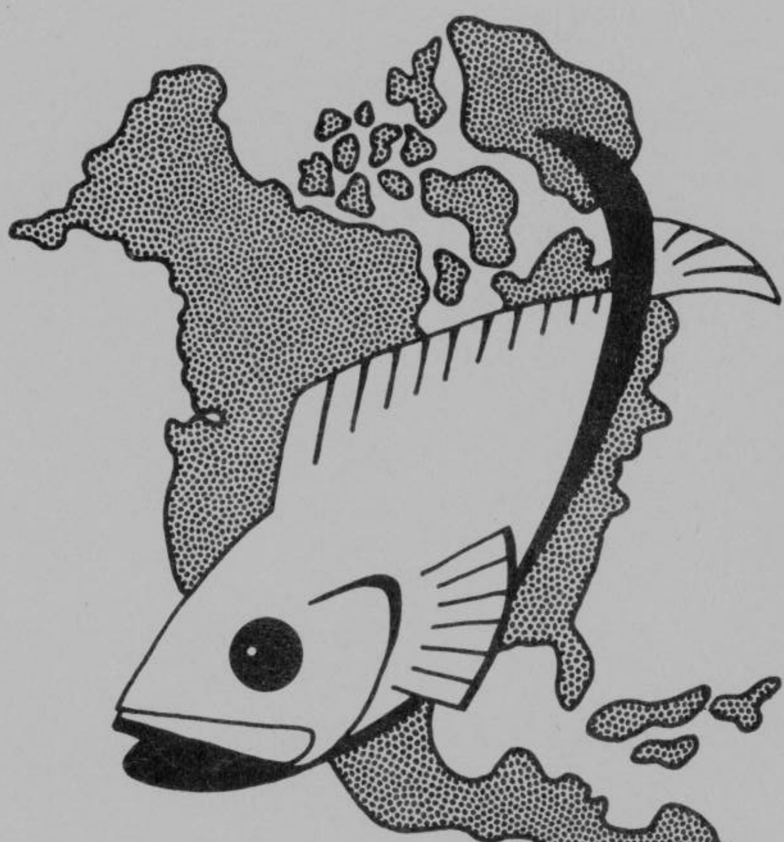
ANNUAL PROCEEDINGS of the TEXAS CHAPTER

AMERICAN FISHERIES SOCIETY

(Held in conjunction with the Oklahoma Chapter)



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KURZAWSKI

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AMERICAN FISHERIES SOCIETY

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September 16 & 17, 1983

University of Oklahoma Biological Station
Kingston, Oklahoma

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1984

TABLE OF CONTENTS

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Liquid refreshments at the Friday evening social were graciously provided by the following:

Coors Central, Inc.
Oklahoma Coca-Cola Bottling Company
North Texas Budweiser Distributing Company

1983 OUTSTANDING FISHERY WORKER AWARD

The recipient of the 1983 Outstanding Fishery Worker Award from the Texas Chapter was

Robert J. Kemp
Fisheries Division Director
Texas Parks & Wildlife Department
Austin, Texas

Bob Kemp is an individual who has, for 33 years, provided innovative leadership in the field of fisheries management. During that time he has initiated many successful biological studies and has been an extremely successful administrator. Some of his accomplishments include:

- the initiation of life history studies of flathead catfish, ending with the technique for successful spawning and rearing of that species in State hatcheries;
- at his own personal expense he imported Florida bass into Texas in 1970, and initiated hybridization and stocking research. After this new state records for largemouth bass were set in 1981 and 1982, breaking a 40-year old record;
- he initiated unique and innovative approaches to managing Texas' system of reservoirs and impoundments by multiple stocking of non-indigenous species;
- he initiated a coastwide monitoring program for coastal species.

He has been an outstanding leader in fisheries management; the variety, quantity and quality of public fishing that Texan anglers enjoy today is directly due to his vision and drive.

THE ROLE OF STRIPED BASS AND HYBRID STRIPED BASS IN TEXAS FISHERIES MANAGEMENT

by

Roger L. McCabe
Texas Parks and Wildlife Department
Waco, Texas 76705

ABSTRACT

The Texas Parks and Wildlife Department's philosophy on striped bass (*Morone saxatilis*) management is to supplement existing recreational fish stocks through more efficient utilization of available habitat. Striped bass and striped bass x white bass (*M. chrysops*) hybrids are typically pelagic, prefer shad as food, and have trophy size potential. These characteristics provide important tools for fisheries managers.

Since 1977 approximately 33 million striped bass and striped bass hybrids have been stocked in Texas' inland waters. The mean annual stocking of 4.7 million fingerlings and fry has been almost equally divided between striped bass and striped bass hybrids. Toledo Bend Reservoir and tail waters of Lakes Livingston, Granbury, and Texoma are principal sources for procuring wild brood stock. Brood fish are collected with electroshockers, gill nets and rods and reels. Hand stripping and tank spawning are used to obtain fertilized eggs. Fingerlings are reared in earthen ponds at three state hatcheries.

Lakes are usually stocked biannually at a rate of 10 fingerlings (37-50 mm TL) per acre. Releases are made in randomly selected open-water areas.

Based on news media coverage, angler feed-back, sales of specialized fishing tackle, and fisherman creel surveys, our striped bass program has been well accepted by the fishing public. Standardized fisheries management surveys indicate that striped bass and striped bass hybrids are improving habitat utilization and are not negatively impacting other sport species.

DEVELOPMENT OF STRIPED BASS FISHERIES IN TEXOMA RESERVOIR

by

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ABSTRACT

The Oklahoma Department of Wildlife Conservation introduced striped bass (Morone saxatilis) into Texoma Reservoir from 1965 through 1974 to create a new sport fishery and provide a biological control on abundant gizzard shad (Dorosoma cepedianum) and threadfin shad (D. petenense) populations. Natural reproduction of striped bass was verified in 1973 and has occurred each year since. In 1976 a project was initiated to study their effects on existing fish populations. During the 6-year period from 1976 to 1982, striped bass increased and became the most abundant sport species. This resulted in the creel limit being liberalized from one in 1976 to 15 in 1981. Largemouth bass (Micropterus salmoides) and spotted bass (M. punctulatus) remained relatively stable during this period, showing some increase in 1981 and 1982. Extremely low water temperatures during the winter of 1976 resulted in threadfin shad being absent from the reservoir in 1977 and 1978. Following their reintroduction in 1979 they became the most abundant species in 1980 and 1981 rotenone surveys. In 1976 the dominant length mode of gizzard shad was 254 mm. However in 1977 the length frequency of gizzard shad became bimodal with the additional mode being in the 76- to 152-mm range. In 1982 the number of small gizzard shad increased with the 102- and 127-mm size groups representing 95% of the population. The white bass (M. chrysops) population declined with the greatest decrease occurring in 1977 following the winterkill of threadfin shad. Crappie (Pomoxis spp.) populations were low all years during the study.

FISH POPULATION CHANGES IN KEYSTONE RESERVOIR FOURTEEN YEARS AFTER STRIPED BASS INTRODUCTIONS[1]

by

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ABSTRACT

During the 14 years after initial introduction, a viable striped bass (Morone saxatilis) sport fishery developed on Keystone Reservoir. Natural reproduction, first identified in 1970, continued through 1979 in tributary rivers. Selected endemic fish species showed no significant changes in standing crop estimates from cove rotenone studies 1971-73, 1976-79. Available prey-predator ratios (AP/P) showed a fluctuating availability of forage for small predators and ample prey for large predators.

1 Paper presented at the Proceedings of the 34th Annual Conference Southeastern Association of Fish and Wildlife Agencies, Nashville, Tennessee, 1980.

STRIPED BASS AND HYBRID STRIPED BASS AS A FISHERY MANAGEMENT TOOL

by

Thomas D. McIlwain
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Ocean Springs, Mississippi 39564

ABSTRACT

Currently, there are three schools of thought relative to the use of striped bass (*Morone saxatilis*) and striped bass x white bass (*M. chrysops*) hybrids in Mississippi fishery management practices. Striped bass are currently being stocked into open coastal streams in an effort to reestablish self-sustaining populations in those coastal streams which historically had populations of striped bass. Hybrid striped bass are being stocked into inland lakes and reservoirs to supplement existing recreational fish stocks, to provide anglers with a wider variety of game fish with which to enhance the fishing experience and in certain regions they are being stocked as a top predator.

Striped bass used in stocking coastal streams are procured from several sources each year. Fry are obtained from South Carolina, North Carolina and Virginia. These fish are reared in a semiclosed recirculating culture system at the Gulf Coast Research Laboratory in Ocean Springs, Mississippi. Generally, two crops of fish are produced each year. These fish are reared to approximately 25 mm TL and are then stocked directly into the coastal streams. Additional fingerlings (ca. 30-50 mm TL) for stocking each year are obtained from the United States Fish and Wildlife Service hatcheries located at Meredian, Mississippi and Carbon Hill, Alabama. These fish are transported to the coast and are stocked directly into coastal streams. Hybrid striped bass used in inland waters are obtained as fry from South Carolina, reared in ponds and are stocked when they reach approximately 50 mm TL.

These programs have been evaluated both by biological sampling programs and by creel reports. Striped bass stocked into coastal streams grow rapidly and mature in those streams. Several year classes are known to exist as a result of these stocking efforts. No hard evidence yet exists as to whether or not the striped bass in the coastal streams are reproducing naturally. Changes in the stocking protocol have been made this year to try to obtain hard evidence of natural reproduction. Hybrid striped bass stocked into inland lakes and reservoirs grow rapidly and are providing excellent fish after only 2 years. Previously, striped bass were stocked into these inland areas and met with only limited success.

ROLE OF HATCHERIES IN STRIPED BASS AND HYBRID STRIPED BASS MANAGEMENT

by

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Austin, Texas 78744

ABSTRACT

Striped bass (Morone saxatilis) and striped bass x white bass (M. chrysops) hybrids are widely utilized as both sport fish and as predators for controlling gizzard shad (Dorosoma cepedianum) and other forage fish populations in Southeastern reservoirs. Texas fish hatcheries in 1983 stocked 2.5 million striped bass and 1.5 million hybrid striped bass fingerlings in support of their primary objective of producing the numbers of fish requested for distribution to designated Texas public waters. Fish hatchery biologists have continually strived to improve and refine the methods for broodstock and fingerling hauling and transportation, for spawning broodfish, and for increased efficiencies for survival and growth of fry and fingerlings during the pond grow-out period in order to produce a quality, healthy fingerling for stocking. Improved methods for pond fertilization, zooplankton sampling and manipulation, and increased knowledge of zooplankton dynamics in rearing ponds have resulted in improved survival and growth of fingerlings which exhibit increased resistance to the stresses of harvesting, transportation, and stocking. Proposed improvements to the spawning and rearing facilities at the Dundee and Possum Kingdom State Fish Hatcheries should result in stronger fry with a subsequent reduction in observed mortalities occasionally seen 24-48 hours after stocking in ponds. Continued improvements in harvesting, handling, and transportation of fingerlings should help to further reduce stress and improve stocking success. The ultimate result of all these efforts should be larger numbers of trophy fish for Texas anglers.

EVALUATION OF THE OKLAHOMA STRIPED BASS X WHITE BASS STOCKING PROGRAM

by

Conrad W. Kleinholz
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ABSTRACT

Striped bass (Morone saxatilis) x white bass (M. chrysops) hybrids were first produced in Oklahoma in 1977. The objectives of the hybrid program were to provide additional angling opportunities, especially in reservoirs with limited populations of crappie (Pomoxis spp.) and black basses (Micropterus spp.) and to provide an attractive sportfish which would prey heavily on native gizzard shad (Dorosoma cepedianum) populations. Striped bass females and white bass males are spawned artificially in May. Swim-up fry (250/hectare) were used for most stockings, but fingerlings (25/hectare) are stocked if populations are not established with fry.

Sixteen reservoirs in Oklahoma have been stocked with hybrids and four of the reservoirs have developed fisheries. Reservoirs with successful fisheries are newer and have greater water clarity than those with nonsuccessful stockings (Mann-Whitney; $P = 0.02$). Nonsuccessful stockings are associated with fry loss at stocking, most common in small reservoirs (Chi-square; $P < 0.01$), and forage problems in turbid reservoirs (Chi-square; $P = 0.02$).

[1] Cooperators of the Unit are the United States Fish and Wildlife Service, the Oklahoma Department of Wildlife Conservation, and Oklahoma State University.

TEXOMA STRIPED BASS BIOTELEMETRY

by

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Norman, Oklahoma 73069

ABSTRACT

Ultrasonic transmitters were surgically implanted into 20 adult, sexually mature striped bass (*Morone saxatilis*) in Texoma Reservoir. These fish were located 140 times from June 1980 through May 1981. Findings confirmed that these transmitter-equipped striped bass were found in the central pool area of Texoma during the summer and early fall. Analysis of their position revealed highest aggregation in August with dispersion occurring in November. Although the degree of aggregation for the most part did not change from June through October, the areas that they inhabited shifted during this time. Only four transmitters were still functioning by the spring of 1981.

PRELIMINARY OBSERVATIONS OF MOVEMENT, MIGRATION PATTERNS AND WATER TEMPERATURE PREFERENCES OF STRIPED BASS IN LAKE WHITNEY, TEXAS

by

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ABSTRACT

Movement, seasonal migration patterns and seasonal water temperature preferences of 30 adult striped bass (*Morone saxatilis*), ranging in weight from 3.0 to 9.0 kg, are being determined in Lake Whitney, Texas and the Brazos River upstream. Preliminary data analyses (early November 1982 - early August 1983) showed movement, areas of concentration and water temperatures occupied varied with season. Movement in the fall ranged from 0 to 16.6 km ($\bar{x}$ = 2.7 km), and fish congregated in middle and lower lake areas. Depths inhabited during this period ranged from 1.5 to 15.2 m ($\bar{x}$ = 5.2 m), and occupied water temperatures ranged from 11.2 to 18.0 C ($\bar{x}$ = 13.5 C). Winter movement ranged from 0 to 17.6 km ($\bar{x}$ = 4.0 km), and fish again concentrated in the middle and lower lake during early winter. However, the fish began to congregate in the river proper as winter progressed. Depths inhabited during this season ranged from 0.9 to 12.2 m ($\bar{x}$ = 5.3 m), and water temperatures occupied ranged from 4.5 to 15.4 C ($\bar{x}$ = 11.9 C). Movement in the spring ranged from 0 to 43.0 km ($\bar{x}$ = 9.3 km), and concentrations of fish were again found in the river proper. However, other fish congregated in middle and lower lake areas. Selected depths during this period ranged from 1.5 to 16.0 m ($\bar{x}$ = 6.1 m), and occupied water temperatures ranged from 11.8 to 24.8 C ($\bar{x}$ = 20.2 C). Summer movement ranged from 0.1 to 15.0 km ($\bar{x}$ = 4.1 km), and fish congregated only in lower lake areas. Inhabited depths ranged from 0.1 to 13.7 m ($\bar{x}$ = 7.4 m) and fish were found in water temperatures ranging from 22.3 to 29.5 C ($\bar{x}$ = 27.5 C). This research will continue through April 1984.

PANEL DISCUSSION
QUESTION AND ANSWER SESSION

Q: WHY DOES RESERVOIR AGE AFFECT STOCKING SUCCESS? WHAT MECHANISM WOULD YOU PROPOSE FOR THIS HYPOTHETICAL "EFFECT"?

A (Kleinholz): I'm going to address that for Oklahoma reservoirs only. In Oklahoma most of our reservoirs are in watersheds composed largely of clay. So the reservoir construction has both direct and indirect affect on productivity of the aquatic ecosystem. As the reservoir ages it functions as a gigantic sedimentation basin. So we have a rather sizeable buildup of clay in these reservoirs. The type of clay that we have in Oklahoma is particularly prone to being resuspended by wind generated currents and we have plenty of wind here. The indirect affect on productivity as the reservoir ages is that more clay tends to become built up in the reservoirs. As such, when there is wind generated currents, there is clay suspended, less water visibility, and therefore less primary and secondary productivity. One of the other affects that reservoir age has on productivity is that specifically in Oklahoma not all of our reservoirs have high exchange rates. As such, they also become nutrient traps and you can have a large amount of energy tied up in types of biomass that don't turn over rapidly — large catfish, bass, turtles, etc. Then, when we do have rapid influxes of water that could help to increase indirectly the nutrient flow by inundating terrestial vegetation alot of times what we have in Oklahoma is a large daily use and that is often followed by other deluges so that we loose alot of that productivity because the phytoplankton and zooplankton being produced is washed downstream. If not it is so turbid that not all of the nutrients that are released are available to be turned into phytoplankton and zooplankton. So as a reservoir ages and becomes more turbid it just becomes less productive. Maybe what we need to do is to get more dredges in and pull the clay out and move it back upstream or maybe sell it to somebody that needs it worse than we do.

Q: DO YOU BELIEVE THAT THE DECREASE IN THE CRAPPIE POPULATION COULD BE CAUSED BY AN INCREASE IN THE NUMBER OF SMALLER SHAD THAT ARE OUTCOMPETING THE CRAPPIE FOR THE AVAILABLE PLANKTON?

A (Combs): Yes, that is a possibility. Unfortunately I can't answer that question with the information that we took and the information available other than that the possibility does exist.

Q: TO WHAT DO YOU CONTRIBUTE THESE PROGRESSIVE, ENTHUSIASTIC ATTITUDES TOWARD FISH CULTURE, PARTICULARLY WHEN FUNDING FOR EQUIPMENT AND PERSONNEL IS LIMITED AND MORALE OFTEN LOW?

A (Geiger): First, I think progressive, enthusiastic attitude has to start from the top. If your Executive Director is not enthusiastic about the program, if the Division Chief is not enthusiastic about the program and it does not filter down through all chains of command you will not win. You will fail. Secondly, by getting your personnel involved and motivated (1) to attempt to try new ideas, (2) showing them that these ideas will work, and (3) trying to stimulate them to take it one step farther (they can develop the research ideas, implement the research and publish the results), this is going to, hopefully, generate a spirit that "Yes, we can do the work. Give us the funds and give us the equipment." Funding for equipment and personnel is limited. Funding is related essentially to how your agency is represented by the public and I think we, as fisheries managers have an obligation to try to express both the good and bad points of our programs. In Texas I think we have a very aggressive leadership at the top of the Parks and Wildlife Department and this aggressive leadership has communicated very effectively to the Legislature which controls the funding. The Legislature has responded with increased funding and a commitment to a 10-year hatchery renovation plan. That's not to say this is a unique situation in Texas. I think this can occur in other states.

Q: HOW OFTEN HAS THE PUBLIC BEEN ASKED BEFORE STOCKING OF STRIPERS OR HYBRIDS? ARE THE PUBLIC HEARINGS HELD? ARE THEY PROPERLY INFORMED OF POSSIBLE POSITIVE AND NEGATIVE EFFECTS?

A (McCabe): Speaking for Texas we have not taken the issue to the public. I guess we operated under the assumption that we know what's best for them. I think alot of this came about just from the evolution of our striped bass program. It started out as a "Let's see if we can do it" and then it transitioned very rapidly into "Well we can do it; let's do it in a big way." I think this is a good idea, I think knowing fishermen's attitudes is always a good idea before you develop any kind of a program. Unfortunately we got the cart before the horse. A fishermen attitude survey is now on the drawing board, but unfortunately we did not do this before we started any of our major programs.

Q: IF WE ASSUME THAT STRIPED BASS SPAWN IN INLAND STREAMS, WOULD NOT A SPOT EXAMINATION OF THE IMPACTS ON THE INDIGENOUS STREAM FISHES AND FISHERIES BE APPROPRIATE? IN OTHER WORDS, IF YOU FAIL TO FIND AN IMPACT OF POINT, IT DOES NOT NECESSARILY MEAN THAT THE IMPACT HAS NOT OCCURRED ELSEWHERE.

A (McIlwain): Let me again just answer for Mississippi. Preface with the remark that we did have a population of striped bass in our area prior to our efforts to reestablish the population. We did a biological analysis in the lower reaches of the streams that we've stocked prior to the stocking effort. We followed that up with several others over the last 15 years or so and we have not been able to identify any impact at this point in time. There is still a very adequate shad population in the area. Additionally, we have a large menhaden population in the coastal streams at certain times of the year. We find stripers feeding on those but to date we have not found any impact. I'm not sure how else you would go about measuring this impact. We feel stripers are occupying a niche that was unoccupied prior to our efforts to reestablish them.

Q: WHEN COMPARING THE MOUTH SIZE OF STRIPED BASS TO LARGEMOUTH BASS, WHY DO YOU BELIEVE THAT STRIPED BASS FEED ON LARGER SHAD (i.e., GIZZARD SHAD) THAN DO LARGEMOUTH BASS? THEREFORE, DOES THE OPEN WATER PREFERENCE OF STRIPERS OUTWEIGH THE STRIPERS SMALLER MOUTH? HAVE STOMACH ANALYSES BEEN LOOKED AT ENOUGH?

A (Harper): To get to the last part of it, I don't know if they have been looked at enough. They have been looked at in great detail. In our study here on Texoma we looked at them, Dave (Combs) looked at them at Lake Keystone, and I'm sure Texas has looked at them on several lakes. You can go through about every state that has striped bass fisheries and they have done stomach sample work. Primarily the clupeids are the primary forage. In Texoma, we found that 4- to 6-inch drum are used to some extent at some times of the year. May fly larvae and insects are used sometimes. But in stomach samples that we did on Texoma we rarely found any largemouth bass. We only found one white bass. We did find striped bass utilized other striped bass somewhat, especially following the huge 1979 year class. Regarding whether the open water preference of the stripers outweighs their small mouth, I think it certainly would. Striped bass actively chase school shad and I don't believe largemouth bass will chase schools of shad that far. A striper will take after a school of shad and follow them for hours feeding on them. And the shad are more territorial and restrict their movements probably more along the shoreline. Now, I would like to address one question that Roger answered for Texas on public hearings. When Oklahoma first got into the striped bass work, we were concentrating on establishing a population in Keystone, but we were getting a lot or pressure to establish them in Texoma. In fact, that is why we stocked 200,000 in the spring of 1977. We also were getting pressure from the other local groups around other lakes to stock them. And since that time we do hold public hearings to the extent I believe we had two or three up in the Eufalla area. Some groups wanting to establish striped bass there and others not. We held one just this year and I believe the concensus was that they didn't want stripers stocked in Eufalla. Therefore, at this the Department is not actively going to try to introduce them in Eufalla.

Q: HOW DOES DATA TAKING FROM THE BOAT AFFECT STRIPED BASS DEPTH?

A (Summers): We didn't really have the means of determining directly depth from our study. It is very difficult to say, then, how taking data from a boat affects striped bass depth. Obviously, when we have gone through surfacing striped bass schools with a boat, those fish have gone down. With ultrasonic telemetry one thing you have to remember is you are going to have to be stopped to do any kind of evaluation of where the fish is; you are not underway when you are tracking fish. In a typical situation you are going to stop at a certain point and listen for a fish. If you pick up any signals at all you are going to start moving toward the fish and stop again, and try maybe through several locations triangulating the exact location of the fish. It is not like radio telemetry where you can just motor along and find the signal and then determine where each exact location is. I would guess that the effect may be minimal.

A (Mulford): I have had the opportunity to see if this affects the depth of the fish. Whenever I find my fish shallow, they are usually in close proximity of a tree line in 1.0 to 1.5 m of water. At these times I don't usually get directly over the fish on purpose. A couple of times I have gone directly over the top of these fish and in one instance the fish did not move off; in the other the fish moved off very slowly down along the tree line. I believe our impact is minimal. If it isn't, I'm sure we don't affect striped bass moving all over the lake as much as the myriad of fishing boats do.

Q: HOW DO FRESHWATER MANAGERS ASSESS THE POTENTIAL IMPACT OF THEIR FRESHWATER STOCKINGS OF STRIPED BASS ON EXISTING SALTWATER FISHERIES FOR OTHER SPECIES (e.g., SHRIMP)?

A (McIlwain): I'm not absolutely sure how you would go about doing that. The only thing I can say in answer to this question is that most of the freshwater stocking over time have ended up supplying a large volume of striped bass to our coastal waters. The Mississippi River down south of New Orleans has a fishable population of striped bass resulting from the stocking efforts of probably all of the states that drain into the Mississippi River. Again, I'm really at a loss to come up with some methodology specifically relating to shrimp. I know in our particular area in Mississippi the stomach analyses that we have done on striped bass that we find in our coastal bays have not contained any shrimp whatsoever. Again, they appear to select primarily menhaden. Small menhaden of course, look like small shad, about the same body shape and form. The Gulf coast has, particularly in our area, a very large menhaden industry and from time to time I get a little uneasy about that, but our fish, again, don't appear to move. They stay basically in the bays although we do have some returns from outside in open waters in the Gulf in the high salinity waters. They primarily occur back in the bays and bayous and the streams that feed these bays and bayous. If I had to guess right now I would say that they do not have an impact on shrimp in our area; menhaden, possibly.

A (McCabe): I would just make a comment similar to what Tom made. We have striped bass in virtually every river drainage in the state of Texas. I don't think we decimated the shrimp. They do have the opportunity to get in the bay systems, but the only occurrence we hear about the striped bass is a very occasional report. So I don't think the populations that are established from inland stockings are dense enough to really impact anything.

Q: WHAT IS THE RELATIONSHIP BETWEEN FISH SIZE STOCKED AND THE SUCCESS OF THE STOCKING?

A (McCabe): I would like to relate two pieces of information. The Striped Bass Committee of the Southern Division is currently conducting a study on stocking standard 2-inch, if you would, fingerling size fish versus advanced fingerlings at Lake Grease in Arkansas. The results are going to be awhile in coming, but that study is being done. From our own experience, we haven't gone into doing a detailed evaluation but we really have seen no difference between dropping down to 1.5-inch fingerlings versus a 2- or 3-inch fingerlings as far as our introduction successes go.

Q: AS LONG AS YOU ARE COMMENTING ABOUT SIZE WOULD YOU BRIEFLY COMMENT ON THE STOCKING RATE AND THE AGE (IN DAYS) OF HYBRID FRY THAT WE STOCK IN OUR RESERVOIRS AS COMPARED TO THE STOCKING RATE AND AGE OKLAHOMA REPORTED IN THEIR HYBRID STOCKING PAPER?

A (McCabe): We started playing with some hybrid fry introductions about 3 years ago and this came about really because we had a surplus of hybrid fry and we didn't have anywhere to go with them. We decided to try it in about five different lakes. And low and behold, they took very solidly in at least three and possibly four of those lakes. So we scheduled to do it again on our alternate year stocking schedule, and it worked again. And these stocking rates varied from about 25, 5-day-old fry per acre up to I think about 100 fry per acre. And they have all been successful in terms of establishing fisheries if you will accept that very subjective qualification. We have done some striped bass fry stocking with 5-day-old fry and have been totally unsuccessful. We have gone to 10- to 12-day-old fry and it appears we have had relatively good success at Lake Texana with a stocking rate of 100 per acre. We did try a 5-day-old fry stocking at Tradinghouse Reservoir, which is a power plant lake, and we did not get any recoveries from that. We also tried a 5-day-old stocking at Lake Tawakoni and got no recoveries from that stock. It appears that 10- to 12-day-old fry stocking is working. That is essentially why we went with that stocking plan in the coastal areas, because it does show some favorable results.

Q: ADULT STRIPED BASS HAVE BEEN KNOWN TO UNDERGO STARVATION BECAUSE OF VERY STRICT THERMAL LIMITATIONS AND STRATA WHERE FORAGE WAS EITHER DEPLETED OR ABSENT. HOW PREVALANT IS THIS IN TEXAS AND OKLAHOMA? DOES THIS INFLUENCE THE SELECTION OF RESERVOIRS THE STRIPERS AND/OR THEIR HYBRIDS ARE TO BE ESTABLISHED IN? AND IF SO, HOW?

A (Kleinholz): There have been reported summer die-offs of stripers in Oklahoma; there have been some in Lake Tenkiller, some here in Lake Texoma, and some in Lake Keystone. But, as far as the hybrid bass, I haven't heard of any die-offs occurring because of that. In one of the lakes that we studied the hybrid bass, it stratifies very quickly in the summer and destratifies very quickly because of wind-generated currents. We see in that lake, only through reports from anglers because the population has never been large enough to successfully sample, that the fish do tend to select the temperature zone if they can find it. But if they can't find it, they tend to stay where they have to have oxygen. David, do you want to comment on the Keystone striped bass population?

A (Combs): I think the question was relating to starvation and forage problems where either the forage was depleted or absent. First of all, in Keystone Reservoir there is no forage problem. In Texoma there apparently is none either. Keystone has an annual summer mortality. It has occurred ever since, I believe, the existence of the striped bass populations there. It varies in effect from year to year; sometimes it is only slight, this year it's excessive. It seems to be a limiting factor, but the fish that we see dead are in relatively good condition. They do not appear to ve emaciated; a few are. They are relatively restricted to larger sizes, as was reported. And I really can't answer it on the basis of where forage is depleted or absent, because we certainly have no forage problems here. But, it certainly seems to be fairly correlated with thermal problems that were reported earlier.

A (McCabe): I think that this question is primarily directed at food availability and the lake that I mentioned, Lake Falcon, where we have a little problem currently in progress, has no forage problems at all. This lake has a very large standing crop of shad and the temperature gradient from top to bottom is so small that I don't really feel like there is a thermal differentiation between where the shad are and where the striped bass are. I think it is just a direct stress related problem. About the other die-offs that we have and the emaciation problems that we have, I can only talk in terms of the symptom, not the cause. We find emaciated fish at

Lake Whitney. We have a very adequate forage base there but a very strong thermocline set up in the summer. At Canyon Lake we have the same thing. The forage base is much smaller, but proportionally the striped bass population is much smaller, so I think there is adequate forage to accommodate that population also. Really the only other major die offs we've had on striped bass occurred at Toledo Bend. And that was pretty well isolated to a dissolved oxygen problem, not a temperature problem.

A (Mulford): The main thing I have seen on Lake Whitney is where stripers have apparently avoided a temperature was when the temperature heated at 25 C up the river in latter May. During the previous 2-week period we were down there and had several fish up the river. Two weeks later when the temperature was at 25 C top to bottom, the fish left this area. And according to the literature this is the temperature they try to avoid beginning at 25 to 27 C. Of course there are no refuge areas in Lake Whitney like there are in Cherokee Reservoir. So I believe the striped bass may try to avoid these temperatures up the river early but once they don't have any choice they have a kinesthesis response where they are just constantly moving around, stop and go movement, hunting for cooler temperatures possibly and then they go into the lower dissolved oxygen. They don't have any choice and I don't believe they are really affected that much, especially on Lake Whitney. They are hunting for this, but they don't find it, and I don't believe it's killing them.

Q: HAS ANY STOCKING OF HYBRID STRIPED BASS BEEN USED IN SMALL PONDS (3 to 5 ACRES IN SIZE) TO CONTROL SUNFISH AND GIZZARD SHAD POPULATIONS? IS ANYONE FAMILIAR WITH THIS PRACTICE?

A (Kleinholz): We had a project that took place down in the Washita Mountains National Wildlife Refuge, outside of Lawton in southwest Oklahoma, in which hybrid striped bass were used to see if they could control stunted sunfish populations. There were a whole lot of problems with the project. In the first place, the ponds not only had very large populations of sunfish, but one of the reasons that they had very large populations of sunfish was that there was extensive vegetation growth, such that there was no cropping by other predators. And hybrid fry were initially stocked in these small ponds as they are everywhere else. And not too surprisingly, there wasn't any survival. So then, fingerlings were obtained. I believe the mean length of these fingerlings was somewhere between 150 and 200 mm total length; pretty good sized fingerlings. They were obtained in the fall and stocked in approximately mid-November. We do not know whether those fingerlings died at stocking or sometime during the winter, spring or whatever. What we do know is that in about 2.5 years three of those fish were recovered, which is a pitiful return. So, apparently there is enough shock from just transporting these fish that they are kind of shaky. One of my study reservoirs is only 100 surface acres. At times it does have and at times it does not have extensive vegetation. When there was extensive vegetation in the reservoir we stocked fry and we got no returns. Where there was not extensive vegetation the following year, we stocked fry and got some returns. I don't know whether that is related to sunfish predation, difference in nutrients available to be turned into plankton or what. The problem seemed to be more closely correlated with the vegetation than it did with the sunfish because sunfish were incredibly dominant during all the years of the study.

COMMENT (Geiger): I would like to make a brief summary on what we have seen here. We've seen the status of striped bass in Oklahoma and in some respects also in Texas. I think since we do have alot of research biologists here we should start asking ourselves where research needs to be directed. What kind of research needs to be done? I think we've got several good answers on where we need to direct our research. For example, management biologists, where are those limnological parameters in your reservoirs and what are the zooplankton dynamics in the reservoirs? Culture biologists, where are you not using some of these more sophisticated tools that you have available to get more predictibility in culture pond management? Why haven't we developed a reliable marking technique for fry and fingerling fish yet to better assess stocking success? If we are going to get into fry stocking, why haven't we got into some more of the sophisticated physiological and biochemical research dealing with adult brood fish in terms of transportation, hauling and physiological stress related to temperature? And what about nutritional stress related to deprivation of food, inactivation of nutritional enzymes, and so on? These are all vital, important research areas I think we need to address if striped bass culture and striped bass management and striped bass fisheries will go forward in the future.

COMPARISON OF PRECISION OF THE OTOLITH AND SCALE METHODS FOR AGEING WHITE CRAPPIE IN OKLAHOMA

by

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ABSTRACT

Scales and otoliths (sagittae) were taken from a sample of 137 white crappie Pomoxis annularis collected by fyke netting from Fort Supply Lake, November 1982. Scales and otoliths from each fish were aged independently by three experienced scale readers. None of these individuals had prior experience ageing otoliths.

Reproducibility of each ageing procedure was tested with a coefficient of variation (CV) and index of precision (D) for the three readers. Mean CV for the scale and otolith methods were 58.6 and 8.2, respectively; mean D were 33.8 and 4.7, respectively.

Differences in back-calculated lengths at each annuli computed from the right versus left otolith were tested using a dependent t-test. None of the differences observed in back-calculated lengths at ages I - IV for any of the three readers were significant at $P < 0.05$.

Use of the otolith method for ageing white crappie in Oklahoma is recommended over the scale method. Once field personnel become efficient at extracting otoliths, processing time in the field is only slightly greater than for taking scale samples. Since ages can be calculated from whole otoliths, no elaborate preparation procedures are required to facilitate ageing.

ELECTROPHORETIC EVALUATION OF TWO SUBSPECIES OF BLUEGILL

by

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ABSTRACT

A "pure" hatchery stock of *Lepomis macrochirus purpurescens* originally from Lake Okeechobee, Florida, and a sample of *L. m. speciosus* from Lake Conroe, Texas were evaluated electrophoretically. Allele frequencies at 19 enzyme-encoding gene loci were determined. Diagnostic electromorphic differences between the two populations were detected at one esterase locus and allele occurrence differences were evident at several additional loci. Estimates of genetic similarity and distance (calculated by Rogers' and Nei's methods) were consistent with those previously calculated for *L. m. purpurescens* and *L. m. macrochirus*. A comparison of allele occurrences previously reported for *L. m. macrochirus* and those of *L. m. speciosus* in this study does not lend support to the recognition of *L. m. speciosus* as a distinct subspecies. Regardless of the subspecific status of Texas bluegill, the distinct genetic differences between these fish and *L. m. purpurescens* in Florida can be used as a mechanism for hatchery stock and management evaluations in Texas waters.

COMPARISON OF NITRITE TOXICITY TO THREE SPECIES OF WARMWATER FISHES

by

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ABSTRACT

Nitrites may reach toxic concentrations in aquatic environments. Inconsistent nitrite toxicity values in the literature have often been attributed to water quality differences in test water (i.e. pH, alkalinity, hardness, chloride). Median lethal concentrations (LC-50) of nitrite were determined for three species of fish under the same water quality conditions (pH 7.9, alkalinity 230 mg/liter, hardness 260 mg/liter, temperature 23 C). Toxicity varied with species; tilapia *Tilapia aurea*, fathead minnows *Pimephales promelas* and largemouth bass *Micropterus salmoides* had 96-hour LC-50 values (mean ± 1 SE) of 53 ± 7, 141 ± 9 and 460 ± 27 mg/liter, respectively. Further research with fathead minnows indictated small fish (< 0.8 g) were more tolerant to nitrite than large fish (> 0.9 g). Size as well as species should be considered when estimating acceptable nitrite concentrations.

EVALUATION OF GENETIC HETEROGENEITY IN A RESERVOIR WALLEYE POPULATION

by

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ABSTRACT

Very little is known about genetic dynamics of reservoir walleye *Stizostedion vitreum vitreum* populations. Identification of distinct unit stocks within a population is necessary for effective management because these stocks within the same lake may have dissimilar growth, abundance, yield, age composition, recruitment and mortality.

Walleyes were collected at three known spawning sites in Lake Meredith, Texas. Collections were made during reproductive and nonreproductive periods to assess possible sex-, temperature-, or location-linked genetic differences among groups of walleyes. Thirty protein systems were surveyed using polyacrylamide and starch gel electrophoresis to identify and monitor possible unit walleye stocks. Results show highly significant location-linked genetic differences during the spawning season ($N > 475$). Results also indicate there are water temperature-related differences at individual spawning sites for walleyes collected during pre-, peak-, and post-spawning activity. Data for walleyes collected during nonreproductive periods ($N > 100$) indicate that some segregation also exists during these times.

Such genetic heterogeneity could be an important management consideration if the majority of annual walleye recruitment in Lake Meredith comes from a single unit stock. If genetically different subpopulations are identified and treated as separate biological units, a more effective management scheme might be developed.

INDICES OF POPULATION SIZE AND SIZE STRUCTURE OF LARGEMOUTH BASS

by

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ABSTRACT

Population estimates were obtained for largemouth bass Micropterus salmoides in 11 flood prevention lakes by mark-recapture. Three estimates were obtained for each lake over a 15-month period (Fall, 1979; Spring, 1980; Fall, 1980). Best estimates ranged from 35 to 1,310 bass < 250 mm TL per hectare and 6 to 107 bass > 250 mm TL per hectare. Relative abundance of the two size groups was represented better by spring than by fall electrofishing. Proportional stock density values of 40 to 60% corresponded to highest bass biomasses. Gill nets poorly represented bass abundance and size distribution.

RETENTION OF WIRE NOSE TAGS BY LARGEMOUTH BASS

by

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ABSTRACT

Coded wire tags were implanted into the snouts of fingerling (mean total length and weight, 92 mm and 10.8 g) largemouth bass Micropterus salmoides to evaluate tag retention. The stainless steel wire tags (1.0 x 0.25 mm) were injected into the nasal cartilage of 200 fingerlings. A control group of 280 fingerlings was handled identically but received no tags. The two groups were mixed and stocked into 0.04-hectare earthen ponds. Random samples were taken irregularly throughout the 16-month study period. Three independent methods of tag detection were used: dissection, electronic metal detection, and x-ray. Largemouth bass fingerlings shed coded wire tags within the first 4 to 6 months, after which tag retention stabilized (58.6% after 16 months). At harvest, no significant differences were detected between tagged and untagged fingerlings for total survival, growth (length, weight, and condition) or behavior.

CHARACTERIZATION AND ALLEVIATION OF HAULING - INDUCED STRESS IN LARGEMOUTH BASS

by

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ABSTRACT

Stress and mortalities associated with long-term truck transport of advanced (200 g, 21 cm) largemouth bass Micropterus salmoides have long been recognized. Our objectives were to characterize stress during and after hauling periods of up to 30 hours at a density of 100 g fish/liter of water and to develop methods to reduce stress and mortalities. Plasma corticosteroid and glucose concentrations were used as general indicators of hauling stress and changes in plasma chloride concentrations and osmolality as indicators of osmoregulatory dysfunction. Fish transported via truck had significantly elevated plasma corticosteroid and glucose concentrations and decreased plasma chloride concentrations and osmolality. Significant mortality was associated with hauls of 24 and 30 hours (38% and 83-92%, respecitvely). Plasma characteristics returned to near normal values 3 to 28 days after hauling with recovery time related to length of haul and associated mortality. Mortality and sublethal stress were reduced significantly (0% mortality during and following a 30-hour haul) when fish were transported and handled as follows:

1. prophylactic disease treatment for 10 days prior to hauling;
2. pre-haul starvation for 72 hours;
3. pre-capture (post-crowding) anesthesia with MS-222 (50 mg/liter);
4. haul in water containing salts nearly isotonic to fish plasma (NaCl, KCl, KH_2PO_4, $MgSO_4$, along with high native calcium and bicarbonate), anesthetic (MS-222, 25 mg/liter), anti-bacterial compound (10 mg/liter oxytetracycline), using cool temperatures (16 C);
5. post-haul ionic tempering in salts nearly isotonic to fish plasma for 24 hours;
6. post-haul prophylactic disease treatment for 10 days.

STRIPED BASS - FORAGE FISH INTERACTIONS IN LAKE TEXOMA

by

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ABSTRACT

From April 1981 to the present we have conducted experimental gill netting every 2 weeks, examined stomach contents of over 1,000 striped bass *Morone saxatilis* and carried out spring-summer larval fish trawling and shoreline seining at weekly intervals. This period includes three major inflow events, and a period of cold sufficient to kill some forage fish. The striped bass population was dominated by the very strong 1979 year class. Primary prey of striped bass was threadfin *Dorosoma petenense* and gizzard shad *D. cepedianum*, with little use of other forage species. Cold weather in January 1981, combined with intense predation by striped bass, resulted in almost complete loss of threadfin shad, which did not reappear in gill net samples until October 1981. Turbid water following major inflows, plus low availability of prey of the proper size resulted in very poor condition of striped bass in late summer 1982. Renewed availability of forage in autumn 1982 resulted in rapid recovery of average condition factor by striped bass. Growth, condition coefficients, dependence on invertebrate prey in April-May, and stomach contents of striped bass all suggest this species may be prey-limited at certain times of year in Lake Texoma. Unpredictable events including inflows, winter cold, and floodgate operations all played a major role in the ecology of striped bass and forage species in Lake Texoma in 1981-1983.

OKLAHOMA CITY URBAN FISHING PROGRAM

by

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ABSTRACT

In the early 1970's, Oklahoma City had one of the first urban fishing programs in the United States. This consisted of fishing access by piers, youth fishing classes, and supplemental fish stockings from the city-operated hatchery. Due to various reasons this program fell by the wayside.

Recent renewed interest in this program has occurred. A fishery biologist has been hired, a fishery management plan has been implemented, and hatchery renovation has started.

AN OVERVIEW OF COMMERCIAL LAKE MANAGEMENT

by

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ABSTRACT

The purpose of lake management on a commercial basis is to provide private lake and pond owners with a means of obtaining reliable and professional advice and service. A man-made body of water must be maintained when the facility is used or visited by people. In order to efficiently maintain these lakes and ponds, the owner should establish thorough yet reasonable goals. The commercial agency must be diversified in order to consult with clients on the following:

1. Design and construction
2. Water quality control
3. Aquatic and riparian vegetation control
4. Fish stocking and management

The lake management agency must also be able to offer cost estimate proposals and budget figures to prospective as well as contractual clients.

SPATIAL INTERACTIONS OF COHABITING PREDATORY FISH SPECIES

by

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ABSTRACT

Reservoirs provide nearly all the angling opportunities available in west Texas. Management of these systems has relied heavily upon extensive fish culture and stocking programs to establish and maintain desirable fish populations. Exotic predators such as walleye Stizostedion vitreum vitreum have been successfully introduced into many west Texas reservoirs. It may be economically inefficient to simultaneously stock several predators that may negatively interact. Negative interactions between successfully established species and additional exotic introductions may adversely affect an already productive fishery.

Habitat-use overlap may be an indicator of interspecific negative interactions. Species showing a high degree of overlap in habitat usage may compete for resources associated with that habitat, possibly limiting production of one or both species.

Ultrasonic transmitters were surgically implanted into 13 walleyes and 13 largemouth bass Micropterus salmoides in Lake Mackenzie, Texas. Tagged fish were tracked seasonally June 1982 through May 1983, and transmitter fixes were plotted on a reservoir habitat grid map. Habitat-use overlap between walleye and largemouth bass varied seasonally. Summer fish showed a higher degree of overlap than fall and winter fish. Overall, habitat-use overlap between walleyes and largemouth bass appeared minimal, and strong competitive interactions seem unlikely. Knowledge of how various species interact will help biologists optimize stocking expenditures.

COMPARISON OF HEAT TOLERANCES OF REDBAND TROUT, FIREHOLE RIVER RAINBOW TROUT AND WYTHEVILLE RAINBOW TROUT

by

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ABSTRACT

Redband trout Salmo sp. ($\overline{X}$ TL = 237 mm), Firehole River rainbow trout S. gairdneri ($\overline{X}$ TL - 90 mm) and Wytheville rainbow trout, a domesticated strain ($\overline{X}$ TL = 258 mm) were acclimated to 15, 20 and 23 C and then subjected to temperature increases of 0.5 C/day until death. Lethal temperature ranges were 25.8 - 27.1, 25.6 - 27.8, and 26.4 - 27.7 C for the three trout, respectively. Upper lethal temperatures (LT_{50}) were also determined for each trout. Firehole River rainbow trout acclimated to 20 C died at a faster rate than at other acclimation temperatures. The other trout died at similar rates among acclimation temperatures.

Rainbow trout Salmo gairdneri stocked annually into put-and-take trout fisheries in Texas are progeny of the domesticated Wytheville strain. This trout is discussed in Kincaid (1981). Texas summer water temperatures commonly exceed the highest temperature (24.0 C) suggested by Hokanson et al. (1977) for short-term survival of rainbow trout. Survival of Wytheville trout is low because water temperatures approach 27 C (White 1968). Domesticated rainbow trout have upper incipient lethal temperatures (Fry et al. 1946) of 23.7 - 26.2 (Kaya 1978; Vancil et al. 1979; Bidgood 1980).

In an effort to expand existing trout fisheries and the fishing season, Texas biologists are evaluating the ability of two reportedly warm-water trout to oversummer. They are the Firehole River rainbow trout from the Firehole River, Wyoming and redband trout Salmo sp. from Parsnip Reservoir, Oregon. Other investigators have reported the upper incipient lethal temperatures for the Firehole River rainbow trout are 25.0 - 26.2 C (Kaya 1978) and upper lethal temperatures (Otto and Rice 1977), LT_{50}, for redband trout are 26.8 - 27.4 C (Sonski 1982). These studies were conducted under different conditions and experimental methods, thus making direct comparisons of results difficult. This study compares the upper lethal temperatures of redband trout, and Firehole River and Wytheville rainbow trout under the same experimental design.

METHODS

Redband trout were obtained from the Fish Cultural Development Center, Bozeman, Montana. These fish were spawned (May 1980) from wild stock captured in Parsnip Reservoir, Oregon. In August 1981, live fish were air-freighted to Heart of the Hills Research Station, Ingram, Texas where they were maintained indoors at 14-21 C for 11 months prior to temperature acclimation. Firehole River rainbow trout juveniles were produced at this station from adult fish collected from the Firehole River. They were held at 16 - 21 C indoors for 9 months before temperature acclimation. Wytheville rainbow trout were obtained from the San Marcos State Fish Hatchery, Texas. These fish were part of stock used in Texas trout fisheries, acquired through Norfork National Fish Hatchery, Arkansas. Fish were transported to Heart of the Hills Research Station by truck in March 1982 and maintained at 18 - 21 C for 8 months prior to temperature acclimation.

During all sequences of the experiment fishes were fed commercial production trout pellets (38% crude protein, 5% fat) according to the feeding table recommended by Sterling H. Nelson and Sons, Murray, Utah. During a 14-day period prior to temperature acclimation all fish were held at 18 C, and an antibiotic was added to their feed (oxytetracycline, 2.5 g/45 kg fish/day). This medication was administered to prevent an infestation of Aeromonas hydrophila. This bacteria had been identified (R. Jones, United States Fish and Wildlife Service, Pinetop, Arizona, personal communication) earlier on some redband trout cultured at this station. The fishes used in the experiment did not display clinical signs of the disease.

Three cylindrical 800-liter fiberglass tanks (diameter = 91.4 cm) served as temperature acclimation-control tanks. Redband trout and Wytheville rainbow trout were held in the main section of each tank; because of their smaller size (Table 1), Firehole River rainbow trout were held in wire baskets (320 x 350 x 150 mm, 6-mm mesh) that were partially submerged and attached to the inside wall of each tank.

Tank temperatures were adjusted from 18 C to acclimation temperatures of 15, 20 and 23 C at a rate of 1.0 C/day. Fish were held at acclimation temperatures for 21 days before placement into the test tank. Temperatures in all tanks were regulated by thermostatically controlled cooling or heating units accurate to ± 0.1 C. Air was supplied to all tanks to mix heated or cooled water. Water passed through gravel and rock filters and feces that accumulated on the bottom of tanks were removed daily.

Testing took place in one tank. This tank was divided with netted frames into three compartments. The electrical system used to produce constant temperature increases was modified from Abell et al. (1977) and consisted of electrically timed, gear-driven thermoregulators which controlled heating elements.

Fishes of each acclimation temperature group were randomly assigned to a compartment. As the water temperature in the test tank reached an acclimation temperature the respective group of fishes (Table 1) were placed in their compartment. Water temperature was increased 0.5 C/day until all fish died. Fishes remaining in the acclimation tanks served as controls.

The temperature was recorded when a species within a compartment stopped feeding and when individual deaths occurred. Fish were considered dead when they lacked opercular movement and did not respond to touch (Otto and Rice 1977).

Mortality data were analyzed for each acclimation temperature group. Percentage cumulative mortalities (arcsin transformation) were regressed on lethal temperatures to determine LT_{50}'s, temperatures when 50% mortality occurred. The effect of acclimation temperature on heat tolerance was determined by quantifying differences in regression line elevation (height of the $\underline{Y}$-intercept) and slope (death rate) using analysis of covariance (Snedecor and Cochran 1978). Differences in elevation were not tested where significant differences in slope were indicated. Size of fishes restricted analysis to the within species classification.

RESULTS AND DISCUSSION

There were little differences in temperatures at which each trout strain stopped feeding. Some fish of each strain first stopped feeding at 25.0 C; no redband trout or Wytheville rainbow trout continued to feed at temperatures greater than 26.0 C. Firehole River rainbow trout fed up to 26.7 C. Embody (1927) reported negligible feeding by rainbow trout in water greater than 25.0 C. Sonski (1982) noted that juvenile redband trout ($\bar{X}$ TL = 130 mm) stopped feeding at 25.5 - 27.0 C. Redband trout and Firehole River rainbow trout feed in their native habitat at temperatures exceeding 28.0 (Kaeding and Kaya 1978; Behnke 1979).

One control mortality was recorded for each species held at the 23-C acclimation temperature. Fishes were probably heat stressed during the experiment and acclimation period. Mortality of redband trout held at 23 C has been previously reported by Sonski (1982; 1983).

There were little differences in lethal temperatures and LT_{50}'s between acclimation temperatures within redband trout and Wytheville rainbow trout (Table 2). Comparison of regression lines for these trout indicated there were no significant differences in slopes or elevations (Table 3). Significant differences did exist, however, between slopes for Firehole River rainbow trout (Table 3); fish acclimated to 20 C died at a faster rate (Table 2).

Firehole River rainbow trout acclimated to 15 C exhibited the highest degree of heat tolerance of all species and acclimation temperatures tested (Table 2). Similarly, Kaya (1978) determined Firehole River rainbow trout acclimated to 13.0 C and 17.0 C had higher upper incipient lethal temperatures than domestic strain (Winthrop) rainbow trout acclimated to the same temperatures. Additional studies indicated redband trout (Sonski 1982), rainbow trout (Vancil et al. 1979) and other salmonids (Fry et al. 1946; Brett 1952) acclimated to warmer temperatures were more heat tolerant than those acclimated to cooler temperatures.

There were differences in heat tolerance for fishes of similar size. The Wytheville rainbow trout had LT_{50}'s 0.6 to 0.8 C higher than those for redband trout (Table 2). Experimental data is not available to compare heat tolerance of Firehole River rainbow trout in this size classification; however, LT_{50}'s determined for 130-mm TL redband trout (Sonski 1982) were similar to LT_{50}'s for fingerling Firehole River rainbow trout.

Fish size may influence results of heat tolerance determinations. Redband trout juveniles (130 mm TL) tested under identical conditions (Sonski 1982) had higher LT_{50} values than determined in this experiment with larger fish. Similarly, data compiled by Hokanson (1977) implies juvenile rainbow trout had higher upper incipient lethal temperatures (25.0 - 26.5 C) than adults (21.0 C). However, Bidgood (1980) found no differences in heat resistance of rainbow trout between five age groups (35 - 107 mm) acclimated to 10.0 C.

Agreement exists between this study and the findings of Kaya (1978) for Firehole River rainbow trout. This species does not exhibit exceptionally higher heat tolerance than domestic strain rainbow trout. These findings are supported by the genetic work of Fisher et al. (1982) who determined that Firehole River rainbow trout were not genetically different from hatchery strains.

Firehole River rainbow trout and redband trout have been reported to survive at water temperatures (Kaeding and Kaya 1978; Kaya 1978; Behnke 1979) well above the lethal temperatures found in this experiment. These trout may survive lethal exposure for prolonged time periods by behavorial adaptations to the environment such as seeking thermal refugia or shifting reproductive season to avoid detrimental effects on eggs and young (Kaya 1977; Kaya et al. 1977; Fisher et al. 1982). Also, Dickson and Kramer (1971) suggested wild rainbow trout are more active than domestic strain rainbow trout at high temperatures. This allows more available energy for swimming (Brett 1964).

Results of this experiment demonstrate a conflict between the experimental heat tolerance of Firehole River rainbow trout and redband trout and survival of these trouts at higher temperatures in native habitats. To resolve the discrepancy field trials are recommended. Redband trout have been selected to be introduced into candidate waters because they are available from Federal hatcheries. Fishery management surveys to determine angler acceptance and oversummer survival will identify if there are additional benefits in stocking redband trout than stocking domesticated rainbow trout into Texas trout fisheries.

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Table 1. Vital characteristics and number of three trout strains used in heat tolerance experiments at Heart of the Hills Research Station, Ingram, Texas, 1982. All length measurements are total length; SD is the standard deviation of means.

Strain	Age (month)	Length (mm) mean	Length (mm) SD	Weight (g) mean	Weight (g) SD	Numbers of fish experimental[a]	Numbers of fish control
Redband trout	25	236.7	34.9	141.0	62.5	5	5
Firehole River rainbow trout	9	90.0	9.8	19.0	6.4	6	5
Wytheville rainbow trout	26	257.5	14.2	199.7	31.0	5	5

[a] Number of fish subjected to temperature increases for each acclimation temperature (15, 20 and 23 C).

Table 2. Upper lethal temperatures and regressions for three trout strains exposed to temperature increases of 0.5 C/day at Heart of the Hills Research Station, Ingram, Texas, 1982.

Strain	Acclimation temperature (C)	Lethal temperature range (C)	LT_{50} (C)	Slope[a]	Intercept[a]	$\underline{r}^2$
Redband trout	15	25.8 - 26.8	26.2	50.37	-1,276.80	0.728
	20	25.8 - 27.1	26.2	45.80	-1,155.18	0.957
	23	25.8 - 27.1	26.2	45.80	-1,155.18	0.957
Firehole River rainbow trout	15	27.2 - 27.8	27.4	103.41	-2,788.42	0.975
	20	27.2 - 27.4	27.2	273.80	-7,411.03	0.995
	23	25.6 - 27.3	26.3	30.75	-763.62	0.823
Wytheville rainbow trout	15	26.8 - 27.7	27.0	66.72	-1,756.84	0.922
	20	26.4 - 27.3	26.8	61.92	-1,614.56	0.829
	23	26.8 - 27.7	27.0	69.76	-1,838.80	0.976

[a] Slope and intercept were obtained from regression equation expressed by arcsin $\underline{Y} = \underline{a} + \underline{bX}$ where $\underline{a}$ = $\underline{Y}$-intercept at $\underline{X}$ = 0, $\underline{b}$ = slope, and $\underline{X}$ = lethal temperature.

Table 3. Tests of significance from analysis of covariance for heat tolerance tests of three trout strains conducted at Heart of the Hills Research Station, Ingram, Texas, 1982. Regression lines were compared for each strain acclimated to three temperatures.

Strain	Slope		Elevation	
	F	df[b]	*F*	df
Redband trout	0.03	2,4	0.02	2,6
Firehole River rainbow trout	5.79[a]	2,5	-[c]	-
Wytheville rainbow trout	0.06	2,5	2.34	2,7

[a] Indicates a significant *F*-value at $\alpha = 0.05$.

[b] Degrees of freedom (df) referring to numerator df, denominator df used to determine critical (table) *F*-values.

[c] Significance test not performed when differences in slope were determined.

ECONOMIC ANALYSIS OF SMALL-SCALE CAGE CHANNEL CATFISH-BLUE TILAPIA POLYCULTURE

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ABSTRACT

Production results from research with caged channel catfish *Ictalurus punctatus*-blue tilapia *Tilapia aurea* polyculture were used to formulate enterprise wholesale and retail budgets for the Oklahoma area. Budgets were based on the total production from three 1-m^3 cages in a 0.4-hectare pond. The wholesale budget showed a net loss of $104.07 after estimated labor costs were added; retail budgets for live and dressed fish showed profits of $426.32 and $604.67, respectively.

Many economic studies have been conducted on the monoculture of caged channel catfish *Ictalurus punctatus*. Brown (1979) and Collins and Delmendo (1979) have derived budgets for large-scale caged channel catfish operations while Rogers and Madewell (1971) and Collins (1978) have composed budgets for somewhat smaller caged channel catfish operations. However, there have been few analyses of truly small-scale operations of caged blue tilapia *Tilapia aurea* culture and no budgetary analysis of a small-scale caged polyculture of these two species.

Williams (1982) and Da Silva (1983) have demonstrated that the addition of tilapia to a caged channel catfish production system will increase average production of the catfish and gross production of the cage. The tilapia apparently stimulate catfish feeding which helps to insure production of harvestable-size channel catfish in one season following spring stocking with 4-6-inch catfish fingerlings. The ability to produce harvestable-size fish in one season is very important in areas such as Oklahoma with relatively short growing seasons. Because of the biological success of caged channel catfish-blue tilapia polyculture in small ponds, we decided to analyze the economic feasibility of such systems.

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The economics of small-scale fish culture may be analyzed from at least four perspectives: (1) raising fish and selling them to a processor at a live-weight wholesale price, (2) selling live fish to the consumer from the pond bank at a retail price, (3) selling dressed fish directly to the consumer at a retail price, or (4) using the fish for personal home consumption. Budgets were prepared from these perspectives.

METHODS

It should be noted these budgets are based on Oklahoma prices which means the cost of production as well as the price for harvested fish is higher than the national average. Budgets were formulated from small-scale polyculture production data (Williams 1982; Da Silva 1983) for the maximum production of marketable channel catfish and blue tilapia in a caged polyculture system in a 0.4-hectare pond. This system involved three 1-m^3 cages, each stocked with 350 channel catfish and 50 blue tilapia.

The costs associated with production were calculated from exact costs incurred during production research in 1982-83 or from estimates of the cost based upon our knowledge of small-scale fish production systems. Channel catfish used in this study weighed an average of 21 g when stocked and were fed ad libitum daily, over a 135- to 140-day growing season. The cost of blue tilapia was $0.20 each for 45-g fish at stocking. The average feed conversion ratio was 1.8. Feed costs were based on the average price of a 36% protein cage fish chow.

Transportation expenses were based on two 160-km round trips, one to purchase fingerlings and one to a processing plant, at a cost of $0.14/km. Construction of cages cost about $45.00 each (Jensen 1981); when amortized over the life expectancy of a cage (about 5 years) the annual cost for three cages was $27.00. Maintenance and miscellaneous equipment included costs of a small boat amortized over 20 years, a dip net, rope and cage repair material. The 1983 interest rate of 15.3% on a 6-month loan was quoted from an area farm production credit association. Pond construction costs were not included in the budget because most potential small-scale fish culturists already have ponds that were built for other purposes.

Labor costs could only be estimated because each situation is different. In actuality, most small-scale fish culturists will provide their own labor but we felt that it was important, in a complete budgetary analysis, to estimate the cost and number of hours of labor involved in the project.

The wholesale price of $2.09/kg (live weight) paid by the processor is an average obtained by requesting price quotations from four area processors (range, $1.87 to $2.42/kg). Retail price of fish sold on the pond bank was $3.30/kg live weight (quoted from a regional Oklahoma channel catfish producer; one of our cooperating caged fish culturists has sold all of her fish at this price). The average additional charge for dressing the fish brings the live weight price for dressed fish to $3.85/kg.

RESULTS AND DISCUSSION

Feed costs were the greatest expense in the enterprise budget (Table 1). The nutritionally complete floating ration recommended for caged fish culture (Robinette 1977) is more expensive than other feeds. We have also fed 32%

floating feed which was not recommended for caged fish culture and obtained adequate growth at a lower cost. However, we have obtained substantially higher growth rates from the 36% cage fish chow. Higher growth rate is important in the northern range of channel catfish production because the growing season is short. An economic compromise that would lower production costs without drastically reducing production is to feed 36% cage fish chow for the first 2/3 of the season and to feed 32% floating feed for the last 1/3 when food consumption is highest.

Total production costs were calculated at $828.70 with a production return of $1,059.63 for a gross return to labor and management of $230.93. This return becomes a net loss of $104.07 when labor is added to the budget. It can be seen from this budget that small-scale caged fish polyculture on a wholesale basis is not profitable unless the fish culturist provides his own labor supply and values his labor very cheaply. Although decreased costs and increased production are possible, it is recommended that a different marketing approach be taken. One recommendation is retail sale of live fish from the pond bank (Table 2). This method is attractive because it eliminates middleman costs, and fresh fish commands higher prices. The expense of transporting fish to the processor is also eliminated by this method. The gross return for this alternative was $868.52 with a return after labor costs of $426.32

Direct retail sale of dressed fish to the consumer offers even greater potential returns (Table 2). The gross return was $1,147.37 with a return after labor costs of $604.67. This technique is feasible on a small scale when selling fish to friends and relatives where home cleaning and storage facilities can be utilized. It must be emphasized that these retail budgets can probably not be expanded upward on a per hectare basis to arrive at a larger income in a large production system. When production exceeds the demand of the high priced pond bank market the remaining fish will have to be sold at wholesale prices, incurring a net loss. Also, if the fish culturist plans to sell to supermarkets, restaurants or other public outlets, inspection by health agencies will probably require additional processing equipment. Therefore, under current economic constraints and rigorous economic analysis, small-scale caged polyculture may not appreciably increase farm income.

Small-scale caged fish culture may be directly compared with the family garden, when the fish are grown primarily for personal home consumption. Most small-scale farmers and gardeners do not rigorously evaluate the cost of their own labor. Disregarding the producer's labor, fish can be grown for $1.59/kg which is a savings of $1.71/kg based on the retail price of fish. Producing one cage of fish for home consumption would result in a savings of about $289.00 over the retail price of fish. This method can result in even greater savings when compared with some supermarket prices. In addition, a fresh, high quality fish is obtained by home production.

Some commercial growers and research scientists believe that small-scale caged fish culture is not a productive enterprise if it does not produce a substantial profit to management after labor and expenses are paid. This basic assumption does not appear to be true for millions of people who annually plant vegetable gardens. These gardens are not always economically profitable under a rigorous analysis, but gardening continues to be popular. Small-scale caged fish culture, like the family garden, may have the greatest potential and ultimately the most success if the fish are produced for home consumption or limited retail sale.

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Table 1. Enterprise wholesale budget based on total production of three 1-m^3 cages each containing 350 channel catfish and 50 blue tilapia in a 0.4-hectare pond in Oklahoma, 1982-83.

Item	Cost or return
Fluctuating production expenses	
Catfish fingerlings 1,050 @ $0.20 each	$ 210.00
Tilapia fingerlings 150 @ $0.20 each	30.00
Fish feed 913 kg @ $0.48/kg	441.70
Transportation of fingerlings 160 km @ $0.14/km	22.40
Transportation to processor 160 km @ $0.14/km	22.40
Cages (3) @ about $45.00/cage amortized over 5 years	27.00
Cage maintenance (wire, styrofoam), misc. equipment	20.00
Total	$ 769.80
Interest (15.3% on $769.80 for 6 months)	$ 58.60
Total production costs	$ 828.70
Production	
169 kg/cage x 3 cages = 507 kg; 507 kg @ $2.09/kg = a return of	$1,059.63
Production cost per kg of fish	$ 1.63
Gross returns to labor and management	$ 230.93
Labor	
Fingerling transport 8 hours @ $3.35/hour	$ 26.80
Stocking fingerlings 8 hours @ $3.35/hour	26.80
Feeding 136 days @ 0.5 hours/day @ $3.35/hour	227.80
Harvesting fish 8 hours @ $3.35/hour	26.80
Transporting fish to processor 8 hours @ $3.35/hour	26.80
Total	$ 335.00
Total production and labor cost	$1,163.70
Return to management after labor cost	-$ 104.07

Table 2. Enterprise retail budget based on total production of three, 1-m^3 cages, each containing 350 channel catfish and 50 blue tilapia in a 0.4-hectare pond in Oklahoma, 1982-83.

Item	Cost or return: Live weight	Cost or return: Dressed weight
Fluctuating production expenses		
Catfish fingerlings 1,050 @ $0.20 each	$ 210.00	$ 210.00
Tilapia fingerlings 150 @ $0.20 each	30.00	30.00
Fish feed 913 kg @ $0.48/kg	441.70	441.70
Transportation of fingerlings 160 km @ $0.14/km	22.40	22.40
Transportation to processor - not applicable	0.00	0.00
Cages (3) @ $45.00/cage amortized over 5 years	27.00	27.00
Cage maintenance (wire, styrofoam), misc. equipment	20.00	20.00
Total	$ 747.40	$ 747.40
Interest (15.3% on $747.40 for 6 months)	$ 57.18	$ 57.18
Total production costs	$ 804.58	$ 804.58
Production		
169 kg/cage x 3 cages = 507 kg;507 kg @ $3.30/kg = live weight return; $3.85/kg = dressed weight return	$1,673.10	$1,951.95
Production cost per kg of fish	$ 1.59	$ 1.59
Gross returns to labor and management	$ 868.52	$1,147.37
Labor		
Fingerling transport 8 hours @ $3.35/hour	$ 26.80	$ 26.80
Stocking fingerlings 8 hours @ $3.35/hour	26.80	26.80
Feeding 136 days @ 0.5 hours/day @ $3.35/hour	227.80	227.80
Harvesting fish 8 hours @ $3.35/hour	26.80	26.80
Selling fish to consumers 40 hours @ $3.35/hour	134.00	134.00
Dressing fish 30 hours @ $3.35/hour	0.00	100.50
Total labor costs	$ 442.20	$ 542.70
Total production and labor cost	$1,246.78	$1,347.28
Return to management after labor cost	$ 426.32	$ 604.67

CHANGES IN FISH ABUNDANCE WITH TIME OF DAY AND AMONG YEARS AT A STATION IN LAKE TEXOMA

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ABSTRACT

Abundance of fishes was sampled at 2-hour intervals with seines and gill nets at the same location, at a similar season, and with equivalent effort since 1972. Many fishes were in shallow waters at night (adult Dorosoma cepedianum, Cyprinus carpio, suckers, catfishes, Morone spp. and Pomoxis spp.) but others were most abundant during daylight hours (Notropis spp., Dorosoma petenense, many centrarchids and Menidia beryllina). The sampling hour substantially impacted the abundance of fishes captured. Relative abundance of fishes changed among years. Not only was species abundance impacted, but trophic equivalents commonly responded inversely. That is, when Menidia beryllina were rare, Notropis spp. were very abundant and, when Morone saxatilis were introduced, numbers of other top carnivores, such as M. chrysops, declined.

Fish abundance is known to vary geographically, with habitat, annually, seasonally and with time of day. Information relative to each change is essential to the understanding of ecological interactions. The geographic variation of North American fishes is reasonably well known and has been summarized by Lee et al. (1980). Information on habitat abundance is relatively extensive, i.e., Jenkins and Morais (1971) have shown certain environmental parameters differentially influence fish abundance in reservoirs. Changes in abundance at one location with time are less extensively documented. Baker and Ross (1981) have shown flooding of Mississippi streams may differentially impact resident fishes. Deacon and Wilson (1967) have shown Crenichthys baileyi has daily and annual movements within a restricted environment in Nevada. Mense (1967) has shown the abundance of Menidia beryllina varies with location and time of year in Lake Texoma. Knowledge of the degree of these fluctuations is essential to biologists attempting to manage a given body of water. The data presented in this study relate to the relative numbers of fishes caught in one location in Lake Texoma at one season and at 12 different clock hours among 11 years.

METHODS

Samples were obtained from the shore area adjacent to the University of Oklahoma Biological Station in an embayment locally known as Mayfield Flat (Fig. 1). An intermittent creek commonly flows water draining from the research laboratories on the campus as well as run-off from local rains. Other streams emptying into Mayfield Flat flow only during wet weather. Mayfield Flat was also the location for the field work associated with the report by Patten et al. (1975). This location is protected from most winds except those from the SE, thus often has less severe wave action than more exposed shores. It differs from many protected areas by having little or no inflow except during very high rainfall.

Approximately 115 m of shoreline was sampled every 2 hours, at 0200, 0400, etc. hours (CDT). Two gill nets (inshore of 25-50-mm stretch mesh; offshore of 75-100-mm stretch mesh, each approximately 60 m long and set on the bottom) were examined at the same time (the initial gill net setting preceded the first seine hauls by 2 hours). Seine hauls involved a large bag seine, 12-15 m long and 2 m deep and three shorter seines, 4-8 m long and 1.5 m deep. The large seine sampled water up to 1.5 m deep (from that depth to shore, the others along shore at about 0.5 m depth and about 0.25 m depth). The precise location of sampling varied among years dependant upon lake level, i.e., during low water sampling was farther south. Sampling usually began at 0800 hours but was begun at 0600 hours, 1800 hours (twice), and 1600 hours. Sample intervals overlapped so that an average of 13.3 samples per year were obtained. The second sampling had equivalent numbers of fishes as the initial effort at the same clock hour, suggesting that sampling did not substantially deplete fishes in the area. An extreme example would be the capture of *Menidia beryllina* in 1976, when 5,252 were obtained in the first 0800 sample and 10,139 in the sample 24 hours later. When a clock hour was repeated, the two samples were averaged.

Sampling was done between 10 June and 21 July 1972, 1973 and 1975-1983. For clock hour studies annual catches were summed regardless of lake turbidity or climate to obtain a generalized value for early summer activity cycles. Years with high turbidity showed reduced diel cycles and those with few clouds and little moonlight had pronounced diel cycles. Those factors are averaged in the data presented.

Fish abundance can be presented in terms of total numbers or biomass. Utilization of numbers would emphasize small fishes and utilization of biomass would emphasize large fishes. I have attempted to obtain a compromise by a combination of the two. Data are reported in fish units. In this formulation, 10 g of biomass equals one fish. That is, a 1-kg fish is the same as 100 fish weighing 10 g. Each would be equivalent to 101 fish units. Other formulations to obtain fish units would obtain similar results. Actual numerical and/or biomass data can be obtained upon request.

RESULTS

A total of 132,378 fish weighing 511.8 kg were collected (after averaging the replicated clock hours) representing 40 species and two hybrids (Table 1). Three species (*Menidia beryllina*, *Dorosoma petenense*, and *D. cepedianum*) made up almost 94% of the numbers of fish captured (53% *M. beryllina*, 36% *D. petenense*, and 5% *D. cepedianum*). Two other species made up at least 1% of the catch, Notropis venustus (1.2%) and N. lutrensis (1.0%). Biomass was more equally distributed with the top three species [Dorosoma cepedianum (28%), Ictiobus bubalus (15%), and Carpiodes carpio (11%)] comprising just over 50%. Three species had a considerable contribution to the biomass: Morone chrysops (6%), Menidia beryllina (6%), and Dorosoma petenense (5%). Eight other species made up more than 1% of the biomass -- Cyprinus carpio, Lepisosteus osseus, Ictalurus punctatus, Morone saxatilis, Lepomis macrochirus, Pylodictis olivaris, Ictalurus furcatus and Hiodon alosoides.

The 40 fish species were grouped into 26 categories with sufficient data to provide comparative information. Hybrids, Notropis shumardi, N. stramineus, Pimephales promelas, Hybopsis aestivalis, Notemigonus crysoleucas, Lepomis microlophus, and L. cyanellus were not treated further. A number of closely related taxa were combined for treatment: all four species of Lepisosteus; all three species of catfishes; both species of Ictiobus; both species of Pomoxis.

Diel cycles

Some fishes were obtained at much greater frequency at one clock hour than another. A figure of 8.3 would be the expected percent activity at any clock hour, thus an eight or nine in Table 2 would be the expected. Those numbers were less frequent than one and two. Six fishes had no 8's or 9's and only two had more than three. Thus, the abundance of fishes was quite uneven and reflects differing activity cycles.

Fish groups were ranked with regard to degree of daylight/nocturnal activity by obtaining a ratio between activity at 0800 - 1600 and 2200 - 0400 hours. Three fishes had nocturnal captures more than four times that of daylight captures (Table 2). The two species of Morone had similar activity cycles with hardly any captures between 1000 and 1600 hours. Both had more than 60% of the fish units captured between 2200 and 0400 hours. Similar patterns prevailed in Ictiobus spp. captures. Carpiodes carpio capture rates were virtually the same except the night captures were only 3.9 times the daylight captures.

Four groups of fish had night captures more than twice that of daylight captures. Lepisosteus spp. actually had the greatest nocturnal captures (73%) of all fish categories, but the daylight captures were also relatively high (26%). They were virtually absent in dawn (0600 hours) and dusk (1800 - 2000 hours) samples. Three of the four species adhered to the pattern, L. spatula being the exception with a single capture at 1800 hours. Because few Lepisosteus spp. were obtained, details of the fluctuations may involve some degree of chance. Cyprinus carpio, catfishes, and Pomoxis spp. had similar capture rates with 52 to 56% of the fish units in night samples and 18 to 25% in day samples. Each group showed much more dawn/dusk activity than did Lepisosteus spp.

Four species had more night captures than day captures, with the differential less than doubled. As none had more than half of the fish units in night samples each had many captures at dawn and dusk. Dorosoma cepedianum data are expected to most accurately reflect fish activity as they are among the most frequently caught fish. The data suggest two activity peaks, night and late afternoon. These two peaks represent different age groups with the young of the year heavily represented at 1600 and 1800 hours and adults dominant between 2200 and 0600 hours. Both young and old were obtained at diverse clock hours without the pronounced inactive periods exhibited by Morone spp. or the more extreme daylight-active species. Both Aplodinotus grunniens and Percina macrolepida had high nocturnal capture rates but both also had high dawn/dusk captures. Actually, P. macrolepida had nearly half the captures at dawn or dusk, suggesting it is most commonly inshore at dawn and dusk. The abundance of Hiodon alosoides is somewhat suspect due to small capture numbers, nevertheless nearly half of the fish units were obtained at 0200 and 0400 hours. This suggests they are most active late in the night.

In contrast to the nocturnal species, seven species were much more abundant in daylight samples with day capture rates more than six times the night capture rate. The most pronounced daytime activity was for Gambusia affinis. This emphasis on day captures parallels the observations obtained in Clear Creek, Texas (Hubbs 1971) and is undoubtedly real despite the relatively small sample size. Dorosoma petenense and Menidia beryllina were the two most numerous fishes in Lake Texoma samples. Both were virtually absent between 2200 and 0400 hours and dominant at all other times. In as much as the abundance always rebounded the following morning, these species must have been elsewhere in Lake Texoma. Occasional observations of small fish over deep water at night suggests they migrate offshore at night. The offshore migration is coincidental with the inshore migration of Morone spp. Each of the species has a size differential of inshore abundance associated with spawning time. A large fraction of the early morning Dorosoma petenense obtained inshore in the morning (0400 and 0600 hours) were reproductive adults. The frequency of these fish was much lower at other clock hours. Similarly, large adult Menidia beryllina were most common at 0800 and 1000 hours.

Three of the four remaining day-active fishes were cyprinids. The abundance of Notropis potteri and Hybognathus placitus mostly reflects circumstances in 1978 in which year those species were relatively common in samples. Both were abundant in day (and dawn/dusk) samples but scarce at night. The strong day dominance in Notropis lutrensis may be influenced by one large sample at 1000 hours (in 1972). Consequently, the data were recalculated after equating samples from 1000 hours and 0800 hours. Even with this adjustment 64% of the captures were between 0800 and 1600 hours and only 8% between 2200 and 0400 hours. Notropis lutrensis differs from its close realtive N. venustus by having a reduced night and early morning capture rate. The data suggest Micropterus punctulatus is a day-dominant species. The small sample size and major oscillations in abundance suggest that conclusion may be tentative. It is likely additional data would provide a capture pattern similar to its close relative, Micropterus salmoides (still day active, but less dominantly so). Notropis atherinoides had a day capture rate in excess of four times the night capture rate. It also seemed to have peak captures at dawn and dusk.

Two cyprinids and three centrarchids were captured more than twice as often in the day samples as in the night samples. The two cyprinids, Notropis venustus and Pimephales vigilax were active from dawn through dusk. Available data were insufficient to ascertain whether dawn and/or dusk had equivalent or greater activity than daylight hours. Three centrarchids (Micropterus salmoides, Lepomis macrochirus, and L. megalotis) all seemed to be quite active at dawn and dusk and inactivity seems to primarily occur during darkness.

The last species, Hybopsis storeriana, had only slightly higher day capture rates than night capture rates. The pattern of captures suggests activity at dawn and dusk more than in day or night.

Differences Among Years

Variations in abundance among years was substantial (Table 3). Differences in Dorosoma petenense and Menidia beryllina were closely associated with cold winter weather. The winters of 1977-78 (B. Kimmel, then at University of Oklahoma Biological Station, Kingston, Oklahoma, personal communication) and 1981-82 (W.J. Matthews, University of Oklahoma Biological Station, Kingston, Oklahoma, personal communication) were unusually cold. Dorosoma petenense has been shown to suffer extensive winter cold mortalities (Hubbs 1951; Pflieger 1975). Similarily, Menidia beryllina has a warm minimum incubation temperature (Hubbs et al. 1971), thus would be assumed to be warm adapted. M. beryllina had its least fraction of fish units in 1978 and no Dorosoma petenense were obtained in the 1978 sample. The impact on D. petenense was extensive as the populations were depressed through 1979. Although they represented almost half of the fish units in 1981, their abundance was reduced two orders of magnitude the next year. The impact of the cold weather was less extensive than in 1978, as Menidia beryllina did not decline and a few Dorosoma petenense were obtained in the 1982 samples. D. petenense had resumed a dominant role by 1983, comprising 40% of the fish units.

Low abundance of the dominant small forage species coincided with increased abundance of other small forage species. More than 90% of the Notropis potteri and Hybognathus placita were obtained in 1978. Notropis atherinoides reached its maximum abundance in 1978, that increase continued into 1979, and the next greatest relative abundance was in 1982. Notropis lutrensis and N. venustus had population maxima in 1982 and 1978, respectively; relative abundance in the alternate year was far above average. Five of the seven small cyprinids had population maxima in years when Dorosoma petenense or Menidia beryllina had population minima; the other two species, Pimephales vigilax and Hybopsis storeriana, were not discordant with that pattern but the increases were less striking. Relative abundance of Lepomis macrochirus seemed to reflect a response to the decline in abundance of Dorosoma petenense and/or Menidia beryllina. The maximum relative abundance of Lepomis macrochirus was in 1978. That abundance was primarily due to young of the year that presumably use similar foods. In 1979 L. macrochirus were relatively abundant and moderately large individuals; in 1980 they were mostly quite large individuals. It seems as if there was a high survival of young in 1978, and as they grew they continued to contribute to the fauna of Mayfield Flat for the next 2 years. The next greatest abundance of L. macrochirus was in 1982, again with many young present.

The relative abundance of suckers was at maxima in 1978 (Ictiobus spp. only) and 1982 (Ictiobus spp. and Carpiodes carpio), perhaps as a result of organic matter increase from dead Dorosoma spp. and/or Menidia beryllina.

The realtive abundance of the two major genera of game fishes had contradictory results - in 1978 Morone was low and Micropterus was high; in 1982 the relationship was reversed. Despite the high level of abundance of Morone spp., in 1982 this circumstance was not entirely favorable as M. saxatilis had minimal foods and growth (W.J. Matthews and L.G. Hill

University of Oklahoma Biological Station, Kingston, Oklahoma, personal communications).

The introduction of Morone saxatilis would be expected to have an impact on abundance of other top carnivores. That impact should be greatest on M. chrysops but there is a suggestion that Micropterus spp. and Hiodon alosoides have become less abundant with time. A comparison of data from 1972-1975 with that from 1980-1983 shows the total fish units in Micropterus spp. (summed) dropped from 0.47% to 0.19%. An analysis of total units in the three genera provides substantial evidence for an impact (Table 4). Morone chrysops declined 55% from 1972-75 to 1980-83. Similarly, Micropterus spp. declined 55%. A major decline appears in the Hiodon alosoides comparisons with a drop of 86%. Analysis of biomass shows that Morone chrysops declined 64%, Micropterus spp. declined 53%, and Hiodon alosoides declined 89%. In biomass terms, the gain was 4,088 g/sample (in Morone saxatilis biomass), but the loss of M. chrysops biomass was 3,415 g (84% of the gain), the Micropterus spp. loss was 397 g (10% of the gain), and the Hiodon alosoides decline was 891 g (22% of the gain). Essentially the top carnivore biomass and/or fish units remained the same with the impact being merely a transfer to Morone saxatilis.

The introduction of Morone saxatilis would also be expected to have an impact on the food base. They attain larger sizes than M. chrysops, Micropterus spp., or Hiodon alosoides, thus large individuals could eat larger prey. Lake Texoma is like other south central reservoirs in having abundant populations of Dorosoma cepedianum that make up a large fraction of the food of Morone saxatilis. The expected reduction in Dorosoma cepedianum abundance did occur with a decline of 51% in fish units and 36% in biomass.

DISCUSSION

Reservoirs are dynamic ecosystems. Fish population samples would be expected to be influenced by precise location within a reservoir, season, year and time of day. This study shows the year of sample and clock hour of sample have major impacts on the abundance of fishes in the sample.

The most prominent fishes in terms of numbers were small forage fishes and in terms of biomass, large detritovores. Game fishes made up about 1% of the total number of individuals and 10% of the biomass. In terms of top carnivores, Morone spp. were vastly more abundant than Micropterus spp. These results are in accord with observations of numbers of fish of the two genera obtained by sport fishermen (L.G. Hill, University of Oklahoma Biological Station, Kingston, Oklahoma, personal communication). These data also parallel those reported by Patten et al. (1975) for the same part of Lake Texoma.

Diel Cycles

There is a tendency for similar fishes (phylogenetic or trophic) to have similar periods of activity. All suckers (Ictiobus spp. and Carpiodes carpio) were more active at dark hours than during daylight. Both species of Morone had similar high activity after dark and minimal captures around midday. All four species of Notropis present were active during daylight and had a reduced frequency in night samples. Trophic equivalents often have similar patterns.

Menidia beryllina, Gambusia affinis and Notropis spp. are all consumers of small invertebrates and were scarce in night samples and consistently abundant in daylight collections. Cyprinus carpio had diel capture rates much more like that of other benthic omnivores such as the suckers. The substrate-oriented centrarchids (Micropterus spp. and Lepomis spp.) all had minimal dark captures compared with daylight captures and high captures at dawn and/or dusk. The more open water Pomoxis spp. had capture rates quite similar to the pelagic Morone spp. In general, closely related trophic equivalents followed the same activity cycles. Some exceptions may illustrate means of reducing dietary overlap. Notropis lutrensis had much more pronounced nocturnal inactivity than did N. venustus. Dorosoma petenense and D. cepedianum differed in that the former predominated in daylight samples and the latter was more common in dark samples. Although part of the difference involved nocturnal captures of D. cepedianum of sizes greater than the maximum for D. petenense, the pattern remained with individuals between 50 and 100 mm standard length. The relative capture frequencies ranged from the most nocturnal to most daylight active in the following sequence: Ictiobus spp., Morone chrysops, M. saxatilis, Carpiodes carpio, Pomoxis spp., Lepisosteus spp., Cyprinus carpio, catfishes, Aplodinotus grunniens, Dorosoma cepedianum, Percina macrolepida, Hiodon alosoides, Hybopsis spp., Lepomis macrochirus, L. megalotis, Notropis venustus, Pimephales spp., Micropterus salmoides, Notropis atherinoides, N. potteri, Menidia beryllina, Micropterus punctulatus, Hybognathus placitus, Notropis lutrensis, Dorosoma petenense, and Gambusia affinis.

Relative capture rates reflect presence in the sampling area. When capture rates were low the fish were either inactive or elsewhere. Because the fish were not obtained in increased numbers at other locations, it is not possible to eliminate either alternative. Especially with regard to fish obtained by seines, it is most likely that the fish moved to another location. A gill net capture would result from fish moving into the net, a seine sample would strain the water column and an inactive fish is as liekly to be captured as an active fish. The great changes in abundance of small Menidia beryllina must result in differential abundance at the seining station. At night they could conceivably be 1) buried in the bottom; 2) in the brushy areas difficult to seine; or 3) in mid lake. The last possibility is supported by the observation of small fishes in mid lake at night.

Regardless of the ecologic interpretations, these observations apply to relative sampling times. If a seine haul is obtained at noon it would probably contain more than five times the Menidia beryllina in a similar haul at midnight. Similar results would be expected for Dorosoma petenense, Notropis spp., and Gambusia affinis. Conversely, that midnight seine haul would have four times the Aplodinotus grunniens in the noon sample. Similar results would be expected with Pomoxis spp. A gill net set between 0600 and 1800 hours would be expected to obtain vastly different results from one set between 1800 and 0600 hours. The latter is the more standard technique and would over-represent the nocturnal species such as Morone spp. and under-represent the more daylight-oriented species such as Micropterus spp. The data herein are in accord with a sampling over as many clock hours as possible and defintely including equivalent dark and daylight sampling effort as well as some dawn and dusk efforts.

Differences Among Years

Analysis of captures during the individual years shows considerable variations. Differences among the captures of large fish may be attributed to chance occurrence. For example only one Lepisosteus spatula was taken and only 1 year could be represented. In addition to changes apparent in total captures, activity cycles varied among years. Those years when the lake was very turbid had less pronounced diel cycles than those with clear water. Heavy storms decreased the inshore abundance as reflected by seine hauls.

The major differences involved substantial changes in abundance of prominent fishes. The 1977-78 winter was unusually cold with ice forming in protected areas of Lake Texoma (B. Kimmel, University of Oklahoma Biological Station, Kingston, Oklahoma, personal communication). Subsequently, Menidia beryllina were very difficult to capture in the 1978 summer. There were virtually no adults and the captures were primarily young-of-the year. During the 1978 summer young grew rapidly and became reproductive by early July (Hubbs and Dean 1979), whereas few young-of-the year normally breed during their first year (Hubbs 1982). In 1978 there was a scarcity of M. beryllina and that year class had unusually rapid growth. An even more extreme decline in abundance of Dorosoma petenense occurred in 1978. None were taken in 1978 and they were rare in 1979. After another cold winter (1981-82) they were again scarce. Immediately after the cold weather, D. petenense were very numerous in Morone saxatilis stomachs (W.J. Matthews, University of Oklahoma Biological Station, Kingston, Oklahoma, personal communication). Dr. Matthews feels M. saxatilis were feeding on distressed D. petenense. The population resumed abundance in 1983.

Those years with low abundance of Dorosoma petenense and/or Menidia beryllina were those with the maximum abundance of the four Notropis species and Lepomis macrochirus. Those five species were placed in the same feeding category as Menidia beryllina by Patten et al. (1975). Two species, Notropis atherinoides and Lepomis macrochirus, retained increased abundance in the 1979 (and 1980 for L. macrochirus) samples. The 1978 samples were of small fish and the subsequent samples were of increasing average sizes. Because the fish feed on similar foods, it is likely that reduced feeding by Menidia beryllina and Dorosoma petenense permitted increased food availability for the Notropis spp. and Lepomis macrochirus. These observations are in agreement with a hypothesis that Menidia beryllina and/or Dorosoma petenense outcompete the other species for food in much of the area adjacent to the sample station. Other interactions are less apparent. Predator abundance during those 2 years was high (Micropterus spp. in 1978, Morone spp. in 1982) or low (Micropterus spp. in 1982, Morone spp. in 1978). There was a trend for detritovores to have high abundance in those years.

The impacts of introductions of game (or any other fish) are seldom measured (W.R. Courtenay, Jr., Florida Atlantic University, Boca Raton, Florida, personal communication). The sampling intervals used in this report included some years before and others after the successful release of Morone saxatilis in Lake Texoma. The sampling years were arbitrarily grouped in three units - before any captures, when only hybrids were obtained, and after M. saxatilis were obtained at the sample site (or other collections within 500 m of that location). These samples included equivalent numbers and biomass of predacious fishes before and after M. saxatilis were present. M. saxatilis merely replaced their trophic equivalents. In this measure each kilogram of M. saxatilis was at the expense of 852 of M. chrysops, 97 of Micropterus spp. and 218 of Hiodon alosoides. In total, the gain of 1 kg was at the expense of 1.167 kg.

M. saxatilis have the potential of eating a larger fraction of Dorosoma cepedianum than would M. chrysops, Micropterus spp., or Hiodon alosoides. The expected reduction in D. cepedianum biomass did develop with a decline in abundance between 30% and 50% dependant upon whether fish units or biomass is used for the comparison.

CONCLUSIONS

The sample location used in this study represents a dynamic fish ecosystem with differences among years and clock hours. Some fish are much more abundant in the area at night and others in daytime samples. Any sampling protocol to estimate relative abundance of fishes must incorporate equivalent effort at all clock hours.

Relative abundance varies among years with trophic equivalents substituting for each other. When the dominant forage fishes are scarce, other forage fishes are more abundant than usual.

Introduction of Morone saxatilis was associated with an equivalent decline in abundance of similar top carnivores. The majority of the impact was on M. chrysops, but Micropterus spp. and Hiodon alosoides also showed decreased abundance. M. saxatilis presence was also associated with a decline in Dorosoma cepedianum abundance. The introduction of a non-native fish had effects on potential competitors and prey.

ACKNOWLEDGMENTS

The field work for this study was done at the University of Oklahoma Biological Station. I thank its Director, Loren G. Hill, for facilities to carry out the study. I also thank the Oklahoma Game and Fish Commission for permission to sample in the lake. Most of the field work was done by students enrolled at the University of Oklahoma Biological Station. I profited by discussion of fish abundance and/or physical conditions in Lake Texoma with Drs. L.G. Hill, B. Kimmel, W.J. Matthews, and R.W. Drenner.

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Table 1. Summary of fishes collected by gill net and seine sampling, Lake Texoma, Oklahoma, 10 June - 21 July 1972, 1973 and 1975-1983. Sampling was conducted at 2-hour intervals. Species are listed by order of importance assuming 10 g of fish is equal to one fish. When clock hours were repeated during sampling, samples were averaged before calculation of importance totals.

Species	Number	Biomass	Species	Number	Biomass
Menidia beryllina	70,029	29,021	Lepisosteus oculatus	9	4,412
Dorosoma petenense	49,179	27,038	Lepomis megalotis	176	2,317
Dorosoma cepedianum	6,038	143,856	Micropterus salmoides	45	2,999
Ictiobus bubalus	57	76,098	Ictiobus niger	2	3,400
Carpiodes carpio	105	54,002	Hybopsis storeriana	191	683
Morone chrysops	659	33,244	Lepisosteus platostomus	5	1,962
Cyprinus carpio	103	23,114	Micropterus punctulatus	18	1,770
Lepomis macrochirus	857	12,039	Morone hybrids	11	1,189
Notropis venustus	1,646	3,488	Pomoxis nigromaculatus	21	624
Lepisosteus osseus	11	21,394	Notropis potteri	78	37
Ictalurus punctatus	63	18,881	Lepomis microlophus	20	558
Morone saxatilis	209	16,351	Hybognathus placitus	59	10
Notropis lutrensis	1,340	1,189	Percina macrolepida	38	98
Notropis atherinoides	938	260	Lepomis hybrids	5	343
Pylodictis olivaris	4	9,007	Lepisosteus spatula	1	322
Ictalurus furcatus	8	6,384	Notemigonus crysoleucas	5	14
Hiodon alosoides	18	5,935	Notropis shumardi	1	4
Pimephales vigilax	555	1,013	Pimephales promelas	1	2
Pomoxis annularis	145	4,554	Notropis stramineus	1	tr*
Gambusia affinis	574	121	Hybopsis aestivalis	1	tr*
Aplodinotus grunniens	151	4,097	Lepomis cynellus	1	tr*

*tr = trace

Table 2. Percent of various fish units (see Table 1) obtained at different clock hours from a cove in Lake Texoma. If a clock hour was repeated during a sample the figures are averaged. Values used are based on the equivalency of one fish and 10 g.

Species	Time of sample												% Active	
	0600	0800	1000	1200	1400	1600	1800	2000	2200	2400	0200	0400	0800-1600	2200-0400
Lepisosteus spp.	0	3	4	9	8	2	1	1	38	17	0	18	26	73
Dorosoma cepedianum	10	5	7	2	4	10	14	6	17	11	9	6	28	43
Dorosoma petenense	16	4	4	9	11	21	14	19	1	0	1	1	49	3
Hiodon alosoides	7	0	6	8	8	20	0	0	3	0	24	25	42	52
Notropis venustus	8	10	11	11	9	9	8	11	9	5	4	4	50	22
Notropis lutrensis	5	12	35	10	8	8	8	8	2	1	1	3	73	7
Notropis atherinoides	12	8	11	10	10	9	20	9	2	2	3	4	48	11
Notropis potteri	7	19	2	9	15	7	16	15	2	1	2	4	52	9
Pimephales vigilax	11	12	10	9	9	7	8	15	5	5	4	6	47	20
Hybopsis storeriana	14	13	8	3	4	11	11	10	7	6	9	4	39	26
Hybognathus placitus	0	25	7	2	19	10	27	3	5	0	2	0	63	7
Cyprinus carpio	16	9	0	4	5	4	5	6	27	18	2	5	22	52
Carpiodes carpio	15	2	2	3	4	6	4	5	23	10	18	6	17	57
Ictiobus spp.	12	2	6	1	2	4	3	2	18	12	25	12	15	67
Catfishes	0	1	3	10	8	3	11	9	13	14	13	16	25	56
Gambusia affinis	1	0	19	35	27	9	2	1	2	1	1	0	90	4
Menidia beryllina	9	18	10	11	9	12	11	11	2	2	3	3	60	10
Morone chrysops	6	10	1	1	1	1	6	15	30	17	10	5	14	62
Morone saxatilis	12	14	0	1	0	1	2	2	16	29	15	9	16	69
Micropterus salmoides	10	32	1	11	2	12	6	8	1	5	0	11	58	17
Micropterus punctulatus	33	6	30	0	19	0	6	1	0	0	5	1	48	6
Lepomis macrochirus	13	15	5	9	12	7	9	12	8	4	3	4	41	19
Lepomis megalotis	9	13	9	5	12	11	6	13	9	4	7	2	50	22
Pomoxis spp.	14	5	2	0	0	11	2	6	31	11	11	1	18	53
Percina macrolepida	15	17	2	2	4	2	4	17	15	4	13	2	27	34
Aplodinotus grunniens	13	7	5	2	2	11	6	9	23	7	8	7	27	45

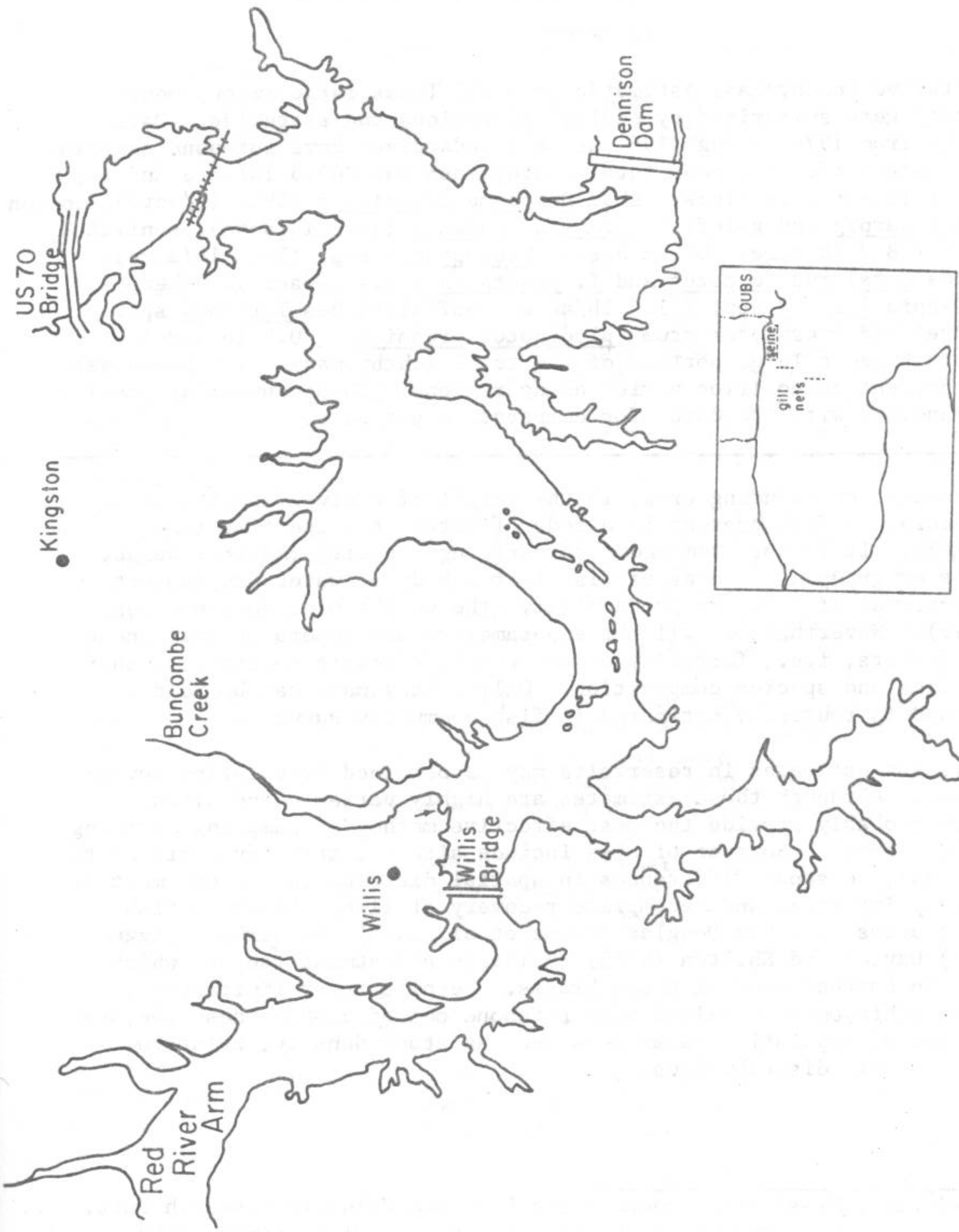
Table 3. Percent of various fish units (see Table 1) in annual samples from a cove in Lake Texoma. If a fish was not obtained in a sample, that is designated by --; if a fish was less than 0.005% of the sample it is recorded as 0. Values used are based on the equivalency of one fish and 10 g. The patterns of abundance are consistent with those presented here regardless of the tabulations used (total biomass, numbers of fish, or any combination).

Species	Year										
	1972	1973	1975	1976	1977	1978	1979	1980	1981	1982	1983
Lepisosteus spp.	0.85	--	0.44	1.64	1.41	0.08	1.30	0.73	6.68	0.90	--
Dorosoma cepedianum	20.5	17.8	16.9	4.4	5.1	17.1	14.0	9.6	4.0	7.9	13.1
Dorosoma petenense	41.3	36.1	20.2	14.5	14.8	--	0.8	34.3	49.1	0.4	40.5
Hiodon alosoides	0.47	--	1.31	1.00	--	--	0.02	--	--	0.01	0.24
Notropis venustus	2.25	1.40	0.30	1.19	0.38	4.44	0.40	1.40	0.41	2.39	0.61
Notropis lutrensis	2.30	0.25	0.08	0.32	0.09	2.28	0.43	1.25	0.37	3.23	0.50
Notropis atherinoides	0.01	0.01	--	0.11	0.30	5.06	1.66	0.02	0.69	1.23	0.92
Notropis potteri	--	--	--	0	0	1.88	--	0.02	--	0.01	--
Pimephales vigilax	0.78	1.08	0.09	0.26	0.01	0.80	0.18	0.11	0.14	0.88	0.31
Hybopsis storeriana	0.04	0.01	--	--	0.04	1.10	0.14	0.03	0.10	0.04	0.62
Hybognathus placitus	--	--	--	--	--	1.68	--	--	0.01	--	--
Cyprinus carpio	4.31	4.52	2.65	0.82	--	0.18	--	0.39	0.05	1.38	0.10
Carpiodes carpio	1.37	4.92	0.55	2.03	9.69	--	9.02	10.10	1.30	6.09	0.30
Ictiobus spp.	--	--	2.2	13.7	4.0	29.9	4.7	1.8	2.2	14.3	--
Catfishes	0.45	0.57	6.55	0.88	2.17	8.37	5.71	1.96	0.40	2.93	0.21
Gambusia affinis	0	0.06	0.01	--	--	0.02	--	--	2.40	0.15	0.01
Menidia beryllina	19.0	30.8	40.1	57.9	68.1	15.9	50.8	33.7	29.5	35.8	36.0
Morone chrysops	3.78	0.89	5.48	0.47	1.45	0.63	5.34	0.20	0.36	9.43	1.19
Morone saxatilis	--	--	--	--	--	--	--	0.46	0.71	9.61	3.82
Micropterus salmoides	0.73	0.41	0.04	0.15	0	1.13	0.29	0.06	0.13	--	0.04
Micropterus punctulatus	0.01	0.01	0.21	0	0.07	0.62	0.10	0.37	0	--	0.16
Lepomis macrochirus	1.46	0.55	0.32	0.32	0.34	8.17	3.96	1.89	0.50	1.87	0.23
Lepomis megalotis	0.14	0.24	0.24	0.13	0.53	--	0.21	0.33	0.13	0.37	0.11
Pomoxis spp.	--	0.13	0.96	0.14	--	0.05	0.86	--	0.27	1.83	0.70
Percina macrolepida	0.05	0.07	--	--	--	--	0.01	--	0.01	0.25	0.02
Aplodinotus grunniens	0.04	--	1.36	0.12	0.03	0.55	0.29	0.44	0.34	0.48	0.24

Table 4. Number of selected fish units assuming 10 g of fish is equal to one fish (or biomass in g) per year before and after *Morone saxatilis* taken in samples, Lake Texoma, Oklahoma.

Species	1972-75	1976-79	1980-83
Morone saxatilis	none	hybrids only	461 (4,088)
Morone chrysops	605 (5,335)	267 (2,240)	275 (1,920)
Micropterus spp.	87 (744)	43 (358)	39 (347)
Hiodon alosoides	103 (1,006)	59 (597)	14 (115)
Dorosoma cepedianum	3224 (20,557)	1113 (6,897)	1579 (13,110)

Figure 1. Map of Lake Texoma showing location of the Unitersity of Oklahoma Biological Station (arrow); inset is a map of Mayfield Flat adjacent to the University of Oklahoma Biological Station. The shore line would approximate that of a lake level 185 m above sea level.


US 70 Bridge
Kingston
Dennison Dam
Buncombe Creek
Willis Bridge
Willis
Red River Arm
OUBS
Seine
gill nets

AVERAGE ICHTHYOMASSES IN TEXAS LARGE IMPOUNDMENTS

by

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ABSTRACT

Quantitative ichthyomass estimates from 111 Texas large impoundments (> 500 acres) were summarized by ecological regions and statewide. Data were obtained from 1974 through 1982 using standardized cove rotenone sampling techniques. Statewide, the mean total ichthyomass was 240.5 lb/acre and the most abundant fishes were gizzard shad *Dorosoma cepedianum* (69.2 lb/acre), common carp *Cyprinus carpio* and goldfish *Carassius auratus* (48.8 lb/acre), sunfishes *Lepomis* spp. (38.7 lb/acre), black basses *Micropterus* spp. (18.8 lb/acre), and catfishes *Ictalurus furcatus* and *I. punctatus* (16.4 lb/acre). When present, tilapia *Tilapia* spp. (51.5 lb/acre), buffalofishes *Ictiobus* spp. (32.4 lb/acre) and freshwater drum *Aplodinotus grunniens* (20.3 lb/acre) usually contributed a large portion of the total ichthyomass. Ichthyomasses as well as percent composition varied among regions. These summaries provide reservoir managers with standards for comparative purposes.

Ichthyomass, or standing crop, is the weight of a given species or group of species of fish present in a body of water at a specific time (Bennett 1962). It is not analogous to carrying capacity (maximum weight of a species or group of species of fish that a body of water may support in a certain interval of time) or productivity (the weight of fish added per unit of time). Nevertheless, all three parameters are generally influenced by similar factors; i.e., fertility of the water, climatic conditions, basin characteristics and species composition. Only ichthyomass can be readily determined and is routinely estimated in fish community surveys.

Ichthyomass estimates in reservoirs may be obtained by sampling coves with rotenone. Although those estimates are highly variable and often biased, they probably provide the most effective method of sampling standing waters (Holden 1980). Sources of bias include site selection (restricted to littoral areas), seasonal differences in spatial distribution, escapement of fish from sampling area, and incomplete recovery of fish. Based on fish population studies in Lakes Douglas (Hayne et al. 1978) and Barkley (Aggus et al. 1979) Davies and Shelton (1983) summarize adjustment factors which may be used to correct some of these biases. Despite their limitations, estimates of ichthyomass obtained with rotenone can be used to describe, in a relative sense, population parameters such as stock density, relative abundance, and size distributions.

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Since 1974, biologists of the Texas Parks and Wildlife Department have collected ichthyomass data in many state reservoirs by sampling coves with rotenone. Information obtained is used to assess the status of fish communities and provide management recommendations, a process often partially accomplished by examining differences and resemblances with related fish communities. A summary of available ichthyomass data would provide fishery managers with standards for comparative purposes and, thus, serve as a tool for developing management recommendations.

The purpose of this paper was to compile ichthyomasses available from 111 Texas large impoundments ($>$ 500 acres), and summarize the data by reservoir, ecological region and statewide. No attempt was made to explain ichthyomasses or distinguish statistical differences between reservoirs or ecological regions.

METHODS

Cove rotenone data were collected from 1974 through 1982 as part of standardized fish community surveys conducted throughout Texas. Coves representing the range of ecological areas in a reservoir were selected. A barrier net (3/4-inch bar mesh) was placed across the mouth of a cove the day before rotenone application, bundled along the float line to allow fish migrations to and from the cove. The lead line of the barrier net was released to the bottom of the cove between 2 hours after sunset and 2 hours before sunrise the night before treatment. The cove was treated the following morning with liquid rotenone (5% active ingredient), applied at a concentration greater than 1 ppm, and fish were recovered for a 2-day period. The first day, fish were separated by species and inch groups, weighed and counted. The same procedure was followed the second day, except that weights were estimated from those recorded the first day, and determined only for fish not recorded the first day. When necessary, small fish were subsampled by randomly selecting at least 10 lb of well mixed fish.

Normally, three coves each of at least 1 acre were sampled in reservoirs $\leq$ 10,000 acres. In reservoirs $>$ 10,000 acres, three or more coves with a total area greater than 5 acres were sampled. Once sampling was begun on a given reservoir, all coves were sampled within 30 days. Physical limitations required occasional, minor deviations from these guidelines.

Rotenone data were summarized by reservoir, ecological region (Fig. 1) and statewide, and reported by species (Table 1), group of species and all species combined. Species were grouped based on similarity in their trophic relations (Ploskey and Jenkins 1982). All values represent actual recoveries. Annual ichthyomass estimates were averaged to obtain a single value for each reservoir. Multi-annual estimates for individual reservoirs were combined when computing regional and statewide averages. Regional and statewide averages include only reservoirs in which the species, or group of species, being averaged was sampled. Therefore, the sum of regional and statewide means for single species and group of species does not equal the mean total of all fishes. Both weight and percent of total weight were calculated in regional and statewide summaries.

RESULTS AND DISCUSSION

Statewide, the mean total ichthyomass was 240.5 lb/acre (Table 2). The most abundant fishes by weight were gizzard shad (69.2 lb/acre), common carp and goldfish (28.8 lb/acre), sunfishes (38.7 lb/acre), black basses (18.8 lb/acre), and blue and channel catfishes (16.4 lb/acre). When present, tilapia (51.5 lb/acre), buffalofishes (32.4 lb/acre) and freshwater drum (20.3 lb/acre) usually contributed a large portion of the total ichthyomass. Compared to the national average reported by Jenkins (1975), ichthyomasses in Texas reservoirs were normally higher (Table 3).

Ichthyomasses and percent compositions varied among ecological regions (Table 2,4). The highest mean total ichthyomass was recorded in the South Texas Plains (373.4 lb/acre); however, sample size was small (N=6) and this mean might be inflated. The lowest mean total ichthyomass was recorded in the Pineywoods (209.7 lb/acre). The most conspicuous shifts in percent composition between regions were the decrease in sunfishes and black basses, and increase in gizzard shad, common carp and goldfish, carpsuckers, and buffalofishes from the Pineywoods towards the High and Rolling Plains (east to west).

The limiatations of sampling coves with rotenone must be kept in mind when using these summaries. Cove sampling examines only a portion of the fish community since fish inhabiting the littoral areas are not necessarily representative of those in the open water environment. Hayne et al. (1967) indicated that although cove samples represented the total ichthyomass of a reservoir arm, they overestimated weight of young fish and underestimated weight of harvestable fish. Aggus et al. (1979) reported cove samples underrepresented the total ichthyomass of a reservoir arm, and that ichthyomasses of most species were unevenly represented in coves relative to the arm. Hall (1974), nevertheless, asserted that while cove sampling reflects the situation in shoreline areas only, the littoral zone is probably the most productive in a reservoir and where most fish and fishing occurs. From that viewpoint, ichthyomass estimates derived through cove sampling may provide meaningful information to reservoir fishery managers.

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Table 1. Common and scientific names of species and groups of species in this study. All names used are in accordance with Robins et al. (1980).

Common name(s)	Scientific name(s)
Gars	*Lepisosteus* spp.
Bowfin	*Amia calva*
Gizzard shad	*Dorosoma cepedianum*
Threadfin shad	*Dorosoma petenense*
Pirate perch	*Aphredoderus sayanus*
Pikes	*Esox* spp.
Common carp and goldfish	*Cyprinus carpio* and *Carassius auratus*
Minnows	Other Cyprinidae
Carpsuckers	*Carpiodes* spp.
Suckers	Other Catostomidae
Buffalofishes	*Ictiobus* spp.
Redhorses	*Moxostoma* spp.
Bullheads	*Ictalurus melas*, *I. natalis* and *I. nebulosus*
Flathead catfish	*Pylodictis olivaris*
Madtoms	*Noturus* spp.
Other catfishes	*Ictalurus furcatus* and *I. punctatus*
Silversides and topminnows	Atherinidae and *Fundulus* spp.
Temperate basses	*Morone* spp.
Sunfishes	*Lepomis* spp.
Black basses	*Micropterus* spp.
Crappies	*Pomoxis* spp.
Freshwater drum	*Aplodinotus grunniens*
Darters and logperch	*Etheostoma* spp. and *Percina caprodes*
Walleye	*Stizostedium vitreum*
Mexican tetra	*Astyanax mexicanus*
Rio Grande perch	*Cichlasoma cyanoguttatum*
Tilapia	*Tilapia* spp.

Table 2. Average ichthyomasses (lb/acre) in 111 Texas large impoundments by ecological regions and statewide, 1974-1982. Number of reservoirs are indicated in parentheses.

Species[a]	Ecological Region						Statewide
	Pineywoods	South Texas plains	Post oak savanna, blackland prairies	Cross timbers and prairies	Edwards plateau trans-Pecos mountains & basins	High and rolling plains	
Gars	4.6 (14)	9.2 (4)	7.2 (19)	5.8 (21)	0.6 (7)	8.7 (4)	5.8 (69)
Bowfin	3.8 (11)	- (0)	2.8 (10)	- (0)	- (0)	- (0)	3.3 (21)
Gizzard shad	59.7 (17)	56.6 (6)	76.3 (29)	63.9 (24)	71.4 (12)	76.7 (18)	69.2 (106)
Threadfin shad	13.4 (15)	9.3 (5)	10.3 (18)	7.2 (16)	5.1 (9)	0.9 (4)	8.9 (67)
Pirate perch	0.4 (13)	- (0)	0.1 (5)	- (0)	- (0)	- (0)	0.3 (18)
Pikes	0.7 (15)	- (0)	0.8 (8)	- (0)	- (0)	- (0)	0.7 (23)
Carp & Goldfish	22.7 (13)	84.0 (6)	50.3 (23)	36.7 (24)	59.8 (12)	61.9 (19)	48.8 (97)
Minnows	1.8 (16)	0.4 (6)	1.6 (28)	1.2 (20)	0.8 (10)	3.7 (16)	1.7 (96)
Carpsuckers	1.2 (1)	- (0)	9.2 (6)	8.4 (20)	11.2 (8)	8.1 (14)	8.7 (49)
Suckers	2.1 (16)	- (0)	7.1 (12)	- (0)	- (0)	- (0)	4.2 (28)
Buffalofishes	6.6 (7)	32.8 (2)	36.7 (10)	35.6 (19)	36.5 (5)	43.6 (5)	32.4 (48)
Redhorses	0.2 (3)	- (0)	0.3 (2)	2.7 (5)	5.5 (7)	- (0)	3.1 (17)
Bullheads	3.7 (17)	1.9 (5)	3.9 (26)	1.6 (20)	0.1 (9)	4.2 (15)	2.9 (92)
Flathead catfish	4.6 (12)	0.7 (5)	2.7 (17)	5.1 (22)	2.8 (10)	5.3 (16)	4.0 (82)
Madtoms	0.4 (15)	0.1 (3)	0.2 (20)	0.2 (8)	<0.1 (3)	- (0)	0.2 (49)
Other catfishes	15.0 (16)	49.5 (6)	15.3 (29)	11.0 (25)	14.2 (12)	17.1 (20)	16.4 (108)
Silvs. & Topminnows	0.2 (12)	1.0 (6)	0.3 (23)	0.2 (17)	0.8 (11)	0.2 (10)	0.4 (79)
Temperate basses	2.2 (7)	2.7 (2)	3.3 (14)	1.9 (17)	1.2 (9)	3.6 (10)	2.5 (59)
Sunfishes	57.8 (18)	32.0 (6)	41.1 (30)	35.6 (25)	37.1 (12)	25.0 (20)	38.7 (111)
Black basses	21.4 (18)	34.8 (6)	23.0 (30)	15.0 (25)	11.0 (12)	14.6 (20)	18.8 (111)
Crappies	5.9 (18)	4.7 (6)	8.3 (30)	4.3 (25)	3.9 (11)	5.9 (20)	5.9 (110)
Freshwater drum	27.7 (4)	18.1 (2)	22.0 (21)	19.3 (23)	20.4 (8)	15.4 (8)	20.3 (66)
Walleye	- (0)	- (0)	- (0)	0.7 (3)	0.2 (3)	1.8 (6)	1.1 (12)
Darters & Log perch	0.4 (14)	0.2 (1)	0.6 (20)	0.9 (20)	0.5 (10)	0.7 (17)	0.6 (82)
Mexican tetra	- (0)	0.1 (3)	- (0)	- (0)	0.1 (2)	- (0)	0.1 (5)
Rio Grande cichlid	- (0)	20.0 (6)	1.5 (1)	- (0)	2.8 (6)	- (0)	10.6 (13)
Tilapia	- (0)	67.2 (5)	91.2 (4)	<0.1 (1)	4.5 (3)	6.3 (1)	51.5 (14)
Others	1.0 (2)	1.1 (2)	0.6 (1)	1.4 (1)	- (0)	- (0)	1.0 (6)
All fishes	209.7 (18)	373.4 (6)	244.8 (30)	233.2 (25)	248.7 (12)	226.0 (20)	240.5 (111)

[a] refer to Table 1 for explanation of species

Table 3. Comparison of average ichthyomasses (lb/acre) in 111 Texas reservoirs with those of a national (predominantly southern) sample of 173 reservoirs reported by Jenkins (1975).

Species or group[a]	Ichthyomass	
	Texas	U.S.
Gars	5.8	2.8
Bowfin	3.3	1.3
Gizzard shad	69.2	82.1
Threadfin shad	8.9	10.2
Pikes	0.7	1.4
Carp and goldfish	48.8	22.7
Minnows	1.7	1.3
Carpsuckers	8.7	4.6
Suckers	4.2	3.0
Buffalofishes	32.4	31.4
Redhorses	3.1	5.9
Bullheads	2.9	2.0
Flathead catfish	4.0	2.0
Madtoms	0.2	0.1
Other catfishes	16.4	6.5
Silversides and topminnows	0.4	0.2
Temperate basses	2.5	1.8
Sunfishes	38.7	27.2
Black basses	18.8	10.1
Crappies	5.9	6.2
Freshwater drum	20.3	13.1
Walleye	1.1	0.8
Darters and logperch	0.6	0.3
All fishes	240.5	180.0

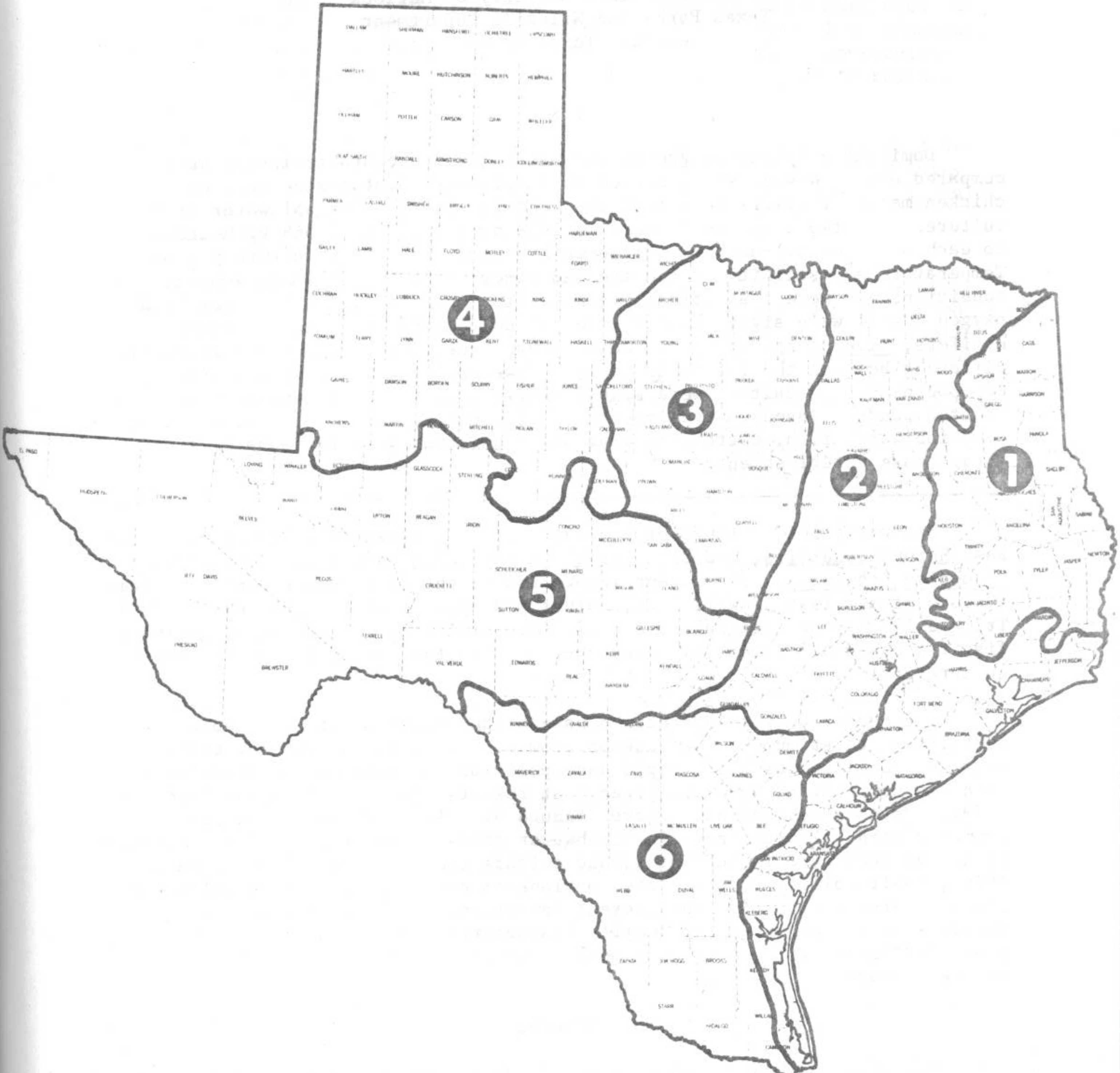
[a] Refer to Table 1 for explanation of species.

Table 4. Average percent ichthyomasses in 111 Texas large impoundments by ecological regions and statewide, 1974-1982. Numbers of reservoirs are indicated in parentheses.

Species[a]	Ecological Region: Pineywoods	South Texas plains	Post oak savanna, blackland prairies	Cross timbers and prairies	Edwards plateau trans-Pecos mountains & basins	High and rolling plains	Statewide
Gars	2.1 (14)	2.3 (4)	2.3 (19)	2.3 (21)	0.2 (7)	2.8 (4)	2.1 (69)
Bowfin	1.5 (11)	- (0)	1.2 (10)	- (0)	- (0)	- (0)	1.4 (21)
Gizzard shad	27.2 (17)	15.2 (6)	28.3 (29)	26.8 (24)	28.7 (12)	34.0 (18)	28.0 (106)
Threadfin shad	6.0 (15)	2.5 (5)	3.2 (18)	2.9 (16)	2.0 (9)	0.5 (4)	3.4 (67)
Pirate perch	0.2 (13)	- (0)	0.1 (5)	- (0)	- (0)	- (0)	0.1 (18)
Pikes	0.3 (15)	- (0)	0.4 (8)	- (0)	- (0)	- (0)	0.3 (23)
Carp & Goldfish	9.6 (13)	22.5 (6)	16.9 (23)	15.5 (24)	24.1 (12)	26.8 (9)	18.8 (97)
Minnows	0.8 (16)	0.1 (6)	0.6 (28)	0.5 (20)	0.3 (10)	1.6 (16)	0.7 (96)
Carpsuckers	0.2 (1)	- (0)	2.3 (6)	3.2 (20)	4.0 (8)	3.8 (14)	3.3 (49)
Suckers	0.9 (16)	- (0)	2.7 (12)	- (0)	- (0)	- (0)	1.7 (28)
Buffalofishes	2.2 (7)	13.3 (2)	10.4 (10)	13.7 (19)	11.4 (5)	16.3 (5)	11.4 (48)
Redhorses	0.1 (3)	- (0)	0.1 (2)	0.9 (5)	2.1 (7)	- (0)	1.2 (17)
Bullheads	1.8 (17)	0.5 (5)	1.5 (26)	0.6 (20)	<0.1 (9)	1.9 (15)	1.2 (92)
Flathead catfish	2.0 (12)	0.2 (5)	0.9 (17)	2.1 (22)	1.1 (10)	2.4 (16)	1.6 (82)
Madtoms	0.2 (15)	< 0.1 (3)	0.1 (20)	0.1 (8)	<0.1 (3)	- (0)	0.1 (49)
Other catfishes	6.9 (16)	13.3 (6)	5.7 (29)	4.7 (25)	5.7 (12)	7.6 (20)	6.4 (108)
Silvs. & Topminnows	0.1 (12)	0.3 (6)	0.1 (23)	0.1 (17)	0.3 (11)	0.1 (10)	0.1 (79)
Temperate basses	0.7 (7)	1.0 (2)	1.1 (14)	0.7 (17)	0.5 (9)	1.6 (10)	0.9 (59)
Sunfishes	27.6 (18)	8.6 (6)	15.5 (30)	15.3 (25)	14.9 (12)	11.0 (20)	16.1 (111)
Black basses	10.2 (18)	9.3 (6)	8.7 (30)	6.4 (25)	4.4 (12)	6.4 (20)	7.8 (111)
Crappies	2.8 (18)	1.3 (6)	3.1 (30)	1.9 (25)	1.5 (11)	2.6 (20)	2.6 (110)
Freshwater drum	7.8 (4)	6.8 (2)	7.2 (21)	8.0 (23)	7.0 (8)	6.0 (8)	7.3 (66)
Walleye	- (0)	- (0)	- (0)	0.2 (3)	0.1 (3)	0.6 (6)	0.4 (12)
Darters & Log perch	0.2 (14)	0.1 (1)	0.2 (20)	0.4 (20)	0.2 (10)	0.3 (17)	0.3 (82)
Mexican tetra	- (0)	< 0.1 (3)	- (0)	- (0)	0.1 (2)	- (0)	0.1 (5)
Rio Grande cichlid	- (0)	5.3 (6)	0.8 (1)	- (0)	1.2 (6)	- (0)	3.1 (13)
Tilapia	- (0)	16.4 (5)	32.4 (4)	< 0.1 (1)	1.7 (3)	4.4 (1)	15.8 (14)
Others	0.6 (2)	< 0.1 (2)	1.3 (1)	1.2 (1)	- (0)	- (0)	0.6 (6)

[a] refer to Table 1 for explanation of species

Figure 1. Ecological regions of Texas included in this study: (1) Pineywoods, (2) Post oak savannah, blackland prairies, (3) Cross timbers and prairies, (4) High and rolling plains, (5) Edwards plateau, trans-Pecos, and mountains and basins, and (6) South Texas plains.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COMPARISON OF ZOOPLANKTON PRODUCTION IN BRACKISH WATER PONDS FERTILIZED WITH COTTONSEED MEAL OR CHICKEN MANURE

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ABSTRACT

Dominant zooplankton groups and water quality characteristics were compared over a 4-week study period to determine if cottonseed meal or chicken manure fertilizer yielded the best forage base for saltwater fish culture. The two fertilizers were individually applied at 568 kg/hectare to each of three 0.1-hectare unstocked brackish water fish culture ponds. Temperature and salinity of the treated ponds reflected seasonal ambient conditions and were statistically similar for both fertilizers. Dissolved oxygen levels were significantly lower in cottonseed meal treated ponds. Rotifers, Oithona sp. and polychaete larvae densities were not significantly different between the two fertilizers. However, Acartia tonsa and mixed copepod nauplii densities were significantly greater in cottonseed meal treated ponds. Based on the importance of copepods in the diet of cultured brackish water fish, cottonseed meal was considered best for zooplankton forage base establishment.

Saltwater pond culture of recreationally important fish, such as striped bass Morone saxatilis, red drum Sciaenops ocellatus, and spotted seatrout Cynoscion nebulosus, is a recent innovation in the southeastern United States (Colura et al. 1976; Powell 1976; Colura and Hysmith 1976; Perry et al. 1977; Trimble 1979). An integral aspect of successful pond culture of planktivorous fish fry is establishment of acceptable zooplankton forage for a 4-to 6-week culture period.

Freshwater culture operations have historically employed organic fertilizers to stimulate zooplankton growth. Fertilizers with low carbon to nitrogen (C:N) ratios allow rapid decomposition and nutrient utilization by plankton communities and have given best results (Snow et al. 1964; Boyd 1979). Cottonseed meal and chicken manure have low C:N ratios and are commonly used as fertilizers in freshwater ponds (Snow et al. 1964). Although both have been used in saltwater pond culture (Colura et al. 1976; Powell 1976), their ability to stimulate zooplankton community growth in saltwater ponds remains unstudied. The present investigation compares selected zooplankton groups and water quality characteristics of unstocked saltwater ponds fertilized with cottonseed meal to those of ponds fertilized with chicken manure.

METHODS

The study was conducted 11 May to 6 June 1982 in six replicate 0.1-hectare rectangular earthen ponds at the Texas Parks and Wildlife Department Marine Fisheries Research Station, Palacios, Texas. Three randomly selected ponds each received 568 kg/hectare cottonseed meal (43% protein) and the remaining ponds received an equal amount of untreated chicken manure. Fertilization consisted of an initial 284-kg/hectare application of each fertilizer spread evenly on dry pond bottoms. Ponds were then filled (1.5 m depth) within 12 hours with 0.5-mm saran sock filtered Matagorda Bay water. The remaining fertilizer was applied by broadcasting 31.6 kg/hectare of each fertilizer to each replicate three times weekly for 3 consecutive weeks. Filtered bay water was added to ponds during the study to replace water lost to seepage and evaporation.

Water quality was examined daily at each pond drain box between sunrise and 0730. Bottom dissolved oxygen, surface water temperature and salinity were determined by the membrane electrode method (Delta 1010, National Sonics Corporation), a glass thermometer and refractometer (American Optical Corporation).

Zooplankton in each pond were sampled every other day. A 25-liter composite sample was collected by pooling 5 liters of water from each pond corner and drain box. Water was collected using a 12-volt flexible impeller pump apparatus attached to a truck-mounted, counter-weighted boom (Farquhar and Geiger in press) and filtered through a 64-μ Wisconsin plankton net. Zooplankton samples were preserved in a 4% buffered formalin-sucrose solution until enumeration. Analysis was accomplished by diluting each zooplankton sample in a graduated cylinder until it contained approximately 200-500 organisms/ml. Diluted samples were mixed to ensure homogeneity and a 1-ml subsample was recovered with a Hensen-Stemple pipette. Organisms were identified and counted using a Ward plankton counting wheel and steromicroscopy. If individual subsamples yielded $<$ 200 organisms, additional subsamples were enumerated until 200 organisms or five subsamples were examined. Population densities (number of organisms/liter) were determined for mixed rotifers, mixed copepod nauplii, mixed polychaete larvae, the calanoid copepod _Acartia tonsa_, and the cyclopoid copepod _Oithona_ sp.

Qualitative population trends of zooplankton communities established in cottonseed meal and chicken manure treated ponds were examined by calculating the daily percent composition of each faunal group over the study period. A mixed model two-way analysis of variance (Sokal and Rohlf 1969) was used to compare the mean daily value of each water quality characteristic and $\log_{10}$ transformed density of each zooplankton group observed in cottonseed meal treated ponds to those of chicken manure treated ponds. Fertilizer was considered a fixed variable and day a random variable. Zooplankton samples collected on 29 May were deleted from statistical analysis due to loss of one sample.

RESULTS

Rotifers, copepod nauplii, and to a lesser extent _A. tonsa_, dominated pond zooplankton communities for both fertilizer treatments (Fig. 1). _Oithona_ sp. and polychaete larvae were generally present as minor community segments. Growth curves of individual zooplankton groups in cottonseed meal and chicken manure treated ponds suggested fertilizer type affected growth patterns (Figs. 2 and 3). Peak total zooplankton densities were achieved on day 11 in both treatments, with total zooplankton abundance in the chicken manure ponds 1.8 times that of the cottonseed meal ponds. However, total zooplankton populations declined more rapidly beyond day 13 in the chicken manure treated ponds. At study termination, total zooplankton density of the cottonseed meal treated ponds was 2.8 times that of chicken manure ponds.

An apparent bimodal growth pattern for rotifers and mixed copepod nauplii occurred in cottonseed meal fertilized ponds (Fig. 2). In contrast, a distinct unimodal growth curve for these zooplankton groups occurred in chicken manure ponds (Fig. 3). Although peak densities of rotifers and copepod nauplii through day 11 were greater in chicken manure ponds, higher densities occurred in cottonseed meal ponds between days 19 and 27. Patterns for A. tonsa were similar in both treatments, but densities in cottonseed meal treated ponds were 2 - 3 times that found in chicken manure treated ponds beyond day 19. Growth patterns and densities for Oithona sp. and polychaete larvae were similar for both treatments.

Two-way analysis of variance (Tables 1 and 2) indicated cottonseed meal produced significantly greater densities of copepod nauplii and A. tonsa than chicken manure; mean daily densities of rotifers, Oithona sp. and polychaete larvae were unaffected by fertilizer type. Days were a significant source of variation for all zooplankton groups. Fertilizers were a significant source of variation only for copepod nauplii. Significant interaction between the two sources of variation occurred only for A. tonsa populations.

Both water temperature and salinity were statistically similar for the fertilizer treatments (Table 3) and reflected seasonal ambient conditions. Mean ($\pm$ SD) pond temperatures averaged 26 $\pm$ 0.2 C and increased from 23 to 29 C over the study period, while salinities ranged from 8 to 11^{o}/oo, and averaged 10 $\pm$ 0.00^{o}/oo.

Dissolved oxygen was significantly different between fertilizer treatments and both varied between days (Table 3). Mean ($\pm$ SD) daily dissolved oxygen concentrations of the cottonseed meal and chicken manure treated ponds were 4.4 $\pm$ 0.1 and 5.2 $\pm$ 0.1 mg/liter, respectively. Minimum dissolved oxygen levels of 1 - 2 mg/liter occurred the day following initial fertilization in both treatment groups. Thereafter, dissolved oxygen generally exceeded 3 mg/liter except for days 19 to 22 in cottonseed meal treated ponds (Fig. 4).

DISCUSSION

Cottonseed meal treated ponds provided a better zooplankton forage base for saltwater pond fish culture than chicken manure, as evidenced by greater production of A. tonsa and copepod nauplii. A. tonsa is a food of larval marine fishes and copepod nauplii are an excellent initial food (Houde 1972; Ogle 1979). Also, populations of rotifers, an important larval fish food (Baxter 1981), were strong in cottonseed meal treated ponds, although densities were not greater than those in chicken manure treated ponds.

Low Oithona sp. densities in both fertilizer treatments may be due to low salinity (8 to 11^{o}/oo). Gilmore et al. (1975) reported Oithona sp. were most abundant at 22^{o}/oo salinity, and exhibited a low tolerance to salinities $<$ 10^{o}/oo. Similarly, Srithavatch (1973) found Oithona sp. densities increased at salinities $\geq$ 10^{o}/oo.

Slight increases in polychaete larvae during the last week of the study (June) may reflect reproduction of pond established adults or larval introductions from Matagorda Bay. Polychaete larvae are most abundant in summer with peak densities in Matagorda Bay occurring in June (Srithavatch 1973).

The population dynamics of cottonseed meal treated ponds suggested a strategy of stocking larval fish 9 to 11 days after initial fertilization when ponds exhibited a large rotifer population coincident with peak copepod nauplii densities. Stocking ponds near this time would ensure availability of appropriately sized forage. Further, relatively strong populations of rotifers and copepod nauplii were maintained for 3 weeks after initial fertilization, and would provide adequate food until stocked fish attained sufficient growth to feed on increasing A. tonsa populations.

Reduced dissolved oxygen in cottonseed meal treated ponds had no effect on zooplankton production and should not affect fish culture at late spring temperatures. The period of lowest dissolved oxygen would be avoided by stocking fish approximately 10 days after initial fertilization to coincide with peak zooplankton densities. Low dissolved oxygen concentrations encountered in the latter portion of the study should not be lethal because most larval marine fishes can withstand dissolved oxygen concentrations reduced to 40% saturation (Blaxter 1981). However, if the prestocking fertilization program was conducted during mid-summer, high temperature and concomitant dissolved oxygen reductions may require cottonseed meal application rates less than 568 kg/hectare.

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Table 1. Mean ± 1 SE (N = 13) zooplankton densities (number/liter) in 0.1-hectare ponds treated with cottonseed meal or chicken manure, 11 May to 6 June 1982.

Fertilizer	Pond	Rotifers	Copepod nauplii	*Acartia tonsa*	*Oithona* sp.	Polychaete larvae
Cottonseed meal	A	531 ± 229	409 ± 78	122 ± 52	19 ± 12	13 ± 6
	B	456 ± 217	377 ± 69	83 ± 32	6 ± 2	14 ± 9
	C	356 ± 194	465 ± 102	93 ± 34	20 ± 7	9 ± 4
	Average	446 ± 121	417 ± 48	100 ± 23	15 ± 5	12 ± 4
Chicken manure	D	638 ± 423	356 ± 114	65 ± 26	14 ± 3	9 ± 4
	E	554 ± 296	375 ± 102	40 ± 12	6 ± 3	11 ± 9
	F	214 ± 76	328 ± 82	49 ± 16	16 ± 7	11 ± 7
	Average	466 ± 172	353 ± 56	51 ± 11	12 ± 3	11 ± 4

Table 2. Summary of two-way analysis of variance of mean daily zooplankton populations in 0.1-hectare ponds treated with cottonseed meal or chicken manure, 11 May to 6 June 1982.

Zoo-plankton group	Source of variation	Degrees of freedom	Sum of squares	Mean square	F
Rotifers	Total	77	62.958		
	Fertilizers	1	0.004	0.004	0.012 NS
	Days	12	44.703	3.725	13.745 **
	Fertilizers x Days	12	4.142	0.345	1.273 NS
	Error	52	14.109	0.271	
Copepod nauplii	Total	77	17.063		
	Fertilizers	1	0.335	0.335	5.492 *
	Days	12	14.220	1.185	34.853 **
	Fertilizers x Days	12	0.731	0.061	1.794 NS
	Error	52	1.777	0.034	
Acartia tonsa	Total	77	35.809		
	Fertilizers	1	0.412	0.412	1.579 NS
	Days	12	26.167	2.181	18.641 **
	Fertilizers x Days	12	3.132	0.261	2.231 *
	Error	52	6.098	0.117	
Oithona sp.	Total	77	27.060		
	Fertilizers	1	0.377	0.377	1.866 NS
	Days	12	10.093	0.841	3.092 **
	Fertilizers x Days	12	2.426	0.202	0.743 NS
	Error	52	14.164	0.272	
Polychaete larvae	Total	77	33.014		
	Fertilizers	1	0.265	0.265	1.448 NS
	Days	12	24.299	2.025	16.875 **
	Fertilizers x Days	12	2.201	0.183	1.525 NS
	Error	52	6.249	0.120	

NS Not significant at $P = 0.05$
* $P < 0.05$
** $P < 0.01$

Table 3. Summary of two-way analysis of variance of mean daily water temperature, salinity and dissolved oxygen in 0.1-hectare ponds treated with cottonseed meal or chicken manure, 11 May to 6 June 1982.

Water quality characteristic	Source of variation	Degrees of freedom	Sum of squares	Mean square	*F*
Temperature	Total	155	347.44		
	Fertilizer	1	0.01	0.01	0.33 NS
	Days	25	340.61	13.62	227.00 *
	Fertilizer x Days	25	0.74	0.03	0.50 NS
	Error	104	6.08	0.06	
Salinity	Total	161	19.30		
	Fertilizer	1	0	0.00	0.00 NS
	Days	26	11.93	0.46	7.67 *
	Fertilizer x Days	26	0.70	0.03	0.50 NS
	Error	108	6.67	0.06	
Dissolved Oxygen	Total	155	203.67		
	Fertilizer	1	30.70	30.70	48.73 *
	Days	25	83.11	3.32	3.46 *
	Fertilizer x Days	25	23.93	0.96	1.52 NS
	Error	104	65.93		

NS Not significant at $P = 0.05$

* $P < 0.01$

Figure 1. Relative abundance of zooplankton in 0.1-hectare ponds treated with 568 kg/hectare cottonseed meal or chicken manure 11 May to 6 June 1982.

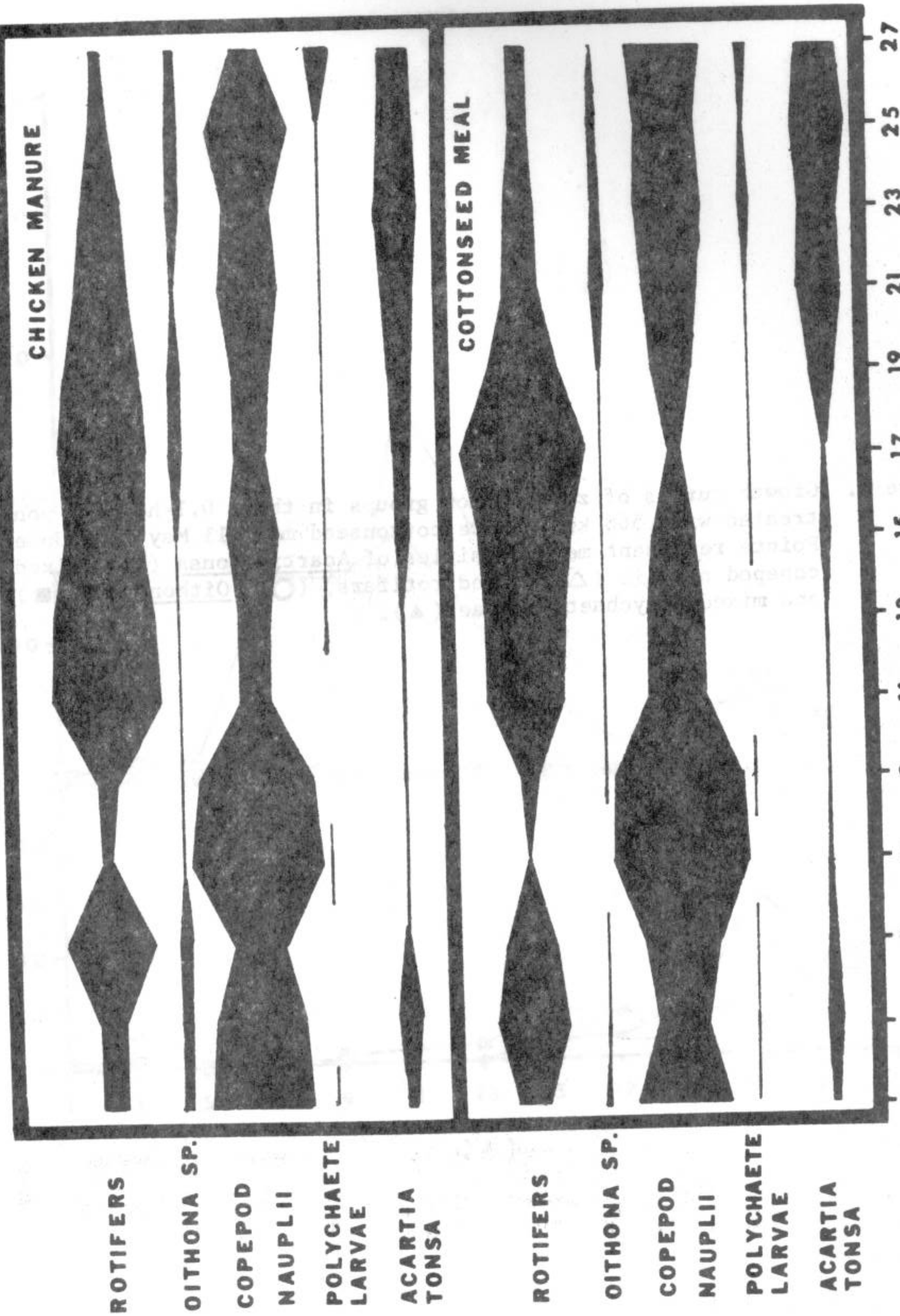

CHICKEN MANURE
COTTONSEED MEAL
ROTIFERS
OITHONA SP.
COPEPOD NAUPLII
POLYCHAETE LARVAE
ACARTIA TONSA
ROTIFERS
OITHONA SP.
COPEPOD NAUPLII
POLYCHAETE LARVAE
ACARTIA TONSA
1
3
5
7
9
11
13
15
17
19
21
23
25
27
DAY

Figure 2. Growth curves of zooplankton groups in three 0.1-hectare ponds treated with 568 kg/hectare cottonseed meal 11 May to 6 June 1982. Points represent mean densities of <u>Acartia tonsa</u> (●), mixed copepod nauplii (△), mixed rotifers, (○), <u>Oithona</u> sp. (■), and mixed polychaete larvae (▲).

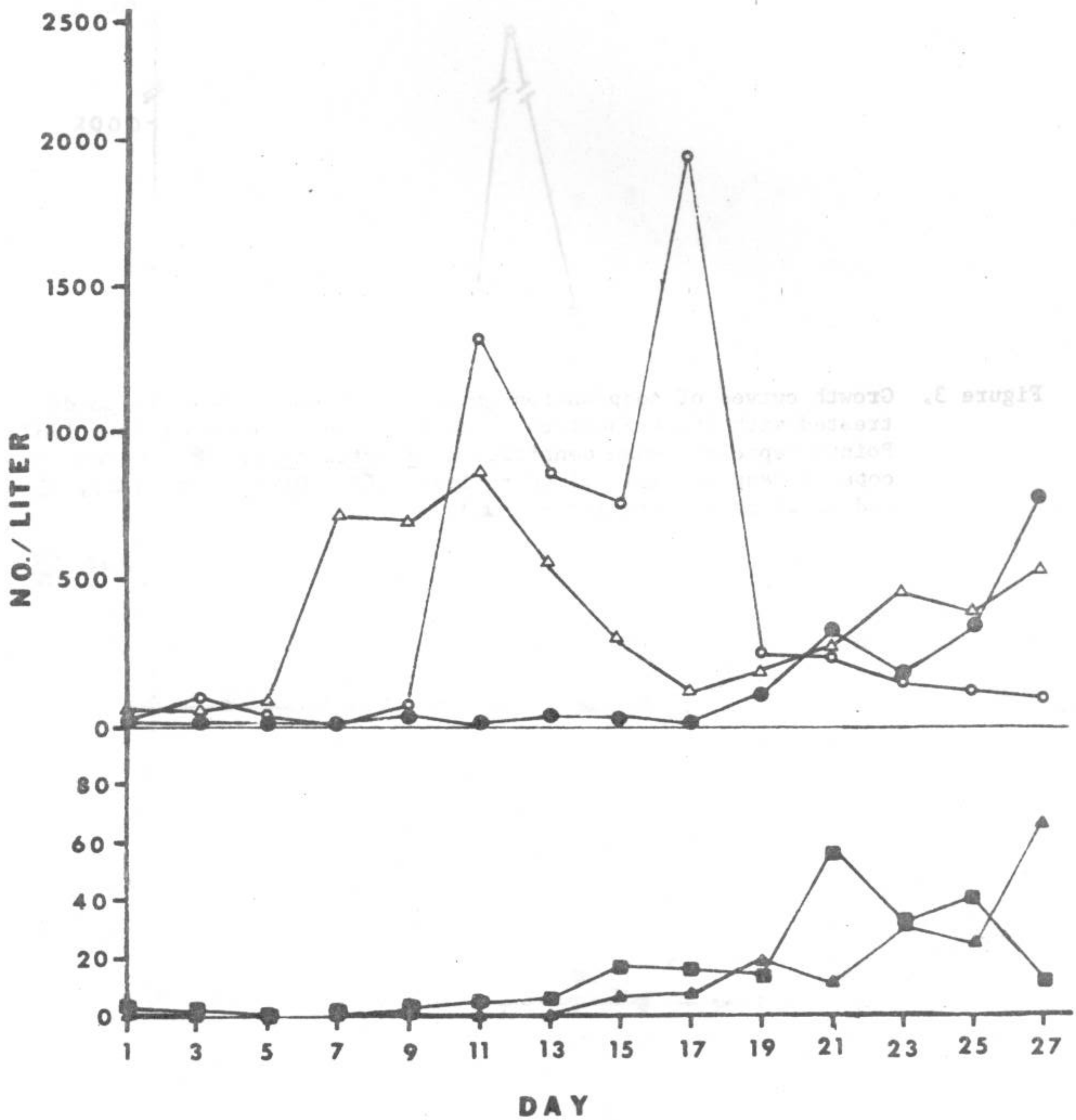

2500
2000
1500
1000
500
0
80
60
40
20
0
NO./LITER
1
3
5
7
9
11
13
15
17
19
21
23
25
27
DAY

Figure 3. Growth curves of zooplankton groups in three 0.1-hectare ponds treated with 568 kg/hectare chicken manure 11 May to 6 June 1982. Points represent mean densities of *Acartia tonsa* (●), mixed copepod nauplii (△), mixed rotifers (○), *Oithona* sp. (■), and mixed polychaeta larvae (▲).

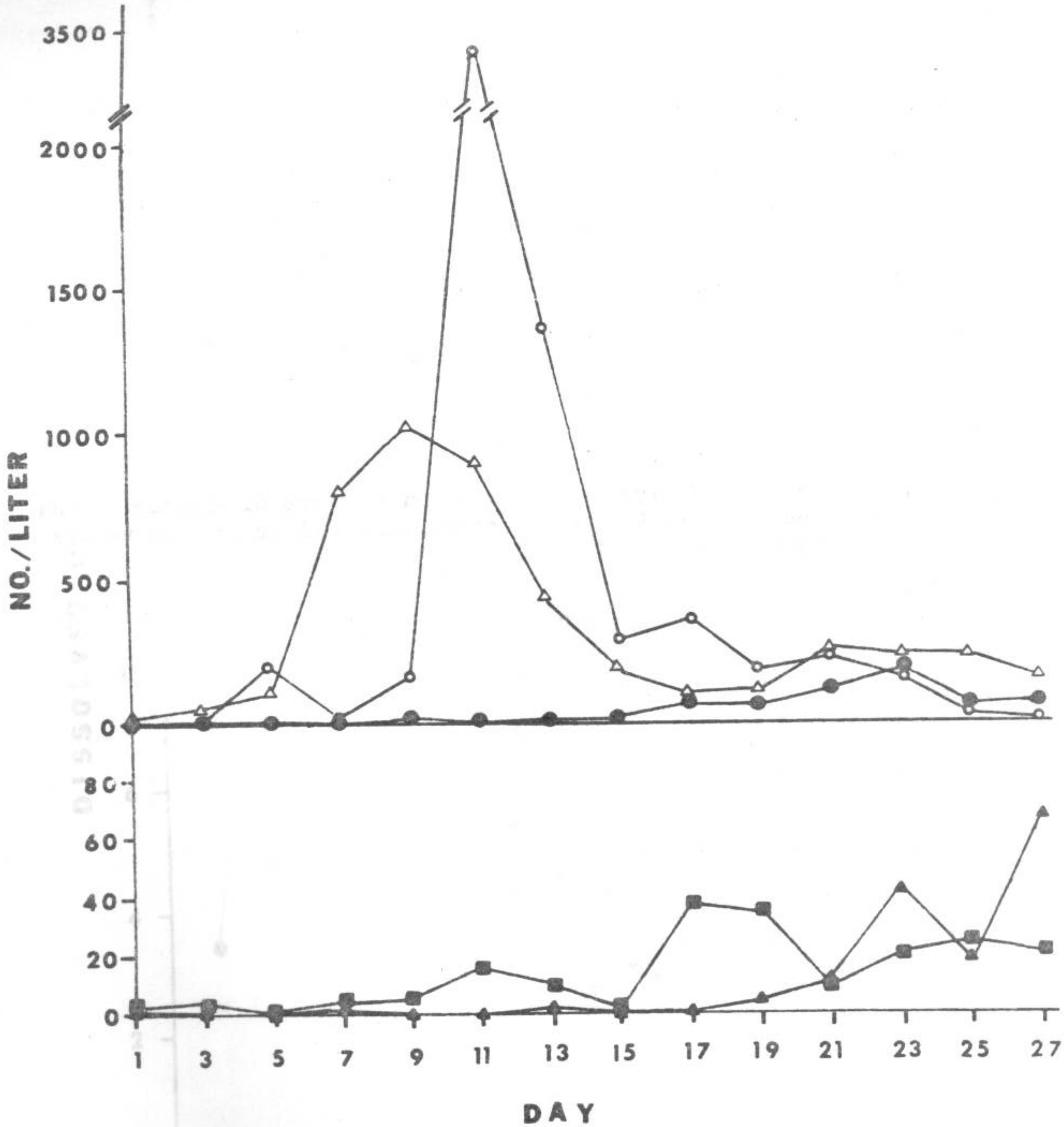
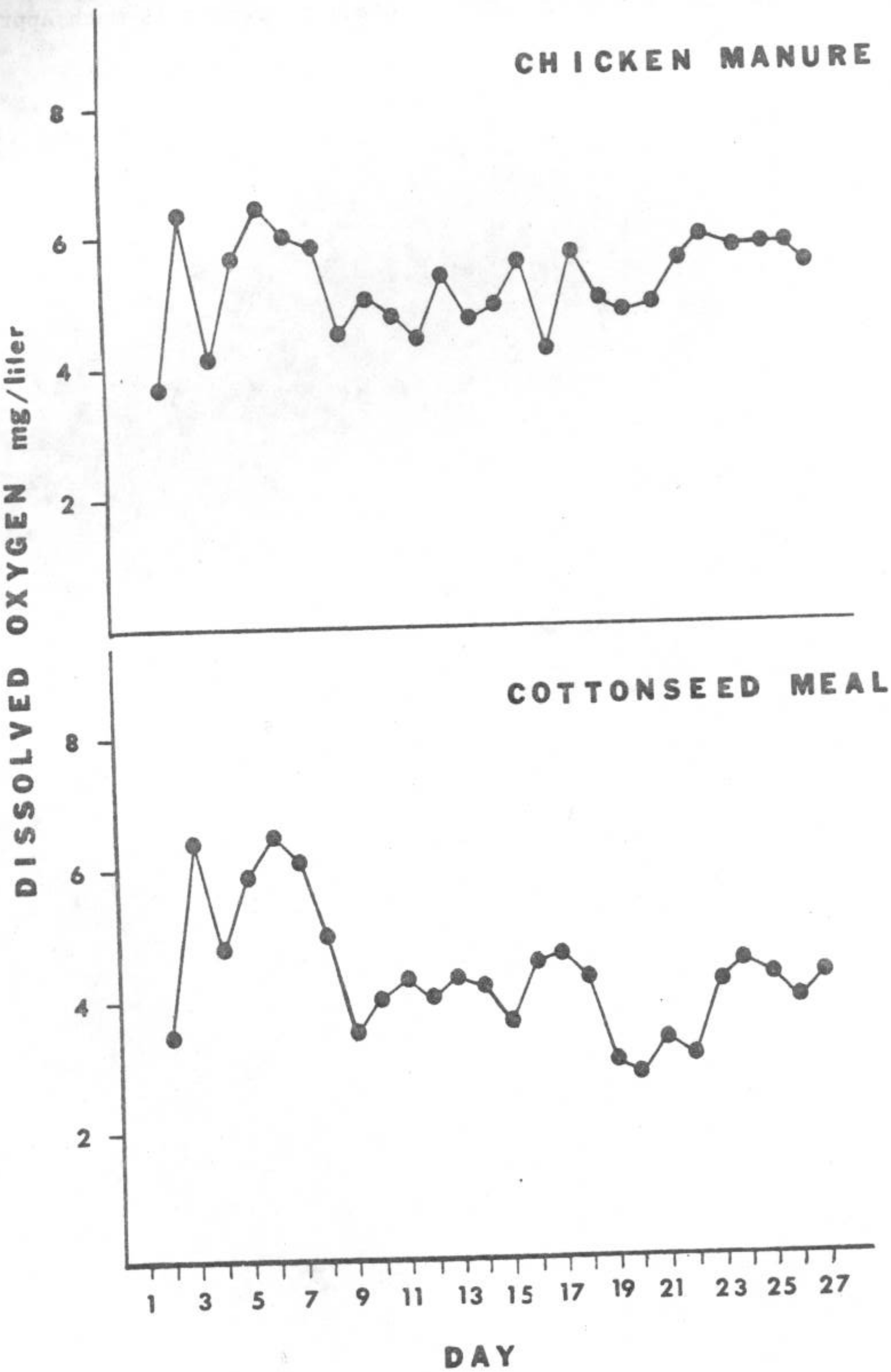

3500
2000
1500
1000
500
0
80
60
40
20
0
NO./LITER
1
3
5
7
9
11
13
15
17
19
21
23
25
27
DAY

Figure 4. Mean dissolved oxygen concentration in three 0.1-hectare ponds treated with 568 kg/hectare cottonseed meal or chicken manure 11 May to 6 June 1982.


CHICKEN MANURE
COTTONSEED MEAL
DISSOLVED OXYGEN mg/liter
8
6
4
2
1
3
5
7
9
11
13
15
17
19
21
23
25
27
DAY

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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.

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