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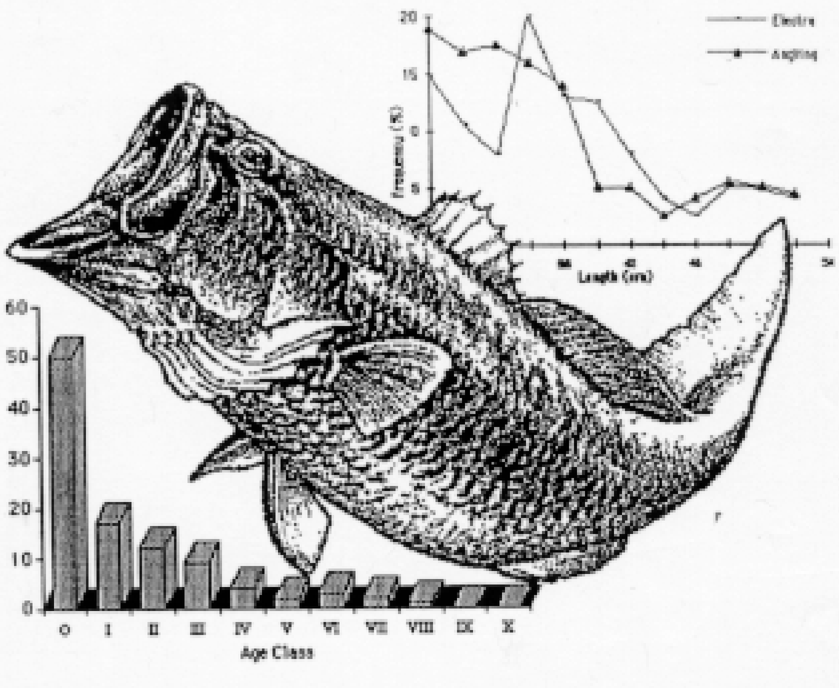
A MANAGEMENT PLAN FOR BASS IN CONNECTICUT WATERS

and Recommendations for Other Warmwater Species



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A Management Plan for Bass in Connecticut Waters:
Recommendations for Management of Other Warmwater Species

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Introduction

Connecticut's warmwater fisheries are an extremely important component of the State's overall angling activity. Connecticut anglers spend approximately 1.9 million trips/year in search of trout and 1.2 million trips/year in pursuit of saltwater fish (all species combined). The remaining effort (2.2 million trips/year) is devoted to fishing for largemouth and smallmouth bass (1.3 million trips/yr) and other warmwater species (0.9 million/yr) such as northern pike, panfish and catfish (USF&WS 1993). Moreover, general interest in warmwater fishing (especially for bass) and sophistication of fishing techniques have all continued to increase over the last few decades. For example, the number of competitive bass fishing tournaments in Connecticut has increased more than 5-fold over the last 10 years (from 124 in 1986 to 630 in 1996). With both increasing interest and fishing pressure comes an increasing need for innovative and effective management to sustain and enhance angling quality among Connecticut's warmwater fisheries.

The purpose of this plan is to formalize the Fisheries Division's warmwater management goals and direction over the near future. The preparation and publication of a formal plan will help convey a clear understanding of our intentions to the public while giving us objective benchmarks by which to monitor success. Implementation of this plan will increase the opportunity for Connecticut anglers to have more enjoyable and successful fishing both in the near future and for many generations to come.

Warmwater Fisheries Management in Connecticut

During the first half of the 20th century, most of the fisheries management effort in Connecticut centered around stocking and introductions of non-native fish species. The State Board of Fisheries and Game attempted to introduce almost every fish species conceivable into every lake or pond possible in an effort to see "what would take". Most of these introductions were apparently done with little consideration of their potential impact on lake ecosystems and the other fish species living within them. Some introductions were very successful and beneficial (for example, largemouth bass). Others, in hindsight, were doomed to failure due to habitat limitations (e.g., landlocked salmon). Some (such as white perch and carp) are thought to have negatively impacted other fish populations.

The earliest management regulations (minimum length limits, creel limits and closed spawning seasons) were imposed to protect some species of newly introduced fish. The philosophy of the time was to prevent overharvest (via creel limits), to protect fish during spawning (closed seasons) and to allow fish to grow large enough to spawn at least once (minimum length limits). Later (1960's - early 80's), minimum length limits were tailored to achieve the maximum sustainable harvest in weight. During the same time period, however, many anglers were becoming more interested in sport fishing quality (average size and numbers of larger fish caught) than with harvest. In response, the philosophy of "optimum yield" was adopted, which considers not only quantity of fish harvested, but the overall quality of the sport fishery.

Despite advances in fisheries management, biologists were discovering nationwide that similar management strategies did not necessarily have the same effect in every lake. For example, changes in length limit regulations usually resulted in improved bass fishing. In some lakes, however, the same management scenario caused bass growth rates and subsequently the quality of fishing to decline. It became apparent that different inherent characteristics of lakes, such as trophic status or fish species composition, were affecting the outcome of attempts to improve fishing. It was also apparent that optimum angling quality could be best addressed on a lake by lake basis. Moreover, the single species approach to management was too simplistic for warmwater lakes because of the complex interactions which exist among resident fish species. Informed management strategies could only be formulated through an understanding of these interactions in the context of lake and pond ecosystems.

In response to the need for lake-specific warmwater information, the Fisheries Division initiated a five-year (1980-84) intensive study of nine Connecticut largemouth bass lakes (Jacobs et al. 1986). This study concluded that growth and mortality rates varied widely among the State's bass populations and that the statewide regulations (12-inch minimum length limit, 6-fish creel limit) may not be appropriate for all waters. It further recommended that the efficacy of lake-specific management through alternate length limits be investigated. Two projects were launched (1986-94) in response to this initial work. The first was a study of experimental length limits on largemouth bass in three Connecticut lakes. The second was a statewide electrofishing survey of more than 100 Connecticut lakes and ponds (including sections of the Connecticut and Housatonic Rivers).

Results of Recent Connecticut Warmwater Fisheries Work

Experimental Length Limits on Largemouth Bass

Experimental length limits were imposed in 1989 on three Connecticut lakes in order to test their effectiveness toward improving the quality of angling for largemouth bass. The regulations were a 15" minimum length limit (Moodus Res.), a 12-15" slot length limit (Pickerel L.) and a 12-16" slot length limit (Lake Saltonstall). The lakes were monitored by electrofishing and creel survey for three years prior to (1986-88) and five years after (1989-93) the regulations were implemented (Jacobs et al. 1995).

Findings

- **Densities and angler catch rates of large (>12") bass improved** by as much as 60% among the three study lakes within five years of implementing alternative length limits. After 10 years, densities of large bass in two of the study lakes were more than twice those observed under the previous 12-inch minimum length limit.

- **Nationwide, conservative slot and minimum length limits have proven to be the most**

cost effective methods of improving angling quality for black bass. In many cases, protecting larger bass also benefited panfish angling because increased predation by bass caused panfish growth rates to improve. The size and type of length limit chosen must be tailored to the individual waterbody depending on such things as bass growth and recruitment levels and forage availability.

Conclusions

- ♦ **Alternative slot and minimum length limits can significantly improve bass fishing** and are the most promising methods for statewide management of Connecticut bass fisheries.

Statewide Lake and Pond Electrofishing Survey

In 1987, the Fisheries Division initiated a statewide electrofishing survey of more than 100 Connecticut lakes and ponds including many sites on the Connecticut River (Jacobs and O'Donnell 1996). This survey gave us current data on the status of the State's most important warmwater fisheries and allowed us to identify those waters that might be in need of alternative management.

Findings

- ♦ **Fish Population Parameters Vary Widely Among Connecticut's Warmwater Fisheries**. Data from the recently completed Statewide lake and pond electrofishing survey (Jacobs and O'Donnell 1996) revealed that Connecticut's warmwater fisheries are extremely varied. Physically and chemically, the State's public lakes and ponds differ considerably in their ability to produce fish populations. They range in size from less than 10 acres to more than 5,000 acres. Some have maximum depths of only 3 feet, whereas others exceed 100 feet. Trophic status among Connecticut lakes ranges from oligotrophic with extremely clear water and little submerged vegetation to highly eutrophic, turbid and vegetation-choked. Fish species composition also varies among lakes. Many small ponds have only a handful of fish species, while a few of the larger riverine impoundments contain almost every freshwater species known to exist in the State. Finally, fishing pressure varies among Connecticut's public lakes due to differences in characteristics such as lake size, type of access and proximity to urban centers. These factors and others cause **fish population parameters (recruitment, growth, mortality and population structure) to be extremely variable among individual lakes and ponds** for all of the popular game and panfish species.

- ♦ **Four Common Problems/Conditions Exist in Some Connecticut Lakes and Ponds**. Despite the wide variation that exists among Connecticut warmwater fisheries, four common problems/conditions were identified which could be either corrected or capitalized on through alternative management.

  1. **High Bass Mortality.** Total annual bass mortality rates were found to be high (>50%) in 27% of largemouth and 74% of smallmouth bass populations among the

Connecticut lakes and ponds surveyed. Most of this mortality is probably due to angler harvest because, in typical populations, only 15-20% of adult bass die of natural causes each year. Under a 12-inch minimum length limit, excessive harvest results in low densities of larger bass (>12 inches) which adversely affects angling quality.

2. **Bass Stockpiling**. Angling quality suffers in many (39%) Connecticut lakes and ponds due to moderate to severe stockpiling of either largemouth or smallmouth bass smaller than the 12-inch minimum length limit. Stockpiling occurs when bass recruitment (the numbers of young fish that are spawned and survive) greatly exceeds predation (the numbers which are eaten by predators). High densities of small bass causes increased competition for limited food supplies and subsequently growth rates decline. Under these circumstances, bass do not grow fast enough to replenish the legal size (>12 in.) fish which are harvested by anglers. This results in poor quality angling because the fishery is dominated by 8-12 inch fish with few larger ones present.

3. **Panfish Stockpiling.** Fifty-three percent of Connecticut lakes exhibit moderate to severe stockpiling of panfish below catchable size and slow panfish growth rates. This causes angling quality for these species to suffer. Panfish become stockpiled for the same reasons that bass do (excessive recruitment in conjunction with angler harvest and inadequate predation). In some severe cases, panfish are so overabundant that stunting has occurred which means that the fish die of old age before they ever become large enough to be of interest to anglers.

4. **Surplus Forage.** Many lakes and ponds (59%) contain surplus forage fish populations (alewives, shiners, killifish, etc.).

♦ **High Vulnerability of Fish Populations in New Opened Water Supply Reservoirs.** Fish populations in the State's unfished water supply reservoirs are extremely vulnerable to angling, with bass being 4 to 10 times easier to catch than in the State's public lakes (Jacobs and O'Donnell 1996). Because of this high vulnerability, newly opened reservoirs can be easily and quickly overfished. The Fisheries Division monitored three newly opened reservoirs from which an estimated 65 to 80% of the largemouth bass over 12 inches and 53 to 90% of the sunfish over 6 inches were harvested after only one year of angling (Jacobs and O'Donnell 1996). Other studies have similarly documented extremely high first-season harvest rates from newly opened lakes (Schneider 1973, Clady et al. 1975).

Conclusions

♦ Fisheries potential in many of our State's waters could be enhanced through lake-specific management. Many of our State's warmwater fisheries contain healthy, balanced fish populations. However, angling quality is not optimum in other lakes due to unbalanced conditions (poor fish growth rates, population structures and predator/prey ratios). Because problems/conditions that exist among individual Connecticut warmwater lakes and ponds are extremely varied, they are not always best addressed by statewide regulations.

- Where bass mortality is high, angling quality could be improved by reducing fishing mortality on larger bass (>12 inches). A slot or minimum length limit (such as a 16-inch minimum or a 12-16 inch protected size range) in combination with a reduced creel limit on large fish would best provide the necessary protection. Although total numbers of bass caught may not increase, the quality of bass angling would improve because catch rates of large bass and the average size of bass caught would both be enhanced.

- Where bass are stockpiled below 12 inches, a slot length limit could improve bass angling quality. A slot limit (such as a 12-16 inch protected size range) with a reduced creel limit on large bass would increase the abundance of the larger fish that anglers most want to catch. It would also allow anglers to harvest and thin out the overabundant smaller bass (those less than 12 inches). Increased numbers of larger bass would not only directly improve angling quality, but would increase predation on the smaller bass which would help to reduce overabundance and improve bass growth rates. An additional benefit to slot limits is that they increase the anglers' opportunity to harvest bass. Although they must release larger fish, the anglers have access to the more abundant and easier to catch small bass (less than 12 inches). Thus, with a newly imposed slot limit their chances of catching bass that they could take home would actually increase.

- When bass stockpiling is severe, the introduction of an additional predator (such as walleye) and/or protection of another existing predator (such as placing a more protective length limit on chain pickerel) may also be necessary to sufficiently reduce numbers of small bass to levels that would positively affect growth rates.

- Where panfish are stockpiled, the quality of panfish angling could be improved by increasing the numbers of large predators in the fishery. This could be accomplished through a more protective slot or minimum length limit on bass with a reduced creel limit on large fish and/or protection or addition of other predators. Increasing the numbers of large gamefish would result in greater predation and thus thinning of overabundant small panfish and can lead to improved panfish growth rates. Angling for both gamefish and panfish could thus be improved through addition/protection of larger predators.

- Waters that have surplus forage could potentially support more predators (gamefish) than they currently contain. This represents an opportunity for improved angling through alternative management. Densities of large predators could be increased through a more protective slot or minimum length limit on bass, increased protection of other resident predators (such as chain pickerel), introduction of new predators, or a combination of these. The probability of significant improvement in angling quality as a result of management changes greatly increases when surplus forage exists.

♦ Without special regulations, fish populations in newly opened water supply reservoirs can become quickly depleted by angling. This creates "boom and bust" fisheries with excellent fishing the first year followed by mediocre to poor angling thereafter. Special regulations (such as slot limits or high minimum length limits on bass) are needed to sustain high quality angling in these unique resources.

Angler Attitudes in Connecticut

Angler attitudes regarding sport fishing are and probably always will be personal and diverse. Despite this, there has been a nationwide trend in angler attitudes toward the "sport" aspect of angling. Most anglers now place much more importance on catching and fighting larger fish than on the number of fish they are able to take home. Especially in Connecticut, where the per capita income is relatively high, anglers are much more apt to view fishing as a means of recreation, sport, challenge, or to "get away from it all" than as a food source. Nonetheless, the opportunity to take fish home to eat remains an important facet to many anglers. Even among these anglers, however, the "quality" of their fishing experience (catching larger fish) has typically become more important than the quantity of fish caught.

There has also been an increasing conservation ethic and awareness among anglers over recent years. It was not too long ago that people thought of fish and many other natural resources as inexhaustible. Photos from the early part of the century of anglers with as many as 100 large bass on a stringer attest to the rampant exploitation and waste of the times. Now anglers realize that harvest can have profound effects on fish populations and that only through careful conservation can the quality of a fishery resource be maintained. Toward this end, anglers have come to accept and expect management practices such as creel and length limits to preserve their sport fishing.

Findings

♦ More than 60% of Connecticut anglers release all of the legal size (>12 inches) bass that they catch.

♦ More than 90% of the anglers interviewed in the three lakes with experimental length limits (Moodus, Pickerel and Saltonstall) responded that they preferred the more protective regulations to the statewide 12-inch minimum length limit.

♦ Compliance to the experimental length limit regulations was good, with less than 4% of the anglers harvesting illegal fish.

♦ In 1997, 792 anglers were asked their opinions on bass length limit regulations during creel surveys on eight Connecticut lakes. More than 89% of the anglers who fish for bass, but do not fish in bass tournaments, said that they were in favor of either a 16-inch minimum length limit or a 12 to 16-inch slot limit on bass with less than 8% opposed (the remainder had no preference). Among tournament anglers, 59% of them were in favor of a more protective minimum length limit with 36% opposed. Tournament anglers were much more in favor of the 12 to 16 inch slot limit, however, with 79% saying that it was a good idea and only 14% opposed.

Conclusions

- ♦ Most Connecticut anglers prefer a reduced opportunity to harvest bass in order to catch more large fish.

- ♦ Most Connecticut anglers embrace the concept of lake-specific alternative length limit regulations for bass.

- ♦ Most tournament bass anglers are also in favor of more conservative length limit regulations as long as their opportunity to weigh-in legal size fish is not too restricted.

Potential Management Tools for Warmwater Fisheries

The key to improving angling quality in warmwater lakes and ponds is to employ management tools that are most likely to achieve or maintain a desirable fish community balance. As importantly, these management tools must prove to be cost-effective on a statewide scale. Myriad techniques and strategies have been attempted nationwide in efforts to protect warmwater fish stocks and/or improve angling quality. The following is a review of the more popular or effective methods along with comments on their potential for management in Connecticut. Management strategies fall generally under two categories; 1) physical management and 2) management by regulation. Physical management involves direct physical, chemical or biological manipulation of fish or fish habitat. Management by regulation typically involves protecting fish or certain size classes of fish from harvest. Regulations may be lake-specific or more general (as in statewide regulations). Typically, physical management techniques have less statewide application because of the expense and manpower involved. The following is a review of management tools which are used to enhance warmwater fisheries and a discussion of their applicability to Connecticut waters.

Physical Management Tools

Stocking

Supplemental Stocking of Resident Predators. Maintenance stocking of fingerling bass or chain pickerel is generally thought to be an ineffective management technique for most waters (Heidinger 1976, Boxrucker 1986). As previously discussed, a “more is better” philosophy frequently backfires with warmwater fish species because growth rates decline as densities of young fish increase. In the southern and western United States, fingerling bass stocking is successfully employed in some large reservoirs where recruitment is extremely limited due to lack of spawning and nursery habitat. Connecticut lake and pond survey data indicate that recruitment of bass and pickerel is generally not limiting in our lakes and ponds, however. In fact, excessive recruitment and subsequent stockpiling of small bass and panfish is a common problem among our warmwater fisheries (see Findings and Conclusions for further discussion). In these cases, stocking more fingerlings would only exacerbate the situation.

Stocking catchable size warmwater fish temporarily improves fishing in direct proportion to the numbers stocked. Unlike trout, however, warmwater fish are extremely expensive to raise to adult size in hatcheries. They do not tolerate crowding, have generally slower and more variable growth rates than domestic hatchery trout, are cannibalistic and usually require live food (e.g., shiners). Moreover, there is always a danger of altering the genetics and, therefore, reducing the survival rates of resident fish populations when hatchery fish are introduced. Therefore, warmwater fish should only be stocked in Connecticut to reestablish populations in waters from which they have been extirpated.

Introduction of New Predators. Introductions of large gamefish such as walleye or northern pike have the potential to create exciting new angling opportunities. Experiments with walleye and pike introductions in Connecticut have been encouraging. Annual fingerling stockings or managed pike spawning marshes have resulted in fishable adult populations of these species in every lake attempted (pike in Bantam L. and Mansfield Hollow Res. and walleye in Gardner L., Rogers L., L. Saltonstall and Squantz P.). Despite their great promise for improving the diversity of angling opportunities in Connecticut, fish such as pike and walleye come with one significant drawback. Due to their specialized spawning requirements, they probably cannot successfully reproduce in most Connecticut lakes and ponds. Thus, they fall under the category of intensive management because fishable populations may only be sustainable through annual fingerling stockings. This may limit the number of lakes in which these fish can be managed due to the time and money involved in buying and/or raising fingerlings.

Continued management of these fish in selected waters can be justified, however, for several reasons. First, pike and walleye are very popular gamefish that can potentially provide high quality angling in Connecticut lakes. Adding new gamefish species also increases the diversity of angling opportunities for Connecticut anglers. Walleye, for example, can provide new open water fisheries in waters with marginal trout habitat. They also can be caught during times of the day (at night) and year (ice fishing) when other species may not be available. Finally, resident predators (bass and pickerel) may be unable to fully control the potpourri of introduced forage and panfish species which occur in many of our lakes. As previously discussed, this is because natural balance between predator and prey populations is less likely among fish species which did not evolve together (i.e. non-native species). It may thus be necessary to introduce additional predators to achieve balance and improve overall angling quality in many of our lakes and ponds.

Introductions of piscivorous predators such as walleye have been effective in altering panfish population structure in neighboring New York State (Mills et al. 1987). It is too soon to know what effect our newly established pike and walleye populations will have on resident fish populations. Thus far, no effects to other gamefish or panfish species have been detected. Assessments of the current pike and walleye projects are scheduled to be completed in 1999 and 2000, respectively. Reports based on this work will include analyses of the most cost-effective methods for establishing these gamefish as well as recommendations for possible expansion to additional lakes and ponds.

Forage Fish Introductions. Although forage fish introductions have occasionally produced desirable results with salmonid fisheries (for example, alewives supporting salmon in the Great Lakes), they are generally ineffective management tools for warmwater fisheries. New forage fish usually have difficulty surviving in environments where every ecological niche is already filled. Also, if new forage fish become established, the effects on warmwater fish populations are often difficult to predict. Bass catch rates actually decreased when threadfin shad were introduced into California reservoirs because the shad competed with young bass for food (Von Geldern and Mitchell 1975). Many popular forage fish species, such as landlocked alewives, are pelagic and are thus underutilized by warmwater predators that tend to stay in shallow water close to shore (Phillips et al. 1987).

The amount of available forage in a warmwater lake or pond is generally governed by the lake's fertility. Due in part to influxes from such sources as farm fertilizers and septic systems, most of Connecticut's lake and ponds are classified as eutrophic or meso-eutrophic which means that they are highly fertile. Thus, quantity of forage is typically not a problem among our State's waters. Forage fish introductions in Connecticut would probably be ineffective in improving warmwater fisheries and should only be used to restore extirpated populations.

Removal of Overabundant Fish

Physical removal of rough fish (e.g., suckers and carp) or small panfish can help to improve bass angling quality in small ponds. Dense panfish populations compete for food with young gamefish such as bass and can inhibit their reproduction (Bennett 1951). In larger lakes, however, it would be highly impractical to remove the numbers of fish necessary to make an impact on angling quality. Parker (1958) reported that it was necessary to remove 10-50% of all sunfish, golden shiners, perch, suckers and rock bass from a pond in order to increase bass densities. Neumann et al. (1994) had to remove 40% of the overabundant small bass (less than 12 inches) from a pond in order to improve bass growth rates and subsequently population structure. To capture this many fish using traditional fisheries gear would require tremendous manpower. Anglers could help by harvesting small panfish and (where legal) small bass, but unfortunately most of the target fish are often too small to be caught by angling.

Habitat Improvement (Artificial Structure)

Artificial structure can be created by submerging a variety of natural or man-made objects.

Such structures provide attachment points for many aquatic organisms as well as cover for game and forage fish. Artificial structure serves to concentrate gamefish (Prince et al.1975) and angler catches can be positively affected (Mitzner 1984). Natural materials such as brush piles and trees have been found to be more effective structure than man-made constructs (tires, fish hab modules, etc.)(Brouha 1974, Mosher 1985, Pierce and Hooper 1979). In a small pond which is devoid of cover, it may be possible to alter the habitat enough to increase the number of gamefish the pond produces. There is no evidence that artificial structure can increase fish productivity in larger lakes and ponds, but that it may only serve to make fish easier for anglers to catch by concentrating them in known areas (Grossman et al. 1997). Barring future evidence to the contrary, there seems to be little merit in this practice for Connecticut's public lakes and ponds.

Water Level Manipulation

Management by lake flooding or drawdown can be an effective warmwater management tool where feasible. Good year classes of largemouth bass can result from the flooding of terrestrial vegetation in the spring and early summer which provides young-of-the-year fish with additional food and cover (Bennett 1971). An experiment with controlled early spring flooding is presently being conducted in Connecticut (Mansfield Hollow Res.) in an attempt to create optimal spawning conditions for northern pike. Lake drawdowns can be beneficial to fisheries by killing overabundant aquatic vegetation which sometimes makes it physically difficult for anglers to catch fish as well as for predators to find forage. Also, late summer drawdowns have resulted in improved bass growth rates because they concentrate predators and forage fish into a smaller area (Bennett 1954, Heman et al. 1969, Benton et al. 1992).

Water level manipulation via control valves in dams is possible in many Connecticut lakes. Because this is a relatively inexpensive process, controlled flooding or drawdown should be considered as a management option for some lakes. There are some potential pitfalls that would preclude drawdown management in most of our public lakes, however. Most importantly, lake shore property owners probably won't want their land flooded in the spring and/or their docks and boat launches to be high and dry in the late summer. Also, it may be impossible to draw down many lakes enough to have noticeable effects on the fish populations. Moreover, the desired effects on fish populations as a result of drawdowns are not always realized (Bennett 1971). Thus, experiments with spring flooding or late summer drawdowns should be made only in Connecticut lakes in which property owners would not be negatively impacted.

The timing of drawdowns is critical to prevent harm to fish populations and to aquatic ecosystems in general. For example, a substantial drawdown during May or June can result in fish recruitment failure because most warmwater fish spawn during those months. A drawdown during this time can leave fish nests and/or nursery habitat "high and dry". Winter drawdowns are a popular request among lake shore residents to prevent ice damage and facilitate dock repair. They can be an effective method of controlling aquatic vegetation, however, winter drawdowns can also harm a lake ecosystem in several ways. In very shallow lakes, winter drawdowns expose fish to possible winterkill which is caused by supercooling of bottom waters and/or oxygen depletion. Winter drawdowns may also result in substantial mortality of juvenile fish due to increased stress from loss of winter habitat (shallow areas of detritus and submerged vegetation). Early spring spawners such as yellow perch and chain pickerel can experience recruitment failure if lakes are drawn down in winter and not refilled before March. Finally, winter drawdowns can have devastating effects on animals such as amphibians and aquatic insects that hibernate in lake bottoms. For these reasons, winter drawdowns should generally be avoided. If determined to be absolutely necessary, winter drawdowns should be conducted on a biannual basis (or less frequently).

Aquatic Weed Control

Aquatic vegetation can have both positive and negative effects on warmwater fisheries. Excessive plant growth can monopolize light and nutrients in a lake and prevent stored energy from ascending the food chain. At high densities, aquatic plants reduce the ability of fish predators to find and capture forage species (Cope et al. 1970, Bailey 1978, Colle and Shireman 1980). This condition often results in overcrowding and stunting of panfish species as well as reduced growth rates of predatory fish (such as bass and pickerel).

Overabundant aquatic plants may also induce winterkill or summerkill in very shallow ponds. In these cases, life supporting oxygen is removed from the water by bacterial decay of plant matter faster than it can be added by photosynthesis. Sport fisheries can be severely impacted because larger fish are often the most sensitive to low oxygen concentrations.

On the positive side, aquatic plants provide habitat for invertebrates and positively affect sportfish densities by increasing production at the lower end of the food chain (Wiley et al. 1984). In addition, vegetation provides escape cover for the young of most warmwater fish species and spawning habitat for many (examples, pickerel, yellow perch, and golden shiners). Research suggests that, up to a certain point, there is a positive relationship between plant standing crop and largemouth bass production. The best bass production was found when 20% (Durocher et al. 1984) to 36% (Wiley et al. 1984) of lake bottom areas were covered by vegetation. Our own lake and pond survey data similarly indicates that largemouth bass are most abundant in Connecticut lakes that have 15-30% vegetative cover (smallmouths, however, prefer lakes with lower plant densities)(Jacobs and O'Donnell 1996).

Based on the above, it is recommended that the abundance of aquatic plants be limited to moderate levels (20-40% of a lake's surface area) when feasible. This will serve to maximize both production and catchability of sportfish. Eradicating submerged vegetation to below the 20% level should be discouraged, however, due to possible negative impacts on fish production. Potential methods of controlling overabundant aquatic vegetation are outlined below.

Drawdowns. As previously discussed, drawdowns may be an effective way of controlling overabundant aquatic plants in some lakes. This practice can have serious drawbacks, however, and thus has limited value as a fish management tool in Connecticut (see discussion under Water Level Manipulation).

Chemical Herbicides. Application of chemical herbicides is a very efficient method of eliminating aquatic plants. We do not recommend their use for larger Connecticut waterbodies, however, for several reasons. Chemical treatment can be indiscriminate relative to aquatic plant species, thus desirable native species are destroyed along with exotic nuisance species. Also, destruction of large areas of aquatic plants results in the quick release of nutrients into the water which can lead to undesirable algal blooms (Boyde 1971). Long-term vegetation control using herbicides requires frequent retreatment and is thus prohibitively expensive as a statewide management method. Chemicals may also adversely impact lake and pond food chains and improper dosages can directly kill fish (e.g., zooplankton and trout are especially sensitive to copper sulphate). Additionally, many chemicals require a temporary ban on recreational use, such as swimming and fishing. This is impractical on lakes and ponds which are open to the public. Most importantly, there may be unidentified environmental or health hazards associated with chemical application. Thus, chemical herbicides should be conservatively recommended only for small private ponds with severe weed growth.

Mechanical Harvesting. Mechanical harvesting of aquatic vegetation is generally effective and should be recommended for lake associations and private land owners. It is an environmentally friendly technique because chemicals are not introduced into a lake. Also, removal of the harvested material prevents the quick release of nutrients into the water caused by decaying plants, thus reducing the possibility of algal blooms. In addition, harvesting allows the greatest control over where and when weeds are removed from a lake. Although this practice should be recommended to individuals or groups with the financial means necessary to undertake such a project, it has limited value as a statewide fisheries management technique. Initial costs of the necessary equipment are great and it is a labor intensive process.

Grass Carp. The grass carp is an exotic fish species native to Asia. It is a relative of the common carp, but is atypical because it feeds entirely on vegetation. Grass carp are fast growing and can weigh up to 40 pounds (Sutton and Vandiver 1986). Various states have recently been experimenting with introducing triploid (sterile) grass carp into lakes as a method of controlling nuisance aquatic plants. In many instances, these fish have been extremely effective in reducing plant abundance (Van Dyke et al. 1984, Maceina et al. 1991, Bettoli et al. 1992). They have the advantage of being a “natural” or biological control and thus do not introduce chemicals into lakes and ponds. Waters need not be treated annually because one stocking can remain effective for as long as the carp survive. Also, sterile grass carp introductions are “reversible” because the fish cannot reproduce. They also offer none of the disadvantages associated with lake drawdowns. Although aquatic plant control via grass carp shows promise, there are several concerns associated with the introduction of this exotic fish species. Among them are: 1) The magnitude of plant control appears to be difficult to control. Low carp stocking levels have resulted in little impact on plants, whereas high carp numbers have completely denuded some lakes (Fowler and Robson 1978, Noble et al. 1986); 2) Grass carp prefer some plant species to others, thus may eliminate desirable native plants instead of unwanted nuisance species (Fowler and Robson 1978, Bain 1993); 3) Removal of too many macrophytic plants can result in undesirable algal blooms, 4) Grass carp might escape and produce undesirable effects in other systems; and 5) Either the grass carp themselves, the removal of too many aquatic plants or the removal of the wrong species of aquatic plants may have negative effects on other fish species and/or lake ecosystems in general (Bain 1993).

It is currently legal (under a permit system) for private land owners in Connecticut to stock triploid grass carp into small ponds, but the effects of these introductions have not been completely assessed. Due to the expense of purchasing fish (10-12" fish can cost over $10 each), grass carp will probably never be a widespread method of controlling aquatic vegetation on a statewide basis. Where funds are available, however, experiments with introductions of triploid grass carp into selected public lakes and ponds may be warranted. If introduced into public lakes, however, careful assessment would be absolutely necessary to evaluate the impacts of grass carp on both aquatic vegetation and resident fish populations.

Regulatory Tools

Closed Seasons

It is a popular belief among many anglers that bass should be protected during the nesting season in order to ensure future recruitment. Very few states, however, have closed seasons for bass or other warmwater fish species. Removing the male bass from a nest usually does result in mortality of the eggs or fry (Kramer and Smith 1962, Philipp et al. 1994). However, the total numbers of young produced annually appears to be more affected by abiotic conditions such as water level fluctuations and temperature changes at the time of spawning than by the number of successful nests. Apparently, survival of young warmwater fish is highly compensatory which means that a high percentage survive whenever fewer are produced. No correlation has ever been established between the number of spawning bass and subsequent number of young produced (Summerfelt 1975, Von Geldern 1971, Kramer and Smith 1962, Mraz and Cooper 1957, Mraz et al. 1961, Saila and Horton 1957, Schneider 1971). In addition, other studies have indicated that closed seasons result in no more young produced than during more liberalized seasons (Bennett 1971, Fox 1975). Closed seasons around spawning time are believed to be justified in geographic areas and with species which appear to be recruitment limited (such as smallmouth bass in many Canadian lakes). In Connecticut lakes and ponds, however, recruitment of warmwater fish species (including smallmouth bass) is more often excessive than inadequate (see Statewide Land and Pond Electrofishing Survey). Thus, a closed season to protect spawning fish does not currently appear necessary in Connecticut.

Annual harvest of warmwater fish might be reduced in Connecticut with a spring closed season because many species are very susceptible to angling then, but more importantly, because most of the angling effort occurs during the spring. It would be unfair to deny anglers their catch during the spring simply because that is when they most like to fish. Thus, a closed season is not recommended in Connecticut.

Creel Limits

It is generally accepted that creel limits have little effect on harvest rates of most warmwater fish species. This is typically because a very small percentage of anglers catch their limits (Redmond 1974). In Lake Saltonstall, for example, where the density of legal size bass was perhaps the highest of any Connecticut public lake, only 1% of the anglers who kept bass caught their limit of 6 fish (Jacobs 1987). Moreover, the most highly skilled anglers in our State (such as bass tournament anglers) tend to release most of the fish that they catch. Panfish creel limits as low as 10 to 15 fish have had no effect on reducing harvest in other states (Colvin 1997, Miko 1997).

Connecticut currently has no creel limit on panfish and 6-fish limits on bass and pickerel in lakes and ponds. Typically, limits as low as 1 or 2 fish would be necessary to significantly reduce harvest of gamefish species such as largemouth bass. This may be warranted in selected lakes where management emphasis is to be put on catch rates of larger fish rather than numbers harvested. It may also be desirable for highly vulnerable populations such as those in newly opened reservoirs (see discussion under Recommendation 5 in the "Recommendations and Action Plan" section). Although higher creel limits (such as the existing 6 per day limit on bass) may not directly reduce harvest of gamefish such as bass, they do serve to reinforce a conservation ethic and should be retained in Connecticut for this purpose.

Alternative Length Limits

Manipulation of fish population structure through lake-specific length limit regulations has proved to be the most cost effective method of managing warmwater gamefish (Anderson 1980b). The earliest length limit applications in Connecticut (early 1900's) were implemented to protect newly introduced bass and allow them to spawn at least once before they could be harvested. Length limit investigations during the 1970's (mostly 12-inch minimum length limits on largemouth bass) were designed to maximize the weight of fish harvested by anglers. Results from these early experiments were quite variable, however. While some researchers claimed that length limits improved yields of both bass and panfish (Saila 1957, Hickman and Congdon 1974, Hoey and Redmond 1974, Ming and McDannold 1975), others reported a rise in bass abundance below legal size (stockpiling) and declines in bass growth due to increased intraspecific competition over available forage (Farabee 1974, Rasmussen and Michaelson 1974). It became apparent that the optimal length limit strategy was lake-specific because bass population growth and possibly natural mortality are density-dependent and that individual lakes vary in their capabilities of producing prey and predator biomass (Eddy and Carlander 1940, Pardue and Hester 1966, Rawstron and Hashagen 1972, Adams et al. 1982, Novinger 1984).

More recent length limit applications have acknowledged the importance of angling quality (i.e. improved catch rates of larger fish and average size of catch) and panfish population control rather than attaining maximum yield (Anderson 1977, 1980b). This new philosophy was adopted because increasing numbers of anglers reported that it was more important to be able to hook and fight "quality size" fish than to catch their creel limit (Clark 1974, Anderson 1984). Moreover, preventing the overharvest of larger predators can result in increased predation on panfish which leads to improved panfish growth rates and a more balanced fishery. This new approach to length limit management involves protecting the larger, quality size fish and takes the form of either higher minimum length limits (for example, a 16-inch minimum on bass) or slot length limits (such as a 12 to 16-inch bass slot limit).

Minimum length limits are typically used when fish recruitment is low to moderate, thus protecting smaller fish until they reach a desirable size. Nationwide, minimum length limits of 15 inches or more have been very successful in improving bass population structure and angler catch rates of quality size (>12 inches) bass (Van Horn et al. 1981, Novinger 1984, Novinger 1987, Ager 1988, Armstrong et al. 1990, Lundquist 1990, Buynak et al. 1991, Mosher 1991). In Connecticut, increasing the minimum length limit from 12 to 15 inches in Moodus Reservoir resulted in a 74% increase in population densities and a 61% increase in angler catch rates of bass larger than 12 inches (Jacobs et al. 1995). In other states, minimum length limits have also successfully been used to improve fishing for various panfish species such as black crappie (Colvin 1991, Webb and Ott 1991).

Slot length limits are usually applied when small bass are overabundant (due to high recruitment) resulting in slow growth rates (Anderson and Weithman 1978, Anderson 1980b, Gablehouse 1980, Eder 1984, Novinger 1984). Slot limits protect fish within a discrete size range to provide quality catch-and-release angling as well as increased predation on panfish. In the case of a 12 to 16 inch slot limit, small (<12 inch) bass as well as the larger (>16 inch) fish may be harvested. Thinning out overabundant small bass can improve growth rates and prevent stockpiling of fish below quality size. Slot length limits have an added appeal in that they can please anglers who wish to take fish to eat as well as those who are more concerned with fighting and releasing quality size fish.

Slot length limits have resulted in dramatic improvements in bass population structure and sometimes growth rates (Eder 1984, Gablehouse 1984, Novinger 1989, Lundquist 1990, Prather 1990, Mosher 1991). Bass growth may not improve when anglers are unwilling to harvest the smaller fish, however (Gablehouse 1984). Under these circumstances, a slot limit performs as if it were a minimum length limit. Slot length limits have been assessed in two Connecticut lakes (Jacobs et al. 1995). In Pickerel Lake, a 12-15 inch slot limit resulted in a 52% increase in the densities of larger bass as well as a 60% improvement in angler catch rates. Bass growth rates also improved in Pickerel Lake, although it may have been for reasons other than the new length limit regulations. A 12-16 inch slot limit was assessed on Lake Saltonstall, a newly-opened water supply reservoir that contained more large (>12 inch) bass than any other Connecticut lake open to fishing. Angler catch rates and densities of large bass remained similar to earlier years (which were under a 12-inch minimum length limit) despite the fact that angler effort doubled since that time.

In the case of a stockpiled bass population, it is important to realize that a slot limit is not necessarily a failure if anglers don’t harvest enough small bass to positively affect growth rates. The slot limit nonetheless increases the **opportunity** for anglers to take fish home to eat because bass under 12 inches are both more abundant and easier to catch than larger fish. Thus, an angler has a greater chance of harvesting a legal limit of bass under a 12 to 16 inch slot limit than under a 12-inch minimum length limit. Moreover, if bass are stockpiled, it makes no sense to retain a 12-inch minimum length limit which protects the small surplus fish but allows anglers to take the quality size fish which are in short supply.

Summary of Key Findings and Conclusions

- ♦ Warmwater fishing, especially for bass, is extremely popular among Connecticut anglers
- ♦ Most Connecticut anglers desire higher quality fishing than they currently experience
- ♦ Bass fishing quality could be improved in many Connecticut waters
- ♦ Most Connecticut anglers are in favor of lake-specific, more conservative regulations on bass
- ♦ Alternative length limit regulations in conjunction with conservative creel limits (1-2 large fish) are the most cost effective way to improve angling quality for bass on a statewide basis
- ♦ Enhancing populations of large predatory gamefish, either through protection of resident gamefish (such as bass) or introduction of new gamefish (such as walleye) can indirectly improve angling for panfish

Goals and Objectives for Future Management

The goals for warmwater management of Connecticut lakes, ponds and major rivers are:

1) To optimize the quality of angling for warmwater fish species. Management objectives will seek to increase the average size of fish caught and the numbers of larger fish available to anglers in selected lakes.

2) To enhance the diversity of warmwater angling opportunities. Diversity of angling opportunities will increase by managing for a greater variety of species (introduction of new gamefish) and by varying management objectives (e.g., managing for large fish in some lakes vs. total numbers of fish in others).

3) To maintain ecosystem integrity in managed waters. We will strive to ensure that our efforts to improve recreational fishing will not compromise environmental integrity within affected waters. Moreover, we will pursue and endorse management actions which enhance and protect aquatic habitat and species diversity.

3.0 Objectives GOALS??????????????? for Bass Management Lakes

The long-term objectives for the Bass Management Lakes are:

Quality Bass Management Lakes -

- Maintain or improve bass population structure such that at least 60% of the catchable bass population exceeds 12 inches in length.
- Double the numbers of bass greater than 12 inches.
- Maintain or improve bass growth rates such that they reach 12 inches in less than 3.6 years for largemouths and 4.4 years for smallmouths (the present State averages).
- Maintain or improve panfish growth rates such that they equal or exceed present State averages.

Trophy Bass Management Lakes (in addition to all of the above) -

- Double the numbers of bass greater than 18 inches.

RECOMMENDATIONS FOR ACTION

Approach

Our approach to management of warmwater fisheries will be one of lake-specific, system-wide management. Under this approach, lakes and ponds will be examined as systems to determine if and where management other than the statewide defaults could result in significant improvements in angling quality. This involves considering factors such as population density, size structure and growth of all fish species present (predators, panfish and forage species). Using this knowledge, we will apply management strategies that have the best potential for overall improvement of angling quality within each individual fishery. Our initial actions will include:

- Applying alternative length and creel limits to selected largemouth and smallmouth bass fisheries.

- Investigating the effects of introducing new predators (walleye and northern pike) to Connecticut lakes.

- Data collection and literature review to investigate several other promising management tools for warmwater systems.

Each of the previously discussed problems/conditions that exist in some Connecticut lakes (see Findings of Statewide Lake and Pond Electrofishing Survey) may be caused or exacerbated by insufficient numbers of larger predators. For this reason, the primary emphasis of our warmwater fisheries management will be that of **predator management** through alternative bass length limits and possible introduction of new predators (gamefish). Predator management involves increasing the size structures and/or densities of gamefish in selected lakes. Increasing the densities of large gamefish directly results in improved fishing for those fish species. Additionally, this approach can also result in beneficial effects on the trophic levels below (the panfish) because gamefish are their primary predators in warmwater lakes and ponds. This is often termed “top-down” or “trophic cascade” management. For example, more protective length limit regulations usually result in increased numbers of larger bass (the primary predators in most lakes). These predators then feed on and reduce the numbers of overabundant small panfish (such as bluegills) which means that there is more food available for the remaining panfish. This can result in increased panfish growth rates and eventually increased numbers of larger panfish in the fishery. Thus, for example, angling quality for both bass and panfish may be improved through manipulation of bass regulations alone.

The initial focus of our warmwater management plan will deal primarily with alternative length and creel limits on largemouth and smallmouth bass because:

- ♦ The two bass species are collectively the State’s most popular warmwater gamefish (1.3 million angler trips/year, USF&WS 1993).

- ♦ Bass are the primary predators in almost all of our lakes and ponds and thus play key roles in maintaining predator/prey balance.

- ♦ The Fisheries Division has been collecting data on bass populations since the early 80's and, therefore, has considerable knowledge of bass population dynamics in Connecticut.

- ♦ Most importantly, experiments with alternative length limits have proven to be successful in improving the quality of bass angling in Connecticut (Jacobs et al. 1995).

Selection of Bass Management Lakes

Sites were selected from among the lakes and ponds sampled during the statewide electrofishing survey (Jacobs and O’Donnell 1996). Length-frequency, growth and mortality data for all important gamefish, panfish and forage fish species were reviewed for each lake by the entire Inland Fisheries field staff (biologists and technicians). The list of lakes that could most benefit from alternative bass management were identified and then compiled by consensus (see Appendix 2.0).

Minimum requirements to be selected as a Bass Management Lake were:

- ♦ Lakes had public access and significant bass fisheries.
- ♦ Lakes were sufficiently sampled by electrofishing (at least two samples demonstrating similar fish population parameters) to determine whether and what management changes were needed.

Additional criteria for Quality Bass Management Lakes were:

- ♦ Lakes had one or more of the four problems/conditions as previously discussed (high bass mortality rates, bass stockpiling, panfish stockpiling and/or surplus forage).
- ♦ Total annual mortality rate for either bass species exceeded 50%.

Trophy Bass Management Lakes were chosen from among those which were predisposed to producing trophy size bass. Criteria were:

- ♦ The fishery was already in a relatively good state of balance (relatively little stockpiling and good growth rates).
- ♦ Bass mortality rates were moderate to low.
- ♦ Forage fish densities were moderate to high.
- ♦ Densities of bass over 18 inches were relatively high (i.e. they have a proven potential for producing large bass).

The list of proposed Bass Management Lakes in Appendix 2.0 does not likely include all Connecticut lakes which might benefit from alternative regulations. Rather, they were those identified by Fisheries staff as "most in need" and/or "most likely to succeed". For example, they were the lakes which exhibited the most severe stockpiling, highest bass mortality rates, etc. If alternative bass regulations prove to be successful in these lakes (and public acceptance is high), other lakes with more moderate problems/conditions may be added in the future. Moreover, other lakes which have not yet been sampled may also be added if the criteria listed above are met.

Proposed Alternative Length and Creel Limits for Bass Management Lakes

Quality Bass Management Lakes

Selected lakes will receive either: 1) a **12 to 16 inch slot length limit and a 6-fish creel limit (only two of which may exceed 16 inches)** if bass recruitment appears to be moderate to excessive (contributing to bass stockpiling and slow growth rates) or 2) a **16 inch minimum length limit and a 2-fish creel limit** if bass recruitment is limited (see Appendix 2.0). Allowing anglers to thin out overabundant small bass in slot length limit lakes should help to improve bass growth rates and reduce stockpiling. Both slot and minimum length limit regulations should result in increased densities of larger predators (bass). Over time, these increased densities of predators should help to reduce the densities of overabundant panfish and small bass resulting in increased growth rates, improved size structures and improved quality of angling for both bass and panfish. Meanwhile, anglers will experience increased catch rates for quality size bass (>12 inches) and, under slot limits, increased opportunities to harvest smaller bass.

Trophy Bass Management Lakes

Selected lakes will receive either: 1) a **12 to 18 inch slot length limit and a 6-fish creel limit (only one of which may exceed 18 inches)** if bass recruitment appears to be moderate to excessive or 2) **an 18 inch minimum length limit and a 1-fish creel limit** if bass recruitment is limited (see Appendix 2.0). These regulations should result in all of the enhancements described for Quality Bass Management Lakes as well as increase the probability that Connecticut anglers may catch truly memorable, trophy sized bass.

KEY RECOMMENDATIONS

Recommendation 1: Implement and assess alternative length and creel limit regulations on largemouth and smallmouth bass in selected lakes.

Justification: Protecting larger bass through special regulations on selected lakes will improve angling quality for both bass and panfish in affected waters and will increase the diversity of fishing opportunities for Connecticut anglers.

Action Required: A total of 28 selected lakes and ponds will receive alternative length and creel limit regulations on largemouth and smallmouth bass (see Appendix 2.0 for list of proposed lakes). Biologically, it would be best to have a unique management strategy for each individual lake. However, to minimize confusion among anglers and bolster compliance, bass management in Connecticut lakes and ponds will be limited to three categories. Those lakes which receive alternative length and creel limit regulations will be termed **"Bass Management Lakes"** of which there will by two categories; **"Quality Bass Management Lakes"** (18 lakes will receive 12-16" slot limits, 4 lakes will receive 16" minimum length limits) and **"Trophy Bass Management Lakes"** (5 lakes will receive 12-18" slot limits, one lake will receive an 18" minimum length limit). The third category will be all other lakes and ponds and will default to the statewide 12-inch minimum length limit and 6-fish creel limit. The new regulations will go into effect on January 1, 2000. An interim assessment of the short-term effects of the regulations will be completed by 2006.

Recommendation 2: Determine the success and effects of introducing new predators to Connecticut lakes and ponds.

Justification: Introduction of new predators such as northern pike and walleye can produce exciting new fisheries and increase the diversity of fishing opportunities for Connecticut anglers. Additionally, bass alone may not be able to adequately control/utilize overabundant forage fish populations in some lakes. This is especially true in cases where bass densities are low due to habitat restrictions or the dominant forage species are not often targeted by bass (e.g., alewives). Gamefish such as pike and walleye may not be able to successfully reproduce in most Connecticut lakes. However, annual fingerling stocking has proved to be a viable and cost-effective method of sustaining populations of these predators in selected lakes.

Action Required: Two experimental projects, the introduction and assessment of northern pike and walleye in selected Connecticut lakes, are scheduled to be completed by the year 2000. Recommendations concerning further introductions of these predators will be made based on the findings of these projects as they relate to the goals of this plan. The feasibility of introducing other large gamefish/predators (such as channel catfish) to Connecticut lakes and ponds will also be investigated via literature search.

OTHER RECOMMENDATIONS

Recommendation 3: Evaluate alternative management measures for chain pickerel.

Justification: Chain pickerel in excess of 20 inches are very common in unfished Connecticut waters, but uncommon in our public lakes. This infers that pickerel size structure and angling quality may be enhanced through alternative management such as more protective length limit regulations. Moreover, control of overabundant panfish numbers may prove difficult using special bass regulations alone. Managing an assortment of predators may be necessary to noticeably impact our often overly prolific sunfish and perch populations. Chain pickerel are logical candidates for this type of management because they presently exist in almost all Connecticut lakes and ponds.

Action Required: Further analysis of lake and pond survey data and literature review. Determine angler attitudes and preferences. Recommendations will be made by 2006.

Recommendation 4: Evaluate alternative management measures for panfish.

Justification: The quality of angling for panfish can also be adversely impacted when fishing pressure is too high (Coble 1988). Indirect management using predators may improve angling for panfish to a point. However, further improvements in panfish population structure may require management alternatives such as minimum length limits (Colvin 1991, Webb and Ott 1991).

Action Required: Further analysis of lake and pond survey data and literature review. Determine angler attitudes and preferences. Recommendations will be made by 2006.

Recommendation 5: Monitor the effects of habitat manipulation or exotic species introductions on warmwater fish populations.

Justification: Both the introduction of exotic species and habitat manipulation, especially that which involves elimination of aquatic plants, can have profound and sometimes unpredictable effects on fish populations. Lake drawdowns and applications of chemical herbicides commonly occur on Connecticut public lakes, often without regard to or assessment of impacts on lake ecosystems. The first experimental stocking of triploid (sterile) grass carp into a large public pond (Ball Pond, 82 acres) occurred in the fall of 1997. The Fisheries Division has sampled Ball Pond by electrofishing several times and thus has "pre-grass carp" background data.

Another topic of concern has been the establishment of the first zebra mussel population in Connecticut (East Twin Lake, first identified in 1998). In other states, zebra mussels have had tremendous impacts on aquatic ecosystems wherever they have become established.

Monitoring these and other alterations to lake habitats is important to determine what impact they may have on Connecticut warmwater fish populations.

Action Required: When resources permit, lakes will be sampled by electrofishing, both before and 2 to 3 years after a major habitat modification or establishment of exotic species occurs. Changes in fish population parameters (species composition, growth, size structure, etc.) will be assessed. Based on this information, determinations will be made on how to mitigate damage to fish communities and/or how some of these practices may be used to enhance Connecticut fish populations.

Recommendation 6: Investigate the potential benefits of stocking bass from unfished reservoirs into public lakes.

Justification: There is evidence that angling selectively removes faster growing, more aggressive and easier to catch fish, thereby potentially altering the gene pool of fish populations in fished lakes (Handford et al. 1977, Ricker 1981, Burkett et al. 1986, Alexander 1987, Garrett 1993, Nuhfer and Alexander 1994). The stockpiling of small bass and sunfish may be exacerbated in our public lakes because angler harvest of fish has selected in favor of slower growing, less efficient predators (Jacobs and O'Donnell 1996). Therefore, it is possible that bass populations in Connecticut's unfished water supply reservoirs are genetically different (faster growing, more aggressive and easier to catch) than those in heavily fished public lakes. If so, there may be merit to experiments with stocking of reservoir bass into selected bass management lakes. This could infuse the gene pools of bass in the public lakes with the superior traits of the reservoir populations. However, much of this subject is theoretical, therefore it is uncertain whether such endeavors could have any detectable impact on angling quality.

Action Required: Recommendations concerning this topic will be made after further monitoring of the literature and discussions with researchers currently working on fish genetics. Recommendations will be made by 2006.

Recommendation 7: Recommend that Connecticut water companies consult with the Fisheries Division prior to opening any reservoir to public fishing.

Justification: Connecticut is one of the few states in which most water supply reservoirs are closed to fishing. In recent years, some of these previously unfished water supply reservoirs have been opened to public fishing. When first opened, these reservoirs afford a unique angling opportunity because of initially high angler catch rates of large fish. However, these "naive" fish populations are extremely vulnerable to angling and can be easily and quickly overfished. Special regulations are usually necessary to preserve the angling quality of these resources.

Action Required: Recommend to all Connecticut water companies that they consult with the Fisheries Division prior to opening any reservoir to public fishing. Any special regulations recommended by the Fisheries Division should be implemented before a reservoir is opened.

Future Monitoring and Assessment

Assessment of Alternative Length and Creel Limit Regulations

An interim assessment of the success of the alternative management regulations will be conducted which will consist of 1) biological sampling of fish populations and 2) determination of public acceptance/approval of the new regulations.

Biological Sampling of Fish Populations

Due to the large number of lakes that will receive alternative length limit regulations, biological sampling will be done at a minimal level such that only significant changes in the fish populations will be discernable. Electrofishing will be the only tool necessary to determine the effects of the new regulations. Jacobs et. al (1995) determined that bass angling and electrofishing catch rates were related (R^2=0.46, p<5%), thus the quality of angling within each lake can be inferred from electrofishing alone. Each lake will be electrofished a minimum of 3 times in 3 different years before regulations are changed. It is necessary to sample each site at least 3 times in different years to determine 1) how much such parameters as fish recruitment and growth rates vary annually within each lake and 2) if these parameters are relatively stable or are changing. Most of the "pre-regulation change" data needed has already been collected during the statewide lake and pond electrofishing survey (Jacobs and O'Donnell 1996). Thus, it will only be necessary to sample each lake one or two additional times before the new regulations are implemented on January 1, 2000.

Based on the results of previous alternative length limit experiments in Connecticut (Jacobs et. al 1995), it should take between 3 and 5 years for bass population structures to respond to the regulation changes. Therefore, initial post-regulation effects will be assessed by electrofishing 3 times, within 3 to 5 years of implementation (2003-05). Although the initial effects (such as changes in bass population structure) should manifest themselves in a relatively short period of time, indirect effects (such as changes in growth rates) of any management changes made to warmwater fisheries may take ten or more years to be realized. This is because 1) bass are relatively long-lived, slow-growing fish; thus populations respond slowly to changes in harvest and 2) any indirect effects on bass or panfish growth rates can only begin to occur **after** the densities of larger bass have significantly increased. The Bass Management Lakes would therefore have to be revisited at some point in the future to determine extent of long-term, indirect effects.

Determination of Public Acceptance/Approval of New Regulations

Unlike some marine fish stocks which have been harvested to the point of collapse (such as Atlantic cod and haddock), survival of bass, or most other warmwater fish species, does not depend on more restrictive regulations. Instead, our proposed regulations will serve to improve the quality of fishing and restore fish populations to a more desirable state of balance. The most important prerequisite to implementing these management changes is to ensure that **this is what the majority of the angling public desires.**

Prior to making regulation changes, public input will be solicited at meetings of organized fishing clubs and through public informational meetings and regulation hearings. Throughout we will continue to inform the public of the potential benefits of the alternative warmwater management strategies through oral presentations and newspaper press releases. Public approval will also be assessed informally based on feedback from typical day-to-day phone conversations. In addition, a proposed statewide general survey of angler attitudes and preferences would provide important feedback from constituents who may not be represented by other methods.

Sampling other lakes and ponds when resources permit.

Not all of Connecticut's important public lakes and ponds were sampled during the statewide lake and pond electrofishing survey. Lake-specific management requires current information on individual waterbodies in order to determine if, and what, alternative management may be needed. Sampling additional lakes will enable us to increase and update the lake and pond survey database and make management recommendations on additional warmwater fisheries.

Additional lakes and ponds will be sampled by electrofishing on an ongoing basis as resources permit. Sites will include those which were insufficiently sampled during the lake and pond electrofishing survey (only once or twice) as well as important lakes and ponds which have never been sampled.

Monitoring popular bass tournament lakes.

The popularity of bass tournament fishing has exploded over the last decade. Moreover, bass tournament pressure is highest on our largest and most important warmwater lakes. Their general recreational importance, and this sudden increase in fishing pressure, justifies that these resources be monitored to ensure continued angling quality. Sampling bass tournaments directly has proven to be an extremely inexpensive way of monitoring population densities and structures of adult bass populations on our larger lakes (Jacobs et al. 1995). Often at larger tournaments, many more legal size bass can be measured by a single person in a few hours (at the weigh-in site) than can be sampled by a full night's electrofishing with a crew of 3 to 5 people.

Important bass tournament lakes will be sampled every two or three years to monitor trends in bass population structure and tournament fishing success. All bass brought to weigh-in will be measured and effort (angler-hrs) recorded by Fisheries personnel. Primary bass tournament lakes to be monitored are Candlewood, Lillinonah, Zoar, Pachaug and the Connecticut River. Secondary sites (those with fewer tournaments) that will be sampled if resources permit are Mansfield, Gardner and East Twin.

Developing New Initiatives

New initiatives in warmwater fisheries management will be developed and implemented based on information obtained from the above actions. Recommendations and modifications to this plan will be proposed as public opinion becomes apparent and new information becomes available. Subjects for future consideration will include:

- ♦ Modifications of regulations on Bass Management Lakes or statewide waters based on prelimary results.
- ♦ Creation of additional Bass Management Lakes based on information collected during biological sampling of other lakes and ponds.
- ♦ Implementation of alternative management strategies for other warmwater fish species (introduced predators, length limits on chain pickerel, etc.).
- ♦ Ongoing sampling and assessment of warmwater lake and pond fisheries.

Implementation Schedule

1999 — Complete sampling (electrofishing) on proposed bass management lakes to acquire pre-regulation change data.
Finish field work on walleye introduction project

2000 — Implement alternative length limit regulations on bass in 28 lakes
Make recommendations concerning expansion of pike and walleye introductions

2000-2003 — Sample important warmwater fisheries as resources permit, including:

- ♦ Waters never sampled by DEP Fisheries
- ♦ Waters in which habitat manipulation or exotic species introductions have occurred or will occur
- ♦ Other important warmwater fisheries as necessary

2003 — Evaluate impact of grass carp introduction into Ball Pond. Make recommendations concerning future use of grass carp as a vegetation control measure.

2003-2005 — Sample each of the bass management lakes 3 times by electrofishing to evaluate short- term effects of alternative length limits

2006 Write report which includes evaluation of and recommendations concerning:

- ♦ Short-term results of bass length limit regulations.
- ♦ Alternative management of chain pickerel and panfish
- ♦ Effects of habitat manipulations and exotic species introductions
- ♦ Stocking reservoir bass into public lakes
- ♦ Effectiveness of special regulations on water supply reservoirs
- ♦ Other modifications as needed

REFERENCES

Adams, S. M., R. B. McLean, and M. M. Huffman. 1982. Structuring of a predator population through temperature-mediated effects on prey. Can. J. of Fish. and Aquat. Sci. 39(8):1175-1184.

Ager L. M. 1988. Effects of an increased size limit for largemouth bass on fish populations in West Point Reservoir. Final Report Dingell-Johnson Proj. F-33. Georgia Dept. Nat. Res. Game and Fish Div. Atlanta, Georgia. 23pp.

Alexander, G. R. 1987. Comparative growth and survival potential of brown trout (*Salmo trutta*) from four wild stocks and one domestic stock. Mich. Acad. 19:109-119.

Anderson, R. O. 1977. Management of small warm water impoundments. Fisheries 1(6):5-7, 26-29.

Anderson, R. O. 1980a. Proportional stock density (PSD) and relative weight (Wr): Interpretive indices for fish populations and communities. pp. 27-35. In: Practical fisheries management: more with less in the 1980's. S. Gloss and B. Shupp (eds.). Proc. 1st Ann. Workshop of the N. Y. Chapter Am. Fish. Soc.

.

Anderson, R. O. 1980b. The role of length limits in ecological management. pp. 41-45. In: Practical fisheries management: more with less in the 1980's. S. Gloss and B. Shupp (eds.). Proc. 1st Ann. Workshop of the N. Y. Chapter Am. Fish. Soc.

Anderson, R. O. 1984. Perspectives on bass length limits and reservoir fishery management. Fisheries 9(4): 6-9.

Anderson, R. O. and A. S. Weithman. 1978. The concept of balance for coolwater fish populations. Am. Fish. Soc. Spec. Publ. 11:371-381.

Armstrong, M. L., S. Henry and C. Hilburn. 1990. Lake Ashbaugh largemouth bass length-limit evaluation. Final Report D-J project F-42-2. Arkansas Game and Fish Commission. Little Rock, Ark. 34pp

Bailey, M.W. 1978. A comparison of fish populations before and after extensive grass carp stocking. Trans. Am. Fish. Soc. 107:181-126.

Bain, M. B. 1993. Assessing impacts of introduced aquatic species: Grass carp in large systems. Environ. Mngt. 17(2):211-224.

Bennett, G. W. 1951. Experimental largemouth bass management in Illinois. Trans. Am. Fish. Soc. 80:231-239.

Bennett, G. W. 1954. The effects of a late-summer drawdown on the fish population of Ridge Lake, Coles County, Illinois. Trans. N. A. Wildl. Conf. 19:259-270.

Bennett, G. W. 1971. Management of Lakes and Ponds. Van Nostrand Reinhold Co. New York. 375p.

Benton J., D. Douglas, and L. Prevatt. 1992. Fisheries studies of the Oklawaha chain of lakes: effects of extreme drawdowns. Final Report Wallop-Brreuz F-30-18. 44pp.

Bettoli, P. W., M. J. Maceina, R. L. Noble and R. K. Betsill. 1992. Piscivory in largemouth bass as a function of aquatic vegetation abundance. N. Am. J. Fish. Mngt. 12:509-516.

Boyde, C. E. 1971. The limnological role of aquatic macrophytes and their relationship to reservoir management. Pages 153-166 in G. E. Hall (ed.). Reservoir fisheries and limnology. Amer. Fish. Soc. Special Pub. No. 8. Bethesda, MD.

Boxrucker, J. 1986. Evaluation of supplemental stocking of largemouth bass as a management tool in small impoundments. N. Am. J. Fish. Mngt. 6:391-396.

Brouha, P. 1974. Evaluation of two reef materials and point or cove locations for construction of artificial reefs in Smith Mountain Lake, Virginia. M.S. Thesis, Virginia Polytechnic Ins. and State Univ., Blacksburg, Virginia.

Burkett, D. P., P. C. Mankin, G. W. Lewis, W. F. Childers and D. P. Philipp. 1986. Hook-and-line vulnerability and multiple recapture of largemouth bass under a minimum total-length limit of 457 mm. N. Am. J. Fish. Mngt. 6:109-112.

Buynak, G. L., L. E. Kornman, A. Surmont and B. Mitchell. 1991. Evaluation of a differential-harvest regulation for black bass in Cave Run Lake, Kentucky. N. Am. J. Fish. Mngt. 11:277-284.

Clady, M. D., D. E. Campbell, and G. P. Cooper. 1975. Effects of trophy angling on unexploited populations of smallmouth bass. pp. 425-429. In: Black Bass Biology and Management. H. Clepper (ed.). Sport Fishing Inst., Washington, D.C. 534p.

Clark, C. W. 1974. Possible effects of schooling on the dynamics of exploited fish populations. J. Cons. int. Explor. Mer. 36(1):7-14.

Coble, D. W. 1988. Effects of angling on bluegill populations: Management implications. N. Am. J. Fish. Mngt. 8(3)277-283.

Colle, D. E. and J. V. Shireman. 1980. Coefficients of condition for largemouth bass, bluegill and redear sunfish in *Hydrilla*-infested lakes. Trans. Am. Fish. Soc. 109:521-531.

Colvin, M. A. 1991. Evaluation of minimum-size limits and reduced daily limits on the crappie population and fisheries in five large Missouri reservoirs. N. Am. J. Fish. Mngt. 11:585-597.

Colvin, M.A. 1997. Crappie Management in Missouri's Large Reservoirs. Contributed paper. Panfish Biology and Management Symposium. Joint Meeting of NY & PA Chapters of the Am. Fish. Soc. Oswego, NY. Jan. 30, 1997.

Cope, O. B., E. M. Woodard, and G. H. Wallen. 1970. Some chronic effects of 2,4-D on the bluegill

(*Lepomis macrochirus*). Trans. Am. Fish. Soc. 99:1-12.

Durocher, P. P., W. C. Provine and J. E. Kraai. 1984. Relationship between abundance of largemouth bass and submerged vegetation in Texas reservoirs. N. Am. J. Fish. Mngt. 1:151-158.

Eder, S. 1984. Effectiveness of an imposed slot length limit of 12.0-14.9 inches on largemouth bass. N. Am. J. Fish. Mngt. 4:469-478.

Eddy, S. and K. D. Carlander. 1940. The effect of environmental factors upon the growth rates of Minnesota fishes. Proc. Minn. Acad. Sci. 8:14-19.

Farabee, G. B. 1974. Effects of a 12-inch length limit on largemouth bass and bluegill populations in two northeast Missouri lakes. pp. 95-99. In: Symposium on Overharvest and Management of Largemouth bass in Small Impoundments. J. Funk (ed.). N. Central Div. Am. Fish. Soc. Spec. Publ. No. 3. 116p.

Fowler, M. C. and T. O. Robson. 1978. The effects of food preferences and stocking rates of grass carp (*Ctenopharyngodon idella* Val.) on mixed plant communities. Aquatic Botany 5:261-276.

Fox, A. C. 1975. Effects on traditional harvest regulations on bass populations and fishing. pp.392-398. In: Black Bass Biology and Management. H. Clepper (ed.). Sport Fishing Inst., Washington D.C. 534p.

Gabelhouse, D. W. 1980. Black bass length limit investigations. Final Rep. Dingell-Johnson Proj. No. F15R. Kansas Fish and Game Comm., Kansas. 83p.

Garrett, G. P. 1993. Heritability of Angling Vulnerability in Largemouth Bass. Final Report Dingell-Johnson Proj. F-31-R-19. Texas Parks and Wildlife Dept. Austin, Texas.

Grossman, G. D., G. P. Jones and W. J. Seaman, Jr. 1997. Do artificial reefs increase regional fish production? A review of existing data. Fisheries. 22(4):17-23.

Handford, P., G. Bell, and T. Reimchen. 1977. A gill-net fishery considered as an experiment in artificial selection. J. Fish. Res. Bd. Can. 34:954-961.

Heidinger, R. C. 1976. Synopsis of biological data on the largemouth bass. *Micropterus salmoides* (Lacepede) 1802. F.A.O. Fish. Synopsis No. 115. Rome. 85p.

Heman, L. M., R. S. Campbell, and L. C. Redmond. 1969. Manipulation of fish populations through reservoir drawdown. Trans. Am. Fish. Soc. 98(2):293-304.

Hickman, G. D. and J. C. Congdon. 1974. Effects of length limits on fish populations of five north Missouri lakes. pp. 84-94. In: Symposium on Overharvest and Management of Largemouth bass in Small Impoundments. J. Funk (ed.). N. Central Div. Am. Fish. Soc. Spec. Publ. No. 3. 116p.

Hoey, J. W. and L. C. Redmond. 1974. Evaluation of opening Binder Lake with a length limit for bass. pp. 100-105. In: Symposium on Overharvest and Management of Largemouth bass in Small Impoundments. J. Funk (ed.). N. Central Div. Am. Fish. Soc. Spec. Publ. No. 3. 116p.

Jacobs, R. P., G. W. Benz and E. E. Beckwith. 1986. Stock assessment of largemouth bass (*Micropterus salmoides*) in selected lakes with special reference to the 305mm minimum size limit. Final Rep. 1985. Federal aid to Sport Fish Rest. F57R1. Conn. Dept. Environ. Protection, Hartford. 84p.

Jacobs, R. P. 1987. Cooperative survey of largemouth bass fishing tournaments & Lake Saltonstall fisheries investigations. Progress Rep. 1987. Dingell-Johnson Proj. F57R5. Conn. Dept. Environ. Protection, Hartford. 69p.

Jacobs, R. P., E. B. O'Donnell and A. P. Petrillo. 1995. Assessment of experimental length limits on largemouth bass and Lake Saltonstall fisheries investigations. Final Rep. 1994. Federal Aid in Sport Fish Rest. F57R. Conn. Dept. Environ. Protection, Hartford. 170pp.

Jacobs, R. P.,and E. B. O'Donnell. 1996. An electrofishing survey of selected Connecticut lakes. Final Rep. 1995. Federal Aid in Sport Fish Rest. F57R. Conn. Dept. Environ. Protection, Hartford. 190pp.

Kramer, R. H. and L. L. Smith, Jr. 1962. Formation of year classes in largemouth bass. Trans. Am. Fish. Soc. 91:29-41.

Lundquist, M. E. 1990. Effects of minimum and slot length limit regulations for largemouth bass and bluegill fisheries in four lakes in Wisconsin. Masters Thesis. Univer. of Wisconsin. Stevens Port, Wi. 197pp.

Maceina, M. J., P. W. Bettoli, W. G. Klussmann, R. K. Betsill and R. L. Noble. 1991. Effect of aquatic macrophyte removal on recruitment and growth of black crappies and white crappies in Lake Conroe, Texas. N. Am. J. Fish. Mngt. 11:556-563.

Miko, D.A. 1997. Angler Preferences and Attitudes Regarding Panfish Harvest Regulations as Measured by On-Site Surveys. Panfish Biology and Management Symposium. Joint Meeting of NY & PA Chapters of the Am. Fish. Soc. Oswego, NY. Jan. 30, 1997.

Mills, E. L., D. M. Green and A. Schiavone. 1987. Use of zooplankton size to assess the community structure of fish populations in freshwater lakes. N. Am. J. Fish. Mngt. 7:369-378.

Ming, A. and W. E. McDannold. 1975. Effects of length limit on an overharvested largemouth bass population. pp. 416-424. In: Black Bass Biology and Management. H. Clepper (ed.). Sport Fishing Inst., Washington, D.C. 534p.

Mitzner, L. 1984. Assessment and development of underwater structure to attract and concentrate fish. Iowa Conservation Commission, Fisheries Section.

Mosher, T. 1985. An evaluation of synthetic fish attractors and brush piles at a small prairie lake. Kansas Fish and Game Comm., Topeka, Kansas.

Mosher, T. D. 1991. A review of black bass length limits in Kansas State fishing lakes 10 years after implementation. Kansas Fish and Wildl. Div. Project FW-9-P-10.

Mraz, D. and E. L. Cooper. 1957. Reproduction of carp, largemouth bass, bluegills and black crappies in small rearing ponds. J. Wildl. Mngt. 21:127-133.

Mraz, D., S. Kimiotek, and L. Frankenberger. 1961. The largemouth bass: it's life history, ecology and management. Wisconsin Conservation Dept., Madison, Wisconsin.

Neumann, R. M., D. Willis, and D. Mann. 1994. Evaluation of largemouth bass slot length limits in two small South Dakota impoundments. Prairie Nat. 26:15-32.

Noble, R. L., P. W. Bertolli and R. J. Betsill. 1986. Considerations for the use of grass carp in large, open systems. Pages 46-48 in G. Redfield, J. F. Taggart and L. M. Moore (eds), Lake and Reservoir Management: VolII. Proceedings of the 5th annual conference and international symposium. N. Am. Lake Mngt. Soc., Washington, DC.

Novinger, G. D. 1984. Observations on the use of size limits for black basses in large impoundments. Fisheries 9:2-6.

Novinger, G. D. 1987. Evaluation of a 15.0-inch minimum length limit on largemouth bass and spotted bass catches at Table Rock Lake, Missouri. N. Am. J. Fish. Mngt. 7:260-272.

Novinger, J. B. 1989. Slot length limit for largemouth bass in small private impoundments. Final Rep. 1988 Dingell-Johnson Proj. F1R37. Missouri Dept. of Conser. Jefferson City, Missouri. 22pp.

Nuhfer, A. J. and G. R. Alexander. 1994. Growth, survival and vulnerability to angling of three wild brook trout strains exposed to different levels of angler exploitation. N. Am. J. Fish. Mngt. 14:423:434.

Parker, R. A. 1958. Some effects of thinning on a population of fishes. Ecology 39:304-317.

Pardue, G. B. and F. E. Hester. 1966. Variation in the growth rate of known-age largemouth bass (*Micropterus salmoides* Lacepede) under experimental conditions. Proc. 20th Ann. Conf. S.E. Assn. Game Comm., 20: 300-310.

Philipp, D. P., C. A. Toline, B. F. Philipp and F. J. S. Phelan. 1994. The impact of pre-season catch-and-release angling on the reproductive success of bass, p. 7-16, In: S. J. Kerr and R. Cholmondeley [ed] Bass Management in Ontario Workshop Proceedings, WP-004, Oct. 3, 1994, Queen's University Biological Station, Ontario.

Phillips, C. L., E. C. Schluntz and J. J. Bender. 1987. Landlocked alewife (*Alosa psuedoharengus*) research and management in Connecticut lakes and ponds. Final Report Dingell-Johnson. Proj. F57R5. Conn. D.E.P., Bureau of Fish., Hartford, CT 21pp.

Pierce, B. E., and G. R. Hooper. 1979. Fish standing crop comparisons of tire and brush fish attractors in Barkley Lake, Kentucky. Procedings of the Annual Conference of the Southeast Ass. of Fish and Wildlife Agencies 33:688-691.

Prather, K. W. 1990. Evaluation of a 12 - 16 inch slot limit on largemouth bass at Elmer Davis Lake. Fisheries Bulletin No. 89. Kentucky Dept Fish and Wildlife. 19pp.

Prince, E. D., R. F. Raleigh, and R. V. Corning. 1975. Artificial reefs and centrarchid bass. pp. 498-505. In: Black Bass Biology and Management. H. Clepper (ed.). Sport Fishing Inst., Washington, D.C. 534p.

Rasmussen, J. L. and S. M. Michaelson. 1974. Attempts to prevent largemouth bass overharvest in three northwest Missouri lakes. pp. 69-83. In: Symposium on Overharvest and Management of Largemouth bass in Small Impoundments. J. Funk (ed.). N. Central Div. Am. Fish. Soc. Spec. Publ. No. 3. 116p

Rawstron, R. R. and K. H. Hashagen. 1972. Mortality and survival rates of tagged largemouth bass (*Micropterus salmoides*) at Merle Collins Reservoir. Calif. Fish and Game 58(3):221-230.

Redmond, L. C. 1974. Prevention of overharvest of largemouth bass in Missouri impoundments. pp. 54-68. In: Symposium on Overharvest and Management of Largemouth bass in Small Impoundments. J. Funk (ed.). N. Central Div. Am. Fish. Soc. Spec. Publ. No. 3. 116p.

Ricker, W. E. 1981. Changes in the average size and average age of Pacific Salmon. Can. J. Fish. Aquat. Sci. 38:1636-1656.

Saila, S. B. 1957. Size limits in largemouth black bass management. Trans. Am. Fish. Soc. 87:229-239.

Saila, S. B., and D. Horton. 1957. Fisheries investigation and management in Rhode Island lakes and ponds. Rhode Island Division of Fish and Wildlife, Providence, Rhode Island.

Schneider, J. C. 1971. Characteristics of a population of warm-water fish in a southern Michigan lake, 1964-1969. Final Rep. Dingell-Johnson Proj. No. F29R. Michigan Dept. of Nat. Res., Michigan. 158p.

Schneider, J. C. 1973. Angling on Mill Lake, Michigan, after a five-year closed season. Mich. Academician, 5:349-355.

Summerfelt, R. C. 1975. Relationships between weather and year-class strength of largemouth bass. pp. 166-174. In: Black Bass Biology and Management. H. Clepper (ed.). Sport Fishing Inst. Washington, D.C. 534p.

Sutton, D. L. and V. V. Vandiver,Jr. 1986. Grass Carp: A fish for biological management of *Hydrill*a and other aquatic weeds in Florida. Bulletin #867. Florida Agricultural Stations, U. of Florida, Gainsville. 10p.

USF&WS. 1993. National survey of fishing, hunting and wildlife-associated recreation. U. S. Fish and Wildlife Service. Government Printing Office. Washington, D.C.

Webb, M. A. and R. A. Ott, Jr. 1991. Effects of length and bag limits on population structure and harvest of white crappies in three Texas reservoirs. N. Am. J. Fish. Mngt. 11:614-622.

Wiley, M. J., R. W. Gorden, S. W. Waite, and T. Powless. 1984. The relationship between aquatic macrophytes and sport fish production in Illinois ponds: a simple model. N. Am. J. Fish. Mngt. 4:111-119.

Van Dyke, J. M., A. J. Leslie, Jr. and L. E. Nall. 1984. The effects of the grass carp on aquatic macrophytes of four Florida lakes. J. of Aqu. Plant Management. 22:87-95.

Van Horn, S. L., W. R. Champman, and F. A. Harris. 1981. Results of a 45-cm (18-in) minimum size regulation on largemouth bass populations. Proc. Ann. Conf. S.E. Assoc. Fish & Wildl. Agencies. 35:424-429.

Von Geldern, C. E., Jr. 1971. Abundance and distribution of fingerling largemouth bass, *Micropterus salmoides*, as determined by electrofishing, at Lake Nacimiento, California. Calif. Fish and Game. 57(4):228-245.

Von Geldern, C., Jr. and D. F. Mitchell. 1975. Largemouth bass and threadfin shad in California. pp. 436-449. In: Black Bass Biology and Management. H. Clepper (ed.). Sport Fishing Inst., Washington, D.C. 534p.

APPENDIX

1.0 APPENDIX

1.1 Life History, Biology and Management of Connecticut Warmwater Fishes

Gamefish

The term gamefish refers to those fishes that typically reach a large size and fight hard when caught on rod and reel. They are aggressive fish with strong swimming capabilities. For these reasons, they are usually the fish most sought after by anglers. For the same reasons, gamefish are also the apex predators in Connecticut lakes and ponds. Apex predators are those fish that prey on smaller animals, but have few natural enemies because of their large size, thus they are at the top of the food web. Apex predators serve an important role in aquatic ecosystems because, through their predation, they control the numbers of smaller fish species. Thus, in most natural systems, a balance is achieved between predators and prey species such that neither becomes so abundant that they overrun their food supply.

Warmwater gamefish in Connecticut can be divided into two groups. The first are the "resident gamefish," which may be native or introduced, but are presently widespread and naturally reproduce in lakes and ponds. The second are the "introduced gamefish" which have been recently introduced and currently exist in only a few Connecticut lakes or ponds.

Resident Gamefish

Largemouth and Smallmouth Bass. Although not native to the State, the largemouth bass is our most widely distributed fish species and can be found in almost all of Connecticut's lakes and ponds. It is also the dominant predator in most of our warmwater fish populations. It can thrive in a wide range of habitats, but prefers lakes in which 20-36% of the total acreage is covered by submerged vegetation (Durocher et al. 1984, Wiley et al. 1984). The smallmouth bass, also an introduced species, is more habitat-limited than the largemouth. It prefers clearer, deeper lakes with less vegetative cover whereas most Connecticut lakes are shallow, eutrophic and weedy. The smallmouth thus occurs in only half of all Connecticut lakes with about 50% of these containing fishable populations.

Both bass species eat a wide variety of food items including fish, crayfish and insects. True to their name, largemouths can utilize larger prey items. Smallmouths are faster swimmers, however, contributing to their effectiveness as predators and their renown as fighters on rod and reel. Bass are generalists in their feeding strategies, sometimes lying near cover and using ambush tactics and sometimes actively foraging for prey. Both bass species spawn between mid-May and June in Connecticut. The males build saucer-shaped nests, usually in shallow water (2 to 8 feet). They then guard the eggs and later the fry for several weeks after spawning. Compared with other lake and pond fish species, bass are slow growing and long-lived. In Connecticut, it takes largemouth bass 3.6 years on average to reach 12 inches, whereas the slower-growing smallmouth bass average 4.4 years to reach the same size. Either species can live for 15 years or more. Bass can commonly grow up to 4 or 5 pounds and 18 to 20 inches in length with maximum size for largemouths being greater than that for smallmouths (State records: 12 lb 15 oz vs. 7 lb 12 oz).

Largemouth and smallmouth bass are collectively the most sought after fish species in most Connecticut lakes and ponds. Creel surveys conducted on three Connecticut lakes that were not stocked with trout found 45 to 60 percent of the anglers fishing for bass. Many bass anglers practice catch-and-release with 50-60% of anglers releasing all of the legal size (>12 inches) fish caught. Competitive catch-and-release bass fishing tournaments are also becoming more popular in Connecticut, with the number of registered events increasing from 124 to 630 over the last decade (1986-96). Statewide regulations on bass in lakes and ponds are a 12-inch minimum length limit and a 6-fish (both species in aggregate) creel limit. There are currently several lakes which have been designated as "Bass Management Areas" and have special bass regulations. They are: Moodus Reservoir (15-inch minimum length limit); Pickerel Lake (12-15 inch slot limit); Lake Chamberlain and the Maltby Lakes (12-16 inch slot limit, only one of which may be over 16 inches) and Lake Saltonstall (12-18 inch slot limit, only one of which may be over 18 inches).

Chain Pickerel. Chain pickerel are present in almost all lakes and ponds in Connecticut. Historically the chain pickerel was probably THE apex predator inhabiting most of Connecticut's lakes and ponds. This is because the pickerel is our only native warmwater species that can reach weights in excess of 5 pounds. They can exist in a variety of habitats, but similar to bass, thrive best in waters with at least some submerged vegetation.

Chain pickerel feed primarily on fish and sometimes crayfish, and like the largemouth, can eat large prey items. Chain pickerel are typically ambush feeders, meaning that they remain motionless most of the time and rely on great bursts of speed to intercept their prey. Consequently, they are usually associated with some kind of structure (vegetation, stumps, etc.). Pickerel spawn in the early spring (usually March - early April in Conn.). Their eggs are deposited over vegetation in very shallow water, thus egg survival is particularly dependent on stable water levels. No parental care is afforded the young. Chain pickerel are relatively fast growing, short-lived fish species. They reach the statewide 15-inch minimum length limit in 2.8 years on average and have a maximum life span of around 8 years. Although pickerel commonly grow to sizes of more than 24 inches and 4 pounds (State record: 7 lb 14 oz) in unfished water supply reservoirs, these sizes are rarely attained in Connecticut waters where fishing occurs.

Chain pickerel are not often targeted by open water anglers in Connecticut, however, many anglers enjoy catching and releasing them. Because pickerel remain active during the winter months, most pickerel are harvested through the ice. Statewide pickerel regulations for lakes and ponds are a 15-inch minimum length limit and a 6-fish creel limit.

Introduced Gamefish

Northern Pike. Northern pike are widely distributed throughout northern portions of Europe, Asia and North America and are the largest predatory freshwater fish in Connecticut. Although not native to the State, a naturally reproducing population has existed in the Connecticut River since the late 1800's. Additionally, pike populations have been established in two lakes (Bantam L. and Mansfield Hollow Res.) through annual stockings of fingerlings that are produced from managed spawning marshes. Similar to their smaller cousin, the chain pickerel, pike prefer lakes with moderate amounts of submerged vegetation which provides protective cover for juveniles as well as ambush and foraging sites for adults.

Adult pike are voracious predators that feed almost exclusively on fish. Because of their size, they can eat much larger food items than most other freshwater predators. Pike spawn just after ice-out in very shallow water, usually over flooded terrestrial vegetation. As with pickerel, the adults do not care for the young. Because successful spawning requires consistent and lengthy spring flooding, natural reproduction of pike in most Connecticut lakes would be extremely limited. As a result, supplemental stocking is typically required to maintain a fishable population. In Connecticut, pike are very fast growing and short-lived, reaching 26 inches by their 3rd year of life with a maximum life span of about 8 years. They commonly reach lengths exceeding 30 inches and weights of 6-10 pounds and can get much larger (State record: 29 lbs).

Pike fishing is very popular in the Connecticut River where the population is well established. Pike were first introduced into Bantam Lake in 1971 and marsh management was intensified in 1987. This fishery is extremely successful, each year yielding many large fish. Stocking at Mansfield Hollow Reservoir began more recently (1992) and the population and fishery there are still expanding. Pike are especially popular with ice anglers because, like pickerel, they are very active in the winter. During the open water period, many pike are caught incidentally by bass anglers. Statewide regulations on northern pike are a 26-inch minimum length limit and a 2-fish creel limit. Special regulations apply in Bantam Lake (36-inch minimum length, 1-fish creel limit during December-February) and the Connecticut River (24-inch minimum length limit).

Walleye. The walleye is a very popular gamefish species throughout much of North America. Although they are not native, a small self-sustaining population does exist within our State boundaries in the northern stretches of the Connecticut River. Additionally, walleye populations are currently being established through annual fingerling stocking in four Connecticut lakes; Gardner Lake, Rogers Lake, Lake Saltonstall and Squantz Pond. Walleyes prefer cooler and larger lakes with low to moderate amounts of submerged vegetation. They can exist in shallow, turbid lakes, but require deep-water sanctuary in high transparency lakes because of their large, extremely light-sensitive eyes.

Adult walleyes will eat almost any species of fish as well as some invertebrates. Their ability to see in low light conditions make them very effective night predators. They are most active just after dusk and just before dawn at which times they actively forage for food. The walleye is both a pelagic and shallow water predator and thus fills a unique predatory niche; one that is particularly valuable in lakes with marginal or limited trout habitat. Most walleyes migrate up sizeable river tributaries in the early spring to spawn. Some populations are also capable of spawning in lakes on clean, wave-washed gravel. Because neither of these habitats is common among Connecticut lakes, supplemental fingerling stocking is required to sustain walleye populations in most of the State's waters. Walleye growth rates in the four Connecticut lakes where they have been introduced are relatively fast with many fish reaching the statewide 15-inch minimum length limit by age 3. Walleyes also have exceptionally low natural mortality rates (<10% of adults die of natural causes annually) and can reach ages of 15 years or more. They can also grow to large sizes with 2 to 6 pound fish being common and weights over 10 pounds occasionally attained (State record: 14 lbs 8 oz).

Fingerling walleyes were first introduced into Connecticut lakes in 1993, thus the walleye populations and fisheries in those waters are still expanding. Successful walleye angling often requires specialized techniques and knowledge. Connecticut anglers are just beginning to be aware of and learn how to use this new resource. Thus, increasing numbers of anglers are catching walleyes in the lakes where they have been established. Walleyes have the added attractiveness of being catchable year-round, both during times of open water as well as through the ice. Statewide regulations for walleye are a 15-inch minimum length limit and a 5-fish creel limit.

Channel Catfish. Channel catfish are not currently managed as gamefish in Connecticut (there is no statewide creel or length limit). They are included in this section because of their ability to reach large size, their popularity as gamefish in other parts of the country, and their potential to be a significant predator in Connecticut lakes and ponds. Channel catfish have been widely introduced throughout Connecticut. They can be found in low numbers in some of our lakes and ponds, however, the only abundant population occurs in the Connecticut River. Channel catfish can thrive in a variety of lake habitats, but throughout their range seem to do best in larger impoundments with significant river tributaries.

Similar to other catfish, channel cats are opportunistic feeders, eating such items as insects, crayfish, snails, clams, worms and fish. They are much more active predators than smaller catfish species such as bullheads, and can be caught on artificial lures as well as on live bait. Spawning takes place in late spring or early summer where a nest is typically built under a log or an undercut bank. The eggs are guarded by both parents with the male continuing to guard the newly hatched young for several weeks. Because they prefer spawning in rivers, supplemental fingerling stocking would be necessary to sustain channel catfish populations in most of the State's lakes and ponds. Channel cats are long-lived, slow growing fish. Specific growth and mortality data is lacking for Connecticut populations. Based on populations in nearby states, however, they probably reach 10 to 12 inches by their third or fourth year and may live as long as 25 years. Channel cats commonly reach sizes of 2 to 6 pounds in Connecticut with the State record being over 23 pounds.

Channel catfish are not as popular among Connecticut anglers as, for example, species such as trout or bass. However, they are extremely popular in other areas of the country (nationally, catfish are the 3rd most sought after fish type) and are renowned for their palatability. Thus, they may be a potentially valuable addition to the diversity of gamefish and predators in selected Connecticut lakes and ponds.

Panfish

The term panfish is applied to almost any fish species that is good to eat and typically will "fit in the pan". These intermediate size fish species play transitional roles in lake and pond food webs. When small, they feed primarily on zooplankton and insects and are themselves important food items for larger predators such as bass and pickerel. As adults, the larger panfish can become significant predators in their own right and thus may help to keep the numbers of often overabundant small fishes in check. Panfish (especially sunfish) are usually much more abundant than gamefish and make up the bulk of the biomass in most warmwater lakes. There is currently no limit to the numbers or sizes of panfish which can be taken in Connecticut.

Larger Panfish

The three larger panfish species (those that can grow to 10 inches or more) that are common among Connecticut's lakes and ponds are black crappie (also white crappie in the Conn. River), yellow perch and white perch. Although their individual spawning habits vary, all are capable of producing extremely high numbers of young when conditions are optimal. Because of their tremendous reproductive potential, populations can easily become stunted when the densities of young fish are too high. The larger panfish species are very important components of Connecticut's warmwater fisheries. According to creel surveys of typical warmwater lakes and ponds, as many as 40 to 50 percent of anglers fish for "anything". For these anglers, it is often one of these large panfish species which they prefer to catch because all three are good to eat, are often abundant and grow large enough to be worth keeping.

Yellow Perch. The native yellow perch is the most common of the three species, being found in 97% of the State's lakes and ponds. They can be found in almost any freshwater habitat, from slow-moving streams and small farm ponds to large reservoirs. In larger lakes, yellow perch are pelagic, forming large schools that seek out deeper, cooler water in the summer. In Connecticut, yellow perch spawn from late March to early April. Their eggs are draped in gelatinous, ribbon-like masses over vegetation in shallow water. The adults do not protect the eggs or newly hatched fry. Yellow perch are omnivorous, feeding on many small animals including crayfish, aquatic insects, mollusks and fish. Growth rates can be extremely variable. Healthy perch populations grow quickly to about 10 inches during their first 4 to 5 years and very slowly thereafter. They can live as long as 13 years and reach sizes up to 16 inches (State record: 2 lb, 13 oz.). Yellow perch are good tasting and very active in the winter. For this reason, they are extremely popular with ice fishermen and are perhaps the State's most commonly caught fish during the winter months.

Black Crappie. The black crappie (or "calico bass") is an introduced member of the sunfish family that is found in 74% of Connecticut lakes. Crappie spend most of their time in shallow water and are usually associated with some kind of structure such as weed beds or sunken trees. Connecticut black crappie spawn in April which is a month earlier than any other members of the sunfish family. As with other sunfish species, the male builds a nest by clearing a small depression in sand or gravel, often in very shallow water (10 to 24 inches). The male protects the eggs and subsequently the fry for a few days until they leave the nest. The black crappie diet is similar to that of the yellow perch. Young crappie eat primarily zooplankton, switching to aquatic insects and finally fish as they grow. Black crappie can grow very quickly, usually reaching 10 inches within 3 to 4 years. They commonly reach 10 to 12 inches in length and can exceed 16 inches (State record: 4 lb). Although they are not particularly strong fighters on rod and reel, crappie are nonetheless popular with anglers because they are easy to catch, reach reasonable size and are good to eat.

White Perch. The white perch is a member of the sea bass family and is native, as an anadromous form, to the coastal fresh and brackish waters of Connecticut. They were later introduced to inland lakes and ponds where land-locked populations developed. Land-locked white perch are currently found in 30% of Connecticut's lakes and ponds. Land-locked white perch are pelagic and seem to do best in larger, deeper lakes. Spawning takes place in the early spring with eggs being broadcast over gravel or vegetation in 2 to 20 feet of water. After spawning, the adults do not protect the eggs or fry. White perch eat a variety of food items, including aquatic insects, small crustaceans and fish. They forage in large schools and usually seek deeper water during the summer. Normally, white perch will reach 10 inches in 4 to 5 years and can reach sizes up to 16 inches and ages exceeding 12 years. Because they are extremely prolific spawners, however, land-locked white perch tend to become overcrowded and subsequently stunted. Their abundance is their main appeal to anglers because large numbers can often be caught in a short time period.

Smaller Panfish (Sunfish)

At least one species of sunfish can be found in all of the State's lakes and ponds. The most common species of sunfish are the bluegill and pumpkinseed (or common sunfish), each occurring in at least 95% of Connecticut lakes. Other species found in Connecticut are the redbreast sunfish (39% of lakes), rock bass (38%) and the relatively rare green sunfish (4%). Despite the sunfishes' collective abundance, only the pumpkinseed and redbreast sunfish are native to the State. Sunfish spend most of their time in shallow water, although habitat preferences vary with species. The bluegill and pumpkinseed seem able to survive almost anywhere, but are usually most abundant in shallower lakes with moderate to dense submerged vegetation. Similar to the smallmouth bass, rock bass prefer clearer lakes with gravel and rock bottoms, whereas redbreast are most abundant in riverine impoundments.

Even as adults, sunfish have relatively small mouths, thus their diet is comprised mostly of smaller food items such as aquatic insects, fish eggs and fish larvae. The rock bass, which has a slightly larger mouth, will also consume small fish and crayfish. All sunfish spawn by building and guarding nests in very shallow water (1-6 feet) between mid-May and July. Bluegills often spawn in very large colonies of 20 to 60 closely packed nests. Because sunfish are often the primary food source for large predators such as bass, they produce vast numbers of young to ensure survival. Sunfish growth rates vary with species. In healthy populations (where numbers of young are not overabundant), most sunfish species can reach 6 inches in 3 to 4 years. Sunfish are overabundant in many lakes. In severe cases this leads to stunting, where maximum size may only be 5 inches which is too small for most anglers to consider worth catching. Bluegill and rock bass are Connecticut's larger sunfish species. When growth is good and fishing pressure light, bluegills can commonly reach 8 to 10 inches and live 10 years. Rock bass will occasionally exceed 12 inches.

Because sunfish are typically many times more numerous than gamefish, they (especially bluegill) are by far the fish type most often caught by anglers in most of Connecticut's lakes and ponds. Their availability, willingness to bite and great numbers make them ideal for anglers who cannot afford a boat or expensive tackle because they can be caught from shore on very simple gear.

Brown Bullhead and American Eel

Brown bullhead and American eel are native species that can be very abundant in Connecticut lakes and ponds, but are not often sought after by anglers (though they can be readily caught and can be delicious if properly prepared). Their abundance in some waters makes it certain that they play significant roles in lake ecosystems. However, they have been much less studied than other more popular sport fishes, thus these roles are poorly understood.

Brown bullheads are present in almost all of Connecticut's lakes and ponds. They seem to prefer lakes with at least moderate amounts of submerged vegetation and are most abundant in shallower ponds where they can become stunted. They are primarily nocturnal feeders which eat a wide variety of foods including insects, crayfish, snails, and fish. Spawning takes place in a small depression or burrow built by the male during late spring or early summer. The eggs are guarded by both parents and the newly hatched fry are then guarded by the male for up to several weeks after hatching. No growth data is available for Connecticut, but based on New York State growth information it is likely that they reach 10 inches in 3 to 5 years. Bullheads commonly reach sizes of 12 to 14 inches in Connecticut with maximum size exceeding 15 inches (State record: 3 pounds).

American eels are found in 68 percent of the State's lakes and ponds, being most common in sites near the shoreline or major river systems. Like bullheads, they are primarily nocturnal and prefer lakes with some kind of cover (vegetation) to hide in during the day. American eels are also opportunistic feeders which will eat almost any animal food items they can find. They are active predators of smaller fish but can also act as scavengers, feeding off the carcases of larger dead fish. It is unclear to what extent eels are preyed upon by other fishes in freshwater lakes and ponds. Eels have a unique and complex life cycle. It is believed that all eels spawn in the same general area of the central North Atlantic known as the Sargasso Sea. Similar to Pacific salmon, the adults die after spawning. After hatching, the larval eels drift northward with the Gulf Stream. Once they reach a developmental stage where they can actively swim (at which time they are called elvers), they migrate inshore and swim up rivers and streams along the Atlantic coastline. The females may migrate far inland and spend most of their adult lives in freshwater lakes and streams. The males usually stay closer to saltwater, in estuaries and coastal streams. When they are sexually mature (males at 4-6 years, females at 7-9 years) they migrate back to the Sargasso Sea to spawn and complete their life cycle. Most eels caught on rod and reel are between 12 and 24 inches with maximum size being more than 3 feet.

Most likely due to their nocturnal nature and physical characteristics, eels and bullheads are both underutilized by anglers in most of our lakes and ponds. Bullheads are armed with three very sharp spines which effectively repel most fish predators (and probably some anglers). Eels produce large quantities of slime that can make them difficult and unpleasant to handle and unhook. In Connecticut, there is no limit to the numbers or sizes of bullheads or eels which may be taken by angling.

Forage Fishes

Forage fishes are those which are not typically targeted by anglers (usually due to their small size), but are nonetheless extremely important to lake and pond fisheries because they are the preferred food sources for many predatory fish species. All Connecticut fish species in this category lack the rigid spines which are used as defense against predation by many fish. They are also generally cylindrical in shape which makes them easy for predatory fish to swallow. They make up for this lack of defense by being extremely prolific spawners and thus ensure their continued existence by sheer strength of numbers. Many forage fish species such as alewives, killifish, and spottail shiners do not usually grow to more than 4 or 5 inches in length. This causes them to remain vulnerable to predation throughout their lives. Golden shiners may reach lengths of 10 inches or more and eventually become invulnerable to all but the largest fish predators. The white sucker, creek chubsucker, and carp are preyed upon only as juveniles because they quickly grow to very large size (over 18 inches).

The most abundant and important forage fish species in Connecticut lakes and ponds are alewives, golden shiners and (in riverine systems) spottail shiners. Alewives are a non-native landlocked form of a normally anadromous species. Thus, instead of spending most of their lives in saltwater and ascending rivers to spawn, they complete their entire life cycle in freshwater lakes. Landlocked alewives can be found in 36% of Connecticut lakes and ponds. They spawn by scattering their eggs over lake bottoms during late May-early June. Alewives feed almost entirely on zooplankton and fish larvae. When they are overabundant, alewives are significant competitors with other fish species because almost all freshwater fishes eat zooplankton during their larval stages. Large size zooplankters, which most larval fish species prefer to eat, are often nearly nonexistent in lakes which contain alewives. Their predation on fish larvae can also be excessive enough to affect other fish species' recruitment (the numbers of fish which survive to adulthood). Alewives swim in large schools and are pelagic in nature. Alewives are an especially good food source for predators because of their high body fat content. Pelagic predators such as trout and walleye will feed heavily on them, whereas they are opportunistically fed upon by predators that stick closer to shore such as bass and pickerel. Alewives are short-lived and rarely survive past age 4. Their growth is extremely density-dependent (dense populations grow more slowly), thus both growth rate and maximum size varies considerably among lakes. On average, alewives reach 5 inches in about 2 years with maximum length seldom exceeding 6 inches.

The native golden shiner is found in almost all Connecticut lakes and ponds and seems to be most numerous in lakes with significant submerged vegetation. They are the preferred food species of resident predators such as bass and pickerel. Thus, predator growth rates are almost always good in waters with dense golden shiner populations. Golden shiners feed primarily on small insects, molluscs, large zooplankters and to some extent algae. They scatter their eggs over submerged vegetation during the late spring to early summer and provide no parental care to their offspring. Golden shiners reach about 7 inches in 3 years on average in Connecticut. Typical maximum size is 10 to 11 inches.

Spottail shiners are found in almost all of Connecticut's larger rivers and riverine impoundments, but are typically absent from lakes with no significant river tributaries. Their diet is similar to that of golden shiners. They spawn in fast moving streams during the spring. In riverine systems, spottail shiners often far outnumber any other fish species present and are an extremely important segment of the forage base. Their maximum size is typically about 5 inches.

All of the above forage fish species are managed as "bait species" in Connecticut with no limit to the sizes or numbers which may be taken by angling during the open season.

1.2 Lake and Pond Ecosystems

Food Chains/Webs

The word ecosystem refers to all of the plants and animals in that system and all of the internal and external forces that affect their survival. In general, all living things in lake or pond ecosystems are either directly or indirectly dependent on each other. The simplest metaphor for describing these relationships is that of the "food chain". At the bottom of the food chain are the primary producers (plants) which can convert sunlight directly into usable energy. Aquatic plants come in the forms of phytoplankton (small to microscopic plants which float in the water column) and macrophytes (larger, multicellular plants). The plants are grazed on by invertebrate animals such as insect larvae, snails, and zooplankters (almost microscopic animals). These small invertebrates are then fed on by small fishes which are in turn preyed upon by larger predatory fishes. Ultimately, all fishes end up as "forage" for decomposers such as bacteria and fungi. Each link in the food chain is also referred to as a trophic level with prey species at lower trophic levels (such as shiners and alewives) being more numerous than predators at the higher levels (such as bass and pickerel). Although the concept is simple, the trophic interactions which occur among lake and pond organisms are usually quite complex. For example, their are generally many "microhabitats" (littoral, pelagic, benthic, etc.) within individual lakes which are often occupied by different ages and types of plants and animals. The food chain within lake and pond systems is thus more accurately described as a food web with each species interacting with an array of other species, but with all ultimately being connected by this "web" of interdependency.

The Concept of Balance in Lake and Pond Fisheries

Every successful species of plant or animal has evolved strategies to optimize survival. Predatory species, such as bass and pickerel have evolved to become efficient predators. They are larger and faster than the species they prey on and have developed unique physical and behavioral characteristics (such as the pickerel's teeth and ambush behavior) which assure that they can acquire more energy through the food they capture than they expend to capture it. In response, prey species have evolved structures (such as spines) and behaviors (such as hiding in heavy cover) to help avoid capture by predators. All Connecticut warmwater fish species, including the predators such as bass and pickerel, can fall prey to larger fishes when they are young. For this reason, an almost universal survival technique among fish species is to produce many more young than would be needed to sustain their populations if no predators existed. Thus, a "balance" has evolved between predators and prey. A fishery which is in a desirable state of balance (and in which angling quality is optimal) is one which has enough forage fish to sustain a fishable population of large gamefish and enough large gamefish to prevent forage fish from becoming overabundant. Conversely, a fishery which lacks desirable balance (or is "imbalanced") has few large predators, high densities of smaller fish and consequently poor quality fishing.

Density-Dependent Growth in Fishes

Lakes and ponds are inherently unstable environments. Changes in weather and seasons can cause drastic fluctuations in water level, temperature and chemistry. Because of this, such things as fish spawning success can be extremely variable. In response to uncertain external conditions, fish have evolved internal mechanisms to help regulate their populations. One such mechanism is density-dependent growth. When fish densities are low and available food levels high, fish will capitalize by growing very rapidly. When fish (and many other cold-blooded animals) become overabundant, they respond by growing more slowly. This circumvents the danger that they could deplete their food supply which could lead to starvation and ultimate population collapse. Among lakes sampled during the statewide lake and pond electrofishing survey (Jacobs and O'Donnell 1996), significant linear relationships ($p<0.05$) between growth and density were found for most of the common warmwater fish species including largemouth bass, chain pickerel, black crappie, white perch, bluegill, pumpkinseed, golden shiners and alewives.

When warmwater fisheries become imbalanced, density-dependent growth often aggravates the situation. For example, a decline in numbers of large bass due to harvest by anglers often results in an increase in numbers of forage fish which includes small panfish as well as young bass. High densities of small fish then cause growth rates to decline. It thus takes much longer for both the panfish and the bass to achieve sizes that would be of interest to anglers. The end product is a condition called "stockpiling" which is a fishery with poor angling quality due to an overabundance of small, slow-growing fish and few large ones. The most extreme situation occurs when overcrowding is so high that fish become stunted. In these cases, fish grow so slowly that they never reach sizes desired by anglers. Stunting is more common among panfish species in small ponds and is usually caused by high fish abundance in combination with a limited food supply.

Causes of Imbalance in Warmwater Fish Populations

Many factors may contribute to imbalance in warmwater fish populations. Most, however, fall under one of three major categories; habitat, species composition or harvest by anglers.

Habitat. In the absence of man's influence, larger lake systems naturally tend toward balance, with large predators being relatively common and fish growth rates optimal. Systems which have marginal habitat (such as very small ponds), are nutrient poor (as are many small streams) or are inordinately unstable (e.g., very shallow ponds) may not be physically able to support large predators. Desirable balance may thus be unattainable in many of these types of habitat-limited systems. Even in some larger lakes and ponds, habitat idiosyncracies may influence balance in fish communities. Excessive fish recruitment can occur in lakes that have unusually large areas of ideal spawning or nursery habitat. For example, sunfish prefer to spawn on sandy bottoms in shallow water, thus lakes with large sandy shoal areas may provide so much sunfish spawning habitat that the population easily becomes overabundant. Conversely, fish recruitment may be limited where spawning habitat is lacking. Differing amounts of nursery habitat can also greatly contribute to recruitment levels in individual lakes. Nursery habitats are areas where young fish can find food as well as hide from predators. For many warmwater fish species, this is shallow water in or near some kind of cover (such as rocks or weedbeds). Lakes that are weed-choked, however, often provide young fish too much protection from predators. In this situation, predator growth rates may suffer because they can't forage effectively and juvenile fish growth also suffers due to their own overabundance. Survival of adult fish is usually not as habitat-limited as that of juveniles. However, most adult fish do have habitat preferences, thus the amount of ideal available habitat may also influence their densities to some extent.

Species composition. As recently as 15,000 years ago, Connecticut was completely covered by glacial ice. Primarily for this reason, our State has relatively few native freshwater fish species. Native fish communities in larger lake systems tend to be naturally balanced (high densities of large predators, generally good growth rates for all fish species) because resident species have evolved to co-exist over a very long period of time. Most of our dominant lake and pond fish species have been introduced, however. Thus, fish populations may tend toward imbalance in some lakes because the fish species did not evolve together (at least not in that particular combination or environment). Some of our introduced species (such as largemouth bass and bluegill) seem to be well adapted to Connecticut waters. Others (such as landlocked white perch and alewives) have been "too successful" and often become overabundant due to their prolific reproductive strategies and resident predators' inability to control their numbers. The result among landlocked white perch populations is that they often become stunted. Dense alewife populations influence fish community balance because they severely reduce zooplankton densities which the larvae of most warmwater fish species depend on for survival.

Angler Harvest. Angler harvest is probably the major cause of imbalance in most warmwater fish communities. A comparison of fish populations from Connecticut's public lakes to those in its unfished water supply reservoirs provides an excellent illustration of the effects that angling can have on fish community balance. Most of the State's water supply reservoirs are closed to angling. Barring other factors, their fish populations should, therefore, be in a "natural" state of balance. Indeed, they prove to be excellently balanced from an angling quality standpoint. Most water supply reservoirs sampled during the statewide lake and pond survey (Jacobs and O'Donnell 1996) contained high densities of large, fast-growing fish. Conversely, the same reservoirs typically had much lower densities of small fish than most of the State's public lakes. It is likely that high densities of large fish in the unfished reservoirs help to keep the numbers of small fish in check, thus optimizing growth rates and causing the desirable balanced conditions.

Angling tends to selectively remove larger fish because very small fish are not normally caught by anglers and if caught, are seldom kept. Selective removal of larger predatory fish by anglers can cause increases in numbers of small panfish. As previously discussed, greater numbers of small fish competing for a limited food supply can result in reduced growth rates. The heavier the angler harvest rate, the more unbalanced a fishery tends to become. The end result of excessive angler harvest is a poor quality fishery with few large gamefish and often too many small, slow-growing panfish.

2.0. List of Proposed Bass Management Lakes. Alternative length limits on largemouth and smallmouth bass to be implemented on Jan. 1, 1999. Harvest rate (u%) is the estimated percent of the population which is removed annually by angling (u% calculated as (F x A / Z) x 100, assuming M = 0.2, Ricker 1975).

Lake	Harvest Rate (u%) LMBass	SMBass	Bass Stockpiling	Panfish Stockpiling	Surplus Forage	
Quality Bass Management Lakes - 12-16 inch slot limit						
Bashan L.	27	52	Moderate	No	No	
Billings L.	32		Moderate	Moderate	Moderate	
Black P. (Meriden)		>33	Moderate	No	High	
Bolton L., Mid.	61	>50	Severe	Moderate	No	
*Chamberlain L.		39		No	No	Moderate
Colebrook Res.		>33	Moderate	Moderate	High	
Coventry L.	42	61	Severe	No	No	
Halls P.	44		Severe	Severe	No	
Hayward L.	46		Severe	Moderate	No	
Kenosia L.	>33		Severe	No	Moderate	
Lillinonah L.	21	45	No	No	Moderate	
*Maltby Lakes	?		No	No	Moderate	
Mamanasco L.	38		Severe	Moderate	Moderate	
Mansfield Hollow Res.	33		Moderate	No	High	
Mashapaug L.	?	35	Moderate	Moderate	No	
Pickerel L.	29		Severe	Severe	No	
West Side P.	35		Severe	Severe	High	
Wononscopomuc L.	29		Severe	Severe	No	
Quality Bass Management Lakes - 16 inch minimum length limit						
Highland L.	22	50	No	Severe	High	
Housatonic L.	?	>33	No	No	High	
Quinebaug L.	31	49	No	No	No	
Wyassup L.	>33	24	No	Moderate	Moderate	
Trophy Bass Management Lakes - 12-18 inch slot limit						
Amos L.	5		No	Moderate	High	
Moodus Res.	35		No	No	High	
Mudge P.	41		Moderate	Severe	Moderate	
Pachaug P.	21		No	No	Moderate	
Pataganset L.	16		No	No	Moderate	
Trophy Bass Management Lakes - 18 inch minimum length limit						
*Saltonstall L.	?		No	No	Moderate	

* Water supply reservoirs - special regulations already in place.
? Sample size too small or year-class strength too variable to calculate.
> Too few older fish to calculate precisely.