Aquaculture Conference and Tradeshow

Research & Industry:
Working Together to Advance Aquaculture in the North Central Region

February 17 & 18, 1995
Radisson South, Minneapolis, MN

Proceedings

North Central and Ninth Annual Minnesota Aquaculture Conference 1995

Theme: Research and Industry Working Together to Advance Aquaculture in the North Central Region

Friday Febmary 17

General Session

9:00 Welcome and Introduction

9:15 Keynote speaker - Developing a successful aquaculture enterprise in the North Central Region - Bill Johnson, Rushing Waters Trout Farm, Wisconsin.

10:00 Marketing: Niche marketing through the 90's - John Jensen, Aquaculture Specialist, Auburn University

10:45 Quality Assurance and HACCP: What it means to you - Don Garling, Michigan State University

11:15 North American Fish Farmers Cooperative: A marketing possibility – John Leininger, NAFFC

11:30 **Lunch** -- with entertainment -- Fish Stories, a one act play

Session 1

1:15 Yellow Perch Aquaculture: For real?
Moderated by Fred Binkowski
Terry Kayes, Univ. of Nebraska
Forrest Williams, Bay Port Aquaculture, MI
Chris Star, Bay Port Aquaculture, MI

2:45 Break

3:15 Status of Aquaculture Drugs -- Rosalie Schnick, National Biological Service

3:40 Overview of Effluent/Waste Management -- Ted Batterson, Director NCRAC

4:05 Innovative use of fish offal -- Dave Smith, Freshwater Farms of Ohio, Inc.

4:30 Feeds/Nutrition: Where are we and where are we going -- Paul Brown, Purdue University

5:00 Adjourn

Session 2

1:15 Walleye Culture Workshop: Soup to Nuts
Moderated by Robert Summerfelt, Iowa State U.

1:35 Reproductive Biology and Spawning: --Jeffrey Malison, Univ. of Wisconsin -- Madison

2:05 Walleye Culture at Oneida Fish Culture Station -- Richard Colesante, Oneida Fish hatchery, NY

2:35 Break

3:05 Intensive culture of Walleye Fry -- Andy Moore, Rathbun State Fish Hatchery, Iowa

3:30 Training Pond-Reared Fingerlings to Formulated Feed -- Brian Bristow, Spirit Lake Hatchery, IA

3:50 Cage Culture -- Dave Bergerhouse, Southern Illinois University

4:15 Economics of Walleye Culture -Pat O'Rourke, Illinois State University

4:50 Conclusion -- Robert Summerfelt

5:00 Adjourn

5:15 Trade Show and Reception

Saturday, February 18

General Session

8:00 AquaNic: your on-line source of aquaculture information -- **LaDon Swann,** Purdue University

8:15 Recirculation Aquaculture: How to get up and running -- **Jim Ebeling,** Aquaculture Engineer, Piketon Research Facility, Ohio Cooperative Extension Service

(Moderated by **Gene Hanson,** Aurora Aqua and **Ying Ji,** Minn. Dept. Ag)

10:00 Break

Session 1

Fish Health Management
(Moderated by Joe **Marcino,** MN DNR)

10:30 U.S. FWS fish health policies and services provided by surrounding states. -- **Rick Nelson,** Fish Disease Control Center

11:00 Whirling disease in New york. -- **John Schachte,** New York Fish pathologist

11:30 Management of coolwater diseases. -- Rod Horner, Illinois Fish Pathologist

Session 2

Aeration -- Water Quality -- Fish Density
(Moderated by **Brian Erickson,** Minn. Dept. Ag.)

10:30 Pond Aeration: Matching equipment to needs -- John Jensen, Aquaculture Specialist, Auburn U.

11:00 Water Quality: Requirements/Testing -- **Mike Harrington,** LaMotte Representative

11:30 Affects of density on fish growth performance -- **Larry Belusz,** Alexandria Technical College

12:00 Lunch Aquaculture Industry Involvement in Public Policy -- Bob Baldwin, Michigan Fish Growers Association

Session 3

1:00 Regional Baitfish Picture -Fred Copes, Univ of Wisconsin - Stevens Point

1:30 Cage Culture: what is it and what can it do -- **LaDon Swann,** Purdue University

2:00 Floating Raceways: Workings and uses- **Dan Selock,** Midcontinental Fisheries

2:30 Exotic Species impacts to Aquaculture -- **Jeff Gunderson,** Minnesota Sea Grant

3:00 A Bioenergetics Model for determining aquaculture effluent --**Craig Tikkanen,** Natural Resources Research Institute

Session 4

1:00 Hybrid Bluegill Culture -Joe Morris, Iowa State University

1:30 Commercial Arctic Char Culture: boom or bust - **Richard Moccia,** Univ of Guelph, Ontario

2:00 Sturgeon/Paddlefish Culture: How to -- **Kevin Kroll,** Aquaculture Scientist

2:30 Tilapia Hatchery Techniques and Reproductive Biology -- **Barry Costa Pierce,** Bemidji State U

3:00 Growth and production of white sucker minnows in natural ponds -- **Paul Tucker,** Natural Resources Research Institute

3:30 ADJOURN

4:00 TOUR / OPEN HOUSE of University Aquaculture Facility

General Session

Friday, February 17, 9:00 a.m. to 11:15 a.m.

Veranda Ballroon

Notes

Developing a Successful Aquaculture Enterprise in the North Central Region

Bill Johnson

A profitable fish farm or any aquaculture business is more complicated than it first appears. Many aspects of a successful aquaculture venture must be learned from experience. The producer must be a combination business and sales person, as well as a biologist, lawyer, manager and most importantly a dedicated and tireless worker.

The prospective fish farmer or investor must be aware that both capital requirements and risks are very high. Experience, prior planning and professional expertise can combine to lower this risk. Carefully review all the publications available as well as any information you can secure from practicing fish culturists.

Sit down and write out your goals. Goal setting is an important aspect of beginning a new venture. The process includes two major steps: the first is to write out your goals as clearly as possible, and second, to review these goals from time to time, and make changes as needed. You may hesitate to state specific goals at the beginning, particularly when you don't know much about how to achieve them. You may fear a let-down if your plans do not work out. For this reason, it is important to remember the second step: that goals can be reviewed and changed. A well chosen goal is one you wish to achieve now Reviewing . and modifying a goal as you progress shows you are learning what you are experiencing.

The culture of any organism should be designed to maximize natural productivity in the system while minimizing the risk and cost. Like any aquaculture endeavor, it will require an understandin of: g

- **The biology of the organism to be cultured**
- **A clear understanding of state and federal laws which apply to the venture**
- **Proper site selection and modification techniques**
- **Water control**
- **Water quality**
- **Harvest techniques**
- **Marketing**

In order to have a sound basis for the establishment of a new aquaculture facility (or improve an existing one), you should have or secure a positive answer to each of the following questions:

I. Financing

A. Develop a business prospectus detailing land or space cost, capital expenditure for fish stock, equipment, buildings, pond or tank construction, operating capital needed, labor requirements, costs of financing, production, harvesting and marketing, depreciation schedules and a profit and loss estimate. Such a prospectus is often necessary to obtain financing, but more important, it forces you to take a hard look at the economic factors involved.

B. Are you capitalized at a level sufficient to carry you from raw land development to first harvest? Of the failures I' ve seen in aquaculture the vast majority have failed due to a lack of adequate capitalization. The costs associated with aquaculture are many and often times unexpected financial burdens arrive.

C. Are you psychologically and financially prepared to only break even or perhaps to take a loss for the first year of operation...and quite possibly up to 3 years or longer . ..depending on the complexity of your venture.

II. Sources of Information and Permitting

The first step in this process is to request copies of the application forms and companion materials from all permitting agencies in order to become acquainted with the required information and the form in which it is to be submitted. Follow this step with informal meetings to gain a full understanding of the requirements and procedures and eventually to lay out semi-final plans to the agencies. It is particularly important to include those agencies whose function is described as "Administrative Review" in these informal pre-application discussions. The preparation of pre-development drawings, maps, descriptive reports, etc. as documentary support will prove most helpful to the permitters in unofficially sanctioning this proposal and/or pointing out its weaknesses or inadequacies.

This application preview can often curtail costly mistakes before they occur. It creates a cushion which allows redesigns or modifications to be made in order to come up to regulatory standard, or the subsequent selection of an alternative culture site which may have more suitable development parameters and/or be less environmentally sensitive. An additional positive aspect of this preapplication dialogue is that it does not necessarily require the services of lawyers, engineers, or other consultants DO NOT purchase or lease any property, even if it fully meets your established operational criteria, until you are reasonably certain the parcel(s) are "permittable". A Corps of Engineers biologist can be requested to make an onsite evaluation of your proposed location and give you a written description of its characteristics.

Permitting Comandments

Thou Shalt Not Treat Permitting As An Afterthought

This should be a critical element in the early project planning and site selection. Some permit requirements will vary from site to site; at some locations, certain potentially critical or fatal permits required elsewhere may not even be needed!

If the land is already owned, a careful regulatory assessment may strongly suggest against using it for aquaculture purposes. Keep in mind that no site is ever perfect from all regards --just make sure to avoid anything that poses a fatal flaw.

Thou Shalt *Get Thy Facts Together*

Substantive technical data are required for the site, the project, and the resources required. The facts should be presented in a clear, technically acceptable fashion. Applicants should become familiar with all applicable rules and regulations for two reasons: avoid surprises and appear competent to the regulator.

Thou *Shalt Not Try To Bamboozle The Agencies Or The Public*

It is in the applicant' s interest to present all needed information in a timely fashion and the proper format. The better the agency understands the facts, the easier it will be for them to help. Incomplete or unclear information will translate directly into delays and more time- which is presumed to be of value to the applicant.

Be "heads up" with the public. Without exception, public concern most frequently arises when there is a perception that facts are being hidden. An applicant is under no obligation to publicly "tout" a project, although certain public notices will be required during the permitting process. Generally, all information submitted to a regulatory agency is available to the public/media. If pressed for information, provide a concise project summary (l-2 pages, modeled after a press release) along with a copy of permit applications. Don' t expect a big outpouring of public support to help much; although widespread opposition can hurt. Doesn' t sound fair -- and it' s not -- but it's reality.

Thou Shalt Expect Help Rather Than Harassment From Agency Personnel

Generally, agency personnel are very helpful-- unless an applicant does something that compromises such assistance. In early discussions, expect information and general guidance, not specific decisions on the spot. A refusal to give a spot judgment is not "uncooperativeness", the system just doesn' t work that way - nor would such action be in the interest of either the public or the applicant. If the applicant goes in with a confrontational/adversarial attitude, then this is the type of relationship that will quickly develop.

Thou Shalt Neither Fear Nor Overly Trust Consultants

Competent professional consultants can be invaluable in getting a project permitted quickly and smoothly. Most consultants are very competent in a narrow field; unfortunately most consultants generally believe in only the first half of the above statement. Consultants often have agendas of their own – which they do not perceive to conflict with the owners/applicants goals. While such agendas may not conflict they distract from the most immediate need at hand Every effort be made to keep energies focused on the objective.

One trait shared by most consultants, regardless of their field, is the ability to run up large fees . However, if taken in context, they are often reasonable. (If 6 months is saved on a $5 million project, then the interest savings alone is on the order of a quarter of a million dollars.) The key in effectively using professional help is to establish a specific work statement, budget, and timetable --and then stick to it! Beware of any "professionals" that want to handle dealings with the agencies alone and without the owner present. The owner and regulators should get acquainted. A regulatory proceeding will always go better if there' s a "comfort level" between all parties. However, professional consultants call the shots as far as technical needs, procedural requirements, etc.

Thou Shalt Allot 150-200% of the Time, Energy, and Resources Expected

Unforeseen developments/diversion inevitably arise; while specific items cannot be predicted, contingencies should be provided If there is a critical timing problem, share it with the appropriate agencies. But, do not expect preferential or special treatment -- after all, each persons' problem is always special and urgent to them! Nevertheless, agencies do have a little latitude.

Have you made the following personal contacts?

1 Federal and State agencies, NCRAC, Sea Grant, Dept of Agriculture

2. Universities and colleges, Purdue and the AquaNic system, Extension
3. Fish farming associations (State and national)
4. Professional consultants, fish farmers, feed distributors, merchandisers

Have you obtained publications and printed materials from the following sources?

1. Federal, State, university, and United Nations Food and Agriculture Organization (FAO)
2. Industry journals and magazines
3. Popular and professional books and pamphlets on pertinent subject matter of which several may be obtained from NRAC and Sea Grant offices
4. The National Agriculture Library, Great package is sent and free for the asking

III. Physical Features of an Aquaculture Facility

No two aquaculture sites are exactly the same. Each site will differ in some way or another. Be it water quality, topography or the management style that puts it all together. When choosing a location for your venture please keep in mind the proximity to the markets you will be serving.

The efficient operation of a fish hatchery depends on a number of factors. Among these are suitable site selection, soil characteristics, and water quality. Adequate facility design, water supply structures, water source, and hatchery effluent treatment must also be considered.

Site Location

1. Does your site possess natural elevations so that proper engineering will afford complete drainage to each individual pond?
2. Has chemical analysis of the soils been made to determine their physical qualities for water retention?
3. Have core drillings been made to determine the soil types you are dealing with?
4. Are adjacent lands subject to aerial crop spraying for insects and weeds and have you tested your land for toxic chemical residue from previous years of spraying
5. Is the site free of all possible overflow by flooding?
6. Is drainage to natural waterways available without crossing other private lands?
7. Will your federal, state and local water management agencies permit drainage into existing streams?
8. What size and shape ponds would best fit your needs?
9. Can you economically secure your production complex from poaching?
10. Can you make or take delivery of fish regardless of weather conditions?

Water Supply

Water Quality

Water quality determines to a great extent the success or failure of a fish cultural operation. Physical and chemical characteristics such as suspended solids, temperature, dissolved gases, pH, mineral content, and the potential danger of toxic metals must be considered in the selection of a suitable water source.

Temperature

No other single factor affects the development and growth of fish as much as water temperature. Metabolic rates of fish increase rapidly as temperatures go up. Many biological processes such as spawning and egg hatching are geared to annual temperature changes in the natural environment.

Each species has a temperature range that it can tolerate, and within that range it has optimal temperatures for growth and reproduction. These optimal temperatures may change as a fish grows. Successful hatchery operations depend on a detailed knowledge of such temperature influences.

The temperature requirements for a fish production program should be well defined, because energy must be purchased for either heating or cooling the hatchery water supply if unsuitable temperatures occur. First consideration should be to select a water supply with optimal temperatures for the species to be reared or, conversely, to select a species of fish that thrives in the water temperatures naturally available to the hatchery.

1. What is the source of your water supply: reservoir, well (ground) water, or running stream?
2. Is your water supply adequate for present and future needs?
3. Can you control predators and unwanted fish species if surface water is used?
4. If well water is to be used, has it been tested for chemical adaptability to fish production?
5. Is the volume of the well water adequate and is it economically feasible to obtain?
6. Is it possible or necessary to secure water permits for the needed volume of water for present and future needs?
7. Is your water supply adequate to replace losses from evaporation and seepage?

IV. Feeding

Successful fish farming demands that the aquaculturist have a knowledge and appreciation of nutrition, feeds, and feeding practices Proper feed selection is important from both a nutritional and economical view. A feed should deliver the necessary nutrients, and in a form that can easily be consumed by the fish. Offering the proper type and correct amount of feed will result in more efficient production and increased profits. Feed quality, type and cost should be of primary consideration when selecting a feed.

Feed Source

1. Is feed available in quantities needed and is a constant supply assured?
2. Have your feed rations been proven through experimentation to achieve optimum growth or maintenance for the stock you are feeding?
3. Are the ingredients of your feed supply dependable and relatively constant from batch to batch?

Feeding Procedure

Feeds should be offered in the morning only after the dissolved oxygen levels have started to increase and no later than the middle of the afternoon,to allow digestion to occur during periods of high dissolved oxygen. Fish of all sizes do not consume and assimilate feed efficiently when the oxygen levels are low.

1. What maximum percentage of body weight will be fed and what factors will be fed and what factors will determine the acceleration rate to match maximum consumption?
2. At what water temperature do you plan to begin and to cease feeding?
   a. Will fish in heavily populated feeding ponds die of starvation during the prolonged winter months?
3. What physical apparatus will you use to check food consumption?
4. What adjustments will you make in your feeding program to compensate for cloudy, high humidity, hot days? Prolonged rainy weather?
5. If food consumption stops, what biological and/or chemical analyses must be made immediately?
6. What feeding schedule will you follow?
   a. What is the best time of day?
   b. In what depth of water?
   c. How many areas in a given pond and over how large an area will you feed for best results?
   d. If pelleted, what size (or sized) pellets are best suited for fish from 2 inch fingerling to 1 -l/2 pound fish?

V. Processing

Harvesting

1. What is the most economical harvesting method for your present and future facilities?
2. How will you construct your ponds for most efficient harvesting?
3. What special equipment will be needed for handling fish from harvest facilities to transportation vehicles?
4. Will you need special holding tanks or ponds to keep quantities of fish ready for immediate delivery?

Transportation

1. What facilities do you have available or must you construct for handling fish from harvest to market or processing plant?
2. What will you use for water cooling purposes in transporting fish--ice, refrigerated vans, refrigerated water tank?
3. How will a suitable water supply for long hauls be made available in transit? Aeration equipment needed?
4. Can you ship fish just on ice and avoid hauling large amounts of water?

Processing

1. If you plan to dress and/or package fish for resale, will your facilities conform with state food processing and sanitation codes? Do you need processing and retail sales licenses?
2. Are your production facilities reasonably convenient to a processing plan?
3. Is it to your advantage to contract with a processor for your annual production?
4. Good service and good quality are major keys to sales expansion. Are you equipped to give both?

VI. Marketing

Marketing has a variety of meanings, but one of the most to-the-point definitions is the phrase "providing the right production at the right time at the right place at the right price". This definition implies that marketing is a combination of activities or services which relate to and support the product. Marketing means that in addition to culturing the product (which is only one component in the marketing mix) a variety of services must be completed to generate interest in the product, put it in the "right place", and do so within the right time frame.

Essentially when a producer says that he is ready to market his own production he is stating that his firm will assume the marketing services which are demanded by consumers. In essence, the aquaculturist is opting to "be the system" rather than to use the system. He will displace only the participants in the marketing system not the functions. The realization that the functions of marketing must always be performed by someone, be it producer or mid-level handler, is central in making the decision to vertically integrate. For the producer who opts for performing a variety of marketing services, the price received for the product will increase; however, there is no guarantee of increased net returns unless the decision is supported with proper business planning and evaluation.

A number of aquaculturists seek to displace the mid-level handler and conduct business directly with retail interests. In making the decision to perform as a mid-level handler, the fish farmer needs to know what functions are generally executed by the distributor and what the performance of this functions may cost the fish farming enterprise. Only after these costs are determined can a decision be made which will provide increased economic benefits to the aquaculturist.

Calling on accounts, packaging and physical distribution of products are the marketing functions required to move aquatic livestock from the pond into the market. To give an example, our cost to deliver to a restaurant is $8.00. This covers only driver and vehicle expense.

Market Research

1. Have you studied your market outlets?
   a. Can you provide maximum quality and the types of products and services they require?
   b. What is the trend in production form, packaging, convenience, and price of your product in the market?
2. Are you aware of all your production and processing costs so that you can meet competition in your product field and still make a profit?
   a. What are your overhead and operating costs?
   b. What percent shrinkage or processing loss occurs in your product from harvesting weight to consumer weight?
   c. Do you have an outlet for your processing scrap?
3. Can you assure market outlets of a dependable continuous supply source?

Market Promotion

1. Have you plans, either individually or collectively through a marketing organization, distributors, or retailers, to:
   a. Actively and regularly advertise your product to stimulate or increase consumer sales?
   b. Generally promote your product to improve its public image?
   c. Cooperate with news media in developing articles, pictures and programs to

increase public awareness?

VII. MANAGEMENT

Personnel

1. Are you, or do you have available, a biologist or ichthyologist competent to make immediate diagnosis and proceed with proper chemical treatment of diseases, parasites, low oxygen, etc. ?
2. Can you recognize and eliminate causes of certain danger signals?
3. Do you have adequate skilled help to efficiently carry out all phases of your operation to maintain schedules and to meet emergencies?

Biological and Chemical Controls

1. What apparatus and laboratory equipment will you use for daily testing of oxygen content of your water? (What is a safe margin of oxygen level that must be maintained?)
2. What chemicals, in what amounts are needed for control of algae or other oxygen depleting plant life, and how will they be applied?
3. What preventive controls will be used for diseases of fish?
4. Do you have special permits from and cooperation of state and federal wildlife services for control of migratory waterfowl and other wildlife predators?

Equipment

1. Is 220/440 3-phase electrical power available?
2. What emergency power unit is planned in the event of electrical power failure?
3. Do you have adequate power equipment-- tractors, lifts, conveyors, winches, etc. to facilitate efficient operations?

Plant Layout

1. Are your ponds, tanks, hatcheries, and processing and shipping areas designed for optimum efficiency of labor and time?
2. Are your facilities accessible during prolonged adverse weather?
3. Do you have holding facilities for quarantining incoming or diseased fish or for display?
4. Have you provided for expansion in your production plant layout?

BE ACTIVE IN THE POLITICAL PROCESS

Get involved in the political, governmental and educational processes which will influence (either positively or negatively) the development and growth of “your” industry. If aquaculture industry associations exist in your area, join them and work through them to formulate and implement a fair and simplified permitting process. The point is don’t sit back and wait for someone else to do these things for you - be part of determining the speed and direction of your business.

Literature Cited

Portions of this checklist is based on an outline prepared by Mr. Howard Heck in Kansas and has been adapted from experience in the North Central Region.

Texas Aquaculture Association, College Station, Texas.

Younger, William R.; Moseley, Joe; Shiner, James A. 1987 Texas Agricultural Extension Service and Sea Grant College Program, Texas A&M University.

Marketing Niche Marketing Through the 90's

John W. Jensen
Department of Fisheries and Allied Aquacultures
Alabama Cooperative Extension Service
Auburn University
Auburn, Alabama

Aquaculture is definitely not a get-rich-quick scheme. It is typically like other kinds of agriculture, dependent on large amounts of investment and operating capital, subject to many risks and returning relatively modest profits to capital and management. Failures of aquaculture businesses are common.

I believe, however, that much of the discouraging results and failures surrounding aquaculture come about because of weaknesses in the approach to marketing. Think about it - most producers come from a farm production or a biological sciences background. Few people come into an aquaculture business with a solid, realistic marketing plan and follow through.

I'm here to tell you that if you intend to produce an aquaculture product on a small scale you should spend half your time allotted to the business taking care of the marketing and distribution of your product. Sounds maybe a little extravagant, but it is what I have concluded afte 20 + years working with aquaculture, both in the U.S. and abroad.

"Find out what the people want and give it to them just that way." Those are words from a Fats Waller tune that remind us that you must be sure you are producing a product for which there is a market. And, you must produce a first-quality product in the right numbers and at the right time. The most efficient production of something for which there is no market is all for naught.

I've talked with thousands of potential growers over the years and the largest percentage are interested in the details of producing a crop of fish. Few have given any thought to marketing and when they do the majority would prefer that a processor simply comes to get their fish. Even that simple of a relationship between grower and processor doesn't exist. Planning for both parties must be done. First the grower needs to communicate his/her interest in selling to the processor. The processor must spell out their requirements and have an idea of how much fish will be available. Today contracts are used to nail down quantities that will be sold and purchased quarterly. The processor also will let the grower know of their requirements such as maximum pond distance from the plant, minimum pond size, road access, aerator and tractor availability, minimum load, off-flavor checks, estimates of average weights and total biomass, weighing and payment schedule. Once these details are understood, scheduling occurs that hopefully will fit into the processor's market development plans.

The processor cannot survive without the producer and vice-versa. Producers, however, are most vulnerable because of their short-term need to move fish. Therefore, anything special, but reasonable, that the producer can do to help the processor in arranging for, accessing, harvesting and loading his/her fish may mean the difference between positive and negative cash flow. My recommendation to producers is to get a date with a processor, become engaged and get married!

I don’ t want to concentrate on large-scale processors here because it simply isn't very applicable to the stage of aquaculture development in the region. However, a classic problem that should be addressed is how to make the leap from small-scale to large-scale.

My definition of large-scale is production that can keep one processing line operating for one 8-hour shift, five days a week In the catfish industry, this would mean about 5 million pounds per year or 100,000 pounds per week This may be quite different for other species and truthfully most small-scale operations in Alabama process 500 to 5,000 pounds per week, nowhere close to 100,000 pounds per week of a minimum l-line facility.

More than 300 commercial catfish producers in Alabama and many others throughout the Southeast do not sell to the large processors. They have found that the product they grow is marketable in a variety of ways. They have identified and developed niche markets.

Before you begin an aquaculture business, you should answer the following questions as you plan for the market.

1. What species will be marketed?
2 What is the competition like?
3. What product forms will be marketed?
4. What price will be charged for the product?
5. What type of promotion will be used?
6. What can be offered that is unique to obtain market share?
7. What are the regulations regarding the production and marketing of aquaculture products?
8. Where will the product be marketed?

Niche markets have advantages and disadvantages. The main advantage is that producers have more control over the prices for their products because producers become wholesalers and retailers. They tend to eliminate or reduce the number of middlemen and retain a larger portion of the product. The main disadvantage is the amount of time that must be spent in analyzing and developing markets.

Fish-Out

Fish-out or fee-fishing, where customers pay to fish and/or pay by the pound for what they catch, is probably the most common marketing choice made by catfish producers. However, it's unlikely that fish-out would be the first choice of most producers if other markets and resources were available. There are more than 200 fish-out operations in Alabama, most of which are not run very efficiently. Fish-out has become a way to "sell" fish to recover costs rather than a viable money-making outlet. Just a handful of entrepreneurs have managed fish-out operations to maximize income.

Probably the best way to market catfish or other desirable fish species through fish-out is to use one or two small ponds up to one acre in size for fishing. Fish should be grown in other ponds owned by the operator or hauled to the pond from another farm so that customers can be restricted to certain areas, fish stocks can be kept high so that fishing success (and sales) remains high and inventories can be accounted for.

Ideally fish-out operations should be located near urban centers. People enjoy fishing for recreation, and close-to-home fishing reduces travel time and cost and provides a return on the recreational dollar spent.

The biggest problem with fish-out is getting the fish to bite when the customers are fishing. Catfish usually bite well when the pond is heavily stocked but when half of the fish are caught the remaining ones become hard to catch. Therefore, fish-out operators need to have an outlet for fish that won't bite. If the fish don't bite customers soon spread the word and business is lost.

Fish-out operations are popular in the Midwest. Many of these ponds are stocked with catfish grown in the South. Cooler temperatures make it more profitable to transport the fish than grow them locally.

Pond Draining

Many first-time fish producers, after discovering that processors weren't beating down their door to purchase their product, resorted to advertising the sale of their product to local individuals on a specific day when the pond was drained nearly dry. This has come to be known as a "pond draining". More than a few producers sell some or all their fish this way year after year.

Of course ponds should be small, (generally less than two acres) so that the local market isn't flooded during the short period of selling. Pond drainings are usually held on the weekend when customers drop by to purchase fresh fish offered to the consumer directly from the pond. Autumn, near the end of the growing season, is usually the time when pond drainings are held. Advertisements in local newspapers and word-of-mouth are usually quite effective in drawing crowds even from small towns.

Pond draining can be very risky. The pond can drain earlier or later than the time announced to the customers. Customers may not show up or heavy rains can refill some watershed ponds even with the drain open.

Roadside Sales

Dan Butterfield in Tuscaloosa, Alabama sells every fish from his 100+ -acre fish farm to customers who drive to his farm a few miles south of town. The attraction of live, fresh fish direct from the farmer at reasonable prices is what attracts them and others who buy from several Alabama fish farmers operating roadside sales businesses.

Most roadside operators are seasonal, like roadside vegetable markets, selling only during cool months. Fish are usually harvested from larger ponds and brought to a holding facility, tank or cages, where they can be dipped up and weighed. A custom dressing service is usually offered which can bring in a considerable income without a large investment. Dan Butterfield handles food fish other than catfish including grass carp, bighead carp, silver carp, tilapia and paddlefish.

This type of operation is adaptable anywhere. A source of fish, either locally grown or hauled in, water, tanks near a major road and possibly a permit and you can be in the aquaculture marketing business. I see a great potential in setting up holding facilities for fish at the farmers' markets throughout the U.S.

Small-Scale Processing

Fishermen catch large quantities of catfish from the Tennessee River so it hard to figure how Milton Taylor, fish farmer and small-scale processor can sell his farm-raised product to customers perched on the banks of the River It comes down to dependability. Farm-raised catfish are dependable in quality and can be delivered to customers at a requested size in a specific quantity on a selected day; not like wild, river catfish.

Milton, as well as 12 of his fellow fish farmers in Alabama, realized that catfish could be a profitable farm enterprise if the product could be put into a saleable form. That form required for sales to restaurants, fish markets and individuals is processed, dressed fish. Each week orders are taken, fish are caught up, dressed and packaged. Other fish are kept on hand for walk-in customers.

Small-scale processors need to meet State Health Department standards for operation. However, beyond a building and its sanitary equipment, little is needed in the way of processing equipment: a knife, skinning plyers, tables, sinks, refrigerator, ice machine and freezer are the minimum pieces of equipment required.

Several small-scale processors have expanded into other levels of production and marketing, earning the profits often left to others. They have become vertically integrated on a small-scale. They produce fingerlings for their operations incurring only their direct cost of production. Food fish are sold live or dressed to walk-in customers or local outlets and a portion of the product is cooked and served to customers at their restaurants.

Live-Haulers

Throughout the south, and north into the Midwest, fishing for catfish is a pastime that people are willing to pay for. Most Midwest and some of the cooler southern States find that it is more economical to purchase live fish grown in the deep South rather than try to grow their own at less than optimal temperatures.

Demand from these live markets has created new outlets for growers in southern states. However, it's probably the most difficult market to service because large quantities of fish (10,000 lb+) have to be loaded in minutes onto tank trucks so that fish arrive at their destination in good condition.

Few ponds outside of the Mississippi Delta are of the right type to catch the fish and load the trucks efficiently and rapidly. If watershed ponds are being used, only buyers transporting small quantities of fish can be serviced. Some growers have a holding facility where fish from small ponds can be accumulated until a live-hauler can be arranged for purchasing large lots. This system, though in the planning stages, could open up markets that would otherwise not be available to the individual small producers.

In summary, small-scale aquaculture is working for thousands of producers across the United States. However, each potential producer should carefully evaluate his/her resources before investing in commercial ventures. Innovative approaches to marketing are usually the key to success or failure of fish farming on a small-scale.

Lunch

Friday, February 17, 11:30 a.m. to 1:15 p.m.

Garden Court, pool area

Entertainment:
"Fish Stories" one-act play

Session 1

Friday, February 17, 1:15 p.m. to 5:00 p.m.

Veranda 1-4

Notes

The Development of a Commercially Viable Yellow Perch Aquaculture Facility

Christopher J. Starr
Aquatic Biologist
Bay Port Aquaculture Systems, Inc.
16990 Croswell
West Olive, Michigan 49460

Bay Port Aquaculture Systems, Inc. of West Olive, Michigan, has been producing yellow perch to meet consumer's demands since 1990. The goal of Bay Port Aquaculture Systems is the development of a commercially viable yellow perch aquaculture facility. Although production is the main emphasis at Bay Port, research continues at the facility to advance yellow perch aquaculture.

Constraints restricting the development of yellow perch aquaculture in the past have been 1) survival of first feeding fry on practical feeds, 2) a seasonal supply of yellow perch eggs and/or fingerlings, and 3) lack of an economical supply of heated water for yellow perch growth.

Yellow perch are only approximately 5 mm long at hatching and, therefore have a realitively small mouth size. Researchers have had limited success developing a diet that is nutritionally complete and small enough for the yellow perch to ingest. Lack of swim bladder inflation also seems to affect survival of newly hatched yellow perch. This, along with the dietary concerns has limited the success of training yellow perch fry to accept and survive on practical feeds.

Bay Port Aquaculture Systems produces fingerling yellow perch in ponds to by-pass this concern. Ponds are stocked with newly hatched fry and managed for zooplankton production to provide a natural food source. Once the fish become 1: to 2: they are harvested from the ponds and transported to the production facility, where they are trained to accept practical feeds. Survival of fingerlings during this ìfeed trainingî stage is approximately 90 percent.

Researchers have yet to discover a method of inducing spawning of yellow perch throughout the year. Yellow perch regularly spawn during the spring, thus providing eggs and fingerlings once a year. This presents a problem to fish producers that want to market their fish on a year ëround basis. Producers must implement a production strategy to reduce the growth of a portion of their yearly fingerlings. Once the fingerlings are trained to accept practical feeds, a certain portion of them can be given reduced rations and held in cooler water temperatures to limit growth. It is more advantageous for a producer to limit the growth of smaller fish due to space and water requirements. As fish reach market size and are sold, fish that were ìheld backî can be integrated into the production cycle. This will allow the producer to operate their facility at or near full capacity while providing fish for the market throughout the year. Another advantage of such a production strategy is that producers can skew their production so that more of their fish become market size during those period of the year when there is a greater demand for yellow perch due to less fish available from commercial fishermen.

Researchers have found that 68(F to 72(F is the optimal growing temperature range for yellow perch. Bay Port Aquaculture Systems choose a site adjacent to an electrical generating plant to access a supply of heated water for raising yellow perch. Consumers Power Company's J.H. Campbell Electrical Generating Complex was choosen for this purpose.

At this site, Bay Port not only has access to the heated discharge water, but also to the intake water. The heated discharge water is approximately 25(F to 35(F warmer than the intake water. Intake water is the primary water source during the summer months, while the heated discharge water is the water source during the winter. Water from both sources is mixed during the spring and the fall to provide the desired water temperature. Although Bay Port Aquaculture Systems is located adjacent to a power plant, it is hard to maintain the optimal growing conditions throughout the entire year. However, Bay Port can maintain optimal rearing temperatures approximately 10 to 11 months throughout the year.

Bay Port began by operating a small scale, demonstration project at this site. While continuing yellow perch aquaculture research, the main goal of this project was to determine the constraints of working with a power plant as a water source. After operating this facility for a year, Bay Port began construction of a larger, commercial facility.

Bay Port's commercial facility consists of four outdoor raceways that are 240 feet long. Each raceway is divided into three 8 ft. x 80 ft. sections for easier fish handling. All fish production is conducted in the raceways. Smaller tanks are used for egg incubation, feed training of fingerlings, and current research projects. Bay Port Aquaculture System's current facility is sized to produce approximately 120,000 pounds of whole yellow perch annually.

The target market size for yellow perch at Bay Port is 7.5î to 8î, although the current high demand for yellow perch has caused the sale of smaller fish for the market. Under Bay Portís operating conditions, yellow perch can attain the target market size in 11 to 24 months. Although yellow perch grow rapidly when they are small, growth rates decline dramatically once the fish reaches a size of approximately 6 inches.

Yellow perch at the Bay Port facility are feed a commercial trout diet, since diets specifically formulated for yellow perch are not commercially available. Average feed conversion of yellow perch throughout the growing cycle is approximately 1.5 to 2.0.

There are still many issues of concern for the yellow perch aquaculture industry. Research is needed to produce a reliable supply of inexpensive fingerlings and to increase the growth rates of yellow perch. With the help of researchers, such as those affiliated with the North Central Regional Aquaculture Center, yellow perch aquaculture can be successful.

Status of Aquaculture Drugs

Rosalie A. Schnick
Upper Mississippi Science Center
National Biological Service
P. 0. Box 818
La Crosse, Wisconsin 54602-0818

Introduction

Aquaculture lacks enough properly approved drugs to reduce disease-related mortality and improve production efficiency and product quality. Only three therapeutants (formalin, oxytetracycline, and Romet-30) and one anesthetic (MS-222) are currently approved and available for use in aquaculture. These drugs were limited to a few species, diseases, and uses (Working Group on Quality Assurance in Aquaculture Production 1994).

Determination of Aquaculture Chemical Status

Because of the high cost, the large number of unapproved drugs, and general lack of interest by the pharmaceutical industry in developing aquaculture products due to lack of profitability, aquaculture groups had to identify the most needed chemicals, prioritize them, and eliminate the low priority drugs from consideration. Several aquaculture groups requested and obtain rulings from the U.S. Food and Drug Administration's Center for Veterinary Medicine (CVM) regarding the regulatory status of key aquaculture chemicals. Petitions for those chemicals that the aquaculture groups felt were effective, safe, and had data available were submitted to CVM for determination of low regulatory priority (LRP). CVM will not object to the use of those drugs classified as LRP if they were used under the conditions indicated, at the prescribed levels, according to good management practices, of an appropriate grade for use on food animals, and not likely to cause an adverse effect on the environment. Several groups (U.S. Fish and Wildlife Service, National Biological Service, States, and Fish Health Section of the American Fisheries Society) requested and received rulings that resulted in the declaration of 18 unapproved drugs as being "low regulatory priority", six drugs considered as not low regulatory priority (i.e., requiring INADs), 26 drugs or family of drugs that are considered high regulatory priority (HRP) for enforcement action, two drugs (copper sulfate and potassium permanganate) with deferred regulatory action, and nine chemicals that did not meet the definition of a drug for their intended uses (Table 1). Drugs considered HRP for enforcement action must be covered by either investigation new animal drug permits (INADs) or approved new animal drug applications (NADAs); however, CVM also determined that any nitrofuran (e.g., furazolidone), malachite green, and methylene blue would not be granted any INAD exemptions and that sulfonamides would not likely be granted INAD exemptions until the carcinogenicity issues have been clarified. The two compounds that have been deferred for regulatory action, copper sulfate and potassium permanganate, control fungal and bacterial infections and external parasitic infestations on freshwater fish. CVM has encouraged the development of INADs for both these compounds. Compounds used to regulate water pH or control foam are not considered drugs, and therefore, CVM does not regulate them. These chemicals are under jurisdiction of the U.S. Environmental Protection Agency, and facilities are required to contact the National Pollutant Discharge Elimination System permitting agency prior to discharging water.

Provisions for Unapproved Drug Use

CVM recognized that provisions needed to be developed to allow the use of certain unapproved drugs until the aquaculture industry had a chance to develop data for full approvals (i.e., NADAs). The first provision was the designation of drugs as LRP; currently, 18 unapproved drugs are considered to be LRP drugs.

The second provision for use of unapproved drugs is somewhat limited, but it offers some relief. That provision is extra-label use. CVM will allow extra-label drug use if the health of the animals are threatened and if suffering or death would result from failure to treat the affected animals. Under the extra-label use criteria only formalin could be prescribed for use on species other than those on the label by practicing veterinarians; however, CVM has also decided that extra-label use of medicated feeds is allowed in aquaculture when the medicated feeds mixed with oxytetracycline or Romet-30 are formulated and labeled properly in accordance with medicated feed regulations (Mitchell 1994). CVM has also decided that drugs approved for terrestrial species can be used in aquaculture under this provision.

All the remaining compounds considered to be drugs by CVM that are used in aquaculture are, at the present time, expected to have approvals, or be used under provision of an INAD exemption (Geyer 1993). There are two types of INADs: standard and compassionate. The compassionate INADs are being granted to producer groups and agencies willing to accept the responsibility of administering these INAD's. Each INAD has to be renewed on an annual basis. Under a compassionate INAD exemption, data must be generated to support the approval of the drug; if it is not, the INAD will not be renewed (Geyer 1994). All chemicals defined as drugs that are either currently used or anticipated for emergency use must be covered under an INAD so that the need for emergency use is eliminated or at least greatly reduced. All users of these identified drugs except researchers working on laboratory animals are included under this INAD process --- public and private production facilities, fishery management units, and participants in fishing tournaments, etc (Stefan 1994). This process is not a panacea, but it is the only means of using the needed drugs legally.

Data Generation for Approvals

The INAD process will work only if INADs lead to approved NADAs. The INADs will allow the use of drugs on a provisional basis until all the data needed by CVM for NADAs are generated. These data include target animal safety, residue, environmental, and mammalian safety studies.These data must be developed in a timely manner or the INADs will be rescinded. These data (except field efficacy) must be generated according to Good Laboratory Practices (GLP). A GLP program is expensive and difficult to develop. Without public funding for these studies, aquaculture will continue to suffer major losses.

Certain programs have been initiated that may lead to approved NADAs: Abbott Laboratories for sarafloxacin; Bonneville Power Administration funding for erythromycin research at the University of Idaho; Striped Bass Technical Committee, American Fisheries Society funding for human chorionic gonadotropin at Auburn University and Intervet, Inc.; and National Research Support Program No. 7 for amoxicillin, chloramine-T, copper sulfate, formalin, and oxytetracycline.

Additional funding to support the generation of human food safety, analytical methods development, and environmental fate data for certain drugs was recently obtained by a partnership with the International Association of Fish and Wildlife Agencies (IAFWA), on behalf of state agencies, National Biological Service (NBS), and the U.S. Fish and Wildlife Service (FWS) (NBS 1994). Research to gain approvals or extensions of approvals for eight drugs identified as high priority by the states and to establish crop grouping was initiated July 1, 1994 and will extend until June 30, 1999. During that 5-year period, at least 39 states will contribute a total of $3.9 million, NBS's Upper Mississippi Science Center (UMSC, formerly National Fisheries Research Center, La Crosse, Wisconsin) will provide $4.3 million, and the Fish Farming Experimental Laboratory, Stuttgart, Arkansas (FFEL) will provide some base funding toward a) development of data under GLP provisions to gain CVM approval of NADAs for use in aquaculture for the following essential drugs; 1) extension of formalin to other species, 2) expansion to other diseases and extension to other species for oxytetracycline, 3) copper sulfate, 4) chloramine-T, 5) sarafloxacin hydrochloride (sarafloxacin), 6) potassium permanganate, and 7) benzocaine; b) development of safety and efficacy data to delineate concentrations of hydrogen peroxide for control of fungi on various fish species and eggs and efficacy data to expand the low regulatory priority status of hydrogen peroxide for potential control of external parasitic infestations and external bacterial infections on freshwater fishes; and c) development of research information to allow acceptance of a crop grouping concept by CVM. Data will be generated to allow CVM to assess whether a few selected fish species can be used as surrogates for all or most of the cultured fishes in the United States.

Summary

Progress has been made by focusing on the actions required to resolve the important issues related to the use of chemicals and drugs in aquaculture. Consensus has been built regarding priority needs for drugs and some funding has been obtained that will help generate the data required for drug approvals; however, additional funds are needed to complete full approvals for each priority drug and pursue other priority aquaculture drugs. However, efforts have been initiated to resolve the crisis in aquaculture drugs.

Literature Cited

Geyer, Richard E. 1993. FDA enforcement policy for aquaculture. Salmonid XVII(1):4-10.

Geyer, Richard E. 1994. The aquaculture industry: a look ahead. Salmonid XVIII(1);12-14, 23.

Mitchell, George A. 1994. Compliance issues and drug use in aquaculture production. Presented at NRSP-7/FDA Workshop for Minor Use Drugs: Drugs in Aquaculture: Current Status - Future Goals, September 29 - 30,1994, Bethesda, Maryland.

National Biological Service. 1994. Approval of drugs for public fish production. Upper Mississippi Science Center, La Crosse, Wisconsin. March 1994. 98 pp.

Stefan, Gary E. 1994. Impact of FDA regulations on aquaculture animal drug use. Salmonid XVIII(1): 10-12.

Working Group on Quality Assurance in Aquaculture Production, Joint Subcommittee of Aquaculture. 1994. Guide to drug, vaccine, and pesticide use in aquaculture. Texas Agricultural Extension Service, College Station, Texas. June 1994. 68 pp.

Table 1. Status *of Aquaculture Chemicals (continued)*

Table 1. *Status of Aquaculture Chemicals (continued)*

Table 1. *Status of Aquaculture Chemicals*

Substances-Uses	*Low Regulator Y Priority*	*Drugs not LRP*	*High Regulato ry Priority*	*Chemical s not Drugs*
Acetic acid - fish parasiticide	X			
Acriflavine - egg disinfectant; bactericide, fungicide, and parasiticide			X	
Benzalkonium chloride - bactericide		X		
Benzethonium chloride - bactericide		X		
Benzocaine - anesthetic			X	
Calcium carbonate - water pH and alkalinity control				X
Calcium chloride - osmoregulatory and transport aid	X			
Calcium hydroxide - water pH control				X
Calcium oxide - external protozoacide	X			
Carbon dioxide gas - fish anesthetic	X			
Carp pituitary extract - hormone			X	
Chloramphenicol - bactericide			X	
Cytochalasin B - oyster triploidy inducer			X	
Dimethylpolysiloxane - foam reducer				X
Epinephrine - clam and oyster metamorphosis inducer		X		
Erythromycin			X	
_-Estradiol - hormone			X	
Fluoroquinolones (e.g., enrofloxacin, sarafloxacin) - bactericides			X	
Fuller's earth - egg adhesive reducer	X			
Garlic - helminth and crustacea control in salmon	X			
Human chorionic gonadotropin - hormone			X	
Hydrogen peroxide - fungicide on fish and their eggs	X			
Ice - transport aid	X			

Table 1. *Status of Aquaculture Chemicals (continued)*

L-Dopa – clam and oyster metamorphosis inducer		X		
Luteinizing hormone – releasing hormone analog - hormone			X	
Magnesium sulfate - external monogene and crustacea control	X			
Malachite green - parasiticide and fungicide			X	
Methylene blue - parasiticide			X	
17-alpha-methyltestosterone - hormone			X	
Metomidate - anesthetic			X	
Nitrofurans (e.g., nitrofurazone, furazolidone, nifurpirinol) - bactericides			X	
Onion - external crustacea control in salmon	X			
Oxygen – maintain saturated dissolved oxygen				X
Oxytetracycline - fish marker			X	
Ozone - disinfectant and organic compound remover				X
Papain - egg adhesive reducer	X			
Penicillin - control bacteria in algae fed to oysters				X
Penicillin dihydrostreptomycin - bactericide			X	
Potassium chloride - osmoregulatory aid	X			
Povidone iodine compounds - fish egg disinfectant	X			
Quinaldine - anesthetic			X	
Quinolones (e.g., oxolinic acid, naladixic acid) - bactericides			X	
Salmon pituitary extract - hormone			X	
Sodium bicarbonate - fish anesthetic	X			
Sodium chloride – osmoregulatory aid and parasiticide	X			
Sodium chlorite - bactericide and fungicide		X		
Sodium hydroxide - water pH control				X

Table 1 *Status of Aquaculture Chemicals (continued)*

Sodium sulfite - fish egg hatching aid	X			
Streptomycin - control bacteria in algae fed to oysters				X
Sulfonamides (e.g., sulfamerazine, sulfadimethoxine) - bactericides			X	
Tannic acid and urea - egg adhesive reducers	X			
Thiamine hydrochloride - thiamine deficiency treatment	X			
Trichlorfon - parasiticide		X		
Tris buffer - water pH buffering				X

Feeds and Nutrition
Where Are We And Where Are We Going

Paul B. Brown
Purdue University
Department of Forestry and Natural Resources

Introduction

Without optimum nutritional intake, your fish will not grow maximally, feed conversion ratio (FCR) will be higher than anticipated, health of fish will be impaired, and reproduction will be less than anticipated. If you developed a business plan for your operation, you quickly noticed that feed costs are one of the highest annual costs (Riepe et al. 1992). Simply put, if you are planning to grow a fish, you have to feed it (Brown's tenet number 1). Nutrients are the fuel for your fish; without regular intervals of optimal nutrient intake, physiological and biochemical processes are impaired. Thus, there are basic fish biology as well as practical considerations in feeding fish. Several aspects of practical feeding need consideration before establishing an aquaculture operation.

First, you should compare price, availability and quality of feeds available in your local area. This can be accomplished by calling your local feed store. Most feed companies have data indicating the response (weight gain, FCR, etc.) of targeted species. Next, call the respective experts at the universities represented at this meeting. Talk to as many as you can and develop some consensus among those individuals. We feed a lot of fish and. have conducted numerous unpublished feeding studies.

Available Fish Diets

One of the first realizations you face is that the recommended diets may not be available from your local feed store. Do not worry, there are several well known and respected feed companies in other parts of the country that produce good-quality feeds and routinely ship those to this region. Those companies include Zeigler Brothers, Inc., Gardners, PA; Nelson and Sons, Inc., Murray, UT; Rangen, Inc., Buhl, ID; Bioproducts, Inc., Warrenton, OR; and, Moore-Clark, Co., Vancouver, BC. Regional feed manufacturers include Purina Mills, St. Louis, MO; Hubbard Milling, Mankato, MN; Nunn Milling, Evansville, IN; and, some of the Cargill feed mills.

The next realization you face is that diets may not have been developed for the chosen species. The scientific pursuit of nutrition in aquaculture is so new that we have essentially two general forms of diets-- catfish and salmonids (trout, salmon, and char). Within each of these categories, there are numerous subdivisions. For example, within the area of catfish diets, you can find diets formulated for fry, juveniles, grow-out in ponds, and diets formulated for grow-out in cage culture (Robinson et al. 1994). There are even more divisions within the salmonid diets. If you plan to grow either of these two groups of fish, you have several options when it comes time to purchase feeds. Price, availability and quality should be important considerations in your choice of feed. Most of the people I meet in this region are interested in raising something other than catfish or salmonids. If you plan to raise yellow perch, you will not find a diet specifically formulated around the nutritional needs of that species. The perch's nutritional requirements have not been established. Again, do not worry. There are several research groups working on development of diets for new species (walleye, hybrid striped bass, tilapia, yellow perch, bluegill, crayfish, etc.) and some of the existing catfish or salmonid diets will result in weight gain of your target species. We do not know, in many instances, if this is maximal weight gain, but the fish will grow. Table 1 summarizes the macronutrient levels found in a range of fish diets available in North America.

Table 1. Typical macronutrient concentrations in growout fish diets manufactured in the United States.

Target Species	Crude Protein	Crude Fat
Channel cattish	26-35%	3-10%
Trout	**35-40%**	12-20%
Salmon	40-55%	15-25%

Most people feeding tilapia use one of the catfish diets or one of the new diets formulated for tilapia, while those feeding yellow perch or walleye use one of the trout or salmon diets. If you want to feed a fish for which there are no established nutrient requirements or, therefore, diets, start by feeding a diet formulated for a species with similar feeding habits. For example, catfish are considered more omnivorous than trout or salmon, which are more carnivorous. You will most likely have to try several diets before identifying one that is accepted by a new species and results in weight gains and FCR you consider acceptable.

Typical ingredients

Ingredient use varies with target species. Trout and salmon diets contain more animal by-product meals (fish meal, blood meal or flour, meat and bone meal, poultry by-product meals, etc.) than diets formulated for catfish or tilapia, while catfish and tilapia diets contain more ingredients processed from plants (soybean meal, canola meal, corn grain, wheat products, etc.). Ingredient usage has two primary effects on you--price and flavor.

In general, animal by-product meals cost more than feedstuffs processed from plants. This is particularly true of fish meal and fish oil. Thus, you can expect higher feed prices for trout diets than catfish diets.

Feeding fish meal or oil to fish imparts a “fishy” flavor, while feeding plant feedstuffs results in a milder tasting fish. You need to understand the expectations of your market. Some species in some markets are expected to taste “fishy,” while other consumers desire a mild fish regardless of species.

Current Research and Future Needs

Current research in the field of fish nutrition is varied and includes investigations into the use of new ingredients, waste management, development of diets for new species, interactions of nutrition and disease, nutrition and flavor, nutrition and storage stability, and nutrition and reproduction. All of these areas can have profound impacts on practical aquaculture. The first three topic areas are briefly discussed below.

Ingredient Evaluations

One of the goals of ingredient evaluation is allowing least-cost feed formulation in aquaculture. We can least-cost (choose the lowest cost ingredient at a given point in time) for some species (trout and catfish), but there are still uncertainties. Fish, depending on your viewpoint, are either not domesticated or barely domesticated. Thus, switching dietary ingredients in feeds can result in poor acceptance of the new diet. Manufacturers try to maintain similar ingredient usage over time to avoid poor acceptance. As fish become more domesticated and we understand what factors impact diet acceptability, we will use more least-cost approaches to diet formulation, which will help maintain stable feed costs for you. Some of the ingredients under evaluation include canola meal, canola protein concentrate, soybean protein concentrates, roasted soybeans, alfalfa protein concentrate, corn distillers' grains with solubles, and corn gluten meal and feed.

An additional goal of ingredient evaluations is the continued removal of fish meals from diets. As pointed out above, it is one of the most expensive ingredients in diets; thus, replacing fish meal with high quality plant protein feedstuffs will help maintain or reduce your feed costs.

Waste Management

Food is the primary nutrient source into most of your production systems. If you are a careful feeder, you will have minimal uneaten food; if you are a "dumper," you can have relatively more uneaten food. Either way, you will have some uneaten food. Try to become a "feeder" instead of a "dumper"; wasted food is wasted money. The other source of organic material in your system is feces; that portion of the diet that was not absorbed plus some waste products from normal metabolism. These products, uneaten food and feces, constitute the organic material in your effluent. Several research groups in this region are developing data through the regional aquaculture center that will allow more precise formulation of diets and reduce your effluent worries (Brown 1991ab; Riche, 1993; Cain, 1993). You can find, for example, low-phosphorus diets from most of the feed manufacturers. Precise formulation of diets will result in maximum absorption of nutrients and reduced effluent problems. This is an important factor in increasing densities in the same amount of water.

New Species

Development of animal diets is a long, slow process. Human nutritionists are still working on optimum diets for us. Closer to home, catfish and trout nutritionists are still actively engaged in defining optimal diets for established aquaculture species. In the past four years, two groups have been defining the nutritional needs of hybrid striped bass.. Thusfar, we have established only a few requirements (Brown et al. 1992; Nematipour et al. 1992; Griffin et al., 1992; Keembiyehetty and Gatlin 1992; Brown et al. 1993; Keembiyehetty and Gatlin 1993; Griffin et al. 1994abc; Swann et al. 1994), but are making relatively rapid progress (Brown, 1993). There have been even fewer requirements developed for yellow perch, walleye or bluegill (Dabrowski and Brown, 1993; National Research Council 1993). Lack of optimal diets is one of the basic problems associated with culturing a new species. However, some level of success can be achieved by feeding one of the existing fish diets.

Conclusion

Nutrition drives all physiological and biochemical systems and has significant impacts on the profitability of an aquaculture operation. Without regular, optimal nutrient intake, fish will not function properly. Further, feed costs are one of the most expensive aspects of your operation. Thus, you need to identify a high-quality feed that does not cost much. Quality and value are the key words in nutrition.

Depending on species you are raising, you may or may not find a diet scientifically formulated around your target species. However, you can identify a diet that will result in positive weight gain by contacting fellow aquaculturists or research labs. Talk to as many people as you can initially and stay in touch with them as more data are developed in this area.

Literature Cited

Brown, M.L., G.R. Nematipour and D.M. Gatlin. 1992. Dietary protein requirement of juvenile sunshine bass at different salinities. Progressive Fish-Culturist 54: 148-156.

Brown, P.B. 1991a. Evaluation of fecal collection methods for determining phosphorus absorption in rainbow trout. **In:** Fish Nutrition in Practice, (S.J. Kaushik and P. Luquet, editors). Institute National de la Recherche Agronomique, St. Pee-sur-Nivelle, France.

Brown, P.B. 1991b. Managing aquaculture wastes-- nutritional aspects. Proceeding of the National Livestock, Poultry and Aquaculture Waste Management Workshop, Kansas City, MO.

Brown, P.B. 1993. Using whole-body amino acid patterns and quantitative requirements to rapidly develop diets for new species. European Inland Fisheries Advisory Committee (EIFAC) Workshop on Determining Nutrient Requirements for Fish. EIFAC Occasional Paper no. 29, Rome, Italy.

Brown, P.B., M.E. Griffin and M.R. White. 1993. Experimental and practical diet evaluations with juvenile hybrid striped bass. Journal of the World Aquaculture Society 24:80-89.

Cain, Kenneth D. 1993. Pretreatment of salmonid diets with phytase to reduce phosphorus concentrations in hatchery effluents. M.S. Thesis. Michigan State University, East Lansing, MI.

Dabrowski, K. and P. Brown. 1993. Culture of coolwater fish in the north central region of the United States. Aquaculture of Freshwater Species (Except Salmonids). European Aquaculture Society Special Publication 20:59-60

Griffin, M.E., P.B. Brown and A. Grant. 1992. Dietary lysine requirement of juvenile hybrid striped bass. Journal of Nutrition 122:1332-1337.

Griffin, M.E., M.R. White and P.B. Brown. 1994a. Total sulfur amino acid requirement and cysteine replacement value for juvenile hybrid striped bass (Morone saxatilis x M. chrysops)..Comparative Biochemistry and Physiology 108A423-429.

Griffin, M.E., K.A. Wilson and P.B. Brown. 1994b. Dietary arginine requirement of juvenile hybrid striped bass. Journal of Nutrition 124:888-893.

Griffin, M.E., K.A. Wilson, M.R. White and P.B. Brown. 1994c. Dietary choline requirement of juvenile hybrid striped bass. Journal of Nutrition 124: 1685-1689.

Keembiyehetty, C.N. and D.M. Gatlin. 1992. Dietary lysine requirement of juvenile hybrid striped bass (Morone chrysops x M. saxatilis).Aquaculture 104:271-277.

Keembiyehetty, C.N. and D.M. Gatlin. 1993. Total sulfur amino acid requirement of juvenile hybrid striped bass (Morone chrysops x M. saxatilis).Aquaculture 110:331-339.

National Research Council (NRC). 1993. Nutrient requirements of fish. National Academy Press, Washington, DC.

Nematipour, G.R., M.L. Brown and D.M. Gatlin. 1992. Effects of dietary energy:protein ratio on growth characteristics and body composition of hybrid striped bass, Morone chrysops x M. saxatilis. Aquaculture 107:359-368.

Reipe, Jean R., LaDon Swann and Paul B. Brown. 1992. Analyzing the profitability of hybrid striped bass cage culture. Illinois-Indiana Sea Grant Fact Sheet 92- 18, Illinois-Indiana Sea Grant Program, Purdue University, West Lafayette, Indiana.

Riche, M. 1993. Phosphorus absorption coefficiencts for rainbow trout (Oncorhynchus mykiss) fed commercial sources of protein. M.S. thesis. Purdue University, West Lafayette, IN.

Swann, D.L., J.R. Riepe, J.D. Stanley, M.E. Griffin and P.B. Brown. 1994. Cage culture of hybrid striped bass in Indiana and evaluation of diets containing three levels of dietary protein. Journal of the World Aquaculture Society 25:281-288.

Session 2

Friday, February 17, 1: 15 to 4:50 p.m.

Veranda 5-8

Notes

A Status Report on "The Walleye Culture Manual"

Robert C. Summerfelt
Department of Animal Ecology
Iowa State University
Ames, Iowa 50011

Abstract

This talk describes the current status of a project of the North Central Regional Aquaculture Center to develop a manual that would provide a thorough description of the status of walleye culture from the viewpoint of both the practicing fish culturist and that of scientists and economists who are actively involved in research that is relevant to the walleye culture.

The Walleye Culture Manual (WCM) represents the first effort to describe all aspects of the cultural technology of walleye, including collection of brood fish, spawning, fertilization, egg incubation, and production of fry, fingerlings, and fish suitable for human consumption in the food-fish market. The North Central Regional Aquaculture Center is producing a culture manual based on the up-to-date research and techniques used in the industry of walleye culture.

The Walleye Culture Manual consists of 16 chapters by 17 authors. The chapters consist of literature reviews and summery of one or more case studies written by experienced fish culturists from public agencies and private aquaculturists. The case studies are detailed descriptions of specific cultural practices for all aspects of walleye culture. The WCM will consist of 50 case studies in the manual, written by 55 authors. The case studies are examples of how different people and organizations culture walleye. The case studies provide information not found in scientific publications, which are typically experiments that are designed to evaluate specific techniques or strategies. The case studies give us a clear picture of what is actually being done for each cultural technique. The insight gained from this perspective will serve as a basis for further refinement and improvement in these techniques and as topics for future research.

Chapter and Case Study Titles

Preface: Robert C. Summerfelt

Chapter 1. Introduction: History and Overview- Robert C. Summerfelt

Chapter 2. Reproductive Biology and Spawning - Jeffrey A. Malison and James A.Held

Walleye Spawning Operations at Bonny Reservoir, Colorado Charles D. Bennett and James L. Melby

Walleye Spawning in Michigan James A. Copeland and Martha M. Wolgamood

Collection of Brood Walleye and the Spawning and Incubation of Fertilized Eggs. James E. Harvey and Shyrl E. Hood

Incubation of Walleye Eggs at Garrison Dam National Fish Hatchery David Paddock

Fingerling Production in Drainable Ponds at White Lake Fish Culture Station David D. Flowers

Walleye Culture at the Oneida Fish Cultural Station, New York State Department of Environmental Conservation

Richard T. Colesante, Co
Coolwater Production Supervisor

The walleye production program at the Oneida Fish Cultural Station involves the collection of over 300 million eggs and production of over 200 million fry; This program has been ongoing for approximately 100 years; in 1993, the hatchery was rebuilt with the capability to produce advanced walleye fingerlings under intensive culture techniques. This fingerling rearing program involves feeding brine shrimp initially, followed by formulated diet during a transition period and thereafter until the fingerlings are between 4 - 5.5î in length. The fingerling program requires the production of 200,000 - 300,000 fish, stocked in public waters between August and October. This paper will detail the methods used at the cultural station including:

1) Egg Collection and Fry Production
   - broodstock collection
   - egg take
   - egg incubation
   - fry production

2) Intensive Production of Advance Fingerlings
   - brine shrimp incubation, harvest and feeding
   - rearing tank modifications and fry stocking
   - fry density and light manipulation
   - survival first 30 days, transition to formulated diets (day 30-day 60), post diet conversion (day 60 - day 140)
   - production statistics for 1993 and 1994
   - problems

Intensive Culture of Walleye Fry on Formulated Feed

Alan Moore
Iowa Department of Natural Resources
RR 2
Moravia, Iowa 52571

The production of 6-8 in fingerling walleye from fry on formulated feed in 150 days was investigated. Currently, production methods include stocking fry in ponds, raising them to 2-in (5 cm), then training these fingerlings in tanks to accept formulated feed. Because of mortalities that occur in the pond and during the training process; raising walleye from try to fingerling on formulated feed becomes an attractive alternative. The two main problems of poor gas bladder inflation and low survival have slowed acceptance of this technique; however, these problems have been solved with the use of surface sprayers to increase gas bladder inflation and the use of Kyowa B-400 to B-700 fry feeds (Bio-Kyowa Inc., Chesterfield, MO) to improve feed acceptance. Currently at the IDNR Rathbun Hatchery, 20,000-35,000 six-7-in (15.2-17.8 cm) fingerlings are produced solely on formulated feed. This paper will summarize the walleye fry feeding techniques used at Rathbun.

The Extensive-Intensive Production of Advance Fingerling Walleyes at the Spirit Lake State Fish Hatchery

Brian T. Bristow, Iowa State University, Ames, Iowa

Pond-raised walleye fingerlings have been trained to eat formulated feeds in raceways at the Spirit Lake State Fish Hatchery, Spirit Lake, Iowa, for the past eight years. Insight from these experiences has been incorporated into the tandem culture protocol (pond to tank) to produce about 30,000 advanced fingerling walleyes, 5 - 7 in, for stocking Iowa waters each year. The culture period consists of three intervals: a pond culture period, where fry are stocked into ponds and cultured for about 50 days on natural food; a training period, the first 30 days after the fish are brought into the hatchery; and a grow-out period, which entails the remainder of the culture season (from about August 1 - October 1).

Water from Spirit Lake, passes through a large gravel filter into a l-acre settling pond, and is pumped into the hatchery. Pressurized oxygen is injected into the water between the settling pond and the hatchery at a rate of between 0.5 and 1 gpm (2 and 4 L/min), so the water flowing into the tanks is at about 105% saturation. The water is generally quite turbid (>l0 NTU), and the fish are seldom visible in the culture tanks. Fish performance is best when the water temperature is about 70(F, and growth is best at or about 75(F.

Walleyes are cultured in 156-ft3 concrete raceways that have light blue walls and floors. Water is supplied to each raceway at 20 gpm for an exchange rate of about once per hour. The culture room receives natural lighting from nearby windows and skylights, and overhead lights are on 24 h/day.

For training, fingerlings are fed 8% of their body weight per day, but this rate is reduced to 6% when the fish are 5 inches long, and reduced to 4% when water temperatures fall below 68(F. Feed is dispensed with Louden automatic feeders every 5 min for 22.5 hours/day. The feeders are shut off from 0730 to 0900 hours during tank cleaning. Feeding rates are adjusted daily to compensate for changes in tank biomass from fish growth and mortality.

In late June or early July, pond-reared walleye fingerlings (2.0 in) are stocked in the raceways at a density of about 0.2 lb/ft3 (6,500 fingerlings/raceway). These fish are provided a training diet for 30 days (until August 1). At the end of this 30-day training interval, the number of fish in each raceway is calculated, and the populations reduced to 0.2 lb/ft3 (2,500 fish/raceway) to begin the grow-out phase.

Feces and waste feed are flushed down the drain once daily by pullint the standpipe, increasing the water flow, and sweeping the tank bottom. During this process, the water level is lowered to about 5 in, and the tank walls are sprayed with pressurized water to remove any accumulated fungus or feed residue. Additionally, the tank walls are scrubbed with a coarse brush about once each month. All dead fish are removed and enumerated daily and, when possible, the case of death is recorded.

Performace of fingerlings for the training and grow-out phases is evaluated using survival (%), growth (inches and pounds), and feed conversion. Samples of 50 fingerlings are removed at 15-day intervals from each raceway for measurement of fish length and weight. At the end of the training interval, all fish in each tank are weighed collectively, and populations calculated by counting the number of fish in three 3-5 lb samples. At the end of the grow-out interval, all remaining fish are hand-counted.

Any time a moribund fish is observed during tank cleaning, the gills are removed and observed microscopically. Major increases in daily mortality attributed to disease may be caused by parasite infestations. Parasites we have observed on the gill tissues of moribund fish at Spirit Lake include; Chilodenella sp., ich (lchthyophthirius multifillis), and Costia (lchthyobodo sp.). These infestations have been chemically treated with either a 1 hour bath treatment of 1% salt, or a 1 hour flow-through drip of 100 ppm Paracide F (formalin). For severe ich infections, an 8-hour, 40 ppm formalin drip has been used for about 10 consecutive days.

By following this production protocol we expect about 60% of the fish to accept the formulated feeds and survive the training interval. Mortality during the growout period should be low, and greater than 90% of the fish on hand on August 1 should survive until late September. At water temperatures of about 70(F, growth rates average 0.35 inches/week, and the fish should attain a mean length of about 6.5 inches by late September.

Cage Culture of Walleye

David L. Bergerhouse
Southern Illinois University
Carbondale, IL 62901-6511

Abstract

The culture of walleye (Stizostedion vitreum) in cages is by no means a well established practice. At the current time there is no active industry that uses cages to culture walleye. A limited amount of research has been conducted on walleye cage culture, but there are currently no proven economically viable methods for producing walleye in cages. However, walleye can survive in cages, can be trained to accept artificial feed in cages, can be over-wintered in cages in temperate regions, and can grow to a size at which they are marketable as a food fish. The initial capital investment required to begin rearing fish in cages in existing water bodies is much less than is required for other types of aquaculture. Therefore, cage culture may very well have a role to play in the development of the walleye as a commercial species.

There are a number of advantages to rearing fish in cages. Cages allow the use of existing water bodies that would otherwise not be suitable for aquaculture. Many farm ponds, borrow pits or strip mine lakes do not lend themselves to open pond aquaculture due to their size, bottom configuration, lack of drainability, or the presence of obstructions which make seining impractical. It is easier to monitor the health and growth of fish in a cage than in open ponds. Sampling and harvest are simpler and require less equipment in cages than in open ponds. In some cases a pond used for cage culture can still be used for sport fishing or other recreational activities.

There are several advantages to rearing walleye in cages. Walleye are highly regarded both as a sport fish and as a food fish. Market potential exists both for fingerlings for stocking. to enhance sport fisheries, and for larger fish for human consumption. If walleye are being fed a prepared diet, cages concentrate the fish near the point of feed input. Cages allow fish to be observed and graded to maintain a uniform size and to remove cannibals. Cage culture of walleye does not require expensive tank or raceway facilities, and usually does not require continuous pumping of large quantities of water. The capital and overhead costs of walleye cage culture would therefore be somewhat less than for other types of walleye culture. In temperate regions walleye may be better suited for cage culture than warm water species since they will feed and grow at cooler water temperatures. The growing season for walleye would therefore begin earlier in the spring and extend later in the fall than for warm water species.

There are specific problems involved with rearing walleye in cages. Walleye must be trained to accept a prepared diet. This can be done in cages or in tanks. However, considerable mortality can occur during the training process. Walleye are not highly gregarious by nature, and behavioral problems can occur including cannibalism and competition for feed. Walleye can be easily stressed by handling or by disturbance due to cleaning or maintenance of the cage. When stressed or injured they can be very susceptible to disease, especially if the water temperature in above 25 °C (77°F).

There are a number of site selection criteria that should be met before cage culture is attempted in a water body. The pond should be large enough to support the number of fish in the cage. Most ponds can support only about 1,000 to 1,500 pounds of fish per surface acre without supplemental aeration or water flow. Confining fish in cages does not increase the carrying capacity of the pond. The pond should not have a large biomass of loose fish. These fish are included in the total carrying capacity of the pond. The pond should not be located in an area where it receives agricultural runoff, livestock waste or pesticide contamination. The pond should be deep enough to allow waste materials to be swept away from the cage. At least one to two feet (0.3 to 0.6 m) of water should be kept between the cage bottom and the pond bottom. The water level in the pond should not fluctuate significantly. The pond should be exposed to wind action to aid in water circulation through the cage. The pond must be accessible. If aeration is to be used then access to a power source may be important. It would be desirable for the pond to be in a controlled or secure area to minimize poaching.

Criteria for cage design include size, number of cages, shape, mesh size, flotation, and means of access. Stocking densities can range from over $3{,}600/m^3$ for small fingerlings being trained to $17/m^3$ for food size fish. Food size walleye will likely require at least two growing seasons to reach marketable size. As the fish grow they should be transferred to cages with larger mesh size to allow maximum water circulation. Mesh sizes as small as 3/16 in. have been used for 2.5 in. fish, and gradually larger mesh sizes have been used, up to 3/4 in. for 14 in. fish.

The source of walleye fingerlings is one of the most important considerations in planning a walleye cage culture operation. Trained or untrained walleye fingerlings are available from commercial producers. Walleye are easily stressed by handling, and are highly susceptible to columnaris disease when stressed. Significant mortalities can and often do occur in the first two weeks after stocking. It is vital to acquire the highest quality fish available and to handle them as little as possible when transporting them to the cage. Significant advances are being made with rearing fish from the fry to fingerling stage entirely on artificial diets. If this technology becomes commercialized, then the possibility of acquiring well trained walleye fingerlings in June, when water temperatures are relatively cool, may have great potential for reducing stocking mortality in walleye cages.

Walleye survival in cages has varied from 6.5% to 93%. At the current time there are two many variables involved with cage culture for the percent survival to have any predictive value. However, it has been demonstrated that high walleye survival can be achieved in cages. Walleye have also demonstrated reasonable growth in cages, reaching about 8 in (203 mm) by the end of the first growing season, 12 to 14 in (305 to 355.6 mm) by the end of the second growing season, and a market size of 1.5 lb (681 g) to 2 lbs (908 g) by the middle of the third growing season. As feed quality improves it is entirely possible that this market size could be achieved in the second season.

When walleye are over-wintered in cages it is necessary to keep the area of the pond around the cages free of ice to allow winter feeding, allow water circulation through the cage, and to prevent damage to the cage from ice scouring. Deep airstones and a blower do an adequate job of circulating warmer bottom water to the surface to prevent ice formation.

Winter feeding is important to increase survival and avoid cannibalism. Walleye will continue to actively seek food down to 40°F (4.44° C). Winter feeding rates vary between 0.5% and 1% of body weight per day. Over-winter survival of up to 98.5% has been reported.

When considering cage culture of any species it is necessary to consider possible effects that rearing the fish may have on the environment. Wastes from cage culture are normally released directly into the environment without any kind of treatment. Overloading a water body's capacity to deal with fish waste will have negative effects on both the caged fish and the native biota of the water body. If cage culture is undertaken in public waters the excess nutrients could cause dramatic changes in the productivity of that lake or stream. Nutrient rich water discharged from a constructed pond or lake may alter the nature of the receiving stream. The best way to avoid environmental degradation is careful site selection and to size the operation well within the capacity of the water body.

Cage culture has the potential to contribute to the development of walleye as a commercial species. The low initial cost of cage construction and use of existing water bodies will allow walleye culture to be attempted without large financial investments. Walleye can be successfully trained, fed, over-wintered, and grown to food size in cages. Procurement of trained fish early in the first season, stress and disease control, and development of complete low cost feeds are all important factors in the development of a successful and economically viable walleye culture industry.

Economic Analysis of Advanced Walleye Fingerling Production in an Intensive Recirculating System

Dr. Patrick D. O'Rourke and Annabelle M. T. Edon
Illinois State University, Department of Agriculture

Walleye has been among the most popular species in North American commercial and recreational fisheries. Most recent research has been concerned with the need to enhance wild walleye populations which have come under increasing fishing pressure. Both U.S. and Canadian agencies have invested in the species since the early 1980s with the establishment of stocking programs becoming a priority.

The increasing demand for walleye fingerlings mainly for stocking purpose, and the popularity of food-size walleye with consumers have motivated state hatcheries and the private sector in the United States and Canada to investigate commercial aquacultural production of walleye. U.S. commercial landings have always been minor compared to Canadian landings. Canada, in particular the provinces of Manitoba, Ontario and Saskatchewan, commonly yield about 7 million kilograms of walleye per year compared to an annual average yield of 17,000 kilograms in the Great Lakes and the Mississippi River systems of the Unites. For the years 1985-1992, Canadian exports of food-size walleye to the U.S. averaged 32 percent of Canada's total harvest.

The popularity of walleye as a food and game fish has increased in the upper Midwest. Walleye has been recognized by the North Central Regional Aquaculture Center (NCRAC) as a species with aquaculture potential for the region. Walleye culture is important even though the culture of walleye is not as organized and well-established as salmonid and catfish culture. Interest from the private sector in walleye production is fairly new and continues to grow with the availability of technical information concerning rearing practices.

The economic model presented here for intensive production of walleye fingerlings in an intensive tank system has been based to a large extent on the 1994 study of Mathias and Moodie, "Feasibility of an Intensive Walleye Culture System for Northern Communities." It is the most complete and the most recent source of information concerning input and yield data, as well as prices and cost structure for such a system. Total initial investment was $64,770. Operating cost data came from studies of past and current production systems. The operating costs consisted of: labor, feed, energy, water, egg cost, oxygen, interest on operating capital, maintenance and repairs, fees and licenses, insurance, property tax, depreciation, and miscellaneous expenses.

It was assumed in the model that the production system allowed two production cycles per year. Walleye eggs are available as early as March in the south, until late June early July in the north. The availability of walleye eggs during four months allows two production cycles per year.

The general goal of this study was to determine if the commercial production of advanced (6 inches) walleye fingerlings, reared intensively in a tank system in the North Central Region, would be economically viable. In the simulation, 2,500 iterations generated statistics for the total expense per fingerling produced, the net profit after taxes and interest, and the net present value.

The simulation generated:

1) a mean expense of 71.91 cents per fingerling with a standard deviation of 10.34 cents, a minimum expense of 47.37 cents and a maximum expense of 115.95 cents per fingerling produced,
2) an expected net profit of $6,319 with a standard deviation of $9,834, a minimum profit of ($23, 119), and a maximum profit of $54,606, and
3) a mean Net Present Value of $8,909 with a standard deviation of $32,556, a minimum Net Present Value of ($87,851), and a maximum Net Present Value of $108,861.

The positive expected Net Present Value generated by the simulation, along with an expected net profit of $6,319 indicate that investment in this hypothetical may be acceptable at the discount rate of 15 percent. However, the statistical indicate that the investment would be very risky based on the data and assumptions of the model.

Trade Show and Reception

Friday, February 17, 5:15 p.m. to 7:00 p.m.

Plaza Mall

TRADE SHOW

We'd like to thank these **aquaculture** suppliers of goods and **services** for their support of this **Aquaculture Conference.**

Aquatic Eco-Systems, Inc.
2056 Apopka **Boulevard**
Apopka, FL 32703
Ph: (407) 886-3939
Fax: (407) 886-6787

Cargill-Nutrena Feed Division
P.O. Box 5614
Minneapolis, MN 55440
Ph: (612) 742-7467
Fax: (612) 742-6391

Central Wisconsin Aquaculture
223 Sherman Street
Marion, WI 54950
Ph: (715) 754-2798

Dakota Live Bait Traps
Box68
Sinai, SD 57061
Ph: (605) 826-4170
Fax: (605) 826-4173

Geo-Synthetics, Inc.
428 N. Pewaukee Road
Waukesha, WI 53188
Ph: (414) **524-7967** ext. 198
Fax: (414) 542-8334

Hedlund Aquaculture
P. 0. Box 305
Medford, WI 54451
Ph: (800) **723-6011**
Fax: (715) 748-6103
Fax (715) 748-6103

Internet, Inc.
2730 Nevada Avenue North
New Hope, MN 55427
Ph: (612) **541-9690**
Fax: (612) **541-9692**

Kasco Marine, Inc.
1925 Quinlan Avenue South
Lakeland, MN 55043
ph: (612) 436-7611
Fax: (612) 436-6734

LaMotte Co.
P.O. Box 329
Chestertown, MD 21620
Ph: (800) 344-3100
Fax (410) 778-6394

Minnesota Aquaculture Association
P.O. Bpx 265
Alexandria, MN 56308
ph: (612) 763-6506

Mari Source
P.O. Box 9037
Tacoma, WA 98409
Ph: (206) 475-5772
Fax (206) 474-6013

North American Fish Farmers Cooperative
Box 219
Carrington, ND 58421
Ph: (701) 652-1130
Fax: (701) 652-2055

Peterson Fiberglass Laminates, inc.
300 Stariha Drive
P.O. Box 158
Shell Lake, WI 54871
Ph: (715) 468-2306
Fax: (715) 468-7923

Spruce Creek Fish **Farm**
12148 Aspen Dr. N.E.
P.O. Box 145
Miltona, MN 56354
Ph: (612) 763-6506
Fax: (612) 763-6163

Stoney Creek. Equipment Co.
11073 Peach Avenue
Grant, MI 49327
Ph: (800) 448-3873
Fax: (616) 834-5537

Wisconsin Aquatic Veterinary Service
2027 E. **Mifflin** Street
Madison, WI 53704
ph: (608) 246-0765
Fax: same as above

Zeigler Brothers, Inc.
P.O. Box 95
Gardners, PA 17324
Ph: (717) 677-6181
Fax: (717) 677-6826

General Session

Saturday, February 18, 8 am. to 10:00 a.m.

Veranda Ballroom

Notes

Aquaculture Network Information Center (AquaNIC)

LaDon Swann
Illinois-Indiana Sea Grant Program
Purdue University

Mark Einstein
Department of Animal Sciences
Purdue University

What is AquaNIC

The Aquaculture Network Information Center (AquaNIC) is intended to be a gateway to the world's electronic resources in aquaculture. AquaNIC is maintained at Purdue University in West Lafayette, Indiana and is supported by The Libraries of Purdue University, Purdue University Cooperative Extension Service, United States Department of Agriculture Extension Service, and the Illinois-Indiana Sea Grant Program.

Accessing AquaNIC

AquaNIC uses a Gopher server located in The Libraries of Purdue University and is linked to an Almanac server in Purdue University Cooperative Extension Service. There are three methods that can be used to access information. Information necessary to access AquaNIC is provided below.

Telnet

AquaNIC can be accessed by people with a connection to the Internet through telnetting to The Libraries of Purdue University. This is accomplished by telenetting to thorplus.lib.purdue.edu. When the connection is established you will be prompted for a login. The login is cwis (this must be lower case letters). You will then be prompted for a password. There is no password so press return when prompted for a password. The next screen that you see should contain a list of 16 menu items. AquaNIC is located under number the menu scholarly databases (number 16).

To move around the menus follow the instructions at the bottom of the screen. Once in a file use the spacebar to go down one page at a time. If you would like to exit the file without going to the end using spacebar type the letter "Q" for quit then press the return key. This sequence will take you back to the previous menu.

Modem

AquaNIC can be accessed using one of Purdue University's fifty 14,400 baud per second (bps) modems. It is not necessary for the caller to also have a 14,400 bps, but slower modems mean slower communications. Regardless of the modem used your communication software used the following settings must be made:

Phone number 317-496-1440
Data bits = 8
Parity = none
Stop bits = 1

When settings are made, number called and connection made, you will need to enter connect thorplus.lib.purdue.edu. You will then be promoted for a login. The login is cwis. You will then be prompted for a password. There is no password so press return when prompted for a password. The next screen that you see should contain a list of 16 menu items. AquaNIC is located under number the menu scholarly databases.

Almanac

AquaNIC information can be requested by e-mail using Almanac. The e-mail address is almanac@ecn.purdue.edu. In the body of the text leave a blank line then type the following line exactly as provided: send aquanic catalog. A catalog will be sent to you electronically. Individual or multiple requests can then be made by following the instructions in the catalog.

Commercial Carriers

AquaNIC has also successfully been accessed by users subscribed to commercial carriers such as CompuServe and America On Line. Contact your support group for exact instructions to AquaNIC.

AquaNIC Contents

AquaNIC contain a multi-branched directory containing various types of information. Most files on the AquaNIC can either be viewed on your monitor or a hard copy can be sent to your e-mail address. One of AquaNIC's unique features is that it is linked to several other aquaculture databases on the Internet.
The directory structure of AquaNIC is given below:

1. About AquaNIC
2. Search e-mail addresses
3. Search titles
4: Search text
5. Publications
    a. USDA Regional Aquaculture Centers
        1. Extension Publications
        2. Technical Reports
        3. Annual Progress Reports
    b. Federal Government Reports
    c. State Extension or Sea Grant Publications
6. Newsletters
    a. USDA Regional Aquaculture Centers
    b. National Association of State Aquaculture Coordinators
    c. State
7. Other Aquaculture Information ON the Internet
8. Other Aquaculture Information NOT ON the Internet
9. E-mail Directory of U.S. Aquaculture Contacts
10. E-mail Directory of International Aquaculture Contacts
11. Calendar of Events
12. News Flashes
13. Images
11. Job Announcements

Searching AquaNIC Information

Information in AquaNIC may be searched three ways using a search engine called "jughead." A title search will search for any word that appears in the title of a document. This method is a good general search method. A full-text search will search for any keyword in the text of a document.

Full-text searches using the word aquaculture for example may provide hundreds of "hits". Therefore, the search should be specific. Searches can be narrowed by using more that one keyword. For example, using "aquaculture and Indiana and Illinois and goldfish" would instruct the computer to list only entries that contain all four key words. The search engine recognizes the separators: and, or and not

The last keyword search mechanism is for e-mail addresses. When a search for e-mail addresses is conducted use as much of the person's name as possible.

Who to Contact for More Information

AquaNIC is a flexible electronic information center that is intended to be responsive to the needs of its customers. If you have information that you would like to include or have questions regarding AquaNIC contact:

Mark Einstein
meinstei@hub.ansc.purdue.edu
voice: 317-494-4862
or
LaDon Swann
lswann@hub.ansc.purdue.edu.
voice: 317-494-6264

James M. Ebeling
Research & Extension Associate
Piketon Research and Extension Center
The Ohio State University

You've heard the theory and the concepts behind "The Fish Barn", now finally the details behind the actual construction of that system will be presented. Topics to be covered include selection of tanks, pumps, aeration equipment, overall facility design, plumbing, electrical systems, and monitoring and control systems.

Session 1

Saturday, February 18, 10:15 a.m. to 12 noon

Atrium 3

Notes

Managing Around Cool Water Disease Problems

Rodney Homer
IDOC

Aquaculturists wishing to raise cool water species have few weapons in their chemical arsenal to use against disease. Formalin may be used to control fungus on musky and northern pike eggs, but not on walleye eggs. Formalin may be used to treat parasites on largemouth bass but not on cool water species.

There are no legal antibiotics at all. As a result, all the cool water fish farmer can do is try to manage around disease by paying close attention to stress management, including fish behavior, environment and nutrition. This talk discusses various areas where conditions for the fish can be optimized and the disease organisms placed at a disadvantage.

Water is the place where all culture starts and can spell the difference between success and failure. With the medicine chest empty, you will be far ahead of the game if you can start with heated, degassed well water. We use simple packed column degassers on each tank. Often, simple manipulation of the water temperature is an effective way to combat columnaris disease. Although optimal temperature for the fish is 68-70° F, by lowering the water temperature to 62°F columnaris is placed at a disadvantage.

Using circular tanks is another simple but effective way to deal with a host of problems. Circular tanks are self cleaning and in various depths and sizes can spell the difference between success and failure in the critical period when the fish are being trained to accept a pelleted diet. The flow in circular tanks tends to orient the fish end to end and present fewer cross targets which set off a predatory response.

Special attention must be paid to fish density during the period of training to accept pelleted diets. At no time during this period should the density exceed 0.9lb/cu ft.

Problems with the feed can swiftly precipitate disease. Feed particle size can be critical. Screening the feed to improve uniformity of particle size and remove fines can help prevent non-uniform growth. In escocids, growth rates are often an inch or greater per week. If one animal gets a larger sized food particle than another, and does this very often, it will soon be a few millimeters longer than its neighbors. It will then attempt to cannibalize its brothers and sisters by seizing them by the throat. The attack will fail, but the wounds in the throat of the attacked fish will develop a fungus infection and the affected fish will die.

Similar fungus problems can also be the result of inadequate protein content in the feed, swiftly precipitating nutritional gill disease and fungus. Poor environmental conditions because of fines in the feed can also precipitate BGD and result in fungus problems.

The difficulty in managing around problems with such swiftly growing fish is the rapidity with which problems develop. Literally everything can be fine in the morning and beyond the point of no return by afternoon. Decisions such as changing feed particle size must be made with the knowledge that you will be sacrificing the smaller individuals in the population.

Salt treatments are helpful in treating parasites, fungus, and relieving stress, combined with temperature and density manipulations.

Hydrogen peroxide (H_20_2) has shown some activity against fungus on warm water fish. As a result, we have begun tolerance testing against cool water fish. Small fingerling walleye (< 2”) are the most sensitive to the chemical followed by tiger musky and musky. Trials will begin in the spring of 1995, using 50 to 100 ppm against fungus problems of walleye, and up to 250 ppm with musky and tiger musky.

With few chemicals available it is imperative to anticipate problems before they develop and head them off. The only way to do this is to be a close observer of your fishes behavior. In the videotape by the Canadian DFO, Fish Behavior in Circular Tanks, Dr. Harald Rosenthal discusses the dynamics of water flow, fish behavior, feeding time and ammonia levels. The examples used are trout, but the principles are the same.

Session 2

Saturday, February 18, 10:15 a.m. to 12 noon

Atrium 4

Notes

Pond Aeration: Matching Equipment to Needs

John W. Jensen
Department of Fisheries and Allied Aquacultures
Alabama Cooperative Extension Service
Auburn University
Auburn, Alabama

No one should attempt to be a commercial fish farmer without aeration devices and the knowledge of when and how to use them. Aerators can be used exclusively for emergencies, continuously at night, or all day and night.

Today, aeration equipment is most commonly used in emergencies to keep fish alive and minimize stress associated with oxygen concentrations lower than 3 to 4 parts per million (ppm). Aerators used in this manner are not intended to aerate the entire pond but just a portion of it. Fish move to the zone of oxygenated water found near the aerator. Enough oxygen is supplied to save fish, but not to increase oxygen levels greatly in the entire pond.

Aerators work by increasing the area of contact between air and water. Aerators also circulate water so fish can find areas with higher oxygen concentrations. Circulation reduces water layering from stratification and increases oxygen transfer efficiency by moving oxygenated water away from the aerator. Many units are electrical, so wiring should be properly protected and installed to avoid any hazards from an electrical shock

If a pond shows a decreasing oxygen pattern that will reach 3 ppm or less before sunrise, emergency aeration should be used. In most situations, the critical time for low oxygen levels is from midnight to sunrise. If the oxygen concentration is falling quickly, however, aerators should be started when oxygen reaches 4 ppm. This creates a sufficiently large area of aerated water that fish will find and remain in until oxygen levels improve during daylight hours.

Two terms are commonly used to compare aerator performance. The standard oxygen transfer rate (SOTR) is the amount of oxygen that the aerator adds to the water per hour under standard conditions (68°F. and no initial oxygen) and is reported as lb O_2/hr. The standard aeration efficiency (SAE) is the standard oxygen transfer rate divided by the amount of power required and is expressed as lbs O_2/hr per horsepower (hp) or lbs O_2/hp-hr.

Ratings for tractor-powered aerators are generally given as standard oxygen transfer ratings (SOTR). Other, usually smaller, aerators are normally given standard aeration efficiency ratings (SAE). Efficiency ratings are based on the horsepower applied to the aerator shaft and not the horsepower of the power source. Most commercial aerators have ratings between 1 and 5 lbs. O_2/hp-hr.

Types of Aerators

Fish farmers have used emergency aerators powered by tractor power takeoffs (PTOs) for many years. These PTO aerators can be quite expensive because each aerator requires a tractor. Therefore, most ponds are equipped with electric aerators. Large tractor-powered aerators are used as back-ups during severe oxygen depletions, equipment failure, or power outages.

Several types of aeration devices have been evaluated for use in commercial fish ponds. Most aerators are in one of the following categories: surface spray or vertical pump, pump sprayer, paddlewheel, diffused air and propeller aspirator pump.

Surface Spray or Vertical Pump

Surface spray aerators have a submersible motor which rotates an impeller to pump surface water into the air as a spray. They float, are lightweight, portable and electrically powered. Units of 1 to 5 hp with pumping rates of 500 to 2,000 gpm are available.

They are designed to be operated continuously during nighttime, cloudy weather, or when low dissolved oxygen concentrations are expected. Surface spray aerators have prevented fish kills when used at 1.5 to 2 hp/acre. They are usually of little use in large ponds, because of relatively low oxygen transfer rates and their inability to crease an adequately large area of oxygenated water.

Pump Sprayer

Pump sprayer aerators are found on many fish farms. Most are powered by a tractor power takeoff or electricity. Some units are engine driven and require mounting on a trailer frame for transport. Pump sprayer aerators are equipped with either an impeller suction pump, an impeller lift pump, or a turbine pump. Some have a capped sprayer pipe or "bonnet" with outlet slits attached to the pump discharge. Others discharge directly through a manifold which has discharge slits on top and outlets at each end. Water is sprayed vertically through the discharge slits and from each end of the manifold. This type is commonly referred to as a T-pump or bankwasher and directs oxygenated water along a pond bank where distressed fish often go. Pump sprayers typically have no gear reduction which reduces mechanical failure and maintenance. These units do not erode the pond bottom, and minimum operating depth is reached when the intake is covered with water.

Paddlewheel Aerators

Farm-made paddlewheels are usually made from 3/4 ton truck differentials and vary with drum size and configuration, shape, number and length of paddles.

Units are powered by power takeoffs or driven by self-contained diesel engines. The self-contained units are usually on floats and attached to the pond bank or held in place by steel bars secured in the bank or pond bottom.

Studies have demonstrated that increasing either the speed of the drum rotation (rpm) or paddle depth generally increases aeration capacity. Paddle depth affects oxygen transfer rates more than does the speed of rotation. This increase in capacity is not cost free, because horsepower requirements increase and oxygen transfer efficiency may decrease. The maximum rotational speed of a tractor-powered paddlewheel aerator for extended operation is limited by the tractor, its recommended power takeoff speed under load, and the gear reduction of the paddlewheel.

The shape of the paddles is also important; for example, U, V, or cup shapes are more efficient designs than flat paddles. Paddlewheels create vibrations that can be reduced when paddles are arranged in a spiral pattern.

The oxygen transfer rate and power requirement increase with paddle immersion depth and the diameter of the paddlewheel drum. The size of the spray pattern likewise increases. The power required to operate a paddlewheel aerator at any given speed and paddle depth is constant. Fuel consumption and operating costs depend on the power source.

Most producers do not have enough paddlewheel aerators for all ponds and move these units from pond to pond. A paddlewheel, though mobile, can be difficult to situate in the pond properly so that it is effective without damaging itself or the tractor. Before emergencies occur, their locations should be selected and several trial runs should be conducted so that situating becomes more or less routine.

Paddlewheels can erode a hole in the pond bottom during operation. If the aerator settles into a hole while running, the load increases and reduction gears can break. Weld a metal plate under the paddlewheel to reduce erosion of the pond bottom. It is also important to block the tractor to prevent it from slipping back and increasing the load on the tractor.

When fish are stressed from low dissolved oxygen, they often go to shallow areas of the pond near the banks. The type and design of the paddlewheel aerator may affect the ability to direct the water along the pond bank where the fish tend to congregate. Another consideration is the ground clearance under the frame of the aerator. A paddlewheel aerator with limited ground clearance may get caught on high spots, such as a levee crown, while high clearance models can traverse these areas with ease, but may operate too shallowly to be effective.

Electric Paddlewheel

Electric paddlewheel units are 4 to 12 feet long with paddles of triangular cross section and a total drum diameter of about 28 to 36 inches. Paddlewheel speed is usually 80 to 90 rpm with a paddle depth of about 4 inches, enough to load the motor. The correct paddle depth can be determined in the field as the depth needed to draw the rated amperes of the motor. To extend the service life of the motor, the motor should draw only 90 percent of full load amperes rating, unless the manufacturer recommends differently. Motor sizes generally range from l/2 hp to 10 hp. Motors operating on single- or three-phase current are available.

Methods used to reduce the motor speed to the desired aerator shaft speed include v-belts and pulleys, chain drive and gears an gearboxes. Shafts of most electric motors run at 1,750 rpm and most units are mounted on floats.

Diffused Air Systems

Diffuser aerators operated by low pressure air blowers or compressors forcing air through weighted aeration lines or diffuser stones release air bubbles at the pond bottom or several feet below the water surface. Efficiency of oxygen transfer is related to the size of air bubbles released and water depth. The smaller the bubble and the deeper it is released, the more efficient this type aerator becomes. When tested at normal catfish pond depths, these aerators were found to be inefficient compared to other devices.

Limited studies in commercial catfish ponds showed no improvement in fish production when a diffused aeration system was used. One of the biggest problems with diffused-air systems is clogging of the air lines and diffusers so that periodic cleaning is required. Also, the air lines interfere with harvesting.

Propeller-aspirator Pump

These aerators consist of a rotating, hollow shaft attached to a motor shaft. The submerged end of the rotating, hollow shaft is fitted with an impeller which accelerates the water to a velocity high enough to cause a drop in pressure over the diffusing surface which pulls air down the hollow shaft. Air passes through a diffuser and enters the water as fine bubbles that are mixed into the pond water by the turbulence created by the propeller. They are electrically powered, and models range from 0.125 to 25 ph.

Note: Much of the information was taken from Pond Aeration by Jensen, G.L, J.D. Bankston and J.W. Jensen. Types and Uses of Aeration Equipment. Southern Regional Aquaculture Center, SRAC Publication No. 371. March 1990.

Water Quality Testing Methods for Aquaculture

Mike Harrington
LaMotte Company

Five principal testing methods are defined and explained in this slide presentation. Examples are given and testing tips for trouble-free analysis are provided.

In addition, pros and cons of various equipment are reviewed. The intent of the presentation is to provide producers with an overall review of testing equipment on this market, factors to consider when purchasing testing equipment, and to discuss critical parameters.

To conclude, a summary of testing tips, record keeping, and safety is reviewed.

The Effects of Density On Fish Growth Performance

Lawrence C. Belusz
Alexandria Technical College
Alexandria, Minnesota

Abstract

Above a specific temperature, which varies by species, a fishes' metabolic processes cannot keep up with increased demands for energy, and growth rate begins to decrease. The result of these demands is that for each fish species there is an optimum temperature for growth. Not as well understood is that each species of a specific size has an optimum density, or degree of crowding per unit of space, which also produces an optimum growth rate. For fish culturists attempting to maintain fish density or loading rates (carrying capacity) as high as possible, it is important to realize that management and production tradeoffs are made in return for maximizing the pounds of fish raised per cubic foot of space or gallon of water. These tradeoffs can be observed as a reduced rate of growth which results in a longer time to market, decreased feed conversion efficiency which results in more feed to grow an equal weight of fish, less uniformity in growth which results in fewer fish reaching market weight and increased time spent in size-grading, lower survival of fish which results in more cost per fish, more incidence of disease which results in added operational costs for treatments, and increases in water quality emergencies which result in added operational cost and more stress for fish which in turn leads to reduced growth. An understanding of the optimum spatial requirements of fish and the performance factors which are affected, will enable the fish culturist to produce a given crop of fish at optimum levels of management input which will be reflected in an optimum cost of production.

Lunch

Saturday, February 18, 12 noon to 1:00 p.m.

Plaza 6 **and** 7

Speaker: Bob Baldwin, Michigan Fish Growers Association

Topic: Aquaculture Industry Involvement in Public Policy

Notes

Session 3

Saturday, February 18, 1:00 p.m. to 3:30 p.m.

Atrium 3

Notes

An Overview of the Regional Bait Industry

Fred Copes, Biology Department, UW-SP
Tom Meronek, Fishery Co-op, USBS, UW-SP

Information on the bait industry in the north central states of Illinois, Michigan, Minnesota, Ohio, South Dakota, and Wisconsin was obtained in 1993 from a random mail survey of 420 retail dealers and from 482 selected wholesale dealers, and personal interviews with 21 wholesale dealers and 79 retail dealers.

The estimated total value of purchased bait in the six surveyed states was U.S. $164,622,311 for bait fish, and $91,927,220 for non-fish bait in 1992. These estimates do not include the value of sales of wholesaler to wholesaler and sales from wholesalers in the surveyed states to retailers in non-surveyed states. These estimates for purchased bait totaled $256,549,531. With the additional value of retailer harvested bait, the total estimated value of the industry was $257,118,710.

For the six states combined the bait fish sold were, in order of decreasing value, fathead minnows ***Pimephales promelas,*** lake shiners ***Notropis atherinoides, N. hudsonius,*** and ***N. ludibundus,*** white suckers ***Catostomus commersoni,*** golden shiners ***Notemigonus crysoleucas,*** chubs ***Nocomis biguttatus, Semotilus atromaculatus,*** river shiners ***Notropis blennius (Hybognathus argyritis*** in South Dakota), dace ***Phoxinus eos, P. neogaeus,.*** and ***Margariscus margarita,*** rosy reds a variety of ***Pimephales promelas,*** mud minnows ***Umbra limi,*** and mixed species. Night crawlers ***Lumbricus*** spp. were the most valuable non-fish bait followed in order by leeches ***Nephelopsis obscura,*** grubs ***Calliphora*** sp., ***Eristalis*** sp., and ***Galleria mellonella,*** mayflies ***Hexagenia*** spp., worms ***Helodrilus*** spp. Among others, crickets ***Gryllus*** spp., salamanders ***Ambystoma tigrinum,*** crayfish ***Orconectes*** spp. And others, frogs ***Rana*** spp., and hellgrammites Aeshnidae, Libellulidae, and Corduliidae. The order of value of fish and non-fish bait varied among states.

The percentage of retailers purchasing bait from other states (15) was about half that of wholesalers (34). Few bait dealers reported purchasing bait from Canada, but some dealers reported the purchase of large volumes of lake shiners and night crawlers from Canada.

Sources of Bait

Wholesale bait dealers in the six states reported that about 2/3 of their bait fish volume was harvested from the wild, and l/3 was cultured.

South Dakota wholesale dealers reported harvesting the highest percentage of bait fish from the wild (78%) and cultured the lowest percentage of bait fish (22%). Wisconsin and Minnesota wholesale dealers harvested the lowest percentage of bait fish from the wild (61% and 61%) and cultured the highest percentage of bait fish.

Various species of fish were harvested or cultured more than others. Wholesale dealers reported 100% of lake shiners, the mud minnow, and river shiners were harvested from the wild. Other species more often harvested than cultured were chubs, dace, the fathead minnow, and mixed species. The rosy red was the only species reported as 100% cultured. Other species more often cultured were the white sucker and the golden shiner.

Wholesale bait dealers reported that about half (54%) of their non-fish bait was harvested from the wild and nearly half (46%) was cultured. Corresponding volumes were

14,413,832 dozens of non-fish bait from the wild and 12,255,751 dozens of non-fish bait cultured.

Ohio wholesale dealers reported harvesting the highest percentage of non-fish bait from the wild (93%) and culturing the lowest percentage of non-fish bait (3%). Michigan wholesale dealers harvested the lowest percentage of non-fish bait (39%) and cultured the highest percentage (61%).

Wholesale dealers reported 100% of frogs, hellgrammites, and mayflies were harvested from the wild. Other non-fish baits more often harvested from the wild were night crawlers, leeches, worms, and salamanders. It is likely that salamanders were 100% wild, but retailers harvesting them incidentally from private ponds considered them as cultured bait. No non-fish baits were reported as 100% cultured, but grubs were reported more often cultured than harvested from the wild, and about half of the crayfish came from each source.

Bait Demand and Availability

Opinions on the demand and availability of bait fish varied considerably. About half of the retailers (45%) and wholesalers (52%) reported a constant demand for bait. For the remainder, opinions were virtually evenly divided on whether demand was increasing or decreasing. Most retailers (60%) thought that availability was constant, but 23% thought availability was decreasing. Nearly half (47%) of the wholesale dealers thought availability was constant (38%) or increasing (11%).

Most retail and wholesale dealers reported shortages of various baits during 1992. Mean percent reported shortages were low, ranging from 9% for dace, rosy reds, mud minnows, night crawlers, grubs, worms, crickets, salamanders, frogs, and hellgrammites for some months, to a high of 14% for white suckers, and 17% for leeches. However, in some states more than 20% of the bait dealers reported shortages of some baits in some months. Baits commonly in short supply were fathead minnows, lake shiners, white suckers, golden shiners, night crawlers, leeches, and crayfish.

Bait Fish Supply Shortages

The peak shortages of the fathead minnow, averaged for the six states, were in March and summer. Illinois, Michigan, Minnesota, and South Dakota bait dealers reported an additional shortage during April, and South Dakota was the only state where a large shortage occurred from November to March.

Comments on Conflicts with Conservation Agencies

Bait dealers appeared to want to communicate with conservation officials on issues affecting their industry and to have representatives present when regulations are changed or new regulations are proposed. Bait dealers were concerned that they were not treated fairly by conservation agency officials. Dealers reported they were harassed by conservation wardens that continually wanted to inspect their trucks. Dealers reported that many lake front property owners were unaware of bait dealers' right to harvest bait. If a conflict with a landowner occurred, conservation officials were said to side with the landowner. Some bait dealers reported they were blamed for problems that were already out of control, such as the spread of zebra mussels. Bait dealers were frustrated because they were excluded from ponds that were used for gamefish culture or for wildlife nesting areas (e.g. loons). It appeared to bait dealers that their conservation agencies would stifle rather than stimulate the bait industry.

Conservation agencies could benefit from improved relations with bait dealers. Agencies could consider bait harvesters as commercial fishermen and sample their catch periodically. Bait dealers cover large areas and log many hours when harvesting bait fish. With cooperation, bait dealers could provide information on the distribution of fish species, including threatened or endangered species and of exotic species, success of gamefish spawning based on the capture of juveniles, and a yearly index of forage fish biomass.

Ecological Issues

A common concern of bait dealers was wading birds, Kingfishers, cormorants, and pelicans that eat their fish. Bait dealers indicated the birds were a nuisance and little could be done to stop their destruction because permits for controlling these birds were difficult to obtain. Permits for control of nuisance birds are issued jointly by state wildlife officials and a U.S. Fish and Wildlife Service district office of law enforcement. The federal permit is contingent on state laws and not valid until the state permit (if required) is obtained (U.S. Fish and Wildlife Service (Region 3), Law Enforcement, Minneapolis, personal communication.)

Pesticides, herbicides, and fertilizers were another concern. The application of chemicals was cited as a cause of bait fish population declines. Bait dealers reported that many times streams were devoid of bait fish when a heavy rain followed an agricultural chemical application. The frequency of such reporting suggests that chemical application probably deterred bait fish harvesting in some agricultural areas.

Needs of the Bait Industry

Bait dealers indicated they needed information on: 1) proper care of bait fish in retail stores; 2) how to maintain water quality in bait tanks; 3) proper design of bait tanks to maintain bait fish; and 4) information on bait fish disease and mortality problems. Dealers wanted new or improved chemicals for control of bait fish disease and parasites, prolonging the life of minnows, and maintaining bait tank water quality. However, many products are already on the market that would meet needs of bait dealers. Dealers wanted help from state biologists because they need someone to turn to when problems arise in their bait tanks. Comments indicated that most biologists were unaware of the needs of the bait industry and were unequipped to help.

Reduced animosity and competitiveness among bait dealers should be beneficial. Bait dealers could form a large organization to represent their interests in each state. As one dealer reported, there are no standards for bait sales. Standardized grade sizes for bait fish, and dozens per pound for leeches would help bait dealers and purchasers evaluate the bait they are selling and purchasing, and reduce ambiguity in bait classifications. Sharing of information on bait culture techniques and maintenance could increase the profitability of bait dealers.

Bait Fish Culture

The future bait industry may rely heavily on culture of bait species. Preferences and needs of the industry indicated that research on raising golden shiners, lake shiners, the river shiner, the creek chub or hornyhead chub, finescale dace or pearl dace, and some suckers Catostomus spp. May be beneficial. The golden shiner is cultured extensively in Arkansas. Some other species listed are exclusively harvested from the wild and consequently not always available. Research on culturing bait fish species in use or in the region seems to be practical and the least controversial from an ecological point of view. Bait fish culture is and will become a more important part of Aquaculture in the midwest.

Cage Culture of Fish in the North Central Region

LaDon Swann, Illinois-Indiana Sea Grant Program; J. E. Morris, Iowa State University; Dan Selock, Southern Illinois University-Carbondale; and Jean Riepe, Purdue University

Introduction

The commercial production of fish is most commonly performed in open ponds, raceways, water reuse systems, and cages. **Cage culture of fish is an intensive production method which allows the farmer to utilize existing farm ponds, borrow pits, or strip pits, that would normally be unsuitable for open pond culture, by enclosing fish in cages or pens.**

Generally yields (pounds/acre) are greater in open pond culture. However, there are times when existing bodies of water do not lend themselves to open pond culture and cage culture may be the best alternative. There are other advantages to cage culture and include:

1. Cage culture is an inexpensive method to develop fish husbandry skills before considering more expensive production systems.
2. Fish health and growth are easier to monitor.
3. Harvesting is simpler.
4. Pond construction costs are eliminated when existing ponds are used.

In spite of the advantages cage culture offers, there are disadvantages which are largely a result of high densities of fish confined to the small volume of a cage. The disadvantages need to be weighed against any advantages before attempting cage culture. The primary disadvantages are as follows:

1. Water quality problems especially dissolved oxygen can develop due to high stocking densities.
2. Disease outbreaks spread very quickly.
3. Damage to the cages can result in escape of fish.
4. Fish are easier to poach or vandalize.
5. The farmer must have daily access to the cages.
6. Production rates are lower than in production ponds.

Site Selection

As mentioned cage culture can be practiced in standing bodies of water such as ponds, strip-mine pits and barrow pits. In addition, large public reservoirs, rivers and streams can be used for cage culture, if permitted by regulatory agencies. Agencies which may have authority over public waters are the State Department of Natural Resources or Conservation, U.S. Environmental Protection Agencies and U.S. Army Corps of Engineers.

The ideal pond for cage culture should have the following characteristics:

1. Be **at least** one surface acre with larger ponds preferred.
2. The pond should have a depth of eight feet in at least l/3 to l/2 of the pond area. The remainder of the pond should be at least four feet deep.
3. Water levels should not fluctuate more than l-2 feet during the summer.
4. There should be not more than a 10 acre watershed per surface acre of water.
5. Livestock should not have direct access to the pond.
6. There should be no runoff from row crops or livestock feedlots.
7. There should be no chronic problems with aquatic weeds.
8. The watershed should be vegetated to prevent siltation.

Water Quality

Maintaining high water quality will determine the success or failure of any aquaculture operation. Fish are dependent on water for all their bodily functions and slight changes in water quality will affect fish. Guidelines for the most important parameters will be given.

Many water quality parameters are measured using units called parts per million (ppm) or milligrams per liter (mg/l). Because both units are the same, during the following discussion of water quality ppm will be used.

Temperature

Ponds will stratify when the water warms and cools. This results when a warm layer of water forms over a cooler layer underneath. During the summer these two layers will not mix. This results in poor water quality (low oxygen and high ammonia) in the cooler-bottom layer. Mixing (turnover) of the two layers will result in an overall temperature.

Fish are cold-blooded animals and will have approximately the same temperature as their surroundings. Various species have different optimum growth temperatures. Each species can be categorized into coldwater, coolwater or warmwater species, based on optimum temperatures for growth. Coldwater species such as trout and salmon grow best within a temperature range of 48^{o}-65^{o} F. Coolwater species such as hybrid striped bass, yellow perch and walleye grow best between 60^{o}-82^{o}F. Warmwater fish such as catfish and tilapia grow best at a temperature range of 85^{o}-90^{o} F.

Oxygen

High concentrations of dissolved oxygen (DO) are vital to successful fish culture. The amount of oxygen which can be dissolved in water is dependent on water temperature, altitude and salinity. For example, water at 68^{o} F is saturated with oxygen at 8.8 ppm while at 90° F saturation is 7.3 ppm. Optimal fish growth occurs when oxygen levels are maintained above 6 ppm for cool-and coldwater species and above 5 ppm for warm water species. Death may occur at levels less than 3 ppm. Symptoms of low DO are lack of feeding and fish gasping near the surface. Low DO levels can be expected to occur during the early morning hours and during or after periods of cloudy weather.

PH

The scale used for measuring the degree of acidity is called pH, and ranges from 1 to 14. A value of **7** is neutral, neither acidic nor basic; values below 7 are considered acidic; values above 7 basic. The acceptable range for fish culture is between pH 6.5-9.0. The pH will increase during the day as photosynthesis removes free carbon dioxide. At night photosynthesis ceases and carbon dioxide is produced (during respiration) which will decrease the pH.

Alkalinity and Hardness

Alkalinity is a system which prevents or “buffers” wide pH fluctuations. It is a measure of the carbonates (CO_3^{--}) and bicarbonates (HCO_3^{-}) as expressed in terms of calcium carbonate ($CaCO_3$). Fish will grow over a wide range of alkalinities but values from 120-400 ppm are considered optimum.

Alkalinities in natural water sources will vary depending on alkalinities of soils within the watershed. For example, mining pits often have very low alkalinities which must be increased for fish production through addition of some form of buffers. The most common buffer used to increase alkalinity is ground agriculture limestone.

Ammonia

Fish excrete ammonia and a lesser amount of urea into the water as wastes. Two forms of ammonia occur in aquaculture systems, ionized and un-ionized. The un-ionized form of ammonia is extremely toxic to fish while ionized ammonia is not. Both forms are grouped together as total ammonia. The percent of total ammonia which is in the un-ionized form is dependent on pH and temperature. Higher pH and temperatures result in a higher percentage of the un-ionized form.

In natural waters, such as lakes, ammonia may never reach toxic levels due to the low densities of fish. But in cage culture where water circulation is restricted, ammonia buildups can occur. Ammonia buildups and low DO can be reduced through proper spacing of cages and regular cleaning of the cage netting.

Species Selection For Cage Culture

The desired species characteristics for cage culture are:

- fast growth rate, in regional environmental conditions,
- tolerance for crowded conditions,
- native to the region and,
- good market value.

Species that have been raised in cages in Central United States include: channel catfish, bluegill striped bass hybrids, walleye and trout. The culture of each will be discussed.

In addition to species selection, a range of stocking rates for each species will be provided. These rates are impacted by the quantity and quality of feed being used and the water itself. In the event that the cages are placed into flowing water (streams, rivers, etc. with a constant flow) it may be possible to increase the stocking rates listed under each species.

It is often best to stock cages two weeks prior to the anticipated growing season (based on preferred temperatures). Fish handled during these cooler water temperatures are less active and thus, are less excitable. Reduced stress decreases the potential for injury. As with all forms of aquaculture, the individual fish farmer should buy only high quality fingerlings that are relatively free of disease.

Channel Catfish

Channel catfish are closely related species to the are blue catfish, and black bullhead. Emphasis will be given to channel catfish. Channel catfish is a warmwater species that has a well established market. In addition, availability of fingerlings, tolerance for variable water conditions and adaptability to cages increase their suitability for cage culture.

Fish are typically found in warmer waters, and optimal growth occurs in water temperatures between 80-85°F. Growth stops below **45°F,** and above 95°F. This preferred water temperatures limits their culture in this region. Channel catfish may be stocked into cages when water temperatures exceed 50°F. Stocking at temperatures above 80°F may adversely stress the fish and lead to disease.

The size of channel catfish fingerlings to be stocked depends on the length of growing season, availability and marketing strategy. Generally 6-to 8-inch fingerlings are stocked into cages. If a 1 l/4- to 1 l/2-pound fish is the desired market size, it may be necessary to stock a larger fingerling or to stock at a lower rate. It is not uncommon to stock 8-to 10-inch fingerlings where the growing season is 180 days or less. Availability and cost of larger fingerlings may make stocking these sizes prohibitive. Also, a fingerling over 10-inches in length may not adapt well to a cage.

Stocking densities for channel catfish fingerlings in cages range from 6 to 14 per cubic foot of cage. This equals to 250 to 600 fish in a 4 x 4 feet cylindrical cage. Generally speaking it is best to stock at the low densities (7 to 9 per cubic foot) when first attempting cage culture and particularly if supplemental aeration is not present. You should not stock below a density of 6 per cubic foot or channel catfish will fight, leading to injury and disease. Some recommended stocking rates for small cages are given in Table 1.

Even with supplemental aeration available it may be advantageous to stock additional cages rather than overstock individual cages. Overstocking individual cages can lead to serious growth and health problems.

Table 1. Suggested stocking rates for cage culture.

Cage Size	Stocking Rates
4 X 4 feet (cylindrical)	300-400
4X4X4feet	400-500
8X4X4feet	800-1000
8X8X4feet	1500 - 2000

Blue catfish and bullheads have been stocked in cages with limited success. Blue catfish have a slightly cooler temperature preference than channel catfish. This preference for lower temperature may make this species more appropriate in the midwest than the channel catfish. Additional research needs to be done to address the possibility of culturing the blue catfish in this region.

The black bullhead has been successfully cultured in cages in New York. Researchers found that it was possible to get these fish to marketable size (greater than l/2 pound) in one growing season by stocking 6-inch fingerlings. Stocking rates varied between 4 to 12 fish per cubic foot. Fingerlings of both bullheads and blue catfish are usually difficult to find and may be expensive.

Bluegill

Bluegill and their hybrids have been reared in cages with some success. Of the variety of crosses, the fry obtained from the female green sunfish X male bluegill cross are the major hybrids available to aquaculturists. Temperature tolerances and preferences of bluegill are similar to those for channel catfish (described previously). Bluegill, are more aggressive, will take food at lower temperatures than catfish, and should be stocked before the water temperatures reach 60°F. Bluegill and their hybrids are considered to be good candidates for aquaculture in the Midwest since they will feed during lower water temperatures than channel catfish.

Fingerling bluegill should be 3 inches or larger at stocking and should be graded carefully to assure uniformity. Stocking densities for bluegill are at the upper range of those given in Table 1. At present there are no diets formulated for bluegills. Catfish, trout and salmon diets have all been used to feed these fish with limited success.

Striped Bass

Striped bass and associated hybrids have been successfully raised in cages. Hybrids survive under more extreme environmental conditions and grow faster then the pure striped bass.

Since the preferred water temperature of striped bass is 77-82°F, this fish is better suited for culture in the North Central Region than channel catfish. Tentative stocking rates for hybrid striped bass are approximately 6 fish per cubic foot. At present the greatest problem in cage culture of hybrid striped bass is the availability of large or advanced fingerlings at a reasonable price. A minimum 6-inch fingerling is needed for stocking and 8-inch fingerlings would be preferable. Fingerlings should be graded closely as cannibalism is a problem in young hybrid striped bass.

Walleye

This species has been cultured recently in cages in the North Central Region. Current information is limited. Preferred temperature for growth is 68-77°F with the ideal temperature around 73° F.

The greatest losses result from cannibalism and training the fish to consume commercial diets. In one recent Iowa study, walleye fingerlings were stocked at 4 fish per cubic-foot for the first year. Fish were again graded in the fall and restocked at one fish per cubic foot. These research studies indicated that competition is still a problem at stocking densities as low as one fish per cubic foot.

Production costs are high due to the previously stated reasons and because the commercial diets that are available are expensive and limited in supply. However, the market price for walleye is quite high compared to channel catfish and trout. Additional research is required to develop acceptable diets and lower fingerling costs.

Trout

Rainbow, brown and brook trout have been reared in cages. Rainbow trout are most often cultured because of the availability of fingerlings, established markets, and adaptability to cages. Basic culture of all three species is very similar. Several salmon species have also been cultured in cages, but discussion will be limited to the rainbow trout.

Trout are cold water species that require well oxygenated waters. Optimum growth temperature for trout is between 55 and 65° F, but acceptable growth is attained between 50 and 68° F. At 70°F severe heat stress begins, usually followed by death if exposure is prolonged. Below 45°F feed conversion drops significantly and therefore, growth. These temperature regimes make cage culture of trout a fall through spring activity in the Midwest, except where cold spring water or high altitude maintains lower summertime water temperatures.

It is necessary to stock a 6- to 8-inch fingerling trout in most of the North Central Region to obtain a l/2- to l-pound trout by the end of the growing season. Stocking should begin as soon as the water temperature drops below 68°F. Harvesting should begin as soon as the water warms in the spring to 68°F. Failure to harvest in time will mean loss of fish and profit.

Stocking densities for trout in cages may be higher than those for catfish. The higher oxygen levels maintained by cooler water and smaller sizes at harvest allow trout to be stocked at the higher densities of Table 1 without concern for aeration and low dissolved oxygen. With experience, densities as high as 15 fish per cubic foot may be acceptable.

Other Species

The species discussed are by no means the only species that may be cultured in cages. Selection of other species not listed in this publication should be made with the list of desirable culture characteristics (listed in the first portion of this text) in mind. As interest intensifies and additional research takes place, further information regarding species selection and techniques will develop.

Floating Fish Cage Construction

Fish cages can be constructed from a variety of materials. Generally, the longer a material can last in contact with water, the more expensive it is to use. Some consideration should be given to the expected "life" of the fish cage.
There are a few basic principles to consider when planning to build a fish cage:

1. All materials used for the cage should be durable, nontoxic, and rustproof. Copper and zinc can be toxic. Galvanized wire has been used in the past, but it usually rusts-out after only one year and fish may injure themselves on the rough surface. Plastic netting is often used, however, the presence of animals (minks, muskrats, and beavers) may require the use of vinyl coated wire fabric. Sunlight can also damage the plastic mesh, so leaving the cages in the water year around may be better than pulling them out and storing on the pond bank.
2. The netting material used for the body of the cage must allow maximum water circulation through the cage without the possibility of fish escapement. Mesh sizes less than l/2 inches (in.) often clog with algae. Netting material of l/2 in. and 3/4 in. mesh size are most commonly used. A 4-in channel catfish will be held within l/2 in. fabric but not within 3/4 in. fabric. Similar materials are used for a feeding ring that extends about 12 in. down from the top of the cage. The feeding ring must be small enough to hold-in the floating pellets, yet large enough to stay clean (usually l/8 in. in size).
3. Some type of flotation is needed to suspend the cage at the water's surface (small inner tubes, plastic jugs, or pieces of Styrofoam). Clear plastic jugs do not last as long as colored ones. PVC cement should be applied to the cap threads to prevent water leakage into the jugs.
4. Sunlight stresses fish, therefore, a lid should be included to block some of the light. Lids also prevent predators from entering the cage and fish from jumping out. The lid should incorporate a feeding hole for free access. Cage fabric lids covered with burlap or fiberglass (filon) lids are suggested.
5. Fish cages should have a volume of at least 1.2 cubic yards (1.0 cubic meters).

Cylindrical shaped cages appear to work the best; however, square or rectangular shaped cages are widely used. The cylinder has no corners for the fish to bump into and become injured. When constructed properly, they are light enough for one person to pull partially out of the water to crowd the fish. Regardless of the shape, do not lift the entire cage out of the water with the fish inside, unless the cage is properly reinforced. The plastic will usually break at the seams.

A sturdy, long-lasting cylinder cage can be made with the following dimensions. The finished cage. is 4 feet tall, 38 inches in diameter, and has a cubic volume of 31.3 cubic feet (1.2 cubic yards).

The materials needed are:

1. Three plastic hoops, each 38 inches in diameter. Either l/2 or 3/4-in black plastic water supply line with an insert coupling (glue with PVC cement) works fine. A 10-ft. length of water line makes a 38 in. diameter hoop.
2. Plastic netting 1/2 in. or 3/4 in. mesh 4 feet wide by 18 ft. long will be needed for the walls, top, and bottom of the cage.
3. Plastic netting 1/8 in. in mesh size and 12 in. wide by 10 feet 4 in. long will be needed for the feeding ring.
4. Nylon rope 1/8 in. in diameter and 50 feet long will be needed to sew the netting together.
5. About 50 cables ties at least 4 in. in length will be needed to hold the fabric in place during sewing.

The steps taken to build a cage are:

1. Cut and glue the hoops together.
2. Cut the 18 foot piece of plastic mesh at 10 foot 4 in. for the cage wall. Lay two hoops on the remaining piece of mesh and cut around them for the top and bottom pieces. It's easiest to place the hoops under the fabric and then trim around the outside of the hoop with scissors.
3. Attach the cage wall to the outside of one of the hoops using 6 to 8 of the cable ties. Position the hoop at the top full row of squares or diamonds in the fabric and let the cage wall overlap itself by about 4 in. The cable ties hold the mesh in place for the next step. Three ties will hold the overlap in place.
4. With the cage wall standing on end, lace the top full row of mesh to the hoop using the1/8-in. nylon rope. Skip every two spaces on this top ring; make sure the starting knot is secure and remove any slack when the ring is completed. Tie another secure knot once around the ring.
5. Cut another piece of the rope and lace down the overlap (seam) on one edge or the other. Again skip every two spaces and remove any slack. At the bottom is, tie a knot and then lace up the other edge of the overlap. It is critical for the overlap to be flat and have no gaps or folds that would enable the fish to escape.
6. Turn the cage over, position a second hoop inside the top full row of spaces, secure it with a few cable ties, place the bottom piece of mesh (38 in. diameter) over the opening and lace the cage wall hoop, and bottom piece in one operation.Again, no gaps can be left. It is helpful to have a second person inside the cage to send the rope back to the outside on each stitch. Depending on the height of the second person, the cage can be placed on three chairs to raise it up and allow easier lacing.
7. Lace the other 38 inch piece to the last hoop for the lid. Two spaces can be skipped between stitches. The lid should be tied to the top of the cage by short lengths of rope once the fish are stocked. Burlap or other light materials can be fastened to the lid to offer shade.
8. Make a feeding ring by fastening the l/8-inch mesh fabric inside the top opening of the cage with cable ties. Attach both top and bottom of the ring to the cage wall.
9. Position the flotation devices on the cage wall so the top of the cage will be about inches above the surface of the water. Four empty one gallon bleach jugs will float the cage easily. A few small holes will need to be made in the bottom ring so it will fill with water to stablise the cage.

Fish Cage Placement

One of the most important considerations affecting cage culture is the placement of the cage. It is very important that the wastes from the fish and excess fish feed fall through the cage and away from the immediate area of the cage. Therefore, the fish cage should be placed in an area where there is at least two feet of water between the bottom of the cage and the pond or lake bottom. It is undesirable for wastes to accumulate near the fish cage.

The fish cage should also be placed where the water can move freely through and around the cage. Vascular aquatic plants (those with stems), wind protected coves, and areas around excessive structures should be avoided. Since wind action is the primary contributor to water movement, the cage should be placed in open water where the prevailing winds can create water movement. Even the slightest breeze helps to flush water through and around the cage, remove waste products, and provide fresh, oxygenated water.

Disturbances near the cage, such as swimming, boating, and fishing activities, are not desirable. Channel catfish are especially susceptible to distractions which lead to reduced feeding, stress, and secondary diseases.

Fish cage placement should take into account daily feeding. Easy access during all sorts of weather conditions is desirable. The fish are more easily fed and managed when they can be approached by foot (cage anchored in open water) as opposed to by boat (cage attached to a rope and/or concrete block).

The cages should be at least three to four feet apart for proper water circulation. If the location of the cage does not offer adequate wind action for water circulation, it may be desirable to have a source of electricity nearby so supplemental aeration devices can be used.

Feeding

Feeding is the most important management practice that a fish farmer does each day. Simply stated, no feed will mean no growth. Without growth there will be no profit! It is important to also realize that feed will be the highest cost incurred on a fish farm. In fact, feed will comprise over 50% of your variable costs.

In cage culture feed selection is extremely important because fish are not able to forage for insects and other food items which are available in the pond. As a result the feed selected should be nutritionally complete. Also, because fish cannot feed on the bottom the feed used should float. There are processed feeds made for cage culture which meet these two requirement. However, any high quality feed that floats can be used in cage culture.

When selecting fish feed, keep in mind that different species will require different protein levels. Channel catfish are usually fed a 32% protein floating pellet. Trout and salmon on the other hand, are fed floating diets with protein levels ranging from 40-46%. Unfortunately, there are no commercial diets prepared for other species such as bluegill, hybrid striped bass and walleye. Most farmers raising these species use trout or salmon diets.

Feeding frequency is as much of a management consideration as it is a concern for the fish. Fish should be fed as much as they will eat in ten minutes in the morning and again in the afternoon. If this is not possible then feed fish all they will eat in 15 minutes around mid-morning.

Harvesting And Overwintering

Harvest time is one of the most enjoyable aspects of aquaculture. In cage culture where small cages are used, the harvest process is usually easier than in open pond culture. Fish are concentrated in the cages and can be removed using dip-nets. In larger cages or pens the harvesting process is more complicated. Fish must be crowded to harvest. Cages may be partially lifted from the water or some type of screen or grate used to crowd the fish inside the cage.

Overwintering of fish in cages is not difficult. If adequate oxygen levels are maintained, fish can survive the harshest midwestem winters. There are two methods of over-wintering caged fish. The preferred method is to keep the cages on the surface. Ice cover should be minimized to prevent damage to the cages. The second method involves suspending the cages below the ice. This method requires more care to avoid low dissolved oxygen levels.

Diseases And Other Problems

Cage culture is a complex form of aquaculture. Fish which are crowded are susceptible to many types of diseases. If a disease outbreak occurs, medicated feeds or baths in chemicals are sometimes used to treat fish. These are costly, time consuming, and sometimes ineffective.

The best way to avoid disease outbreaks is to practice good fish and water management. Water quality should be monitored on a regular basis and steps taken if DO or ammonia levels are unacceptable. Proper handling of fish is also important. Fish live in water and excessive time out of water will place disease-causing-stress on them.

Economics of cage culture

Before deciding whether to undertake or to continue a commercial aquaculture enterprise, the successful aquaculturist needs to develop a business plan and evaluate the potential profitability. Enterprise budgeting is a management tool useful for both planning and profitability analysis. Developing an enterprise budget is an excellent, organized method for helping the aquaculturist understand all aspects, costs, and input requirements of every stage of the operation, from production system selection to product marketing.

To facilitate profitability analysis, enterprise budgets require numerical estimates of production assumptions and factors (such as pond size and feed conversion), direct costs (for feed), indirect costs (for equipment), marketing revenues, and input requirements (such as investment costs and feed quantities needed). Additionally, enterprise budgets encourage consistent and accurate record keeping.

Enterprise Budget

The enterprise budget in Table 2 outlines the financial considerations important to hybrid striped bass cage culture. With appropriate changes the enterprise budget can be used for other species. The budget reflects specific production and marketing conditions, as set forth in the first section of the table; it represents an average year in the operation of the enterprise. The budget is divided into four sections: Assumptions and Production Factors, Direct Costs, Indirect Costs, and Profitability Calculations.

The assumptions and estimates of production factors, costs, and revenues summarized in Table 2 should serve only as guidelines for potential or current aquaculturists. Even though the figures reflect average management skills and costs, they cannot accurately represent any particular situation. A column titled "Your Farm" has been included in the budget for the individual to adjust the given budget figures to the realities of each aquaculturist's situation.

The equations used to make budget calculations are included in Table 2 to enable aquaculturists to calculate their own figures, whether through use of a calculator or computer spreadsheet. Farmers with their own computers can easily incorporate budget items and equations into a spreadsheet program. Alternatively, County Agricultural Extension agents can assist interested parties in the use of FINPACK or other software packages for computerized budget analysis.

Table 2. Enterprise Budget for Hybrid Striped Bass Cage Culture in an Existing: 5-Acre Pond in Indiana.

Assumptions and Production Factors

Pond size: 5 acres
Harvest size: 1.5 lbs
Production cycle: 6 months
Cage description: 3.5'x4', cylindrical
Fish marketing: fish sold live, pond-side
Labor needed: 45 min/day = 22.5 hrs/month

Production: 1,000 lbs/A = 5,000 lbs.
Market price: $2.00/lb.
No. of harvested fish/cage: 250
Interest rate: 12%
Death loss: 10%
Fingerling size: 6-8 inches

No. of fish harvested: 5,000 lbs - 1.5 lbs = 3,333 fish
No. of fingerlings purchased: No. of fish harvested(l-death loss)=3333(l-.10)=3333.9=3704 fingerlings
No. of cages: No. fish Fish/cage = 333 250 = 13.33 + 1 = 14 cages
No. of fingerlings/cage: No. fingerlings (No.cages-1)=370413=285 fingerlings/cage
Feed conversion: 2.0 lbs. feed/lb. gain
Feed quantity: No. fingerlings purchased x harvest size x feed conversion=3704 x 1.5 x 2.0=11,112 lbs. of feed
Cage construction costs: $15 labor + $20 frame, flotation + $5 wire + $25 netting = $65/cage
$65/cage x 14 cages = $910 total

Direct Costs

Budget item	unit	cost/Unit	Quantity	Annual cost	% of TC	Your Farm
Fingerlings	head	$0.75	3,704	$2,778.00	43.7%	______
Feed	lb.	$0.25	11,112	2,778.00	43.7%	______
Chemicals	cage	$2.50	14	35.00	0.6%	______
Subtotal of operating				$5,591.00	88.0%	______
capital	$	6%	$5,59 1	335.46	5.3%	______
Interest on operating capital				$5,926.46	93.2%	______
Total Direct Costs/Year						

Indirect Costs

Budget Item	Useful Life A	Initial Investment B	Annual Depreciation C = B ÷ A	Average Interest D = (B÷2)xi.r.	Annual cost E = C+D	% of Total Costs	Your Farm
Cages	10 yrs.	$910	$91.00	$ 54.60	$145.60	2.3%	____
Boat	10 yrs.	500	50.00	30.00	80.00	1.3%	_
Oxygen meter	5 yrs.	400	80.00	24.00	104.00	1.6%	
Permits, etc.	1 yr.	50	50.00	3.00	53.00	0.8%	_
Miscellaneous[a]	4 yrs.	150	37.50	9.00	46.50	0.7%	____
		$2,010		$120.60			
Total Indirect Costs/Year					**$429.10**	**6.8%**	____

[a] Scales, rope, dipnets, and buckets.

Profitability Calculations		**Your Farm**
Total yearly costs (Direct + Indirect)	$6,355.56	______
Break-even price (Total Yearly Costs ÷ Production)	$1.27/lb.	______
Breakeven price - direct (Direct Costs ÷ Production)	$1.18/lb.	______
Gross revenue (Production x Market Price)	$10,000.00	______
Net revenue (Gross Revenue - Total Yearly Costs)	$3,644.44	______
First year cash requirement (Total Investment + (2 x Total Average Interest) + Total Direct Costs)	$8,177.66	______
First year cash requirement excluding interest (Total Investment + Subtotal of Operating Capital)	$7,601.00	______

Bibliography

Better Freshwater Fish Farming: Raising Fish in Pens and Cages. Food and Agriculture Organization of the United Nations, Rome, 1990. 83pp.

Buttner, J. K. Cage culture of black bullhead - Part one of a two part Series. In Aquaculture Magazine, Volume (2):32-46.

Buttner, J. K. Cage culture of black bullhead - Part two of a two part Series. In Aquaculture Magazine, Volume(2):55-65.

Masser, M. P. 1988. Cage Culture: Species Suitable for Cage Culture. Southern Regional Aquaculture Center Publication No. 163. Stoneville, Mississippi.

McLarney, W. 1987. The Freshwater Aquaculture Book. Hartley and Marks, Publishers. Point Roberts, Washington.

Morris, J.E. 1991. Managing Iowa Fisheries: Cage Fish Culture. Iowa State University Extension Publication Pm-1352c.

Swann, D. L. and P. B. Brown, Editors. 1990. Midwest Regional Cage Fish Culture Workshop. Jasper, Indiana. 55 pp.

Floating Raceways: A Culture System To Match Your Needs And Resources?

Dan Selock
Mid-Continental Fisheries

As aquaculturists, we often search for the "ideal culture fish," depending upon our length of growing season, average water temperature, and markets. For some it's channel or blue catfish, baitfish, tilapia, largemouth bass, or even crawfish. For others it's trout, salmon, hybrid striped bass, walleye, or yellow perch. Along with this search for the best fish species is also a search for the "ideal culture method." Which method, open pond, cage, raceway, or recycle system, best fits our resources of land, type of water impoundment, water supply, existing equipment, labor force, and investment capital? We all have our unique situations and problems.

Recently, an innovative fish culture method has surfaced- the Caillouet Floating Raceway System (patent pending). It is the reorganization of existing, proven ideas into a new form. The system incorporates the advantages of raceways with the economy of airlift pumping and the need for solids removal, all done in an existing body of water. The system consists of four raceways divided by wooden walkways. Pond water is airlifted into one end of the raceway at a rate of 300 to 500 gallons per minute. It flows through the solid walled raceway, passes through a clarifier, and is discharged back into the pond for denitrification and aeration. Each raceway is four feet wide, four feet deep, forty feet long and holds about 500 cubic feet of water. A complete water exchange can be made in as fast as eight minutes. Solid wastes are collected in the clarifier at rate of 60% to 90%, depending on fish species and size, and removed from the pond to be used as fertilizer on land. Channel and blue catfish and trout have been successfully stocked at the density of 12 fish per cubic foot of water. Yellow perch have been stocked at 30 fish per cubic foot of water. Higher stocking densities are predicted with more experience. Due to the economy of airlift pumping, nearly three million gallons of water can be moved through the system for about $4.00 per day.

Currently there are three Caillouet Floating Raceway Systems in operation. One, which is in Brewton, Alabama, is rearing channel and blue catfish at a stocking density of 12 fish per cubic foot and using demand feeders. Wayne Caillouet, the system's inventor, is pleased with growth rates, feed conversions, and rate of survival. The other two raceway systems are near Marion, Illinois, and contain channel and blue catfish, rainbow trout, and yellow perch. The trout are raised during the winter months only. A small hatchery was constructed on the floating dock during the spring of '94 and used air from the system to hatch channel catfish eggs. Catfish broodstock were paired-up in one of the raceways with dividers - "motel rooms." The fertilized eggs were moved from spawning cans in the raceway to the hatchery tanks, only a matter of about 12 feet away. The eggs hatched, yoc fry were moved to holding tanks, also on the floating dock, where swim-up fry were fed until they reached about an inch in length and then stocked back into one of the raceways. So, the system allows the fish culturist to manage all stages of fish growth, from broodstock to egg to fry to fingerling to stocker or food size. Bird predation started to be a problem before a roll of poultry netting was installed to cover the raceways. This was especially important with the smaller fish.

The solid waste collected from the clarifiers has been found to have a nitrogen - phosphate - potash ratio of 18 - 13 - 3. There was also one pound of calcium and 1.91 pounds of magnesium per 1000 gallons of sludge. Water temperatures have remained relatively steady compared to the air temperatures, and no water quality problems have been experienced.

Drs. Michael Masser and Kyung Yoo at Auburn University presented information on a prototype floating raceway system for channel catfish in March of ‘92, and Masser, Hawcroft and Yoo presented information on raceway waste removal in January of ‘ 94. Both systems were similar to the Caillouet system, but not as commercial in size nor believed to be as efficient in waste removal and water movement. Regardless of the size and design, the researchers stated that “data from ‘92 suggested that growth, survival, and feed conversion of the In-pond Raceway system are superior to that of floating cages.” Several aquaculturists feel there is a need for further research to compare floating raceways to open pond methods regarding production rates and costs, especially using the raceways as nursery facilities

A World Aquaculture Note in March of ‘89 written by a fellow aquaculturist in Norway stated that for salmon culture “sea cages represent a simple and inexpensive technology, but problems from self-pollution due to waste feed and feces, high levels of ammonia, reduced water circulation, and availability of oxygen due to fouling of nets, sea lice, algal blooms, and disease are often experienced...raceway (floating) fish contained more white muscle, which is higher quality, than red muscle.” After slaughtering and quality ranking, 97% of the raceway fish were of superior quality, compared to 87% of the net pen fish. At the end of the experiment, the total growth of the raceway group was 38% higher than the control group. It was mainly the swimming muscle that had increased in weight. Raceway fish also had a higher condition factor and lower mortality than fish in net pens.

John Morrison and others at the Southeastern Fish Cultural Laboratory in Marion, Alabama, used the Caillouet design and recently compared the survival of floating raceway reared catfish fry to pond reared fry. Predation by insects and/or wild fish and feeding efficiency were better controlled in the raceways. Difficulty was experienced with predation and feeding efficiency in the open pond. Losses were reduced in the raceway.

Is this the “ideal culture method?” Well, nothing is ideal, but this system does allow you to raise a variety of fish species in a small space, observe feeding behavior, and sort and grade easily. Treatment for external parasites can be performed with a controlled bath in a single raceway at a time, versus treating the whole pond. Off-flavor is not a problem, since water flow keeps the entire pond mixed and aerated. Harvest is simple and inexpensive at any time, in any weather. Most labor costs are less. An existing body of water deeper than six feet can be used. And this system offers the aquaculturist a practical way to protect small fish from those darn birds. You be the judge. Call Wayne at 205/809-0241 in Alabama or Dan at 618/997-2117 in Illinois for their testimonies.

Zebra Mussels, *Dreissena polymorpha*, and other Eurasian aquatic exotic species pose direct and indirect threats to the aquaculture industry and the environment.

Jeffrey L. Gunderson and Douglas A. Jensen
Minnesota Sea Grant Extension

The North American invasion by Eurasian aquatic exotic species like the zebra mussel, Dreissena polymorpha, Eurasian watermilfoil, Myriophyllum spicatum, Eurasian ruffe, Gymnocephalus cernuus, and the rudd, Scardinius erythrophthalamus, will negatively impact aquaculture. The purpose of this presentation is to increase awareness of the problems posed by zebra mussels and other Eurasian aquatic exotic species to the aquaculture industry, to present methods to prevent their spread to new locations, and to describe where more information can be obtained Since exotic species pose a serious threat to the biotic integrity of many water bodies and may reduce recreational and industrial uses of lakes and rivers, state management agencies will be increasing their control over the transfer of water in and through their states.

Transfers of fish for stocking and sale of fish as bait, present the greatest risk of introducing exotic species and will be most effected by new rules and regulations that attempt to prevent aquaculture related introductions. Any accidental introduction of exotic species by the aquaculture industry will likely have serious repercussions on the industry as a whole. Exotic species, especially zebra mussels, may also directly cause problems for aquaculture facilities that become infested or that draw water from infested waters. For example, zebra mussels can clog water intake pipes and screens, ruin pumps, cover nearly all solid substrate, and reduce natural food available for fish. Preventing or coping with zebra mussel infestations will likely increase costs of aquacultural production.

The aquaculture industry must develop proactive solutions to the problems posed by exotic species and work cooperatively with task forces designed to reduce the risks that zebra mussels pose to the environment, recreational and industrial water users, and the aquaculture industry itself.

Zebra mussels and other exotic species may inadvertently help the bait aquaculture industry. As exotic species spread through North Americaís lakes and rivers, many fisheries management agencies are restricting the wild harvest of bait or preventing the importation of bait harvested or raised in waters infested with exotic species in an effort to slow the spread of exotic species. While this may put bait harvesters out of business, it will encourage the culture of bait in exotic free waters. There are chemical treatments, however, which can be used to kill larval zebra mussels in fish hauling water, thereby greatly reducing the risk of spreading zebra mussels from infested waters.

Dr. Susan Fisher (Ohio State University) has examined the use of potassium chloride (KCI) as a zebra mussel control agent. KCl was chosen because it is relatively inexpensive, it has low toxicity to other aquatic organisms, and it is very water soluble. Dr. Fisher reported that KCl was a good choice to kill zebra mussel larvae in water used to transport fish. And because it has already been FDA approved as a fish therapeutant, there are no FIFRA registration problems. On average, KC1 is an order of magnitude less toxic to fish than to zebra mussel larvae, but toxicity varies from one fish species to another. While the selectivity of KC1 makes it a good choice to kill larval zebra mussels in fish hauling water, it is not as effective at killing juvenile and adult zebra mussels. Therefore, the KC1 treatment does not eliminate all risk of spreading zebra mussels in fish hauling water.

Research has found that zebra mussels clarify water, remove phosphorous and reduce biological oxygen demand (BOD). Consequently, zebra mussels may be useful as a biofilter to help clean aquaculture effluent. Since the organic material removed from the water by zebra mussels is incorporated into a mucus and expelling to the bottom along with feces, a system would have to be developed to remove and dispose of this material at regular intervals. Zebra mussels should only be considered for this type of use if the receiving waters are already infested with them and state regulations permit their use.

The best way to guarantee that zebra mussels will not negatively impact your aquaculture enterprise is to prevent your facility from being infested by checking the water source of all fish delivered to your facility and by using groundwater from a spring or well. If surface water from a lake or river already infested or at risk of being infested is used, a buried intake or sand filter should be considered to reduce the potential problems for your facility and to prevent the spread of exotics to new waters if you sell bait fish or fish for stocking.

More information about exotic species can be obtained by contacting the Exotic Species Information Center at the Minnesota Sea Grant Extension Program, 2305 East 5th Street, Duluth, MN 55812. (218) 726-8712. Or, contact the Zebra Mussel Information Clearinghouse, New York Sea Grant Extension, 250 Hartwell Hall, SUNY College at Brockport, Brockport, NY 14420-2928. (800) 285-2285.

FIS-C: An Aquacultural Bioenergetics Model for Estimating Waste Loads and Optimizing Feeding

C. Tikkanen, J.Schuldt, R.Axler, M.McDonald and J.Henneck
Natural Resources Research Institute
University of Minnesota Duluth
5013 Miller Trunk Highway
Duluth, MN 55811

Fish culture has great potential in Minnesota but possible water quality impacts have slowed its development. We have developed a bioenergetics-based aquacultural effluent model (FIS-C) for estimating the actual and potential impacts of chinook salmon and rainbow trout waste loads on the receiving waters. FIS-C uses fish growth during a time interval to estimate consumption, respiration, egestion and excretion. The model allows estimation of the magnitude and seasonality of discharges, and because it can discriminate among waste fractions, it can be used to predict the efficiency of waste collection strategies.

The model has already proven to be a robust estimator of consumption, when fish growth is known, for a variety of wild species and for net-pen cultured chinook salmon. In 1994, we expanded its physiological parameters library to include rainbow trout and are calibrating it with detailed mass-balance nutrient budgets from two commercial trout farms. Exemplary data will be discussed in the context of FIS-C's use for improving the efficiency of current operations, and for providing more accurate economic and environmental assessments of potential future expansions.

Session 4

Saturday, February 18, 1:00 p.m. to 3:30 p.m.

Atrium 4

Notes

Status of Sturgeon and Paddlefish Aquaculture in the United States

Kevin J. Kroll
Department of Fisheries and Aquatic Sciences
7922 N.W. 71st Street
University of Florida
Gainesville, Florida 32606
Telephone: (904)-336-9118

Introduction

The sturgeon and paddlefish are chondrostean fish (order Acipenseriformes), an ancient group that have remained virtually unchanged for over 200 million years. Their skeletal system is primarily composed of cartilage, although their ancestors were bony fishes. Sturgeons are armored by five rows of bony scutes, whereas the paddlefish are devoid of these protective plates.

These fish inhabit the inland and coastal waters of the Northern Hemisphere. Coastal sturgeon spend most of their life in estuarine or open sea areas and spawn in freshwater during the spring. All sturgeons and the Chinese paddlefish are carnivorous, feeding mainly on mollusks, crustaceans, worms, and fish. In contrast, the American paddlefish is a filter feeder ingesting primarily planktonic organisms.

Sturgeons and paddlefish are amongst the largest freshwater fish in the world. The Russian beluga sturgeon can reach 4000 lb, over 20 feet in length, and live over 150 years. It was not uncommon to use horses to pull 1800 lb white sturgeon from the Snake River in Idaho during the turn of the century. And in China's Yangtze River, piscivorous paddlefish have been caught up to 21 feet in length.

Worldwide, the sturgeons (family Acipenseridae) and their relatives the paddlefishes (family Polydontidae) consist of 24 and 2 species, respectively. The United States has 7 species of sturgeon and 1 paddlefish species. Two anadromous species, the shortnose and Atlantic sturgeons, inhabit the estuarine and marine environments of the North American east coast. The American paddlefish, and the shovelnose, lake and pallid sturgeons are found throughout the Mississippi's freshwater river systems. On the west coast are the remaining 2 sturgeons, the green and the white, both are anadromous.

Wild sturgeons and paddlefishes are sensitive to overfishing due to delayed sexual maturation (15-20 years) and long reproductive cycles in the females (3-5 years). Through the centuries, however, sturgeons and paddlefishes have been heavily fished worldwide for their prized flesh and eggs. The hunt for caviar nearly exterminated most sturgeons in the U.S. during the late 1800' s. More recently, because loss of spawning habitat due to river damming and water pollution, most of the species are considered threatened or endangered.

Although the sturgeon and paddlefish fisheries has been a valuable resource, intensive domestic rearing of the North American species for restocking and food has been investigated only within the last 20 years. Russia has been the main producer of sturgeon caviar for the last 100 years; however, production consisted of sea ranching. Millions of fingerlings were stocked into the Caspian Sea and harvested when the were ripe. Their populations now have nearly collapsed due to overfishing and pollution (Birstein 1993). In the United States, artificial production of sturgeons and paddlefish have been attempted since the turn of the century. On a commercial basis, however, only white sturgeon and paddlefish are successfully cultured. Limited results have been obtained in raising the lake, Atlantic and shovelnose sturgeons. The pallid and shortnose are endangered species and cultured only for research purposes. Large scale production of the white sturgeon for meat and American paddlefish for mitigation purposes have been well established. Therefore, they serve as good models for fish farmers interested in breeding and rearing these fishes.

White Sturgeon Aquaculture

Commercial production of meat and caviar has been thoroughly investigated and established for the white sturgeon at the University of California, Davis. Development of hatchery technology was intiated in 1980 and currently there are three major farms in California producing 1 million pounds of sturgeon meat annually. Fish are raised in tanks and raceways on formulated diets to l0-15 Ibs and their growth is superior to many other species used in aquaculture. However, sturgeon farming in the past decade has been a fragile industry due to the lack of domestic seed production. Fingerlings for growout were produced by artificially spawning wild females during their spring spawning migration. To alleviate their dependance on this unreliable seed supply, the University and private industry raised domestic broodstocks obtained from spawning wild fish. Males sexually matured at the age of 3-4 years, and females at an age interval of 7-9 years in the domestic environment. Female maturation was cut in half or a third in the intensive rearing systems. In addition to a stable supply of meat and seed for fingerling production, several farms have been sucessfully marketing the caviar from domestically reared females.

Spawning and rearing of white sturgeon is complex due to the unique reproductive biology of the sturgeon species (Binkowski and Doroshov 1985; Doroshov 1985). Unfortunately, sturgeon will not spawn naturally in the tank environment; hence, requiring artificial hormonal stimulation to spawn. Moreover, sex and reproductive state cannot be determined externally, but requires surgical biopsy. Methods for spawning are described by Conte et al. (1988). Accurate determination of the proper time to spawn, requires surgical removal of eggs and either sectioning or invitro incubation in progesterone. Females and males selected for breeding are injected with either carp pituitary (4mg/kg) or LHRHa (lOOug/kg). Sperm is collected from the vent about 12-24 hours after injection and refrigerated until needed. Ovulated eggs are removed by caesarian section after anesthetizing the female (50 ppm MS-222). Sperm is diluted(1:200) with water prior fertilization to minimize polyspermy. To prevent eggs from sticking together, they are mixed with clay, silt, or Fuller's earth (Sigma Chemical Co.), and then incubated at 56-60_F in MC Donald jars. Hatch occurs within 7 days and feeding commences in 10-14 days post hatch.

Fry and fingerlings are fed salmonid diets; however, only 60% will accept the formulated diets. Growth is exponential. Within 3 years of culture (at 70_F), fish will reach their market size of 15-20 lbs. Food conversion in tanks is typically 2: 1. The market has been mainly directed towards the resturant industry. Sturgeon meat wholesales for $4/lb, $12/lb smoked, and domestic caviar retails for $150-200/lb.

Paddlefish Aquaculture

Paddlefish are currently being cultured for restocking purposes in order to preserve the species and provide sport fish (Graham et al. 1986). In 1989, the Missouri Department of Conservation and University of California Davis conducted a cooperative study to improve hatchery technology for the paddlefish and investigate its potential for intensive rearing(Kroll et al. 1991). Since, the paddlefish is a close relative of the sturgeon, spawning and egg incubation techniques were adopted from the white sturgeon. Prior to this study, fry were raised in fertilized ponds for about 4-5 months until the were stockable size (l0-12 inches). However, due to unreliable blooms of zooplankton, production was inconsistent. During this study it was apparent that larval and juvenile paddlefish readily accept slow-sinking formulated diets even though they normally feed on zooplankton less than l/20 inch. The effect of temperature on larvae feeding sucess was also investigated (Kroll et al. 1992). Larval paddlefish were successfully reared for 1 month in tanks on formulated diets (80% survival) and displayed fast growth. Semi-extensive rearing of paddlefish by feed supplimentation in pond tripled growth and increased production by 20-fold compared to extensive rearing.

Present culture of paddlefish for meat and caviar is very small and the market is unknown. Many studies are investigating polyculture of paddlefish with catfish. Currently, China is importing large numbers of juvenile American Paddlefish for pond culture.

Future

Due to dwindling natural populations of sturgeons and paddlefish in the world, aquaculture of these species by both the public and private industry may be these groups only hope. Aquaculture of these valuable fish provides: safe high quality meat and caviar, rescues endangered species, and makes these ancient fish available for research and the public sports fishery. Nearly, half of the sturgeon species in the United States are threatened and may soon be extinct.

Aquaculture is recognized as the fastest growing branch of agriculture, consumption of seafood in the U.S. has been increasing about 5% per year.

Literature Cited

Birstein,V.M. 1993. Sturgeon and Paddlefishes: Threatened Fishes in Need of Conservation. Conservation Biology 7(4):773-787.

Binkowski, F.P. and S.I. Doroshov (eds.). 1985. North American sturgeons: biology and aquaculture potential. Dordrecht, Netherlands: Dr W. Junk Publishers. 163 p.

Doroshov, S.I. 1985. Biology and culture of sturgeon Acipenseriformes. pp. 251-274. In: Recent Advances in Aquaculture. Vol. 2. J.F. Muir & R.J. Roberts, eds. Boulder, CO: Westview Press.

Conte F.S., Doroshov S.I., Lutes P.B., and Strange E.M. 1988. Hatchery Manual for the White Sturgeon, Acipenser transmontanus Richardson with Application to other North American Acipenseridae. Oakland, CA: Univer. of Calif. Publication Division of Agriculture and Natural Resources., 104 p.

Graham K.L., Hamilton J.E., Russell T.R., and Hicks C.E. 1986. The Culture of Paddlefish- A Review of Methods. Pages 78-94. In: The Paddlefish: Status, Management, and Propagation. (Ed. Dillard J.G., Graham K.L., and Russell T.R.). American Fisheries Society Special Publication No. 7, 159 p.

Kroll K.J., Van Eenennaam J.P., Doroshov S.I., Hamilton J.E., and Russell T.R. 1992. Effect of Water Temperature and Formulated Diets on Growth and Survival of Larval Paddlefish. Transactions of the American Fisheries Society 121:538-543.

Kroll K. J., Van Eenennaam J.P., and Doroshov S.I. 1991. Improvement of Hatchery Technology for Paddlefish, Polyodon spathula (Walbaum). Final Report #MCC-88-01-00, Missouri Department of Conservation, 159 p.

Reproductive Biology and Hatchery Techniques for Nile Tilapia *(Oreochromis niloticus)* in Tanks

Dr. Barry A. Costa-Pierce
Associate Professor of Fisheries
Bemidji State University
Bemidji, & Adjunct Associate Professor
Department of Fisheries and Wildlife
University of Minnesota, St. Paul, MN

Background

Tilapia are superb candidates for aquaculture: they adapt well to formulated feeds; exhibit fast growth to 2 kg/year; are easy to reproduce in captivity; are hardy, easy to transport and tolerate poor water quality; are disease resistant; tilapia produce white flesh with a high dress-out; and the fish are adaptable to a wide variety of farming systems from shallow ponds to cages and high density, recirculating tank systems. Its disadvantages are that it is a fully, tropical, stenothermal animal requiring high temperatures of 28-32° for optimal growth; females are precocious breeders that don't feed when mouthbrooding, leading to stunting and slow growth of female biomass; and the fish still does not have wide market recognition in North America, thus increasing market costs and overall marketability.

There are some 300 species of the tilapiine fishes in Africa with various attractive characteristics for aquaculture but only 3 are farmed widely. Research has found that Nile tilapia (Oreochromis niloticus) is the most rapidly growing species in the wild and in culture; this has led to the virtual disappearance of Mozambique tilapia (***O. mossambicus)*** as a candidate species for aquaculture in many countries. Nile tilapia has a disjunct distribution in their place of origin, with distinct populations in the Nile Delta and Israel, and another set of fish populations in West-Central Africa. Recent genotypic x environment research has indicated the Egyptian strain to be superior to West African varieties of Nile tilapia

Genetic Integrity of Stocks

There are many questions about the genetic integrity of Nile tilapia stocks in Hawaii, North and South America due to the small size of the original founder populations, hybridization, introgression, and consequent deterioration of farmed stocks over time. For these reasons, most stocks in the USA cannot claim to be pure lines of a specific species, rather hybrids classified properly as ***Oreochromis*** spp. Most farmers do not realize that the commonly referred to "Florida tilapia" or "red tilapia" is a hybrid with O. mossambicus, and that the color gene resides as a recessive gene on the normally black/dark colored O. mossambicus, and that no amount of selection with this hybrid can produce a pure red strain that breeds true red coloration.

Inadequate knowledge of the genetic status of farmed stocks throughout North America is a alarming considering the increased popularity of the fish as a potential aquaculture species and the large capital investments being made in infrastructure, with comparatively little attention being given to the suitability of the main component of the operation, the fish. Poor breeds will be a major, long term stumbling block to commercial aquaculture of the tilapias where such unknown stock origins and questions of genetic purity exist.

Biology of Tilapia in Africa

In the wild in Africa, Nile tilapia inhabit the littoral zones and shallow areas of both riverine and lentic waters, feeding on a wide spectrum of plankton, epibenthic materials and detritus. Tilapia in the wild can readily switch feeds, and the fish are classified ecologically as opportunistic, omnivorous browsers. If improperly fed and maintained, however, some tilapias can even become predators on small fish, as resulted from the escape of O. ***mossambicus*** (Mozambique tilapia) into the milkfish ponds of the island nation of Kiribati (Pacific Ocean).

Nile tilapia are maternal mouthbrooders forming nests in “arenas” that increase in size according to water depth. The shape and size of nests differs greatly by species. At maturity (50-200 cm total length) males congregate in breeding “arenas”. In these arenas, males court and fertilize 3-5 females and actively defend the nest from other intruding males. Females take the fertilized eggs and moves to the shallows, mouthbrooding the fertilized eggs for 5-7 days when they hatch. After hatching the females mouthbrood and protect the young for another 14-25 days. Fry are initially released in shallow water but as they grow move to deeper waters. Adults leave the breeding grounds after spawning and frequent shallow, weedy areas and sandy shores. Non-breeding adults also live in open waters off exposed, sandy beaches.

Reproductive Biology in Culture

In culture, the main concern is to achieve the highest fry production per adult female over the shortest possible time period. Such production would maintain stable fish production over an annual cycle and insure continual supply of fingerlings to growout systems.

The main concerns in optimizing tilapia hatchery systems are maintaining proper environmental conditions, female:male sex ratios, female size, and stocking rates. Optimal female:male sex ratios have been found at 3:l at densities of l0-14 broodstock per m^2. Above these densities and ratios fry production decreases due to crowding, aggression and predation. Below these densities there are insufficient numbers of females to carry on continuous breeding with the a viable males. Optimal female size for highest egg production has been found at 50-100 g; broodstock should be replaced when females reach 250-300 g sizes. Males should be approximately the same size as females since larger males have been shown to be overly aggressive and less fecund. It has been found that after three spawning periods female fecundity drop precipitously. It is recommended that after 3 spawning periods, females be removed from males and put into separate conditioning ponds with good water quality and 30-32% protein feeds. Optimal environmental conditions for spawning are temperatures 25-32°, a 14:l0 light:dark photoperiod, feeding 6 times per day with a high protein feed at 3% adult broodstock body weight per day, and complete protection of breeding tanks from disturbances such as shaking/vibrations of tanks, excessive foot traffic. In a public setting, complete covering of the sides of aquarium tanks may be needed to initiate spawning due to routine and excessive disturbances.

Variables affecting the growth of white sucker minnows *Catostomis commersoni* in natural ponds.

Paul Tucker & Carl Richards
Natural Resources Research Institute
University of Minnesota-Duluth
5013 Miller Trunk Highway
Duluth, Mn 55811, USA

Abstract

Natural pond harvest is the primary source of White sucker *(Catostomis commersoni)* bait in Minnesota. The white sucker comprises about 46% of the total gallons of cultured bait fish and approximately 62% of the total sales . The greatest shortage of marketable-sized sucker minnows occurs in July after most of the stock that was held in over-winter ponds becomes depleted. Product for this market is supplied from ponds stocked in May of the same year. We examined a group of 14 natural ponds ranging in size from 5 to 135 acres for the purpose of determining which environmental variables affected growth of stocked white sucker minnows, and which of those variables could be controlled by producers. A series of biotic and abiotic factors were measured in each pond. Multiple regression analysis was used to identify which variables had most influence on sucker growth. Growth was analyzed in terms of length, weight, and condition. Results indicate that approximately 75% variance in length could be explained with conductivity, relative abundance of other fishes in the pond, and a measure of wind accessing the pond. These variables account for approximately 48%, 29%, and 23% of the model respectively. The same three variables were significant in explaining the model for weight and accounted for 44%, 34%, and 22% respectively. The model produced for the condition of the sucker minnows explained roughly 54% of the total variation and was represented only by the variable abundance of other fishes in the pond. When considering whether or not to lease a new pond or renew leases on existing ponds, bait producers could measure these variables and make management decisions based in part on those measurements. For example, the feasibility of reducing or eliminating other fishes in a pond or considering the orientation of the pond with prevailing winds may play a large part in determining the quality of production realized by the producer.

Acknowledgments

Sponsors:

North Central Regional Aquaculture Center (NCRAC)
North Central Aquaculture Conference
NCRAC Extension Technical Committee
Minnesota Department of Agriculture
University of Minnesota
Sea Grant College Program
UMD Biology Department
Department of Fisheries and Wildlife
Minnesota Fish Farmers Association

Planning Committee:

Ira Adelman, University of Minnesota Department of Fisheries and Wildlife, St. Paul, MN
Larry Belusz, Alexandria Technical College, Alexandria, MN
Fred Binkowski, Center for Great Lakes Studies, Great Lakes Research Facility, Milwaukee. WI
Brian Erickson, Minnesota Department of Agriculture -- Marketing Division, St. Paul, MN
Don Garling, Michigan State University Department of Fisheries and Wildlife, East Lansing, MI
Jeff Gunderson, Minnesota Sea Grant Extension and UMD Biology Department, Duluth, MN
Gene Hanson, Aurora-Aqua, Inc., Kandiyohi, MN
Ying Ji, Minnesota Department of Agriculture -- Marketing Division, St. Paul, MN
Terry Kayes, University of Nebraska Department of Forestry, Fisheries and Wildlife, Lincoln, NE
Ron Kinunnen, Michigan Sea Grant College Program, Marquette, MI
Joe Marcino, Minnesota Department of Natural Resource, St. Paul, MN
Mike McLean, Minnesota Sea Grant College Program, Duluth, MN
Joe Morris, Iowa State University Department of Animal Ecology and NCRAC, Ames, IA
John Ringle, Leech Lake Indian Reservation, Cass Lake, MN
Robert Summerfelt, Iowa State University Department of Animal Ecology, Ames, IA
LaDon Swann, Illinois/Indiana Sea Grant Extension, Purdue University, West Lafayette, IN
Judy Zomerfelt, Minnesota Sea Grant College Program, Duluth, MN