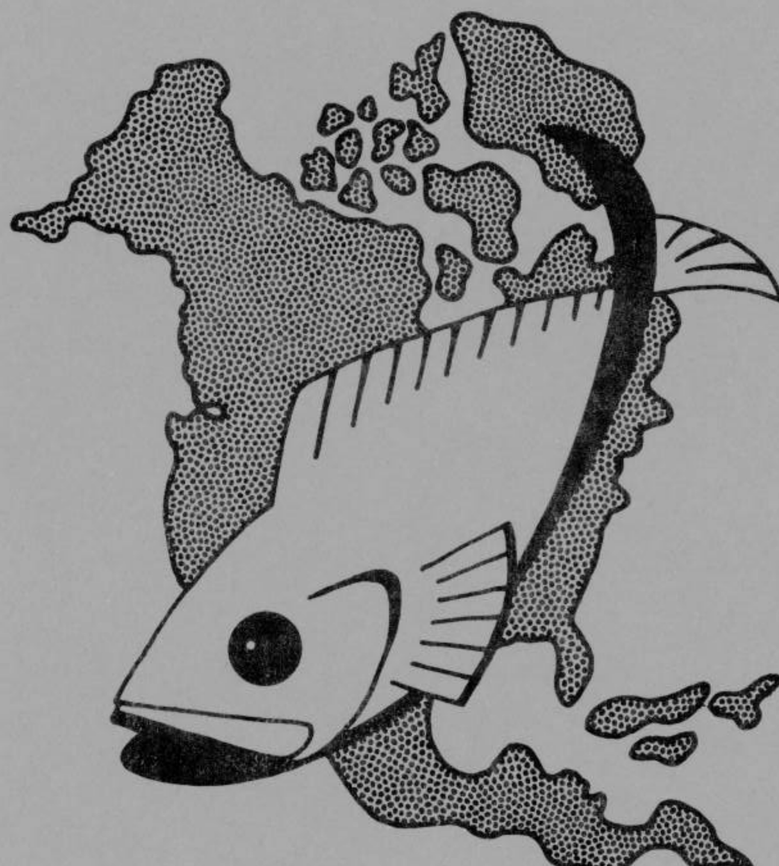
ANNUAL PROCEEDINGS
of the
TEXAS CHAPTER
AMERICAN FISHERIES SOCIETY



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ANNUAL PROCEEDINGS OF THE TEXAS CHAPTER
AMERICAN FISHERIES SOCIETY

October 4 & 5, 1985

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In addition, personal contributions were made by the following individuals:

WAYNE BOYD
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ROBERT NITSCH
Ballinger, Texas

1985 OUTSTANDING FISHERY WORKER AWARDS

There were two recipients of the 1985 Outstanding Fishery Worker Award from the Texas Chapter. The recipient in the Research Category was

Dr. Connie R. Arnold
Aquaculture Laboratory
University of Texas Marine Science Institute
Port Aransas, Texas

Connie Arnold received his Ph.D. in Chemical Oceanography from Texas A&M University in 1968. From 1968 to 1971 he worked with the National Marine Fisheries Service in Narragansett, Rhode Island. While there he was the first person to spawn scup, tautog, winter flounder and Atlantic cod. Dr. Arnold moved back to Texas in 1971. From 1972 to 1977 he worked at the National Marine Fisheries Service laboratory in Port Aransas. During that time he was the first person to spawn spotted seatrout, red drum, southern flounder, Atlantic croaker and red snapper. The University of Texas Marine Science Institute took over the laboratory in 1977 and Dr. Arnold is currently Director of the Aquaculture Laboratory there. He has published 41 papers in scientific journals. For his outstanding accomplishments in the reproductive biology of fishes and his successful spawning of numerous species through the alteration of photoperiod, temperature and internal hormones, the Texas Chapter presented this award.

The recipient in the Education Category was

Dr. Donald E. Wohlschlag
University of Texas Marine Science Institute
Port Aransas, Texas

Donald Wohlschlag received his Ph.D. in Zoology from Indiana University in 1949. From 1949 to 1965 he was Professor at Stanford University. In 1965 Dr. Wohlschlag moved to Texas. From 1965 to 1970 he served as both Director and Professor at the University of Texas Marine Science Institute in Port Aransas. In 1970 he gave up the directorship to devote his full attention to teaching and research. He served as Professor of Zoology and Marine Science from 1970 to 1985. Through 1983 he had published 97 articles in scientific journals and books. Throughout his career he has served on numerous committees and commissions and edited papers for numerous journals. For his valuable contributions to the many thousands of scientists he has helped to educate, the Texas Chapter presented this award.

INTRODUCTION

by

Gary Valentine
United States Department of Agriculture
Soil Conservation Service
Temple, Texas 76501

ABSTRACT

The issue of aquatic vegetation can most appropriately be viewed as two-sided. Sometimes it is a nuisance; sometimes it is beneficial. The fishery biologist managing for sport fish will see it as beneficial, at least up to a point. The commercial catfish farmer or bait producer will probably regard it as a nuisance. The waterfowl manager will probably view it as beneficial, especially if species consist primarily of southern naiad or one of the pondweeds (Potamogeton spp.).

Very often the relationship between aquatic vegetation and managers' goals vary on the same body of water. For example, on a given pond, the waterfowl manager may want large areas of shallow water with dense stands of aquatic vegetation, or recommend summer drawdowns followed by planting of Japanese millet and fall inundation. The fishery manager, on the other hand, may want to deepen the shoreline, enter a fertilization program, or recommend winter drawdowns.

PERSPECTIVES AND PROBLEMS FOR THE SMALL POND OWNER

by

Jim Davis
Texas Agricultural Extension Service
College Station, Texas 77843

ABSTRACT

For most small pond owners there are three kinds of aquatic plants: scum, moss and weeds. Scum includes all the algae; moss includes all submergent vegetation; weeds includes emergent vegetation, usually along the bank. The most common reasons for building ponds are 1) livestock watering, 2) erosion control, 3) property appreciation, 4) waterfowl hunting and 5) bird watching. Fishing is not included in the list because for most small pond owners, fishing was not the original reason for constructing the pond. Aquatic plant control on ponds built for livestock watering must consider the welfare of the livestock. Most erosion control ponds start out muddy, but then the landowners clear up the water and develop an aquatic vegetation problem. In these cases, livestock welfare is usually not very important. Any aquatic vegetation in property appreciation ponds is too much. Owners of waterfowl hunting ponds usually encourage aquatic vegetation growth, especially pondweeds and duck potato. Owners of ponds built for bird watching want aquatic vegetation along the edge but not in the middle. Once fish become established in almost any small pond, the pond owner does not want to jeopardize their welfare for the sake of vegetation control.

Regardless of the original reason for building small ponds, if a vegetation problem occurs, 1) it will usually be expensive to control and 2) control will have limited effectiveness over time.

VEGETATION PROBLEMS IN URBAN DEVELOPMENTS

by

Mac McCune
Lake Management Services
Richmond, Texas 77469

ABSTRACT

There are basically two types of urban development impoundments: 1) residential and 2) corporate. In either case, any aquatic vegetation is considered an eye sore. Of primary concern is the desire to avoid getting into an expensive maintenance nightmare. Fish are of virtually no concern. Common problematic aquatic vegetation types include lilies, floating pondweeds, primrose, coontail, bushy pondweed and plankton. Aquatic vegetation problems are often magnified in urban developments because of the formal landscaping and planting and associated heavy nutrient loading the waters receive. One of the best ways to minimize aquatic vegetation growth is to incorporate structures into the initial design of impoundments such as bulkheads and aprons of soil cement that suppress marginal vegetation. Another scheme involves installation of planter boxes which provide a controlled environment for specific vegetation types. The basic problem in most urban settings is that the developers want clear water to enhance property values and aesthetics, but not the aquatic vegetation that inevitably comes with the clear water.

POWER GENERATION AND VEGETATION

by

Dan Gipson
Gulf States Utilities
Willis, Texas 77378

ABSTRACT

Lewis Creek Reservoir is a 1,000-acre power plant cooling reservoir located just west of Willis, Texas. It was impounded in 1970. Hydrilla was first noticed in the reservoir in 1978 but did not present any problems at that time. In fact, in 1978 and 1979 Hydrilla appeared to filter the water circulating through the power plant. In 1980, annual (July-August) die-offs of Hydrilla began which resulted in large masses of the vegetation entering the intake structures. This required tremendous physical removal efforts by virtually all power plant personnel at a time of the year when peak demands occur. In 1981, a mechanical harvester was employed but Hydrilla spread faster than it could be harvested. In 1983, Lewis Creek Reservoir was stocked with 22,000 grass carp. By 1984 virtually all aquatic vegetation in the reservoir was gone; it still is.

RECREATIONAL VALUES AND VEGETATION

by

Ike Barrett
San Jacinto River Authority
Conroe, Texas 77305

ABSTRACT

Lake Conroe is a 21,000-acre reservoir located on the West Fork of the San Jacinto River near Conroe, Texas. The reservoir was constructed by the San Jacinto River Authority in 1970 in cooperation with the City of Houston as a water supply reservoir with a storage capacity of 430,000 acre-feet. The lake was completed and filled in 1973.

Hydrilla was first observed in Lake Conroe in 1975. Research was immediately initiated to try to develop control measures using chemicals and mechanical harvesting. Neither was successful. In addition to land developments around the lake, recreational uses include fishing, swimming, boating, hunting and bird watching. Continued growth of _Hydrilla_ adversely affected virtually all segments of water-related recreation. This resulted in formation of the Lake Conroe Association. This organization spent in excess of $100,000 a year for chemicals alone. This enabled control in only 300-400 acres of the 8,000-9,000 acres infested with _Hydrilla_ at a cost of more than $100/acre. Marina operators were especially hurt by the _Hydrilla_ problem, as were the land developers. Grass carp were introduced into Lake Conroe in 1981 and the aquatic vegetation problem was eliminated.

VEGETATION AND RESERVOIR SPORTFISH PRODUCTION

by

William Provine
Texas Parks and Wildlife Department
San Angelo, Texas 76904

ABSTRACT[1]

Survey data from 30 Texas reservoirs, collected between 1976 and 1978 as part of the Dingell-Johnson Reservoir Management Project, were analyzed to determine which factors affected largemouth bass (Micropterus salmoides) standing crops and their recruitment to harvestable size. A highly significant, positive relationship ($P < 0.01$) was found between percent submerged vegetation (up to 20%) and both the standing crop of largemouth bass and numbers being recruited to harvestable size. The relationship seemed to be linear within the range of values observed. Any reduction in submerged vegetation below 20% of the total lake coverage resulted in a decrease in recruitment and standing crop of largemouth bass. Conversely, to increase standing crop and recruitment of largemouth bass more than 10 in long in reservoirs having little or no cover, a program to increase submerged vegetation either through introductions or water-level manipulation should be implemented.

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1 Durocher, P.P., W.C. Provine, and J.E. Kraai. 1984. Relationship between abundance of largemouth bass and submerged vegetation in Texas reservoirs. North American Journal of Fisheries Management 4:84-88.

LAKE CONROE: FISH COMMUNITY RESPONSES

by

Robert Betsill
Texas A&M University
College Station, Texas 77843

ABSTRACT

In 1981, aquatic vegetation on Lake Conroe, mainly <u>Hydrilla</u>, had increased to cover over 45% of the lake's surface, extending out to about the 20-foot depth contour. The fish community at that time was characterized by 1) numerous small fish, 2) fairly slow growth, 3) lower shad densities than in other reservoirs in the area, 4) slower largemouth bass growth than the statewide average and 5) very large and diverse sunfish populations.

Grass carp were introduced into Lake Conroe in 1981 and by 1983 virtually all submerged vegetation had been removed from the reservoir, resulting in tremendous changes in the fish community. Both gizzard and threadfin shad densities increased sharply. Most sunfishes declined, with longear sunfish being the notable exception. The most pronounced declines were noted for the vegetation-dependent species such as dollar, spotted, bantam and pygmy sunfishes. Most minnows increased dramatically. Channel catfish increased from 3/hectare in 1983 to well over 400/hectare in 1985. White bass populations showed a tremendous increase, probably as a result of increased shad availability. Standing crops of largemouth bass remained surprisingly constant, although following vegetation removal, growth rates increased substantially and the bass population was characterized by fewer, larger fish.

PANEL DISCUSSION
QUESTION AND ANSWER SESSION

Q: WHAT CHEMICALS DO YOU USE FOR AQUATIC VEGETATION CONTROL?

A (McCune): Basically, we use all of the approved aquatic herbicides and algacides. We probably use more algacide, both granular and liquid, than anything else. Probably next on the list would be granular herbicide such as Aquathol (2,4-D). We also use a lot of lake dye such as Aquashade. Lake dye has proven to be a good management tool for slowing down aquatic vegetation, primarily by limiting sunlight. With it you can still expect some marginal vegetation, but in 4- to 6-foot depths, we have used it to virtually eliminate aquatic vegetation.

Q: AT WHAT APPLICATION RATES DO YOU RECOMMEND USE OF LAKE DYE?

A (McCune): We use it at the manufacturer's recommended rate of 1 gallon/4 acre-feet. Lake dye has two main uses. The first is to slow down or control aquatic vegetation and the second is to sell property. So, whether the water has vegetation or not we use a lot of lake dye, simply to color the water, because people associate clean water with the color blue. A normal application will last 3-4 months in the Houston area, depending on dilution factors such as rainfall. There have been some studies that have shown lake dye definitely retards plankton development, so its use should be of some concern where fisheries are involved. Further research is needed in this area.

Q: HOW WELL DOES THE LEGAL GRASS CARP X BIGHEAD CARP HYBRID WORK ON AQUATIC VEGETATION?

A (Davis): Generally speaking, in the studies we have conducted and those in Florida, the hybrid grass carp has proved relatively ineffective for the control of aquatic vegetation. We have gone as high as four times the stocking rate for regular grass carp without getting any control. In one particular study, they stocked 140 hybrids/acre without any effect on Eurasian water milfoil, which is normally easy to control with regular grass carp. This is not to say they won't ever work, but to date, in Texas, we have not had any success in the control of aquatic vegetation with hybrid grass carp.

Q: WHAT DID <u>HYDRILLA</u> DO TO THE COOLING CAPACITY OF LEWIS CREEK RESERVOIR?

A (Gipson): The <u>Hydrilla</u> did not affect the cooling capacity of the reservoir. Only when the plants broke loose and came into the intake screens was the plant affected.

Q: THEN THERE WERE NO NET CHANGES IN INTAKE TEMPERATURES DURING THE TIME OF <u>HYDRILLA</u> INFESTATION AND <u>HYDRILLA</u> REMOVAL?

A (Gipson): That is correct. We never noticed any differences in temperatures.

Q: WAS FISHING PRESSURE INVERSELY CORRELATED TO THE AMOUNT OF VEGETATION? DOES THIS NOT LIMIT RECREATION?

A (Provine): I don't know, but with the amount of vegetation coverage we looked at, I doubt fishing pressure would have been adversely affected at all. There's got to be a point where aquatic vegetation would limit recreation, but it wasn't in any of the reservoirs we looked at. Possibly on Lake Conroe this was the case, but it's not in reservoirs with 20% coverage.

Q: WOULD SIZE OF THE RESERVOIR HAVE ANYTHING TO DO WITH THIS?

A (Provine): I think both size and shape would have a lot to do with the effects of aquatic vegetation coverage because of the amount of edge available. I could see where 50% coverage in some areas may represent an ideal situation, while 50% in other areas would be very detrimental.

A (Davis): I think that answer is very well taken because both size and shape are important. As one of the papers presented in the Reservoir Proceedings indicated, shoreline development was one of the most important factors affecting recruitment and population levels in largemouth bass.

Q: COULD WE NOT PROTECT BASS FROM ANGLING PREDATION WITH MORE STRICT HARVEST REGULATIONS WITHOUT LIMITING RECREATION?

A (Provine): I think any restrictive regulation, as far as size limits, doesn't necessarily restrict recreation. Size limits do not keep you from catching that fish; they keep you from retaining it. Recreation would not be detrimentally affected unless the major aspect of that recreation was the ability to take something home.

Q: WHAT TRENDS WERE NOTED IN THE AVAILABLE PREY:PREDATOR RATIOS BEFORE AND AFTER GRASS CARP INTRODUCTION INTO LAKE CONROE?

A (Betsill): We have not yet made those analyses. However, I think there is an inherent problem with AP:P ratios in terms of Lake Conroe data. The very dense vegetation means that just because sunfish are present, they aren't necessarily available to bass. Apparently, prior to the introduction of grass carp there was far more prey available for bass than was necessary. Even though following grass carp introduction some of the forage base was lost, the fact that bass relative weights stayed between 95 and 100 suggests there is still adequate forage. Of course, the decline in sunfishes was taken up by increases in shad and other species.

Q: WHAT IS THE PRESENT STATUS OF GRASS CARP IN LAKE CONROE?

A (Betsill): Grass carp were originally stocked at approximately 30/hectare. The lake now probably has 5-10/hectare. Condition factors were down 30-40% 2 years after removal of vegetation; they are probably somewhat lower now. They are currently feeding primarily on terrestrial vegetation that falls into the lake. Even with the loss in condition, they now average about 10 pounds.

Q: SINCE HYDRILLA HAS BEEN ELIMINATED, WHAT ARE THE GRASS CARP EATING IN LAKE CONROE? ARE THEY NOW EATING OTHER FISHES?

A (Betsill): I'm not at all convinced they turn carnivorous. We have yet to see an animal in any of the many stomachs we have examined. Stomach contents are strictly vegetation. Now, with the exception of terrestrial leaves, detritus and bark, most stomachs are empty.

Q: HAS THERE BEEN ANY REGROWTH OF HYDRILLA IN LAKE CONROE?

A (Betsill): I haven't seen any substantial amounts of Hydrilla since it's elimination.

Q: IS THERE ANY RESEARCH TO SUPPORT THE CONTENTION THAT GRASS CARP WILL BECOME CARNIVOROUS UNDER CERTAIN CIRCUMSTANCES?

A (Anonymous): Approximately 130 grass carp stomachs were examined in Florida and what animal matter was eaten was incidental.

A (Davis): With reference to whether or not grass carp will take live bait, I think you need to remember that live bait is quite different from something alive and free in the reservoir. It has been my observation that fishermen on Lake Conroe using live bait at night will catch some grass carp if they can locate a large school of fish.

Q: WHAT IS BASS RECRUITMENT IN LAKE CONROE NOW THAT THE VEGETATION IS GONE?

A (Betsill): According to our seine samples, it appears there is about a 2/3 reduction in the size of year classes since vegetation removal. However, prior to vegetation removal we saw problems in recruitment from age 1 to age 2, which was the time they turned piscivorous. Regarding the earlier discussion about fishing techniques for grass carp, dog food or corn work much better than live bait.

Q: WHAT ABOUT THE DRAMATIC DECLINE IN THE BLUEGILL POPULATION IN LAKE CONROE?

A (Betsill): During peak vegetation abundance, the standing crop of bluegill was about 80 kg/hectare. This represents a tremendous resource that wasn't being utilized by predators. The reason for the decline following vegetation removal was probably a combination of factors: 1) lack of protective cover which increased predation and 2) lack of vegetation for spawning habitat.

Q: WERE THERE ANY CHANGES IN WATER QUALITY FOLLOWING VEGETATION REMOVAL?

A (Betsill): That was one of the first things we noticed very quickly. There was roughly a 40% decline in water clarity, due primarily to the phytoplankton bloom resulting from nutrients being released from vegetation. At the same time phosphate and ammonia levels increased. Oxygen levels during peak vegetation infestation would often go to 0 in some stands of <u>Hydrilla</u>, but since its removal, oxygen levels have remained satisfactory. The elimination of the vegetation occurred over a long enough period of time that no oxygen problems were associated with it.

Q: WHAT WAS THE CHANGE IN WATER CLARITY?

A (Betsill): Transparencies ran up to 2.5 m, generally around 2.0 m prior to vegetation removal. They are now running around 0.9 m.

Q: DID CLAY TURBIDITY HAVE ANY EFFECT ON THE DECREASED TRANSPARENCIES?

A (Betsill): I don't think it did. Trends in chlorophyll <u>a</u> followed transparencies so closely that we feel phytoplankton is the primary causative agent.

Q: AT WHAT POINT IN A BASS' LIFE (AT WHAT SIZE) IS ITS DENSITY MOST IMPORTANT TOWARD RECRUITMENT?

A (Provine): For the 30 lakes we looked at, there were no significant correlations between numbers of small bass and standing crops of bass. But there was a lot of variability in the data. There were numerous reservoirs with relatively high densities of aquatic vegetation and tremendous numbers of young bass, and we originally thought these numbers would carry through (recruit) and yield higher standing crops. But there were enough lakes in the reservoirs we looked at that had low numbers of smaller bass but still recruited sufficiently. I would say it's throughout their life regardless of what the correlations showed, because there was a lot of variability in the data and that variability just happened to fall out when you got to recruitment size, which we called 10 inches.

A (Phil Durocher): You have to remember that these rotenone surveys were conducted in late July, August and September. I believe the effects on recruitment had already occurred during the first three months of summer and its the ability of the young fish to survive that first summer that determines recruitment.

A (Betsill): Regarding the suggestion that recruitment success is determined the first three months of summer, just going with what I saw on Lake Conroe, there was a great reduction in numbers of bass between age 1 and age 2. These fish were not harvestable at age 1; generally they were not harvestable at age 2. Therefore, it appears that reduction would ultimately affect recruitment.

Q: WHAT WAS THE WATER LEVEL DURING THE SPAWNING SEASONS IN LAKE CONROE?

A (Barrett): I don't believe water level fluctuations had any effect on bass spawning. The lake has maintained a surprisingly constant level. We had a maximum drawdown in 1980 of 3.5 feet, but that was in August. During the spring, the lake has always maintained a pretty constant level.

Q: DO YOU ANTICIPATE A MOVEMENT OF THE GRASS CARP TO OTHER WATER SYSTEMS BY OTHER MEANS THAN AUTHORIZED STOCKINGS?

A (Davis): Generally speaking, there are some fish that are illegally being moved out of Lake Conroe to other bodies of water on a regular basis. To be honest, people have seen that grass carp can eliminate vegetation, so they catch some and transport them for that purpose. So, my answer would have to be yes, I would expect so.

Q: DO YOU THINK THE ILLEGAL STATUS OF GRASS CARP WILL CHANGE TO LEGAL IN TEXAS?

A (Provine): It doesn't look like it. Granted, they are very good at eating aquatic vegetation and we have some problems with Hydrilla, but the majority of our public reservoirs appear to have too little vegetation, and it's that majority of public reservoirs that's going to dictate what is legal and illegal. I don't think we're going to legalize a fish that has a reputation for consuming vegetation when our problem is a lack of vegetation. We are charged with managing the sport fishes of this state and we can see a relationship between aquatic vegetation and the abundance of sport fish, so I don't see us detrimentally affecting sport fish, which is what I think we would be doing by legalization of grass carp.

A (Ernest Simmons): Although I cannot speak for the Texas Parks and Wildlife Commission, I have seen no indication that they are likely to liberalize the regulations pertaining to grass carp or triploid grass carp.

A (Clark Hubbs): I think the barn door is open and by 1995 grass carp will be widespread throughout the state. At that time the ban will be irrelevant. The current legislation merely delays the impact.

A (Anonymous): I don't think there's any reason for anyone in this room to believe that grass carp aren't being transported all over this state right now in 1985. The problem of people taking grass carp out of Lake Conroe is nothing compared to how many come in illegally. There is a strong sentiment in the public sector that is pulling these fish into the state like crazy; they resent being told they can't legally get them.

A (McCune): Let's face it, money talks. What's happened is the cost of aquatic herbicides has gotten sky high. Now that people have seen what the grass carp have done on Lake Conroe, they figure it's much cheaper to go over there and catch a few grass carp and transport them to their pond than to pay someone to do it with chemicals. The problem is economic. We appear to be treating the symptom rather than looking for a solution.

Q: ISN'T THE PROBLEM AT LAKE CONROE MINOR COMPARED TO THE IMPORT OF FISH FROM OUT-OF-STATE SOURCES?

A (McCune): That's a very good point. I know a lot of people who will take a weekend trip across the state line to get grass carp. I was using Lake Conroe strictly as an example. And of course, up north they don't ask you what your address is.

Q: IS THERE A STOCKING RATE FOR GRASS CARP THAT WILL GIVE YOU CONTROL WITHOUT ELIMINATING ALL THE VEGETATION?

A (Davis): I wish I could say yes, but realizing every lake is different, when trying to come up with a stocking rate, you're already behind before you get started. At this point, all the information we have would seem to indicate that trying to use a particular number can't be done. It all depends on the nutrient level in the water body. Frankly, we don't know enough to give a particular stocking rate for a particular pond, and based on experience in Florida, I don't see being able to do it in the foreseeable future.

Q: WHAT GEAR DID YOU USE TO SAMPLE CHANNEL CATFISH AND COULD GEAR EFFICIENCY BE AFFECTED BY <u>HYDRILLA</u>?

A (Betsill): We used rotenone, gill nets, seines and electrofishing. I feel like the variety of gears, consistency of effort and intensity of sampling overcame biases associated with the vegetation. The magnitude of the changes I don't feel could be explained by sampling bias alone.

Q: IF THE TEXAS PARKS AND WILDLIFE DEPARTMENT WAS FORCED TO GIVE ONE CLEAR ANSWER ABOUT WHAT THEIR PUBLIC WOULD RATHER HAVE, 1) MORE SMALLER FISH OR 2) FEWER BIGGER FISH, WHAT DO YOU THINK THE ANSWER WOULD BE?

A (Provine): I don't think we should second guess the public. I think we have enough reservoirs in Texas that we can give them both and I think we're trying to strive for that.

Q: FOR SMALL POND, LATE SUMMER TREATMENT WHERE LABOR ISN'T AVAILABLE, WILL BARBED WIRE ANCHORED TO A POST AND PULLED BY A TRACTOR SUCCESSFULLY REMOVE CHARA AND NAIAD, OR OTHER FINE-STEMMED PLANTS?

A (McCune): It depends on what you call successful. You can remove some of it that way. This would certainly reduce the risk of fish kills associated with oxygen depletion. However, you might stir up anoxic bottom sediments in the process, which could cause the problem anyway.

A (Ed Schwille): Control is strictly temporary. You're going to get regeneration immediately after pulling anything through.

A (Davis): Under circumstances where the weed population is so heavy that you are not getting water movement and you're building up bad water on the bottom, it is effective . It is very short term, but you may be able to get enough water movement to get rid of your bad water on the bottom.

Q: WHAT WAS THE PERCENT INCREASE OR DECREASE IN DROWNINGS IN LAKE CONROE SINCE THE VEGETATION DISAPPEARED?

A (Barrett): I have no statistics to answer that.

Q: WHAT DO YOU THINK THE RELATIONSHIP BETWEEN WEED COVER AND BASS STANDING CROP WOULD LOOK LIKE ABOVE 20% SURFACE COVERAGE? WHEN WILL THE EXTENT OF AQUATIC VEGETATION BECOME DETRIMENTAL?

A (Provine): Judging from other papers I've seen, probably somewhere between 36 and 50%. It would depend on both the size and shape of the individual reservoir.

A (Betsill): For Lake Conroe, it's peak vegetation coverage was 45% in 1981. At that time, the bass standing crops were well beyond the critical inflection point in the linear relationship between bass standing crops and vegetation coverage, where standing crops decline. We did not have 20% coverage on Lake Conroe, on the way up or down, long enough to get any measurements. But, in Lake Conroe, 45% was well beyond the point where vegetation coverage becomes detrimental.

Q: WHAT IS THE MECHANISM BY WHICH MACROPHYTES INCREASE BASS STANDING CROPS?

A (Provine): It looks like a big factor is just cover. There have been many reports in the literature showing the relationship between inundated terrestrial cover and increases in bass year classes and I believe that cover, regardless of whether it's terrestrial or aquatic, is certainly one of the key factors.

Q: WHAT WAS THE IMPACT OF THE RECORD COLD SNAP IN 1983 ON AQUATIC PLANT GROWTH IN LAKE CONROE?

A (Barrett): By the time the cold snap occurred, the vegetation had already been removed.

Q: BY CLASSIFYING LAKES BY THE AMOUNT OF VEGETATION COVER ONLY, YOU LUMP MUDDY RESERVOIRS WITH PLANKTON-BASE RESERVOIRS. DO YOU THINK BY LUMPING THESE YOU BIASED PRODUCTIVITY ESTIMATES OF PLANKTON LAKES DOWNWARD WITH THE INHERENTLY LOW READINGS TYPICAL OF MUDDY LAKES?

A (Provine): No, I didn't. Before we looked at these reservoirs, the few very muddy ones were taken out.

Q: WHAT WAS THE IMPACT OF VEGETATION REMOVAL IN LAKE CONROE ON THE DUCK POPULATION?

A (Barrett): We noticed a decrease in the duck population.

Q: DO YOU EXPECT CONTINUED SPAWNING SUCCESS AND ESPECIALLY RECRUITMENT OF LARGEMOUTH BASS IN LAKE CONROE?

A (Betsill): In the spring of 1985 we did see considerable numbers of bass fry, so we know the bass are continuing to spawn. After our 1986 sampling we hopefully will be able to say something definite about recruitment.

Q: WOULD ANY OF THE PROPOSED BASS REGULATION CHANGES APPLY TO LAKE CONROE AND IF SO, WILL THEY AFFECT RECRUITMENT?

A (Ernest Simmons): We (Texas Parks and Wildlife Department) would prefer that no regulation changes take place on Lake Conroe until the experiment is fully concluded.

Q: THE MODEL FOR BASS AND VEGETATION LEVELS CERTAINLY SEEMS REASONABLE ON THE 30 LAKES STUDIED, BUT DO YOU HAVE ANY DATA ON OTHER IMPORTANT GAME SPECIES SUCH AS CATFISH, CRAPPIE OR STRIPED BASS ON THESE 30 LAKES AND HOW THEY RESPOND TO VEGETATION?

A (Provine): No.

Q: WHAT ARE THE PROBLEMS OR POTENTIAL FOR OVERPOPULATION WITH GRASS CARP?

A (Betsill): The numbers of grass carp in Lake Conroe are steadily declining. We have seen no evidence of reproduction either in the reservoir or the San Jacinto River. We do not expect any increases in their numbers.

Q: WHAT WOULD HAPPEN IF BASS FISHERMEN DECIDED TO STOCK HYDRILLA ALL OVER THE STATE?

A (Provine): There was a special law made to stock grass carp in Lake Conroe. We're governed by politicians and I see no reason why pressure wouldn't be brought about to duplicate that situation if another problem resulted. But that's a lot better than doing it statewide.

Q: WHAT WOULD BE THE EFFECT IF HYDRILLA WERE TRANSPLANTED TO WEST TEXAS?

A (Provine): In most of the reservoirs in West Texas, Hydrilla probably would not grow.

Q: DO WE HAVE SUITABLE HA
A (Provine): In most of the reservoirs in West Texas, Hydrilla probably would not grow.

Q: DO WE HAVE SUITABLE HABITAT FOR WIDESPREAD REPRODUCTION OF GRASS CARP IN TEXAS?

A (Clark Hubbs): In Lake Conroe there is not a sufficient length of river upstream to provide for natural reproduction. However, in most of our other major reservoirs there is sufficient river upstream to provide reproductive requirements.

A (Anonymous): Grass carp probably require less flow than striped bass, so most likely anywhere striped bass can spawn would be suitable for grass carp to spawn.

PRELIMINARY RESULTS OF THREE POND CULTURE TRIALS OF RED DRUM

by

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ABSTRACT

Two 0.4-hectare brackish water ponds in Palacios, Texas were stocked with red drum *Sciaenops ocellatus* fingerlings in November 1984 and June 1985 at a rate of 8,750/hectare. The first trial tested the ability of supplementally fed red drum fingerlings to overwinter in ponds. This trial was ended in May 1985 because of 95% overwinter mortality. Mean TL of the surviving fish was 137 mm at the end of the trial. In the second trial, currently in progress, red drum fingerlings stocked in June 1985 are being grown out to marketable size (454 g) on commercial feeds. The mean TL of the fish was 168 mm and mean weight 53.3 g after 3 months of grow out. In the third trial, also currently in progress, 4,000 red drum stocked in June 1985 are being grown out to marketable size on natural forage in a 1.6-hectare freshwater pond in LaWard, Texas. This pond also contains a population of hybrid tilapia. The mean TL of the fish was 113 mm and mean weight 27.8 g after 3.5 months of grow out.

THE *IN VITRO* EFFECTS OF STEROIDS, HUMAN CHORIONIC GONADOTROPIN AND CYANOKETONE ON GERMINAL VESICLE BREAKDOWN OF THE STRIPED MULLET OOCYTES

by

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ABSTRACT

The *in vitro* effects of steroids, human chorionic gonadotropin (HCG) and cyanoketone on germinal vesicle breakdown (GVBD) of striped mullet *Mugil cephalus* oocytes were investigated. All concentrations of HCG (5, 10 and 50 I.U./ml) induced GVBD. 17α,20β-dihydroxy-4-pregnen-3-one (17α,20β -diOH prog) and deoxycorticosterone (DOC) were the most potent steroids in inducing GVBD, and were effective at 10 ng/ml. Progesterone and pregnenolone at the highest concentrations (1 μg/ml) were moderately effective, whereas 17β-estradiol, cortisol and testosterone were only marginally effective in inducing oocyte final maturation. The androgens, 11β-hydroxyandrostenedione and 11-ketotestosterone did not stimulate GVBD. The results indicate C21 hydroxylated steroids are potent inducers of final oocyte maturation in mullet. Further, co-incubations with 17β-estradiol, cortisol and testosterone did not alter the maturation-inducing effects of HCG or 17α,20β -diOH prog. Cyanoketone, a blocker of 3βHSD activity, was only partially effective in blocking GVBD induced by HCG. This suggests that Δ5 (pregnenolone derived) steroids, as well as Δ4 steroids, may be involved in final oocyte maturation in this species.

TECHNIQUES TO AGE AND COMPUTE BACK-CALCULATED LENGTHS FROM LARGEMOUTH BASS AND CRAPPIE OTOLITHS

by

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ABSTRACT

Largemouth bass *Micropterus salmoides* and white and black crappie *Pomoxis annularis* and *P. nigromaculatus* were collected from Texas and Florida lakes to determine the feasibility of using otoliths to age and back-calculate lengths of fish. Otolith annuli were formed once a year between April and June. Generally, young fish formed annuli before older fish during this time period. Crappie age was correctly interpreted to age 9 using whole view examination. Discrepancies between whole and sectioned view annuli counts were only 1%. For largemouth bass, sectioned otolith views gave more reliable ages than whole view examination for fish age 4 and older. Whole view annuli counts underestimated the age of older bass. Coefficient of determination values indicated otolith radius measured in whole view was a better predictor of fish length than sectioned otolith radius for bass and white crappie. Thus, back-calculating fish length may be less precise if section views are used. Incorporation of logarithmic transformation to the Fraser-Lee equation computed accurate back-calculated lengths when compared to other methods.

COMPARATIVE TOXICITY OF NITRITE TO FRESHWATER FISHES

by

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ABSTRACT

The primary purpose of this study was to determine the toxicity of nitrite to several species of freshwater fishes and to investigate the underlying physiological mechanisms which account for differential toxicity among species. Green sunfish Lepomis cyanellus was the most resistant species studied while channel catfish Ictalurus punctatus was the least resistant. Ninety-six-hour median lethal concentrations correlated significantly with both the percentage of hemoglobin in the methemoglobin form and plasma nitrite concentrations among species. Plasma nitrite levels also correlated significantly with percent methemoglobin. Environmental chloride did not increase the tolerance of largemouth bass Micropterus salmoides to nitrite toxicity as it did for channel catfish. These results indicate plasma nitrite concentrations determine the toxicity of nitrite to fishes. Further, plasma nitrite concentrations in various species depend on the discriminatory ability of the active transport system in fish gills which ordinarily transports chloride ions.

FECUNDITY DETERMINATIONS IN SPOTTED SEATROUT, A MULTIPLE SPAWNING FISH

by

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ABSTRACT

Spotted seatrout Cynoscion nebulosus has a protracted spawning season from April through September in South Texas. Frequency analysis of oocyte diameters revealed that oocyte growth is asynchronous, with no distinct modes of maturing oocytes. However, in 75% of the fish analyzed, a distinct batch of full grown or hydrated oocytes could be discerned. Fecundity of this batch of oocytes ranged from 130,000 to 795,000 oocytes (average 348,000), and showed no correlation with fish size or month of the spawning season. In contrast, the total number of oocytes and the number of growing oocytes were significantly correlated with standard length. However, the total number of oocytes did not decrease during the spawning season (average number 8,490,000). Similarly, the number of growing oocytes was not significantly different in April, May or August (average number 3,200,000), although there was a significant mid-summer decrease in June and July. These data show the difficulty of determining total annual fecundity, or the number of eggs a female will spawn during the reproductive season, in a multiple spawning fish such as spotted seatrout. To obtain a better estimate of total annual fecundity, spawning frequency was determined by the percentage of spawning fish captured during the spawning season. Twelve to 40% of the fish captured during each month were spawning. However, only spawning grounds were sampled, which may result in an overestimate of spawning frequency. From this data, it was estimated that spotted seatrout may spawn as many as 60 batches of eggs in one reproductive season, resulting in a possible annual fecundity of 20,000,000 eggs per female.

GROWTH AND SURVIVAL OF GRASS CARP AND GRASS CARP ♀ X BIGHEAD CARP ♂ F_1 HYBRIDS IN A TEXAS COOLING RESERVOIR

by

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ABSTRACT

Grass carp *Ctenopharyngodon idella* and grass carp x bighead carp F_1 hybrids (*C. idella* ♀ x *Hypophthalmichthys nobilis* ♂) were stocked into Lewis Creek Reservoir, Montgomery County, Texas. Lewis Creek Reservoir, a cooling reservoir for Gulf States Utilities Company, had approximately 50% coverage of *Hydrilla* in July 1983. Approximately eight fish of each species per vegetated hectare were stocked during August and September 1983. By April 1984, virtually no aquatic vegetation remained in Lewis Creek Reservoir. Grass carp growth rates were faster than those of hybrid carp. In July 1985, grass carp averaged 610 mm and 2,185 g, while hybrid carp averaged 431 mm and 573 g. Examination of stomach contents indicated both species consumed aquatic vegetation, mainly *Hydrilla*, through April 1984. Following vegetation elimination, stomachs of grass carp contained mainly plant debris, while most hybrid carp stomachs were empty. Condition factors declined 20% and 30%, respectively, for grass carp and hybrid carp following vegetation elimination. Survival of grass carp was higher than that of hybrid carp. Due to their higher survival and growth rates, grass carp appear to be a more effective vegetation control agent than hybrid carp.

COMPARISON OF UTILIZING FORMULATED FEED OR POND FERTILIZATION IN REARING GOLDFISH FINGERLINGS

by

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ABSTRACT

The impact of pond fertilization versus formulated feed on goldfish *Carassius auratus* production in ponds was compared to determine the best method for production. Production in fertilized ponds averaged 28.4 kg/hectare/day. Production in ponds fed formulated feeds averaged 6.2 kg/hectare/day. Percent return of fingerlings averaged 14.2% in fertilized ponds compared to 6.8% in ponds fed formulated feed. Secchi disk visibility (a measure of phytoplankton production) averaged 42 cm in the fertilized ponds and 97 cm in the fed ponds. Populations of adult copepod and cladoceran zooplankters averaged 18 organisms/liter for all study ponds, while rotifer populations in fertilized ponds averaged 978 organisms/liter and 54 organisms/liter in the fed ponds, thus indicating higher zooplankton productivity in fertilized ponds. Drained fertilized ponds were completely devoid of submerged vegetation while the fed ponds averaged 10,876 kg/hectare. This study indicates a comprehensive pond fertilization program can increase fish production and reduce unwanted aquatic vegetation compared to non-fertilized ponds fed only formulated feed.

PRELIMINARY ELECTROPHORETIC ANALYSES OF GUADALUPE BASS AND OTHER BLACK BASSES

by

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and

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ABSTRACT

Genetic relations among four species of black bass in Texas were examined using starch-gel electrophoresis. Guadalupe bass *Micropterus treculi*, spotted bass *M. punctulatus*, smallmouth bass *M. dolomieui*, and largemouth bass, both the northern *M. salmoides salmoides* and Florida *M. s. floridanus* subspecies, were assayed. Protein electrophoresis allowed assignment of individuals to specific, subspecific or intergrade status. Assays of at least 64 presumptive loci products showed species and subspecific differences. This information will enable us to examine the extent of intergradation among these fishes, both on hatcheries and in the wild. These data are useful in defining ranges, immigrations due to stocking, and hybridization beyond the F_1 generation.

ADDITIONAL GENETIC MARKERS FOR LARGEMOUTH BASS

by

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ABSTRACT

Electrophoretic analyses have provided information concerning intraspecific genetic variation in largemouth bass *Micropterus salmoides*. New genetic differences were found among four stocks of fish: two domestic and two wild stocks. The domestic stocks originated from northern and Florida subspecies intergrade populations. One wild stock represented the northern subspecies, *M. s. salmoides*, and the other, the Florida or southern subspecies, *M. s. floridanus*. More than 60 presumptive loci were examined with electrophoresis. At least 11 (18%) were polymorphic. Of the polymorphic loci, two represented known, fixed subspecific differences. Variation among the stocks at the rest of the polymorphic loci was expressed as allele frequency differences. These additional genetic markers substantially increase the probability of accurate stock identification beyond the F_1 generation. These additional biochemical markers allow greater accuracy in measuring gene flow between stocks or populations over time. Loss of genetic variation (inbreeding), which is of particular interest to those involved in largemouth bass breeding and stock management programs, can now be more accurately monitored.

COLD TOLERANCE OF JUVENILE TARPON IN FRESH WATER

by

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ABSTRACT

Tarpon Megalops atlanticus is a fish which is often severely impacted by sudden extreme temperature declines; however, there have been few attempts to define their tolerance to cold in sea water, and none in fresh water. In the present study, juvenile tarpon 231 to 520 mm TL were subjected to water temperature decreases of 0.2 to 1.5 C/day in fresh water. Low temperature response (loss of equilibrium or death) occurred between 18.2 and 9.5 C with a weighted mean response temperature of 11.8 C. Cold tolerance was highly variable among individual specimens; more rapid temperature decreases often resulted in ultimately lower response temperatures.

The tarpon Megalops atlanticus is a renowned gamefish in warm, inshore Atlantic and Gulf of Mexico waters (Hildebrand 1963, Hoese and Moore 1977). Juveniles commonly occur in headwaters of brackish and freshwater streams (Hildebrand 1963) and adults also occasionally enter fresh water (Moffett and Randall 1957). Breder (1944) reported tarpon survived up to 6 years in a freshwater aquarium and juveniles easily withstood transfer from fresh water to sea water and back.

Moffett and Randall (1957) commented that despite numerous references to the species in both scientific and lay-oriented literature, few fishes have had more written about their habits with so little in the way of corroboration. Since tarpon is a highly desirable game fish which achieves a large maximum size, to 2.49 m (Bigelow and Schroeder 1953), and survives well in freshwater, it is a species about which more information should be obtained to allow more efficient fisheries management.

Tarpon is a species often severely impacted by sudden extreme temperature declines (Storey and Gudger 1936, Storey 1937). This kind of temperature change is common in Texas and would likely be the most significant limiting factor affecting tarpon populations. The literature contains a paucity of cold tolerance reports including Moffett and Randall (1957), who gave cold shock results for 16 juveniles in sea water, and Rickards (1968), who made several field observations of cold related mortality.

When a large number of small juvenile tarpon, which are uncommon in Texas waters, were collected at a location near the Texas coast in 1983, it provided the opportunity to gain more information on their cold tolerance.

METHODS

A group of juvenile tarpon were captured on 7 November 1983 in a drainage ditch adjacent to Highway 185 along the Powderhorn Ranch, Calhoun County, Texas. Ninety-four of these tarpon were transported to Heart of the Hills Research Station (HOH), Texas Parks and Wildlife Department, Ingram, Texas for study, and the remaining individuals were released.

Upon arrival at HOH, fish were anesthetized with dimethylketone alpha methyl quinoline (Hypno, Jungle Laboratories Corporation, Cibolo, Texas), and checked for parasites and disease symptoms (none were found). All fish were then placed in a 24,250-liter rectangular tank with flow-through fresh water. Live goldfish <u>Carassius auratus</u> or green sunfish <u>Lepomis cyanellus</u> were fed daily at one to three per tarpon, a rate deemed acceptable for good maintenance. Water temperature in the holding system ranged from 19 to 31 C with a mean of 25.6 C during the holding period. Tarpon acclimated well and fed readily.

Tarpon were maintained in the large holding tank until randomly selected specimens were transferred to test tanks. Each circular 1,700-liter fiberglass test tank was fitted with an external biofilter and a chiller (Frigid Units Incorporated, Toledo, Ohio). Both test fish and those remaining in the main holding tank (controls) were anesthetized with Hypno and treated with a furacin (0.5 mg/liter) dip to discourage handling-related infections. Ideally, control fish would have been held in tanks identical to those of test fish; however, lack of availability of such tanks and a desire to simultaneously test as many fish as possible precluded doing so.

Test fish were randomly distributed at a rate of 5-6 per tank on 10 September (33 fish among six tanks), 3 December (35 fish among seven tanks) and 18 December 1984 (18 fish among three tanks). Differences in specimen and tank number reflected tank availability on test dates. A minimum post-transfer period of 24-48 hours was given before water temperature reduction began. Goldfish were provided as food throughout the test period.

The initial study objective was to decrease water temperature at a rate of 1 C/24 hours; however, due to efficiency differences among chillers and wide fluctuations in ambient air temperature, this constant rate of decrease was not always attained. Mean daily rate of temperature decrease ranged from 0.2 to 1.5 C/day. Test fish were observed and tank temperatures (nearest 0.1 C) were recorded twice daily (0800-0900 and 1500-1600 hours) with a laboratory thermometer marked in 0.2-C increments. They were monitored more frequently as lower temperatures were approached. When test fish responded to decreasing temperatures, their condition was recorded as loss of equilibrium (LOE) or dead. The initial intent was to decrease temperature only to LOE, then to remove and revive test fish for later release. However, this goal was confounded by the fact that some specimens abruptly died with little evidence of LOE that was clearly observable in others. Fish were weighed (g) and measured (mm total length, TL) after removal from the test tanks. Nitrite and ammonia levels were periodically monitored to assure that water quality was not a problem.

Both LOE and dead were sometimes combined, as response, in data analyses. Several sources of possible variation were examined using linear regression and analysis of variance (ANOVA) with $\alpha = 0.05$ (Simpson et al. 1960, Sokal and Rohlf 1969). Variables examined in this fashion included: (a) response temperature and specimen length, (b) type of response (LOE or dead) and response temperature, (c) type of response and specimen length, (d) condition factor and response temperature, (e) response temperature and mean rate of temperature decrease, as well as (f) variation within and among tanks and test dates. Rate of temperature decrease was examined by determining the temperature change per day (Δ T) for each specimen, then calculating the mean of all positive and negative Δ T's over the test period. Data obtained from this direct-type bioassay (Finney 1978) are presented as a scatter-plot (response temperature vs number of fish).

RESULTS AND DISCUSSION

Tarpon ranged in length from 231 to 520 mm TL ($\overline{x} = 419$ mm TL). All control fish survived, therefore no adjustments for control or holding mortality were made. Test tarpon responded to temperatures from 18.2 to 9.5 C with a weighted mean response temperature of 11.8 C (SE = 0.259). Approximately 80% of the specimens responded to temperatures below 14.0 C (Fig. 1).

Regression analysis indicated there was no significant difference between response temperature and specimen length or condition factor, which considers both length and weight. Similarly, ANOVA indicated there was no significant difference between type of response (LOE or dead) and response temperature or specimen length.

Significant differences were found among test dates and tanks within dates; however, sources of variation could not be clearly identified. A primary criticism of direct bioassays is the bias created by time lag associated with different responses (Finney 1978). Time in hours from the start of a test until response temperature is reached was certainly a consideration in the present study, but the associated time-temperature relationship was obscured by varying rates of temperature decrease and by occasions where temperatures decreased, rose slightly, then decreased again. Regression analysis indicated there was a significant relationship between mean rate of temperature decrease and response temperature, where the greater the daily rate of temperature decline, the lower the response temperature (Fig. 2).

The wide range of response temperatures suggested substantial individual variation among specimens. Finney (1978) observed that "critical dose will generally vary considerably from subject to subject, and even from one occasion to another; hence only an estimate of potency is obtained..." While differences in response temperatures were not unexpected, the extent of these differences was somewhat surprising (9.5 to 18.2 C). However, some specimens at both temperature extremes lost equilibrium and recovered when removed from test tanks.

Prior to actual low temperature response (LOE or death), behavior of many tarpon changed from quietly hovering just above the bottom to that of restlessly swimming throughout the test tank. Also, it was noted that specimens changed from a light blue-gray dorsal coloration to a deep steel-blue before response. This color change usually preceded response by 1-4 hours but occasionally occurred up to 12 hours in advance. While continuous observation of test specimens was not possible, these clues served to indicate when more intensive observations would be necessary.

One interesting aspect of this study was that some specimens lost equilibrium and remained LOE for an extended period while others appeared to die outright without any substantial indication of equilibrium loss, even among specimens in the same tank with the same temperature history. Among two tarpon responding at 16.6 C, one died abruptly while the other lost equilibrium. Among nine responding at 9.8 C, four died abruptly and five lost equilibrium. Although the response of every fish was not observed, preresponse clues facilitated numerous such observations.

Test tarpon fed to at least 16.2 C. Feeding probably occurs somewhat below this temperature but monitoring and maintenance activity around test tanks inhibited feeding behavior.

Moffett and Randall (1957) reported cold shock tests among 16 tarpon 71 to 130 mm FL in sea water. Among their specimens, one of two tested at 18.0 C died, two at 17.0 C died and one of two at 14.8 C survived, but in distress. Rickards (1968) hypothesized that the lower temperature limits for juvenile tarpon were between 12.0 and 16.0 C for a sudden extreme temperature decrease and possibly lower, if the change was gradual. The mean freshwater cold tolerance response temperature of 11.8 C obtained in the present study is consistent with values previously reported for salt water.

These results suggest that tarpon is a potential candidate for introduction, perhaps as part of a predator fish management strategy, into certain Texas freshwater reservoirs which are thermally heated by electric generating stations. Some such reservoirs maintain water temperatures from December through February of 15 C or greater. Only in cases where unusually cold winters correspond with periods of plant outage would potentially serious winter-kills occur.

ACKNOWLEDGMENTS

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Figure 1. Number of tarpon (231 - 520 mm TL) responding (loss of equilibrium or death) to water temperatures in freshwater cold tolerance tests, 1984. Weighted mean is indicated.

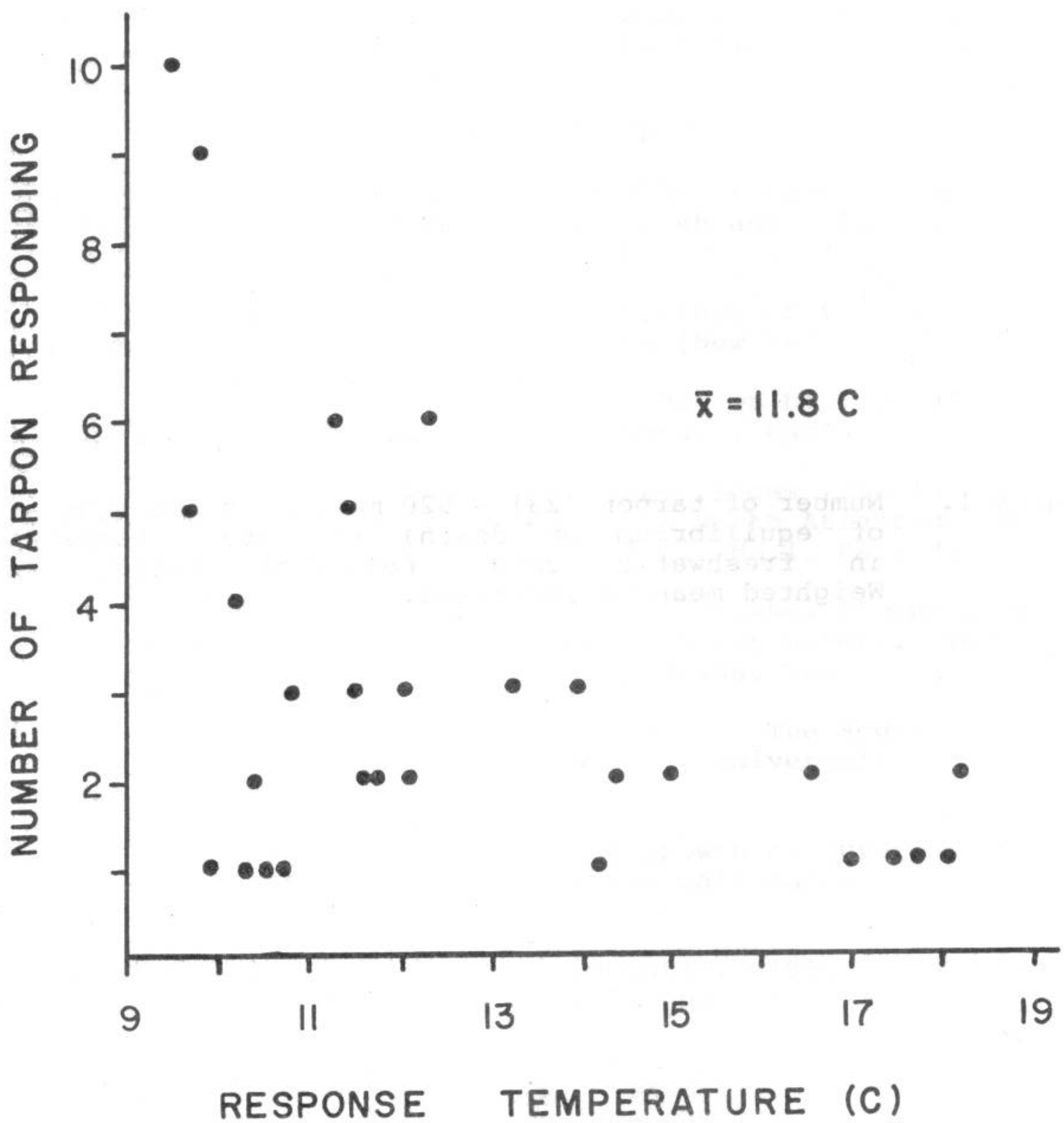
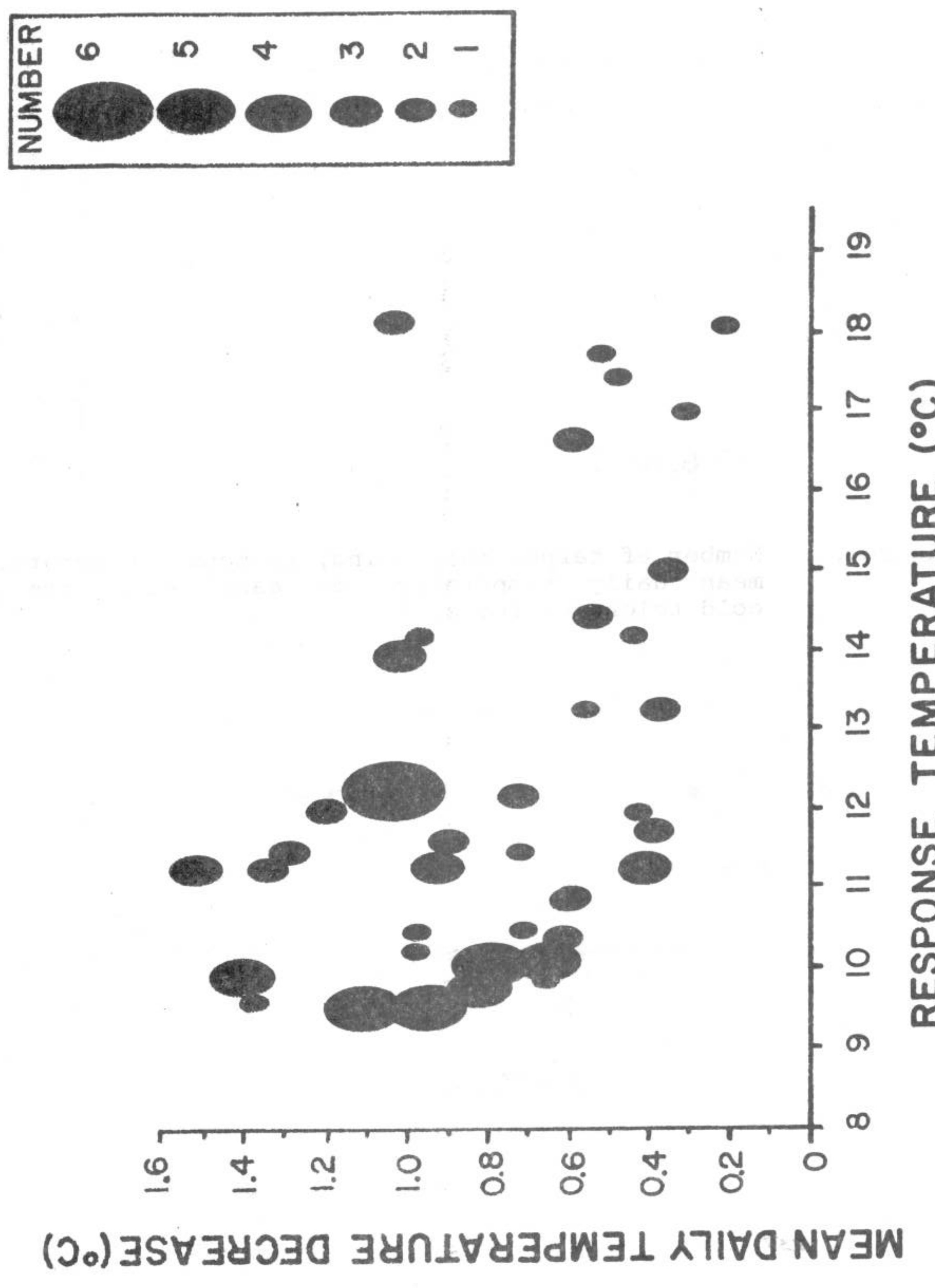

NUMBER OF TARPON RESPONDING
10
8
6
4
2
x̄ = 11.8 C
9
11
13
15
17
19
RESPONSE TEMPERATURE (C)

Figure 2. Number of tarpon responding, response temperature and mean daily temperature decrease during freshwater cold tolerance tests, 1984.


NUMBER
6
5
4
3
2
1
MEAN DAILY TEMPERATURE DECREASE (°C)
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
8
9
10
11
12
13
14
15
16
17
18
19
RESPONSE TEMPERATURE (°C)

IDENTIFICATION OF THREE MORONE SPECIES AND THEIR HYBRIDS THROUGH ISOELECTRIC FOCUSING

by

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ABSTRACT

Samples of three Morone species and F_1 hybrids of these species were evaluated using isoelectric focusing. Focusing of sarcoplasmic proteins for individual striped bass Morone saxatilis, white bass M. chrysops and yellow bass M. mississippiensis produced banding patterns unique to each species. Comparison of banding patterns of known individuals to those of F_1 hybrids of these species indicated that these hybrids demonstrated collective banding patterns of both parental species.

Isoelectric focusing appears to have potential in many areas of fishery biology and aquaculture. Cost of individual analysis are at or below costs of comparable starch-gel investigations.

The utility of electrophoretic procedures in evaluation of fish species and hybrids has been demonstrated in a multitude of recent studies. The vast majority of these investigations has utilized starch-gel electrophoresis as the method of choice for visualization of taxon-specific isozyme loci (Harvey et al. 1980, Philipp et al. 1982, Harvey 1983, Philipp et al. 1983). The reliability and discriminatory power of starch-gel electrophoresis is well documented and this procedure has become an extremely important analytical tool in a wide variety of fishery applications.

In recent years, isoelectric focusing has begun to emerge as a very powerful electrophoretic technique for identification and evaluation of fish species (Laird et al. 1982, Carpene' et al. 1983). While the theory and technique associated with isoelectric focusing is not complicated, its explanation is lengthy. Excellent treatment of this subject can be found in Righetti (1983). The excellent resolution associated with isoelectric focusing (Mackie 1980) and the fact that tissues to be evaluated can be collected using non-invasive techniques (Whitmore 1984) make isoelectric focusing a very attractive alternative to starch-gel procedures.

We have begun utilization of isoelectric focusing in polyacrylamide gel media for genetic evaluation of several species of important sport and commercial fishes. These evaluations are part of ongoing culture and stocking programs aimed at both restoration and/or supplemental stocking of these species. The purpose of this paper is to report what appears to be very promising results for the use of this technique in species and hybrid identification. While the genus Morone is investigated here, we believe isoelectric focusing has similar applications in evaluation of most important commercial and sportfish species.

MATERIALS AND METHODS

Sample Collection

Samples of three Morone species (Family Percichthyidae) and of suspected hybrids of species within this genus were collected and identified by Texas Parks and Wildlife Department personnel. Initial classification as to species (or hybrid) status of individual fish was done using meristic and/or morphometric criteria. Species collected were striped bass Morone saxatilis, white bass M. chrysops and yellow bass M. mississippiensis. Additional striped bass were obtained from the United States Fish and Wildlife Service hatchery at Inks Lake, Texas.

Hybrid fish were tentatively identified as either white bass x striped bass hybrids or striped bass x yellow bass hybrids and confirmation of hybrid status was made using starch-gel electrophoresis (Avise and Van Den Avyle 1984, D. P. Philipp, Illinois Natural History Survey, Champaign, Illinois, pers. comm.). However, the parentage of these hybrids was not made known to us prior to evaluation. An additional sample of known striped bass x white bass hybrids was obtained from experimental diploid and triploid populations currently being cultured at North Carolina State University.

All fish collected were frozen prior to transportation to the laboratory at the San Marcos State Fish Hatchery. Sample sizes and location of collections are summarized in Table 1.

Tissue Preparation

Approximately 1 gram of white skeletal muscle was removed from each fish and placed in a cryotube. Muscle tissues were then homogenized in an equal volume of deionized water. It is important to note that while tissue homogenates for starch-gel electrophoresis are often homogenized in a buffer solution, buffer solutions of any sort should be avoided in tissue preparation for isoelectric focusing. In fact, water samples used for tissue homogenization should be as pure as absolutely possible in order to prevent interference with ampholyte-carrier media used in the analysis. Homogenates were centrifuged at 2,000 rpm for 10 minutes. Supernatants were frozen until thawed for analysis.

Gel Preparation

Gels were prepared according to LKB Application Note #2217 (LKB-Produkter 1983). These gels are thin layer acrylamide gels of 0.2-mm thickness. Gels were made using a broad pH range ampholyte, pH 3.5 to 10.0. It has been our experience that the reagents used in preparation of acrylamide gels must be of the finest quality available. Failure to use high quality acrylamide, ammonium persulfate and ampholytes results in poor acrylamide polymerization and poor resolution of protein bands. Modifications to the procedure outlined in the LKB application note can be found in Radola (1980). These modifications can result in significant reductions in the cost of individual gels.

Running Conditions

Gels were run using the LKB Multiphor II electrofocusing unit, the LKB Multitemp II circulating water bath and the LKB 2117 power supply. The temperature of the water bath was held at 10 C during the entire focusing period.

While anolytes, catholytes and running conditions outlined in the LKB application note appear to give good results, we found that modifications of various components of the procedure produced better resolution of protein bands. We chose to use a catholyte solution (pH 11.5) of 2.0 M ethylenediamine, 0.025 M arginine and 0.025 M lysine. The anolyte solution (pH 2.8) was 0.025 M aspartic acid and 0.025 M glutamic acid.

Samples were applied using an application mask with 1.0 mm x 10 mm wells (FMC Corporation, Rockland, Maine). The application mask was placed 3.0 cm from the cathode and approximately 2.0 μl of homogenate was placed in each well.

Running conditions were quite different from those outlined in the LKB application note. We found that we could get more consistent results using the following running conditions. Initial power was set at 4.0 watts and the voltage was limited to a maximum of 2,000 volts. Current was adjusted until the initial voltage was 200 volts (current was between 10.0 and 15.0 milliamps). Samples were focused until the current remained constant for 10 to 15 minutes, which usually took place between 2 and 3 hours after starting the run. The sample application mask was removed after samples had been focused for 30 minutes.

Staining Procedures

The gels were fixed for 5 minutes in 200 ml of 20% trichloroacetic acid. The gels were then washed in 200 ml of destaining solution (35% ethanol, 10% acetic acid). Gels were stained with 300 ml of staining solution (0.5% Coomassie Blue R-250 in destaining solution). Gels were destained with several changes of destaining solution and then allowed to air dry.

RESULTS

The three *Morone* species evaluated in this study could easily be segregated by examination of six distinct protein bands that focused in the pH 3.0 to 5.0 range of the gel (Fig. 1).

Bands were numbered such that the most anodal band was designated 1, the second 2, etc. The numbering of these bands is (at this time) arbitrary for this genus, as no white perch M. americana were available for evaluation. The striped bass is characterized by bands 2 and 6, the yellow bass by bands 1 and 4, and the white bass by bands 3 and 5 (Fig. 1). These banding patterns were consistent for all Morone samples analyzed.

Through determination of the banding patterns of striped bass, white bass and yellow bass, and subsequent comparison to hybrid samples, we were able to correctly identify all of the unknown (to us) Morone sp. hybrids. Hybrids demonstrate bands characteristic of both parental types. For instance, the striped bass x white bass hybrid demonstrates the number 2 and 6 bands of the striped bass and the number 3 and 5 bands of the white bass (Fig. 1). Triploid hybrids were indistinguishable from diploid individuals.

While we do not know the exact mechanism of inheritance for these protein bands, we have demonstrated banding patterns characteristic of non-F_1 hybrids of striped bass and white bass (Fig. 2) in evaluations done subsequent to this initial investigation. These have been verified as being non-F_1 individuals by use of starch-gel electrophoresis of the known discriminatory isozyme loci of these two species (Avise and Van Den Avyle 1984).

DISCUSSION

The technique associated with isoelectric focusing is, in our opinion, much more delicate than that of starch-gel electrophoresis. While a wealth of technical information can be easily obtained, the quality of results using isoelectric focusing remains largely a matter of systematic trial and error. However, results can be characterized by exceptional resolution when the technique is mastered and the equipment is properly configured.

Cost of any analytical technique is always a major concern. Ampholytes are quite expensive, ranging from about $80/25 ml for Servalyte® ampholytes (Serva Incorporated, Westbury, New York) to $140/25 ml for Ampholine® (LKB-Produkter, Houston, Texas). Our experience suggests that, for the most part, ampholyte cost is not related to quality of results. Through utilization of thin-gel procedures as outlined by Radola (1980), we have cut costs of individual analysis to about $0.25/animal evaluated. This is certainly similar to, or less than, the cost of analysis using starch-gel electrophoresis. The actual equipment (power supply, focusing unit and temperature bath) costs are much greater than that necessary for starch-gel electrophoresis and could well be the determining factor in an individual researcher's decision of which technique to employ in genetic analysis.

A major advantage of isoelectric focusing when compared to starch-gel electrophoresis is the actual running time required for analysis. We can consistently process samples, make acrylamide gels and complete the analysis in less than 4 hours. Gels can be made beforehand and kept for several days while completed gels last indefinitely after final staining and drying.

The potential for isoelectric focusing in a wide variety of applications is enormous. Its utility in identification of fish species and hybrids of these species is well demonstrated herein. Additionally, we have already put this technique to use in assessing stock status of hatchery stocks, verification of genetic status of potential record fish, assessment of striped bass x white bass hybrid reproduction, and in prosecution of game-law violators.

Isoelectric focusing of sarcoplasmic proteins alleviates several of the problems associated with isozyme evaluations, principally isozyme lability and scoring of gels. Secondarily, this procedure does not require many of the expensive reagents necessary to carry out the biochemical reactions of histochemical staining.

It is not our suggestion that isoelectric focusing can replace starch-gel electrophoretic procedures; it certainly will not do so. The decision regarding which technique to use must be made on a situational basis as each technique has its advantages and limitations. However, we believe isoelectric focusing is a very powerful addition to the tools involved in these types of investigations. When used in the proper context, we believe that this technique will prove as useful and powerful as other electrophoretic techniques.

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Table 1. *Morone* species and hybrids evaluated, location of collection, and number of individuals analyzed by isoelectric focusing. Analyses were conducted at San Marcos State Fish Hatchery, September, 1985.

Species	*N*	Collection location
White bass	10	Lake Long, Texas
Striped bass	3	Inks Lake, Texas
Striped bass	4	Canyon Lake, Texas
Yellow bass	3	Lake Fork, Texas
Yellow bass x striped bass	3	Henderson County, Texas
Striped bass x white bass (triploid)	6	North Carolina State University
Striped bass x white bass (diploid)	5	North Carolina State University

Figure 1. Isoelectric focusing banding patterns of sarcoplasmic proteins of striped bass, white bass, yellow bass, F_1 striped bass x white bass hybrids and F_1 striped bass x yellow bass hybrids. Discriminatory proteins focus in the pH 3.0 - 5.0 range.

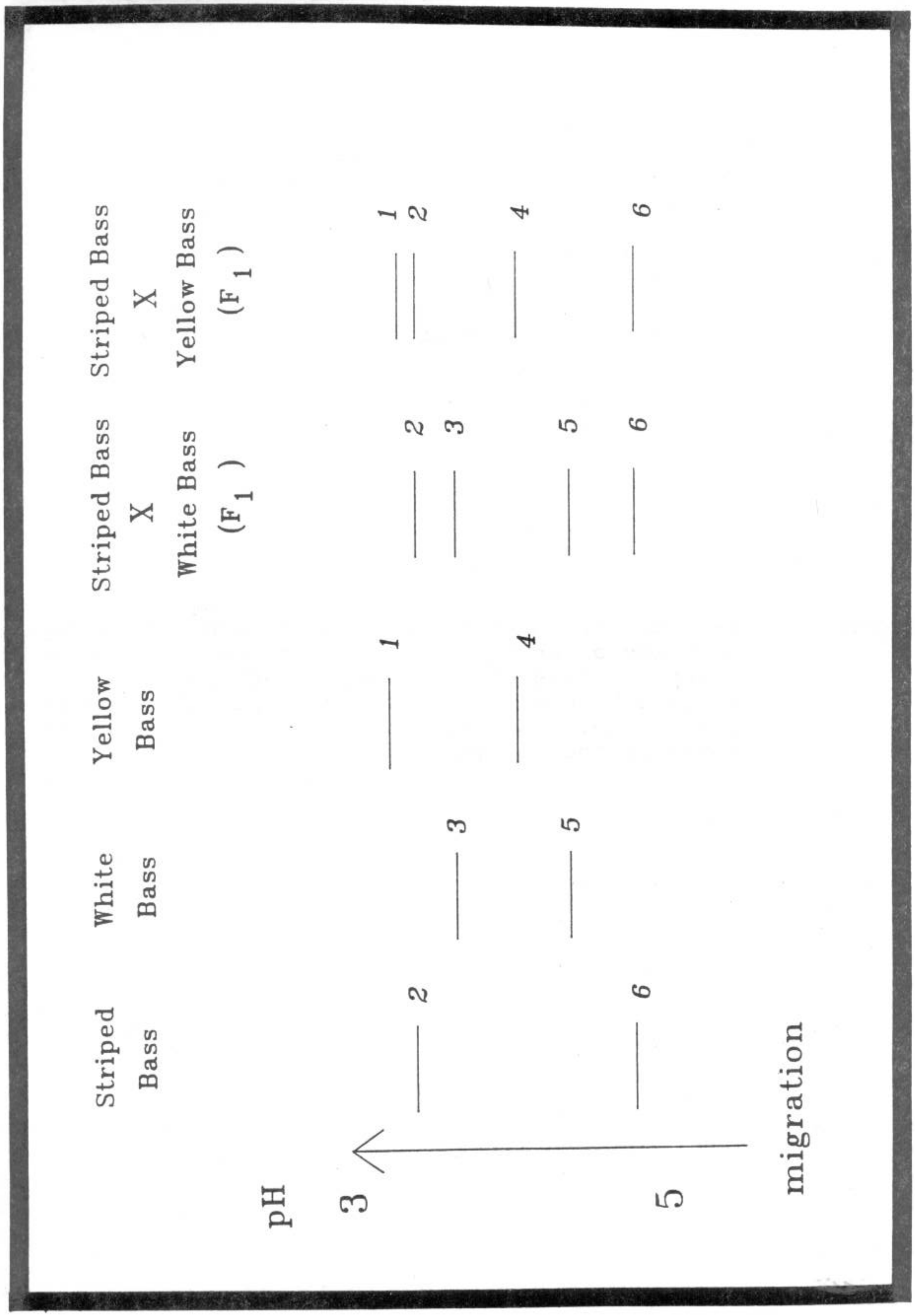
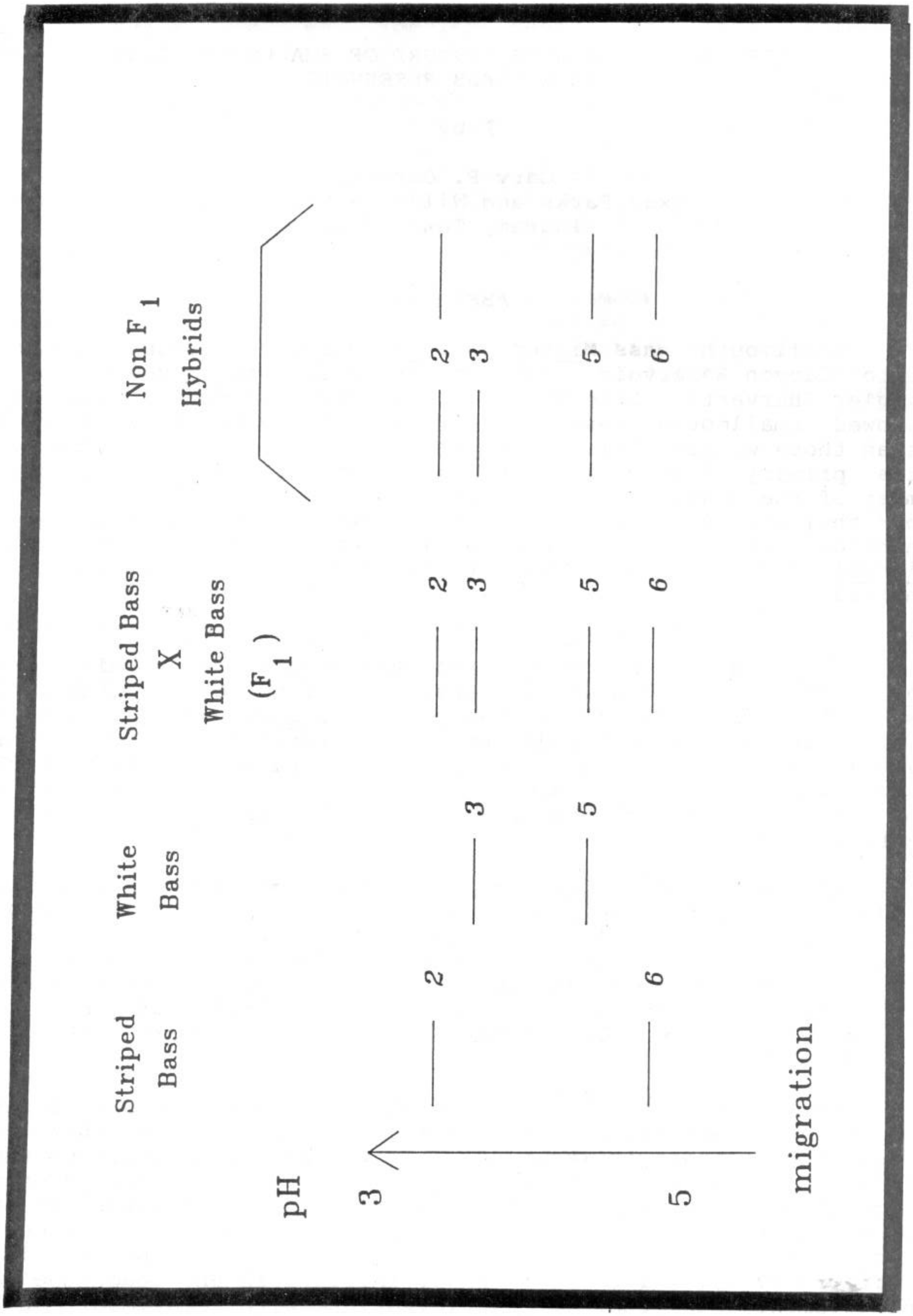

pH
3
5
migration
Striped Bass
White Bass
Yellow Bass
Striped Bass X White Bass (F_1)
Striped Bass X Yellow Bass (F_1)
1
2
3
4
5
6

Figure 2. Isoelectric focusing banding patterns of sarcoplasmic proteins of striped bass, white bass, F_1 striped bass x white bass hybrids and non-F_1 hybrids of these species. Discriminatory bands focus in the pH 3.0 - 5.0 range. Non-F_1 hybrids lack at least one band found in the F_1 hybrid.


Striped Bass
White Bass
Striped Bass X White Bass (F1)
Non F1 Hybrids
pH
3
5
migration
2
3
5
6

ASPECTS OF THE LIFE HISTORY OF SMALLMOUTH BASS IN A TEXAS RESERVOIR

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ABSTRACT

Smallmouth bass *Micropterus dolomieui* have been introduced into Canyon Reservoir, Texas to increase fishing recreation and angler harvest. Life history data collected during this study showed smallmouth bass in the reservoir generally grew faster than those within their native range. Fishes and crayfish were the primary food items with fishes dominating the diet during most of the year. First reproduction was at age II and the peak of the spawning season was in March. They were found to hybridize extensively with a local endemic, the Guadalupe bass *M. treculi*, with almost 15% of the reservoir population being hybrids.

The native range of the smallmouth bass *Micropterus dolomieui* encompassed approximately 1/5 of the United States and was the second largest in the genus *Micropterus* with only the largemouth bass *M. salmoides* having a larger range. By the early 1800's man had begun to expand this range by transferring smallmouth bass to new habitats. These introductions were due primarily to their popularity as sportfish (MacCrimmon and Robbins 1975).

Smallmouth bass were originally stocked in Texas waters in 1916 (O'Malley 1917) but did not become established. In 1974 an intensive stocking program was begun in the Edwards Plateau region with the intent of increasing angler harvest in the area. In Canyon Reservoir alone, 300,000 fingerlings have been stocked. There is now a self-sustaining population in this reservoir with a state record smallmouth bass (2,775 g) being taken there in December, 1982.

While much angler-type information on when and how to catch smallmouth bass has been generated in the short time they have been in the state, little is known of the life history of these fish in Texas or of their impact on native fishes. Problems regarding the future genetic integrity of an Edwards Plateau endemic, the Guadalupe bass *M. treculi*, have been recently documented (Edwards 1979, 1980; Whitmore and Butler 1982; Whitmore 1983). The major factor involved in the Guadalupe bass predicament was that of hybridization with smallmouth bass. Edwards (1979) first reported the existence of naturally occurring hybrids between Guadalupe and smallmouth bass from Canyon Reservoir and the Guadalupe River downstream. These two allopatrically evolved species seemed to lack effective reproductive isolating mechanisms. Similarity of color pattern and morphology (Hubbs and Bailey 1942), and a certain degree of niche overlap greatly enhance the chances of hybridization between these two species. Edwards (1979) initially identified hybrids by superficial examination and later confirmed the identification by use of an index of hybridization. With Edwards' hybrid index as well as an electrophoretic analysis using three diagnostic loci, Whitmore and Butler (1982) reported a more extensive geographic range of hybridization.

In order to better manage smallmouth bass fisheries, information is needed on their reproductive cycle, growth and feeding habits. Additionally, more information on the extent and degree of hybridization between Guadalupe and smallmouth bass is necessary in order to better predict the outcome of introducing smallmouth bass into other locations in Texas.

MATERIALS AND METHODS

Canyon Reservoir, impounded in 1964, is a 3,300-hectare reservoir on the Guadalupe River in Comal County, Texas. A detailed limnological description of the reservoir is available in Hannan et al. (1979).

Fish specimens were obtained primarily by electrofishing with some additional specimens from gill net samples. Collections were made quarterly, 1979 through 1982. All specimens were measured and weighed fresh, then frozen until final analysis. All length measurements were in total length (TL) and weights in grams (g).

Age and growth of smallmouth bass were determined by the scale method. Scales were taken from the ventro-lateral area beneath the distal tip of the left pectoral fin. Scale impressions were made on cellulose-acetate slides with a roller press following procedures described by Smith (1954). Annuli were identified and enumerated under 37 X magnification with a microprojector. Annuli were counted until agreement was reached between readings. For each scale impression, distances from the focus to each annulus and the scale margin were measured and recorded. Back calculated lengths at annuli were obtained by least-square quadratic regression estimates (Jones 1958).

For analysis of feeding habits, only data from smallmouth bass obtained by electrofishing were used. Stomachs were removed by cutting the alimentary tract anterior to the stomach and posterior to the pylorus. Food items contained in this portion of the digestive system were identified and counted. Data were analyzed in terms of relative abundance of various food items and frequency of occurrence.

Gonosomatic indices (G.S.I. = gonad weight x 100/body weight) were calculated using wet weights of ovary and body. Weights were taken using an Ohaus triple-beam balance. For reproductive cycle determinations only females ≥ 250 mm TL were used. Qualitative measures of egg maturity during the peak of the reproductive season confirmed this size as a conservative cutoff point for sexual maturity.

Species designations were made by using an index of hybridization (Edwards 1979) which numerically identifies individuals by summing specific meristic characters. It completely separates the two species and places hybrids in an intermediate position with slight overlap with parental types. The characters used were: dorsal and anal fin spines, dorsal and anal fin rays, right and left pectoral rays, scales above, below and along the lateral line, scale rows around the caudal peduncle and along the cheek. All counts were according to procedures of Hubbs and Lagler (1947).

RESULTS AND DISCUSSION

Growth of smallmouth bass in Canyon Reservoir was generally more rapid than that reported from more northern states (Table 1). In comparing values from this study to those summarized in Carlander (1977), the smallmouth bass in Canyon Reservoir seemed to follow the same trend of faster growth than those from northern states but grew slower than smallmouth bass from southern states until later life.

Similarly, in a study of largemouth bass M. salmoides in Canyon Reservoir, Kolb (1975) found growth rates in ages I-IV to be lower than for largemouth bass in Louisiana, Oklahoma, Arkansas and Tennessee. In fish older than age IV, growth rates were similar to those in Oklahoma, Arkansas and Tennessee. Largemouth bass growth rates in Canyon Reservoir were also greater at all ages than for those from northern latitudes.

Analysis of stomach samples revealed that fishes were the prevalent food of smallmouth bass (≥100 mm) in all months except February when crayfish Procambarus were dominant (Table 2). Fishes observed in smallmouth bass stomachs were Dorosoma spp., Notropis spp., Ictalurus punctatus, Lepomis spp., Percina caprodes, and Etheostoma spp. Insects (Coleoptera and Lepidoptera) were also consumed but were relatively unimportant food items. Since no species patterns were detected, food items were categorized simply as fish, crayfish or insects. The two most prevalent fishes found in the diet were Lepomis spp. (7 stomachs) and Percina caprodes (6 stomachs). Reynolds (1965) also found fishes and crayfish to be the main food of smallmouth bass in the Des Moines River, Iowa with fishes being the major component. However, in that study cyprinids were the primary group utilized. In contrast, Lewis and Helms (1964) found that given a choice between bluegills and crayfish, crayfish were the more heavily utilized food item by both smallmouth and largemouth bass.

In fish longer than 200 mm, the greatest number of empty stomachs was encountered in summer and early winter. The smaller fish followed this general pattern with the exception of the winter months when they seem to have had even greater difficulty obtaining food. If this accurately reflects the situation in Canyon Reservoir, it may help explain the variation in growth rates relative to other southern states, that is, slower at smaller sizes and as fast or faster at larger sizes. Perhaps there is a lack of available forage for smaller fish, thus retarding their growth.

Smallmouth bass reproductive activities reached a peak in March as indicated by GSI values for females (Fig. 1). Qualitative observations of eggs also support this contention. Females with mature eggs were observed as early as February and several spent females were obtained in March. Unfortunately, GSI values for males were inconclusive in terms of a temporal pattern.

The GSI as a function of total length shows an increase in female fecundity with size (Fig. 2). Reynolds (1965) found no correlation between fecundity and female size, however, his specimens were within a small size range (229-318 mm TL). Again, this study revealed no pattern for males. It is possible that the precision of the weighing instrument may not have been sufficient to delineate subtle differences in testes size.

Female GSI values presented here (Fig. 2) are similar to average values given for smallmouth bass in Arkansas (Vogele 1981, $\bar{x}$ = 6.38) and Alabama (Hubert and Mitchell 1979, $\bar{x}$ = 6.0). Edwards (1980) reported an average GSI value for Guadalupe bass females during the breeding season in the Guadalupe River system of 1.32 (range = 0.17 - 6.99), but no size range was given. Hybrids between these two species found in Canyon Reservoir had an average March GSI value of 14.6 (range = 7.59 - 30.29) with a size range of 370 to 540 mm. If GSI values can be equated to fecundity, then smallmouth bass and hybrids in Canyon Reservoir would appear to be much more prolific than the associated Guadalupe bass.

The smallest reproductively mature smallmouth bass female collected in this study was 244 mm long. Based on the age and growth analysis, this would indicate first reproduction at age II. Reynolds (1964) found the smallest size for mature males and females in Iowa was approximately 230 mm. Maturity there was at age II or III. In more northern latitudes, such as Lake Michigan, females typically do not mature until age IV and V (Latta 1963). Farther north, reproductive maturity occurs even later in life (Robbins and MacCrimmon 1974).

Reportedly, initiation of smallmouth bass spawning activities is determined by water temperature, but minimum requirements seem to vary. Turner and MacCrimmon (1970) found that water must reach 15 C before spawning begins while others report that it is necessary for the water temperature to rise above 15.6 C and remain there (Webster 1954; Latta 1963; Pfleiger 1966). Vogele (1981) found active smallmouth bass nests in

Arkansas at temperatures as low as 13.3 C. With the preferred depth for smallmouth bass nests being water of 3 m or less (Latta 1963; Vogele 1981), water temperatures in Canyon Reservoir can exceed all reported minimum temperature requirements as early as February (Hannan et al. 1979).

Hybrids between smallmouth and Guadalupe bass collected in Canyon Reservoir had body coloration similar to that described by Edwards (1979). When meristic characters were summed as in Edwards'(1979) index of hybridization, three groups became apparent (Fig. 3). Species designations were as follows: Guadalupe bass ≤ 204, hybrids = 206 - 213, smallmouth bass ≥ 216. Because of the slight overlap of the modal groups, data from fishes in the overlap zones (205, 214 - 215) were not used to compare relative numbers. It was in the overlap zones that Whitmore and Butler (1982) found mistakes in meristic identification. With this categorization method, there were 8.2% Guadalupe bass, 14.9% hybrids and 76.9% smallmouth bass in Canyon Reservoir during the period of this study (Table 3). Evidence of extensive hybridization in Canyon Reservoir is exhibited by the greater number of hybrids versus the parental Guadalupe bass. The low number of Guadalupe bass relative to smallmouth bass may, in fact, be largely responsible for the extensive hybridization. Hubbs (1955) noted that hybridization in fishes is more likely if one species is in greater abundance than the other, the difference in numbers making it more difficult for the rare fish to find the proper mate. By way of support for this contention, Whitmore and Butler (1982) were unable to find hybrids in Travis Reservoir (an impoundment on the Colorado River, Travis County, Texas) where another established smallmouth bass population exists. This is perhaps due to the large standing crop of Guadalupe bass in that reservoir.

It is likely that the three distinct modes present in Canyon Reservoir will blend over time. The large number of hybrids present are probably backcrossing to parental species and will eventually dilute the purity of both the smallmouth and Guadalupe bass genomes. Also it is likely that genetic purity of the Guadalupe bass upstream and downstream will be impaired by a continual influx of both smallmouth bass and hybrids.

Considerations involved with stocking recommendations for smallmouth bass into new locations should include the degree of hybridization encountered in this study. In this case, not only is the genetic integrity of an endemic species being threatened but the purity of the smallmouth bass stock is being diluted, thus reducing the original intended benefits of the stocking.

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Table 1. Comparison of smallmouth bass growth in Canyon Reservoir during the present study (1979-1982) to that in other locations in North America.

Location	N	Average length (mm TL) at age I	II	III	IV	V	VI
Canyon Reservoir, TX	106	154.5	227.6	325.7	389.7	410.6	
Des Moines River, IA (Reynolds 1965)	270	119.4	228.6	297.2	340.4	388.6	411.5
Malcomson's Pond, IL (Bennett and Childers 1957)	-	134.6	236.2	281.9	309.9	363.2	
Lake Michigan, MI (Latta 1963)	1,892	99.1	160.0	205.7	246.4	292.1	335.3
Cayuga Lake, NY[a] (Webster 1954)	3,025	162.6	213.4	261.6	307.3	348.0	373.4
Tadenac Lake, ON (Turner and MacCrimmon 1970)	141	90.5	163.1	189.0	230.0	291.0	315.0

[a] Mean lengths are from fish taken in October of each year, thus, age is actually I^+, II^+, etc.

Table 2. Food of smallmouth bass in Canyon Reservoir (1979-1982) shown as percentage of stomachs in which each food appeared and, in parentheses, the mean number of items per stomach.

	Jan	Feb	Mar	Apr	Jun	Aug	Sep	Oct	Nov
TL = 100-200 mm									
fish	-	9 (0.09)	75 (0.75)	25 (0.25)	50 (0.5)	-	50 (0.5)	80 (0.8)	56 (0.56)
crayfish	-	18 (0.18)	-	8 (0.08)	-	-	-	20 (0.2)	-
insects	-	-	-	17 (0.17)	-	-	-	-	-
empty	100	73	25	58	50	100	50	20	44
N	2	11	4	12	10	1	2	5	9
TL >200 mm									
fish	62.5 (0.63)	15 (0.23)	62 (0.62)	50 (0.63)	60 (0.6)	60 (1.4)	83 (1.7)	62.5 (0.88)	44 (0.5)
crayfish	12.5 (0.25)	54 (0.77)	38 (0.95)	19 (0.19)	10 (0.1)	-	17 (0.17)	-	13 (0.13)
insects	-	15 (0.38)	-	-	-	-	-	-	-
empty	25	31	24	31	50	40	-	37.5	56
N	8	13	21	16	10	5	6	8	16

Table 3. Relative abundance of Guadalupe bass, smallmouth bass and their hybrids in Canyon Reservoir. Species categorizations are based on the summation of 11 meristic characters as in Edwards (1979).

Year	Guadalupe bass (≤ 204)		Hybrids (206-213)		Smallmouth bass (≥ 216)	
	%	N	%	N	%	N
1979	6.2	2	9.4	3	84.4	27
1980	8.3	9	13.0	14	78.7	85
1981	6.3	2	28.1	9	65.6	21
1982	11.1	4	13.9	5	75.0	27
Total	8.2	17	14.9	31	76.9	160

Figure 1. Average GSI for female smallmouth bass with total length ≥ 250 mm from Canyon Reservoir (1979-1982). Sample size is given beside each point.

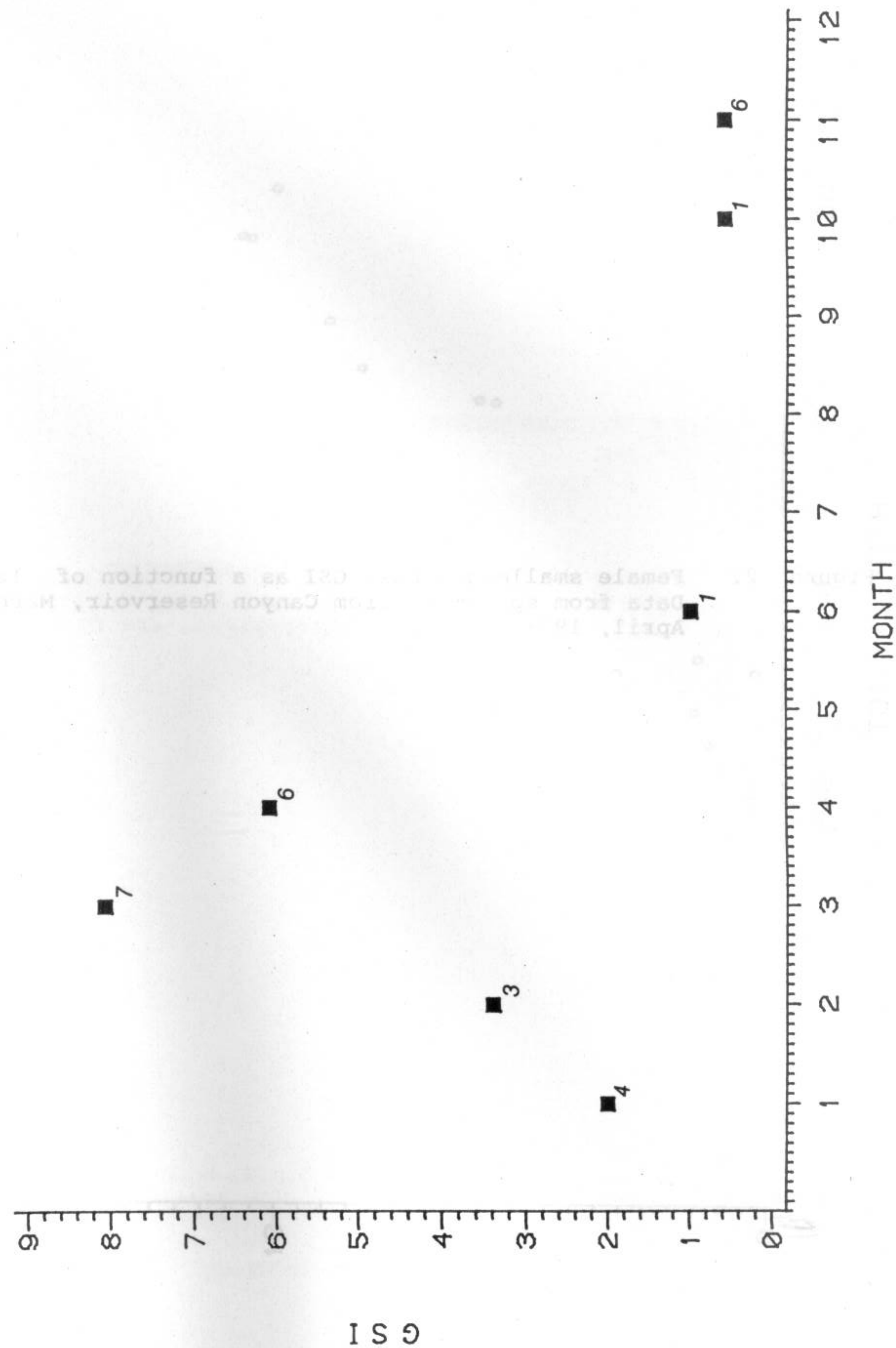

GSI
MONTH
0
1
2
3
4
5
6
7
8
9
10
11
12
4
3
7
6
1
1
6

Figure 2. Female smallmouth bass GSI as a function of length. Data from specimens from Canyon Reservoir, March and April, 1979-1982.

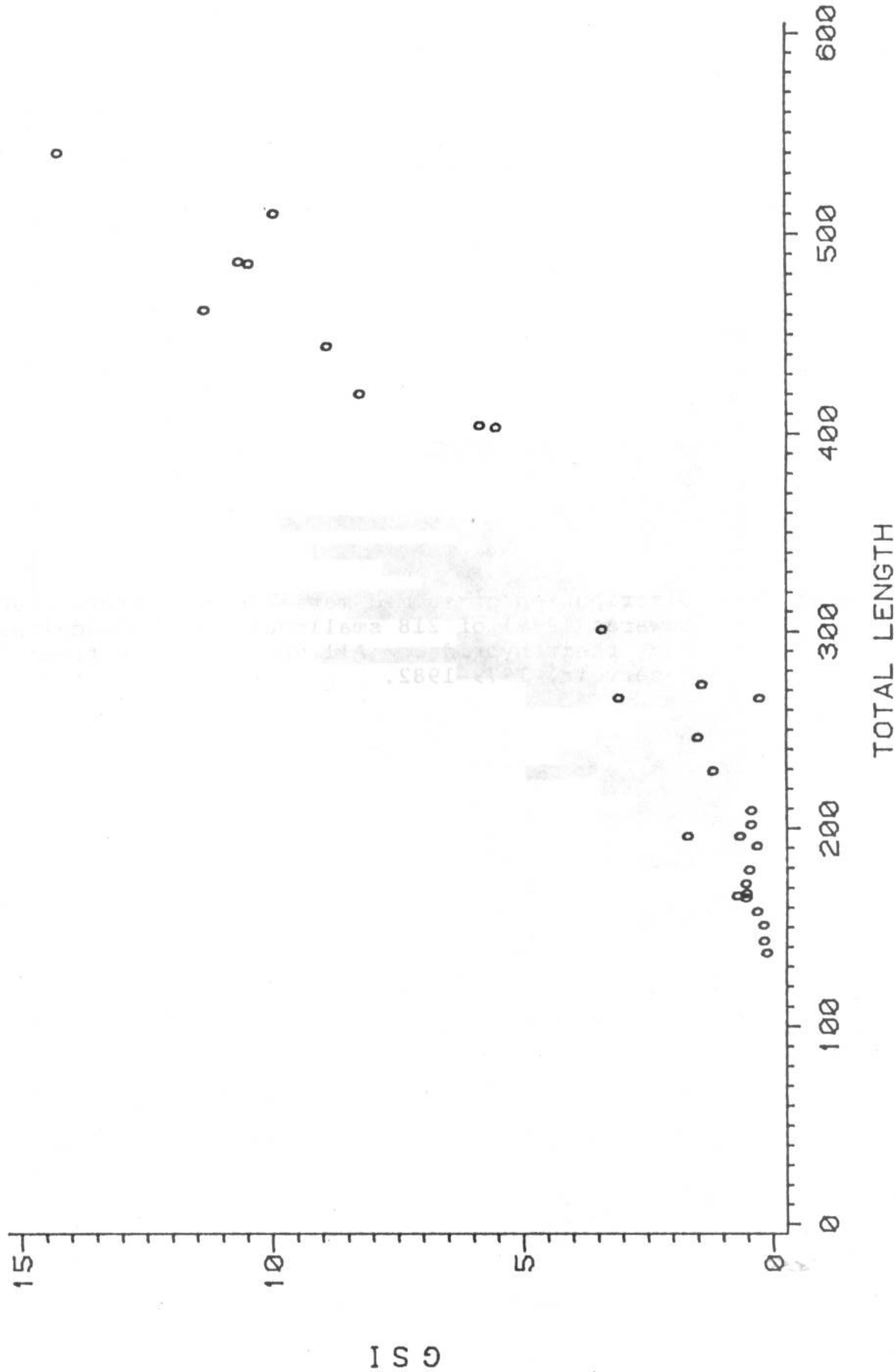
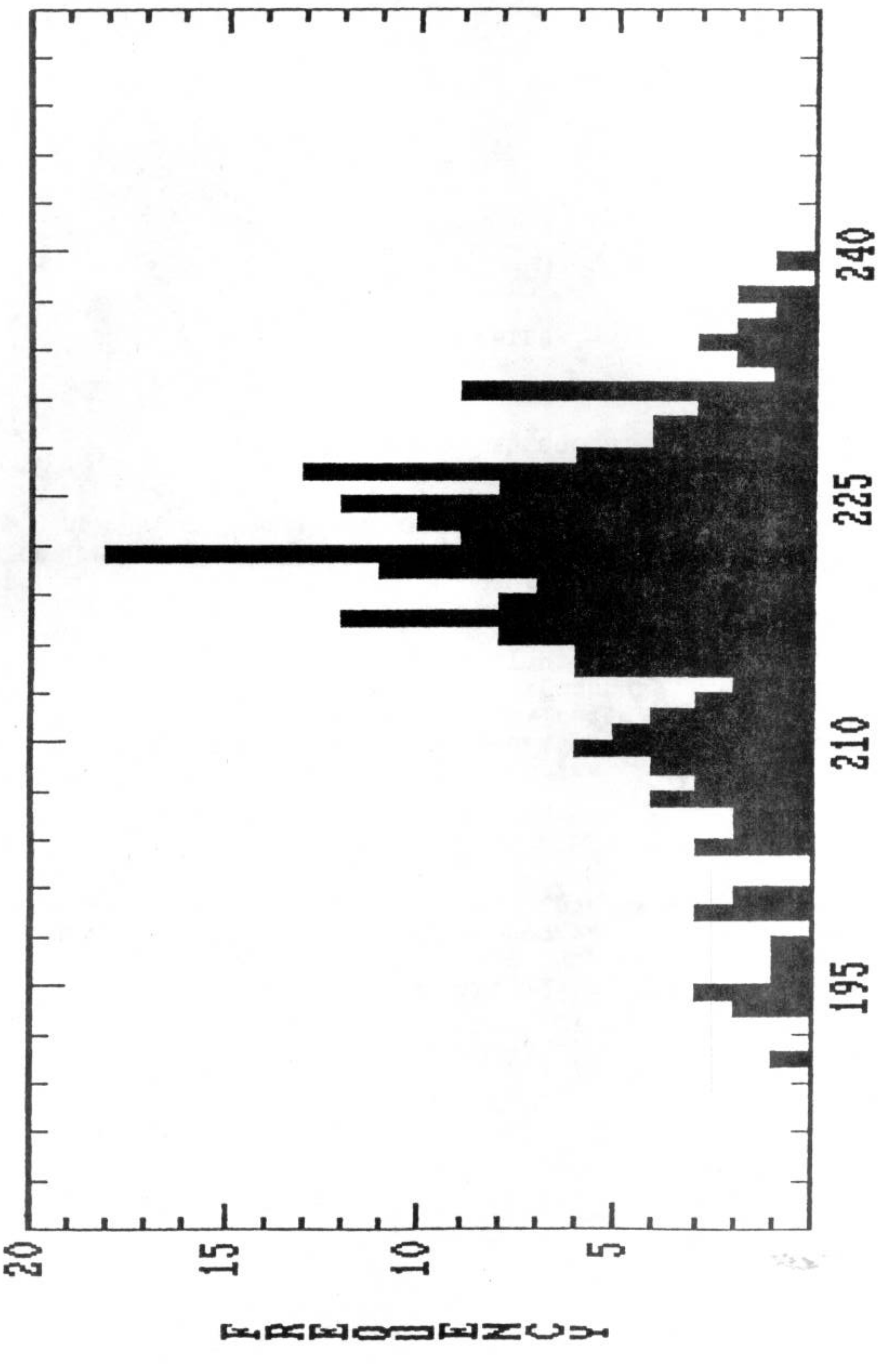

GSI
TOTAL LENGTH
0
5
10
15
0
100
200
300
400
500
600

Figure 3. Distribution of summed meristic characters (used in Edwards 1979) of 218 smallmouth bass, Guadalupe bass and their hybrids. All specimens are from Canyon Reservoir, 1979-1982.


FREQUENCY
20
15
10
5
195
210
225
240
INDEX

TEXAS CHAPTER

OF THE

AMERICAN FISHERIES SOCIETY

The Texas Chapter of the American Fisheries Society was organized in 1975. Its objectives are those of the parent Society -- conservation, development and wise utilization of recreational and commercial fisheries, promotion of all branches of fisheries science and practice, and exchange and dissemination of knowledge about fish, fisheries and related subjects. A principal goal is to encourage the exchange of information by members of the Society residing within the State of Texas. The Chapter holds at least one meeting annually at a time and place designated by the Executive Committee.

MEMBERSHIP

Persons interested in the Texas Chapter and its objectives are eligible for membership and should apply to the Secretary-Treasurer, Valerie Morrill at 1102 S. 7th St., Copperas Cove, TX 76522. Annual membership dues are $5 for Active Members and $4 for Student Members.