VT Fisheries Management

A Class Magazine Produced by Students in Fisheries Management

Department of Fisheries and Wildlife Sciences
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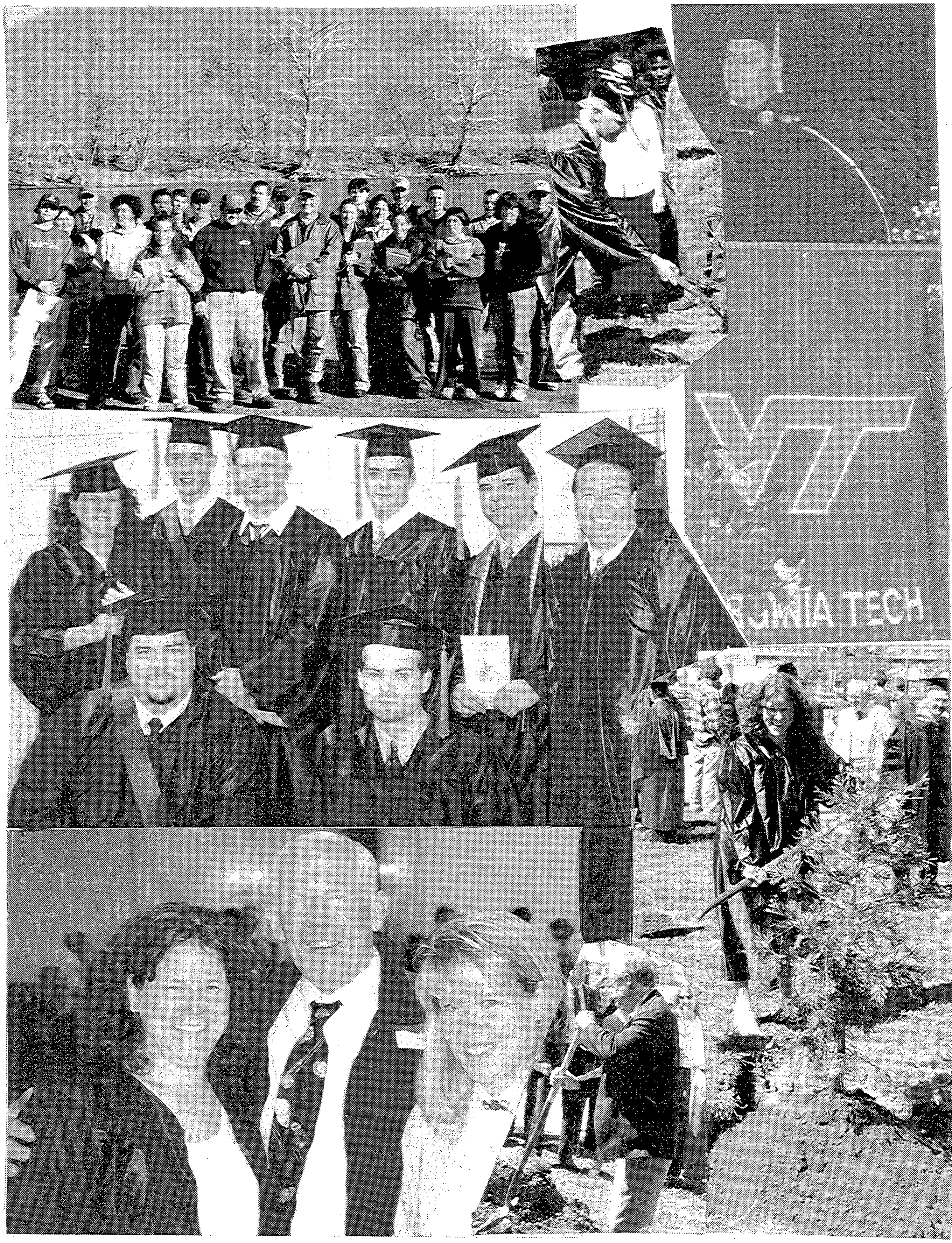
Devoted to identifying fisheries management problems, uncovering their causes, and developing creative solutions



VT Fisheries Management

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Did I Get to See Your Best Work?
Donald J. Orth

You should enjoy reading about what your colleagues learned this semester. I realize that often during the semester you may have been confused about what I wanted when and how much. All I really wanted was to see your best work. And in order to get your best work you need to struggle through discomfort. Remember the first time you attempted to count annuli on a fish scale? Counting was a skill you learned long ago but now you had to interpret and apply some new, and perhaps, vague criteria to a real problem. Learning takes time and much practice and I'm proud to have guided you during your practice here at Virginia Tech.

This year I was honored with an Award of Teaching Excellence from the University. I thank all who may have engaged in some creative writing to support my nomination for the award. But excellence is achieving the goals that one sets. I certainly deserve an award as the most improved teaching professor. Just like learning to age fish, teaching takes much practice and only vague descriptions of criteria for success. At our College graduation ceremony I was able to provide a brief message to the graduates. The simple message is "passionately pursue your dreams." I dreamed of being a teaching professor, but didn't happen that easily for me. What helped me most was when I placed myself into the role of the learner and tried to learn something new. Most recently I tried to learn ballroom dancing. I found that teaching is like dancing in many ways.

Seven Pillars of Teaching and Dancing

1. Both teaching and dancing look easy and fun when you're watching a master. However, both are very difficult to master.
2. You look much better with a partner, especially one who makes you look much better than you really are. Thanks to the students, my partners, for making me look good.
3. The first time you try to teach or dance you are bound to look foolish. Only with practice will you improve. Thanks to my family for providing me the extra time needed for practicing on nights and weekends.
4. Some folks have natural talents that make one look less clumsy and more comfortable with the role. Thanks to my parents, William and Marie Orth, for these genetic traits.
5. The places where both teaching and dancing happen must be open, comfortable, welcoming places - smooth, hard polished floors help. Thanks to the many administrators on campus who have toiled long and hard to maintain, create, and modernize these learning spaces.
6. In teaching as in dancing, many styles and approaches are permitted – and though the times and the music "they are a changin," you can still find masters willing to share wisdom and secrets. Thanks to the many colleagues on campus for sharing with me their success stories. I especially thank the University Writing Program, the Center for Excellence in Undergraduate Teaching, and the Biological Sciences Inititiative for providing many opportunities to discuss teaching with masters.
7. Every once-in-awhile a couple on the dance floor will get on a roll and all the other dancers move aside and recognize and cheer them on. I guess this year was my turn – Thanks to the parents, grandparents, siblings, friends, and graduates for sharing your time to celebrate at graduation.

"Until thought is linked with purpose, there is no intelligent accomplishment...-- James Allen, ***As You Think***

Dealing with the Publics

Anglers and Activists: Fisheries Managers Beware!
Kristen Scott

Issue Definition

The animal right organizations are based on a broad social movement that's gained considerable stature in America. Through judicious use of media and grass root campaigns, animal right activists have highlighted the many animal abuses that occur in society. This gives activists considerable influence in enacting animal welfare laws at the state and federal levels. Campaigns that have been successful in the past were against the use of animals in needless scientific research and product testing and protested the inhumane conditions in which the animals lived. New campaigns now target the traditional hunting and fishing groups. Activists protest the prolonged misery of animals that are shot or fished but not immediately and humanely killed. Between these two groups, the activists and the hunters / anglers, there is considerable controversy which must be dealt with by natural resource managers. People for the Ethical Treatment of Animals (PETA) is currently conducting a No Fishing effort, which casts fisheries managers into an adversarial position. Most managers are under intense political pressure from a diversity of advocacy groups. This pressure is frequently sustained by not only activist groups but by anglers as well (Alverson 1995). This means managers and their judgements are subject to outside pressures, so maintaining objectivity among the controversy isn't easy (Alverson 1995).

Many fisheries managers entered the field partly because they are concerned with animal welfare, the humane treatment of animals without causing undue suffering, but animal activists take the idea farther. They strive for equal consideration among species and believe each individual animal has an inherent right to life without suffering (Wywialowski and Reese 1991). Managers are caught between the anglers and the activists because most agencies mission statements include serving the needs of public members that have a vested interest in aquatic resources no matter how diverse the stakeholders. Agencies provide opportunities for the public to enjoy recreational activities while optimizing the sport fishing experience. In this case of the angler who prefers game fish versus activist who wants no angling, serving the needs of these two radically different stakeholders seem virtually impossible.

Background Information

PETA's Position

PETA is one of the most vocal and largest of the animal right organizations. Founded in 1980, it operates on the principle that animals don't exist to serve humans. Accordingly, animals are not to be worn, eaten, experimented on or used for entertainment (PETA Online 1999). Animals are individual life forms that have the right to equal consideration of their interests. For example, a fish has the right not to have unnecessary pain inflicted on it, and that needs to be taken into consideration (PETA Online 1999). No Fishing is one of the most recent campaigns started that protests the excessively cruel treatment of fish by anglers.

Besides the inhumane treatment, PETA has several complaints about recreational angling. At many of the angling sites, litter is commonplace, which includes empty containers, discarded monofilament and tackle (No Fishing 1999). This material is hazardous to many species such as waterfowl that swallow lead sinkers causing lead poisoning. Also discarded fishing lines entangle both birds and fish leading either to drowning or risk of infections because of cuts. Wildlife rehabilitators claim that litter left by anglers is the single greatest cause of injuries to aquatic animals (No Fishing 1999). Another complaint is the poisoning of lakes to remove unwanted species so the lake can be restocked with preferred game fish. One reason for the need to remove these "trash" species are anglers who use live bait from one water system then release these fish into a new drainage. These introductions of game fish and undesirable fish can disrupt the natural community assemblage by increasing competition, predation and the spread of diseases.

But the main complaint of PETA is the needless suffering of fish caused by anglers. Fish have nervous systems resembling other vertebrates, including humans (No Fishing 1999). This means that fish experience fear and pain. Angling, from PETA's perspective is torturous for fish from start to finish. Beginning when they are impaled in the mouth where there are many sensitive nerve endings, anglers will then proceed to play the fish until it's exhausted. The fish's struggle to escape is described by Michael W. Fox, author of "Do Fish Have Feelings?".

"Even though fish don't scream when they are in pain and anguish, their behavior should be evidence enough of suffering when hooked or netted, they struggle, endeavoring to escape and by so doing, demonstrate they have a will to survive." (No Fishing, 1999)

The fish's misery continues when lifted from the water because the fish slowly handled, resulting in scale loss and torn fins. Other organizations besides PETA oppose angling. The Association of Veterinarians for Animal Rights is also strongly opposed to trophy fishing. Calling it an unconscionable act that would endanger, distress or otherwise kill any animal to obtain a memento for the purpose of entertainment. All fish caught should be immediately killed as painlessly as possible rather than being allowed to asphyxiate on the gill lines (Fetterolf 1993).

However, PETA is the most prominent organization because of their active agenda. To attract notice to their cause PETA has started a grass roots campaign. They protest at fishing tournaments and other popular fishing sites. Tactics include throwing rocks to scare fish away and the use of scuba divers to cut anglers' lines (PanAngler Newsletter 1998). These activities have brought the fishing debate to the nation's attention, through the use of media coverage of these events. The coverage has encouraged legislation proposed by animal right activists that potentially may restrict recreational fishing (American Fisheries Society, 1999).

Angler's Position

Recreational anglers feel that fishing is not a cruel sport nor is it unnecessary. There are many benefits to sport fishing, besides the obvious one of catching the fish. Angling provides a multitude of other valuable experiences. These benefits range from psychological, environmental and social. Positive experiences in angling include the release of tension by escaping the pressures of daily life and exploring new surroundings (Fedler and Ditten 1994). Socially fishing can be a retreat to solitude, or conversely, bring people closer through fishing trips with family and friends (Fedler and Ditten 1994). Other motivations for angling include experiencing the outdoors and the challenge of catching an elusive species (Fedler and Ditten 1994). These benefits are also recognized at a federal level. One executive order realized the social, cultural and economic importance of recreational fishing to the United States and the need to increase angling opportunities through conservation efforts (Rosenberg, 1999).

Anglers have a considerable interest in the conservation of fish populations and the environment. To maintain long-term sustainable yields of harvestable fish, populations need to remain healthy. To this end, anglers in 1993 and 1994 spent four billion dollars in revenues to support cleaner water, fisheries enhancement and habitat restoration (Bass Fishing 1996).

Besides supporting conservation measures, there are voluntary ways anglers can reduce stress on fish. For example, Wisconsin has in its trout regulations guide steps that an angler can take. By not playing a fish to exhaustion, anglers can reduce stress and mortality. Also by restricting most barbed lures and keeping fish in the water as long as possible minimizes scale loss and infections. However what is most upsetting to anglers about the controversy are the protests. To counteract the activists' harassment techniques, legislation is before several states to prevent interference in the taking of a fish by a properly licensed angler. In Alabama, such legislation has already passed (Reiger, 1997).

Conclusion

As the debate between anglers and activists continue, fisheries managers are consistently caught between the two. Managers have the duty to listen to both stakeholders' perspectives with objectivity and sincerity by becoming a conduit for communication. If fisheries resource managers ignore either side the potential for conflict increases and may obstruct management efforts to provide sustainable benefits for humans and the aquatic ecosystem (American Fisheries Society, 1999).

By searching for common goals that activists and anglers can share, these disparate groups can then come to some understanding and compromise (Wywialowski and Reese 1991). One such common goal is animal welfare. By incorporating humane treatment of fish into goals at fishery agencies would lead to an open forum where discussion could reduce potential antagonism. At the National Marine Fisheries Service a national Code of Angler Ethics has been implemented this year (Rosenberg, 1999). This Code includes practicing conservation by carefully handling and releasing unwanted fish and disposing of all trash in appropriate containers (for complete listing, see Appendix A). But anglers aren't the only group that must compromise.

Animal right activists need to expand their concerns beyond individual animals to include the entire community (Wywialowski and Reese 1991). By approaching aquatic resources as an entire ecosystem, mutual respect between anglers, activists and fisheries managers can begin to grow (Dombeck, 1996). The main principle of ecosystem management is to sustain the productivity and diversity of ecological integrity (Dombeck, 1996). Management agencies are stewards of aquatic resources, including sport fisheries and all the components of the aquatic ecosystem (American Fisheries Society, 1999). Thus not only does ecosystem management increase biodiversity but also lends itself to a wide range of public uses, both consumptive and non-consumptive.

In deciding how a fisheries resource should be used, managers need to draw upon a variety of views since managers represent the people for whom the resource is held in trust (American Fisheries Society, 1999). Fisheries managers need to support fishing opportunities and encourage freedom of expression. They also need to expect a rise in the conflicts between stakeholders since there is an increasing population and limited resource (American Fisheries Society, 1999). The only solution for the management of conflicts is effective communication; working together to enhance awareness of the pressing concerns of each group.

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Appendix A
Executive Order for the Final Code of Angling Ethics

[Federal Register: February 18, 1999 (Volume 64, Number 32)][Page 8067-8068]
From the Federal Register Online via GPO Access [wais.access.gpo.gov][DOCID:fr18fe99-44]
SUMMARY: NMFS is adopting this Code of Angling Ethics to implement the public education strategy required under the NMFS-specific Recreational Fishery Resources Conservation Plan.
DATES: Effective March 22, 1999.

ADDRESSES: Copies of the final Code of Angling Ethics are available from Richard H. Schaefer; Chief, Office of Intergovernmental and
Recreational Fisheries; 8484 Georgia Avenue, Suite 425; Silver Spring,
Maryland 20910-3282.
FOR FURTHER INFORMATION CONTACT: Richard H. Schaefer, 301-427-2014.

SUPPLEMENTARY INFORMATION:
Background

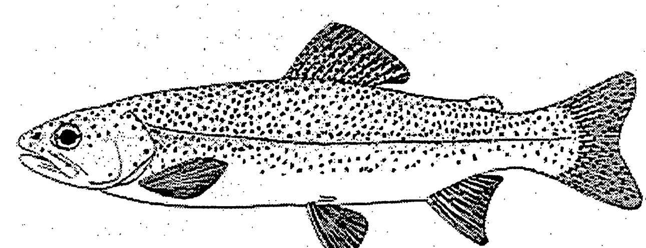
On June 7, 1995, the President signed Executive Order 12962 (EO) - Recreational Fisheries. The EO recognized the social, cultural, and economic importance of recreational fishing to the nation and directed Federal agencies to ``improve the quantity, function, sustainable productivity, and distribution of U.S. aquatic resources for increased recreational fishing opportunities." Further, the EO established the National Recreational Fisheries Coordination Council (NRFCC) consisting of Secretarial designees from the Departments of Commerce, Interior, Agriculture, Defense, Energy, and Transportation, and the Environmental Protection Agency. The NRFCC was directed under the EO to produce a Recreational Fishery Resources Conservation Plan (National Plan). The National Plan, completed June 3, 1996, directed each Federal agency to develop an agency-specific implementation plan that identifies actions needed to meet the goals and objectives of the National Plan. The NMFS-specific Recreational Fishery Resources Conservation Plan, unveiled December 31, 1996, dictates four Implementation Strategies as policy to achieve the goals of the National Plan. Implementation Strategy III, Public Education, states that NMFS will support, develop, and implement programs designed to enhance public awareness and understanding of marine conservation issues relevant to the well-being of marine recreational fishing. One output listed under this Implementation Strategy is ``NMFS will develop, promote and distribute a ``Code of Conduct for Recreational Fishing".''

The following Code of Angling Ethics has been adopted by NMFS:

THE CODE OF ANGLING ETHICS

1. Promotes, through education and practice, ethical behavior in the use of aquatic resources.
2. Values and respects the aquatic environment and all living things in it.
3. Avoids spilling, and never dumps, any pollutants, such as gasoline and oil, into the aquatic environment.
4. Disposes of all trash, including worn-out lines, leaders, and hooks, in appropriate containers, and helps to keep fishing sites litter-free.
5. Takes all precautionary measures necessary to prevent the spread of exotic plants and animals, including live baitfish, into non-native habitats.
6. Learns and obeys angling and boating regulations, and treats other anglers, boaters, and property owners with courtesy and respect.
7. Respects property rights, and never trespasses on private lands or waters.
8. Keeps no more fish than needed for consumption, and never wastefully discards fish that are retained.
9. Practices conservation by carefully handling and releasing alive all fish that are unwanted or prohibited by regulation, as well as other animals that may become hooked or entangled accidentally.
10. Uses tackle and techniques which minimize harm to fish when engaging in ``catch and release" angling.

Dated: February 11, 1999.
Andrew A. Rosenberg, Ph.D.,
Deputy Assistant Administrator for Fisheries, National Marine Fisheries Service.
[FR Doc. 99-4002 Filed 2-17-99; 8:45 am]



Landowners Deny Access to Jackson River
Daniel Nuckols

The denial of access to the Jackson River in Alleghany County, Virginia, by landowners has been an issue ever since the end of the 1800's. The headwaters of the Jackson River start in Highland County and flow nearly 100 miles downstream through Bath and Alleghany Counties. In Alleghany County it joins the Cowpasture River and the two rivers form the James River. In earlier years loggers had problems with landowners during periods when loggers floated logs down the Jackson River to saw mills. In more recent years trout anglers are not allowed to fish in certain areas of the river in Alleghany County including lands owned by Ethridge E. Burr and his neighbors. These lands were given to or otherwise obtained by the original owners many years ago from Kings of English Colonies. These land titles included all land, including streambeds, and wildlife present on the land as property. The access problems arose due to the all-inclusive ownership of the streambed and wildlife included with the title of the lands. 'Ownership rights of river beds are determined at date of formation of union or at date of admission to statehood of those states formed later, and, absent navigational servitude, the landowners had the right to control use of waters if they had title to streambed under Virginia law' (Loving v. Alexander) and royal patents and land grants from the English Crown (Kraft v. Burr). Most of the court cases had to do with determining if the river was navigable or not. Navigability is one characteristic used to determine if a water body will be deemed public or private. The Jackson River access ordeal may have been settled if the navigability portion of the case would have been handled differently. In order for a body of water to be deemed navigable, if must satisfy the following criteria: 1). Past, present, or potential presence of interstate or foreign commerce; 2). Physical capabilities for use by commerce; see appendix A; 3). Defined geographic limits of the water body. Past history supports the navigability of the Jackson River because it was used for floating logs early in the 1900's up to 1939 when a group of men employed by John E. Perkins floated logs to a saw mill downstream to cut into lumber. The plaintiffs were not happy with the Jackson River being labeled as navigable and filed suit in 1979 against the Army Corps of Engineers and said the Corps did not determine navigability in accordance with law because the Jackson River segment is non-navigable and they won the case. In the most recent case, Kraft vs. Burr, the defendant used navigability, but failed to persuade the judge the river was navigable even with the historical usage of the river. Mr. Kraft did not prepare well for his testimony and it showed in the ruling of the courts in favor of the landowners. Why doesn't the public have the right to use a natural resource like the Jackson River segments in question? Why are all natural resources not 'common property'? The colonial titles prevail, and sole ownership is that of the landowners.

In the United States, acceptance of increased public control has been slower than in most other developed countries, partly due to a deeply held belief in the sanctity of private property, particularly land. Also, many people have thought that our supply of land so greatly exceeded demands for it as to make public controls unnecessary (Strong 1975). The United States is not alone in the exercise by society of controls over private land use. Virtually every other country in the world also exercises such controls; these controls are more severe and numerous in other countries than in the United States. The people of the world, working through their governments, have simply said that use of land is too important a matter to be entrusted entirely to the private market (Dysart & Clawson, 1988). Although there are still areas of the Jackson River that the public is not allowed to access, most streams may be accessed if termed navigable. As for the landowners that own the title to the streambed, you can not blame them for their actions and defensive response to the public disputes. Landowners do not want their streams littered and disrespected by the public as is done to most public waterways.

The landowners with legitimate land titles are fighting for their property, given to or otherwise acquired, from the government years ago. The landowners have the legal right to keep people out, but what if the areas under dispute are termed navigable? The outcome of the Loving v. Alexander case in September of 1982 found the Jackson River to be navigable. Why is access still restricted in some areas? In, Kraft v. Burr, September 1996 the Supreme Court of Virginia allowed the landowners with titles of their land from two English monarchs to prevent fishing over their streambeds. In the dispute, which Kraft was offering, he stated that he "lawfully navigated the river overrunning the stream bed owned by the landowners, and so long as he remained in navigable waters and did not touch the banks or drag the stream bed with nets, seines or an anchor, he was not trespassing on the landowners' property" (Kraft v. Burr). Kraft did not convince the judge, so he was found to be trespassing.

Once a river is termed navigable, it remains navigable even if changed circumstances make present commercial use impractical (Loving v. Alexander). Once a river is termed navigable, it becomes public lands and can be accessed by all. Referring back to previous verbiage, if a river was historically navigable, then that is enough evidence to determine a waterway navigable. This section of the river under question was historically used as a transport waterway of logs in the lumber industry. Although such practices are impractical today, the laws stated that once a river is used for such commercial uses, it is navigable forever. Today the access is primarily wanted for angling and canoeing based on canoeing experts that consider the Jackson to be an excellent canoeing stream, except for troubles with landowners along the river (Loving v. Alexander).

Steve Hiner, a trout fishing guide, fishes the Jackson River and is well informed on the access dilemma. Mr. Hiner said the Trout Unlimited (TU) was partly to blame for the loss of the Kraft vs. Burr case and feels that TU caused the landowners to be alienated by the idea of wanting the waters strictly catch and release. Mr. Hiner believes there is no chance of any further legal resolutions, and said it is an opportunity 'pissed away' referring to the resource on the private lands that is not accessible to the public. Larry Mohn, a biologist from the Virginia Department of Game and Inland Fisheries presented more promising information on the issue. Mr. Mohn stated that some landowners have expressed some interest in reopening the river to public fishing. He said VDGIF continues to work with landowners in the hopes of reopening the river to public fishing and he is cautiously optimistic that these efforts will be successful. Mr. Mohn, as like Mr. Hiner, does not see any legal action being likely in the near future, but Mr. Mohn thinks the case may be useful in future cases that deal with navigable waters. He also said a number of public focus group meetings where held during the time when the issues were in active conflict and said at this point a focus group would be of little value because of the sharp division of interests. He also said that there has been little input from the fishing public concerning the Jackson, and that organized fishing groups seem to have written off the tailwater.

Management of private areas such as the Jackson are difficult to deal with. The Gathright Dam in Alleghany County was built during 1979-80 and it was 'expected to help improve the cold tailwater trout fishery' (Orth 1999, personal communication). Below Gathright Dam is the only portion of the Jackson open to the public in Alleghany County. The areas available for public access span from Gathright Dam downstream to Westvaco Dam at Covington. When the dam was built public resources were used to develop a fishery where landowners could deny access if they care to do so (Orth 1999, Personal Communication). In situations such as this, it is not much that can be done from a fisheries perspective. The original plan was to have a higher minimum size limit and a lower creel with no change in recommended gear restrictions, but today the regulation is a 12-inch minimum size limit with 4 fish per day creel limit in the area below Gathright Dam. Mr. Mohn said that VDGIF's current management plan is to continue to monitor the fishery. They are seeing some increase in reproduction and he said the upper reaches might soon support a quality wild trout fishery. He stated that downstream the fishery is in decline and will likely continue that trend without stocking. Without the landowners changing their opinion, conditions will most likely maintain there current trends.

In summary, the Jackson River will remain closed to the public unless landowners changer the opinion and allow access. Mr. Mohn stated that some landowners are interested in opening the River to the public, and this is a step in the right direction. In the opinion of Mr. Hiner, there is no chance of it being opened to the public. I hope Mr. Hiner's opinion isn't correct for the sake of anglers and other user groups who want the river opened to the public. The entire issue is in the hands of the landowners at this point, lets hope the landowners will share their wealth of natural resources with the public in the near future.

Appendix A

Nature of Commerce: type, means, and extent of use. The types of commercial use of a waterway are extremely varied and will depend on the character of the region, its products, and the difficulties or dangers of navigation. It is the waterbody's capability of use by the public for purposes of transportation of commerce, which is the determinative factor, and not the time, extent, or manner of that use. Thus, sufficient commerce may be shown by historical use of canoes, bateaux, or other frontier craft, as long as that type of boat was common or well-suited to the place and period. Similarly, the particular items of commerce may vary widely, depending again on the region and period. The goods involved might be grain, furs, or other commerce of the time. Logs are a common example; transportation of logs has been a substantial and well-recognized commercial use of many navigable waters of the United States. Note, however, that there mere presence of floating logs will not of itself make the river "navigable', the logs must have been related to a commercial venture. Similarly, the presence of recreational craft may indicate that a waterbody is capable of bearing some forms of commerce, presently, in the future, or at a past point in time (Loving vs. Alexander 1982).

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Stocking Policies

Do Stocked Game Fish Play Any Role in Freshwater Mussel Declines?

Rebecca Winterringer

Issue Definition

Freshwater mussels are the largest group of threatened or endangered fauna in the world. Management of these animals is difficult since many aspects of their life are unknown. An integral part of their life history lies with the fish host. Mussels have specific hosts for the maturation of their glochidia (immature juvenile mussels). Many of these hosts are nongame fish species. There is little information on whether stocking directly effects freshwater mussel populations. However, the influence of stocked fish on nongame and endemic species has been researched. The stocking of catchable size trout, a major part of many fisheries management programs, may create severe interaction between large stocked trout and native fishes (Garman 1982). The objective of this paper is to make a link between the depletion freshwater mussels through the depletion of nongame species by stocked game fish.

Background Information

Introduction

It is important for the terms of this paper to describe the life cycle of freshwater mussels. Like almost all species eggs develop via fertilization from the sperm. The same holds true for mussels. Once a female is fertilized, glochidia (larvae) are formed. Some species will then do what in the malacological world is termed as "flapping"- they stick out a portion of their mantel tissue into the water column. Depending on what mussel species, it will resemble anything from a small wounded fish to larvae or eggs. For example, *Lampsilis fasciola*, the Wavy Rayed Lampmussel, waves it's mantel tissue which resembles a darter. It is shaped like a small fish with an eye spot and the pigmented tissue flaps as if it were injured. This action attracts small fish. The fish will attack the "injured fish" and the mussel in turn will spurt out a burst of glochidia. It is at this stage that the glochidia parasitize the fish gills or fins until they mature into juvenile mussels. At maturation, juveniles fall off into the substrate. If it is not the correct fish host the glochidia will not mature nor may not parasitize the gills at all. All freshwater mussels have particular fish hosts necessary for the successful rearing of their juveniles.

As one can see, freshwater mussels have a unique relationship with the ecosystem in which they live. Interrupting the life cycle (elimination of fish hosts or habitat disruption) in any way puts freshwater mussels in immediate peril. Human impacts such as dredging, pollution, sedimentation, impoundments and mining have been documented as causing freshwater mussels to be the most numerous animal group listed as endangered or threatened. Researchers have yet to connect the elimination of fish hosts by stocked game fish as another human impact.

Host fish being a major player in mussel recruitment, to put them in jeopardy places freshwater mussels in danger as well. To put it simple: few or no host fish equals no hope for rejuvenating freshwater mussel populations. Most stocked game fish, especially trout, are of an age where they are highly piscivorous (catchable size >280 mm). Sculpins (*Cottus* spp.) serve as a host for several species of freshwater mussels. Brown trout eat many sculpins (John Ney, pers. comm.). The Virginia Cooperative Fish and Wildlife Research Unit at Virginia Tech in conjunction with Tennessee Wildlife Resources Agency is currently conducting a mass effort for the propagation of endangered and threatened mussels for the release in Tennessee River system. Without those host fish, laboratory rearing would be impossible (Jess Jones, pers. comm.).

Stocking programs are widely used for the sport fishing industry. The number one reason for stockings is to introduce a new sport or commercial species (Heidinger 1993). They bring in citizen support, political and economic gain for the state agency. One almost instant thought that a manger has before stocking a species into a particular system is can this species survive hear with the existing food supply and habitat. Another concern is angling pressure; at what rate will these fish be taken out. The first day a stream is stocked, anglers line the shore or wade into the stream. This promotes impact on the stream bed where freshwater mussels reside. Care should be given when designating a stream as stocked trout waters. Streams with threatened fauna should not be considered as stocking candidates.

The Virginia Situation

As examples, three streams in Southwest Virginia will be examined. These streams are stocked with trout and have species of threatened and endangered mussels. These streams are merely examples of this issue of concern and should not be mistaken for research areas.

The Middle Fork Holston River is home to two species of freshwater mussels; *Lasmigona holstonoia*, Tennessee Heelsplitter and *Epioblasma florentina walkeri*, Tan Riffleshell. The Tennessee Heelsplitter is a special concern and state (VA) threatened species. The host fish for this mussel found sculpins and several darter species to be suitable hosts. The Tan Riffleshell is listed as a federally endangered species. The Unites States Fish and Wildlife Service has implemented a recovery plan for this species. The host fish are sculpin (*Cottus spp.*), greenside darter (*Etheostoma blennioides*), fantail darter (*E. flabellare*), and the redline darter (*E. rufilneatum*).

The Middle Fork Holston River (MFHR) is located in the ridge and valley province of Virginia and is stocked with trout in two areas: the town of Marion and the upper portions (headwaters) of the river. The Tan Riffleshell used to have populations in the Marion area of the MFHR. A recent survey of this river found one individual downstream from Marion but none at the site where they were historically located. The Tennessee Heelsplitter, a headwater species, has a substantial population in the upper part of the MFHR.

The last two streams are Craig creek and Johns Creek both of the James River drainage. Both of these creeks are stocked trout waters and contain an endangered mussel *Pleurobema collina* (Conrad, 1837), the James Spinymussel. The host fish for this mussel are Blacknose Dace (*Rhinichthys atratulus*), Bluehead Chub (*Nocomis leptocephalus*), Central Stoneroller (*Campostoma anomalum*), Mountain Redbelly Dace (*Phoxinus oreas*), Rosefin Shiner (*Lythrurus ardens*), Rosyside Dace (*Clinostomus funduloides*), and Satinfin Shiner (*Cyprinella analostoma*).

John's Creek and Craig Creek are also located in the ridge and valley province of Virginia and both have populations of the James Spinymussel and are designated as stocked trout waters by the Virginia Department of Game and Inland Fisheries. These populations occur near to where stocking occurs.

Making the Link

Put and take trout fisheries and the stocking of cacheable size trout should be a concern in these three streams. Stocking occurs right on top of these threatened species of mussels and their fish hosts. It is common knowledge of the trophic relations in freshwater systems. One cannot stop to wonder if the fish host populations are being effected by this intense predator prey relationship. Predaciousness is a natural occurrence; human instigation of predaciousness is not.

Research conducted by Garman and Nielsen in 1981 found that both large and small stocked brown trout consumed fish although more was consumed by larger trout. In one area of stream, the species composition was taken and the abundance of that nongame fish in the stomachs of brown trout. The Torrent sucker comprised 43% of the nongame species present and was also 55% of the diet found in large brown trout. Stoneroller was estimated to be 20% of the species composition and 8% of the brown trout diet. Other species of interest were Rosyside dace, Fantail darter, Mottled sculpin Bluehead chub and Mountain Redbelly dace which were respectively 14, 1, 2, 6, and 7 % of the species composition and were 15, 15, 8, 0, 0 % of the diet analyzed in brown trout. In this same section of stream, it was observed that Torrent suckers, Stonerollers, and Bluehead chubs decreased in numbers during the experiment. This study kept the length of the brown trout the only variable so the piscivority of this species depends highly on the size (>280 mm) (Garman 1982). Several of these species serve as hosts for the examples of freshwater mussels given in this paper.

The candy darter is a threatened species. Though the candy darter is not a specific fish host, it is an *Etheostoma spp*, just as several of the hosts are. A study was conducted by the U. S. Forest Service and VPI&SU to determine the extent of stocked trout predation on candy darters. Though their results yielded no significant conclusions they did make the following recommendations: 1) more research be conducted to determine the extent and effect of trout predation on candy darters and 2) candy darter populations can be established in other streams in Virginia within their historical range (Leftwich 1994). This study also yielded that brown trout tend to be more piscivorous than the rainbow trout. VDGIF has implemented a stocking only of rainbows in areas where candy darters occur. Though this study was inconclusive, it gives rise to the fact that predation by cacheable size trout is a concern and that VDGIF has taken action for this for threatened nongame fish species. The next step is to have the same action taken for threatened and endangered mussels.

In the western states, Richard Vincent at the Montana Dept. of Fish, Wildlife, and Parks in 1966 and 1976 found that stocked trout were "highly disruptive" to wild populations. Stocked populations reduced wild populations by 90%. The interesting and even more disheartening evidence is that stocked fish, while displacing wild populations, are usually fished or die in too short of a time to establish good populations. "Hatchery fish are knocking out wild trout without making up the difference" (Yuskavitch 1999). This is an example of stocked trout effects on wild populations. This provides evidence of the effect on the ecosystem to which stocked trout are introduced. It's a natural phenomenon for large piscivorous fish to prey on smaller nongame species. Natural freshwater systems tend to be balanced. Stocking disrupts this balance.

Conclusion

In simple predator-prey systems involving an introduced predator, extirpation of a prey species may result (Johaness and Larkin 1961; Macan 1966). In regards to the three Virginia streams of interest, there are no special concern nongame species that are fish hosts for freshwater mussels. Therefore, it is a slim chance that agencies will protect these waters in light of stocking as was done in Stoney Creek for the candy darter. It is difficult and not a very popular issue to protect the freshwater mussels from the effects of stocking since there is no direct effect. However, there is substantial evidence that stocking negatively effects populations of endemic and nongame species as was proven by Garman and Vincent. I recommend that future monitoring of specific host fish be conducted in relation to stocking game fish. Thus, it will be easier to argue the indirect effects of stocking on freshwater mussels.

In answer to the question "Do stocked game fish play a role in the decrease of freshwater mussels?" I do not have a scientifically based answer. I can only make the inference that it may. It is imperative that managers of freshwater systems consider every freshwater relationship before making a decision. It is easy to dismiss the issue of stocking for the exact reasons it was implemented decades ago. However, as time goes by we see that human interaction with nature usually has a negative impact. Why not turn the table and take preventative measures. The idea of creating fixable problems should be laid to rest. Soon it will be too late.

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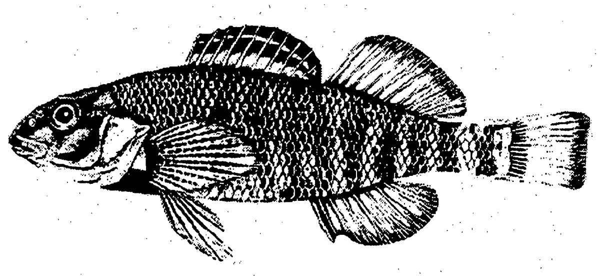

Are Introduced Fishes a Necessary Nuisance?

Robert Deitrick

Introduced fish have been a part of fisheries management since people first began to manage fish. Some species, like the brown trout (*Salmo trutta*) have been well received, although they have caused problems with native trout populations. Others, like the common carp (*Cyprinius carpio*) may have seemed like a good idea at the time, but are now generally regarded with derision in the United States. Introduced fish often crowd out native fish, and it is estimated that 68% of all fish extinctions in North America were due at least in part to competition from exotics (Shafland 1996b). A database compiled by biologists in Gainesville, Florida lists more than 500 fish present in the United States outside of their natural range. Of these, 185 were introduced from foreign countries, and 71 are considered to be established (Nico and Fuller 1999).

This article deals with several examples of introduced fish which have had a substantial impact on native populations, particularly from the aquaculture industry and the ornamental fish trade and in particular the family Cichlidae. Solutions to some of these problems are also examined. While exotic fishes have caused many problems over the years, fisheries managers should not be too quick to ban their import and use altogether, particularly those that provide an economic benefit in the form of aquaculture or in the ornamental fish trade.

Problem Statement

The family Cichlidae is native to much of tropical and subtropical Central and South America, Africa, and Asia, with only a few species venturing naturally into US waters. They comprise some 2,000 species, with more likely to be described. They survive in a variety of habitats and fill a variety of niches. It is this adaptability which makes them so successful wherever they are introduced (Loiselle 1985).

Florida provides an extreme example of the problems that introduced fish can cause. More exotic fish are found here than anywhere else, both in the wild and culture facilities. The Florida Game and Fresh Water Fish Commission maintains a list of 75 species of exotic fish that have been captured in the wild at least once. In some places, introduced fish outnumber the natives by a large margin. This has wreaked havoc on the local ecosystems. A Florida Game and Fresh Water Fish Commission survey in 1994 found 23 established exotic species within the state's waters. Eighteen of these species were definitely reproducing, and the other five were probably reproducing. As an example of the tenacity of these fish and the headaches they cause managers, 10 of these species were believed to have been previously eradicated from Florida waters (Shafland 1996a).

Tilapia (*Oreochromis, Sarotherodon, and Tilapia spp.*) are becoming increasingly important in aquaculture. Their ease of culture and tasty flesh ensure that they have a future in the aquaculture industry (Glenney and Libey 1997).

Due to an accidental release from an aquaculture facility some 30 years ago, the black-chin tilapia (*Sarotherodon melanotheron*) has become established in the upper reaches of Tampa Bay and is currently one of the most abundant fish there The warm, brackish bay closely resembles their native habitat in coastal lagoons in West Africa (Loiselle 1985). The fish is also found in the Cape Canaveral area on the other side of the state. This fish was the first of four species of tilapia to become established in Florida. Surprisingly, despite the rapid colonization of the initial areas, the populations have not continued to spread (Shafland 1996b).

In the west, the problem of introduced fish can have even more devastating effects. Due to the scarcity of water in the desert, some fish have evolved entirely within one drainage or even within one spring. Often, these ecosystems are extremely fragile. The Salton Sea basin in the Coachella Valley in California has only one native species of fish, the Salton Sea pupfish (*Cyprinodon macularius californiensis*). In an attempt to control non native aquatic weeds, *Tilapia zillii* was introduced into the Salton Sea. Almost immediately, the pupfish began to decline in numbers, and today their existence hangs in the balance. The tilapia, meanwhile, are thriving (Loiselle 1985).

California has more than its share of problem exotic fish. A list compiled in 1996 listed 53 species of non-native fish that had been introduced into California, representing 34 genera and 17 families. The list was not further broken up into species native to North America and native to other continents. Since there are only 63 recognized species native to California, 5 of which are extinct, barely half of the fish found there now are indigenous (Dill and Cordone 1997).

In most any pond in a urban or suburban area, one can find a few goldfish or koi swimming around. Sometimes this is the result of a city beautification project; more often, it is the result of someone dumping a fish that grew too large for an aquarium. While goldfish may seem harmless enough, their addition to an area can only add to the problems faced by the body of water. In addition to the ecological problems, these fish are a very visible blemish on the ornamental fish trade.

Other ornamental fish have made a significant mark on the environments in which they were released as well. The oscar, (*Astronotus ocellatus*), has been established in southern Florida since the 1950's. In the mid 1980's, however, the population exploded, with angler catches increasing by 10 to 50 times over what had been caught in previous years. The oscar is now one of the dominant fish in south Florida, supplanting many of the native centrarchid species (Shafland 1996a).

Solutions

With all the problems caused by these introduced fish, should they even be allowed in the country? Absolutely. The ornamental fish trade is estimated to be worth millions of dollars annually, and provides jobs for many people, from fish growers to pet shop employees. Aquaculture is becoming amore important source of fish every year, and many of the fish species that show the most promise are exotic. Limiting these industries' access to exotic fish would limit their growth and have a negative economic impact.

Within the aquaculture industry, measures should be taken to ensure that the fish are unable to escape. Most accidental releases are the result of a poorly designed facility. Unexpectedly heavy rains can flood a facility and wash the fish downstream, or a poorly constructed dike can give way. Problems such as these are relatively easy to alleviate. Commercial aquaculture facilities are already subject to regulations, both in their construction and in any permits that may be necessary to keep the animals. This ensures that a measure of control will be exercised over these fish, and hopefully keep accidents to a minimum. Also, with the advent of recirculating aquaculture, which often takes place indoors, it is possible to grow fish in climates completely unsuitable for their survival. Encouraging producers to work with fish that have no chance of becoming established in the wild may help prevent susceptible species from gaining a foothold in the industry.

Far more difficult to control are introductions by individuals. While states may require permits to possess certain fish, or ban their import all together, very little can be done to prevent an individual from dumping a bucket of fish into a body of water. There are two ways to go about preventing this. The first is the current system of carefully regulating and managing any exotic fish that could pose a problem. The second involves education. Regardless of the laws in place, illegal introductions will only stop insofar as the public is made aware of the problems these introductions cause. More effort should be made to reach private pond owners and the like and educate them on responsible stocking.

Aquarium hobbyists share some of the responsibility for ensuring that exotic fishes stay out of local waters. Anyone keeping an aquarium needs to know that fish should never be released into the wild. A better knowledge of the species of fish being kept can help prevent unwanted fish from being dumped. Many a cute baby oscar has wound up in a local lake after rapidly outgrowing its tank and bullying its tankmates to death. In warmer climates, or in water heated by warm springs or warmwater discharges in more temperate climates, it is easy for these tropical fish to become established. Many pet shops, especially those that specialize in fish, offer basic information on the life history and requirements of the fish they sell. And anyone willing to invest a substantial sum of money in an aquarium setup and fish should spend the extra $15 or $20 and purchase a good book on the care of the fish he intends to keep.

Fish introductions have caused major problems all over the world. In many cases, the damage is irreversible. Because of this, exotic fishes are being viewed in an increasingly negative light. However, past problems with exotic fish should not sour us on exploiting their potential, provided they are used in a sensible and ecologically sound manner.

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Fisheries Issues Close to Home

Native Brook Trout versus Introduced Brown and Rainbow Trout in the Southern Appalachians: Bout of the Century

William C. Markham

Cold, clear, cascading waters- from tiny trickles in the highest ridges to third order tributaries of valley rivers, that is a typical description of a stream in the southern Appalachian mountain chain. These waters once hosted a large number of native brook trout (*Salvelinus fontinalis*). Over the years the numbers of these native fish have declined due to multiple reasons ranging from acidification to warming water temperatures to introduced species of fish (Larson and Moore 1985). The latter is of great concern. It has been well documented that introduced species have both direct and indirect influences in the decline of native fish species of all kinds (Lassuy 1995). There is also a controversy surrounding this because the exotic species that seem to have the most negative effect on brook trout are brown (*Salmo trutta*) and rainbow trout (*Oncorhynchus mykiss*). We will examine what actually happens when browns and rainbows are introduced into brook trout habitat. We will also explore possible management philosophies for dealing with the issue.

Rainbow trout

In the early 1900's, rainbow trout were introduced in lower and mid-elevation streams in the Appalachian mountains where previously only brook trout had existed. Granted, by the time these fish were stocked, populations of brook trout had disappeared from lower elevation streams for other reasons, such as extensive logging (Larson and Moore 1985), but they were still abundant in mid and high elevation steams. Abundance of brook trout steadily declined in areas where rainbows were stocked while the abundance of rainbow trout increased (Kelly et al. 1980).

Even though it is known for a fact that populations of brook trout decline when in the presence of rainbow trout, it is not as clear as to the reason for their decline. It has been thought that rainbow trout have a competitive edge over brook trout and that they are simply able to outcompete them for available resources (Kohler and Hubert 1993). However, competition can be broken down into many areas such as competition for food resources, feeding sites, spawning habitat, and territory. Studies have shown that competition for food, feeding sites, and territory have negligible influences over brook and rainbow population structure. Instead, the only competitive advantage rainbows seem to have over brookies is in selection of spawning habitat, but only under limiting circumstances, and that conditions in the southern Appalachians do not exhibit limited spawning habitat (Clark and Rose 1997).

So if competition for resources is not the cause in the decline of brook trout, what is? The same study that showed competition was not a factor also showed that the low fecundity of brook trout compared to rainbow trout was a factor and so was a higher frequency of year-class failures for brook trout (Clark and Rose 1997). It appears that brook trout naturally have low recruitment in the southern Appalachians because of an inability to produce a large number of eggs and a high probability that a year-class will be wiped out due to flooding. However, when this is coupled with the high fecundity of rainbow trout and their tendency to be more resilient against year-class failures, the recruitment is lowered even further. This is better illustrated when the effects of higher fecundity of brook trout is modeled (see figure 1). When brook trout fecundity is increased, the mean postfry density of brook trout increases, while the mean postfry density of rainbow trout decreases.

Brown trout

Rainbow trout, however are not the only introduced species in the southern Appalachians. Brown trout have also been stocked throughout native brook trout ranges (Mohn 1999). Brown trout are also thought to be a major cause in the decline of brook trout population abundance. The reason is because these fish do exhibit the ability to outcompete native fishes for limited resources (Dewald and Wilzbach 1992). The resources that seem to be most limited in streams of the Appalachian mountains are space and food (Clark and Rose 1997). It has been well supported in several studies that brown trout can and do effectively outcompete brook trout for these two resources (Dewald and Wilzbach 1992).

Trout need specific habitat types to survive. A good habitat site must provide shelter from the sun, cover to avoid detection, an adequate food supply, and a quick escape route from danger. The preferred habitats for both brook and brown trout are covered pools, riffles, and open pools- in order of most to least preferred. Brown trout, being the more aggressive of the two species will drive brook trout from their preferred habitat to areas that do not provide as much protection from the hostile environment (Dewald and Wilzbach 1992), thereby increasing mortality.

Brown and brook trout have the exact same diets. When placed in the same environment with limiting food resources, one would expect to see resource partitioning. However this is not the case. Because of the shift in habitat and the aggressiveness of brown trout, brook trout become inactive and do not feed as efficiently when coexisting with browns (Dewald and Wilzbach 1992). This results in decreased growth rates and consequently, poorer quality fish.

Another reason that brown trout might be contributing to the decline in brook trout abundance is the fact that browns are more resistant to disease. One study has shown that when placed in an environment with browns, brook trout contracted the fungus Saprolegnia sp. which resulted in death. However, when placed in a single species environment, no infestations of the fungus on brook trout were detected (Dewald and Wilzbach 1992). This leads one to believe that brown trout while being more resistant to disease may also be carriers of some diseases that will readily affect brook trout.

The Controversy

It appears that brown and rainbow trout are hardier fish than brook trout and survive better in southern Appalachian streams. So who cares that brook trout are being replaced with them? It depends on who you ask.

If you ask a subsistence fisherman, the more rainbows and browns, the better. They grow faster, get larger, and are more numerous. Even fly fishermen, who are known to like doing things the natural way like to see rainbow and brown trout in our waters because they are more of a challenge to catch than brook trout are.

However, if you ask a conservationist, they might say that brook trout are extremely important to keep around because they are one of the few fish species that we know to be native. In fact, one renowned conservationist, Aldo Leopold, said "the intelligent tinkerer keeps every cog and wheel." More and more people are beginning to view our natural surroundings from an ecosystem perspective in which it is imperative to preserve all things because there is no way to know the complete effects of removing a species from a system. Although brook trout are far from being extinct, they are disappearing from Appalachian waters.

Some might argue that we should not worry about this issue as long as brook trout are still prevalent elsewhere in the world because change is a natural occurrence. While this may be true, this change has occurred and will continue to occur ultimately due to the interference of mankind. Brook trout evolved to exist in the southern Appalachians effectively until we radically altered factors in their environment. Had the introduction of brown and rainbow trout occurred slowly and naturally, brook trout might have evolved further to coexist with these fish. However, this did not happen.

The Future

As professionals dedicated to satisfying the needs and desires of as many people as possible, managers should strive for a balance between rainbow, brown, and brook trout populations. This could be accomplished several ways. First, let's examine a situation in which this balance seems to have been achieved.

Virginia claims over 1840 miles of wild brook trout streams, more than all other southeastern states combined (Mohn 1999). Compare this to 1260 miles of streams containing brown and rainbows. It does not appear that the abundances of brook trout are being significantly altered by the browns and rainbows in the area. This feat is accomplished by a strict no stocking policy in designated native trout waters. Because brook trout require extremely cold good quality water, there are still plenty of streams capable of supporting brown and rainbow trout.

Put-and-take stocking is a large part of the rainbow trout management program. Large numbers of rainbows are stocked in waters that may be unable to support trout over the course of the entire year due to temperature increases (Mohn 1999). This and high fishing pressure prevents the fish from spreading far.

Brown trout are either stocked put-and-take or are stocked as fingerlings in waters unsuitable for brook trout. The best example of this is Mossy Creek, a trophy brown trout fishery in Rockingham county. Mossy Creek is unable to support trout reproduction. It runs through the middle of several heavily used pastures. The bottom is thoroughly silted over, and trout require gravel substrate in order to spawn. However, the stream is spring fed, very cold, yet fertile, which allows excellent growth in trout that are stocked. This management philosophy allows for all trout fans to fish for their favorite species, while still maintaining the ecological integrity of the native fauna.

It appears that by stocking brown trout in waters uninhabited by brookies is the only way to minimize the effects of intraspecific competition because brown trout are able to outcompete them and spread diseases. However, because the only advantage rainbows have over brook trout is their high fecundity, there may be other ways of managing for the two species to coexist.

Not too long ago, it was discovered that grass carp could be genetically engineered to be triploid, rendering them sterile. This was done so that populations would not rapidly overtake a system when using them as a biological weed control (Kohler and Hubert 1993). It may be worth the effort to explore genetic manipulation of rainbow trout to find a genotype resulting in sterility. These fish could then be stocked in native brook trout streams without fear.

It is imperative to keep brook trout populations strong in the southern Appalachian mountains. They are our only native salmonid, and considered important enough to be deemed Virginia's state fish. In order to do so, we must prevent brown and rainbow trout from further invading their habitat. However, this does not mean that we must sacrifice these fisheries. There are enough streams unsuitable for brook trout that are perfectly capable of supporting browns and rainbows. With sound management philosophies and practices a balance can be achieved to satisfy many different publics.

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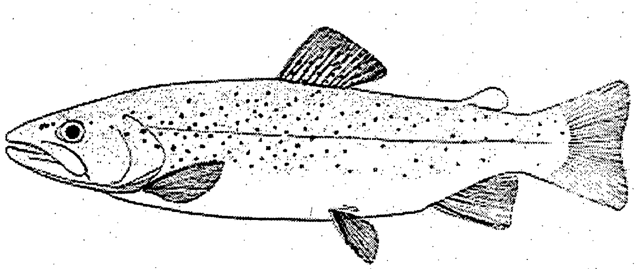

Angling Impacts on Spawning Black Bass

Adrienne Weimer

Black bass (Micropterus spp.) are arguably the most sought after sportfish in North America. Currently twelve states and seven provinces have seasonal regulations that limit bass fishing. Fishing for spawning bass is a management issue with social and biological implications (Schramm 1999). This paper will discuss 1) angling impacts on spawning black bass (hereafter bass), 2) current regulations in North America, 3) management options and implications, and 4) evaluate whether Virginia needs to implement seasonal regulations on bass.

Angling Impacts

Bass Biology

Angling of spawning bass negatively affects the adult population as well as the offspring. Bass are more vulnerable to capture during the spawning season which typically spans April to May, when water temperatures range from 12 to 25°C (Lukas and Orth 1995). This season is characterized by pre-spawn movements inshore and nest building and protection; post-spawn activities occur when fish linger around shallow cover and begin to feed (Schramm 1999).

Male size and aggression may influence the number of offspring in bass broods (Knotek and Orth 1998). Larger males tend to spawn earlier than smaller males, and mate with similar sized (more fecund) females (Wiegmann et al. 1992; Knotek and Orth 1998). Once male and female adult bass mate, the female abandons the nest, leaving the male to take care of the nest and offspring. Male bass do not feed while spawning or guarding the nest. They fan the eggs until they hatch and guard the fry against predators. This process continues until the fry have grown to independence (swim-up stage) and can last up to 7 weeks (Ridgway 1988; Kieffer et al. 1995). Male bass are extremely aggressive and will attack anything that comes near the nest (Schramm 1999). The male bass's vulnerability to capture is increased by their aggressive nature and ease of visibility while attending the nest.\

Angling Stress

Angling can be a cause of anaerobic exercise in fish and can result in significant physiological disturbance. Stressed fish often require hours to days for complete recovery from angling stress (Gustaveson et al. 1991; Kieffer et al. 1995). The initial impact from the capture of spawning bass results in the male bass being removed from the nest. Once this guardian is removed, the offspring are temporarily unprotected and subjected to an increased risk of predation. As the male's absence from the nest increases, so to does the risk of predation (Neves 1975; Kieffer et al. 1995; Knotek and Orth 1998). The greatest impact on the offspring occurs when the parental male is removed and, subsequently, harvested by the angler. The nest is then susceptible to predation, fungal infection, siltation, and various other environmental impacts. Studies have also shown that catch-and-release angling can have detrimental affects on the parents and offspring.

In a study conducted on the effects of catch-and-release angling on nesting male smallmouth bass, Kieffer et al. (1995) found that bass played to exhaustion took four times longer to return to their nests after release than did briefly played fish. Exhaustively played males experienced a 50% nest predation rate during their absence, while briefly played males experienced a 35% nest predation rate. Physiological stress associated with catch-and-release angling can result in poor parental care once the male bass returns to the nest. During the playing period, a fish's energy reserves become depleted and upon return to the nest, the male may inadequately defend the nest against predators, or worse yet, abandon the nest. Studies by Gutreuter and Anderson (1985) and Lukas and Orth (1995) found that a small number of large male bass tend to produce a large number of free-swimming larvae and may significantly contribute to the recruitment process. Anglers may target larger fish due to their ease of visibility and capture during the spawning period. Therefore, angling of spawning bass may strongly impact year-class strength.

Current Regulations

Current regulations concerning the management of spawning bass are varied across the United States. To ensure reproductive success in bass, fishing regulations in jurisdictions not only limit angling harvest of bass during a portion of the spawning season, but ban the capture and release of nesting males (Kieffer et al. 1995).

The Northeast, from Maine to Maryland, encompasses a myriad of regulations concerning spawning bass. Maine's regulations include reduced harvest during the spring and artificial lure restrictions from April 1 – June 20. Connecticut, Rhode Island and Massachusetts have year-round bass fishing seasons. Vermont, New Hampshire and Maryland implement catch-and-release only restrictions during the spring spawning season. New York, New Jersey and Pennsylvania have statewide closed seasons for spawning bass. Lake Erie is the exception, where a creel of one fish over 15 inches per day is allowed. Pennsylvania's regulations are currently under review and new regulations may allow catch-and-release fishing during the spring season. Delaware is the only northeastern state with a year-round bass season.

The southeast region, from West Virginia to Texas, is characterized by a year-round bass fishing season, which does not implement any special regulations during the spring. Bass fishing is a tradition in the southeast and provides enjoyment for many anglers (both local and out-of-state), especially during the spring months. Many states in the southeast employ strict harvest regulations, through length and creel limits, that protect larger males. Missouri, the only state in the region to implement special regulations during the spring, has a closed season from May 1- May 29 on 8 stream stretches.

Minnesota, Michigan and Wisconsin are the only states in the Midwest to implement a closed season for bass. In Wisconsin the bass season opens the first Saturday in May. However, northern Wisconsin has installed catch-and-release regulations for bass, while southern Wisconsin allows harvest of bass. Although Montana and Idaho have a year-round bass season, they are the only states in the West that also have special seasonal regulations for black bass. Montana has implemented strict harvest regulations (1 fish over 22 inches per day) and Idaho has utilized closed harvest seasons (harvest prohibited until July 1) to maintain 'quality' population structures. Collectively, these diversified regulations are designed to protect spawning bass and the fishery resources on which they depend.

Management Options and Implications

As bass angling increases in popularity, fishing pressure and angler catch efficiency will increase. "Overharvest is possible because many bass anglers now use expensive, sophisticated equipment, including electric trolling motors, depth sounders, and fish finders. Increased angling effort on black bass requires more efficient and effective management to maintain the quality of the resource" (Weiss-Glanz and Stanley 1984).

Regulations provide an indispensable and relatively inexpensive management tool to sportfish management. Unrestricted harvest, especially during the spawning season, can have dramatic impacts on a species. Northern states have implemented seasonal regulations to protect bass from exploitation and overharvest. Bass in northern waters have a shorter growing season and therefore, are more susceptible to population impacts due to angling pressure. However, closed season regulations, while prohibiting the harvest of spawning bass, are often difficult to enforce. Many states have coupled year-round open seasons with harvest regulations (creel and length limits) to protect bass populations. These regulations are easy to enforce, allow for increased fishing opportunities for local and out-of-state anglers, and maximize economic benefits to waterside communities (Schramm 1999). Open seasons may also reduce a fish's vulnerability to angling pressure that is associated with 'opening day' phenomenon.

Angler education may also provide a useful management tool to avoid negative impacts on spawning bass. In regions with open seasons, catch-and-release, or special regulations (i.e. artificial lure only), anglers should be encouraged to utilize minimum playing time and quick release techniques. These techniques do not exhaust the fish and will increase the chance of bass returning to the nest.

When implementing regulations, one must consider the unique nature of the habitat, community, and environment of the individual fishery resource. Regulations must be changed in response to changes within the fish community. If a fishery experiences overharvesting, poor recruitment, or a lack of quality-size fish, then regulations should be directed toward the management of spawning adults. "Fisheries are dynamic, so the regulation selection process must be dynamic and adaptive" (Johnson and Martinez 1995).

Does Virginia Need to Implement Seasonal Regulations on Spawning Bass?

Currently, Virginia regulations on black bass include a year-round season that is restricted to a 5 fish per day creel limit. Several waterways and VDGIF (Virginia Department of Game and Inland Fisheries) controlled lakes have length restrictions which insure the productivity and quality of the bass populations therein. The warmer climate of the southeast results in a longer growing season for black bass and an abundance of individuals that does not necessitate closed season or special season regulations in this region.

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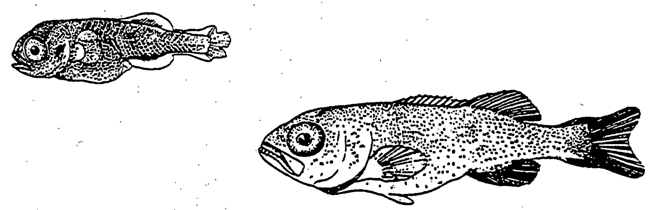

New River Channel Catfish Management To Stock or Not to Stock?

Clifford P. Hutt

Channel catfish *Ictalurus punctatus* have been called the second most important sportfish in North America only surpassed by the largemouth bass *Micropterus salmoides* (Siegwarth and Johnson 1998). In the early 1960s, creel surveys conducted on the New River revealed that channel catfish were the most caught fish in terms of pounds and fourth most caught in terms of numbers (Wollitz 1968). However, creel surveys conducted in the early 1980s revealed disturbing information that channel catfish catches had falling dramatically to the point of being only the fifth most caught fish in the Virginia stretch of the New (Austen 1984). Catch rates had dropped by as much as 96% from 1963 to 1983 (Austen 1984). Anglers still complain about poor catch rates fifteen years later (P. Bielema, Virginia Tech, personal communications).

The causes for this dramatic decline are only speculative, and have not been widely examined. One is the theory that smallmouth bass and channel catfish are competitors for the same food resources, and that increases in the smallmouth bass population since the early 1960s have depressed the channel catfish population. This possibility was suggested by Wollitz in a report he wrote after conducting an extensive creel survey on the New River (Wollitz 1968). Another possibility is that smallmouth bass are feeding on juvenile channel catfish causing poor recruitment. Other potential causes could exist, but there is little scientific evidence to back up any of these theories.

Some have suggested stocking catchable-size channel catfish as a possible means of improving the fishery. Catchable-size channel catfish are generally considered to be greater than 254 mm in length (Broach 1968, Siegwarth and Johnson 1998). They are genrally preferred to stocking fingerlings because of the immediate contribution to the angler's catch (Broach 1968), higher survival rates, and cost-efficient angler returns gained by using larger fish (Spinelli et al. 1985, Storck and Newman 1988, Santucci et al. 1994). The purpose of this paper is to examine the channel catfish decline in the New River, and whether or not stocking is a viable solution to the problem.

The Stocking Option

Channel catfish are generally stocked in water bodies where recruitment is poor or nonexistent in order to sustain a sport fishery (Marzolf 1957, Davis 1959, Storck and Newman 1988). This stocking takes place mostly in small impoundments because they almost always lack the overhead cover that channel catfish require as spawning habitat (Clemens and Sneed 1957, Jenkins and Burkhead 1993). Channel catfish are usually stocked at catchable sizes or greater than 254 mm because of their higher survival rates compared to smaller fingerlings (Broach 1968, Siegwarth and Johnson 1998). Studies have found that fish greater than 200 mm are just as good in terms of survival and cost effectiveness (Storck and Newman 1988, Santucci et al. 1994). The reason for stocking the larger fish is that they exhibit higher survival rates by being to big for most predators to consume which leads to higher cost efficiency (Storck and Newman 1988, Santucci et al. 1994).

The Buffalo River, Arkansas, is one of the few cases were catfish stocking has been implemented due to poor recruitment and been successful (Siegwarth and Johnson 1998). A study assessing the stocking effort on the Buffalo River estimated that as much as 93% of the river's channel catfish population was generated by the stocking efforts (Siegwarth and Johnson 1998). The river is located in the Ozarks, and has a cold tailwater dam on it which inhibits prespawn migration of mature catfish making it the prime explaination for recruitment failure (Siegwarth and Johnson 1994). Attempts to stock catchable channel catfish in the Ohio River only found a 6% return of fish in angler creels (Seaman 1948), and a study conducted on the New River in the early 1970s found a return rate of less than 2% for catchable channel catfish stocked after a fish kill (Bryson et al. 1975).

Channel Catfish in Decline

Channel catfish were once one of the largest portions of angler creels in the New River, but have declined drastically since the 1960s. Creel surveys conducted in 1962 and 1963 found that channel catfish made up 11% of the number of fish caught by anglers in the lower section of the New River which is the stretch of river below Claytor Dam (Wollitz 1968). They were accompanied in the top four by smallmouth bass 32%, rock bass 20%, and white bass 19% (Wollitz 1968). These percentages changed drastically over the next two decades when creel surveys conducted in 1982 and 1983 found that channel catfish only made up 2.2% of fish harvested from the Virginia section of the New River and 0% of those released (Austen 1984). The same study also showed that smallmouth bass made up 28.3% and 60.3%, rock bass 49.5% and 36.1%, and white bass were relegated to an "other" category along with six other species that made up only 1.0% and 0.5%.

The question this data begs one to ask is why the dramatic shift in the river's fish assemblage that left channel catfish on the losing end? Wollitz (1968) observed in his report that the river's smallmouth bass fishery was poor with fish averaging only 9 in. and only 0.5% of fish being greater than 12 in. in length. In the lower section of the New, he concluded that this was because of competition for forage with other predators with the primary one being channel catfish (Wollitz 1968). He was lead to this conclusion by the inverse relationship he found between channel catfish and smallmouth bass numbers as he sampled different sections of the river (Wollitz 1968). Wollitz (1968) advised that any improvements in the smallmouth bass fishery would jeopardize the river's excellent channel catfish fishery because of the competition that existed between them.

In the mid-1960s a 12 in. minimum length limit was placed on smallmouth bass in the New River along with an 8 fish per day creel limit (John Copeland, Virginia Department of Game and Inland Fisheries, personal communication). The purpose of this regulation was to increase the size of harvested bass by protecting fish of sublegal length from harvest. In 1982 and 1983, Douglas Austen, a graduate student at Virginia Tech, conducted another creel survey on the New River to examine the effects of this length limit. He found the smallmouth bass to be stunted and overpopulated (Austen 1984). He also found that channel catfish had declined in the river, and what once made up 11% of angler creels now made up only 2.2% of angler harvests and 0% of angler releases (Wollitz 1968, Austen 1984). This is about a 80% decrease in channel catfish catches by anglers from 1963 to 1983. Kauffman (1983) found similar results on the Shenandoah River following the implementation of the same 12 in. length limit. He observed a 91% decrease in angler harvest of channel catfish (Kauffman 1983).

Shortly after Austen had finished his work, the 12 in. minimum length limit on smallmouth bass in the New River was replaced by an 11-14 in. slot limit (John Copeland, Virginia Department of Game and Inland Fisheries, personal communication). The idea was that it would allow anglers to harvest the smaller fish, reducing the stunted population, and improving the growth rate of those that reach the protected slot range (Noble and Jones 1993). The result has been the transformation of a stunted population into one of the best smallmouth bass fisheries in the state of Virginia. No studies have been conducted to see how the channel catfish fishery has changed since the slot limit was placed on smallmouth bass.

Is Stocking a Solution?

Stocking is generally used when there is poor recruitment due to a lack of spawning habitat (Marzolf 1957, Davis 1959, Storck and Newman 1988, Siegwarth and Johnson 1998). This may or may not be why channel catfish numbers have declined in the New River. Channel catfish may have declined in the New River because of increased competition with smallmouth bass for forage. If so, I doubt stocking catchable size channel catfish would help very much to improve the fishery. Stocking would simply increase the number of fish competing for the same forage which could lead to a multitude of environmental responses. First, it could result in high, density dependent mortality of stocked catfish since they would be less likely to succeed at competing with wild fish (Siegwarth and Johnson 1998). Siegwarth and Johnson (1998) found that stocked catchable-size channel catfish took up to a month and a half to start feeding in the wild. This is probably due to the fact that they were accustomed to artificial feed in the hatchery. Second, it could result in a decline in the smallmouth bass fishery by swinging the competition equation back into the favor of the channel catfish. Either way, we would not like the results.

Another poosible explanation for the decline in channel catfish could be predation on juvenile catfish by the increased numbers of smallmouth bass is reducing recruitment of channel catfish. Kauffman (1983) had observed that young channel catfish were a common occurrence in smallmouth bass stomaches during a diet analysis study. This was following the implementation of a 12 in. minimum size limit. Austen (1984) did conduct a diet analysis associated with his creel survey, but he only reported the percentage of stomach contents that were fish and did not bother to break his data up any farther than that. He did find that fish were not a large part of smallmouth bass stomach contents during the summer months when feeding would be at its peak due to higher metabolisms (Austen 1984).

Since I know of no studies conducted on the diets of smallmouth bass in the New River that are species specific when describing stomach contents, I cannot make any inferences as to how viable this theory is. VDGIF biologists do hope to conduct diet analysis in the near future, and hopefully they will be able to shed some light on this subject. However, if this is the reason for declines in channel catfish then stocking catchables could be a reasonable means of improving the fishery for channel catfish.

It is my conclusion that the decision to stock catchable-size channel catfish in the New River should be postponed until a detailed study can be conducted on the diets of smallmouth bass in the river. If these studies suggest that predation by smallmouth bass on juvenile catfish is a plausible cause for the decline in channel catfish, then stocking should be considered. Any stockings should be conducted in an adaptive management approach. This would work by stocking catchable-sized channel catfish at different densities every year, or every other year, and monitoring angler catches of the stocked catfish. Stocked catfish would be given some kind of mark or tag, possibly a removed pelvic or adipose fin, to distinguish them from naturally produced channel catfish. This adaptive management approach would help to determine if stocking actually helped to improve the fishery.

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Accidents Will Happen

Swimming in Circles
Danny Laffoon

Whirling disease, which infects many trout species, is caused by a parasite that infects fish known as *Myxobolus cerebralis*. The protozoan parasite disrupts the fish's central nervous system by damaging the cartilage surrounding the brain. This causes skull or skeletal deformations, which will cause the fish to swim in circles, hence the name whirling disease. The disease can infect adult trout, but by the time the fish reaches maturity the disease is not harmful to the fish (Burke 1995). The parasite harms the fish the most if it comes into contact with the fish at the fry stage. It is thought that the disease entered the country by a couple different ways. It was first thought that the disease may have entered the United States by ballest water carried by ships from Europe in the 1950's (Hubert 1999). This would explain why it was discovered in New York. Now it is believed that it might have also gotten here by shipping in hatchery bread fish (Brano 1991), and that is the reason why it has run rampant in many of the weastern U.S. states.

Life history

The protozoan parasite requires two hosts in order to carry out its life cycle. The first host is a Tubifex worm (or sledge worm) which is infected by eating a decaying fish, that previously had the disease. It then takes the protozoa about three months, after being ingested by the worm, to produce triactinomyxon spores (TAM), which are what will infect the trout (Hubert 1999). The trout obtains the disease by either eating the worm, or the spores can be released into the water, and the fish can get the disease by just swimming through the spore riddled water. The parasite can either infect its host by epithelial contact, through the gills, fins, or entering through the mouth. The disease has been spotted at many major hatcheries in New York, which has since caused a major concern among many trout fishermen. All of the fish in the hatchery were destroyed and burned to prevent any further contamination of fish stocks (Wildlife Report 1997). A very important fact is that the strain of protozoa does not affect fish, other than salmonids, and is of no threat to humans or other vertebrate species (Burke 1995).

The Wildlife Commission, as well as Trout Unlimited are very concerned with this disease, and are the major contributors to find ways to combat the protozoa. They are steadily researching to find ways to prevent the spread of the disease, as well as if there is a treatment for infected fish. They are also looking for ways to prevent the trout from getting the disease in the first place. Trout Unlimited and the Commission first had to find where the disease is a problem, and doing this can be a time consuming process. The salmonid's head must first be cut along the dorsal midline, then the craneal bones and gill arches are removed. The bones are then centrifuged in a pepsin/tripsin solution to help concentrate the *Myxobolus* spores (Hubert 1999). After this is done it is looked at under a microscope to find the spores, and decide if the fish in that particular region of the lake or stream is infected. Another common practice is to look at the substrate to see if it is suitable habitat for the parasite to live. At this point in the research it is believed that the number of spores released into the water is in direct proportion with the water temperature, riparian characteristics, or land use.

Signs that a fish may have the disease, other than whirling behavior, are black tails, spinal deformations, shortened opercula, shorter lower jaws, opercular cysts, and degenerated fins (Barney 1999). Some of the same signs are associated with other pathogens or protozoa problems in fish, so if there are one or two of the clinical signs in a fish it does not necessarily mean that it has the disease. Either craneal deformations or spinal pressure can cause whirling behavior, not associated with the disease.

Whirling disease has been a management nightmare. The disease will infect specific strains of trout species more abundantly than others, but it will infect all strains of trout. The rainbow trout and brook trout apparently are more susceptible to the protozoa than brown trout appear to be (Vincent 1996). It is thought that the Brown trout evolved with the disease, to make it more resistant to death from the parasite (Vincent 1996). The Rainbow trout in the Madison River in Montana was nearly wiped out by this disease. It was found in nearly 90 percent of the fish in the river, all of which died from the disease (Brandt 1998). Whirling disease did not do nearly this amount of damage to the brown trout population, claiming less than ten percent of the population. It was brought to national attention through money from the 1993 movie *A River Runs Through It*. After the movie millions of people went to the Madison River to go fishing for trout, and they discovered that the fish were infected with whirling disease. The publics cry for help for the fish brought even more money from the nation's government. It was obvious that whirling disease was no longer just a hatchery problem.

It is documented that Brook trout are extremely susceptible to the disease, but it has not yet become a problem in the East where brookies are common. At a conference in 1997 researchers from Montana, Colorado, Idaho, and Wyoming conducted field studies and controlled experiments, and found that brook trout appear to be as vulnerable to the disease as rainbows (Brandt 1998). There are several different theories on why it has not yet become a problem in the east, but they are more physical and environmental than a resistance to the deadly virus. The first is the Tubifex worm itself cannot survive the stream gradients, water conditions including pollution levels and temperature cycles, other stream life that feed on the worm, and bottom sedimentation(Brandt 1998). Without the worm there is no vector for the disease. There is a worm on the East coast that does carry a pathogen that does infect the trout. This parasite must be genetically different from the whiling disease parasite, because it is not nearly as deadly (Margolis 1996). The fish also do not have sever mutations of the head and spinal regions of the body (Brandt 1998). Another reason that the trout on the East Coast may not show signs of whirling disease is brook trout hatch earlier in the year when the water is still very cold, and the spore load (TAM) would be very low at this time. This would increase their average size when the parasite is abundant in the water, hence increasing their chance of survival. George Duckwell, the supervisor of Coldwater Hatcheries in Virginia, states that the overall average temperature of the water is much higher in the East due to the lower average elevation, which can reach as high as 60 or 70 degrees Fahrenheit, and the increased temperature could inhibit, or kill the worm. There is also the theory that whirling disease may have already claimed several victims in the East in remote smaller streams, and nobody knew about it, because most of the management practices concern only stocked trout streams.

Solutions

There are a few things that fishermen can do to help prevent the spread of the disease into other streams. The first is to wash mud off of vehicles, boats, trailers, fishing gear, and anything else that may have come into contact with the water. All of the water from the boat, live tanks, coolers, and equipment should be drained. Fishermen should never transport fish from one body of water to another. They also shouldn't dispose of fish carcasses in any body of water, or through garbage disposals. If an infected fish is caught, do not place it back into the stream, and contact a local official to make sure that they know they have a whirling disease problem. Lastly, never transport aquatic vegetation to another body of water (Brandt 1998).

In the early 90's the disease ran rampant all across the West coast, and the managers did not know what to do, so they held many different meetings, and are now beginning to understand what they believe will help to eliminate the problem. In order to combat the disease in trout, first samples must be taken to figure out why the disease only infects certain trout, and is only in certain strains of the worm. Scientists must also find what habitat the infectious worm likes, and try to limit this type of habitat as much as possible. They can also take the trout that are not infected with the disease, in the infected streams, and breed those fish to hopefully have a resistant strain of fish to the parasite. Another way to combat the disease would be to find the gene in the brown trout that makes it more resistant to being infected, and place this gene into the rainbow and brook trout.

Hatchery managers are very careful with their stocks of fish now. Any fish that is thought to have the parasite must be killed and burned to prevent any further contamination. Constant monitoring during the fry stage is done so the managers can find the disease as quickly as possible.. The number of contaminated fish has steadily declined since the early nineties then due to close inspection of water conditions during all stages of the fishes life.

While whirling disease is a major problem in many trout streams, it does not have to be. There are many different solutions that can be done to help prevent any further contamination of trout streams. There are also different solutions to help prevent the fish from getting the disease in the first place. With the added income that Trout Unlimited is getting from the Federal Government, as well as individual supporters that want trout to be around for their children to have a chance to fish, there is no reason that this disease cannot be taken care of in natural trout streams. With careful management the disease worm will either be removed, or the worm and fish will be able to live together (Hulbert 1996). There is also no reason for the disease to be in hatchery bread fish either. If the water is contaminated, either move to a headwater area, where it is not infected, or breed a strain of fish that is more resistant to the disease. More research does need to be done, but I believe that the answers to solving how to get rid of whirling disease may be simpler than everyone is trying to make it. Hatchery managers interbreed fish all of the time, I don't see the difficulty in breeding two fish that seem to be somehow immune to the disease. With proper management of infected trout streams, and making sure that the worm does not spread to other streams, this disease can be one that eventually will have very little effect on the trout population. Hatchery managers are starting to win the war against the disease, by careful management practices, and constant monitoring of water quality. In just another ten years I look for this disease to no longer be a problem in most of the best trout streams in the West. Trout populations should be back on the incline, and healthy, and fishing should be good once again.

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Zebra Mussels and A Continent Under Siege

Matt Stengel

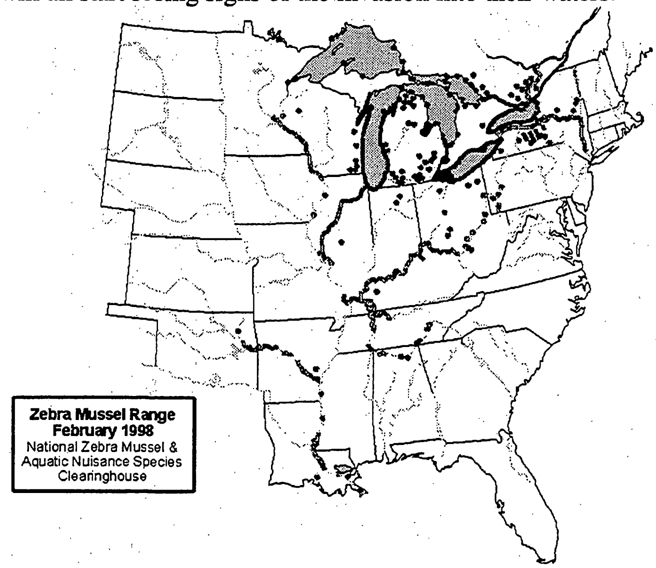
When new species arrive and spread, even if they do not have the appearance of an explosive invader, they may herald the onset of future changes in the balance of population.

-Charles Elton 1958

"Colonization of substrates, water withdrawal facilities and hard bodied invertebrates is a distinctive characteristic of the zebra mussel (*Dreissena polymorpha*) in Europe and now in North America" (Schloesser et al. 1996). The zebra mussel is a freshwater bivalve mollusk introduced to North America from Europe. The zebra mussel ranges from one half inch in length to one and one half inches It is thought to be endemic from the Dnieper or Bug River, both of which open up to the Black Sea. The zebra mussel was brought over by boat and released into North American water from a ship's ballast. It was first sighted in Lake St. Clair near Detroit, Michigan in 1986, and has since spread through the Great Lakes and most of the eastern tributaries. The zebra mussel is causing ecological as well as economical concern. Many studies have been conducted and show the zebra mussel is slowly killing our native mussels in North America, as well as changing the food web in many lakes and rivers. Probably of even greater concern to the people of the United States and Canada is the billions of dollars the industry spend annually trying to rid their intake pipes of this pest. Since this mussel is an introduced species, there are no known natural predators in North America and therefore nothing to keep it in check.

The zebra mussels' success derives from its high fecundity of 30,000 to 1,610,000 eggs/ female, planktonic larvae, and its ability to attach to most hard substrates. Populations can quickly achieve densities of greater than 50,000/m^2 in 2 years. (Neves et al. 1996). Because of their high fecundity and ability to spread quickly, congress has directed several federal agencies to work together to control and manage the zebra mussel. These organizations include the State Department, the Army Corps of engineers, the National Sea Grant Program under the National Oceanic and Atmospheric Administration, The U.S. fish and Wildlife Service, the National Academy of Science, the Tennessee Valley Authority, and Environmental Protection Agency. They are all working for ways of controlling and managing the zebra mussel.

The range of the zebra mussel has grown very quickly over the past decade. It has spread rapidly over a large amount of land and water in many different ways. "It subsequently dispersed east through Lake Erie Canal, into the Hudson River, overland (by unintentional human mediated vectors) into the upper Susquehanna River in New York, and south and west through the Illinois River into the Mississippi River near St. Louis. After entering the Mississippi River, the zebra mussel rapidly spread downstream to New Orleans, LA, and upstream to La Crosse, WI. It is now found in the lower portions of most major Mississippi River tributaries, including the Ohio, Tennessee, Cumberland and Arkansas Rivers, but not the Missouri" (Ram and McMahon 1996). Researchers say that the Mid Atlantic Waters are most at risk. With the zebra mussel range all around the area, the spread of the zebra mussel will most likely occur here. States such as New Jersey, Delaware, Maryland, Virginia and North Carolina will all start seeing signs of the invasion into their waters.



The reason for their quick dispersal is due to human activity. The zebra mussels' larvae attach themselves to any hard substrate by using a proteinaceaous byssal thread that is secreted during a larvae stage. Waterways such as canals, vessels, fishing boats, buoys, nets and sea planes can all be used as an anchor for the mussel. One of the major sources of introductions is by fishermen. The larvae of the zebra mussel gets transported by bait buckets, motors as well as on the hull of the boat. Consequently, the zebra mussels are now being spotted in many inland lakes, rivers and ponds.

In nature the zebra mussel mainly uses the currents for dispersal. They also use birds, insects, turtles and snails. They will collect on basically anything that they can hold onto and they will use it to colonize. Their ability to have free swimming larvae called veligers, has given the zebra mussel an edge over all other native mussels, which must disperse their young by way of fish. But because of their reproductive abilities, the zebra mussels are more inclined to infest lakes, ponds and reservoirs before rivers and streams because their larvae can't swim up current.

With their many forms of dispersal and high fecundity, they are major concern for many industries. The mussels aggregate in dense colonies on just about anything hard under the water. They have even been recently observed colonizing soft substrates such as sand. They can produce colonies up to 700,000 m^2 that can clog pipes (Ram and McMahon). Industries that use water intake pipes such as power plants, water treatment plants and industrial plants spend large amounts of money, billions of dollars every year to keep this exotic species out (Ram and McMahon 1996). These problems not only affect the industry, but will effect the consumer as well. Higher costs of electricity, water and other commodities from clogged intakes, filters and condensers of power generating plants, drinking water facilities and other industrial water users will most likely be the case.

While that problem has economic implications, ecological concerns are also causing some serious dangers. Infestations of unionids have been documented for 31 species in North America (MacIsaac 1996). The zebra mussel has had a catastrophic effect on our native mussel species. They attach themselves to the native mussel in their larval stage. As they grow, they slowly restrict or even prevent normal valve movement of the mussel. This causes the native mussel problems during feeding. Because of the amount of zebra mussels on the shell, the native mussel can become deformed when growing and even lose their ability to open or close the shell (Schloesser, Nalepa, Mackie 1996). Another reason for mortality is the fecal matter that is produced by the zebra mussel. This accumulates around the native mussel and lowers the water quality causing death. Native mussels can also be dislodged and/or starved by the weight of zebra mussels

Another problem with zebra mussels is that they have the ability to change the entire food web. As more and more mussels are produced and grow, more and more food is needed. Eventually the mussels filter a good deal of the plankton and zooplankon out of the water and in the process filter out all the floating sediment. This leads to better water clarity, which in turn allows sunlight to penetrate causing macrophytes to grow. The macrophytes then begin to attract benthic organisms while pelagic organisms slowly disappear or get pushed back into deeper water. With the pelagic species pushed back to deeper and darker water, colonization continues to take place by new fish. Fish that like to live around macrophytes and eat benthic invertebrates that were also attracted to the new plants. In a study conducted by Ricciardi, Whoriskey and Rasmussen, " almost all taxa increase in abundance on substrate covered with mussels (living or dead), and most achieved higher densities in the presence of living mussels compared with dead shells." The thick mats of zebra mussels provide a greater amount of surface area on the bottom and they also provide many new niches and resources. This area is used not only as protection from predators but also as a source of food. Filtering insects as well as other organisms attach themselves to mussels and use the filtration currents of mussels to collect food. Other organisms also use the sediment and biodeposits that get caught between the shells as food. "Zebra mussel biodeposits are nutrient-rich and easily assimilated food source, and the organic enrichment of substrata by mussel biodeposition can alter the local distribution and abundance of benthic invertebrates" (Ricciardi, Whoriskey and Rasmussen 1996). Many predators are also attracted to these areas because of the abundance of organisms the mussels attract. Some benthic fish have also been found to increase in abundance because of all the food found within the mussel beds. As with anything else, when certain organisms do well in an area and become abundant, other organisms suffer and become less abundant. While benthic organisms are thriving because of the zebra mussel, pelagic organisms are not.

Zebra mussels also have the ability to pull large amounts of copper, nickel, and zinc out of the suspended water column. An experiment by Klerks, Fraleigh and Lawniczak modifying metal cycling in North American waters thereby, show that zebra mussels during their filter feeding take up many metals, these metals were later found within the mussels tissues as well as in their pseudofeces found on the bottom. The zebra mussel also showed to have large amounts of contaminants within its tissue. With large densities of this suspension feeder an entire volume of a lake could pass through the zebra mussel population in a matter of days or weeks (Klerks, Fraleigh, and Lawniczak 1996). What this could mean for other species is that important metals that they need for survival may become a limited resource. This in turn could lead to mortality of other organisms.

With all of the problems we are being faced with an obvious question. What can be done to stop the spread of the zebra mussel? For one, scientists are starting to monitor the few organisms that do prey on the zebra mussel. Fish that have upper and lower pharyngeal teeth or lower pharyngeal teeth and chewing pads find an abundant food source. Some of the fish that have consumed the zebra include: carp, walleye, yellow perch, freshwater drum, white sucker, redear sunfish, pumpkinseed, copper river redhorse, white perch, white bass, lake whitefish, lake sturgeon and round goby. However, only one North American fish, the freshwater drum has shown to be a significant predator on zebra mussel (Tucker, Cronin, Soergel, and Theiling 1996). Some of the organisms that feed on the zebra mussel larvae are crayfish, crustacean zooplankton and larval fish. Several species of diving ducks have also been found to eat the mussels. However, because of high reproductive rates of zebra mussels, none of these species have been found to have any serious effects on the zebra mussel population as a whole.

Scientists are also working with water chemistry to see if it is possible to stop the spread of the zebra mussel. Studies conducted by (Hincks and Mackie) show the effects of pH, calcium, alkalinity, hardness and chlorophyll. These effects test the survival, growth and reproductive success of zebra mussels in Ontario lakes. "There was a significant relationship between calcium and pH and adult zebra mussel mortality" (Hincks and Mackie 1996). What they found was that different levels of each of these substances does have an effect on different stages of the mussels' growth. Other results by (Hinks and Mackie) show that calcium, total hardness, alkalinity and to some extent pH may potentially limit the distribution of the zebra mussels.

What we do know now is that growth is affected by temperature. The lower the temperature the slower the growth. Zebra mussels have a tolerance just above the freezing point. They are also vulnerable to higher temperatures of heat. Temperatures that are found in the southern most regions of the U.S. Unfortunately most of the United States is within its optimal temperature range. Researchers also know that zebra mussels can survive salinity as high as 12,2. There also seems to be a higher tolerance of salinity at lower temperatures. This means that some of our estuaries such as the Chesapeake Bay, might not be exempt. Zebra mussels also need a pH of 7.0 or better and high levels of calcium. This could mean water with a pH of below 7.0 and low calcium levels could be safe. But more research is needed to confirm this standard. Zebra mussels also show poor tolerance to low oxygen levels. This again could be a limiting factor to the spread of the zebra mussel.

So what does the future hold for North America? Over the next few years there is going to be a need for more research to figure out what to do with this growing problem. Monitoring of the predation of zebra mussels needs to be watched as well as the effects it may have on the species itself. As well as monitoring the changes in habitat exerted on it by the mussel. Coming up with deterrents that will keep the mussel out of the industries water pipes and not effect the native mussels will also be very challenging. Some of these controls being tested are: chlorination, heating, electrical shock, sonic vibration and chemical treatments. Organizations are also working on educating industry as well as the people. For now education is going to play a huge part in the transportation of the zebra mussels. The more people know the better we will all be. By knowing the problem the public will be able to take better precautions when transporting themselves from one lake to another. Although this alone won't solve the problem of infestations of existing waters. If something isn't done soon to stop the spread of this exotic species it may be safe to say that it could colonize the entire country in only a few decades.

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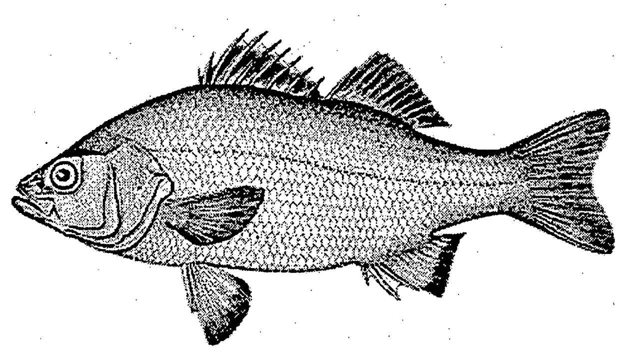

Fisheries Manager's Toolkit

Managing Aquatic Ecosystems With the Use of Grass Carp

Wesley L. Haskins

Grass carp (*Ctenopharyngodon idella*), also called the white amur, are a herbivorous fish exotic to North America. They were first introduced in the United States for the sole purpose of controlling nuisance, problematic aquatic vegetation. Control of aquatic vegetation is needed in cases where fishing, swimming, boating, water quality, and irrigation are negatively impacted by the overabundance of vegetation. Since grass carp have been introduced, many studies have been done on their use and effects on the aquatic ecosystem. The management issue that this report will focus on regards the use of grass carp and their effects on the aquatic ecosystem. First, some background information on grass carp history, biology, and ecology is necessary.

Background Information

Grass carp are native to the rivers of eastern Asia and were imported to the United States in 1963 by Auburn University and the U.S. Fish and Wildlife Service (Sutton and Vandiver 1986). For many years, grass carp were used for experimental purposes and were heavily restricted and regulated. As more and more grass carp began to be used, concern over the possible severe impact to our rivers if reproducing populations developed heightened. As a result, in 1983 a private hatchery in Arkansas developed a process capable of producing sterile grass carp (Bain 1993). By physically shocking grass carp eggs, an extra set of chromosomes is produced in the fertilized egg leading to a triploid, sterile individual (Jenkins and Burkhead 1993). With the advent of this procedure, grass carp use heavily increased and to ensure triploidy, methods of checking grass carp were developed.

The average life span of grass carp is 11 years with their feeding capacity and growth rate slowing as they increase in age. Grass carp are herbivorous grazers on aquatic vegetation usually feeding on submersed plants in shallow water. They can reach lengths as large as 1,100 mm and can weigh up to 59 kg, however, larger individuals have been recorded (Jenkins and Burkhead 1993). In respect to their diet, they have grooved pharyngeal teeth necessary for grinding and shredding vegetation. Reproduction of grass carp is restricted to large river systems. With this basic background information, the uses of grass carp can now be explored.

Uses of Grass Carp

Grass carp are used as a biological method of aquatic vegetation control in ponds, lakes, rivers, and irrigation and drainage canals. Two other methods of vegetation control are mechanical methods and chemical methods. Grass carp are not useful for all aquatic plants because they are selective and have feeding preferences. Some common aquatic weeds which are preferred include hydrilla, coontail, pondweed, watermilfoil, and Brazilian and American elodea (Kay and Rice 1991). Cattails, waterlilies, filamentous algae, and watershield are common aquatic plants that tend to be avoided (Kay and Rice 1991). The effectiveness of grass carp is highly variable and depends on plant species, abundance, and availability along with the density, size, age, and gender of the carp (Sutton and Vandiver 1986).

As of 1994, grass carp were prohibited in twelve states, eight states had no restrictions on use, and the remaining states required an application or permit for triploid grass carp (Cassani 1995). Regulations are different among the states due to differing ideals on the use of grass carp. In Virginia, the Virginia Department of Game and Inland Fisheries requires permits for the purchase of triploid grass carp as does the West Virginia Department of Natural Resources. Maryland has implemented a no risk policy in which triploid grass carp purchase or use at both the state and private level is prohibited due to possible impacts on the Chesapeake Bay (A. Heft, Md. DNR, personal communications). North Carolina requires an application and approval by a district fisheries biologist after an on-site investigation in cases where 150 or more triploid fish are to be used (M. Sharma, N.C. DIF, personal communications). Whether these restrictions are adequate again depends on the ideals which the state agency adopt regarding the use of grass carp in their state. Regulations and requirements in surrounding states are an important concern due to the possibility of grass carp crossing state lines by way of water or individuals. Such unwarranted introductions may have adverse impacts on the water bodies and native plant communities of the nontarget states. As for the stocking rates of grass carp, the feeding rate of the fish and the growth rates of various plants are so variable depending on the environmental conditions present, fixed stocking rates have not been developed. In respect to the uses of grass carp, the advantages and disadvantages should be pointed out.

Advantages and Disadvantages

Advantages of grass carp can best be seen in comparison to chemical means of vegetation control. Herbicides are widely feared and may present risks to animal and human health. Herbicides are expensive and may require drinking, swimming, irrigation, and livestock restrictions (Summerfelt 1993). Herbicides are also usually a short-term means of vegetation control. As a biological control agent, grass carp do not affect waters used for swimming, irrigation, water supply, or livestock (Noble 1989). More importantly, grass carp are inexpensive and feed on plants for a number of years providing a longer control span in comparison to herbicides.

Disadvantages of grass carp are varied. Grass carp are highly migratory and can migrate great distances making them a risk in nontarget areas where they are not wanted. Also, this migratory nature coupled with the fear of reproductive adults produces a concern for our rivers where they could become a problem species. Naturalized grass carp populations are already present in the Mississippi River. Of great importance is the fact that grass carp, as previously noted, will feed on aquatic plants in order of preference. This may result in native, beneficial plants being eaten instead of the plant for which the carp were introduced.

Many have noted that grass carp are an all-or-nothing method of control. It is argued that either grass carp are not effective or they eat all of the aquatic plants in a system producing a "bathtub" effect where the system is void of plants. A final disadvantage is that once grass carp have been introduced, they are hard to remove. Perhaps the area of greatest concern over grass carp once they have been introduced, is their effects on aquatic ecosystems and fisheries.

Effects on the Aquatic Ecosystem

Effects on the aquatic ecosystem resulting from the use of grass carp are for the most part, an indirect result of the loss of vegetation. Grass carp can significantly reduce vegetation and in circumstances where they exceed the carrying capacity of the system, eradicate it completely. In areas where vegetation is the major source of habitat, this can reduce necessary habitat and habitat diversity for both invertebrates and fish (Eades and Steinkoenig 1995). When aquatic vegetation is substantially reduced by grass carp, macroinvertebrate diversity and composition changes. Those species that live within aquatic vegetation are reduced and can be eliminated while benthic species increase (Bain 1993).

Loss of aquatic plants also presents potential problems concerning water quality parameters. Nutrification can result from extensive grass carp feeding because nutrients are liberated from the digestion and excretion of plant material by the carp. Algal blooms are then possible due to the increase in nutrients (Jenkins and Burkhead 1993). Phytoplankton can also increase thereby reducing water clarity (Bain 1993).

Effects on Fisheries

In respect to the loss of vegetation due to grass carp, a positive result in terms of fish feeding involves the increase in plankton from elevated nutrient levels. Such increases may boost fish production, however, this is usually temporary as the plankton levels typically fall to normal levels after a period of time (Noble 1989).

When exotic fish are introduced, diseases and parasites become a concern. Some diseases and parasites carried by grass carp can potentially be transmissible to other fishes (Cassani 1995). However, since triploid grass carp are raised in hatcheries under presumably parasite and disease-free conditions, transmission of diseases is likely to be low, although this hasn't been observed. Also of no major concern, due to the herbivorous nature of grass carp, is whether grass carp compete for food sources with other fishes.

As for fisheries, the most important effect of grass carp surrounds the issue of vegetation removal or eradication. Removal or eradication of aquatic vegetation can alter fish community structure. Those fish that inhabit the littoral zones and use aquatic vegetation as structure decline and those who inhabit the limnetic zones increase (Bain 1993). Also, fish species which spawn in aquatic vegetation and/or use it as feeding grounds are impacted and these activities are altered when vegetation is removed (Bain 1993). In terms of sport fish, the indirect effects of grass carp, in respect to plant removal, are uncertain and likely variable (Bain 1993). Complicating the issue is the fact that eradication of aquatic vegetation and too much aquatic vegetation both impact fish community structure. Intermediate levels of vegetation are desired, which is difficult to attain considering the all-or-nothing scenario that usually arises with the use of grass carp.

Conclusion

Grass carp have advantages and disadvantages and affect aquatic ecosystems and fisheries in different ways. When chosen as a method of aquatic vegetation control, triploid fish should always be used and checked to ensure triploidy. This is an area where biologists need to be more concerned and stringent on regulations. For example, methods of checking for triploidy a second time after the fish leave the hatchery should be explored. When capable, stocking should be done in closed systems where the escape or migration of grass carp into other systems is not possible. This is due to the risk of grass carp entering nontarget systems and reproducing. Also, before stocking grass carp, make sure the target plant species is one which grass carp select to feed on.

One way to improve efficiency of grass carp and to allow for fewer numbers to be stocked is to integrate grass carp practices after a chemical control method has taken place. Additionally, grass carp use will be improved and made environmentally safer as stocking rate models are better defined and successful removal practices are developed. Grass carp do have a place in aquatic vegetation control and education on their use has come a long way, but further research and information is needed as we must be cautious of exotic introductions into our North American waters.

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Passage to the Promised Land? Do Fishways Really Help Migratory Species?

Mary Rummel

In most instances of human/nature interactions, humans have tried to control natural forces. This is true of most rivers in the United States, but does not go on without cause. Most North American rivers are dammed for hydroelectric power, flood control, and water supply. In terms of this paper, a focus is placed on hydropower dams. During the early 1900s, hydroelectric power was on the cutting edge of technology. Water facilitates hydroelectric power, which is in turn used for electric power, irrigation, navigation, and flood control (Collins 1976). These dams block portions of rivers and regulate the amount of water that flows past. Damming a river can create dramatic effects. According to Collins (1976), these effects include hindering passage of migratory fish, changing water temperature and flow, altering food supply, and disturbing the balance of predator/prey relations as well as disease susceptibility. Several of these effects are manageable.

I will focus on the problem of migratory fish passage due to the presence of dams. This is my focus because I think that it is manageable, but I question the use of fishways as the most effective way to deal with the problem. Logically, when looking at migratory species, we must consider that dams are affecting both upstream and downstream migrations. I will narrow my focus to incorporate upstream migrations since fishways benefit these migrations directly. Migratory fish are categorized as either anadromous or catadromous. Anadromous species live in saltwater and spawn in freshwater, whereas catadromous species are just the opposite. However, for both anadromous and catadromous species, movement through rivers, and often past hydropower dams, is necessary for the continuance of the species. Striped bass *(Morone saxatilis)*, Atlantic salmon *(Salmo salar)*, shad *(Alosa* species), and American eels *(Anguilla rostrata)* are all migratory species affected by hydropower dams.

Certain management issues must be included when discussing hydropower dams and fishways. Water drainages tie many states together. Thus, interstate cooperation is very important when determining management actions for dams and fishways. The Federal Energy Regulation Commission (FERC) is in charge of relicensing hydropower dams. When a dam is relicensed, it is a long and involved process and the license lasts for 30 years. Essentially, it is a one-time chance for most managers to make changes towards the enhancement of migratory fish. With many dams coming up for relicensing, this issue is very much in the forefront of the fisheries management field.

Issue Definition

Passage of migratory fish is an issue that is constantly in question. I am curious as to whether fishways have helped stocks of the fish mentioned above. American eels are a species of concern mainly because their numbers are down. They have been completely extirpated from the Roanoke River drainage in Virginia (Jenkins and Burkhead 1994). Atlantic salmon stocks are in serious trouble. Harvest contributes to this, but another concern is their migrations being inhibited by dams. Striped bass populations have fluctuated over the past 150 years (Jenkins and Burkhead 1994). Dam blockage may have contributed to these fluctuations.

Logically, those who say that the above declines are a function of overharvest may oppose this issue. However, in areas like Embry Dam on the Rappahannock River, creel limits of zero are placed below the dam during times of spawning (Montgomery 1999). This suggests that harvest is not an issue year round. Furthermore, dams are more likely to inhibit migrations, thus contributing to the declines. It is the responsibility of state and federal agencies to manage to increase these stocks. Through enacting creel limits, the problem of dam blockage of migrations is isolated. Thus, fish passage is a major issue.

According to Rajaratnam et al. (1991), fishways are hydraulic structures that allow fish to proceed past barriers in order to pursue biological functions such as feeding and spawning. Bender et al (1991) suggests knowledge of hydrology, hydraulics, and fish biology as criteria for construction of fishways. There are basic types of fishways as well as many variations of these types. However, overall efficiency criteria can be quantified for all types of fishways. Efficiency is based on the following: (1) the attraction of fish to the entrance, (2) low height differences of the water between fishway pools that are next to each other, (3) appropriate size of resting pools, (4) presence of descending weir pools, and (5) highest water velocity within the fishway (Bates 1991). According to Bender et al (1991), there are four common types of fishways including culvert, Denil, vertical slot, and pool and weir. All others are modifications of these designs. In another article by Bates (1991), he describes a roughened-chute fishway in addition to the pool and weir fishway. Bates also mentions lifts as types of fishways, but does not go into any great detail based on the fact that they are rare aside from use in fish collection.

Brief descriptions of the different types of fishways listed above illustrate the general differences. Culvert fishways consist of different shaped culverts that have baffles (devices that check or regulate flow) draped across the bottom. Denil fishways consist of baffles that are arranged along the edges of a rectangular chute. Vertical slot fishways have a series of resting pools in rectangular chutes. Baffles are used to separate the chutes into resting pools and have slots, which permit the fish to pass through. Pool and weir fishways are exactly what the name suggests. Weirs separate rectangular chutes into resting pools. Fish overcome the weirs via jumping over or passing through an orifice located at the bottom of the pool (Bender 1992). Roughened chutes are similar to natural streams in that they regulate average velocity by having no obvious steps and adequate roughness (Bates 1991).

Several benefits and drawbacks exist with fishways. Benefits that result from construction of fishways can be categorized as economical, sociological, and biological. More specifically, some less obvious benefits are more nursery and spawning areas, greater numbers of forage fish, better sport fishing and in turn, economic boosts for local businesses, and in some cases, more commercial fishing (unknown 1983). Disadvantages to fishways are that they can be selective for species that are of a certain size and relative weight to the point that they are more fit to be able to utilize fishways. Another disadvantage is that they require periodic monitoring and re-evaluation of their effectiveness (Blackett 1987). Different designs benefit different species of fish and in that sense it is difficult to design and choose a "universal" fishway. Also, fluctuating water levels, which are typical around hydropower dams, make it hard to standardize the details of fishway entrances to most designs (Dominy 1973). Difficulty arises when considering the effects on the fish when using the fishways. These issues are extremely hard to assess. If the fishway is long or hard to surpass, however, fish are susceptible to fatigue. Fishways are expensive to design, test, and construct. Another major issue is whether the benefits justify the expense.

By application of the above concepts and analysis of applicable research, the effectiveness of different types of fishways are in question. It is conceivable that fishways are constructed without careful consideration of certain relevant details. These details somewhat parallel the efficiency criteria above, but are more specific. Proper consideration must be taken for the species that use the fishways and the physical effects on individuals. The main controversy comes from deciding which type of fishway to build.

Background Information

Several publications exist on different types of fishways, their efficiency, and improvements. It is important to realize that designs are constantly being modified. Re-evaluation is needed periodically. Certain goals may be incorporated when considering the design of a fishway. Ideally, a fishway is efficient in terms of passage (i.e. allows for fast passage with minimal energetic loss to the fish), relatively inexpensive, attractive to fish to entice them to enter, and adaptable for use by different desirable species. I have outlined a few studies in relation to the goals just mentioned. They illustrate design considerations for fishways.

A study was conducted on alewives and how two different levels of entrance pool weirs in a pool and weir fishway effect alewife migrations (Dominy 1973). In further research, it was found that a denil fishway with a submerged entrance is the best at attracting fish (Dominy 1973). Based on this, entrance weir height was investigated and showed that lower weir heights allowed alewives to pass at greater rates. Another study showed that American shad and salmonids were not using the pool and weir fishways (Monk et al. 1989). Their study illustrates the different preferences of these two species of fish and proposes changes to the weir design. Length of Denil fishways can also have an effect on passage of fish. The effects of different lengths were studied in regards to nonsalmonid fish (Slatick and Basham 1985). Some species will not attempt to use fishways with lengths of up to 27m. The minimum length, however, was greater than or equal to 15m long (Slatick and Basham 1985). This information can be used to construct a fishway that selects against undesired nonsalmonid species.

I found a few studies that dealt with improvements on vertical slot fishways. One study found that the current standards of fishway parameters are acceptable and minor adjustments would not dramatically change the efficiency of the fishway (Rajaratnam et al. 1991). Bates (1991) modified a pool and weir fishway into a pool and chute fishway. It is designed to work like a pool and weir fishway at low flows, but operates differently at high flows. This design is extremely site specific and requires follow-up studies (Bates 1991).

Certain information is lacking on this topic. More specifically, information is lacking in regulations of fishways. Explicit regulations may not exist for most states and therefore, are unavailable. Alternatives to fishways are complete dam removals. However, I did not pursue the deconstruction of hydropower dams.

Conclusions

I do not think that the question is whether or not we "need" fishways. If dams exist, it is known that they block fish passage and the presence of fishways can only help the situation. I question whether or not they really are the "passage to the promised land" for migratory fish. The answer to this question is yes, they can be the passage to the promised land for some fish. Whether or not they are the passageway for *most* fish and/or can be improved is my spin-off of this question. Only further examination and experimentation can begin to answer these questions. Detailed assessments of fishways can lead to improvements and new designs that can improve efficiency. Further investigations may be accomplished through modeling. Karisch and Power (1994) have developed a way to simulate the effects of different fishway designs. Bender et al (1992) has designed a system to make recommendations on the best type of fishway to construct at a given site. Both will be useful in fishway improvement as well as for educational purposes.

Some management implications are directly related to this inquiry. The future of fishways is in question as a direct result of the uncertainty of the future of hydropower dams. Currently, many hydropower dams are coming up for relicensing. I think that fish passage should be considered in this process. Collaboration between state and federal agencies is essential. Fishways may be more effective when coupled with limits placed on harvesting around dams. Goals and objectives relating to increasing stocks of shad, Atlantic salmon, American eels, and striped bass need to be enacted in relation to their migrations. Fish passage around hydropower dams is a major issue in fisheries management.

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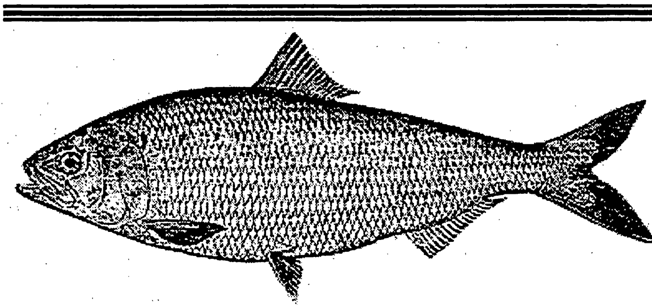

Dam Removal: Fisheries Manager's Dream and a Dam Owner's Nightmare?

Michael Joyce

Currently, there are more then 75,000 dams in the United States, these dams were built for many reasons, including irrigation, flood control, and hydroelectric power generation. Approximately 2,500 of the dams are non-federal hydroelectric projects and fall under Federal Energy Regulatory Commission (FERC) jurisdiction. In the next decade 220 of the 2,500 dams will be up for relicensing. These relicensings come at a time of unprecedented change within the electric utility industry, as electric companies search for ways to remain competitive in a deregulated market (Akridge 1999). In 1986 the Federal Power Act required the FERC to give equal consideration to nonpower resources (fishing, recreation, and wildlife) in licensing hydroelectric dams. Many dams up for relicensing are obsolete or unsafe, while others block the migrations of fish. The FERC is not renewing the license for some dams, and these dams will be removed. Many dams that do receive new licenses are required to provide environmental enhancements as part of the licensing agreement. Citizens and dam owners are upset in some cases over dam removals. These dams have been a part of the area for a long period of time and they fear the effect these removals will have on their way of life (Grover 1998).

This paper will discuss the impact dam installations and removals have on aquatic life. It will also discuss relicensing procedures and the role fisheries biologists have in the process. Finally, I will try to characterize situations where removals have occurred or are considered.

Effects of Dams on Aquatic Life

The American Rivers Organization (ARO) reports that dams damage river ecosystems by flooding and silting-in natural stream areas, depleting oxygen from the water, blocking the passage of migratory fish, and killing fish moving downstream (http://www.amrivers.org/damfacts.html). Kanehl et al. (1997) states that dams change a lotic habitat into a lentic habitat, block the movements of fish and this loss of passage can negatively impact all fish, especially migratory ones. Dams also cause silt problems, deplete oxygen, and effect downstream flows. The National Hydropower Association (NHA) counters that dams create wetlands, support healthy fisheries, and create wildlife habitats on surrounding land (http://www.hydro.org/facts/myths.shtml).

Dams affect both water levels and water temperature. The daily fluctuations of water levels in a dam make it difficult for organisms that spawn close to the shoreline to reproduce. Dams also change the temperature of the water and then release it downstream. Water released from the top of a dam tends to be warmer then it was entering the dam. Water released from the bottom of a dam tends to be colder and often allows for a tailwater fishery. In a tailwater fishery, fish that require colder water, such as trout, are stocked to provide a different angling opportunity for people. Usually, the temperature changes are detrimental to native populations of fish.

In the fall of 1984, the construction of the Taylor Draw Dam on the White River of Colorado was completed. Martinez et al. (1994) compared the pre-dam fish population to the post-dam fish population. Prior to the installation, species composition above the dam site was 88% native and 12% non-native. Below the dam site composition was 70% native and 30% non-native. In 1985 the composition above the site had changed only a small amount with 77% native species and 23% non-native. In 1990, a collection was done below the dam and the species composition was now 80% non-native and 20% native. The change is a complete reversal from the pre-dam collection.

In the 1800s, more than 1.5 million adult salmon returned to the Snake River from the ocean to spawn, by 1994 only 1,800 returned. Thousands of sockeye salmon (Oncorhynchus nerka) used to return to lakes in central Idaho to spawn, but in 1994 only one adult returned to Redfish Lake (Williams and Williams 1995). There are two problems that migratory fish have in getting around dams. The first problem occurs when adult fish return to spawn and are unable to, because they can not get around a dam. The Snake River in Idaho has eight hydropower dams along it, so even if an adult salmon is able to find its way around the first dam it still has seven more to navigate around. The second problem occurs when the juvenile fish try to get to the ocean, they often get passed through a power station's turbine system and do not survive. The hydropower industry has taken extensive steps and spent millions of dollars to minimize the problems migratory fish face in getting around dams. They have built fish ladders and are working to improve turbine systems to allow easier fish passage (http://www.hydro.org/facts/myths.shtml), but is it enough?

Dam Removal and Aquatic Life

Only recently have we begun removing dams, because of this there are only a few case studies that document the changes in aquatic life after a dam removal. The Woolen Mills Dam was removed from the Milwaukee River in 1988. Kanehl et al. (1997) found that the river prior to dam removal had a fair habitat quality, few smallmouth bass (Micropterus dolomieui), abundant common carp (Cyprinus carpio), and poor biotic integrity. In most areas anglers prefer smallmouth bass to common carp as a sport fish. Common carp are tolerant of poor water quality. A poor biotic integrity rating means the river is not well suited for aquatic life. Five years after the dam was removed the habitat quality had improved to good, smallmouth bass abundance had increased substantially, common carp abundance declined dramatically, and biotic integrity had improved to good (Kanehl et al. 1997).

The Dead Lake Dam was installed on the Chipola River, Florida in 1960. Sport fishing was excellent immediately following dam construction, but declined steadily through the 1970's (Young and Crew 1982). When an area is flooded the nutrients that had been dormant in the soil leach into the water and provide nutrients for aquatic life causing a fishing boom, but as the nutrients are depleted the boom becomes a bust. The Dead Lake Dam was removed in 1987, because of poor sport fishing. Hill et al. (1994) did a study to evaluate the effects of dam removal on the sportfish community and to determine if migratory-stripped bass (Morone saxatilis) would return to the area above the dam. The study found water quality improved and the total number of fish species observed increased from 34 to 61. The study also found that striped bass had returned to the upper Chipola River in small numbers (Hill et al. 1994).

In the Willow River State Park, Wisconsin two dams have been removed in the 1990's. The two dams had not produced power since 1963, when the Wisconsin Department of Natural Resources (WDNR) purchased them from the Northern States Power Company. The 60 feet high Willow Falls Dam was removed in 1992 and the 58 feet high Mounds Dam was removed in 1998. The WDNR originally had the dams slated for repairs, but the cost of removal was cheaper. The estimates for repairs of the Mounds Dam ranged from 1.5 to 3.5 million dollars and removal only cost 170,000 dollars. Since the removal of the two dams, water quality has improved and 2.25 miles of cold water trout stream have been restored (http://www.wisconsinrivers.org/willow_dams.html).

FERC Relicensing Procedures and Experiences

A hydropower project license contains specific terms and conditions that specify how the project is to be operated and requires that the project be properly maintained and operated safely. The original license is usually issued for 50 years and a new license for 30 - 40 years. Participants in the relicensing process are the owners of the project, FERC, resource agencies, and the public (http://www.hydro.org/nha2.pdf).

There are two procedures for relicensing, one is the traditional method and the other is a non-traditional method also called the Applicant Prepared Environmental Assessment (APEA) process. The steps of the traditional method (http://www.amrivers.org/inforel.html#whatis) are as follows:

1. Five years before their license expires, the dam owner files notice of intent to seek a new license. FERC provides public notice of the intent.
2. The dam owner consults with resource agencies, and conducts the first set of studies for the application.
3. Two years before the expiration date, the dam owner submits an application for a new license.
4. FERC requests additional information from the applicant, based, in part, on recommendations from interested parties and resource agencies.
5. When the requested information has been submitted, FERC publishes notice that the application is complete, available for review, and ready for environmental analysis.
6. FERC prepares a draft Environmental Assessment (EA) or Environmental Impact Statement describing various proposed methods of operation for each area of concern, listing environmental impacts of each alternative operating scenario and identifying a preferred alternative.
7. If FERC intends to disregard any fish and wildlife terms and conditions recommended by resource agencies, FERC will convene a meeting with the agency to discuss disputed conditions.
8. FERC makes a decision whether to hold a hearing on any material issues of fact.
9. FERC staff issues a final EA or EIS.
10. FERC staff issues a decision on whether or not a license is renewed and if it is renewed under what conditions.
11. Intervening parties and/or the dam owner may request a rehearing of the licensing decision.
12. The five FERC Commissioners issue a decision on the rehearing.

In the early 1990's the FERC began reviewing the relicensing applications of 157 projects. It was the first time FERC had that many licenses up for renewal. The 157 projects received over 700 individual study requests from resource agencies and the public. The large number of requests caused confusion, controversy, and delay. The problems prompted the development of the APEA procedure. The traditional and APEA relicensing procedures are both being used today (http://www.hydro.org/nha2.pdf).Bob Graham works as a fisheries biologist for Virginia Power and he has been involved in the relicensing of the Roanoke Rapids and Gaston Power Stations for Virginia Power. Bob Graham (Virginia Power, personal communication) explained the APEA process as follows:

The applicant for a new license prepares and submits to FERC a draft Environmental Assessment (DEA) instead of submitting the traditional license application. Under the traditional process, FERC would develop an EA or EIS independently of other involved parties. Under the APEA process, the DEA is developed cooperatively with resource agencies and other interested parties. After submittal to FERC, the DEA is sent out for public review and comment, and then FERC turns it into a final EA or EIS. There are two primary advantages of the APEA. First, it gets everyone working together at an earlier stage of the relicensing process. Second, it provides for the opportunity of early settlement negotiations, which are worked into the DEA. As such, we (Virginia Power) were involved in many more meetings with agencies and other parties to discuss research needs, study updates, results of studies, potential environmental enhancements, and negotiations for settlement. The APEA process is supposed to compress the relicensing timetable (somewhat advantageous for the company and agencies), reduce the need for additional studies (advantageous for the company), and provide environmental enhancements sooner (advantageous to the resource). However, I can't say it has worked out in our (Virginia Power's) case.

The Roanoke Rapids and Gaston Power Stations generate 673,000 MWH (megawatt hours) annually, which is enough to supply power to 60,000 homes. Virginia Power has spent 5 million dollars on the relicensing process and the environmental enhancements agreed upon so far will cost an additional 12 million dollars (Bob Graham, Virginia Power, personal communication).

In June 1994, during the negotiations between the Oklahoma Municipal Power Authority and FERC, several fish kills occurred below the Kaw Reservoir in Oklahoma. Low dissolved oxygen levels in water released below the dam caused some fish kills and other fish kills occurred because of rapid shut downs of the dam which stranded fish (Summers and Bolton 1998). The new operational plan for the dam included the following provisions or environmental enhancements:

1. Installation of selective withdrawal plates. The plates should allow water with a higher dissolved oxygen content to be used for releases.

2. Installation of a slipstream nozzle. The nozzle would spray water into the air increasing the dissolved oxygen content of the water.
3. Ramping procedures. A ramping procedure calls for the dam to be shut down incrementally, instead of all at once and it should prevent stranding of fish.
4. Emergency releases. The Oklahoma Department of Wildlife Conservation can call for an emergency release if they determine water quality below the dam is reaching a critical level.

Summers and Bolton (1998) wrote that conflicts arose during the relicensing of the Kaw Reservoir in Oklahoma. They recommend resource agencies prepare for the relicensing process by anticipating data and personnel needs and training employees in conflict resolution.

Characterization of Dams Selected for Removal

In reality most of the dams being removed today were no longer generating power and the dams still generating power that were selected for removal had one common characteristic, anadromous fish restoration (McKitrick, FERC, personal communication). McKitrick also stated the FERC is requiring environmental enhancements such as, improving fish passage, requiring minimum flow levels below the dam, stabilizing water fluctuations, endangered species plans, wildlife plans, water quality enhancements, and erosion stabilization.
The Elwha, Glines, and Edwards Dams were still generating power when they were selected for removal and this has caused many debates. The NHA does not believe the FERC can require a removal unless dam owners agree to it (Church-Ciocci 1994). Last year in North Carolina the Carolina Power and Light Company voluntarily worked with resource agencies to remove the Quaker Neck Dam on the Neuse River. The removal of the dam should help migratory fish (http://www.ehnr.state.nc.us/EHNR/newsrels/reuter.htm).

Conclusions

The NHA states that hydropower is a clean, renewable, and efficient energy source. No greenhouse gases or air pollutants are given off from the generation of hydropower. Seventy percent of the electricity in the Pacific Northwest comes from hydropower (http://www.hydro.org/facts/you.shtml). Unfortunately, the dams needed to generate the electricity block the movement of migratory salmon and prevent them from spawning. Resource managers must understand that for economic reasons not every dam can or should be removed. Managers must be prepared to work with the FERC and dam owners to come up with useful and cost effective environmental enhancements for relicensing agreements. As technological strides are made we should be able to remove more and more dams and return aquatic habitat to its natural state. Bruce Babbitt the Secretary of the Interior once stated, "My generation saw how those rivers were changed, deformed, killed by dams. Your generation must help decide if, how and where those dams stand or fall." At no time has this statement been truer then now, as resource managers we must pick our battles for removals carefully and be prepared to defend our recommendations.

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Will Genetics Help Virginia Anglers Catch Bigger Walleye in the New River?

Kenneth C. Cabarle

Genetics is becoming increasingly important in all aspects of fisheries and wildlife management. Fish and wild animals are subjected to many genetic processes for many different reasons. Certainly manipulation for agricultural use is the first that comes to mind. Recently, genetics has been used to designate protected stocks of fish that would otherwise be indistinguishable from fish of the same species in different geographic locations (example: walleye in the New river). This has led to increased emphasis on genetic evaluation in the decisions made in fisheries management.

Genetics is the study of inheritable traits. Inheritable traits are passed on from generation to generation and are considered an integral part of the evolutionary process. Humans have been un- wittingly using genetics to alter plants and animals for thousands of years. The anisazi in north and south America had domesticated maize. Egyptians had the royal cats and dogs which were the products of genetic manipulations. Ancient china had the goldfish and the carp. The domestication and reproductive manipulation of carp are the earliest origins of the application of genetics in fisheries management. Applications in aquaculture provide the broadest base for moving genetics into the mainstream of fish management. The harvest and subsequent loss of fish stocks at the end of the 1800's opened up a second venue for genetics. Hatcheries and the propagation and maintenance of fish stocks became an area of concentration for genetics in the fisheries field.

Simple genetics:

Aquaculturists were the first to apply the concepts of mendelian genetics to propagate fish. The use of genetics to breed stocks with similar characteristics as there parents became of interest to the aquaculturist. Stocks were typically manipulated genetically to select for fast growth and large size. The aquaculturist also choose traits based on aesthetics. Fish were manipulated to be ornamentals, which would be of great interest for aquarium collectors. Color manipulation is one of the most popular uses of genetics for the propagation of fish for aquarium sales.

There are several other genetic characteristics that are manipulated by simple mendelian genetics. Scale patterns in carp is one that has had wide application. There are several different morphs of scale covering in carp. Carp can be genetically produced that range in scale covering from fully covered to almost completely devoid of scales (Kirpichnikov 1979). Scale patterns are also genetically controlled in several other fish species. Characteristic scale pattern distribution in sticklebacks is controlled and manipulated by classic genetics (Schroder 1973). Many fish can be manipulated for different body shapes through classic mendelian genetics (Purdhom 1993).

Modern Genetic analysis:

Allozymes:
Many characteristics of fish are under the control of genetics but the processes associated are well beyond the scope of classical genetic principles. Characters such as growth rates, stock distinction spawning time, and food conversion efficiency are all under the influence of many factors acting together in a complicated process. To analyze these processes the fisheries manager has to use a stockpile of modern genetic techniques (Carvalho and Pitcher 1995). The use of some of these techniques has become so common place in fisheries management that their acronyms have become everyday speech. The first if these terms that comes to mind is Gel Electrophoresis. Gel electrophoresis is the observation of the movement of soluble proteins(Allozymes) in response to an electrical potential across a gelatinous matrix.

Gels are used to make inferences about how closely fish are related. If the same suite of proteins act in the same way(move to the same position in the matrix) on a gel then a side by side comparison of the two specimens can be made to determine family, genus , and species level relationships between them. Most of the early work on fish stock assessment included gel electrophoresis (figure 1). This technique is also widely used in the determination of taxonomic classifications. Gel electrophoresis is extremely important in the evaluation of fish stock value, health, conservation status, and ecological vulnerability. Evaluation of discernable stocks within the same species (such as in the pacific salmonids) has been made easier by the use of gels. Concerns for stock assessment are becoming increasingly more important as we discover the economic and social value of unique and diverse fisheries.

DNA analysis:
The use of direct DNA analysis has become increasingly more widespread as the applied technology increases in sophistication. DNA analysis differs from Gel-electrophoresis in technique and design. In DNA analysis the actual DNA of fish species is examined for similarities and dissimilarities. DNA analysis can be more accurate than Gels in some cases. In particular in the examination of Mitochondrial (mtDNA). mtDNA is passed on maternally and allows the scientist to examine blood line relationships in evolutionary time scales. Fisheries managers also look at RNA, nDNA (nuclear DNA) and microsatellite DNA for relationships in fisheries stocks and taxonomy.

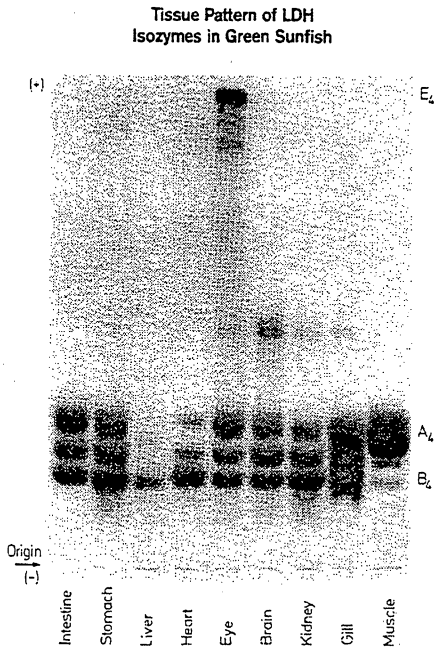

Figure 1: A Typical Gel-Electrophorisis Allozyme Pattern adapted from Schroder, J.H. editor. 1973.

The use of DNA analysis has been utilized in the assessment and monitoring of mixed stocks. Many western rivers support wild salmonid runs as well as hatchery supplements. Managers use DNA analysis to help determine how the hatchery fish are affecting the genetic distributions of the wild and hatchery stocks. This technique also allows the manager to keep updated on wild stock conservation genetics and to avoid hatchery introgressions. The use of this technique has provide insight into the analysis of taxonomic relationships for eggs and larvae. Comparing these techniques will help us understand how they can be applied to managing fish stocks (Kapuscinski 1984), which may lead to better walleye (*Stizostedion vitreum vitreum*) fishing (Murphy et al 1983).

Comparison of Techniques:

All of the techniques mentioned thus far, have had wide application in the profession of fisheries management. However, examination of Allozymes (gel-electrophoresis), mtDNA, and microsatellite DNA are currently the most wildly used. To get a better idea of the applications each lends itself to lets look at some of the advantages and dis-advantages of each.

Allozymes:

Analysis of allozymes has some very distinct advantages in the field of Fisheries Science. First it is the technique that has been around the longest and subsequently there is a great body of work on which to gauge your results. The use of Allozymes is relatively inexpensive, extensive training is not required to perform electrophoresis, and results can be interpreted in classical mendelian fashion.

The main disadvantage of Allozmes in fish management work is that it is sometimes insensitive to the variation that is the key to assessing stock distinction. Furthermore, this lack of sensitivity is multi-dimensional. On one level, not all mutations (which should show up as differences in gel patterns) result in changes in molecules. This essentially makes the molecule, even though it may be different, appear the same as other molecules. Gels that look at these molecules are giving a false reading when we examine them. On another level, this technique only works with soluble enzymes. Certainly soluble enzymes are not the only enzymes that show genetic variation in fish. Subsequently , fisheries scientists and scientists in many other fields have incorporated the use of other more sensitive genetic techniques (Turner 1999).

mtDNA:

Increasingly genetic evaluation is including the use of mitochondrial DNA in the analysis of fish stocks and evolutionary histories. mtDNA is more sensitive to changes in fish stocks over time because of two things. First by looking at the mitochondrial DNA we are only looking at the maternal blood line. In ecologist terms we are cutting the effective population size in half, this allows the evaluation to be much more sensitive to population structure. Second, mtDNA is easily sequenced which makes it ideal for analysis of phylogenetics, systematics, and zoogeographic distributions. mtDNA helps managers evaluate where fish populations come from, how they got there, and who they breed with. These are the foundations of stock assessment and special stock management. mtDNA does have some disadvantages. Because mtDNA analysis only looks at maternal variation, gender bias in migration can be missed. This becomes increasingly important if the males and females of a particular species have life histories that are similar yet subtly different. Additionally, it is slightly more expensive than using Allozymes and can require additional training (Turner).

Microsatellites:

Microsatellites are short, repeated sequences within the DNA sequence. Microsatellites are extremely sensitive markers for the identification of fish stocks. They have two main advantages in fish work. One, they nuclear codominant markers very similar to Allozymes. This allows fish managers to compare sequences and proteins in fish stock assessment. Two, microsatelites are rich in variation which allows the fish manager to get information about gene frequencies within populations.

There are however, several disadvantages to using microsatellite assessment. Microsatelite are more expensive than the previous methods and require a greater degree of training and technical expertise. Because of the large number of alleles required, sample sizes have to be large to assure good estimates. This can be a particular disadvantage when dealing with endangered or threatened populations. Population evaluation of fish typically found in low numbers or highly dispersed fish populations, do not make good candidates for the use of this method.

Because of it's recent development the conceptual tools needed for analysis of microsatellites is underdeveloped. Further development needs to pursued to establish greater confidence in interpreting the results of microsatelite DNA analysis. It is also extremely time consuming to develop microsatelite markers in species where none currently exist. This limits the number of species that can quickly be assessed with microsatellite data. The increasing number of studies using microsatellite analysis will help to make it a more useful tool in the future (Turner, Pers. Comm.).

The New River Walleye Fishery:

All of the above techniques have been established as part of the tools needed for thoroughly assessing stock designations for use in fish management. Many studies have used various combinations of these techniques to determine the status of fish populations and unique stocks. Typically these studies are carried out to determine the existence of unique stocks and subsequently to guide management decisions regarding those populations. All three of these techniques are currently being used to study the future management of the walleye fishery in the New river. This research is a perfect case study of the current and future use of genetic assessment as it relates to fish management decisions.

History of walleyes in the New Rriver:

Records regarding fish collections in the New River date back to the early 1800's but there is no account of walleye in the New river. Stocking records indicate that mixed stocks of walleye have been in the river since 1921. Because of the historical zoogeographic distributions of walleye, in particular in the Mississippi and Ohio drainage's, there is speculation by some that a southern strain of walleye is historically endemic to the New river (Murphy 1981). The fact that early collections, (in particular Cope's collection in 1868) made no mention of walleye in the New leaves some scientists skeptical that a strain of southern walleye was historically found in the New (Jenkins and Burkehead 1994).

Regardless, the fish currently in the New grow big, reproduce well, and are currently in a population increase. This southern strain is thought to grow faster and larger than its northern cousins in southern waters. Indeed, the fact that the current state angling record for walleye is from the New river (see figure 2) is an indication that identifying and using this strain as brood stock for the state of Virginia would benefit anglers. Use of this management strategy for the states walleye stocking program benefits anglers and the state by increasing the odds for catching a trophy walleye. Conservation biology would benefit as well by preserving the genetic purity of a unique and distinct fish.

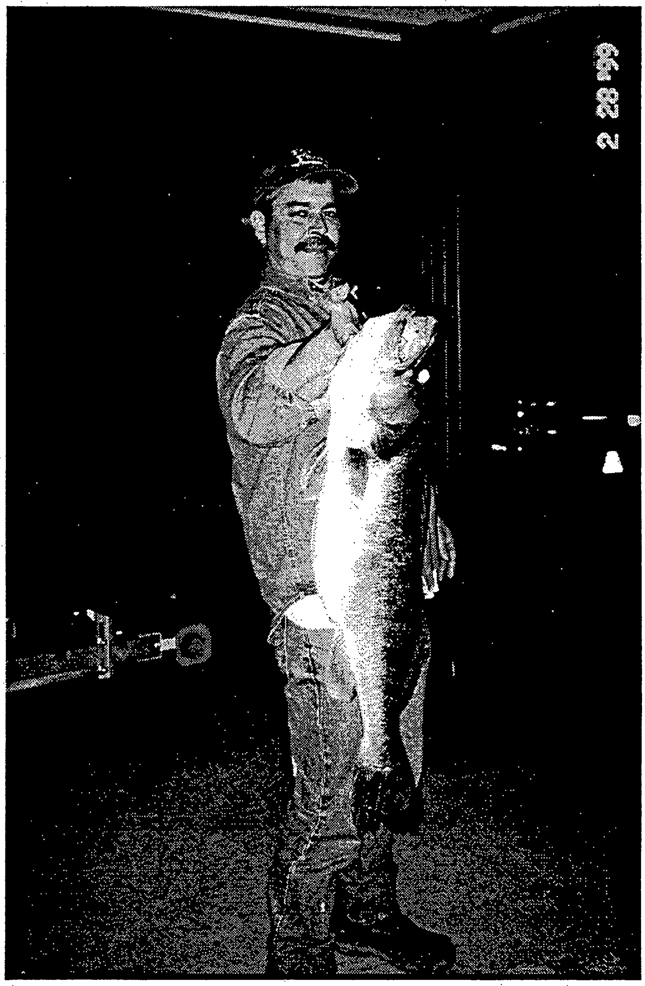

Figure 2: Current Virginia State Record Walleye (*Stizostedion vitreum vitreum*)

Current Research:

In the spring of 1997, graduate student George Palmer in conjunction with Virginia Polytechnic Institute and State University started research into the question of delineating the different walleye stocks in the New River. Mr. Palmers research is funded by the Virginia Department of Game and Inland Fisheries (VDGIF) and his findings will have a direct bearing on the future management considerations for the New river walleye fishery. Mr. Palmers research includes distinguishing spawning grounds for walleye stocks in the New through the use of radio telemetry. This alone however does not tell us if the river holds separate strains or stocks of walleye. In particular, it cannot answer the question of the historical evolutionary relationships within those stocks. For this Mr. Palmer has chosen to use a suite of genetic analyses. In fact, he has chosen to incorporate all three genetic techniques (Allozymes, mtDNA, and Microsatellites) into his study of the possibility of a unique strain of southern walleye in the New river (Palmer unpublished).

Management Implications:

If it is determined, through the research of George Palmer and through future VDGIF studies, that there is a bigger, faster growing historically southern strain of walleye in the New river, management strategies will probably change. With the current state record hovering somewhere close to 16 lbs., and reports of bigger fish being collected in samples by the VDGIF (J. J. Ney, Dept. of Fisheries, Virginia Tech. personal communication), a brood stock of husky, New river strain walleye would be a welcome addition to the states current stocking program. Walleye fishing is big business and a 16 lb. walleye is big by anybody's standards. If it can be determined that these larger fish are unique to this system and historically southern in origin than they can be targeted for brood stock propagation. Increased growth rates are a welcome addition to a fishery especially if those fish are a special stock. Anglers may someday be traveling from all over the country to try there luck on a southern strain lunker walleye in Southwestern Virginia.

In the mean time, George Palmers research continues, with an estimated completion in the fall of 1999. Until that time, the question of a unique southern strain of walleye is up in the air. But, is genetics the only thing that could lay to rest the question of southern walleyes in the New. It has been suggested by Dr. Robert Jenkins (1999), that a thorough investigation of the county records in all county and city seats in South Western Virginia may hold some historical account of walleye in the New river before 1868. Who knows, maybe back then, walleye grew to 20 or even 30 lbs. So as we have seen genetics may indeed be helping Virginia fisherman catch bigger walleye in the present and in the future. The big benefit here is that with the aid of genetics the VDGIF may be on its way to establishing the fact that some of the walleye in the New are historically southern. This will in turn, through appropriate management decisions, help them to maintain the integrity of that stock ,and to take management actions that will help preserve it for future Virginia anglers

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Balancing Act: Humans and Natural Resources (Southern Florida Ecosystem Management)

Dana Roberts

The Southern Florida Ecosystem is a complex network extending from the Chain of Lakes south of Orlando to the coral reefs off the Florida Keys and comprising of eleven physical provinces – over 18,000 square miles of land and water (Science Sub-group Report 1993). About forty percent of the water that originally flowed from Lake Okeechobee into the Everglades is now diverted to the Gulf of Mexico and the Atlantic Ocean. The northern Everglades were drained and designated the Everglades Agricultural Area (EAA). The habitats support sixty-eight federally listed threatened and endangered species. Populations of wading birds have decreased by almost ninety-five percent from 1870 to 1973. Over 1.5 million acres of land are infested with invasive exotic plants. In high-nutrient areas, cattails are replacing native sawgrass, which increases nutrients and salinity in the Florida Bay and the reefs. The increase in nutrients stimulates the growth of algae contributing to dieoffs of corals and seagrasses. The incidence of coral diseases in the Florida Keys National Marine Sanctuary has increased four fold since 1996.

Along with the rapid urbanization and agricultural growth accompanies soil degradation, flood control drainage's/channelization, and the construction of extensively engineered systems of canals, levees, and dikes. Although water is the most limiting resource in the Southern Florida Ecosystem, the issue is not of sufficient water supply but storage and wise use management practices. Another issue is how to restore a natural ecosystem while maintaining the services provided to society.

Massive hydrological alterations have drained half of the Everglades (Harwell et al. 1996) and only one-fifth is highly protected. Two million acre-feet of water are lost from the natural system annually through discharge and seepage (Southern Florida Task Force Biennial Report 4). On its present course, Southern Florida and the Everglades are not sustainable. In order to achieve ecological sustainability, (long-term environmental health and balance), and to restore the natural ecosystem, changes in management are necessary. To rescue the area, environmentalists, water managers, and public officials have joined to plan for the Everglades of the future – an imagined place where water would once again flow freely and the historic mix of plants and animals would flourish.

The integration of the needs of both environmental and human systems is required. The case of South Florida illustrates the complex balance between regional environments and societies that must be achieved to restore and sustain the environment for future generations. The way to restore and sustain the Everglades and South Florida is through ecosystem management. Advocates describe ecosystem management as an approach that will protect the environment, maintain healthy ecosystems, preserve biological diversity, and ensure sustainable development. Ecosystem management, as defined by Grumbine, integrates scientific knowledge of ecological relationships within a complex sociopolitical and values framework toward the general goal of protecting native ecosystem integrity over the long term. Ecosystem management focuses on human and natural systems at regional scales and over intergenerational time periods, and is integrative and adaptive in nature (Harwell et al. 1996).

Background Information

The natural Everglades was little affected by humans until the late nineteenth century. The area was regularly subjected to flooding, freezing, fires, droughts, and storms; thus requiring extensive drainage for human uses (Harwell et al. 1996). In the winter of 1947-1948, massive rainfall flooded millions of acres in central and southern Florida for up to six months, particularly affecting agricultural communities (Bottcher and Izuno 1994). In reaction, the United States Army Corps of Engineers began an extensive public works project, the Central and Southern Florida (C&SF) Flood Control Project. During 1950-1990, Florida population increased from 750,000 to 4.1 million (US Bureau of the Census 1993). Its mission was to make the coast safe for development, the interior south of Lake Okeechobee safe for farming, and areas like the park secure for plants and animals. Ever since the drainage effort began, activists have demanded a park to preserve part of what remained of the Everglades. As a result, in 1947 the Everglades National Park was established. In 1990, over 386 persons per square kilometer lived near the coast, population further west was less than one person per square kilometer (Harwell et al. 1996). Currently, the Everglades and Southern Florida are an extinct ecosystem. What once were episodic disturbances (fire, freeze, drought, storm, and flood) have turned into stressors. The Everglades we know today is crisscrossed with 1,400 miles of canals, levees, spillways, and pumping stations (Derr 1993).

Ecosystem Management Foundations

"Ecosystem based approaches evolved nationally to meet increasing and often conflicting demands on the nation's natural resource base. The approach provides new ways to address emergent environmental problems that have perplexed traditional approaches. These problems include non-point source pollution, toxic contamination of biota, habitat alteration and destruction, and overall loss of biological diversity. The overriding theme of ecosystem management is sustainability. That means preserving the entire ecosystems over the long haul to provide more recreation, a healthier environment, and stronger economies (Wisconsin DNR 1999)." Wisconsin Department of Natural Resources (Wisconsin DNR) uses ecosystem based approaches for its fisheries management, it has strayed away from the traditional manipulation of populations to observing the physical habitat and surrounding areas for factors affecting fish health and populations and overall water quality.

The foundation of ecosystem management is defining ecological sustainability factors. Natural characteristics of the Everglades and Southern Florida essential for sustainability are dynamic storage and sheet flow, spatial scale and habitat heterogeneity. Nine principles/foundations for ecosystem management were developed in regards to the South Florida ecosystem. 1) Use of an ecological approach to recover and maintain biological diversity, ecological function and defining characteristics of the ecosystem.(Forces examination of activities and land use or resource decisions within landscapes.) 2) Recognize humans are part of ecosystems. Sustainable ecological and societal systems are mutually interdependent. 3) Adopt a management approach recognizing ecosystems and institutions are heterogeneous in space and time. 4) Integrate sustainable economic and community activity into the management of ecosystems. 5) Develop a shared vision of desired ecosystem conditions. 6) Provide for ecosystem governance. 7) Use adaptive management to achieve both desired outcomes and critical new understandings in regards to ecosystem condition. 8) Integrate the best science available to form the basis of the decision making process. 9) Implement ecosystem management principles through government and non-government plans and activities. The key to ecosystem management is mutually beneficial solutions.

Participants of Ecosystem Management

Why should people care about ecosystem management? "First, the concept has been embraced by politicians and appointed officials and such debate concluded ecosystem management will be implemented. Second, although ecosystem management is a new concept, it is a better way of management. Third, society needs to focus on policy issues and the role science should and can play (Lackey 1998)."

Scientists, agencies (DNR, DGIF, BLM, USFS, DEP), managers, policy administrators, citizens (consumptive and non-consumptive users), and environmental groups are directly involved with the implementation of ecosystem management. Scientists' adoption of standard definitions and procedures is first step towards ecosystem management implementation. Interagency cooperation and willingness to adopt new paradigms of thinking (conservation biology and ecosystem management) are required of all agency managers. Policy administrators need to revisit and strengthen environmental laws such as the Clean Water and Clean Air Acts. Policy administrators also need to confront the issues of population growth and resource consumption. For ecosystem management to succeed, industrial societies must reduce their growth (Grumbine 1994). Citizen support must stem from environmental education, advocacy and involvement.

The Everglades Coalition, currently chaired by National Audubon Society and consisting of 28 local and national environmental groups, were founded to fight for the Everglades National Park water rights and to save Big Cypress Swamp. The focus of the campaign is to restore the natural sheet flow of water through the Everglades. Two steps must be taken for the restoration to occur 1) the east coast 4.5 million residents must be weaned of its reliance on water from Lake Okeechobee and the water-conservation areas; 2) excesses of agriculture must be curbed (Derr 1993).

Current Research Involving Ecosystem Management in Southern Florida

On-going research projects implementing ecosystem management in Southern Florida include: 1) Central and Southern Florida (C&SF) Flood Control Restudy Project; The C&SF Restudy Project developed modifications using ecosystem management practices by changing the existing project to restore the Everglades and Florida Bay ecosystems. 2) United States Man and Biosphere Systems Reserve (USMAB); The USMAB project conducted a case study of South Florida using ecosystem management as a framework for exploring options for mutually dependent sustainability of society and the environment (Harwell et al. 1996). To examine the environmental effects of human actions, the case study used an approach called scenario consequence analyses.; and 3) Department of Environmental Protection (DEP) Ecosystem Management Initiative. The DEP Project using ecosystem management provides better protection for the state's ecosystem, establishes an agency culture that supports a systems approach to environmental protection and encourages a conservation ethic and sustainable lifestyle among Florida's citizens. These examples and others show that Ecosystem Management is working for Florida – "for the environment, for citizens, and for the businesses that support our economy. Ecosystem management is not one project or program. It is a philosophy that recognizes and seeks to preserve and restore the intricate connections between all parts of the environment, including our human communities. It is a pathway to a sustainable future for Florida." (DEP Executive Summary 1997).

The focus of this paper is the C&SF Restudy Project, for the viability of life in south Florida depends on the projects success. The C&SF Project, first authorized by Congress in 1948, is a multi-purpose water resources project. The authorized purposes of the project include: flood control, regional water supply for agricultural and urban areas, prevention of salt water intrusion, water supply to Everglades National Park, preservation of fish and wildlife, recreation, and navigation. This project makes it possible for over 5 million people to now live an work in the 18,000 square mile area which extends from south of Orlando to Florida Bay. For almost more than fifty years, the project has performed its authorized functions well. However, the project has also had unintended adverse effects on the unique natural environment which constitutes the Everglades and Florida Bay ecosystem.

In 1992, Congress authorized a comprehensive review study (Restudy) of the C&SF Project. The purpose of the restudy is to develop modifications to the Central and Southern Florida Project to restore the Everglades and Florida Bay ecosystems while providing for the other water-related needs of the region. The restudy areas of concern include: 1) Land acquisition; Land is needed for water storage and aquifer recharge areas that will help restore natural hydrology. Since 1996, 309,300 acres have been acquired for $354 million dollars (Southern Florida Restoration Biennial Report 6). Construction and infrastructure improvements; Activities include restoring natural hydropatterns, water quality, flood prevention, and adequate water supply. Removal and modification of existing levees and canals along construction with the construction of new water control structures and pump stations (Southern Florida Restoration Biennial Report 6). Six stormwater treatment areas have been completely constructed and in December of 1997 began flow-through water quality treatment. 3) Habitat/wildlife restoration and preservation; Exotic species control begins with The Melaleuca Control Program, which releases the melaleuca snout-nosed bettle into the wild to eliminate the invasive exotic plant. Other projects include the Florida keys Water Quality Protection Program, the Marine Zoning Plan and the Turner River Restoration. 4) Innovative planning and management; Former adversaries now work together toward reaching common goals. Accomplishments include the Integrated Financial Plan (the coordination of funding and projects between organizations) and the Southern Everglades Restoration Alliance (SERA - a multidisciplinary, multi-agency alliance formed to improve ongoing restoration projects).

Problems of Ecosystem Management

Two things are necessary for managing sustainable ecosystems: a new set of ethics and a new set of scientific standards (Knight 1998). Problem areas in relation to ecosystem management include values/ethics, cost-benefit analysis, intense political pressure, and the effect of decisions outside the framework of the problem. Difficulties arise when boundaries of one ecosystem overlap another agency management areas. Current management policies are to be altered to reflect paradigm shifts in attitudes and values. Political pressure rapidly increased with the popularity and acceptance in the scientific community of ecosystem management. Drastic policy changes will significantly impact governmental agency missions, goals and strategies.

Conclusions

In conclusion, the implementation of ecosystem management is necessary to maintain viable populations, represent all native ecosystem types, maintain evolutionary and ecological processes and manage over time to maintain the evolution of species and ecosystems. Ecosystem management offers a new approach to the solution of old problems. Due to the expansion of current agency boundaries to the boundaries of ecosystems, ecosystem management requires interagency cooperation. Ecosystem management not only benefits the environment but agencies as well. Although ecosystem management alters organizational structures, agencies acquire a new network of colleagues , larger database, and additional manpower. It is time for a new philosophy of thought for natural resource management. Support from scientists, managers and others in increasing. Optimistically, as support increases, so will awareness. Ecosystem management is necessary to sustain ecosystems while human population and land-use development are on the rise.

Needed actions in relation to policy, education, and monitoring are required. Existing policy actions in support of ecosystem restoration include the Water Resources Development Act of 1996, Farm Bill and the Everglades Forever Act; however, others are necessary if the Southern Florida Ecosystem is to be sustained. To be successful, a message needs to be conveyed to constituents and colleagues about the need for, and the value of, viewing ecosystem issues holistically and with a long-term perspective (Southern Florida Task Force Biennial Report 7). Continued land acquisition, water quality improvements, restoration projects, exotic species control, and habitat/wildlife restoration and preservation, are just a few of the continued monitoring activities that are critical to the assessment of the restoration process.

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Save the Bay

Atlantic Sturgeon
The Rise and Fall of an Aquatic Dinosaur in the Chesapeake Bay

Jennifer Rohrer

The Atlantic Sturgeon (*Acipenser oxyrhynchus*) can be described as quite an impressive, unique species, dating back one hundred and fifty million years ago (Leffler 1999). Once known as one of the most valuable fisheries in the Chesapeake Bay and along the east coast during the late 1800's, sturgeon are now facing extinction (Blankenship 1995). These fish do not possess scales as most fish are commonly known to have. Instead, they have five rows of body plates called scutes used as armor for protection. They are bottom-dwelling creatures that prey on other bottom-dwelling species such as mollusks, worms, insects, and crustaceans (NOAA 1997). Because sturgeon are bottom-dwelling creatures, it is imperative that their habitat be capable of providing a sufficient supply of oxygen at depth. This ensures the survival of prey species, ultimately determining the Atlantic Sturgeon's own individual success.

As anadromous fishes, Atlantic sturgeon have migratory patterns that utilize the Chesapeake Bay and its tributaries during one of the most important times of their life cycle. Sturgeon have been known to live up to sixty years, using the Bay and its tributaries for spawning and nursery ground during the months of April and May every two to six years during their life (Jenkins and Burkhead 1993). After spawning, females continue to move down stream while males stay in the Bay until the fall. Juveniles stay from one to six years before moving to coastal waters (NOAA 1997). Due to the length of time spent in the Bay during such susceptible years, the survivorship of these young sturgeon is heavily dependent on current and future living conditions.

The Uphill Battle

Dating as far back as 1888, John Ryder was the first to initiate studies of the sturgeons and sturgeon fisheries along the Atlantic coast of the United States. Ryder concluded that his analysis showed that "The only means of maintaining and increasing the industry is through the artificial propagation of this fish..." (Smith et al. 1980). Life in the Chesapeake Bay has been nothing less than an uphill battle for the Atlantic Sturgeon. Adequate living conditions are not the only problem faced by this fading species; additional problems and barriers exist that have been imposed by man. These problems will be discussed as well as management options currently underway to solve these problems.

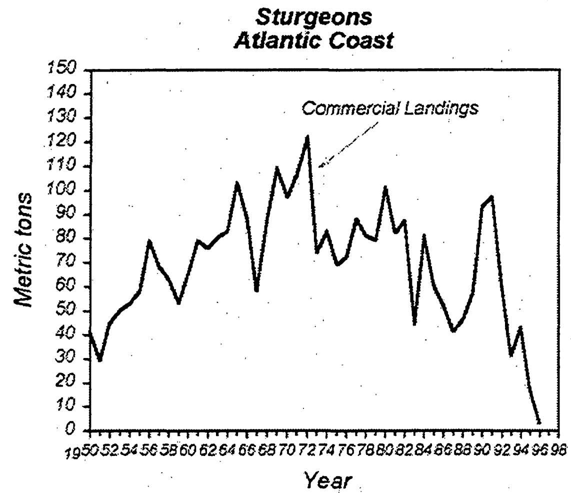
Causes of Depletion

An astonishing number of species are becoming extinct at a rate much higher than ever before. For reasons such as overfishing coupled with early fishing mortality, pollution, and dam construction, the rapidly depleted Atlantic sturgeon populations are a good example of this misfortune.

Overfishing & Early Mortality

The Atlantic sturgeon was once one of the most valuable fisheries in the Chesapeake Bay and along the east coast in the late 1800's. Their eggs (roe), eaten as caviar, were the "cash crop" from Jamestown before tobacco was introduced and may bring fisherman two or three thousand dollars (Blankenship 1995). Their meat, known in New York as "Albany Beef", also provides a profitable market for fisherman (Leffler 1999). In the past, sturgeon were also used for their skin as leather, and their swim bladders were used to obtain gelatin for waterproofing, cement, and wine (Blankenship 1995).

It is easy to see why the Atlantic sturgeon has received such great demand. As a species that is useful for so many things, overfishing became an issue. Sturgeon numbers have decreased so drastically since the 1800's that there are now laws and regulations making it unlawful to take, catch or possess any sturgeon (VMRC 1999). Their life cycle plays a large role in the problems associated with their collapse. Taking approximately nine to twelve years for males and at least fourteen years for females to reach sexual maturity, their populations never get a chance to replace themselves (Leffler 1999).



Pollution

Once reaching maturity, female sturgeon encounter spawning problems due to siltation of bottom habitats and the loss of submerged aquatic vegetation that under good conditions would provide surfaces for attachment of released eggs (Blankenship 1996). Many restoration projects have been implemented to help the Chesapeake Bay return to its natural state; however until it has recovered, many question whether sturgeon will be able to survive in current conditions. Supposing females succeed in laying their eggs, sturgeon populations need fairly good water quality to survive. As bottom-dwellers in the Chesapeake Bay, the spring and summer months are particularly hard on the sturgeon because it is these bottom habitats that are often void of oxygen, thus making some sturgeon feeding grounds barren. Perhaps our goal of returning sturgeon to the Bay will bring on a long-term commitment to Bay restoration. As Dave Secor from the Chesapeake Biological Lab points out, "their recovery would be an important indicator of improvement of water quality, habitat and management of our fisheries resources [in the Chesapeake Bay]" (Leffler 1999).

Dam Construction

The construction of any dam can pose as an obstacle to migrating fish. Sturgeon have been subject to this as dams have been built along rivers for human use, resulting in problems for migrating sturgeon. In order to help solve this problem, Maryland, Pennsylvania, Virginia and Washington, D.C. have been working together since 1993 to reach a 10-year goal of reopening approximately 1,356 miles in the Chesapeake Bay watershed to anadromous fish (Reshetiloff 1997) including blueback herring, alewife, hickory shad, American shad, and yellow perch. Five standard designs that are used to create a fishway or to remove a blockage are denils, steeppasses, pools and weirs, vertical slots, and fish lifts or fish elevators (Reshetiloff 1997). A list of passage sites in the Chesapeake Bay watershed are listed in Table 2, along with descriptions of the type of design used to create the passageway (Table 3).

The Chesapeake Bay does not seem to have any dams that block migration patterns for Atlantic sturgeon. Because sturgeon spawn in tidal waters (Jenkins and Burkhead 1993), dams that have been constructed over the years are further upstream than the sturgeon need to go.

Management Options

In order for the Atlantic Sturgeon to successfully restore their populations in the Chesapeake Bay, there must be a reduction in fishing mortality, an improvement in water quality/habitat, and an increase in total egg production. Some options that are currently underway include monitoring trends, closed fisheries, rewards, and the production of hatchery raised fish.

Closed Fisheries --As of April 1, 1998, all Atlantic coast states closed their fisheries for Atlantic Sturgeon to reduce fishing mortality and increase the total egg production to rebuild stocks. This closure of the sturgeon fishery has caused some tremendous economic losses for fisherman and will continue until stocks are rebuilt. As seen in Table 1, sturgeon landings and profits received by sturgeon fisherman have decreased drastically over the past decade. The sturgeon fishery once brought in an exceptional annual profit of $352,514 in dock-side payments in 1990, and was reduced to nearly $2,000 in 1997 (NMFS 1998). After rebuilding, positive economic gains are expected to be present.

Hatchery Raised Sturgeon & Monitoring --In July of 1996, three thousand three-year-old Atlantic sturgeon were stocked and tagged with coded wire tags in the Nanticoke River. These juveniles were raised in a hatchery in Lamar, PA by the U.S. Fish and Wildlife Service from eggs collected on the Hudson River and are being tracked and monitored to see what their movements are and to identify the habitats that they are using in the Bay and in the tributaries (Blankenship 1996). Now that the juveniles have been stocked, one of the only ways to monitor their long-term success is to wait for them to return to the Bay to spawn , which will not be for another fifteen years.

Current studies are being carried out by Dave Secor at his laboratory in Solomons Island, Maryland at the Chesapeake Biological Lab. In order to grow sturgeon for stocking purposes, he must first find out what kind of habitats juveniles should be stocked into, what kind of environments would be best to help promote populations to reproduce, and to find out if we even have sufficient habitats in Bay waters any more (Leffler 1999).

Rearing fish in hatcheries is also being done to promote commercial benefits of the species by producing fish with rapid growth and early maturation, which is very desirable. Mr. Leo Ray of Western Regional Aquaculture Center grows sturgeon (and others), processes them, and markets them through his business, Fish Processors, Inc. He believes that once hatchery raised sturgeon are old enough to be harvested, that this will ease pressure on the wild stocks by producing juveniles, caviar, and sturgeon meat through aquaculture farms for human consumption (Fitzsimmons 1996).

Current Discoveries --The last egg-laden female Atlantic sturgeon in Maryland was found in the Nanticoke River in 1972. However, the current discovery of an eight and ½ foot sturgeon was found on the banks of the James River on October 11, 1997, indicates that the Atlantic sturgeon in fact still reside in the Chesapeake Bay, however their numbers are still extremely low. This discovery raises a debate on how to save native Atlantic sturgeon (Blankenship 1997). If and when another female sturgeon is captured, it may very well be the last one. In that case, the question arises of what should be done with it. The two options are to sacrifice the fish for eggs to be used for rearing, or to tag and track the fish in hopes of finding others (Blankenship 1997).

Rewards --In some states, such as Maryland, there are reward programs for sturgeon caught and turned over to the U.S. Fish and Wildlife Services. A one-hundred dollar reward is offered for wild sturgeon captures, and there is a twenty-five dollar reward for the three thousand hatchery raised Atlantic sturgeon with internal coded wire tags that were released in July of 1996 into the Nanticoke River. The rewards are not paid if the sturgeon is not alive upon checking at the station (MD DNR 1999).

Stocking Success --Of the three thousand juveniles tagged and stocked in the Nanticoke River in 1996, anglers throughout the Bay and as far South as the North Carolina coast had recaptured 262 tagged fish by early October of 1997. It seems that the sturgeon survived will judging by their growth of one foot from the time of release in July 1996 to the winter. However, these fish won't be seen again until approximately 2010 when spawning begins. This positive information provides hope for future recovery, and is a good indication that the Chesapeake Bay may after all offer a suitable habitat for sturgeon to recover in (Blankenship 1997).

Conclusions

The Atlantic sturgeon, the aquatic dinosaur of the Chesapeake Bay, has seen its days of glory as well as its days of trials and tribulations. Problems such as overfishing, early fishing mortality, pollution, and dam construction, have succeeded in depleting their populations. Management actions are being taken to help the sturgeon become as abundant as they were centuries ago. The Atlantic sturgeon fishery is currently closed to commercial and recreational fishermen, stockings have taken place, rewards are given for stocked fish captures as incentives to fishermen for catch and release, and scientific research is being conducted to find optimal habitat. With continued effort and determination, restoring this species back to the Chesapeake Bay should be a success.

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Table 1. Atlantic Sturgeon Landings and Value, 1990-1997. Source for landings NMFS 1998 Status Review. (Source for value calculated from price per pound as reported by NMFS F/ST Office.)

Year	Pounds	Value ($s)
1990	195,841	352,514
1991	216,790	288,331
1992	129,557	231,265
1993	69,194	107,943
1994	95,809	207,906
1995	38,253	94,867
1996	6,637	17,588
1997	843	1,989

Table 2. Partial list of passage sites in the Chesapeake Bay watershed (Reshetiloff 1997).

- Manchester/Browns Island Dams: Henrico County, Va. - Notch
- Walkers Dam: New Kent County, Va. - Denil Fishway
- Conowingo Dam: Harford/Cecil counties, Md. - Fish Lift
- Tuckahoe Creek Dam: Caroline/Queen Anne's counties, Md. - Denil Fishway
- Union Dam: Howard/Baltimore counties, Md. - Breach
- Lake Waterford Dam: Anne Arundel County, Md. - Pool and Weir
- Standing Stone Creek: Huntingdon Country, Pa. - Denil Fishway
- Safe Harbor Dam: York/Lancaster counties, Pa. - Fish Lift
- Holtwood Dam: York/Lancaster counties, Pa. - Fish Lift

Table 3. Definitions of fishways (Reshetiloff 1997).

- Denil fishway: Series of sloped channels that allow fish to swim over the dam. Baffles in these channels slow the water down and pools between each section allow fish to rest.
- Steeppass: Similar to the Denil but usually has only one sloping channel with baffles. There is no need for resting pools as the steeppass is designed for smaller blockages.
- Pool and weir: A series of pools forming steps ascending a dam.
- Vertical Slot: Similar to the pool and weir except each pool has baffles creating a narrow slot through which the fish swim.
- Fish lift/Fish Elevator: Used to pass fish over large obstructions. The directed flow of water guides fish to a hopper that raises the fish over the dam.

Decline of the American Oyster *Crassostrea virginica* in the Chesapeake Bay: Overfishing and Mismanagement

Richard L. Hubbard

The American Oyster (*Crassostrea virginica*) has been invaluable to the people that chose to inhabit the shores of the Chesapeake Bay since well before Columbus set foot on the "New World". Newell (1988), working independently, calculated that in the times before 1870, there were enough oysters to filter the entire volume of water in the Chesapeake Bay in three to six days, in 1988 it took between 244 and 325 days to filter the same volume of water. " In 1904, 7.6 million Virginia bushels (Va. bu.) of adult market oysters were harvested on roughly 243,00 acres of public oyster grounds. During the 1993-94 oyster season these same grounds produced only 5,484 Va. bu. of market sized oysters" (Hargis and Haven, 1995). The story is the same in the Maryland and the Potomac River oyster fishery. Once the largest shipper and producer of oysters in the United States, the production of oysters by this great body of water has been reduced to a fraction of her former glory. Many fingers have been pointed and many more wait to point in an attempt to explain why this decline has occurred. All to often you hear the of the diseases MSX and Dermo referred to as the culprit. But these serve only as scapegoats, merely as means of distracting attention from the real reason. Overfishing brought about through greed and a continued disregard for biologists and managers warnings were the real reason.

Life History

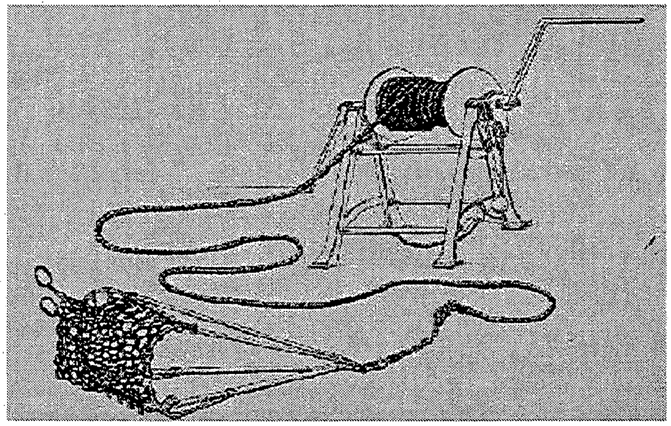
The American oyster is a benthic bivalve that is a filter feeder and is sessile for all stages of life except its larval stage. "When oysters reach sexual maturity, usually around three inches, more than 70 % will be males" (Kennedy, 1981). As they grow older they shift sexes and become females. "The percentage of male to females and age at which they change varies with environmental conditions" (Kennedy, 1981). They spawn in the spring of most years, depending on water temperature. After a large initial release of gametes by both sexes, there are continued smaller spawns until early summer when the sex parts are reabsorbed into the body. The fertilized eggs depend upon currents to carry them to suitable locations in which they can "set." When the larvae settle out of the current they must attach themselves or "set" upon some type of firm substrate; wood pilings, old buoys, sunken cars. The best substrate for larval oysters to settle on is that of their parents' shells. After they attach to a firm place they settle for the rest of their lives, only to be removed by mans interventions. As countless oysters pile up they form huge "reefs" which can contain millions of oysters. "Oyster's are relatively fast growers and can reach market size (three inches) in 24 to 30 months in optimum conditions" (Kennedy, 1981).

Potential Problems

The biggest obstacle that oysters have is that they are attached to the bottom and have no means of moving themselves. As a result, they are very susceptible to problems with the water in which they live. They can be easily drowned by silt that settles out after a large storm, they can die from lack of oxygen if the water conditions become anoxic, they can be poisoned by pollutants that run-off from land, or they can be attacked by disease. The largest of these problems, at current writing, is that of disease. "Oyster mortality from MSX and Dermo first began to appear in Virginia in the 1970's and in Maryland in the early 1980's" (Hargis and Haven, 1995). This disease is especially virulent in the larger reproductive oysters and is much more prevalent in water that has a higher salinity. "The average salinity for the upper Chesapeake Bay is between 15 and 18 PPM" (Kennedy, 1981). During the early 1980's there was a large drought over most of the watershed that the Chesapeake Bay encompasses, as such, salinity in the Bay was high enough for these diseases to reach the Maryland portion of the Bay. These diseases struck at a horrible time and decimated a stock of organisms that was already under a huge amount of stress. "The decline of oysters continued to accelerate until they reached the low of 5,484 Va. Bu. in 1993-94" (Hargis and Haven, 1995).

Industry: History and Harvest

The oyster industry on the Bay began almost as soon as settlers began to inhabit the area. At first oysters were harvested more for the lime (calcium carbonate) that could be rendered from the shells for fertilizer than they were for human consumption. The first sustained harvest occurred as "Yankee skippers" from Connecticut and New York began to look elsewhere for oysters to replete their overharvested beds. Traditionally, oysters were harvested in two main ways; a waterman employed either hand tongs or worked on a dredge boat. Oyster tongs are a pair of tongs, usually with a head of about three feet, attached to a pair of wooden handles that range anywhere from ten to twenty feet in length. The waterman would lower them to the bottom and using the head pull shells from the reef in a continuous open and closing of the tongs before being raised to the boat to be culled or sorted. A dredge boat was a boat that pulled two or more dredges along the bottom of the Bay over oyster reefs. After a lick, or haul of the dredge across the bottom, the dredge is raised to the boat and sorted by crewmen on deck. "In Maryland dredging is restricted to sailboats under ten tons of gross weight" (Peffer, 1979). In Virginia most dredging is done from motor powered boats. The only change in gear in over 180 years of harvesting was the addition of the patent tongs just over 60 years ago.



Harvest Implications

The most efficient means of harvesting oysters, the dredge, also tends to be the most damaging to the oyster reef. The health of the oyster reef is of utmost importance to the continued success of oysters. Unfortunately man has altered these reefs in innumerable ways, from the harvest of shells from historical reefs to use for farming and road building, to the loss of shells to shucking houses who merely shuck and ship oysters for sale. The loss of shells first affects the height of the reef; by lowering the heights, you lose valuable areas for spat to set on. It also becomes much more difficult for silt to be removed. The oysters are no longer exposed to the cleaning power of the current. Finally, culling oysters causes the loss and alteration of the reef. When bringing in either a dredge or tong full of oysters you are not presented with just single oysters ready to be picked and sent to the shucking house. Instead you have a pile of live oysters, dead shells, discarded cans and bottles, mud and anything else that may be in the path of the dredge. As watermen discard all but live oysters, these old shells are tossed over the side and in many cases they land not on the reef itself, but rather to the sides or even out of the area. If these should land in a soft or muddy bottom, the shells can sink and be no use to anyone. "Maryland has made many efforts and spent millions of dollars transferring shells from shucking houses and historical beds that no longer produce, to grounds that are currently in use" (Peffer).

Regulations and Implications

Alarmed by the large amounts of oysters being removed from the waters of the commonwealth, Va. legislators banned dredging for oysters in 1811. Maryland was soon to follow suit and by 1820 had a similar law on their books. Both of these legislatures have played active roles in trying to control the oyster industry since. Following the Civil War and the lift of the ban on using dredges, the oyster industries of both states boomed. Catches continued to skyrocket and times were prosperous. The city of Baltimore became one of the largest shippers of oysters in the world. On the Eastern Shore, the town of Chrisfield rose as the oysters shells from millions of oysters began to pile up and fill in the marsh. These days were often compared to the gold rush of the old west. Indeed it was, the men that worked on the waters were tough and the jobs they held even more so. "In Maryland, the catch peaked at 15 million bushels in 1884-1885 and have continued a downward spiral ever since. In Virginia the catch peaked in 1904 at 7.6 million Va. bu. and has continued to drop as well" (Hargis & Haven).

As previously stated, the first laws to manage stocks of oysters in Virginia occurred in 1811 when the Virginia legislature outlawed dredging. This would be the start of 180 years of rules and regulations that all too often were made on the basis of economic pressures rather than the leading scientific evidence at the times. Maryland too would encounter these scenarios and today faces many of the same problems as Virginia. Since the late 1890's, biologists have been calling for more restrictive measures in an attempt to help conserve stocks and preserve a way of life. Unfortunately, there was simply too much money to be made and most people still operated under the principle that the seas could never be deplenished of their huge resources. Throughout the 20th century, biologists have continued to try a get more restricted rules and regulations to help protect this resource. This was to be of no avail unfortunately. The oyster industries of Virginia and Maryland were extremely well organized and usually managed to get the results they wished from politicians. Finally after 180 years of overfishing and continual mismanagement, the oyster beds of the Virginia portion of the Chesapeake Bay crashed and no one knows if they will ever recover.

Maryland has yet to have the same complete collapse of the fishery, but only barely. This can be tied to the fact that Maryland has engaged in replanting shells on oyster beds for many years and have also transplanted many seed oysters to the public grounds. This is a practice that both states now employ. After the close of oyster season, dredge boats are employed by their respective states to go and fish on grounds designated for seed oysters. These grounds tend to be extremely fertile and often close to overcrowded. The dredgers remove small oysters (one to two inches) and transplant them to the public grounds so that they can replenish the beds. The theory behind this is very good and has been proven scientifically. Unfortunately this is not the answer to the problem, but rather an extension of the inevitable. By seeding these beds yearly you allow them a chance to grow market-sized oysters, unfortunately most of these will be harvested before they have a chance to reproduce.

Conclusion

It is unfortunate that it has taken a crash of an industry to bring attention to the fact that oysters are being overfished and that strict management practices, while recommended for hundreds of years, have gone unheard and unheeded. Will we ever see a return to historical numbers by the oyster? Better yet, will we ever have enough oysters out there to begin the harvest of native Chesapeake Bay oysters for sale to anyone? These are difficult questions to answer and ones that have more than one possible outcome. One can only hope that we will see oysters return to the levels of our forefathers. The main point that people must remember for this is that regulations managing catch, bycatch and culling need to be strictly enforced and followed. There needs to be some way of limiting the numbers harvested, either by a quota or by having a limited entry into the fishery. Also more efforts should be made in the private field of aquaculture to help produce oysters for market. Since 1895, scientists have had the ability to spawn oysters, yet they have met furious opposition from waterman when they attempt to promote private culture of oysters. Hopefully, we will all be able to accept the paradigm shift that is occurring to the people that live on and around the Bay, and work together to help return the Bay to her former self.

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Ecological Effects of Harvesting Menhaden (*Brevoortia tyrannus, Brevoortia patronus*)

Jason K. Restein

Menhaden are a very unique species that establish massive schools. They migrate long distances and represent a large economic and ecological staple of the environment. Menhaden are members of the Clupeidae family of fishes. They are relatively unique Clupeids, characterized by pectinated scales, large heads, no teeth (past juveniles) and their dorsal fin is located in the middle of the pelvic and anal fins (Ahrenholz 1991) (See cover page). The vast majority of species are filter-feeding primary consumers or secondary consumers preying on phytoplankton and zooplankton (Vaughn 1991). They represent a fairly large prey niche in many environments. The two species of menhaden that I will be focusing on are the large-scaled menhaden's, *Brevoortia tyrannus* (Atlantic Menhaden) and *Brevoortia patronus* (Gulf Menhaden). There is a purse-seine reduction fishery, involving Gulf Menhaden and Atlantic Menhaden, which are used in the production of fish meal and fish oil (Ahrenholz 1991). According to Vaughn (1991), menhaden reduction fisheries made up approximately 40 percent of all United States commercial landings during the 1980's.

Menhaden are a large marine migratory species that is solely estuarine dependent (Ahrenholz 1991). Usually, spawning takes place during the cooler months of the year in marine environments where larvae undergo some early stages of growth out at sea (Ahrenholz 1991). Following about 1-2 months later, the larvae begin to move near shore towards estuarine bays, sounds and streams (Ahrenholz 1991). In the majority of cases the young of year menhaden stay in these areas until the fall, which is when they start to migrate towards marine waters (Ahrenholz 1991). Most adults can be found in large estuarine areas where their massive schools are often exploited. (i.e.: Chesapeake Bay).

Impacts on Aquatic Life: Importance of Menhaden as Consumers

Menhaden have had a large affect on ecosystems as consumers in the past as well as in the present. Atlantic menhaden have been observed feeding from the larval stages, through the juvenile stages and into the adult stage (Ahrenholz 1991). It has been found that food selectivity changes as the menhaden grow (Ahrenholz 1991). Gulf menhaden during the larval stage feed mainly on phytoplankton and possibly some zooplankton, whereas the larger larvae forage mainly on zooplankton (Ahrenholz 1991). Following metamorphosis, their adult lives are spent as filter feeding omnivores (Ahrenholz 1991).

Impacts on Aquatic Life: Importance of Menhaden as Forage

Menhaden present their most massive effect on ecosystems as forage fish. According to Frye (1978), menhaden seemingly have "one purpose", which is to be eaten. They exhibit the three main characteristics of the ideal forage fish. They are prolific, harmless and edible throughout life (Ney 1999). Menhaden are potential prey the second they are born, from the larval stage to the adult stage. Also, menhaden have been known to prey upon their own eggs (Ahrenholz 1991). Furthermore, there is an extremely wide range of piscivorous fishes and larvae that prey upon menhaden and menhaden larvae. In the ocean, there are an increased number of invertebrate predators seeking larval menhaden. Their list of predators is large containing chaetognaths, jellyfish, squid, ctenophores, striped bass, some mammals' etc (Clements 1990). Most of the predators of menhaden prey upon the menhaden in an opportunistic pattern (Ahrenholz 1991). Menhaden are the main crop of some fishes diet during harsh parts of the year, because menhaden have historically been more abundant in comparison to other species. Although this may have been true in the past, this may not be true for the future.

Increasing striped bass populations combined with commercial harvesting of menhaden may have the potential to cause a decline in menhaden populations (Atlantic States Marine Fisheries Commission 1998). As stated by the Atlantic States Marine Fisheries commission (1998), "Atlantic menhaden are an extremely important link in the coastal marine food chain, transferring enormous amounts of nutrients into forage biomass and at the same time, improving water quality in the Chesapeake Bay. No other fish has the capability to replace this unique species that can filter the plankton from more than a million gallons of water in 180 days." Extensive ecosystem studies and management is necessary to ensure a positive future for Atlantic menhaden. As illustrated above, menhaden create a foundation that other fisheries and we as a society depend upon.

Harvesting of Menhaden: Ecological Effects

Menhaden form massive schools, making them extremely vulnerable to human predation. Large purse seines are used to capture schools of menhaden, which have been located by sonar. Unfortunately, as with other fisheries, the purse seines do not select only for menhaden. Therefore, every species harvested in addition to menhaden, is bycatch. According to Kirkley (1995), bycatch is the unintentional harvesting of species other than those directly being sought by a fishing operation. Unfortunately, this definition does not indicate the extreme strain that commercial bycatch can place on an ecosystem. Croaker, spot, bluefish, spanish mackerel and many other recreational fishes are readily victims of bycatch (Kirkley 1995, Condrey, Anglin & Rester 1996). In August 1992, a study on bycatch revealed that over seven thousand pounds of marine species were victims of bycatch in solely the month of August 1992 (See Table 1) (Kirkley 1992).

Management/ Regulations on Menhaden Harvesting

Article 2, 28.2-408 of the Laws of Virginia Relating to The Marine Resources of The Commonwealth, 1992 edition states, "It is unlawful to take, catch or round up with purse net, for any purpose, food fish in an amount greater than one percent of the whole catch. If food fish represent more than one percent of the whole catch, the net shall be opened immediately and the food fish released while alive (Kirkley 1995)."In addition, this Article states, "It is unlawful for any vessel licensed for the purpose of menhaden fishing to catch any food fish for the purpose of marketing; for any person to have in his possession food fish in an amount greater than one percent of the bulk for the purpose of manufacturing them into fertilizer, fish meal, or oil; or for any person to use in any manner any food fish, in an amount greater than one percent of the bulk for the purpose of fertilizing or improving the soil (Kirkley 1995)." The above Virginia regulation concerning bycatch is explicit, but very difficult to regulate.

The only way bycatch can actually be regulated is by regulating the possession of bycatch. Although dead bycatch is commonly discarded. In most cases, it is impossible to estimate bycatch until the entire harvest is culled, meaning that the bycatch species have already perished. Another factor of menhaden fishing that is rarely scathed, is the large number of marine vertebrates and invertebrate injuries that occur during a harvest (Alverson et al. 1994). Of course it would be nearly impossible to determine injuries that occur among bycatch species, but it is important to decrease the amount of bycatch falling victim to menhaden harvesting. A recent study by the Virginia Institute of Marine Science (VIMS) indicated that bycatch in the menhaden industry totaled two percent of the total catch (See Table 1) (Kirkley 1995). Two-percent of the catch may not seem like a lot of bycatch but when the total catch of menhaden for a month exceeds 960,000 pounds, then two-percent bycatch is a large amount (Kirkley 1995).

Prognosis

Throughout the past and in the future, harvesting menhaden will surely affect aquatic ecosystems. Menhaden are important as food fish, forage for other fish, as consumers in the ecosystem and as baitfish. Therefore there will be a continued demand for menhaden in the future. When considering management options for bycatch in the future, there are 4 management objectives of which to abide. These include: avoid extinction of species, retain the basic structure and function of the ecosystem, rebuild depleting populations and control increasing populations (Hall 1995). Even though some of the numbers of bycatch are astonishing, bycatch currently, according to todays' research methods, is not a serious problem. A 1992 study by Kirkley indicated that the percent of bycatch relative to the entire bycatch was below the legal limit of one percent in 1992. Also, another study on "By-catch And The Fishery For Atlantic Menhaden, in the Mid-Atlantic Bight (Chesapeake Bay and Mid-Atlantic Coastal area) was much lower than the 1 percent legal limit (Austin 1994). Although many studies reveal that the menhaden commercial fishery is not being overharvested and bycatch is not exceeding 1 percent of total catch, it will be important to minimize the negative ecological effects on ecosystems due to menhaden harvesting.

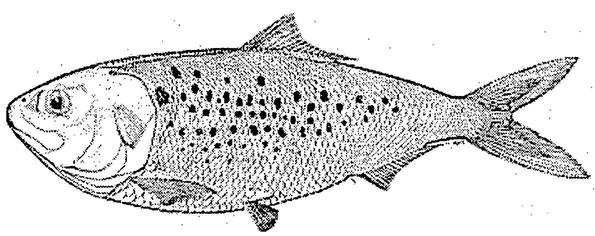
Table 1. Bycatch in the menhaden fishery in terms of numbers and weight, August 1992
Table by Kirkley 1995.

Species	Numbers	Average Size (in.)	Average Weight. (lb.s)	Total Weight (lb.s)
Blue crabs	119	3.54	0.133	15.83
Bluefish	801	13.95	1.18	945.56
Butterfish	141	5.91	0.183	25.79
Croaker	507	8.4	0.257	130.3
Cownose rays	148	16.54	12.235	1810.72
Summer flounder	71	7.48	0.132	9.37
Harvest fish	124	5.02	1	124
Hog choker	472	4.72	0.144	68.19
Lady crab	0			
Oyster toad	0			
Sandbar shark	51	30	6.7	341.7
Silver perch	0			
Spanish mackeral	1144	26.33	3.167	3622.7
Spider crab	49	1.97	0.5	24.5
Spot	46	7.49	0.183	8.42
Squid	126	2.76	0.039	4.93
Striped Bass	0			
Thread herring	95	6.26	0.1	95
Seatrout	220	8.99	0.196	43
Witch flounder	0			
Total bycatch	**4114**		**1.767**	**7270.01**
Menhaden	1,433,000		0.67	960,110.00
Percent of Bycatch:				
Total bycatch	0.29			0.76
Food fish	0.23			0.51

Current regulations concerning menhaden vary up and down the east coast. Today, as illustrated above, menhaden are not severely threatened. The menhaden fishery will remain stable if we continue to practice good management on the ecosystem. It may be important in the future to mold management objectives to smaller regions, producing a greater localized affect that can be observed within the fishery as well as the ecosystem. Also, new regulations may be formed to allow bycatch to be kept rather than discarded (multi-species fisheries), to reduce the wasting of natural resources.

Conclusion

So as you can see, menhaden harvesting affects the ecosystem in many ways. Menhaden harvesting reduces the amount of forage in an estuarine system, reduces the amount of phytoplankton/zooplankton consumption and other species are subject to bycatch. It is important for fish managers to focus on the menhaden fishery and the surrounding ecosystem. Not only for the benefit of the menhaden fishery, but also to ensure a positive future for the entire ecosystem. More importantly, as a benefit for the human race. A definition of fisheries management reads, "the manipulation of aquatic organisms, aquatic environments and their human users to produce sustained and ever increasing benefits to people" (Nielsen 1993). Our goal is to coexist with the menhaden while still producing sustained and ever-increasing benefits to people. As stated by Dr. Steven Murawski, chief population dynamicist for the National Marine Fisheries Service, "We are now seeing a more significant allocation of resources towards ecosystem sciences (University of Alaska 1996). Since fisheries management has changed its focus to ecosystems rather than individual species, it has enabled fisheries managers to understand the influence menhaden have on estuarine ecosystems and the importance of managing this species for the future.



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Chesapeake Blue Crab: Interagency Cooperation is Essential to Fishery Health

Robert N. Dail

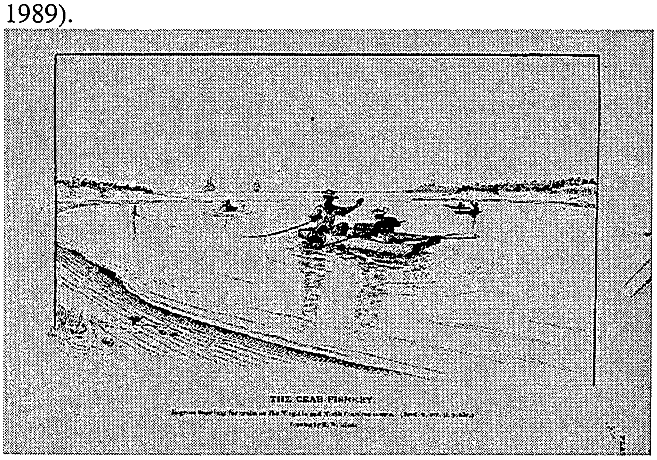
The Chesapeake Bay, one of the most productive estuarine systems in the world, has seen several economically important fisheries collapse in the recent past. The oyster and striped bass (Before intensive management) are just two examples. Many experts believe that the Blue Crab (Callinectes Sapidus) fishery is the next to meet this fate and believe that aggressive management is needed. Others are convinced that there is no danger for collapse of the fishery and that excessive regulations will only hurt the economy of an area dependent on this fishery. Opinions vary from agency to agency and from state to state. There seems to be little consensus on how to deal with this issue. While both sides fight on how two manage this fishery, will the final looser be the blue crab? Or will cooperation between agencies provide the ecosystem-wide management that is necessary to manage this fishery?

Importance

The blue crab fishery provides the most valuable crop harvested from the Chesapeake Bay. Every year between 75 and 90 million pounds of blue crabs are harvested; bringing in an average of one dollar per pound at the docks. This accounts for 70 percent of the value of the food fish taken from the bay every year(Abbe and Stagg 1996). This is a large amount of money but it only accounts for the price at the docks of commercial harvest. The total benefit to the economies surrounding the bay from the harvest and sale of blue crabs is much higher. In addition to this commercial harvest, the Chesapeake Bay has a large recreational blue crab fishery. Given the economic importance of this fishery, it is little wonder why great concern is being raised over some recent studies indicating that CPUE for blue crabs in the bay is declining and crab abundance is down.

Biology of the Blue Crab

The Blue Crab uses the Chesapeake Bay throughout its life cycle. Females release young in the high-salinity water near the mouth of the bay. These young are transported passively from the mouth of the bay into the estuary. The immature blue crabs migrate molt and mature within the bay nursery using submerged aquatic vegetation as cover (Street 1999). Adults then forage and mate in the estuary. When females mature they migrate back to the mouth of the bay to release their fertilized eggs(Caddy 1989).


THE CRAB FISHERY.

Problems With the Fishery

Although the blue crab is a very important and abundant organism, little is known about its ecology or biology. Until recent years, even basic information on the blue crab was not known. Even the life span of the blue crab was an educated guess at best. Managers in Virginia and Maryland, the two main stakeholders in the system, relied only upon CPUE and a winter dredge to help judge management needs(Leffler 1996). This lack of information above everything else has lead to divergent management practices and disjointed regulations in Virginia and Maryland. The blue crab fishery obviously bridges both states and problems with the fishery will not be resolved until there is cooperation between both states.

Past Studies

Blue crab populations in the bay have a highly spasmodic cycle. They are influenced by many factors such as winds, currents, disease, and fishing pressure. Recent studies indicate that landings are not increasing with effort. This has lead scientist to believe that it was fishing pressure that influenced this decline in harvesting success(Abbe Stagg 1996).

Other causes have been postulated however, for the fisheries decline. A three- year study was conducted to determine the prevalence of disease in blue crabs overwintering in the Maryland portions of the Chesapeake Bay. This study found that many of the crabs exhibited nodal formation and other indications of stress. Parasites that were identified included viruses, bacteria microsporidians, hyperparasitized trematode metacercariae, nemerteans and gregarines(Messick 1992). Another study, proposes using a modified ricker method of stock recruitment to account for environmentally induced variation in recruitment. Significant factors used in this method include radiant energy, streamflow and salinity(Tang 1985). Most studies however, have focused on the effects of catch on the blue crab populations with little weight given to the other factors that obviously affect the abundance of the blue crab in the bay.

One of the major studies that has been used as an indication for the overfishing of the blue crab fishery is a study by George Abbe and Cluney Stagg. Samples were taken in Calvert county, Maryland from 1968 to 1995. It was found that from 1969-1982 the annual male ratio has decreased from 66% to 38%. This ratio has not varied much since 1983 however. The mean carapace width and weight of males have both significantly decreased. And percent of legal catch has had it's three lowest years since 1992. The percent of legal males dropped from 56% in 1968 to a low of 13% in 1994.(Abbe and Stagg 1996) This trend toward less legal males may indicate that the males are being removed soon after they become legal. With fewer legal males available, females may receive more pressure, which may

Another study conducted by Rom Lipcius, a crab researcher at the Virginia Institute of Marine Science studied catch during the peak spawning months in the lower bay from 1989 to 1998. Lipcius and the staff at the Virginia Institute of Marine Science forund that from 1989 to 1992 the average catch netted 175 grams of adult females per trap. From 1994 to 1998 however, that average fell to 55 grams using the same gear and techniques(Virginia Pilot 1999). This study indicates a great reduction in the numbers of females in the lower bay during peak spawning times.

Government Actions

Annual monitoring of the bay-wide blue crab populations in 1995 indicated that crab populations had plummeted 34 percent in the previous five years. Maryland acted quickly imposing a set of temporary crabbing restrictions in the fall of 1995(Leffler 1996). This begn to draw public attention to the state of the crab population. Virginia followed in 1996 by limiting the number of pots that could be used in the bay and it's tributaries. The action was essentially frivolous in Virginia however, since it almost immediately began to issue hardship permits. These permits allow watermen that have been affected by the regulations to put in more pots. Hardship permits were granted for 15,000 extra pots in one month alone(Virginia pilot). It is easy to see that this knee-jerk legislation did nothing to improve the condition of the fishery.

To gain more information on the state of the crab population, the Chesapeake Bay Stock Assessment Committee or (CBSAC) of the Maryland DNR was formed in 1996. This three-state partnership announced that it recommended restoring underwater grass beds to provide shelter for young crabs. The grasses are an important component in the life cycle of the crab, and once covered 600.000 acres in the bay. Today they cover only 60,000. The partnership which includes Maryland, Pennsylvania, Virginia, Washington D.C. And the U.S. Environmental Protection Agency will also conduct stock assessment of the blue crab fishery(Blackenship 1999).

Controversy

In 1997 the Chesapeake Bay Stock Assessment Committee completed it's first stock assessment of the Blue Crab populations in the Chesapeake Bay. The committee decided that there was no overexploitation of the Blue Crab in the bay(Blackenship 1999). This conclusion was in direct contradiction to many opinions held by the scientific community. The previous studies by Abbe, George and Stagg had concluded differently, as had Rom Lipcius and the staff of the Virginia Institute of Marine Science. Collection of data by different persons using different gear in different areas has lead to much confusion over the true state of the fishery and vastly differing opinions on management options.

Conclusion

The controversy between experts is one of the largest dangers to the blue crab fishery today. With so many interests and so few concrete answers, it is necessary for inter-agency cooperation. Until this year their has been little of this cooperation. Maryland and Virginia had different legislation based on different expert opinion. The blue crab fishery must be managed as one fishery not two.

Beginning in March of this year The Chesapeake Bay Stock Assessment Committee has agreed on a two year moratorium on new regulations of the crab fishery pending further study. During this "cooling off period" scientists from a diverse section of constituents will discuss not only the stock size but other factors influencing management objectives such as social and economic issues(Blackenship 1999). This cooperation should lead for the first time to a clear, holistic view of the fishery stock and condition. It will also, hopefully, eliminate poor management decisions based on instantaneous reaction as seen in 1996 and 1997.

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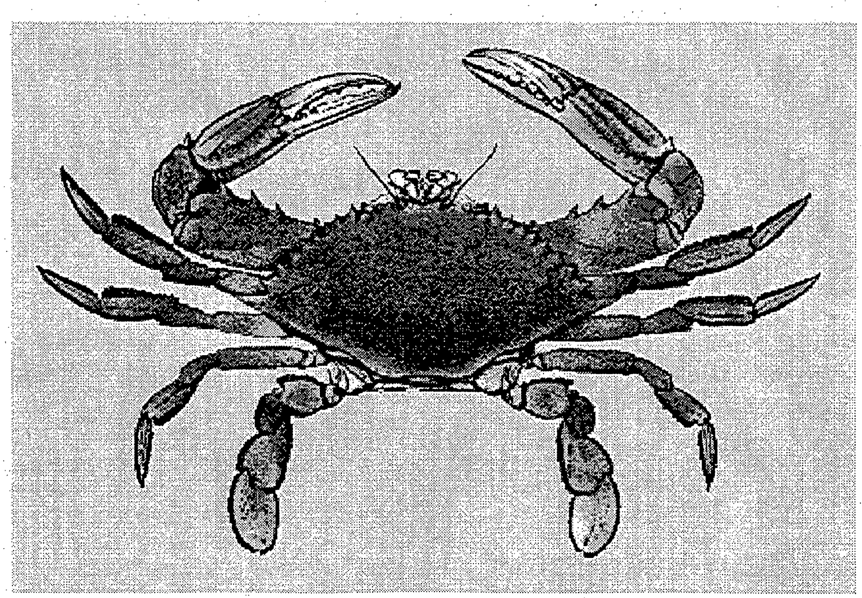

Declining Marine Fish Stocks

Atlantic Cod: Learning the Hard Way

Pete Lewis

Introduction

In one generation Americans and Canadians have seen the rise, decline, and collapse of the Atlantic cod commercial fishery. Now fish biologists working with government officials are left to reestablish these populations, in order to resume a fishing industry for cod in both countries. The following document will provide a background of the cod fishery that will lead to the reasons the fishery collapsed, and outline the lessons that can be learned from this great tragedy.

Background

Once the cod fishery had collapsed fishermen and biologists alike were left searching for an explanation to justify the collapse. Study after study has been conducted to prove that ecological changes of the environment caused the collapse. Fingers have been pointed to many ecological factors that include; cooling water temperatures, changes in water salinity, and shifting predator-prey relationships, that include a controversial theory that an expanding cod-eating population of seals are suppressing cod numbers. Although some ecological changes may have played small roles in the collapse, the bottom line is overfishing is to blame. A brief look into the background of the commercial cod fishery paints this vividly clear picture.

The Atlantic cod has had a rich history along the coasts of Newfoundland, Canada and the New England states of the U.S. Settlers were attracted to the rich coasts as far back as the late 1400's. The cod were plentiful and for hundreds of years provided the settlers not only with food, but also with the basis of an industry. This industry grew to new heights, during the late 1800's, as more efficient fishing techniques were being used.

During the late 1800's, fisherman had switched from conventional handlines to more efficient longlines and cod traps (Kunzig 1995). Longlines were ropes that stretched up to a mile in length with 100's of hooks that would lie on the bottom for hours before being cranked aboard. These techniques brought the annual catch to upwards of 60,000 tons off the coast of New England in 1895 (Kunzig 1995). With inefficient means of mass harvest, the cod survived the first four centuries without any substantial loss to the overall population. However, at the turn of the century as technology advanced, the cods' fate would change.

In the early 1900's, the first American and Canadian trawlers sailed into the North Atlantic fishing grounds. These ships used otter trawls, which are 150 to 200 foot long nets shaped like windsocks. Large wooden planks called otter boards are attached to both sides of the mouth, in order to keep the mouth of the net open as it is drug along the ocean floor sweeping fish into the closed end (Kunzig 1995). As early as 1914, committee appointed by the U.S. Commissioner of Fisheries reported that the trawlers were already causing declines of fish in the North Sea, however the department took no measures to curtail activity in the U.S. to prevent similar declines (Kunzig 1995). By the early 1960's Europeans' were using factory trawlers that were able to catch, process, and keep fish fresh allowing them to stay at sea for days at a time. In fact, one factory ship could catch as much cod in one hour as one ship could catch in year during the sixteenth century. These European factory trawlers invaded the Grand Banks of Newfoundland and George's Banks of New England in the early 1960's. This was the beginning of the end (tripling the catch total of 1954 by 1968) as these ships hunted and ravaged the cod 365 days a year until 1977 (Sierra 1995). In 1977, with enough pressure from local fisherman, the U.S. and Canada imposed a 200-mile limit off their shores that would not let foreign vessels within 200 miles of their shores (Sierra 1995). This decision would allow Canadian and U.S. fisherman to catch cod in a sustainable manner allowing the population to recover in these rich fishing grounds. The idea of sustainable catch allowing the populations to recover, was only that an idea. Between 1977 and 1983, the fishing boats leaving New England ports nearly doubled from 825 to 1,423 (Kunzig 1995). Likewise the Canadian government wanted a modern domestic seafood industry so much, they subsidized high tech hunts and also had a stake in two private fishing corporations (Sierra 1995). By 1985, a study by Myers and Hutchings (Nature 1997) already proposed that the cod population was not growing at all and in fact it was beginning to slide.

From this point, the decisions made regarding the cod were made on a political basis. Despite pressure from inshore fisherman and scientists alike, Canadian and U.S. governments failed to curtail any offshore trawling activities. Into the late 1980's cod populations dropped substantially, so fishermen fished that much harder and longer to maintain the high harvest they were accustomed too. Despite this fact the governments did not insert any regulations, fearing job losses (Kenzig 1995).

Current Status

In 1992, the Atlantic cod industry in Canada hit rock bottom, and the government had to completely close the open season on cod. This decision put 40,000 people out of work and shut down Newfoundland's largest industry (Nature 1997). The U.S. on the other hand still had a little time to learn from Canada's mistake, but it did not. The year 1994 marked the close of the open cod season off New England coasts, causing the New England economy losses up to $125 million (Kenzig 1995). The exploitation of these spawning grounds has driven cod reproduce at earlier ages and smaller sizes (Trippel 1995). Spawning at smaller sizes means producing fewer eggs. On average a cod releases around 370,000 eggs but in the years before overfishing it would not be uncommon for an adult female to release up to 3.2 million eggs (Science News 1995). By reproducing at smaller sizes and younger ages overfishing has caused significantly smaller recruitment classes. Another key factor related to overfishing of cod is that they have given up dominance on the banks becoming prey to skates, dogfishs, and seals, however no one knows how this will affect the cod (Kenzig 1995).

Now, six years later how have cod populations taken to the recovery process? To address the problems of the Atlantic fishery, the Canadian government has formed the Fisheries Resource Conservation Council to research against stock collapse and measures to reach sustainable yields in the future. The United States Fishery Management Councils and the National Marine Fisheries Service have developed similar plans to prevent collapse and to replenish stocks (Trippel 1995). As far as the cod populations current status, there is no real sign of recovery. Current projections for cod remain negative, with the prospect of cod recovery worsening since the government closed the fishery in 1992, suggesting the closure will remain for years to come (1996 online). In addition, a three-year study by Canadian Dr. Kim Bell determined that the Atlantic cod population as a whole was endangered, however this report has been disputed (Canadian Geographic 1997). Also providing evidence of no substantial recovery was found in Canada in 1994 and then again three years later when short cod seasons were opened. In 1994, a fishery was opened for four weeks in Newfoundland so fisherman could catch and freeze fish for their families. Many fishermen realized just how few cod there were and returned to port after a few days (Sierra 1995). Three years later, a two-month quota of 16,000 tons of cod was given to 5,500 fisherman; they reach the quota in just three days (Canadian Geographic 1995). Putting a number on just how many cod are left has become an extremely hard task since numbers have plunged so low. One study that seems to be the most accurate estimates the spawning biomass of Atlantic cod to be below 20,000 tons. As recent as a few decades ago this number exceeded a million tons (Smedbol et al. 1996). This is the harsh reality that overfishing has caused the Atlantic cod populations and forced fish biologist to begin putting the pieces of the puzzle back together.

Lesson to be Learned

By examining the picture of the collapsed Atlantic cod fishery in both the United States and Canada many valuable lessons can be learned. It has been documented by scientific information that the cause of the cod collapse was do to overexploitation. Amid scientific information warning of a collapse, why was this fishery allowed to continue to be overexploited? After examining this case study of this collapse (the first of its magnitude in history) the answer appears all to clear, politics. Although many lessons have been taken from this complex collapse, all of them stem from the political decisions made over the past fifty years. In both countries pressure was put on politicians to allow the fishery to continue with only insignificant restrictions placed on total allowable catch. The decision making officials completely ignored many scientific warnings that biologist presented to them. A great example of this came when Mr. John Crosbie then Trade Minister of Canada said it would be demented to reduce catch quotas. Crosbie went on to say that he was the person that had to deal with economic, social, and cultural effects that reduced quotas bring, not the biologist (1996 online). The ignorance of these officials became evident as their decisions lead to a complete collapse of a fishery and industry that caused thousands of jobs along with the only way of life many had ever known.

The cod fishery has awakened the public to the fact that political decisions must not be compromised when science has proven that a fishery may be in jeopardy. Now politicians must open their ears to science and not allow deep-pocketed influences to destroy not only resources but also people's livelihoods.

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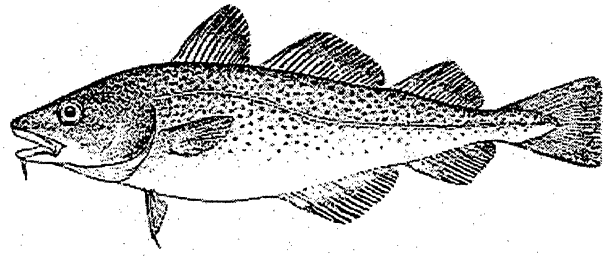

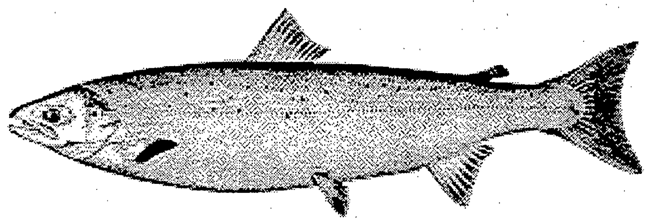

Atlantic Salmon Aquaculture Practices, Controversy,and the Need for Regulation

Jeremy Bendler

The capture fisheries of the world are being harvested at close to their maximum sustainable yield (Chamberlain 1995), but the demand for food on the world wide level is rising. One capture fishery that is in trouble is the wild Atlantic salmon, (*Salmo solar*). In Nova Scotia escapements of salmon were less that conservation requirements (Sealane 1996). This means that these populations have been harvested to below levels at which they can sustain themselves naturally. In order to fill the harvest requirements for Atlantic salmon and provide job security and stability for the seafood industry serious management actions must be taken. These actions may include among other things the aquaculture of Atlantic salmon. There are two common methods of salmon aquaculture, net-pen and salmon ranching. The problem of declining Atlantic salmon populations does not stop at borders and can not be ignored by any country with a vested interest in commercial salmon harvest, or even salmon consumption. The U. S. for the most part has fallen behind or is lacking in programs to promote, manage and regulate aquaculture as an alternative to wild harvest.

A Need for Aquaculture in the U. S.

Atlantic salmon is the species most commonly farmed world wide due to market preferences and cost advantages (BCESAO 1998). Currently there is a growing number of salmon aquaculture facilities in the United States and throughout the world (Hansen et al 1997). On a global scale, however, the U. S. produces a low percentage of the total farm raised Atlantic salmon. Maine is number one in production of farm raised salmon in the U. S. (ASM 1999), and should take the lead in promotion of aquaculture and encouragement of other coastal states to follow their example. Aquaculture accounted for 17% of the world's fisheries in 1993 and the percentage is rising. The United Nations predicts that in the year 2010 that aquaculture will account for 35% of total world fish supply for human consumption (BCESAO 1998). As influential as the U. S. is in world economies, there is a definite need for the promotion of aquaculture on a national level. Farm raised salmon help to augment the demand for flesh in grocery stores and in restaurants. Farm raised salmon currently account for one third of all salmon harvested worldwide (BCESAO 1998). Aquaculture can be an effective strategy in the revitalization of rural and coastal economies while preserving the environment, natural fisheries and natural resources (NADP 1996).

Farm raised salmon often escape their confinements and join the wild stocks (Hansen et al 1997). It has been suggested by Lund et al that 30 to 40% of the overall marine catch of Atlantic salmon in some years is of escaped farm raised origin (1991). This statistic makes it obvious that aquaculture plays an important role in the Atlantic salmon capture fishery, even if the role is unintentional. Hatcheries are the cornerstone of enhancement programs, and have been for over a hundred years (Ritter 1997). Enhancement programs which use farm raised salmon help to restore and rehabilitate existing salmon stocks, colonize new habitat, compensate for environmental disturbances, and foster research and development of new techniques (Ritter 1997). Enhancement programs are necessary in cases of habitat degradation of spawning grounds or in a case of commercial over harvest. The farm raising of salmon also gives scientists greater insight into their biology (Ritter, 1997). This greater knowledge base will help to protect the native salmon stocks in the future, as well as make aquaculture techniques more efficient.

Salmon Ranching vs. Net-Pen Aquaculture

There are two common aquaculture techniques employed in the raising of Atlantic salmon for commercial harvest. They are salmon ranching and the net-pen method. In salmon ranching the salmon are raised to smolts or pre adults and then released into the wild on the premise that they will return to the hatchery stream in 2 –5 years as full grown adults, in expectation of breeding, and can be harvested. In the net-pen method fish are raised in cages which are in their natural habitats, from young to adults (Stickney 1988). Net pen aquaculture, while more labor intensive is the more effective and efficient method o Atlantic salmon aquaculture.

Salmon Ranching

Salmon ranching introduces many fish, freely, into the environment, which bolsters the capture fishery, but there are many adverse effects that an increased number of salmon will have on the ecosystem (Ritter, 1997). On a smaller individual level the introduction of farm raised salmon for ranching operations may cause reduced genetic diversity and reduced population fitness (Ritter, 1997). This has huge implications to the future health of native salmon stocks. If farm raised salmon are less adept at finding food in the wild or are not as successful at spawning compared to the native stocks then what will happen when the farm raised genes are integrated into the population. Beveridge says that the protection of biodiversity is essential from the aquaculturists point of view (1997).. The effects of aquaculture on biodiversity may be indirect, such as the degradation of habitat and the reduction of available niche spaces or direct, as in the introduction of exotic genes into the native gene pool (Beveridge, 1997). Adaptations to the genetic stock of a certain run of salmon may be extremely harmful, resulting in weakened fitness, productivity, and local characteristics. Some of these changes may be advantageous for anglers but they tend to reduce population fitness and productivity (McGinnity, 1997). It is common, however, for escapes or non-returns from hatcheries to occur. In Nova Scotia rivers, aquaculture escapees may have contributed 49.1% of egg deposition in 1995 (Sealane 1996).

Net-Pen Aquaculture --There are many positive aspects of net-pen aquaculture. This is why marine based net pens are the only aquaculture system presently employed by commercial salmon farms in British Columbia marine areas (BCESAO 1999). The typical farm is a hectare or less and comprises several pens, each a few meters long and several meters deep (Stickney 1988). The harvest is more consistent, than with other methods, due to a high level of control associated with penning the fish into known and constant locations, and is not dependant on spawning runs, as traditional capture fisheries are. Instead net-pen aquaculture provides a year round harvest. Harvest is also easy in cage aquaculture, not requiring a commercial fishing fleet, saving time and money. With these savings the final product is produced at prices competitive with the price of commercially harvested, or ranched salmon. The net-pen raised product sells for a higher price because of higher quality flesh. Due to artificial selection methods net-pen salmon are more disease resistant and grow faster than wild salmon (ASOM 1999). Net-pen operations are also advantageous because they offer low startup and operating costs, ease of operation, and options for immediate expansion (BCESAO 1998).

Commercial Fishermen's View

Commercial salmon fishermen have developed a strong antagonism towards net-pen salmon aquaculture both in the United States and Canada. Many commercial fishermen see net-pen aquaculture as a direct threat to their very existence. Commercial fishermen feel that net-pen aquaculture may alleviate the need for the commercial industry as happened with the channel catfish (*Ictalurus punctatus*) (Stickney 1998). In this way the net-pen aquaculture poses a direct threat to the fishermen's livelihood, unlike ranching which enhances their catch (Hansen 1997). The fishermen may feel that the aquaculture of salmon will cause a glut on the market and drive prices down, but in reality, if both fisheries are properly managed, there will be no excess production (Stickney 1988). To further the debate many say that the quality of net-pen raised salmon is superior to that of captured salmon, and the cultured salmon may bring more than twice the price of the captured fish (Stickney, 1988). So capitalism wins because it economically more beneficial to raise Atlantic salmon through net-pen aquaculture than it is to enter a capture fishery.

How to Regulate U.S. Aquaculture -- Management Context

American aquaculture isn't just about fish farming, regulation, or aquatic animal health; its about cooperation between industry, government and academia (APHIS 1997). The U. S. currently produces about 1% of all harvested Atlantic salmon. This virtually insignificant role of the U. S. in Atlantic salmon production may be due in part to the cumbersome and obstacle strewn permitting process. It would take an a net-pen aquaculture facility of only 32 hectares to produce an amount of Atlantic salmon equal to the amount imported to the U. S. from Norway each year. The heavy lobbying of the commercial fishing industry also helps to keep aquacultural potential rather unrealized in the U. S. (Stickney 1988). The principal goal of the U. S. aquaculture development shall be to improve the international competitiveness and sustainability of our aquaculture industry. The United States is far behind the progress of other nations in their development of a strategic plan concerning aquaculture. Foreign governments, especially in Europe, are dissatisfied with the U. S. aquatic health infrastructure, and tend not to purchase U. S. exports (NADP 1996). If properly implemented, regulated, and financed, domestic production of salmon should provide a positive economic influence for all U. S. citizens, including existing commercial fishermen (Stickney 1988).

The United States may follow the lead of other countries in regards to sound and practical hatchery and aquaculture regulations. In Norway many commercial fishermen are also fish farmers (Stickney 1988). In British Columbia the federal government regulates the food, drugs, health of fish in aquaculture facilities, protection of wild stocks, and navigable waters. In BC aquaculture facilities and practices are guided and regulated by the health of animals act, feeds act, food and drug act, pest control products act, and the like (BCESAO 1998). In order to become a recognizable and respected player in the world marked for aquaculture products the U. S. government must implement a strategic plan for federal action, involving federal institutions, academic institutions and partners in the private sector. Steps have been taken in the right direction for management and regulation of the aquaculture industry. At the Animal and Plant Health Inspection Service Aquaculture Roundtable USDA officials and the aquaculture industry came together to form a plan for future cooperation. This type of cooperation is critical, along with federal funding and research (NAPD 1996) if the U. S. plans to be a significant player in the world aquaculture of Atlantic salmon.

Conclusions

The future looks bright for aquaculture. Traditionally captured salmon are only available seasonally, but in today's market people want fresh seafood all year round (Stickney, 1988). Per capita seafood consumption has been steadily rising since 1969 but the commercial harvest reached a plateau in 1989. If the world population continues to grow at the current rate and fish consumption remains the same then where will the fish come from to meet the increasing demand...Aquaculture. Commercial fishermen feel that net-pen aquaculture is in direct competition with their livelihood. Is there a place for commercially captured Atlantic salmon harvest fisheries in the future? There surely will be but it will only be with the help of aquaculture that the fishery will not collapse. Could the capture fisheries form a cooperative with the salmon aquaculturists, or are they on their own. Much can be gained through cooperation of farmers and commercial fishermen, such as the development of stronger lobbying groups, and common processing and marketing strategies (Stickney 1988). The fate of some commercial fishermen may be in question but with the help of well managed, promoted, and regulated net-pen aquaculture there will be a sustainable harvest of Atlantic salmon for consumers in the future. The government must intervene and consider net-pen aquaculture as a viable solution to the current problem of depleted Atlantic salmon stocks.

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The Industry Collapse of the Patagonian Toothfish

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Abstract

In the present state of the world's fisheries, where 60 percent of 200 major fisheries have either plateaued or are in decline, long-range fleets sail to ever more remote places in search of expansive fish stocks (Darby, 1998). One fish stock that is being exploited is that of the Patagonian toothfish (*Dissostichus eleginoides*). The sustainability of the Patagonian toothfish is being severely threatened by illegal and unregulated fishing in the Southern Ocean despite very little knowledge of the species. It has been suggested that if harvest continues at the current rates, the Patagonian toothfish can be fished for only another two to three years (New Zealand, 1999). This instance is a primary example of how a fishery can most inevitably collapse without proper management.

Introduction

Increased fishing pressure has led to the development of long-range fleets capable of remaining at sea for several months and exploiting both international waters and offshore waters belonging to other nations (Coggan, 1996). "Advances in gear technology now enable such vessels to exploit deeper water and there is a growing interest in deep-sea fisheries throughout the world" (Coggan, 1996:300).

Dissostichus is one such deep-sea species that commands high prices in Japan and America. It lives on the edge of the continental shelves of the South Atlantic (Pearce, 1996) and is named for its razor-sharp teeth (CSIRO, 1997). It can live at depths of 3,500 meters, reach the age of 50 and grow to 2.2 meters (New Zealand, 1999). Already, stocks around South Africa's sub-Antarctic Prince Edward and Marion Islands have collapsed as a result of poaching (Hordern, 1999). Last year some 60,000 tons worth about $100 million, were traded, according to New Zealand officials (New Zealand, 1999). And an illegal catch of toothfish is estimated by the Federal Government at 114,000 tons, worth over $500 million, during the years of 1997 and 1998 (Darby, 1998). This population is being exploited mainly by North Atlantic fishermen-dubbed the Vikings by Alistair Graham – and by Latin Americans he calls the Spanish Armada (Darby, 1998). "Caught by long-liners-vessels that pay out dozens of long lines, each with up to 10,000 baited hooks" (Pearce, 1996:14), it is feared that the Southern Ocean will soon be fished out as well as causing devastating effects on seabirds, which often die while trying to take the longliners' bait (New Zealand, 1999). It is estimated that tens of thousands of seabirds are killed annually, including endangered species of albatross (Hogarth, 1999).

Regulation

Patagonian toothfish are currently being caught in three places: off Argentina, off South Georgia, and around the Falklands (Pearce, 1996). Various countries are trying to regulate the toothfish industry. And they have begun, in recent years, to perform much needed research.

The Falkand Islands Government (FIG) regulates the area of the Patagonian shelf around the Falkand Islands (Coggan, 1996). "Growing concerns for the conservation of stocks led them to introduce the 150 nautical mile Falklands Interim Conservation Zone (FICZ) in February 1987, within which fishing effort has been limited to about 200 vessels per year from 600 vessels in previous years" (Coggan, 1996:298). The Fisheries Department of the FIG licenses regulates and monitors fishing within the FICZ area. The Department now holds a wealth of data on fish but data on deep-water fish are rare and limited mostly to samples collected on commercial long-liners. "In 1996, the Fisheries Department of the FIG took the opportunity to grant an application by a local fishing agent to license a vessel for a short-period of exploratory deep-sea fishing and, at the agent's invitation, to place observers on the vessel" (Coggan, 1996:300). Twenty-two deep-water stations to the east and south of the Falkland Islands were sampled by commercial bottom trawl deployed in upper, middle and lower benthopelagic zones. After the study was conducted, several notable trends were established in regard to the Patagonian toothfish. The study showed that length-frequency analyses revealed a tendency for larger individuals to inhabit deeper water. *Dissostichus eleginoides* was the least abundant in the mid-depth zone, to the east of the Falkland archipelago. "Juveniles are caught commonly as bycatch in demersal fisheries targeting squid and fin-fish in depths less than 200 meters over the Patagonian shelf" (Coggan, 1996:309). Smaller *D. eleginoides* comprised a significant portion of the catches from the upper benthopelagic zone. This means that it is possible that any fishery exploiting this zone could adversely affect recruitment to the deeper, adult stocks. The low abundance found in the mid-benthopelagic zone may reflect trends in the geographical rather than depth distribution of this species (Coggan, 1996).

Fishing carried out in the Antarctic is regulated by the conservation measures of the Hobart-based Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR) (Hordern, 1999 and Australian, 1998). "A deep-water demersal long-line fishery for the Patagonian toothfish has been established in CCAMLR Subarea 48.3 (South Georgia) since 1989" (Parkes, 1996:56). Vessels from the former Soviet Union dominated the fishery for the first three years. Since the start of the 1991/92 season vessels from Chile, Bulgaria, and the Republic of Korea and Argentina have entered the fishery. CCAMLR has given a high priority to the scientific assessment and sustainable development of the longline fishery. However, the effect of this fishery on this species is hard to assess. "Particular problems that have been encountered include a lack of detailed data from the early years of the fishery, differences in catchability between vessels due to differences in fishing method, and changes in hook type" (Parkes, 1996:56). There is also a considerable amount of uncertainty concerning the stock structure of *D. eloginoides* in Subarea 48.3. Since 1991 assessments by the CCAMLR Working Group on Fish Stock Assessment (WG-FSA), of the status of the toothfish fishery, have been based on attempts to estimate local abundance using a Leslie depletion model. However, the overwhelming indication from analyses is that the model is too simple and there is too much residual variance for it to be applied effectively to the local-scale longline catch and effort data in the studies conducted over the period of 1992 to 1994 (Parkes, 1996).

Enforcement

Enforcement of the regulations protecting the Patagonian toothfish industry is very difficult. The country of South Georgia has learned this first-hand. South Georgia is a dependent territory of the British government (Pearce, 1996). Although there is no formal link with the Falklands, which is also a dependent territory, in practice South Georgia is largely administered from the Falklands. The government of South Georgia first issued licenses to catch toothfish in its waters in 1993. But despite set catch limits, pirates set their lines throughout the year. And even though passing vessels in 1995 saw nine pirate vessels, only one was apprehended. This is because it is very difficult to prove that the boats are fishing. Most captains claim they were lost, broken down or just passing through. And most vessels are spotted by military planes and ships serving the South Georgia garrison, which makes it even more difficult since they have so far refused to become involved in policing fisheries (Pearce, 1996). "In theory, Britain has recourse to the convention members, which include the main nations fishing in the Southern Ocean" (Pearce, 1996:15). But CCAMLR only requires countries to report possible infringements of fishing rules to the "flag states" of the ships that are then responsible for taking disciplinary action. And many states do not perform their disciplinary duties. However, steps are being taken to enforce these regulations. In 1996, the UN agreed a treaty on conservation of international fisheries that encourages regional fisheries organizations such as the CCAMLR to introduce tougher enforcement regimes. And soon after, Britain pushed for formal prior notification of all ship movements in the CCAMLR region. Australia and New Zealand backed using satellites to keep track of ships. The Foreign Office has stated that if the South Georgia government had a fisheries protection vessel of their own, the laws could better been enforced. And regular patrolling using the Cordella, a Falklands fishing patrol vessel hired by the South Georgian government, is too expensive (Pearce, 1996).

Australia has made many significant steps towards managing enforcement better also. The Australian Antarctic

Division has monitored catch and effort of the fishery since it began in 1994, and has collected information on bycatch and biology (CSIRO, 1999). Beginning in 1996, Australia has welcomed action by Norway to prevent Norwegians from poaching Patagonian toothfish (Australian, 1998). The Australian government prohibits fishing vessels with Norwegian interests, which are participating in unregulated and illegal fishing in the Antarctic Ocean and elsewhere under flags of convenience, from obtaining quotas or licenses to fish in Norwegian waters (Australian, 1998). Its government also calls on other countries whose nationals operate under flags of convenience to follow the lead of Norway and take steps towards deterring such activity by their nationals (Australian, 1998).

The various actions that Australia, the Falkland Islands and South Georgia are taking are very hopeful. However, more development needs to occur. Many states still do not control their registered vessels. The Chileans have done a lot in the way of enforcement, but some Chilean long-liners have now re-registered as Argentinian vessels (Pearce, 1996). This is because prosecutions are rare here. The Argentinian government claims that its fishing ships may be passing through the South Georgian waters, though it is less clear about where they are going. And Argentina and Chile both said that new tougher enforcement schemes would infringe their "right of free passage" in the Southern Ocean. Many people in the South Georgian area believe the crucial factor in Britain's reluctance to police the waters of South Georgia is political (Pearce, 1996). Unfortunately, this problem may be difficult to fix.

Conclusion

The Patagonian toothfish decline is just one example of many fish population exploitations. There are various reasons for these population collapses. As a result of increased fishing pressure, long-range fleets have been made that are capable of exploiting the deeper waters of both international waters and offshore waters belonging to other nations. And we know very little about the population structures and life patterns of the deep-water species caught by these vessels. The fact that no one knows how many toothfish live in the South Atlantic or how fas they reproduce is a perfect example of this. Consequently, more research may be needed in order to assess these problems more specifically, and stricter more enhanced regulations can follow. Another major problem deals with regulation. The Patagonian toothfish is being severely threatened largely because of illegal and unregulated fishing in the Southern Ocean where it is found. And the responsible countries have found regulating the industry extremely difficult. This is due to that fact that many states do not perform the disciplinary duties they are responsible for. And it is very difficult to prove that a pirate boat is fishing, once they are seen.

In order to continue using fish as a valuable resource, management must be planned, enacted and enforced. Countries must communicate and unite in their creation and enforcement of a management strategy. And most importantly, we must be responsible in our actions and utilization of the resources we are so fortunate to have available. If we do not do these things, there will soon be no resources left for us to use. Finally, the industry of the Patagonian toothfish is a clear example of how a fishery can easily and almost undoubtedly collapse without proper management and regulation.

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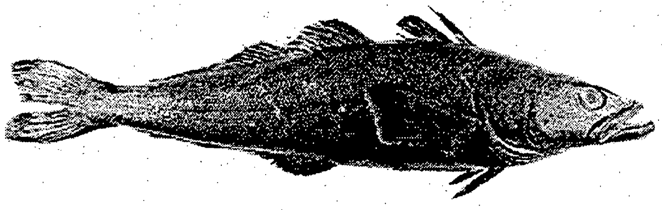

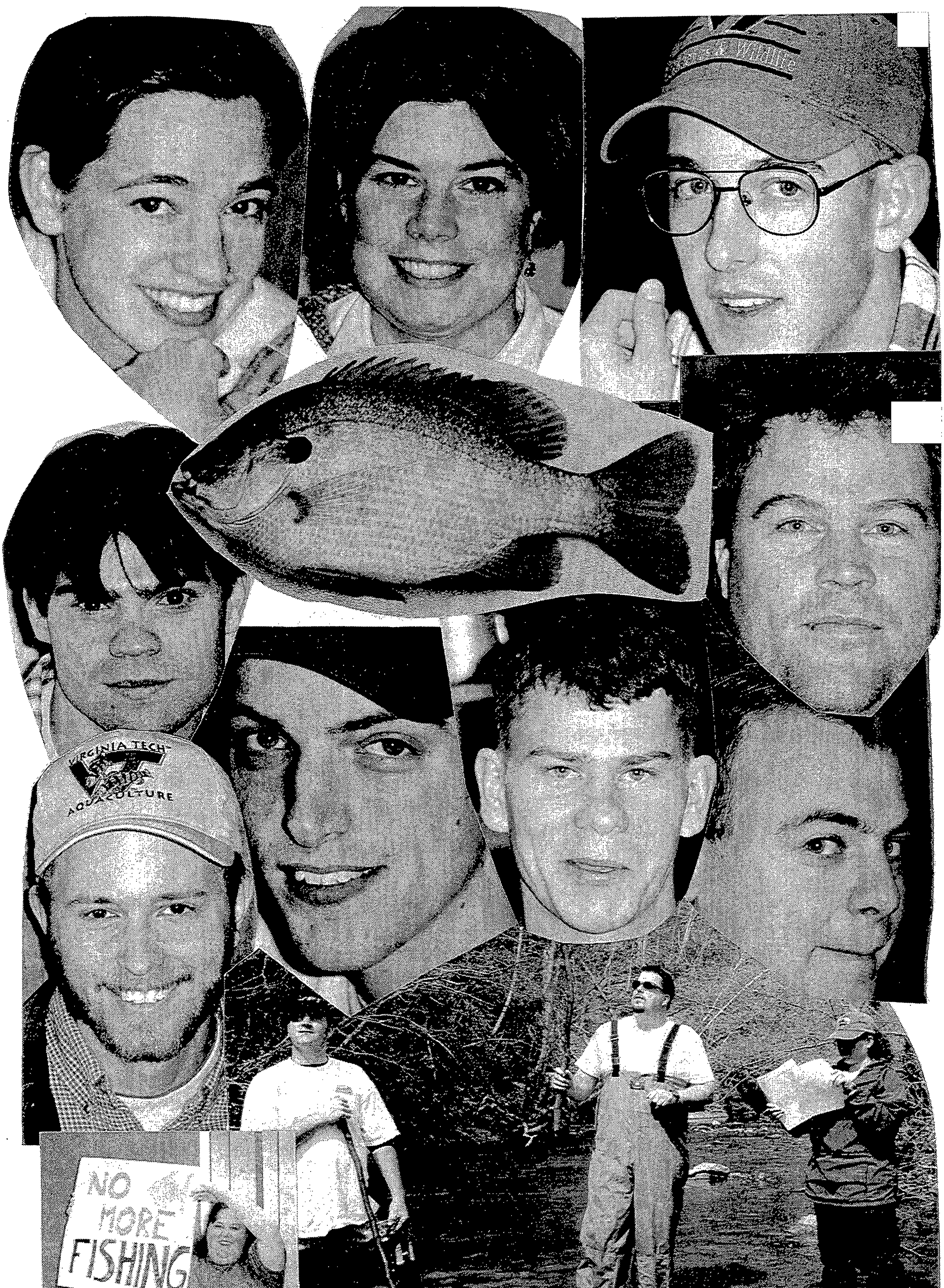
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