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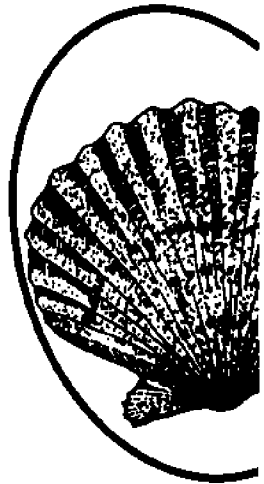
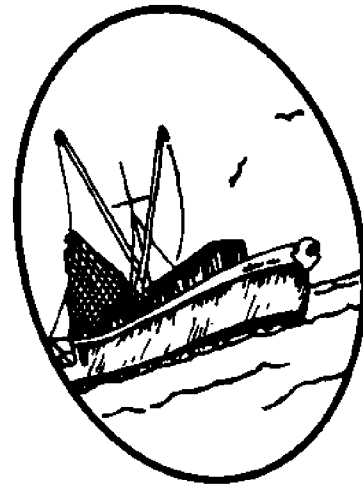
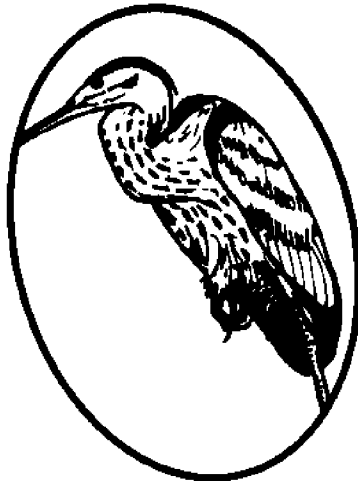
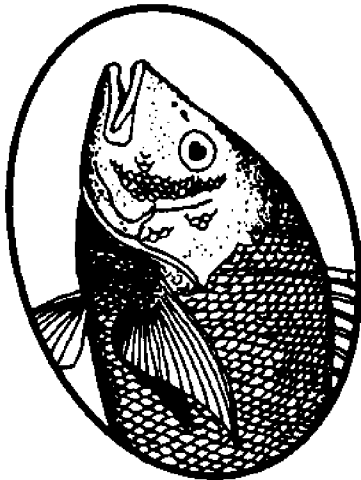
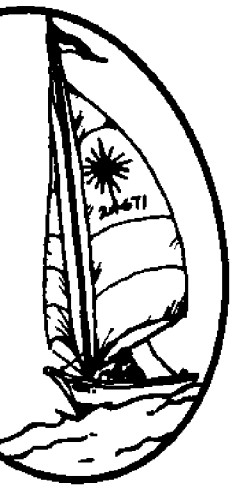
Working Paper 81-2

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A Discussion of Aquaculture Candidate Species For Eastern North Carolina

William L. Rickards

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INTRODUCTION

This paper contains summary statements relating to the research and development potentials for culturing various species of finfish and crustaceans in eastern North Carolina. Only those species which can be maintained and grown in fresh or slightly brackish water are included because only these types of water are available in quantity at the NCSU aquaculture research and demonstration facility near Aurora, NC.

Species included in these summaries have been assigned an evaluation (high, medium or low) which reflects the availability of information and expertise at Aurora, economic and biological feasibility of the species, and experience with the species either within the staff at Aurora or private enterprise within North Carolina. All of the species discussed herein possess at least reasonable potential for commercial culture in North Carolina, and they therefore could become the subjects of research or demonstration efforts at Aurora.

Candidate species discussed are:

	<u>Page</u>
American eel, <u>Anguilla rostrata</u>	1
Striped bass, <u>Morone saxatilis</u>	2
Rainbow trout, <u>Salmo gairdneri</u>	3
Coho salmon, <u>Oncorhynchus kisutch</u>	3
Yellow perch, <u>Perca flavescens</u>	4
Tilapia, <u>Tilapia zilli</u>	5
Channel catfish, <u>Ictalurus punctatus</u>	6
Channel bass, <u>Sciaenops ocellatus</u>	7
Spotted seatrout, <u>Cynoscion nebulosus</u>	7
Sturgeons, <u>Acipenser</u> spp.	7
Baitfishes and aquarium fishes	8
Other sportfishes	9
Blue crab, <u>Callinectes sapidus</u>	9
Freshwater prawn, <u>Macrobrachium</u> spp.	10
Crawfish (several species)	10

I. American eel, Anguilla rostrata (evaluation: high)

A. Rationale: high market demands and prices, especially in Japan, have created considerable interest in eel farming in the U.S. over the past six years. The UNC Sea Grant College Program has supported a demonstration project and limited research efforts since 1975. This has been largely a technology transfer effort based upon Japanese eel culture methodology. Thus, strong markets and existing technology combine to make this a high potential species for aquaculture.

B. Present status:

1. North Carolina - As described above, UNC Sea Grant has developed the expertise and is conducting research on eel culture and related biological aspects of wild eel stocks. A continuing demonstration of eel culture techniques has approximately 15 contacts per week from persons interested or involved in eel farming.

2. Other regions - Eel culture is being conducted on a commercial basis in nearly every country of northern Europe, Italy, Japan, Taiwan, Hong King and the Philippines. In the U.S., eel culture is being developed in Massachusetts, South Carolina, Florida, Georgia, Guam, Maryland, and New York; all of these operations are using at least some information gathered from UNC Sea Grant.
 3. Problems - Present obstacles to full-scale development of eel farming in the U.S. are: (1) an unknown source of seed stock (elvers) from natural waters; (2) a relatively expensive diet which has not been adequately researched for alternative ingredients and least-cost formulation; (3) several unknowns relating to appropriate stocking densities, expected production rates, diseases and treatments, optimum feeding rates, etc. for American eels in pond culture.
- C. Future considerations: present and planned studies of eel nutrition, diseases and pond grow-out production parameters will provide a solid foundation upon which the eel farming industry may continue to develop. The Aurora facility will be the focal point for such studies, and researchers from several institutions (and states) will participate.

The demonstration of eel culture techniques will continue to extend the most up-to-date technology to potential as well as active eel farmers.

It is anticipated that North Carolina will become involved in research and management of wild eel stocks (nearly every other Atlantic coast state has begun to address eel fishery management questions during the past three years). During 1980, UNC Sea Grant tested a new mark-recapture technique which will be passed along to the fishery biologists for use in elver population studies. Research in other southeastern states on eel biology and population dynamics will also be made available to state and university researchers for application to management of North Carolina eel stocks.

- II. Striped Bass, Morone saxatilis, and its hybrids with white bass and white perch (evaluation: high).
- A. Rationale: a strong demand exists for striped bass fingerlings for stocking programs in natural waters as well as for pan-sized fish for human consumption. However, there is a need for research and technological development before successful large-scale culture will be possible.
 - B. Present status: apparent declining trends in the wild stocks of striped bass have generated much interest on the part of state and federal agencies and the private sector in the cultivation of striped bass.

1. North Carolina - Both the Division of Inland Fisheries and the Division of Marine Fisheries have expressed interest in the development of capabilities and sources of fingerlings for stocking to renew wild populations in our rivers and estuaries. The low survival rates experienced by cultured striped bass larvae have led to the development of hybrid striped bass. Two such hybrids are being studied at Aurora by N.C. State University researchers. Hybrids of striped bass with white bass or white perch appear to be more easily handled with lower mortality than striped bass; the hybrids may also be more amenable to pond culture.
2. Other regions - Studies of both cage culture and pond culture of the hybrids are being conducted in South Carolina to examine problems complementary to the North Carolina efforts. Several states are researching various aspects of culturing striped bass, and the technology for spawning and rearing is available.
3. Problems - As already indicated, survival rates of striped bass larvae are low. In addition, cannibalism is very common even when food is readily available. While the growth rates of striped bass may be good in ponds, stocking densities must be relatively low (or grading to eliminate size differences must be conducted frequently).

Virtually nothing is known of the dietary requirements of either striped bass or its hybrids. Diets currently utilized are generally trout or catfish rations that may contribute to the development of diseases which have plagued cultured striped bass, especially in brackish water.

- C. Future considerations: while a limited amount of technology is available for use in demonstrations, most work with striped bass and its hybrids should concentrate on research to solve existing problems. There are some indications that it may be possible to someday imprint striped bass for a "sea-ranching" concept similar to that used with salmon. However, for the present, research into pond production, diets, diseases and survival of released fingerlings would appear to be of primary importance.

III. Rainbow trout, Salmo gairdneri, and Coho salmon, Oncorhynchus kisutch (evaluation: high and medium, respectively)

- A. Rationale: federal, state and private efforts in culturing salmonid fishes have produced an extensive data base and farming technology. Markets are strong although a small producer may have difficulty breaking into existing markets.

B. Present status:

1. North Carolina - Rainbow trout are currently farmed in western North Carolina. Coho salmon are not native to the state and would have to be introduced if farmed.

During 1979 and 1981, UNC Sea Grant investigated the feasibility of farming both species during the summer months in the phosphate mine de-watering canal of Texasgulf, Inc., Aurora. Fish were obtained from the National Marine Fisheries Service, Seattle, WA, and growth performances were extremely promising for the rainbow trout and only somewhat less for the coho salmon.

2. Other regions - Farming of both species is an established business based upon existing technology. While considerable research is being conducted on both, it is largely a matter of "fine tuning" current methodology and economic returns.
3. Problems - Both of these salmonid fishes are normally associated with cold waters, and culturing them in the southeastern states has usually been associated with colder times of the year. However, with the existence of the rather unique water-use system of Texasgulf Inc., which employs large amounts of ground-water at a nearly constant temperature of 63°F, it now appears possible to farm salmonids during the summer months in eastern North Carolina. The uniqueness of this system must be emphasized. Since rainbow trout and/or coho salmon culture are based upon a firm technology, only limited research is needed to adapt the technology to the particular physical system being employed. Thus, most problems involve biological engineering.

Some trout farmers have experienced recent difficulties in placing their product into market channels at prices competitive with large producers in the western states. While this may continue to be a problem for small producers, the production capacity of the Texasgulf canal system and the uniqueness of the system to large industries may preclude some of these marketing concerns.

- C. Future considerations: further research is needed to fully adapt the technology to particular aspects of the Texasgulf system. Once this is done, the methodology and experience gained will be made available to other potential trout farmers of sufficient size through publications and demonstrations.

IV. Yellow perch, Perca flavescens (evaluation: medium)

- A. Rationale: mid-west market demands for yellow perch are very strong and the technology for hatching and rearing fish to market size is available.

The only reason for not assigning this species to the high category is the current lack of experience or expertise with rearing the fish in North Carolina.

Raising yellow perch in North Carolina could fulfill either or both of two goals: (1) provide fingerlings for sale to midwestern yellow perch farmers at least two months in advance of their present availability; (2) produce a market-size fish through complete grow-out culture.

B. Present status:

1. North Carolina - The yellow perch is a native species which is not presently being researched or used in commercial aquaculture.
2. Other regions - University of Wisconsin Sea Grant researchers have developed spawning and rearing techniques for the yellow perch. However, because of climatic considerations, farmers in that region must either use heated, recycled water or expect fish to reach market size in two to three years.
3. Problems - The lack of a strong supply of fingerlings has hindered development of the industry. Also, dietary information is needed if the fish are to be fed prepared rations. The costs of heating and recycling the culture water are increasing daily and the economic feasibility of this system is in question.

- C. Future considerations: a demonstration of spawning and production of fingerling yellow perch in North Carolina (accompanied by cooperative efforts with U. Wisconsin Sea Grant) could assist the economics of both regions by initiating and improving the industry.

The possibility of pond or cage culture of yellow perch to market size should be investigated in North Carolina.

Some nutritional research may be needed for the development of large-scale culture in ponds or cages.

V. Tilapia, Tilapia zilli (evaluation: high)

- A. Rationale: Many of the man-made canals and drainages in coastal areas are becoming choked with aquatic vegetation. Tilapia zilli is an herbivorous species which reproduces readily under both controlled (laboratory) and natural conditions but does not survive water temperatures below about 50°F (10°C). Thus, it appears to be an excellent candidate for vegetation control.

B. Present status:

1. North Carolina - The species is being used in at least two North Carolina localities for aquatic vegetation control even though little research has been conducted on needed stocking densities, reproductive rates, and rates of vegetation consumption in the state.
2. Other regions - Principal research in the U.S. has been centered at Auburn University where spawning and rearing methods have been refined. T. zilli is being used to control aquatic vegetation in Florida, South Carolina, Alabama, and several other southern states. A highly successful fishery for tilapia has been developed in

Florida; thus, it is possible that market-size fish could be harvested for sale leaving the smaller, faster growing fish to consume the vegetation.

3. Problems - As with the introduction of any non-native fish into a system, care must be taken to protect native species. There are indications that improperly managed Tilapia introductions can lead to negative effects on the natural stocks which are present. However, T. zilli's inability to tolerate low temperatures provides an excellent management tool for controlling the species.

- C. Future considerations: there is a need for studies of rates and preferences of vegetation consumption, reproductive success, stocking density vs. reproduction and vegetation control, etc. so that the species can be evaluated for use in the state. Care must be taken so that this fish does not become established in areas where warm effluents allow it to over-winter before its impact on other aquatic organisms is fully determined. A controlled canal system such as that at Texasgulf Inc., Aurora, could serve as an ideal study site.

IV. Channel catfish, Ictalurus punctatus (evaluation: medium)

- A. Rationale: catfish farming is an established industry with a small effort presently in North Carolina. An appreciable amount of interest exists for developing catfish farming in the state, but the lack of established markets in the state and/or channels to established markets has hindered the industry.
- B. Present status:
 1. North Carolina - Over the past 10 years, several North Carolinians have attempted to farm catfish; only a few of these are still in business.
 2. Other regions - The existence of the catfish farming industry in the Arkansas - Mississippi region is well documented. The industry is expanding both in total production and in geographical scope.
 3. Problems - If the catfish industry is to develop in North Carolina, the various support services (i.e. disease diagnosis, advisory information), a source of fingerlings, and marketing channels must be developed at the same time. Also, the relatively narrow profit margin in catfish farming is presently greatly influenced by high transportation costs which must be overcome by the development of local markets for the product. Finally, the limited growing season for catfish in North Carolina requires that the farmer either stock ponds with larger fingerlings or use heat to produce market-size fish in a reasonable time.

- C. Future considerations: since the methodology for successful catfish farming is known, a demonstration of techniques could serve this potential industry. At the same time, the development of expertise would form the basis of needed support services.

The development of fish-out operations in conjunction with catfish farms is a highly successful business in some regions and holds considerable potential for North Carolina.

VII. Channel bass, Sciaenops ocellatus (evaluation: medium)

- A. Rationale: the species has potential for introduction into fresh water as a game fish. It also is a popular food fish and could be reared to pan-size for marketing.
- B. Present status:
1. North Carolina - There are no culture activities at present, but the fish is sought by many fishermen as game or food.
 2. Other regions - Technology for spawning and rearing has been developed in Texas where fingerlings are being provided for placement in farm ponds. The species is also being introduced into some freshwater reservoirs as a game species.
 3. Problems - Largely unknown. The potential appears strong, but efforts have begun too recently to fully evaluate the species.
- C. Future considerations: At this point, a demonstration spawning and fingerling production effort would serve interested persons. Fingerling channel bass could be produced for stocking natural waters to augment or initiate both commercial and recreational fisheries.

Some dietary research may be needed for fingerling production.

VIII. Spotted seatrout, Cynoscion nebulosus (evaluation: medium)

The state-of-the-art for seatrout is identical to that of the channel bass, as is the potential for research and demonstrations. Thus, the same comments apply to the spotted seatrout as were presented for the channel bass.

IX. Sturgeons, Acipenser spp. (evaluation: low)

- A. Rationale: at least one species, the short-nosed sturgeon, is on the endangered species list and efforts are being made to produce fingerlings for stocking natural waters. The profit potential for contracted production of such fingerlings may be substantial.

B. Present status:

1. North Carolina - No activity.
2. Other regions - Spawning and rearing of sturgeons is being studied in California and South Carolina. Most of the data base on this species group is from Russia.
3. Problems - Largely unknown. Relatively slow growth rates, diseases, and dietary requirements appear to be the major hurdles for fingerling production.

C. Future considerations: there is a potential for both research and demonstration efforts in North Carolina on a cooperative basis with other states.

X. Baitfishes* (evaluation: medium) and Aquarium fishes** (evaluation: medium)

A. Rationale: technology for producing these fishes is readily available and markets (both local and national) are very strong.

B. Present status:

1. North Carolina - There are a few bait producers in the state, but they are relatively small. Aquarium fishes are produced only on a small scale (indoor tanks) for sale to pet shops.
2. Other regions - Fishes in these groups constitute a sizeable economic influence, especially in Florida and Arkansas.
3. Problems - Relatively large amounts of land are required for bait minnow production. Diseases are a major concern of aquarium fish breeders.

C. Future considerations: because of the profit potential of fishes in these groups, it is possible to use heated or indoor tanks for their production. A demonstration of the use of greenhouses as culture enclosures could stimulate the development of an industry in the state.

*Baitfishes include - fat head minnow, Pimephales promelas
goldfish, Carassius auratus
golden shiner, Notemigonas chrysoleucas
top minnows, Fundulus spp.

**Aquarium fishes include numerous species currently raised in the U.S. or imported to supply the pet fish trade. They are too numerous to list here.

XI. Other Sportfishes (evaluation: low)

This group includes the freshwater basses and sunfishes, crappies and pickerels.

- A. Rationale: technology is available for producing most of the principal species in the group. Production of fingerlings for stocking farm ponds, fish-out operations, and lakes or reservoirs is feasible.
- B. Present status:
 - 1. North Carolina - The state operates a hatchery which produces stock for natural waters but not for grow-out or fish-out facilities.
 - 2. Other regions - Nearly every state has a similar program with some variation in the species being emphasized.
 - 3. Problems - There is a lack of technology for the intensive culture of many species in this group even though they can be produced in rather extensive conditions. Since most production is geared to larvae or fingerlings, most disease, nutritional and growth problems are not encountered often.
- C. Future considerations: a limited demonstration of fingerling production could be of use to those wishing to produce such fish for sale to farm pond operators, hunting-fishing clubs, and fish-out pond businesses.

XII. Blue crab, Callinectes sapidus (evaluation: high)

- A. Rationale: the shedding of blue crabs to produce soft-shell crabs has proven to be a lucrative business for those who succeed. Interest is high in this type of operation and the technology is relatively simple.
- B. Present status:
 - 1. North Carolina - A few successful crab shedding businesses have developed, and markets could readily absorb greatly increased production.
 - 2. Other regions - Virginia, Florida and South Carolina have recently produced printed materials detailing crab shedding procedures and facilities.
 - 3. Problems - Expansion of the industry suffers from a lack of immediately available expertise and information on system maintenance, shedding procedures, and other operating details.
- C. Future considerations: a demonstration crab shedding operation could serve to answer the needs of the industry. Once operational, this advisory activity could have a great impact

on the fishing economy of those involved since the soft-shell crabs sell for several times the cost of hard crabs.

XIII. Freshwater prawn, Macrobrachium spp. (evaluation: low)

- A. Rationale: available technology and ready markets make this species of interest to aquatic farmers.
- B. Present status:
 - 1. North Carolina - No activity.
 - 2. Other regions - Freshwater prawns are being cultured commercially in Hawaii, several South American countries, Colorado, California, and Florida. Aquaculture research is being conducted in South Carolina, Hawaii, the Philippines and other tropical areas.
 - 3. Problems - Cannibalism limits the stocking densities which can be employed and, therefore, the production. This is principally a warm-water genus, and farming in North Carolina would require either the use of heat or stocking of ponds with juveniles. Many potential disease and nutritional problems have not yet become common enough to warrant concern.
- C. Future considerations: a feasibility study (and subsequent demonstration) of prawn culture in a heated greenhouse could lead to the development of a new industry, especially if waste heat from an existing industry could be used.

XIV. Crawfish, several possible species (evaluation: medium)

- A. Rationale - technology is available and market conditions are very good, especially for soft crawfish as fishing bait. A soft two-inch crawfish may sell for as much as \$2.00.
- B. Present status:
 - 1. North Carolina - No activity.
 - 2. Other regions - An established industry in Louisiana, Texas and parts of California. Considerable research is on-going at Louisiana State University.
 - 3. Problems - Harvesting is labor-intensive and costly. Also, market channels are only weakly formed with prices fluctuating a great deal during the harvest season. Diseases and nutritional requirements are largely unknown.
- C. Future considerations: advisory activity and a demonstration scale effort could stimulate development of this industry in North Carolina. Areas with particular potential are the swampy coastlands which could be "cultivated" for crawfish production. Research into the production of soft-shelled crawfish through dietary additives or eyestalk ablation could benefit the entire industry.