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THE BIOLOGICAL AND SOCIAL IMPACTS OF BASS TOURNAMENTS

LITERATURE REVIEW AND DISCUSSION

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BASS TOURNAMENTS

INTRODUCTION

There is a growing public concern over impacts of tournament bass fishing on the fishery resource. In an effort to investigate potential social and biological impacts we conducted a literature review of bass fishing tournaments throughout the nation. This brief paper summarizes this information.

METHODS

A review of bass tournament literature was conducted by the Montana State Library system at the request of MDFWP Region One fishery division. The literature search located approximately 30 articles, reports and studies. Eleven pertinent articles were selected for this discussion.

PROBLEMS AND ISSUES

1. Concern by the public over fish mortality and biological impacts associated with tournaments.

2. Friction between tournament and non-tournament anglers.

3. Demand on time and personnel of state agencies to assist tournaments.

4. Poor information exchange between tournament sponsors and state fishery agency.

DISCUSSION

Problem & Issue (1)

Survival of angler caught fish is highly variable but depends largely on temperature. Tournament-related mortalities range from 4-49 percent averaging approximately 10 percent. In northwestern states some authors suggest that 70° F. is the maximum temperature desirable for catch and release tournaments. Situations exist where bass may be caught during cool morning temperatures and held until midday when temperatures become excessive. Tournaments conducted during July and August will result in the highest mortality of released fish.

A concern continues to exist involving the removal of the adults from the nest which will cause high mortality of eggs or fry due to suffocation and predation. Numerous studies have shown that heavily fished lakes do not experience weak or missing year classes as a result of heavy fishing pressure during spawning. In northern latitudes weak year classes already exist due to variable survival from fluctuating climatic conditions and additional loss from tournaments may contribute to mortality.

Overharvest of bass from tournaments was a concern when catch and release was not practiced. A national inquiry from 46 tournaments revealed the each tournament harvested an average of 0.053 pounds of bass per acre, which is roughly 1 percent of the mean yearly bass harvest for waters examined.

Problems and Issue (2)

Conflict between tournament and non-tournament anglers continues to be an issue. The general public felt that tournament anglers did not respect non-tournament anglers fishing particular spots. They also felt that boats racing to particular areas was dangerous and offensive to other anglers. The public also felt that campsites, boat ramps, and docks, were at times dominated by cliquish groups of tournament anglers.

Problem and Issue (3)

State agency personnel (DFWP) will not tag fish for tournaments in Montana. Data collection by DFWP personnel will be at their discretion depending upon needs. Minimally, we would like fish length and weight, and the number of daily fishing hours per fisherman and the total number of fish caught.

Problem and Issue (4)

Participant preoccupation with fishing, winners, and winning, overshadows the obligation some sponsors feel toward the resource. This jeopardizes the accuracy of possible data collection; may negatively impact the fishery and create a poor image.

RECOMMENDATIONS

A. Max prize money @ 15,000. Will reduce attraction to out-of-state anglers and reduce overall pressure and avoid climate of intense competition where social problems are most severe.

B. Limit participation per tournament based on host water size.

Size (acres)	Max. Number of Contestants
300 or less	25
301 - 3,000	50
3,001 - 6,000	100
6,001 - 10,000	150
> 10,000	200

Based on premise that angler conflicts were not obvious at past use levels and some increase could be acceptable without problems.

Also limit contests to maximum of three days and limit the number on each water per year.

C. Reduction of Fish Mortality

Tournaments should ideally be scheduled to avoid extremes of water temperature. In northwest Montana, these consistently occur during August.

The use of total length measurements, verification by the other angler, and immediate release is the most favorable method to reduce bass mortality.

It may be desirable to use a combination of measure-release and weigh-in. In this case, each angler may keep the largest one or two bass caught in a livewell for weigh-in and measure and release all other bass. The total weight is equal to converted lengths of released fish plus the weighed-in fish.

Livewells provide a temporary holding facility for weigh-in tournaments. A central weigh-in facility would ideally be roving on the water and would effectively reduce transport and holding time and disperse released fish. Boat operation also has potential to severely stress livewell fish. A live-release policy should also be in effect enforced by a dead fish penalty.

A central weigh-in is the least desirable method for tournament scoring. If they must be used they must have an adequate holding facility either in the lake or in an aerated, tempered, holding tank that meets capacity recommendations (1 gallon water/1 pound fish). The fish release site must be adjacent to good quality water with depths exceeding twenty feet. Release sites must also be located away from busy public use areas.

The majority of tournament-caught bass that die are a result of stress from angler negligence and inadequate livewell systems. Proper livewells should measure at least 18" long, 12" deep, and 12" wide and be fitted with aerators and fresh water pumps. A mandatory inspection should be held before each tournament for qualification. Livewell additives are recommended by many, however, chemicals within these additives are not approved by the USFDA for use on food fish. Therefore, the use of salt is recommended which stimulates mucus secretion. Sea salt is preferred, but rock salt or uniodized table salt is effective. Salt is added to a holding tank or livewells at a rate of 0.5% (0.7 ounces of salt/gallon water).

The confinement time of fish in livewells should be minimized to prevent stress. Total livewell capacity should be at least 1 gallon of water for 2 pounds of fish. Studies also concluded that levels of dissolved oxygen in livewells reached critical levels when pumps were not operated continuously.

Livewell temperatures should optimally equal the natural lake temperature. During warm summer days, uninsulated tanks tend to warm rapidly and ice may be required to match temperatures.

Another strategy used to minimize stress in livewells is a reduced limit. Northwestern Montana possession limits generally allow 5 bass daily.

SUMMARY

The following is a list of prioritized tournament recommendations.

1. Minimize tournament participation to recommended levels to reduce impacts.

2. Use all means possible to reduce fish stress and mortality.

    A. Schedule tournaments to avoid temperature extremes.

    B. Immediate release tournaments.

    C. Dead fish penalties.

    D. Requirement of aerated, circulating livewells with capacity of 1 gallon of water/2 pounds of fish (minimum size of 18" x 12" x 12"). Suggest using sea salt in live wells at concentration of 0.7 ounces/gallon.

    E. Rank scores by length for small fish and weight for 2 largest fish.

F. Maintain roving weigh-in facility with immediate release.

G. Provide adequate central weigh-in facility.

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EFFECTS OF POTENTIAL INTRODUCTIONS OF SMALLMOUTH BASS (*MICROPTERUS DOLOMIEUI*) INTO WATERS OF THE CLARK FORK, FLATHEAD, AND KOOTENAI DRAINAGES OF WESTERN MONTANA

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INTRODUCTION

The smallmouth bass *Micropterus dolomieui* was originally restricted to fresh waters of eastern central North America. The original range was limited to the Great Lakes-St. Lawrence system and the systems of the Ohio, Tennessee, and upper Mississippi rivers (Scott and Crossman 1973). The species has been widely introduced and self-sustaining populations established across the continental United States and Canada, and in Hawaii, Asia, and Africa (Coble 1975). Introductions of smallmouths have also been made into South America and Europe (Robbins and MacCrimmon 1974).

Introductions into the far-western United States were first made by the U.S. Fish Commission into California in 1874 (Lampman 1946). Introductions into the Northwest, however, were made considerably later around the 1920's. State game protectors made extensive introductions in Oregon in 1921 to 1925. Robbins and MacCrimmon (1974) reported that according to fish stocking records introductions of smallmouth bass were made into Church, Emmert, and Horseshoe lakes in Montana in 1913 by the U.S. Bureau of Fisheries. An estimated 15,800 fish were stocked at this time. They also reported self-sustaining populations were found in Helena Valley Reservoir and the Tongue River in southeastern Montana although these probably died-out. Bass stocks throughout the Northwest generally received light fishing pressure before World War II (Henderson and Foster 1956). Early fishing pressure on smallmouth came from immigrants from eastern and midwestern areas who were familiar with the species.

Overview of life History

Smallmouth bass are generally a long-lived species. Individuals to 15 years old have been reported (Scott and Crossman 1973). Fish older than 7 years are uncommon for midwestern waters (Robbins and MacCrimmon 1974) although older smallmouths are common in the Pacific Nothwest. In the Snake River, Washington, Bennett et al. (1983) reported 13 year old smallmouth bass, whereas Keating (1970) collected smallmouth that were 8 and 9 years old in the Snake and Clearwater rivers, Idaho. Sexual maturity is attained at age 2 in the south to age 6 in the north (Edwards et al. 1983). Fish in the 7-20 inch range are common and the largest recorded smallmouth bass was 12 lb and 27 inches long from Kentucky.

Smallmouth spawn in nests constructed by males at depths from 1-21 ft on clean stone, rock or gravel substrate in streams, rivers, ponds, lakes and reservoirs (Robbins and MacCrimmon 1974). Location of nests is usually in areas of slow current or current protected areas. Timing of spawning varies from mid-April to July but is closely linked with water temperature. Most spawning activity has been reported to occur at temperatures above 59°F. Embryos develop successfully at water temperatures from 55-77°F (Coble 1975; Graham and Orth 1986) and incubate in 4 days at 59-65°F (Turner and MacCrimmon 1970). Postlarval fish require about 8-11 days after hatching to swim-up from the nest.

First year growth is highly variable ranging from an average of 2.8-6.9 inches (Carlander 1977). First year growth in the northern part of the range is probably the most critical in determining year class strength (Shuter et al. 1980). Juveniles less than 2 inches (50 mm) generally do not have the energy reserve to survive the winter and survival increases with increasing body size. Later spawning and/or lower water temperatures during the growing season contribute to smaller body size which results in higher mortality and a weaker year class. Preferred water temperatures range from 70-80°F (Robbins and MacCrimmon 1974). Activity is closely linked to water temperature and at temperatures below 50°F, smallmouth bass become lethargic and locate spaces between boulders, hollow logs and other suitable crevices for over-wintering. Munther (1967) reported that most young-of-the-year (YOY) fish went beneath the rock substrate when temperatures were lowered below 44-46°F in a controlled stream environment.

Food of young smallmouth bass is typically zooplankton, followed by insects, fish and crayfish. Reviews by Scott and Crossman (1973) and Coble (1975) document the importance of the large food items such as fish and crayfish throughout the range of smallmouth bass. Fedoruk (1966) found that crayfish were found in approximately 68% of the bass stomachs examined from Falcon Lake, Manitoba; insects were found in comparable abundance but comprised considerable less bulk than crayfish. Keating (1970) reported that crayfish comprised 86% of the total weight of food items in bass from the flowing portions of the Snake River. Bennett et al. (1983) indicated that fish and crayfish were dominant food items in smallmouth from Little Goose Reservoir on the lower Snake River. Dunsmoor (1990), however, reported that zooplankton were extremely important in the diet of smallmouth bass in Brownlee Reservoir, on the Snake River, Idaho. Fish and crayfish abundance was reduced in smallmouth longer than 8 inches; these larger fish were intensively feeding on zooplankton which apparently did not adversely affect growth rates.

Temperature and turbidity are important limiting factors for extending the range of smallmouth bass. Water temperature is the single most important ecological factor limiting world distribution (Robbins and MacCrimmon (1974). Also, turbidity has been important in limiting the establishment of introduced populations of smallmouths in many areas of the Rocky Mountains where turbidity levels are too high. The significance of turbidity has been seen in Lake Erie where smallmouths have decreased their depth of spawning probably as a result of increased turbidity.

The purpose of this study was to examine published and unpublished literature to assess the potential to introduce smallmouth bass into Montana waters, west of the Continental Divide.

OBJECTIVES

1. Characterization of smallmouth bass fisheries at similar latitudes and climatic conditions to those found in northwestern Montana including (but not limited to):
   a. Mean annual and range of catch rates,
   b. Sport fishing yields,
   c. Seasonal factors affecting sport fisheries,
   d. Overall life history characteristics (effects of temperature on spawning and embryo survival; habitat preference; pioneering tendencies; limiting factors for population viability; age and growth; forage preferences and limitations),
   e. Special management problems with smallmouth fisheries;

2. Review of impacts and success of new smallmouth introductions including interspecific interactions between smallmouth bass, largemouth bass, northern pike, trout, kokanee salmon, and forage fishes;

3. Assess potential impacts of introductions of smallmouth bass into new waters within their existing range and into waters beyond their range in northwestern Montana (Clark Fork, Flathead, and Kootenai drainages).

Characterization of smallmouth bass fisheries at similar latitudes and climatic conditions to those found in northwestern Montana.

Mean Annual and Range of Catch Rates

Catch rates for most smallmouth bass populations are generally lower than for other sport fishes and vary between riverine and standing waters. Mraz (1960) reported catch rates from 0.002-0.02 smallmouth/hour for Lake Geneva, Wisconsin. Seasonal catch rates were 0.013 and 0.008 fish/hour for 1958 and 1959. Highest catch rates were in July and August. Bandolin (1973) reported catch rates for South Branch Lake, Maine to range from 0.06-0.32 smallmouth/hour. Seasonal average catch rates were 0.12 in 1971 and 0.30 fish/hour in 1972. These catch rates are high relative to those for smallmouths from Michigan waters. Ryckman and Lockwood (1985) reported that catch rates in lakes throughout the state of Michigan ranged from 0.001-0.0687 smallmouths/hour for approximately 25 lakes. Wagner (1968) conducted creel surveys on Little Bay de Noc in Lake Michigan and found a catch/hour of smallmouth of 0.02. In Brownlee Reservoir, Idaho, smallmouth harvest (smallmouth that were removed by fishermen) rates for the 1983 and 1984 fishing seasons were 0.28 and 0.27 fish/hour, respectively (Rohrer 1984). In Dworshak Reservoir, an oligotrophic system on the North Fork of the Clearwater River, Idaho, Statler (1988) reported harvest rates of 0.003 and catch rates of 0.02. In California, Von Geldern (1972) found an average catch rate of 0.061 smallmouth/hour in Folsom Lake, on the east side in the Central Valley in 1962. He also reported catch rates for "bass" (largemouth and smallmouth) varied considerably among anglers ranging from 0.18 for "efficient" anglers to 0.06 for the remaining groups. In Lake Sakakawea, Missouri River, North Dakota, Owen and Power (1989) reported an overall average catch rate for boat anglers of 0.013 smallmouth/hour. Catch rates ranged from 0.001-0.0129 smallmouth/hour from the mid to lower Lake Sakakawea.

Catch rates in streams and rivers appear to be higher or similar to catch rates in lakes throughout the range of smallmouths. In Courtois Creek, Missouri, catch rates for smallmouth bass ranged from 0.07-0.12 fish/hour over a 10 year period (Fleener 1975). In Oregon, Daily et al. (1990) reported catch rates for the Umpqua and South Umpqua rivers to be 0.8 and 1.2 bass/hour. However, a large proportion of these fish were returned and harvest rates were about 0.4 bass/hour on both systems. In Michigan, Ryckman and Lockwood (1985) reported catch rates for smallmouth bass ranged from 0.0021-0.0062 for two locations of the Detroit River.

Sport Fishery Yields

Bandolin (1973) examined the smallmouth bass fishery in South Branch Lake, Maine; based on data presented the yield was estimated as 0.03-0.06 lb/acre. Mraz (1960) estimated a yield of 0.1 lb/acre for Lake Geneva, in southeastern Wisconsin. Sports fisheries in both lakes for all fishes were considerably better, averaging about 1 fish/hour. In Courtois Creek, Missouri, smallmouth bass harvest was relatively stable over a 10 year period with an average of 8.7 lb/acre (Fleener 1975). Von Geldern (1972) reported yields of all game fish to be 3.2-6.7 lb/acre for three California reservoirs; catch composition was given as 37% "bass" for one reservoir (total=4.8 lb/acre) to 12% smallmouth bass. Based on this a preliminary estimate of smallmouth yields would be 0.4-0.9 lb/acre.

Seasonal Factors Affecting the Fishery

Smallmouth bass exhibit reduced activity as temperatures decline below 50°F and as light conditions decrease. Coutant (1975) indicated that catch-per-unit-of-effort (CPUE) rose sharply above 55°F. Mraz (1960) compared catches of smallmouth bass throughout the fishing season. He stated that catch rates of smallmouth bass in Lake Geneva, Wisconsin, were low prior to the spawning season and then generally high as a result of an increase in feeding activity as well as spawning activity. From May 1 to June 25, 1958 and 1959, following spawning, 35-44% of the total catch occurred compared to 14.4-25.6% during the spawning season. In South Branch Lake, Maine, the heaviest fishing pressure in June coincided with the highest bass catch per hour (Bandolin 1973). Rohrer (1984) reported that the catch rates in Brownlee Reservoir, Idaho, were highest during June and lowest during August and September. The bass fishery in Brownlee improved during October and catch rates were similar to those during June. In 1984, Rohrer and Chandler (1985) reported a similarly high catch rate in June but no increase in October as observed the previous year. Wagner

(1968) reported that no smallmouth were harvested through the ice in Little Bay De Noc in Lake Michigan. Statler (1989) conducted monthly creel surveys in Dworshak Reservoir, Idaho and reported that the smallmouth fishery extended from May through October, 1988. No fish were caught by anglers before or after this period.

Peterson and Myhr (1977) reported that most smallmouth bass moved after dark; however, the majority of movements were during daylight hours which would affect their vulnerability to the fishery. Helfman (1981) reported an offshore evening movement; larger bass were active later in the night than smaller ones. Munther (1970) described the winter movements of smallmouth bass to deeper water, often accompanied by aggregation behavior, or entrance into crevices, caves or fissures in substrate. Largemouth bass tend to be more active during the winter than smallmouth.

Water and Air Temperatures

Water temperature is the single most important ecological factor limiting world distribution of smallmouth bass (Robbins and MacCrimmon 1974). Fraser (1955) demonstrated that smallmouth bass populations of South Bay, Lake Huron, fluctuated by more than 50% over a 5 year period. Examination of scale samples revealed that considerable variation existed in year-class strength. His interpretation was that the occurrence of dominant year-classes suggested that climatic factors may have been involved in determining success of the year-class. Fry and Watt (1955) examined yields of smallmouth bass hatched in the decade of the 1940 in Manitoulin Island, Lake Huron, Ontario, and found more or less synchronous fluctuations in year-class throughout the region. Their best correlations were between regional air temperature and year-class production. These studies provided the background for Shuter et al. (1980) who used field and laboratory studies to generate data for a simulation model. Their work showed two critical stages: from fertilization until the young leave the nest and over-winter mortality. High mortality results from exposure of embryos and larvae to extreme temperatures. The ratio of energy stored/metabolism increases with fish size which enhances survival. Their model predicted the observed northerly limit of smallmouth bass and the importance of one or both of these factors in determining year-to-year variation in recruitment.

Other authors also have alluded to the importance of having sufficient thermal units to develop a significant fishery. Graham and Orth (1986) reported that mean daily water temperature was the single most important variable in predicting year-class success. Searns (1982) found that the number of young-of-the-year (YOY) smallmouth bass present in the fall in Nebish Lake, Wisconsin, was positively correlated with air and water temperature during June and the period from June-August. Oliver and Holeton (1979) reported that the mean length of surviving over-wintering smallmouth were larger than those that died.

Hubert (1988) indicated that the natural range of largemouth and smallmouth bass was related to the agricultural growing season. He considered a growing season of 100 days or more and an elevation less than 6230 ft as determinants of a successful bass population in Wyoming. Johnson et al. (1977) found that smallmouth distribution into Ontario was limited to the north by the July mean temperature of 64°F or the mean annual frost-free period of 100 days. Coble (1967) found that total annual growth in ages 3-5 smallmouth bass in South Bay, Lake Huron and in several other widely scattered populations was related to mean surface water temperature from July through September. Coble (1967) computed thermal sums of degree-days above 50°F (50°F is considered the minimum temperature for activity) as a comparison and found smallmouth at 848-3100. Annual growth increments for Ages 3-5 fish were 0.38-2.58 inches; these populations had from 1794-2279 degree-days >50°F. Smaller growth increments were generally associated with lesser degree days as water temperature accounted for up to 36% of the variation in growth of smallmouths. Other abiotic and biotic factors accounted for the remaining 64% of the variation in growth.

Coutant (1975) reported the growth optimum temperature for smallmouth bass near 78.8°F. Based on his data, growth at 72°F would be about 50% of that at the optimum temperature.

Coble (1975) stated that wide fluctuations in year-class size are common in smallmouth bass populations. Although causes of the variations are not known, Coble believed they were related to temperature in the fish's first summer and not the number of spawners.

Habitat

Habitat preferences for smallmouth bass have been examined in field and laboratory studies. Optimum smallmouth bass habitat is found in both lotic and lacustrine systems. Carlander (1975) reported that smallmouth bass are primarily stream fish in the South but are mostly in lakes in the North.

Cover and *Substrate*.-Sechnick et al. (1986) did not find substrate to be an important factor although numerous other authors have. Carlander (1975) reported that smallmouths preferred riverine habitat with gravel or rubble substrate. Paragamian (1976) found a direct relationship between standing crops of smallmouth bass and the percent of rock and gravel substrate. Rankin (1986) believed that coarse substrate, depth and slow current were of basic importance to smallmouth habitat selection. Hubert and Lackey (1980) found that smallmouth bass utilize reservoir shorelines with rocks, stumps, sunken trees and crevices in hard clay banks. They also found that bottom relief was the major variable governing distribution and movement patterns in a Tennessee reservoir. Sechnick et al. (1986) found that cover influenced habitat selection by juvenile and adult smallmouths. Optimum riverine habitat has abundant shade and cover (Carlander 1975). Todd and Rabeni (1989) found low affinity for vegetative beds although log jams and root wads were highly important during the summer. Probst et al. (1984) found that smallmouth were highly associated with log complexes in streams. Johnson and Hall (1977) found that smallmouth bass were strongly associated with lakes with boulder covered bottoms. Edwards et al. (1983) rate gravel, broken rock (0.2-0.8 in) and boulders with adequate interstitial space as the most suitable. Depth is important in lakes and streams because smallmouth use deep, dark quiet areas as cover (Edwards et al. 1983). Milewski and Willis (1990) collected smallmouths in 1989 by electrofishing over rock/boulder substrates at a rate roughly seven times that compared to substrates of gravel/sand from eastern

South Dakota lakes. None were collected over silt/organic matter. In 1990, Milewski and Willis collected smallmouths at a rate of 6 fish/hour over wave protected sand/gravel substrate. Substrate was identified by Edwards et al. (1983) as a very important habitat attribute; gravel, broken rock (0.6-0.79"), and boulders rated a 1.0 on the suitability index compared to a suitability of 0.2-0.3 for silt, sand, pebbles, and bedrock.

Stream Gradient/Velocity.-Carlander (1975) reported that smallmouth bass require riverine systems with moderate current. Stream gradients of 4-25 ft/mi (0.08-0.47% gradient) are preferred (Paragamian 1976). Rankin (1986) found that smallmouth prefer currents of <0.5 feet/second and rarely higher than 0.67 feet/second. Todd and Rabeni (1989) reported preferred velocities to be <0.6 feet/second. Hubert and Lackey (1980) found smallmouths in portions of the reservoir with surface velocities of 0.3-1.3 feet/second. Sechnick et al. (1986) also found that current influenced bass habitat selection. Edwards et al. (1983) indicated that gradients from 0.08-0.46% were the optimum and steeper and lesser gradients were less suitable for smallmouths.

Light Intensity.-Sechnick et al. (1986) found that light intensity was an important habitat attribute that affected smallmouth bass abundance. Their tests were conducted in an artificial stream but suggested that cover which reduces light intensity is important. Light intensity was not considered an important habitat attribute affecting habitat suitability by Edwards et al. (1983).

Depth.-Pool depth more than 3.9 feet supports the highest standing crops (Paragamian 1976). Depth less than 18 inches (45cm) was avoided. Todd and Rabeni (1989) reported that smallmouth seldom selected depths less than 2.2 feet. Pool depth of 3-16 feet was considered the best by Edwards et al. (1983); shallower pools decreased dramatically in suitability while deeper pools decreased gradually in suitability. Pool frequency was also important; 50-75% pool frequency was considered the most suitable condition by Edwards et al. (1983). In lakes and reservoirs, mean depth of 30-33 feet was the most suitable and deeper and shallower systems linerarly decreased in suitability (Edwards et al. 1983).

Turbidity.-Turbidity to 30 JTU's was not considered to affect the habitat suitability for smallmouth bass but higher turbidities decreased the suitability dramatically (Edwards et al. 1983). Robbins and MacCrimmon (1974) indicated that turbidity was an important factor limiting the distribution of smallmouths as they demonstrate intolerance to turbidity.

Other Habitat Attributes.-Six parts per million dissolved oxygen was considered a minimum for maximum habitat suitability for smallmouth bass (Edwards et al. 1983). Average TDS and pH were also considered important in assessing the habitat suitability of a system for smallmouth bass; pH's about 8 and TDS from 100-375 ppm were deemed important by Edwards et al. (1983). The importance of water temperature for spawning, and rearing of fry, fingerlings and adults has been covered earlier.

Standing Crops

Standing crops of smallmouth bass vary greatly throughout the native range but generally decrease from south to north. Jenkins (1975) reported a mean standing crop of smallmouth bass of 1.6 lb/acre to a maximum of 6.6 lb/acre based on data from 45 reservoirs. He also found that standing crops of smallmouth bass were positively correlated with redhorse suckers, spotted sucker, and rainbow trout. Jenkins (1975) found that smallmouth bass crops appeared highest in older, larger, less fertile reservoirs with shorter growing seasons (no western reservoirs included in the analysis). Schneider (1973) reported that Katherine Lake, a soft-water lake in the Upper Peninsula, Michigan, had 10 lb/acre. He also reported adjusted standing crops for a number of other Michigan lakes ranged from 6-32 lb/acre of bass. Adjusted biomass estimates for reservoirs generally were similar or lower than lakes although one "pond" had an estimated 128 lb/acre. Jenkins (1975) reported that higher standing crops for smaller waters, such as ponds, may be attributed to ecological conditions and favorable species composition. Although bass were not separated by species (smallmouth, largemouth and spotted bass were pooled), smallmouth bass comprised approximately 12% of the total bass biomass (Jenkins 1975). Standing crops in Katherine Lake on Michigan's Upper Peninsula are probably more representative of conditions in Montana because of the northerly geographical location of Katherine Lake. In Wisconsin, Ages 2 and 3 smallmouth bass from Nebish Lake had an estimated standing crop of 2.9 lb/acre (Anonymous 1971) although no data were given on the proportions of these two age classes to the stock. Klingbiel (1984) reported on population data for smallmouth bass in Wisconsin. His data indicated a modal standing crop of less than 1 lb/acre although a few systems, especially rivers, had smallmouth standing crops in excess of 10 lb/acre. In South Branch Lake, Maine, Bandolin (1973) estimated the standing crop to be 1.43-2.42 lb/acre.

Anticipated standing crops of smallmouth bass in Montana are probably comparable to those for largemouth bass in waters of similar geograhical area. Hatch (1990) estimated the standing crop of largemouth bass in Long Lake, on the Spokane River, Washington to be from 1.1-4.8 lb/acre. Rieman (1987) found that standing crops of largemouth bass ranged from 3.6-20.0 lb/acre in six north Idaho lakes. The modal standing crop for Rieman's lakes, however, was about 2.8 lb/acre.

Funk (1975) compared standing crops of smallmouth bass in Courtois Creek, Missouri, with those from other geographical areas. Ranges of standing crops presented were 0.2-41.3 lb/acre for Oklahoma and Indiana. Unfortunately, streams listed were from latitudes considerably south of Montana.

Pioneering

Limited information was found in grey and published literature on pioneering of smallmouth bass. Fletcher (1988) reported extensive range expansions from the Yakima River; smallmouth bass spread downstream into the Columbia River and into other tributaries. They moved north in the Columbia River to the Okanogan River, and into the Snake River and major tributaries such as the Grande Ronde and Owyhee rivers in Oregon, several hundred miles in total distribution. Rawson (1945) reported that smallmouth bass introduced into West Hawk Lake, Manitoba, migrated downstream and became established in Caddy Lake. Also, bass moved downstream from Lake of the Woods to become established in the Winnipeg River and into Lake Winnipeg. Additional evidence that they will disperse from a general stocking area comes from the Noxon Reservoir example (Huston 1985). Smallmouth distributed themselves widely throughout the reservoir within a few years. However, they have been slow to move downstream into Cabinet Gorge Reservoir immediately downstream from Noxon. Fish in general, based on the author's observations distribute relatively quickly downstream although movement upstream is considerably slower. However, no published/unpublished literature has been located to suggest that upstream movement does not occur. Daily et al. (1990) reported smallmouths were widely distributed in Oregon's South Umpqua and Umpqua rivers but not in the North Umpqua. Water temperatures were considered too low in the North Umpqua River which suggests that smallmouths will not migrate to and reside in an area that has unsuitable habitat.

Forage Preferences

Numerous authors have reported the importance of crayfish in the diet of smallmouth bass (Edwards et al. 1983; Coble 1975; Minckley 1982). However, other authors have found that other food items are also important and can sustain the bass population. For example, fish comprised a large portion of the diet of smallmouths at various locations in John Day Reservoir, Oregon, ranging from 96 to 62% (weight) of the diet (Poe et al. 1988). Little seasonal differences were found in the John Day study. Invertebrates, mainly crayfish, increased in importance from upstream to downstream and ranged in importance from 2-36%. Crayfish were the most important food item of bass from about 2-4 inches and up to about 10 inches. Prickly sculpin was the most important food item of bass from 10-16 inches and suckers were that for smallmouths larger than 16 inches. In complete contrast to John Day, Dunsmoor (1990) reported that zooplankton comprised a significant contribution to the total caloric intake of smallmouth bass in Brownlee Reservoir, Idaho. Other authors have reported that zooplankton are important during the first year but then other items usually become important. Anonymous (1971) reported that adult bass fed on yellow perch, aquatic insects, and crayfish in Nebish Lake, Wisconsin. Bennett et al. (1983) found that invertebrates, mainly crayfish, were the most important food item of smallmouths in Little Goose Reservoir, Washington. In Brownlee Reservoir, Idaho, Rohrer (1984) found that crayfish were the highest incidence volumetrically of various items during the late August to November period although fish and plankton were higher during mid-July through August. During April through June, 1984 in Brownlee Reservoir, Rohrer and Chandler (1985) found that crayfish and fish were about equally present in the diet of smallmouths. In Lower Granite Reservoir on the Snake River, Bennett and Shrier (1986) showed that fish were important dietary items in shallow waters (<20 feet) in spring 1985, while crayfish was the predominant item in bass sampled along deep (>60feet) waters. Two years later in Lower Granite Reservoir, Bennett et al. (1988) reported substantial seasonal differences in the diet of smallmouths; during spring 1987, insects (primarily chironomidae pupae) and crayfish were predominant food items. During summer 1987, crayfish and insects were predominant food items although fish (suckers) were also important dietary items. In the fall, crayfish was the most predominant food item. In Dworshak Reservoir, Idaho, Statler (1990) found that fish were present in 61.5% of smallmouth stomachs examined (n=52) and mayflies were also an important item. Diptera and Hemiptera were important in smaller (<10 inches) bass from Dworshak Reservoir. Statler (1989) found that Hymenoptera, fish, Tricoptera, and Diptera predominated the food items during the 1988 bass stomach sampling. These are especially interesting food items as water levels annually fluctuate over 100 feet in Dworshak which results in an unproductive littoral zone in the reservoir.

Diseases

The black basses are hosts for hundreds of parasitic protozoans and metazoans, fungi, bacteria, and viruses (Sullivan 1975). Most do not cause harm to either fish or man. Some of these infect many species of fish and not only the black basses. Most of these diseases infect fish under intensive culture conditions or in eutrophic waters. Although this list is extensive, few problems in nature, especially in less eutrophic northwestern waters, ever develop. Highly industrialized and/or culturally eutrophic waters are systems that usually develop these parasite and disease problems. All of these are ubiquitous in nature and affect a wide variety of other species. None of these pose a threat to man but can affect the aesthetic appeal and may affect growth and performance.

Parasitic Diseases

Ichthyophthirius multifilis.-Ich is probably the most widely distributed disease in fish. It appears as a series of macroscopic white dots on skin, fins and gills. Bass rarely die from Ich in the wild but large numbers of bass may die in a hatchery.

Epistylis.-*Epistylis*, or red-sore disease, is a stalked, ciliated, colonial protozoa that affects the sides of bass. Common occurrence is in eutrophic systems.

Trichodina.-*Trichodina* is a microscopic ciliated protozoan more common in hatcheries. Outbreaks occur especially in fertilized ponds with crowded individuals.

Bass Tapeworm.-*Proteocephalus ambloplitis*, the bass tapeworm, are transferred directly to bass by consumption of the initial host, copepods, or consumption of an infected prey species. Bass accumulate more tapeworms with age and sterility can ensue as ovaries become full with pleurocercoids (larval tapeworm) or death as visceral organs become infected.

Anchorworm.-*Lernaea*, or anchorworm gives the appearance of a stick lodged under the skin of a bass. Anchorworms are rarely lethal to bass but their appearance makes fish less attractive to anglers. Once in a wild population of bass they are difficult to eliminate.

White, Yellow and Black Grubs.-These grubs (*Posthodiplostomum minimum*-white, *Clinostomum marginatum*-yellow, and *Uvulifer ambloplitis*-black) are caused by larval trematodes that appear as macroscopic small white dots, usually in the visceral organs and kidney. They have three stages; the first stage infects snails, the second stage infects fish and the third stage infects aquatic birds (herons). Most bass have some of these worms without noticeable effect, but high abundance can impair organ function. Although mortalities from yellow grub are rare, the aesthetic value of the fish can be lessened. Neither control of heron abundance nor snail control is realistic.

Philometra.-*Philometra nodulosa* and *P. cylindracea* are nematodes that accumulate behind the eye and in sinuses of bass heads. Large numbers create a condition called "pop-eye". *Philometra* is not lethal but may cause partial blindness.

Contracaecum.-*Contracaecum* is a large, macroscopic nematode generally found in the gut and visceral mesenteries of many fishes. Juvenile forms are found in copepods and fish and the adults are found in piscivorous animals. This nematode is not lethal to bass.

Fungal Disease

Saprolegnia.-*Saprolegnia* is a fungus that is usually a secondary invader in bass that usually starts on necrotic tissue. Uncontained growths can affect live tissue or high abundance of *Saprolegnia* in organic rich waters can infect fish.

Bacterial Diseases

Bacterial Hemorrhagic Septicemia.-This bacterial infection, usually caused by *Aeromonas hydrophilla* and occasionally *Pseudomonas flourescens*, is usually common in the spring. Reddened sores on the sides, fins, and mouth are the usual symptoms of this bacterial infection. The infection may become systemic and cause a swollen abdomen. Bass may die from this disease, especially if bacterial growths increase rapidly although symptoms disappear as the summer approaches.

Columnaris Disease.-*Columnaris* Disease is caused by the myxobacteria, *Chondrococcus columnaris*, that result in large gray patches on the dorsal and lateral surfaces. Extensive infections spread to the gills and interfere with oxygen transport that can be lethal to bass.

Viral Disease

Lymphocystis.-*Lymphocystis* is a viral disease that causes infected cells to exhibit excessive growth. In bass these growths usually occur on the fins. These are not fatal but can destroy the aesthetic appeal of the fish.

Natural Mortality

Total mortality of a fish stock is related to fishing mortality and natural mortality. Pauly (1980) developed a model to predict natural mortality of fish stocks based on the annual mean water temperature and two growth parameters from the von Bertalanffy growth equation. The model is:

$\log M = -0.0066 - 0.279 \log L + 0.6453 \log K + 0.4634 \log T$

where

M = Instantaneous natural mortality

log = Natural or common log

L = Theoretical maximum length of individual

K = Growth coefficient from von Bertalanffy equation

T = Annual mean temperature

Values used for predictions of smallmouth bass mortality for populations in Montana were based on growth rates of smallmouths reported by Huston (1985) for Noxon Rapids Reservoir (K=0.1639; L =686mm; t_0=0.2968; T=11.08 C/52°F). Based on Pauly's model an estimate of instantaneous natural mortality (M) of introduced smallmouth stocks would be about 0.148 which computes to about 14% annual mortality (A). This computation indicates that for systems that might have similar growth rates and temperature conditions as the Clark Fork River, natural mortality would be relatively low. For comparison, a similar computation for the smallmouth stock in the Snake River reservoirs indicated about 13% annual natural mortality.

Proportional Stock Density

Structure is one measure of the size and age composition of a stock. One method to assess stock structure is the PSD or proportional stock density. The PSD is the ratio of quality sized fish to the number of stock sized fish. For smallmouth bass, stock sized fish are usually 7" and quality sized fish are 11" (Anderson and Weithman 1978). A recommended PSD value is 40-60%, at least for mid-western waters. A number of factors affect the PSD of a fish stock including growth rates and exploitation; the more larger individuals in the population the higher the PSD value. Rohrer (1984) found a PSD of 5% for Brownlee Reservoir, Idaho in 1983 and 8% in 1984 (Rohrer 1985). These values are extremely low but comparable to Fernan Lake, Idaho, a largemouth bass population that receives intense fishing pressure in northern Idaho (Rieman 1987). A PSD of 49% was calculated for John Day Reservoir on the Columbia River using length frequencies combined over 3 years (1983-1985) of electrofishing data from March through June (Nigro et al. 1985a; Nigro et al. 1985b; Nigro et al. 1985c). Proportional stock densities were calculated using electrofishing data for the lower Snake River reservoirs and ranged from 9-38% for Lower Granite and Ice Harbor reservoirs, respectively (Bennett et al. 1989).

Review of literature on impacts and success of new smallmouth introductions and interspecific interactions.

Interspecific Interactions

Limited literature is available on effects of smallmouth bass introductions and interspecific interactions with largemouth bass (*Micropterus salmoides*), northern pike (*Esox lucius*), trout, kokanee (*Oncorhynchus nerka*), and forage fishes. Jenkins (1975) analyzed species interactions by correlation analysis of standing crops from fishes in about 173 reservoirs in the United States. He reported a positive relationship between rainbow trout (*O. mykiss*) and smallmouth bass but a negative relationship between smallmouth bass and largemouth bass. However, Jenkins (1975) attributed the negative relationship between smallmouth and largemouth bass to dissimilarity of environmental factors rather than interspecific competition. No other species of trout/salmon or northern pike interactions were evaluated in his analysis. Fletcher (1988) indicated that smallmouth bass gradually displaced largemouth bass in Lake Osoyoos, Washington, probably a result of the habitat being more suitable for smallmouths. Carlander (1975) reported common species associations with smallmouth bass on rocky shoals. He listed pumpkinseed (*Lepomis gibbosus*), yellow perch (*Perca flavescens*), and northern pike as species commonly found with smallmouth but did not provide a discussion of possible interactions. He further stated that in the Lake Ontario-St. Lawrence smallmouth populations, growth was slow the first 3 years probably because of competition with rock bass (*Ambloplites rupestris*) and yellow perch. Yellow perch provide both negative and positive interactions to smallmouth bass. Forney (1972) reported that young yellow perch were consumed by smallmouth. He found in Oneida Lake that high perch densities and warmer temperatures contributed to an increase in growth increments of Age 1 and older smallmouth bass. However, he found a negative relationship between perch abundance and growth of young-of-the-year bass that suggested possible competition.

Carlander (1975) reported that few data on community relationships are available on introduced smallmouth populations. Smallmouth have been introduced into many trout lakes north of their normal range. Little evidence exists that bass have had any appreciable affect on lake trout populations but may have caused the decline in brook trout (*Salvelinus fontinalis*) in Lake Opeongo (Martin and Fry 1972).

Most interactions assessed between salmonid fishes and smallmouth bass have been related to predation. In John Day Reservoir, Oregon, smallmouth bass longer than 8 inches consumed an average of 0.003, 0.009, 0.019, 0.118, and 0.070 salmonids per day for April, May, June, July, and August, respectively (Vigg et al. 1988). Consumption rates of salmonids were highest in July and August, the time of elevated water temperature (70-78°F) and the availability of smaller salmonids (fall chinook). Bennett et al. (1983) found that smallmouth bass were not a major predator on salmonids in Little Goose Reservoir, Washington. The frequency of occurrence in the diet was about 2% although their estimate was considered an underestimate because bass sampled by electrofishing were generally small and not totally representative of the population size structure. Also, water temperatures were marginal for bass feeding activity (46-57°F). Upstream from Little Goose Reservoir on the lower Snake River, salmonids comprised 26% (percent wet weight) of the food items in the spring in Lower Granite Reservoir (Bennett and Shrier 1986). Bennett et al. (1988) found that salmonids contributed the most to the overall total weight of food items (28.2%) of smallmouth bass in the spring in Lower Granite Reservoir during 1987. Of the bass with salmonids in their stomachs from Lower Granite, chinook salmon *(O. tshawytscha)* averaged 1.75/bass stomach. Palmer et al. (1985) examined contents of 1,683 smallmouth bass stomachs in John Day Reservoir, Oregon. Salmonids contributed 3.8% of the diet of smallmouths. No salmonids were found in stomachs of bass larger than 1.3 inches (400 mm) in length. Fletcher (1988) referenced studies conducted in the John Day and Owyhee rivers, Oregon, that showed low water temperatures during the steelhead and salmon emigration accounted for low predation by smallmouth. Suckers, squawfish and chiselmouth were being reduced in the Owyhee River by smallmouth bass, while in the John Day River, smallmouths were able to inhabit miles of stream habitat that otherwise would not be used by game fish.

Limited literature has been found that examined the impacts of smallmouth bass on sockeye salmon/kokanee populations. Fletcher (1988) indicated that he could not find any clear evidence that the slight reduction in return rate of sockeye salmon to Lake Osoyoos, Washington, was related to smallmouth bass. Kokanee populations increased in Anderson Ranch Reservoir and Lucky Peak Reservoir, near Boise, Idaho and Dworshak Reservoir, near Orofino, Idaho, during the time smallmouth bass were present (Fletcher 1988). These three reservoirs have runs of early tributary spawning kokanee. The potential for bass predation on kokanee juveniles differs between tributary and lakeshore spawners. Lakeshore spawning kokanee spawn in the late fall and winter and incubation of kokanee embryos in the gravels probably would not be affected by smallmouth bass. During emergence, however, juvenile kokanee may be preyed upon by smallmouth bass. During the spring, kokanee emerge from May through June, a time that smallmouth bass are usually migrating into shallow waters to seek warmer temperatures and initiate feeding activity prior to spawning. At this time, predatory interactions between kokanee and smallmouth bass could occur. Some literature suggests that open water recruitment of kokanee occurs immediately after emergence (Hassemer 1984). If this were the case, predatory influences by smallmouth bass probably would be minimal. If kokanee forage in shallow water prior to recruiting to pelagic waters, however, smallmouth could have deleterious predatory effects on kokanee. Water temperature is probably the most important factor contributing to possible predation. At temperatures below 50°F, the reported minimum temperature for active foraging by smallmouth bass (Coble 1975), predation would probably be minimal. Higher water temperatures, however, would increase the predatory influence that smallmouth bass would have on kokanee.

Spawning and incubation of kokanee in smaller, colder tributaries would probably not be directly impacted by bass. However, at the time of emergence and recruitment to the lake, young-of-the-year kokanee could be readily available to smallmouths at tributary mouths. Kokanee would be concentrated and available at a time that the lake temperatures would be above 50°F and smallmouths would be actively feeding.

Smallmouth bass are known to prey heavily on stocked trout in two Idaho systems. In Brownlee Reservoir, the Idaho Department of Fish and

Game annually stocks catchable rainbow trout in the fall. Smallmouth bass commonly prey heavily on these trout and numerous bass have been seen with "tails" extending from their mouths (Dunsmoor 1990). Also, smallmouth stocked in Hayden Lake, prey heavily on fingerlings and a similar observation of trout extending from bass stomachs is a common sight in Hayden Lake (Melo Maiolie, Idaho Department of Fish and Game, Coeur d' Alene, Personal Communication). In Lake Sammamish, Washington, Fletcher (1988) found no clear evidence that the slight reductions in cutthroat trout and fall chinook salmon were related to smallmouth bass.

Smallmouth bass may have a beneficial influence on the structure of the fish community. Fletcher (1988) referenced a personal letter from Herb Pollard, Fisheries Biologist, Idaho Fish and Game, that indicated smallmouth seem to be controlling populations of redside shiners, northern squawfish, and chiselmouth in Anderson Ranch Reservoir, Idaho. Squawfish numbers also decreased in Brownlee Reservoir, Idaho following the introduction of smallmouth bass. Pollard also stated that "two-story" fisheries with smallmouth and salmonids work out well in large, deep, fluctuating reservoirs with problem populations of native cyprinids.

These studies show that when salmonids and smallmouth bass coexist in a system, that under suitable water temperature conditions for smallmouth feeding (>50°F) and sufficiently small salmonids are available, that smallmouth will actively prey on salmonids. Studies completed in the Columbia River suggest that smallmouth predation on migrating juvenile salmonids increases with higher water temperatures (Vigg et al. 1988); conversely, lower water temperatures in tributaries may account for low predation. Other studies have found that reduced numbers of nongame fishes may actually favor some species of salmonids in the same habitat, probably by reducing food competition and predation (Fletcher 1988).

Potential impacts of introductions of smallmouth bass into new waters in northwestern Montana (Clark Fork, Flathead, and Kootenai drainages).

Potential Impacts of Introductions

Smallmouth bass were first introduced into the Clark Fork River drainage in 1982 (Huston 1985). Young-of-the-year smallmouth were introduced in the upstream end of Noxon Rapids Reservoir and stocked again in 1983 although fish were generally in poorer condition than those in 1982. An intensive survey to assess bass (*Micropterus* spp.) distribution in 1984 yielded 39 smallmouth ranging in size from 7-9.3 inches. More recent scale sampling indicated that spawning in Noxon Rapids occurred as early as 1985 which suggests that bass were spawning as Age 3 fish (Huston 1990).

Growth rates on smallmouth in Noxon Rapids have been good based on comparison with Little Goose Reservoir smallmouth. Huston (1990) reported that length at age was 3.0, 6.4, 9.7, 12.4, 14.5, 16.5, and 17.9 inches for age classes 1-7. These growth rates exceed those for the Snake River (Figure 1) and compare favorably with other populations in Washington, Oregon and Idaho (Table 1). Comparison of growth rates from other northerly populations suggests that growth rates for smallmouth in Noxon Reservoir are presently good compared to those in similar geographical areas. Water temperatures for Little Goose Reservoir, Snake River Washington, indicate year-to-year differences, with some years having temperatures exceeding the preferred temperature for about 45 days (Figure 2). The slowest growing stock was from Cow

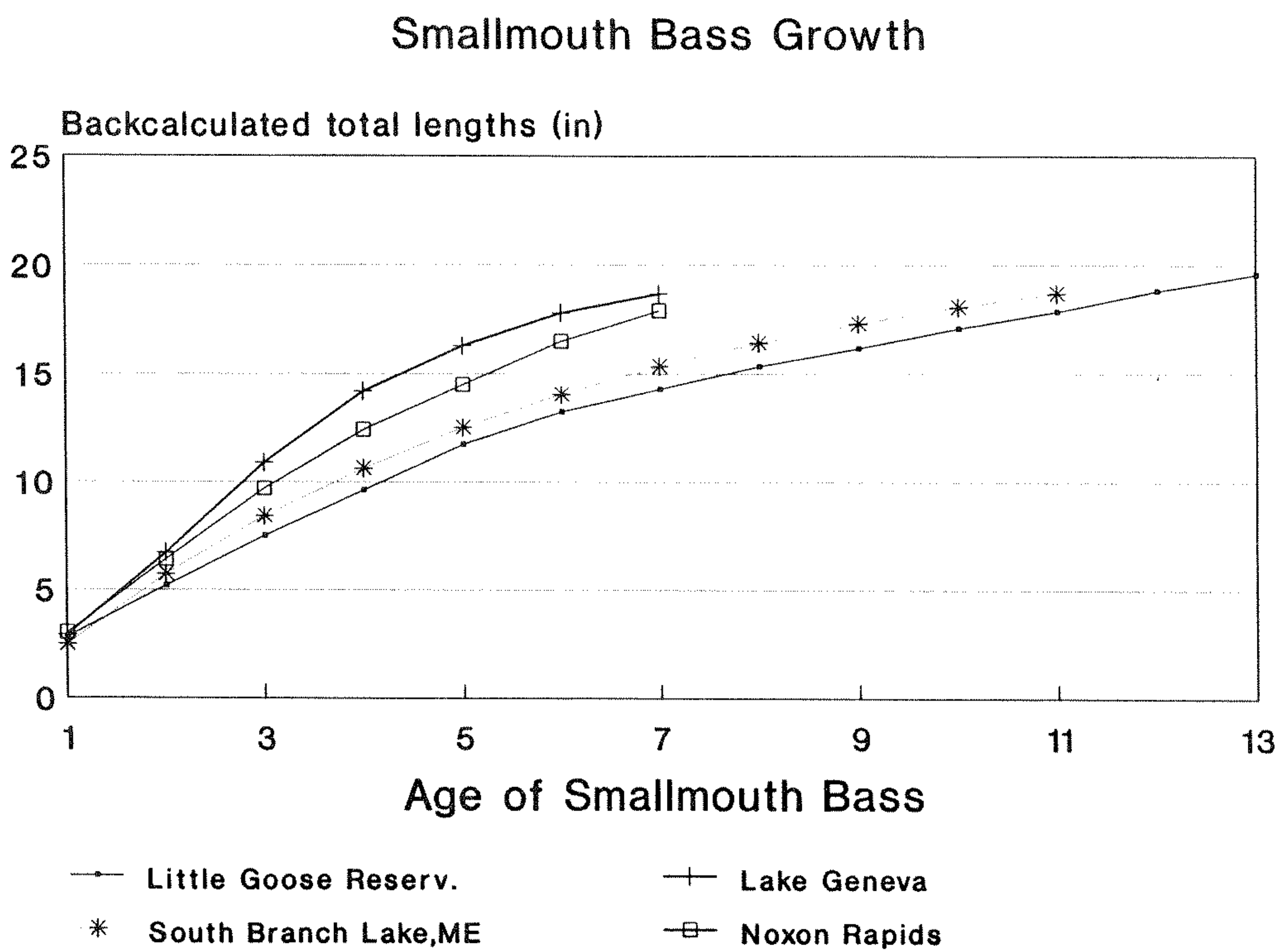


Figure 1. Comparison of growth rates for smallmouth bass in Little Goose Reservoir, Washington, South Branch Lake, Maine, Lake Genva, Wisconsin, and Noxon Rapids Reservoir, Montana.

Table 1. Back-calculated length at age data for various populations of smallmouth bass. Population codes are as follows: 1-Waugoshance Pt., MI (Latta 1963); 2-John Day Reservoir, OR. (Poe et al. 1988); 3-South Umpqua, OR. (Daily et al. 1990); 4-Umpqua River, OR. (Daily et al. 1990); 5-Lake Sammamish, WA. (Pflug and Pauley 1984; 6-Brownlee Reservoir, ID. (Rohrer 1984); 7-Cow Creek, OR. (Daily et al. 1990); 8-Snake River, OR. (Keating 1970); 9-Upper Snake River, ID. (Keating 1970); 10-Lower Snake River, ID (Keating 1970); 11-Clearwater River, ID.(Keating 1970); 12-Little Goose Reservoir, WA. (Bennett et al. 1983).

Population	Age Class										
	1	2	3	4	5	6	7	8	9	10	11
Waugoshance Pt., MI.[1]	3.9	6.3	8.1	9.7	11.5	13.2	14.6	15.8	16.8	17.4	17.9
John Day Res., OR.[2]	2.5	7.0	10.8	13.0	14.4	15.3	16.2				
South Umpqua R.,OR.[3]	3.1	7.5	10.8	13.4	15.2	16.3	16.8				
Umpqua R.,OR.[4]	3.5	8.0	10.8	12.6	13.9	14.9					
Lake Sammamish,WA.[5]	4.0	7.3	10.2	12.4	14.6	15.1	16.3				
Brownlee Res., ID.[6]	2.8	6.2	9.2	11.8	13.9	15.1	16.6	18.4			
Cow Creek, OR.[7]	2.5	4.9	6.2								
Snake River, OR.[8]	3.4	5.9	8.4	9.8	10.8	11.6	12.2	12.8			
Upper Snake R. ID.[9]	3.4	5.7	8.1	9.4	10.5	11.5	12.2	12.8			
Lower Snake R. ID.[10]	3.2	5.6	7.6	9.5	10.6	11.6	12.4	12.8	13.3		
Clearwater R., ID.[11]	3.2	5.4	7.1	8.7	9.8	10.6	11.3	12.0			
Little Goose Res., WA.[12]	2.8	5.2	7.5	9.6	11.7	13.2	14.3	15.4	16.2	17.1	17.9

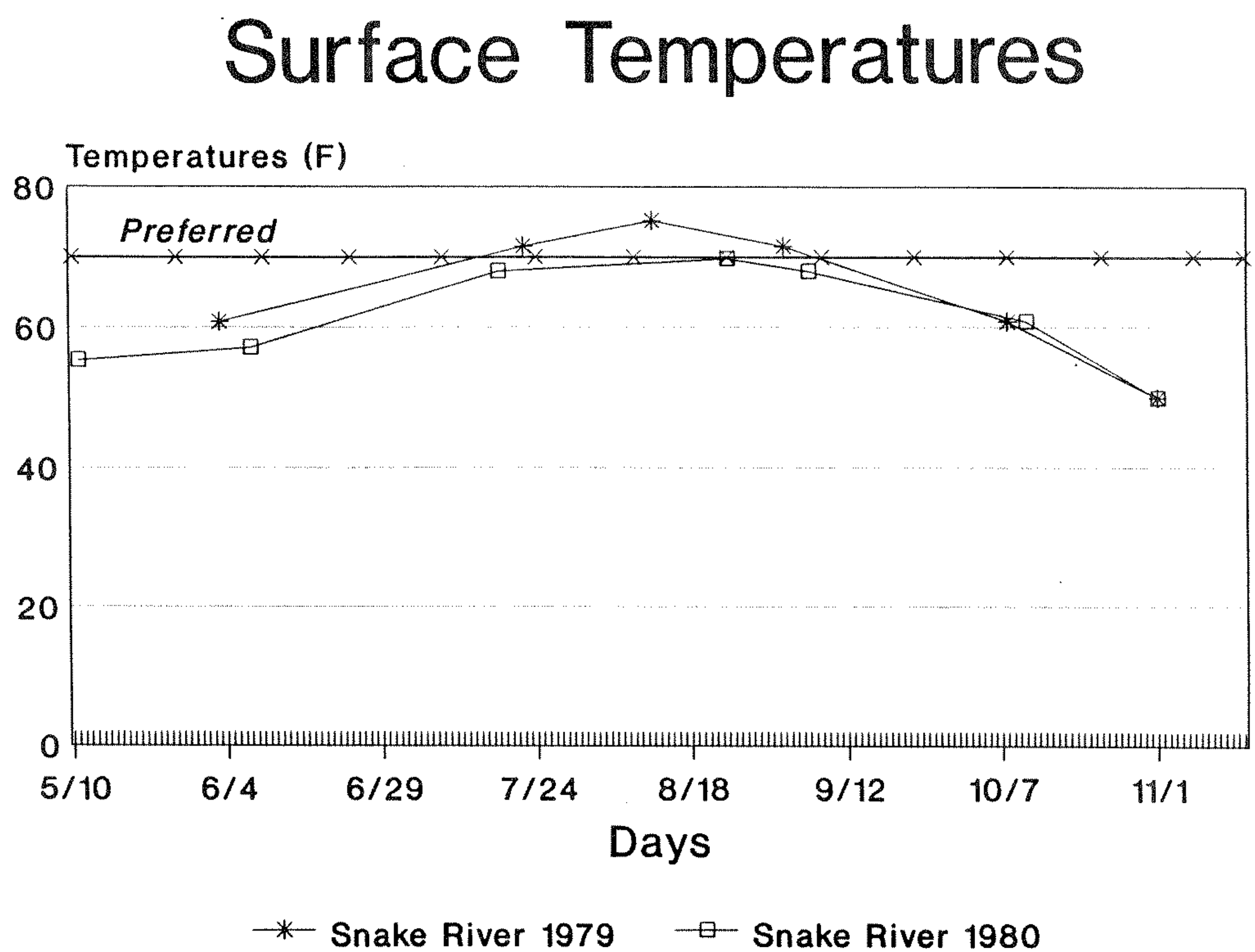


Figure 2. Surface water temperatures from Little Goose Reservoir, Snake River, Washington for 1979 and 1980. The "preferred" water temperature for smallmouth bass is indicated.

Creek and the Snake River (Daily et al. 1990). Cow Creek is a very interesting system because large smallmouths were never observed in the system as Daily et al. (1990) speculated that the larger fish emigrated to the Umpqua River. In addition to the Snake River, a good comparison is available with the smallmouth population in the Umpqua and South Umpqua rivers, Oregon. Growth there was considered good but the river has considerably higher water temperatures than any of the Montana systems under consideration. The Umpqua populations are of interest because Daily et al. (1990) considered the North Umpqua River too cold for smallmouths although they have access to the system. As can be seen, water temperatures in the North Umpqua River are similar to several of the systems that are under consideration for the introduction (Figures 3-4).

General Analysis of Smallmouth Bass Introduction

As indicated earlier, two critical factors control the success of smallmouth bass introductions: turbidity and temperature. Based on available data, turbidity does not appear to be a significant factor in regulating smallmouth bass success in the Montana waters currently under consideration. Air and water temperatures, however, need to be carefully examined in light of the breadth of temperature requirements for smallmouth bass. Water temperature prior to the spawning season determines the timing of spawning. Under constant water temperatures during the growing season, earlier spawned bass would be larger than those spawned later. Higher water temperatures up to the optimum of

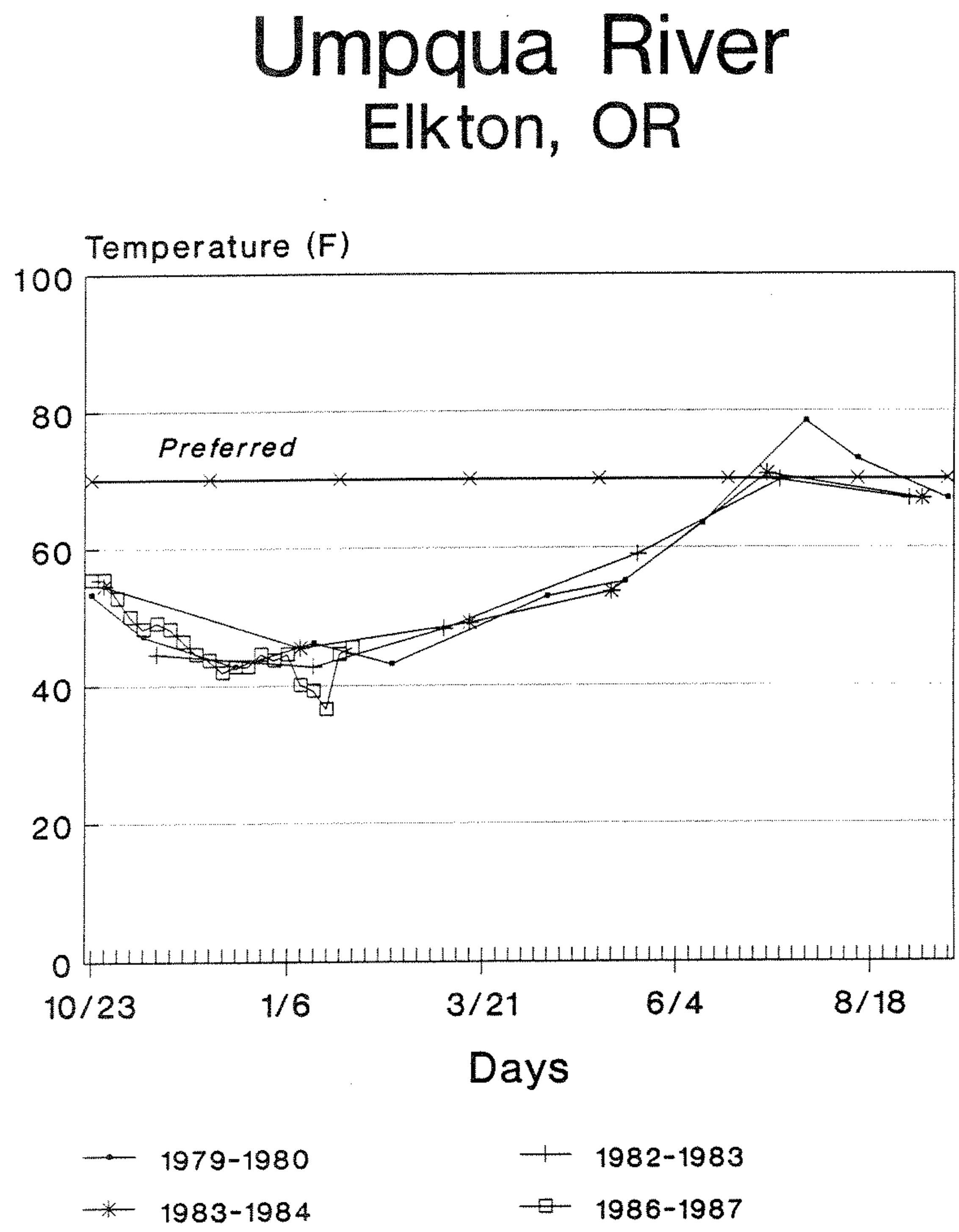
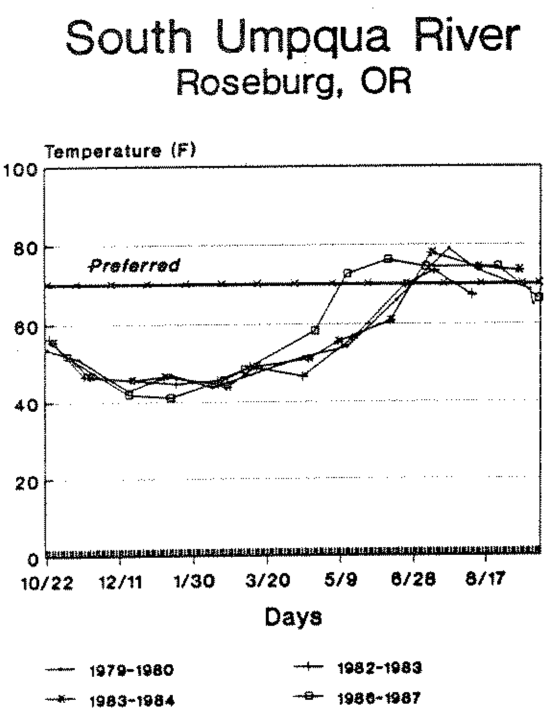


Figure 3. Water temperatures for four flow years for the Umpqua River, OR.



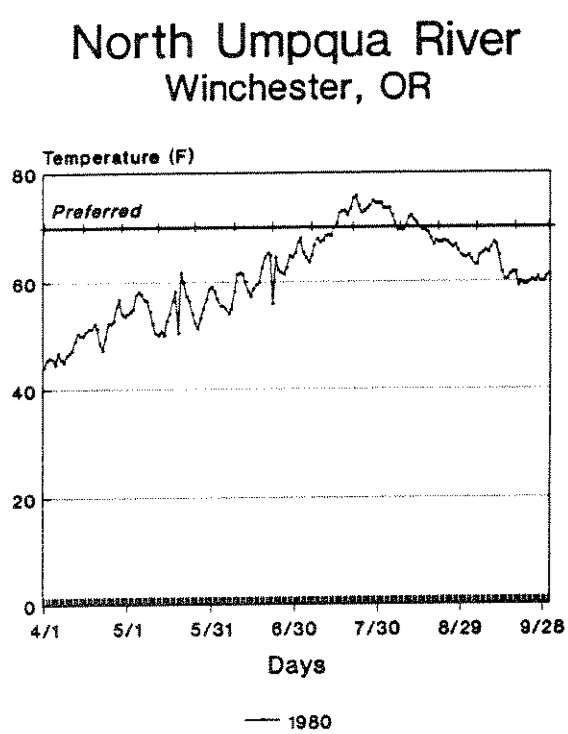


Figure 4. Water temperatures for four flow years for the South Umpqua, and the North Umpqua River, OR.

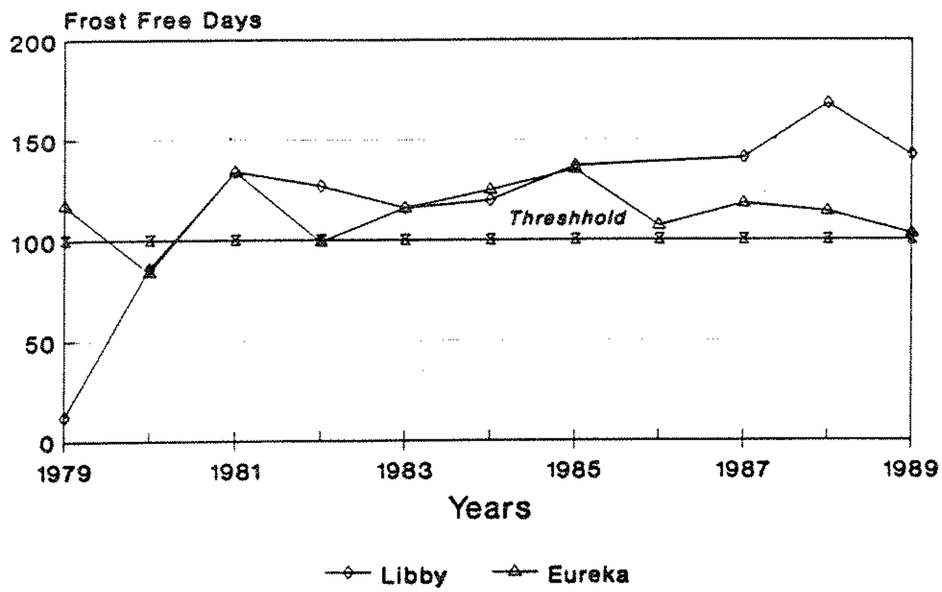
82°F and the longer the growing season result in higher quality rearing conditions for smallmouth bass. The critical factor in determining year-class strength is survival through the first winter. If young-of-year (YOY) smallmouth do not grow to 2-2.5 inches, over-wintering mortality will be high and a successful year-class will not be produced. Water temperatures in excess of 50°F are needed for growth and the longer those temperatures exist, the better the growth conditions. Coutant (1975) found that growth in smallmouth at 72°F would be about 50% of that at the optimum of 82°F. Most of the waters under consideration have their highest water temperatures in the low 68-70°F range and some closer to 64°F. Therefore, water temperature appears to be one of the more important factors. Based on this literature review and the extant water temperature regimens under consideration, the sports fishery that could be produced would probably be characterized by variable year-class strength; warmer years with earlier springs and higher temperatures would provide more favorable conditions for stronger year-classes. Conversely, later springs and lower summer temperatures would result in slower growth, smaller individuals that would experience higher mortality and contribute to weaker year-classes. The importance of temperature, however, needs to be carefully examined. Largemouth bass in northern Idaho (Rieman 1987) and Noxon Reservoir (Huston 1985) exhibit reasonable growth under fairly limited temperature units and support important fisheries under "marginal" temperature conditions.

One measure of the growth conditions has been the length of the agricultural growing season or the number of frost-free days above 32°F (Hubert 1988). Hubert (1988) stated that a minimum water temperature condition would be created by air temperatures that exceed 100 days of frost-free conditions. Hubert reported that the northerly limit of smallmouth bass natural distribution is related to 120 frost-free days although the naturalized range into Canada has been extended to areas in the 95-100 days of frost-free conditions. These vary greatly from location to location in the drainages under consideration for smallmouth bass range extensions. Ten years of data suggest high variation in the length of the growing season among years in some areas ranging as high as 170 days to a low of a couple of weeks. Based on an analysis of the Climatological Records for Western Montana, the longest growing season appears to be in the Flathead River drainage at Polson and the shortest on the Clark Fork at Trout Creek and Heron (Figures 5-6). Conditions in Whitefish, Missoula, and Libby based on a minimum of 100 frost-free days are satisfied although those in Olney and St. Regis were less than the suggested minimum. Obviously, frost pockets exist in these areas and differences occur among recording stations but air temperatures have been correlated with smallmouth bass year-class strength.

Hubert (1988) also stated that elevation is a factor that affected bass distribution in Wyoming. He reported that bass distribution was limited to areas less than 5390' (1780m) elevation. Reported elevations of areas under examination were all less than 5390' and therefore, based on a criterion of elevation, all the proposed sites are potentially suitable for smallmouth bass.

Enumeration of degree-days when water temperatures >50°F is another measure of suitability of water temperatures. Coble (1967) showed that a relationship existed between total annual growth and water temperatures. He reported that smallmouth were found in waters with 848-3100 degree-days. This analysis is useful because it provides a

Air Temperatures



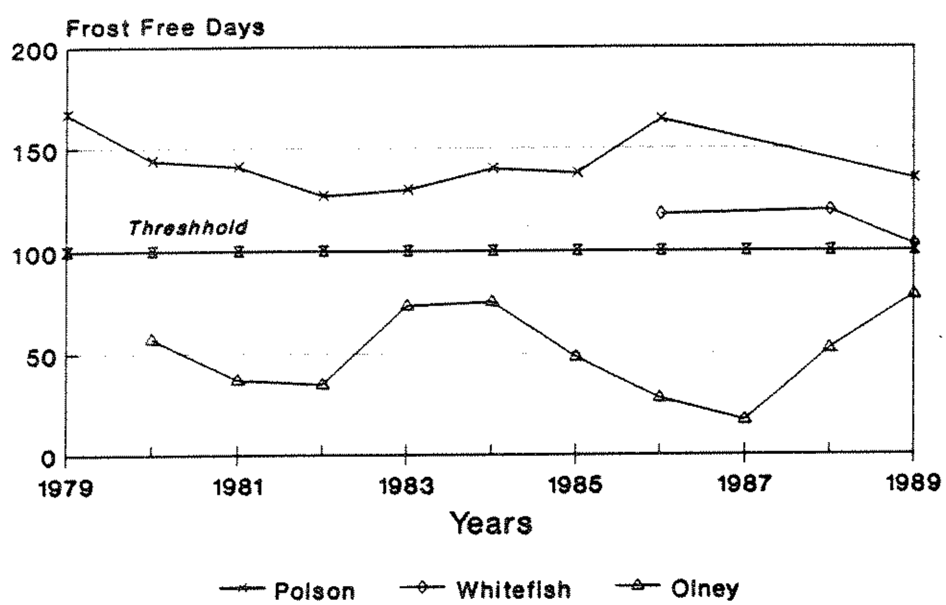


Figure 5. Comparison of number of frost-free days (>32°F) from 1979-1989 for Libby and Eureka, and Polson, Whitefish, and Olney, Montana. The reported threshold for smallmouth at 100 days is indicated.

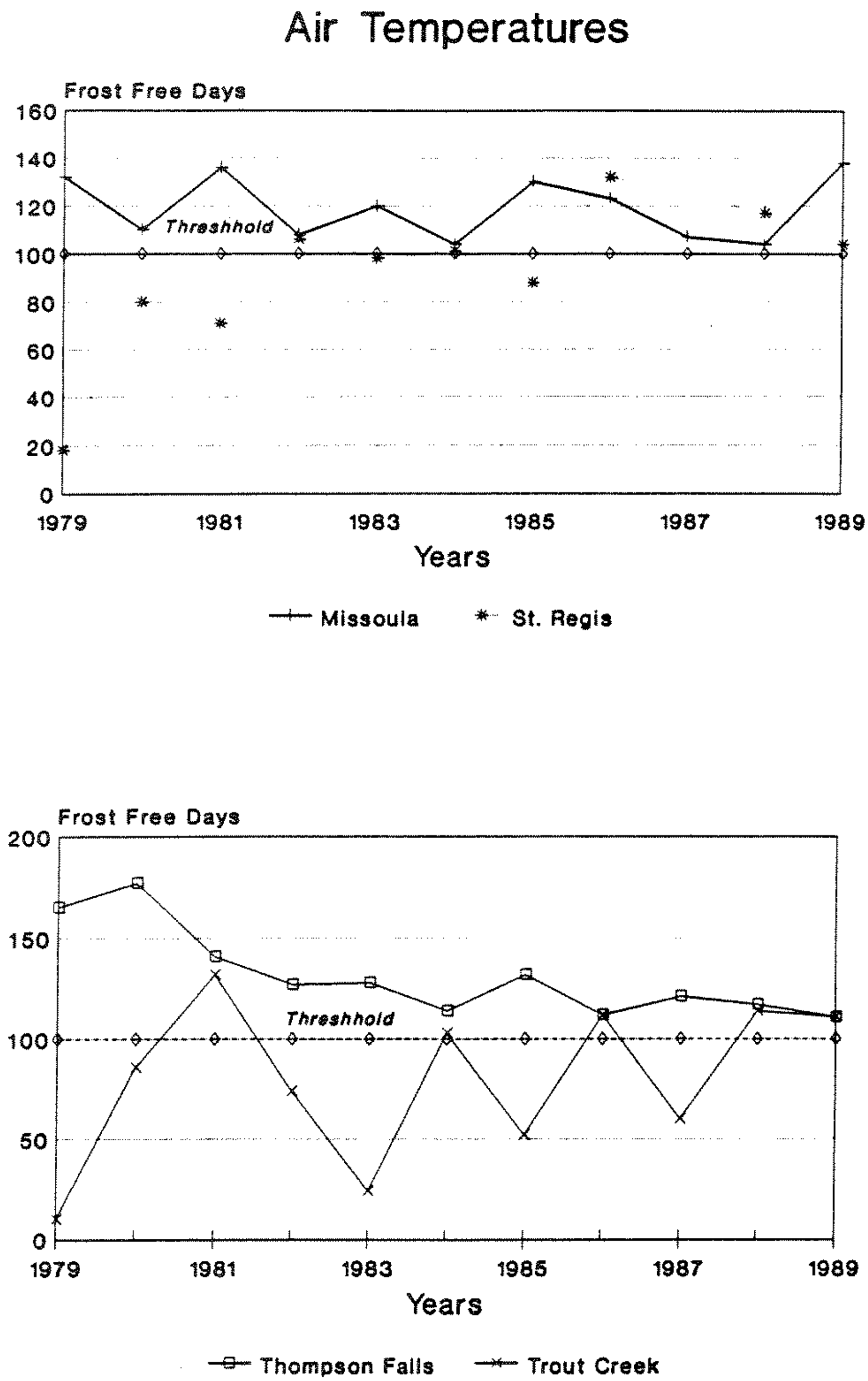


Figure 6. Comparison of number of frost-free days (>32°F) from 1979-1989 for Missoula and St. Regis, and Thompson Falls and Trout Creek, Montana. The reported threshold for smallmouth at 100 days is indicated.

means to assess the quality of the temperature conditions for smallmouths rather than a threshold measure like length of the growing season.

Examination and potential for introductions are discussed individually by systems. Comparisons are made when possible with Little Goose Reservoir, Washington, and the Umpqua River system, Oregon. A good data set with water temperature and fishery growth information exists on both systems.

Analysis of the suitability of these waters have been facilitated by application of the suitability models developed by Edwards et al. (1983). The models consider the following components: food, cover, water quality, and reproduction. The optimum condition rates a value of 1.0 and less than optimum receives a lower suitability rating. Data are lacking to assess all of these components although characteristics that decrease the suitability from 1.0 are examined.

Candidate Waters Region 1

Lakes

Horseshoe Lake (Lincoln County).-Horseshoe Lake, at 3,350' elevation within the Kootenai River system, has a maximum depth of 133', an average depth of 44' (18.2 m) and surface area of 159 acres. Water transparency is high with a secchi depth in August of about 28'. Zooplankton abundance is considered high although the lake has high transparency. Surface water temperatures attain a maximum of 70-72°F from mid July to August, cool to about 68°F by mid September. By mid

June water temperatures are about 58°F and exceed 50°F for about 120 days during the summer. The average pH is 8.2. Sparse littoral vegetation occurs along the shoreline and cover is available from submerged trees. Substrate is predominantly silts (90%) although the remaining substrate is gravel and cobble. Crayfish are present. The fish population is predominated by northern squawfish, largescale and longnose suckers, pumpkinseed, peamouth, redside shiners, with fewer numbers of largemouth bass and mountain whitefish.

Based on calculation of parts of the lacustrine habitat suitability index, Horseshoe Lake would range from a high of 0.9 in the water quality to a score of about 0.7 for cover (some submerged trees available) on a scale of 0 to 1.0. The deep average depth decreases the suitability to about 0.8 and the high proportion of fines in the substrate further decrease its suitability (0.28). Limited "cover" data, suggests that the lack of large boulders and crevices could decrease the suitability for adults. Based on available data, Horseshoe Lake has some potential for smallmouths. Unfortunately, the high proportion of silts in the substrate decrease its suitability and probably would dramatically reduce standing crops.

Horseshoe Lake (Lake County).-Horseshoe Lake in Lake County is at 3,060' elevation. The lake is 35 surface acres in area, 31 feet maximum depth, and average depth of 12-15 feet. Total alkalinity is 9-15 PPM and TDS (total dissolved solids) are 110. Horseshoe Lake contains pumpkinseed and a fair smallmouth bass population with numerous small fish but few adults. The previous state record smallmouth bass (about 4.3 lbs) was caught here. Crayfish are also present. Moderate vegetation along the shoreline would provide cover for smaller rearing smallmouths. Submerged trees could provide habitat for adults. Silt is the prevalent substrate comprising about 90% while gravel and cobble comprise the remaining 10%. The relatively shallow depth (suitability=0.4) and the high proportion of silt (suitability=0.28 weighted value) decrease its suitability for smallmouth although the TDS levels of 110 indicate favorable (suitability=1.0) water quality. Lack of temperature data, however, precludes more in-depth suitability analysis for water quality.

Loon Lake (Lincoln County).-Loon Lake in Lincoln County is at 3,350' elevation. Maximum depth is 114 feet with an average of 40 feet. Moderate aquatic littoral vegetation is present and adult smallmouth cover would be provided by submerged trees. The substrate composition is more suitable than some of the lakes being about 60% fines and 40% gravel and cobble. Loon Lake currently contains low to moderate numbers of smallmouth bass (to 14 inches), largemouth bass, pumpkinseeds, northern squawfish, Eastern brook trout, and rainbow trout. Crayfish have not been reported in Loon Lake. Based on the average depth, the suitability index for smallmouth bass is 0.9. Water temperatures and other water quality could be highly suitable for smallmouth although the weighted suitability of the substrate is decreased to about 0.52 because of the high proportion of fines. Water temperature data should be collected to further assess Loon Lake's suitability for smallmouth bass.

Loon Lake (Lake County).-Loon Lake in Lake County is at 3,066' elevation. The lake has an average depth of approximately 20 feet. Crayfish have not been reported in Loon Lake; largemouth bass, smallmouth bass, pumpkinseeds, and yellow perch are the finfish present. Largemouths currently outnumber the smallmouth about 9:1. As in other lakes in this area, vegetation along the shoreline is present with submerged trees for cover. The substrate is predominantly silt and consists of 80% fines and 20% gravel/cobble. The high proportion of silty substrate decrease its suitability for smallmouths to about 0.36. The mean depth of 20 feet increases the suitability to about 0.6. The finer substrate decreases its suitability which is probably the reason that largemouth bass greatly outnumber smallmouth bass. Therefore, this lake should be low on the priority list for lakes under consideration.

Upper Thompson Lake (Lincoln County).-Upper Thompson lake is at an elevation of 3,350'. Mean depth is about 20 feet. As in many other lakes being considered for smallmouths, vegetation along the shoreline is present with submerged trees for cover. A diverse finfish community is present including rainbow trout, largemouth bass, pumpkinseed, northern pike, yellow perch, and longnose and coarse scale suckers. Smallmouth bass have recently been illegally introduced. Crayfish are present. The average depth rates a suitability score of 0.6 although the substrate composition of 80% silts and 20% gravel and cobble reduce the suitability for smallmouths to about 0.36. As with Loon Lake (Lincoln County), the substrate does not appear highly suitable for smallmouths and even though they have been illegally introduced, their abundance will probably be low.

Lake Five (Flathead County).-Lake Five in Flathead County is at an elevation of 3,200' in the Flathead River system. The lake is 235 surface acres with extensive littoral areas less than 20 ft (6.6 m). Maximum depth is 62 ft and average depth is 20 ft. Average pH is 8.4. Moderate amounts of littoral vegetation occur along the shoreline and some cover is provided by submerged trees. Surface water temperatures warm slowly to about 63°F in mid June, peak at about 70°F, and cool to the low 60°F by early to mid September. The estimated growing season would be about 120 days over 50°F. Crayfish are not present. Largemouth bass, pumpkinseed, yellow perch, longnose sucker and Eastern brook trout are present in the lake. Historically, some 2-3 lb smallmouth bass were present, probably a result of illegal transplants.

The habitat suitability index of water quality for Lake Five is 0.82, slightly lower than Horseshoe Lake (Lincoln County). Factors that decrease the index are the higher pH as well as low water temperatures. This index value may be inflated because of gross interpolation of temperature data. Based on the temperature data spawning would probably commence around the end of June to early July which would be similar to the time of spawning in Little Goose Reservoir, WA. The lake deserves closer evaluation because of the high suitability values. Data on substrate composition and other aspects of habitat quality for smallmouths should be examined.

Blue Lake (Flathead County).-Blue Lake at an elevation of 3,100 feet is a 12 acre lake with a mean depth of 30 ft (9.9 m) and maximum depth of 76 ft. Shoreline gradients are steep and the substrate consists of interspersed boulders and gravel. Average pH is 7.5. *Chara* beds occur along the shoreline and a few submerged trees provide in-water cover. Zooplankton abundance has been estimated to be high although the mean

August secchi disc reading is about 19'. Brook trout, rainbow trout, yellow perch, pumpkinseed, and redside shiners (*Richardsonius balteatus*) have comprised the bulk of the fish community; brook trout numbers have declined since 1969 and redside shiners have increased since 1978 (Domrose 1989). Crayfish have not been observed in Blue Lake. Summer water temperatures were considered "cool", partially related to underground springs. A mid-July (1969) temperature of 65°F suggest a cooling influence to the springs. The average depth of 30' scores a value of 1.0 on the suitability index although the cooler mid-July water temperatures suggest low water quality suitability for smallmouths. The apparent abundance of zooplankton during the summer could be a very good source of food for young bass. Substrate appears favorable also although the lower water temperatures suggest marginal habitat. Further temperature monitoring should be conducted on Blue Lake; if temperatures indicate in excess of about 850 degree days with temperatures near the minimum preferred of 70°F, this lake should be thoroughly considered for smallmouths.

Flathead Lake.-Flathead Lake is at an elevation of 2,893 feet. The abiotic and biotic habitat characteristics vary considerably within the lake (Hanzel 1970). Surface water temperatures generally warm to 50°F by the end of May and may be at or exceed 70°F in July and August and then cool to 50°F by mid-October. Water temperatures during the warmer months were similar within the first 10 feet and then decreased with depth. The north and south ends of Flathead Lake are shallower than other parts being about 120 feet in maximum depth, the west side grades from 180-300 feet, and the more precipitous east side grades up from 300 feet deep (Hanzel 1970). Most of the east shoreline drops-off precipitously while other areas gradually increase in depth towards the lake's center. A number of areas around the lake are influenced by currents from tributaries and prevailing winds.

Hanzel (1970) first reported a mixed fish community of cold, cool and warmwater species dominated by lake whitefish *(Coregonus clupeaformis)*, bull trout (*S. confluentus*), kokanee, and northern squawfish (*Ptychocheilus oregonensis*). Since then, the fish populations have undergone a change and presently have not reached an equilibrium. Lake whitefish and lake trout now dominate the large expanse of pelagic and deep water zones while yellow perch, bull trout northern squawfish and peamouth (*Mylocheilus caurinus*) predominate near shore areas (L. Hanzel, Montana Fish, Wildlife and Parks, Kalispell, Personal Communications). Other minor species found in the lake include: mountain (*P. williamsoni*) and pygmy whitefish; Westslope cutthroat trout *(O. clarki lewisi*); rainbow and brook trout; largemouth bass; northern pike; pumpkinseed; redside shiners; slimy sculpin (*Cottus cognatus*); black bullhead (*Ictalurus melas*); and, longnose and largescale suckers. Efforts are being made to restore the kokanee population through hatchery supplementation (Hanzel et al. 1988). Progressive changes in the fish population and factors affecting fish changes include: reduced reproduction of river spawning areas by hydropower discharges; over-fishing; fluctuations in lake level elevations and establishment of a opossum shrimp (*Mysis relicta*) population in the lake (Leathe and Graham 1982; Hanzel et al. 1988).

Water chemistry data indicated pH ranged from 7.9-8.3 although higher readings were measured in other sections of the lake (Hanzel

1970). Total alkalinity ranged from about 80-100 ppm and conductance was about 150-160 umhos/cm. Dissolved oxygen ranged between 7.8-12.3 ppm. Based on the reported conductivity for Flathead Lake, the total dissolved solids would be about 82-112 ppm.

Beattie and Tohtz (1990) reported high plankton populations in June and July which would coincide when smallmouth would be rising from the nest to initiate active feeding. Abundance of plankton at this time could provide a readily available food supply for the small bass. Another possible source of food for larger bass would be with crayfish that are present in the lake.

Another part of Flathead Lake that could be considered for introduction of smallmouth bass is the South Bay (Polson Bay). This area is the southern-most part of the lake being separated from the main lake by a string of islands and constricting peninsulas. The South Bay has the most extensive shallow habitat, a maximum depth of 34.8 feet and average depth of 15.1 feet. Water levels fluctuate about 10.2 feet although the lake is near full pool from May through early September (Cross and Waite 1988). Average pH is 7.8. Much of the inundated littoral areas contain gravel and cobble with some boulders although the bulk of the habitat consists of sandy cobble and muddy ooze. Water temperature data presented by Cross and Waite (1988) indicated that temperatures above 50°F occur from the second week in May and continue through about mid-October. The estimated number of degree-days >50°F was about 900, similar to the lower Flathead River.

Fish species that predominated in gill nets and accounted for greater than 90% of the catches were yellow perch, northern squawfish, and peamouth (Cross and Waite 1988). Game fishes were rare.

Based on the temperature data available, the South Bay has more suitable temperature conditions for smallmouth than the main lake. The overall suitability index for cover, however, is low (0.23) because of the shallow average depth (4.6 m) and the predominance of sandy-ooze substrate.

Limited water temperature data on Flathead Lake suggest that smallmouth spawning would be initiated in late June to early July and the growing season would extend through mid October. Water temperatures are probably similar to those in the Snake River (Figure 2). The number of degree-days exceeding 50°F would be approximately 900-1,000 with the highest temperatures slightly above the preferred temperature of adult smallmouth at 70°F.

Based on available water quality data, the suitability of Flathead Lake is about 0.92. Water temperatures below 70°F and low TDS levels decrease the suitability from 1.0. The habitat of Flathead Lake including the deep average depth is probably not a major factor because of the existence of the shallow littoral areas (Hanzel 1970). Water temperatures and other water quality characteristics in Flathead Lake are probably similar to those in Hayden Lake, Idaho where Idaho Fish and Game recently stocked smallmouth. Smallmouths in Hayden Lake are growing about 1 inch/year and actively spawning although their slow growth to the minimum size limit (14 inches) and their predation influence on stocked trout is a concern. An examination of the habitat suggests that Flathead Lake appears suitable for smallmouths. Water temperatures, although lower than optimum, would be adequate to provide the required thermal units. Overall lake productivity appears higher than some of the oligotrophic systems which could enhance the growth potential of individuals and the stock. Negative interactions between smallmouth and salmonids could occur during the spring and fall as a result of predation.

Little Bitterroot Lake.-Little Bitterroot Lake at 3,903 feet elevation is a deep (260 ft) oligotrophic system. Sparse littoral shoreline vegetation is present with some submerged trees. Substrate is predominantly fine silts (70%) with about 30% gravel and cobbles. Secchi depth is about 38-40 feet. As would be expected the zooplankton abundance is low. Water levels typically fluctuate about 3-5 feet during the year. Average depth is about 125 feet (41.3 m). Water temperatures average about 70°F through August and probably exceed 50°F for about 90 days. Other water quality characteristics such as pH is about 7.0-7.9, alkalinity is about 45-53 ppm, and specific conductance is about 234-275 umhos/in (85-100 umhos/cm). Based on the conversion from conductivity, total dissolved solids would be in the range of 47-70 ppm. The lake supports a population of crayfish of moderate abundance. The fish community consists of salmonids (rainbow trout, kokanee, Eastern brook trout), yellow perch, longnose suckers, and pygmy whitefish.

Habitat suitability of Little Bitterroot Lake is decreased by the deep average depth (125 feet/41.3 m) as well as the low water temperatures. The lower pH and total dissolved solids suggest a lower suitability for smallmouth than some other systems. High secchi disc with low total dissolved solids (suitability=0.3-0.6) suggest a low productivity index, a system too "unproductive" for smallmouth. A suitability index based on this deep system could be about 0.5. The scattered vegetation along the shoreline would be good cover for fry and fingerlings but limited cover for adults also lessens the suitability of Little Bitterroot Lake. Smaller sized materials in the substrate further detract from Little Bitterroot Lake's suitability for smallmouths.

Dog Lake.-Dog Lake in the Flathead River system is at 3,680 feet elevation. Moderate vegetation along the shoreline and some submerged trees would provide cover. Substrate is about 80% fines and 20% gravel and cobble. The maximum depth is about 25 feet and mean depth is about 10 feet. Secchi disc depth in August is about 13 feet, which is compatible with the moderate zooplankton abundance. Dog Lake currently supports mainly coolwater fishes. Northern pike, northern squawfish, yellow perch, are the coolwater species and Eastern brook trout are also present. Other non-game species are: longnose sucker (*C. catostomus*), largescale sucker (*C. macrocheilus*), redside shiners, and peamouth. Crayfish are not known to be present in Dog Lake. Water temperatures in mid-July were about 69°F, pH was 8.3 and conductivity was 446 umhos/in (162 umhos/cm). Based on the specific conductance, the total dissolved solids would be about 90-115 ppm. These temperatures would probably warm to about 70°F through August.

The suitability of Dog Lake is difficult to evaluate based on especially limited water temperature data. The high water temperatures of 70°F make this lake appear suitable for successful fry rearing and development of strong year-classes. The average depth of 10 feet, however, rates low on the suitability index (0.25) as does the high proportion of fines (0.36). The recommendation for making smallmouth substrate and shallow average depth.

Lake Blaine (Flathead County).-Lake Blaine, at 2,990 feet elevation, is another deep lake being about 140 feet deep and averaging 60 feet (18 m). Limited water temperature data suggest that water temperatures average about 70°F in August and probably exceed 50°F for about 90 days. Average pH is 8.3. Moderate shoreline aquatic vegetation is present in littoral areas and some submerged trees provide cover. Substrate is predominantly fines (80%) although the remainder is gravel and cobble. A natural water level fluctuation of 5 feet occurs as a result of seepage and evaporation during the drier seasons. Largemouth bass, yellow perch, pumpkinseed, kokanee, lake trout, northern pike, Eastern brook trout, northern squawfish, peamouth, longnose sucker, largescale sucker, and lake whitefish make up the fish community. Crayfish are not present.

As with many of these other lakes that have an average August temperature of 70°F, the rearing capability for smallmouth is marginally suitable. Water quality suitability is reduced slightly as the pH is above 8.0. The deep average depth (60 feet) also decreases the habitat suitability to about 0.5 and the predominant silt substrate also rates low (0.36). In-water cover may be limited for larger fish although the vegetation along the shoreline could provide cover for smaller bass. The finer substrate detracts from the suitability of Lake Blaine.

Rivers

Lower Flathead River.-The lower Flathead River changes in physical habitat from the tailwater at Kerr Dam to the confluence at the Clark Fork River. The first 4.4 mi (7km) is characterized as steep rocky canyon with high water velocity. Gradient here is approximately 8 feet/mi (0.15%) with the substrate consisting of a boulder-bedrock mixture with cobble and gravel (DosSantos et al. 1988). The river widens downstream with highly eroding banks; the river is a smooth glide with a silty-bedrock bottom. River gradient here is about 3.2 feet/mi (0.06%) and becomes progressively less downstream to the confluence with the Clark Fork River. Closer to the Clark Fork, the lower Flathead River has backwaters and islands and more gravel substrate. Water temperatures average about 54°F for June, attain a summer high of 72°F in August and cool to about 50°F by the second week in October (DosSantos et al. 1988). In total, the river on the average has about 900 degree-days >50°F with an estimated high of 1250 to a low of 675. Crayfish have been observed in the river.

Habitat suitability of the lower Flathead River is affected by the substrate of silty-bedrock and the lower gradient in the lower river. Both of these substrates rate lower on the suitability scale (0.2) than gravel and boulders. The gradient of 0.15% is highly suitable in the upper section but decreased gradient in the lower river reduces its suitability (0.6). Overall, based on the riverine habitat model for smallmouth, the suitability index for cover would be about 0.6. Water temperatures are suitable; spawning would probably occur from early to mid-July and on a warm year bass would probably grow into October. The lower Flathead River although cooler is comparable in substrate to the Umpqua River, OR. Suitablity varies with location in the river because of lower gradients and finer substrates. Overall, the lower Flathead River appears capable of supporting smallmouths.

Pleasant Valley Fisher River.-The Fisher River, a tributary of the Kootenai River, is lake outlet in origin and remains under the influence of the surface lake water for about 11 miles. The substrate composition is about 50:50 gravel and cobble and changes more to a gravel substrate further downstream. Pools have a sandy substrate, comprise about 50% of the stream section and average about 3 feet (0.99 m) in depth. Stream gradient changes from 0.95% in the first 2 miles, 3.31% in the next 2 miles, 0.68% in the next 6.8 miles and about 0.66% further downstream. The available temperature record from 1976, 1980 and 1985 suggest year to year variation but temperatures generally do not attain the preferred adult temperature of 70°F in some years and not until mid-July during other years (Figure 7). Water temperatures warm early and generally exceed 60°F, the expected water temperature for spawning by early July. Water temperatures in August average about 64°F and exceed 50°F for about 120 days. The fish community consists of Eastern brook trout, mountain whitefish, dace (*Rhinichthys* spp.), rainbow trout, longnose and largescale suckers, redside shiners, and sculpins. No crayfish have been observed in this river.

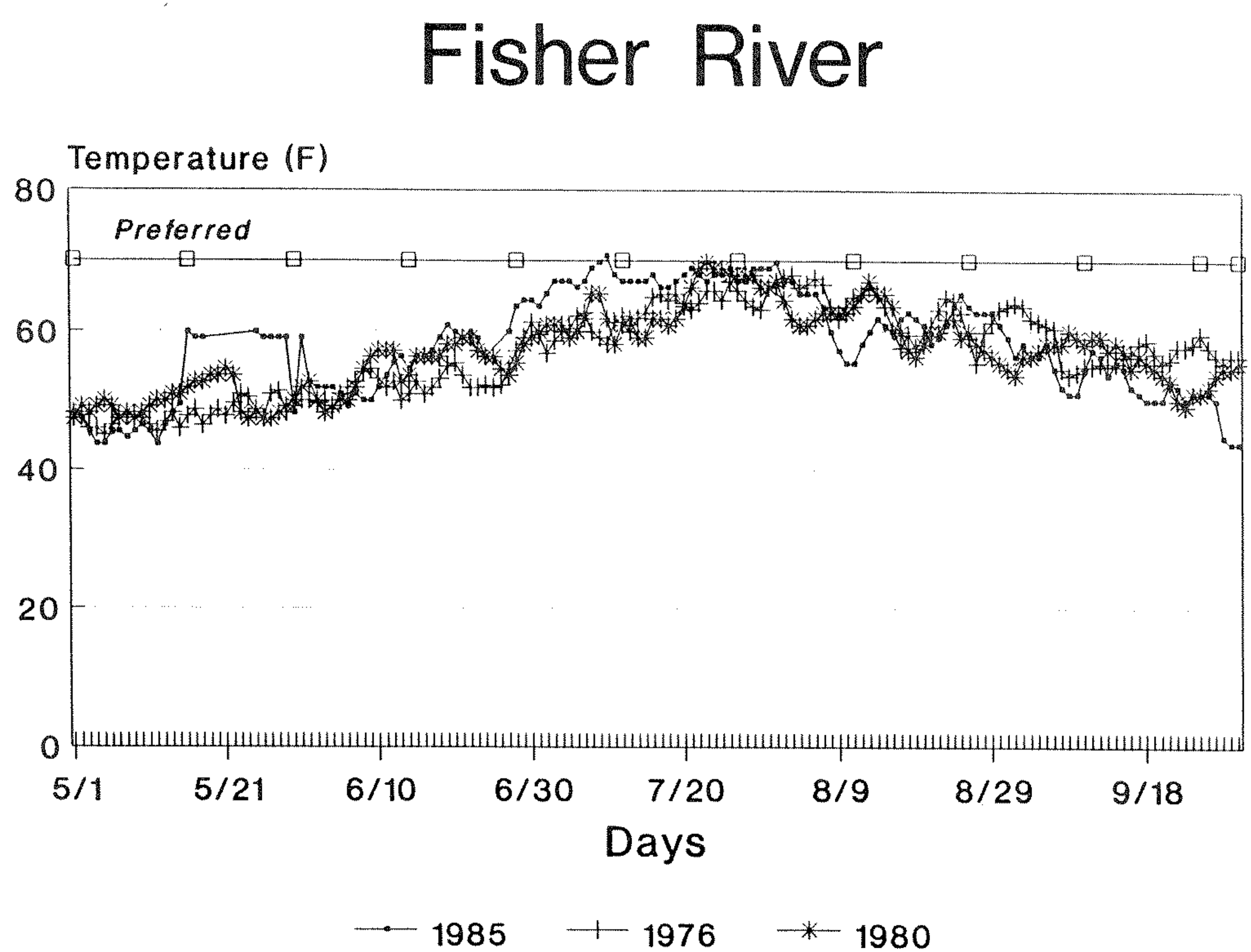


Figure 7. Surface water temperatures for Fisher River, Montana for 1976, 1980, and 1985. The "preferred" water temperature for smallmouth bass is indicated.

The presence of smallmouth bass in Loon Lake (Lincoln County) immediately upstream of the Pleasant Valley Fisher River does provide access. However, none have been reported to date. The suitability of the Pleasant Valley Fisher River for smallmouth bass is enhanced by the high quality substrate and the frequency of pools. Stream gradients in the range of 0.66%-3.31% are excessive for smallmouth and decrease the Fisher River's suitability to 0.6. The shallow average depth of pools (<3 feet) also decreases the suitability to an index of about 0.5. Water temperatures less than the adult preferred temperature of 70°F make this a highly marginal river for smallmouth rearing. Spawning, based on the available temperature record, would probably occur about the first of July, followed by low rearing temperatures in August, would probably result in small young-of-the-year smallmouth going into the first winter and high over-winter mortality. Lower rearing temperatures would probably result in smaller growth increments although substrate of the Pleasant Valley Fisher River is more suitable than many areas being assessed.

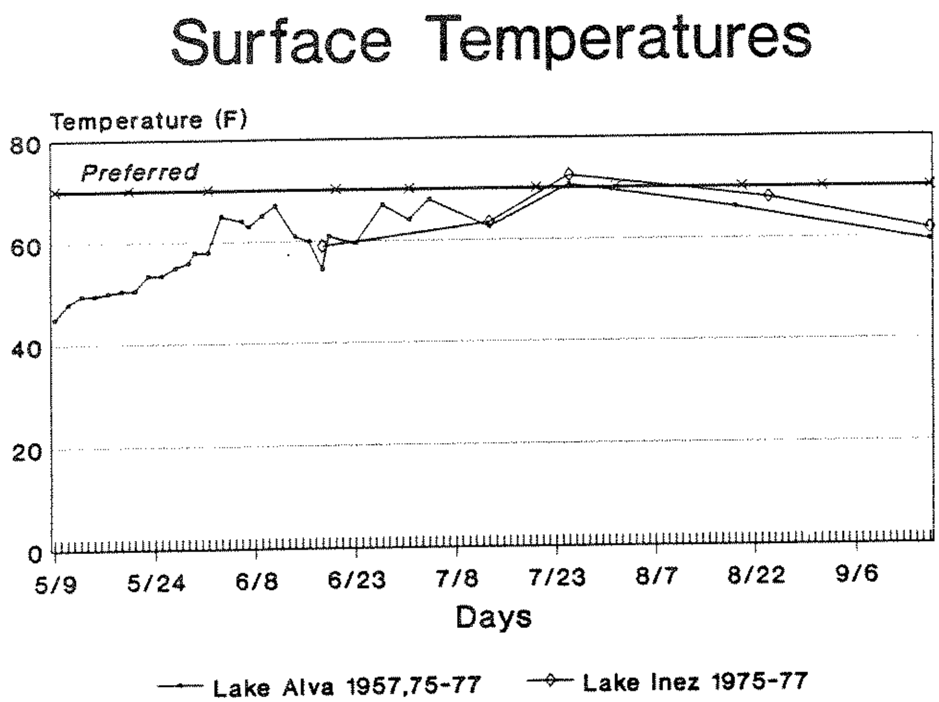
Stillwater River.-The Stillwater River, a tributary of the Flathead River, originates as a lake outlet which accounts for the warmer summer temperatures of 70°F during August. Water temperatures extend above 50°F for an estimated 120 days. Substrate consists of gravel to boulders in the upper 15 miles to silt and clay downstream. Summer turbidity is moderate. Pool area is about 30% and pools average about 8 feet (2.6 m) in depth. Average depth is 5 feet. Stream gradient is about 2% and the resultant velocity is about 1 feet/sec. Average pH is 7.85. A mixed fish community inhabits this river consisting of salmonids (lake trout, westslope cutthroat trout, Eastern brook trout, bull trout, and mountain whitefish), yellow perch, northern pike, northern squawfish, peamouth, longnose and largescale suckers, redside shiners, and sculpins. Crayfish have not been reported in the Stillwater River.

The habitat suitability of the Stillwater River is enhanced by the gravel-boulder substrate in the upper 15 miles and the average pool depth (8.5 feet). The lower percent pools (30%) decreases the index to about 0.4. Water temperatures are within the suitable range of 70-84°F although on the low part of the range which decreases the rearing potential for smallmouth bass. Other habitat characteristics such as pH are favorable for smallmouth except turbidity. Turbidity less than 30 JTU's would not decrease its suitability while higher turbidities would decrease the suitability for smallmouth. The Stillwater River has favorable substrate, pool riffle configuration, and water temperatures that appear suitable for smallmouths. More water temperature data should be collected to better assess the suitability of the Stillwater River.

Candidate Waters Region 2

Lakes

Alva.-Lake Alva is one of the Clearwater chain lakes. Data from gill netting in 1982 indicated that yellow perch dominated the system (Peters 1982). Crayfish are present. The lake is generally more oligotrophic than some farther downstream on the chain. Water temperatures warm more slowly, peak earlier and cool faster than the Snake River although limited temperature data are available (Figures 2 & 8). Highest water temperatures are about 70°F although they cool quickly after mid-July to about 60°F the end of September. Based on the limited temperature data, water temperatures exceeding 60°F would enable spawning to occur early in June although temperature decreases might result in nesting failure (Figure 8). This decrease in temperature may be related to a cold frontal system during the limited years of data collection or be representative of the actual thermal characteristics of Lake Alva. Overall, the length of the growing season for smallmouths would be about 150 days and the degree-days would be about 925. Because of limited water quality data and habitat data, more detailed assessments are not possible at this time. These data should be collected to make a more in-depth assessment because based on existing water temperature, Lake Alva is suitable for smallmouths. Other water quality data should be collected such as total dissolved solids, pH and physical habitat



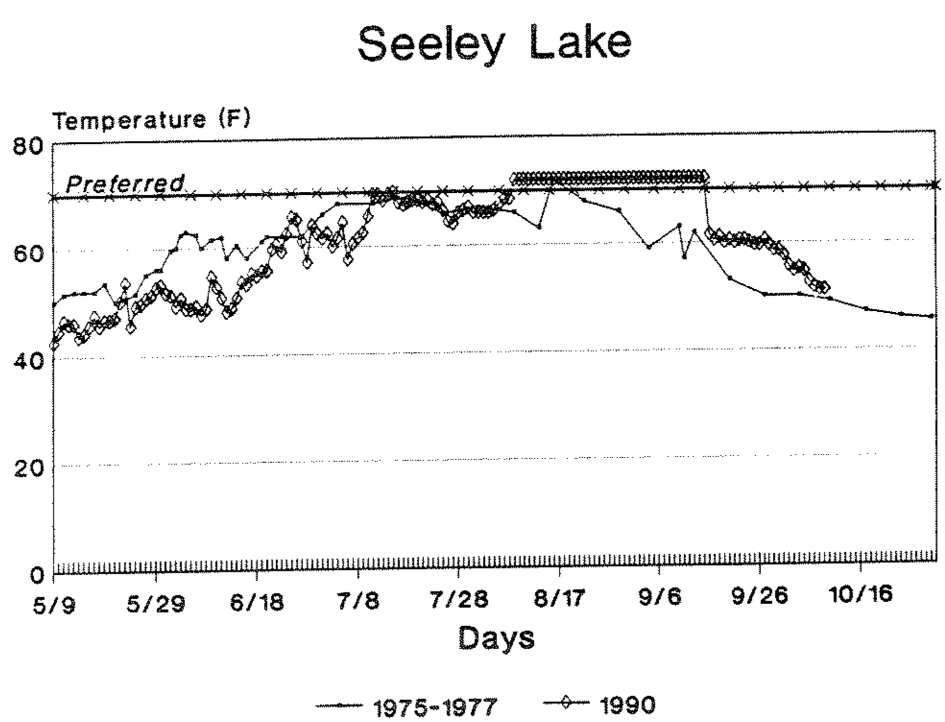


Figure 8. Surface water temperatures for Lake Alva, Lake Inez, and Seeley Lake, Montana. The "preferred" water temperature for smallmouth bass is indicated.

information to provide a clearer picture of the suitability of Alva Lake. Being oligotrophic, however, may severely limit food availability, especially zooplankton, for young bass.

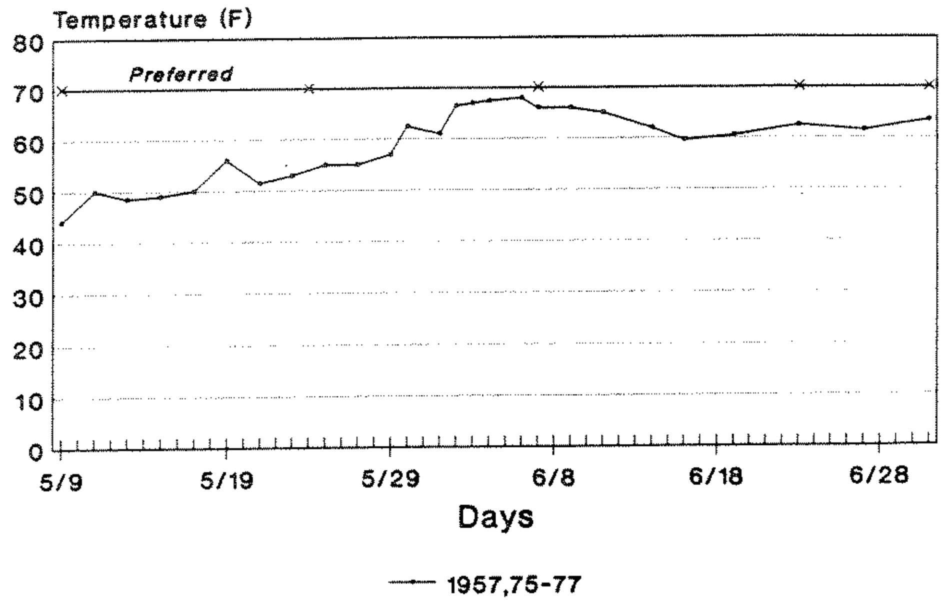
Inez.-Lake Inez is the next lake downstream from Lake Alva on the Clearwater chain. Like Lake Alva, it too is oligotrophic. Water temperatures are similar to Lake Alva although slightly higher with the highest temperatures attaining about 70°F (Figure 8). Fishery surveys conducted during 1982 (Peters 1982) and 1986 (Peters 1985) have shown that the lake is dominated by yellow perch, plus abundant pumpkinseeds and suckers. Peters (1985) indicated that several Yellowstone cutthroat trout appeared in the recent survey. Crayfish are present in Lake Inez. A thorough analysis of Lake Inez is difficult with the limited data base. The thermal characteristics appear suitable but more data are needed. As with Lake Alva, more information should be collected to objectively evaluate its suitability for smallmouths.

Seeley.-Seeley Lake is an 863 acre glacial lake, larger and more fertile than Alva or Inez. Maximum depth is 115 feet and mean depth is 60 feet (Cladouhos 1971). The bottom is largely silty with numerous logs that sank during the early 1900's from log drives. Cladouhos (1971) reported a mean pH of 8.0 and maximum temperatures of 75°F. Water temperature records for Seeley Lake were variable between 1975-77 and 1990 (Figure 8). Turbidity during 1970-71 ranged from 1-18 JTUs. Excessive growths of aquatic macrophytes have been a problem in Seeley Lake for several decades and probably inhibit plankton production (Cladouhos 1971). Trout were rare in the 1973 and 1982 gill net surveys (Peters 1982).

Yellow perch were about equally abundant in both surveys and were present in a 1986 survey. A 1988 survey showed that northern squawfish outnumbered salmonids in the lake (Peters 1985). Kokanee and rainbow trout have been planted in the lake. The planting of Yellowstone cutthroat was considered successful in 1985 by Peters (1985). Crayfish are present. Based on available temperature data, spawning of smallmouths would occur from early June to early July. Cooling can occur as early as mid-August and water temperatures suitable for growth extend about 120 days through September. Seeley Lake has about 820 degree-days. Based on the number of degree-days, I consider Lake Seeley very marginally suitable for smallmouths. Coble (1967) indicated the lowest number of degree-days to be 848 and on the average water temperatures in Lake Seeley would not appear to provide sufficient thermal units for good recruitment and growth. Also, macrophyte development and smallmouth bass are not usually compatible which further suggests low suitability.

Placid.-Placid Lake, surveyed by gill netting in 1981 and 1982, contains a high proportion of non-game species. Northern squawfish and peamouth were most abundant during the 1982 survey (Peters 1982). Yellow perch were also present during the 1982 survey. Crayfish are present in the lake. Water temperatures for Placid Lake indicate a warming in mid May through early June but maximum water temperatures are less than the preferred adult temperature of 70°F (Figure 9). The last temperature record in June suggested that temperatures peaked but more data are required to assess the overall quality of this system. Further

Placid Lake



Salmon Lake

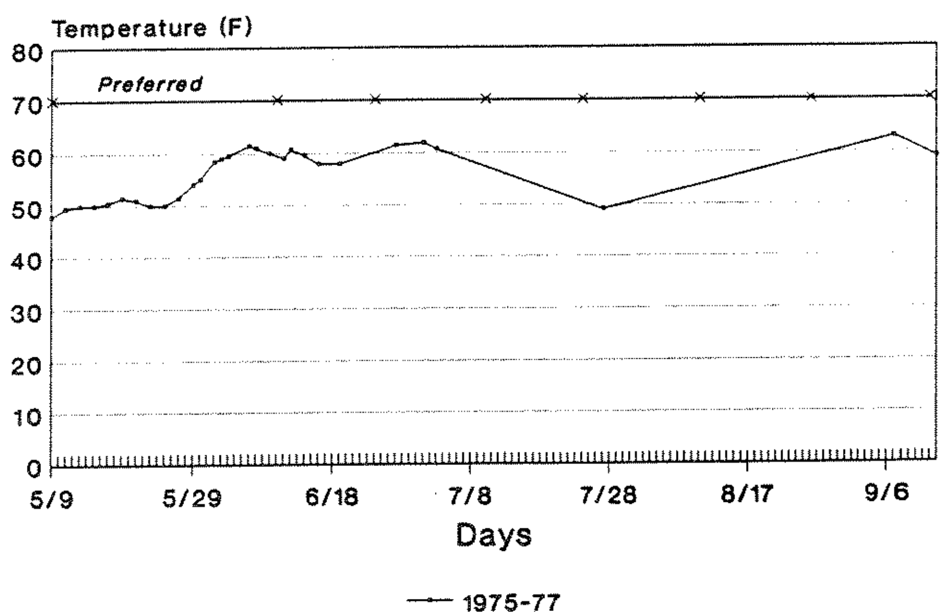


Figure 9. Surface water temperatures for Placid Lake and Salmon Lake, Montana. The "preferred" water temperature for smallmouth bass is indicated.

temperature data are required to more completely assess the suitability of Placid Lake for smallmouths.

Salmon.-Northern squawfish and peamouth dominated gill net catches in a 1982 survey of Salmon Lake (Peters 1982). Yellow perch were also present although the mean size was less than 6 inches (15 cm). Six large brown trout were sampled also in that survey. Crayfish are present. Water temperature data for Salmon Lake are limited but suggest a more rapid warming in early June followed by a more rapid cooling in the fall. The lack of warming beyond the 61-64°F (Figure 9) temperature suggest that smallmouth spawning might not occur in Salmon Lake. Even if spawning did occur, the effect would be fewer temperature units resulting in a growing season shorter than some of the other systems currently being examined.

Complete habitat suitability of all of the Clearwater Chain Lakes is difficult to assess with scanty habitat and morphometric data. Water temperatures are probably one of the keys to the success or failure of a smallmouth bass introduction. Surface water temperatures generally warm faster than the Snake River (Figure 2) but do not appear to continue to increase as those in the Snake. Also, temperatures increase and then decrease several °F in the spring which may cause nest desertion during the spawning season. During some years, however, these fluctuations probably would not occur and successful reproduction could result. The rapid cooling in the lake, probably the result of the high elevation, would shorten the growing season and contribute to smaller growth increments.

Rivers

Clearwater River below Salmon Lake.-The Clearwater River below Salmon Lake occupies a channel through glacial till and glacial outwash (Anonymous 1990). The river has similar thermal characteristics as Salmon Lake and probably exceeds optimum temperatures for salmonids although cold ground water refugia exist. Waters reportedly warm to as high as 80°F during the later part of July and August. Substrate consists of sands to boulders with moderate silt deposits. The game fish community consists of rainbow and brown trout (*Salmo trutta*) with some whitefish. Crayfish are present in the Clearwater River.

As with the rivers under consideration for smallmouth bass introduction in Region 1, the river gradient, pool abundance and depth, substrate, and water temperature all contribute to the suitability of the Clearwater River. Based on the reports that river temperatures are >80°F, water temperatures would be near optimum for smallmouth bass. Deeper pools would enhance the river's suitability. Sandy substrate and silt would not be favorable for smallmouth, however, and rate a low suitability index value (0.2). Stream gradients from 0.10-0.45% are the most suitable for smallmouth. Based on the available morphometric and water quality data, the Clearwater River would be one system that deserves further analysis of its potential.

Clark Fork River below Missoula.-Much of this habitat is characterized by runs about 8 feet in depth and pools exceeding 15 feet deep. Further downstream the river widens and riffle habitat becomes less common. The Clark Fork River is about 250-500 feet wide in this section. Numerous non-game species inhabit this section including suckers, northern squawfish, and dace and sculpins in lesser abundance. Rainbow trout comprised about 80-89% of all trout in 1984 (Peters 1985) and provide the bulk of the sports fishery (Johnson and Schmidt 1988). Peters and Spoon (1989) reported large bull trout in the section near the inflow of the Blackfoot River. Smallmouth bass have been recently found in the Clark Fork River as a result of illegal transplants. Crayfish are present.

Habitat suitability of the Clark Fork River is related to existing water temperature and other significant habitat attributes. Based on water temperatures near 70-72°F and the present water quality in the river, the preliminary suitability of water quality of the Clark Fork is good (0.9). Water temperatures exceed 50°F from about early June through September which would provide about 120 days for growth (Figure 10). Growth rates of smallmouth bass in Noxon Reservoir exceed those of the Snake River although water temperatures in the reservoir are probably higher than those upstream in the river. Cover, although not known for the river, also would affect the suitability of the Clark Fork. Pool depths of 16 feet and a stream gradient of 0.16% are optimum for smallmouth. The only apparent habitat limitation is water temperature. The estimated number of degree-days >50°F of 825 is lower than any population Coble (1967) evaluated for growth comparisons. If a

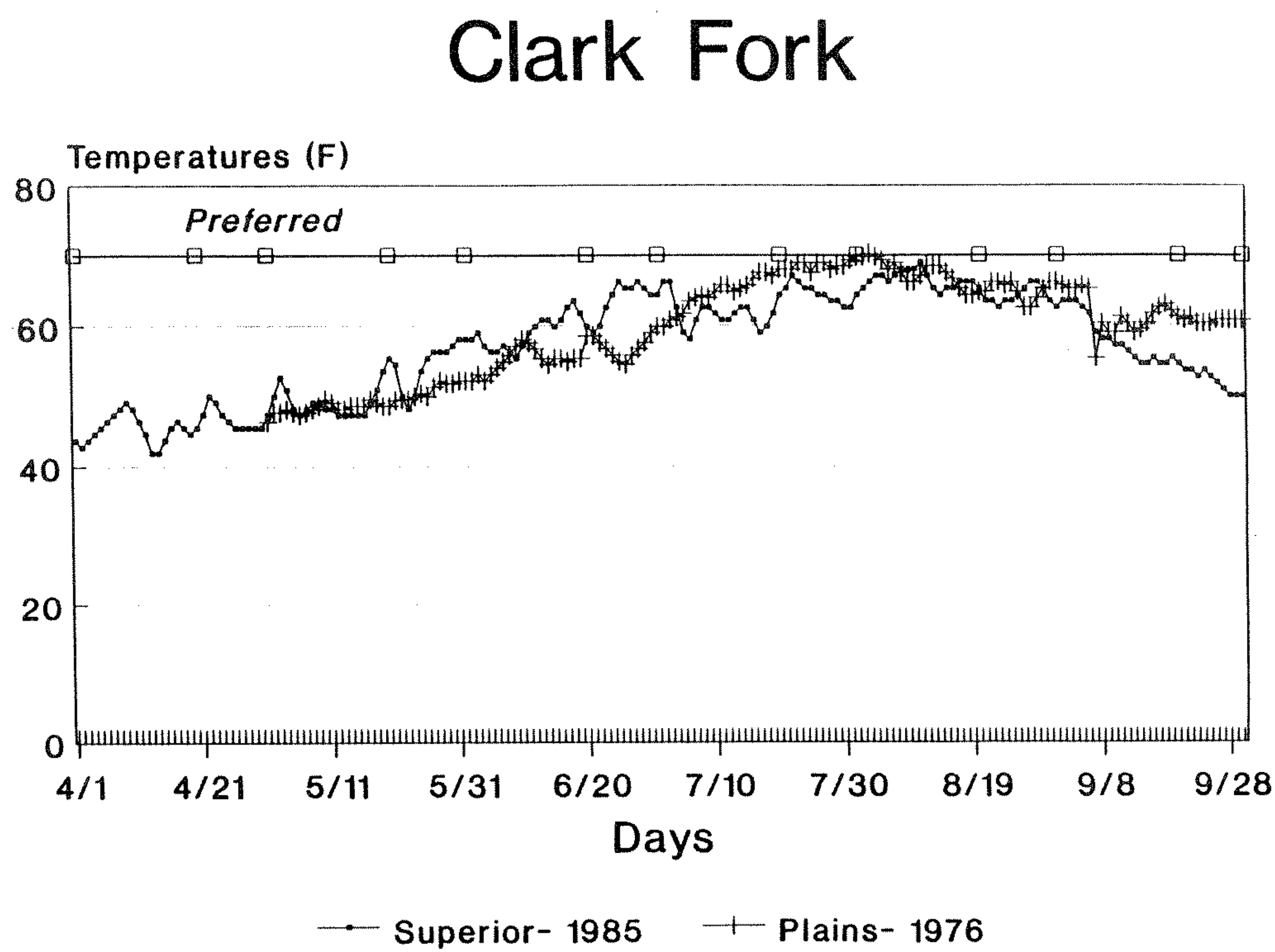


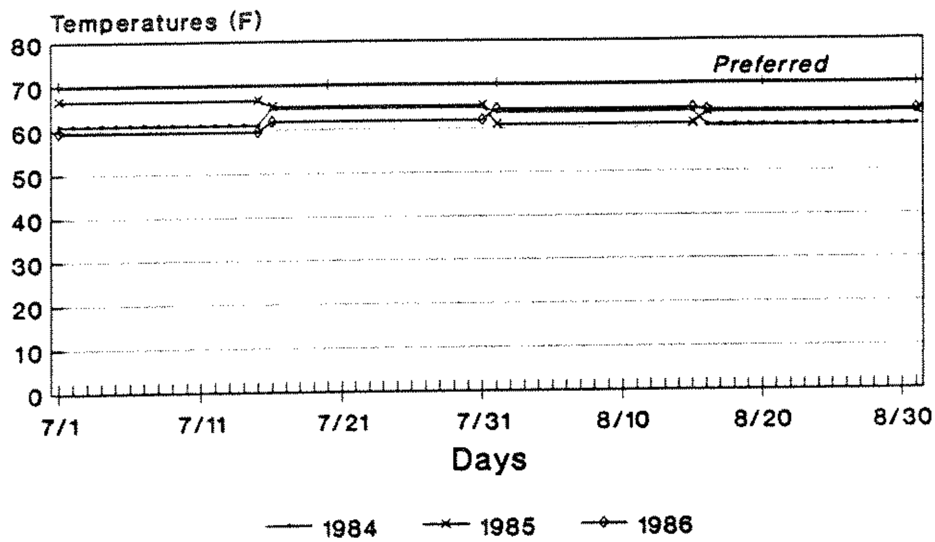
Figure 10. Surface water temperatures for Clark Fork River, Montana from the Plains and Superior monitoring stations for 1976 and 1985. The "preferred" water temperature for smallmouth bass is indicated.

section of the Clark Fork River were warmer than the two reporting stations at Superior and Plains, then smallmouth should be strongly considered for introduction into those sections. However, based on the present temperature data for 1976 and 1985, water temperatures would probably preclude successful establishment of a widespread population with the result being small localized "pockets" of bass at warmer locations (i.e. eddys, warm tributary inflows, etc).

Bitterroot River below Florence Bridge.-Physical habitat is similar to that of the Clark Fork River although suspended sediments are lower than in the Clark Fork. Johnson and Schmidt (1988) reported that the highest water temperatures in the Bitterroot River was 74°F. However, Spoon (1987) reported that highest water temperatures were in the middle section (Hamilton) and actually were lower near the mouth. Spoon's (1987) temperatures were variable among 1984-1986 but indicated temperatures were in the 60's°F from early July and returned there by later August. Highest temperatures reported by Spoon (1987) were 70.4°F. Water temperature data available for the Bitterroot at Darby indicate water temperatures would probably limit smallmouths in that section (Figure 11). Downstream near Hamilton, water temperatures increase and during some years exceeded the preferred 70°F temperature during July (Figure 11). Unfortunately, water temperatures before July were not available for the Bitterroot River which makes further assessments difficult.

Bitterroot River

Darby



Hamilton

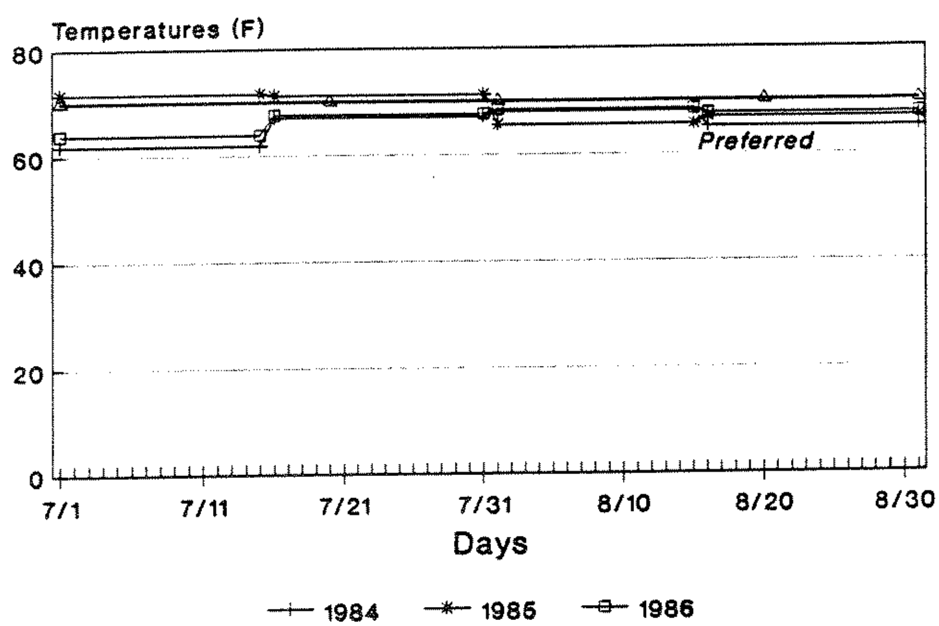


Figure 11. Surface water temperatures for Bitterroot River, Darby, and Hamilton, Montana for 1984, 1985 and 1986. The "preferred" water temperature for smallmouth bass is indicated.

In the lower reaches near Missoula, the Bitterroot averages about 0.57% gradient. The streambed has large beds of deposited gravel and numerous side channels (Spoon 1987). Depth is shallow although good instream cover is available. Upstream of this section the river is dewatered. Rainbow and brown trout numbers are generally low in this section.

The suitability of the Bitterroot River based on the gravel substrate, and gradient is high for smallmouth bass. Water temperatures are below the preferred for smallmouth bass, as in the Clark Fork River, decrease its suitability from 1.0. River gradient is suitable but depth and pool characteristics are not known from existing information. Percent instream cover around 25-50% are necessary for the most suitable habitat conditions along with percent pools of 50-75%. Depth of pools from about 5-16 feet is the most suitable habitat for smallmouth in riverine systems. Crayfish are present for food. Based on the data available, the Bitterroot River should be more closely examined to assess its complete suitability for smallmouths. Additional data collections should be conducted to further evaluate the suitability of the Bitterroot River as this data set suggests good suitability for smallmouths.

Blackfoot River below Clearwater River.-River gradient is moderate in this section (14.8 feet/mi) with a few higher gradient areas (Peters and Spoon 1989). Boulders and rubble sized particles dominate the substrate. The runs are usually deep with deep pools flowing into broad riffles with high current velocities. Peters and Spoon (1989) indicated that water temperatures were above 68°F for 38 days in this section of the Blackfoot River. Johnson and Schmidt (1988) reported the highest water temperatures recorded in this river to be 70°F although Peters and Spoon (1989) reported highs near 75°F during 1988. Using Peters and Spoons's data, the Blackfoot River would have about 680 degree-days above 50°F. Temperature data from 1988 suggest favorable temperature conditions that actually exceed the preferred 70°F from the later part of July and most of August (Figure 12). Water temperatures before mid-July, 1988 were not available. However, water temperatures in 1988, a drought year, were about 5°F higher than during the 1960's and 1970's. If water temperatures were abnormally high in 1988, the number of degree-days for a "normal" year would be considerably lower for the Blackfoot River.

Rainbow, cutthroat and bull trout reside in this section. Numerous smaller rainbows were sampled in 1985 although the data suggested high mortality and/or migration from this area. The high numbers of small rainbow trout suggested that recruitment was not limiting the trout population in this section of the Blackfoot River. Large fluvial bull trout frequent this lower reach and the Clark Fork River (Peters and Spoon 1989).

Substrate with large boulders and gravel provide optimum habitat in the Blackfoot River. River gradient of 0.3% is optimum for smallmouth. Instream cover would be provided by the boulders although additional cover from logs, root wads, etc. is not known. Based on the available data, the Blackfoot River has questionable water temperatures but favorable river gradient and substrate for smallmouth bass. Crayfish presence is not known. Cursory analysis of the Blackfoot River suggests that additional water temperature data for a "normal" flow year

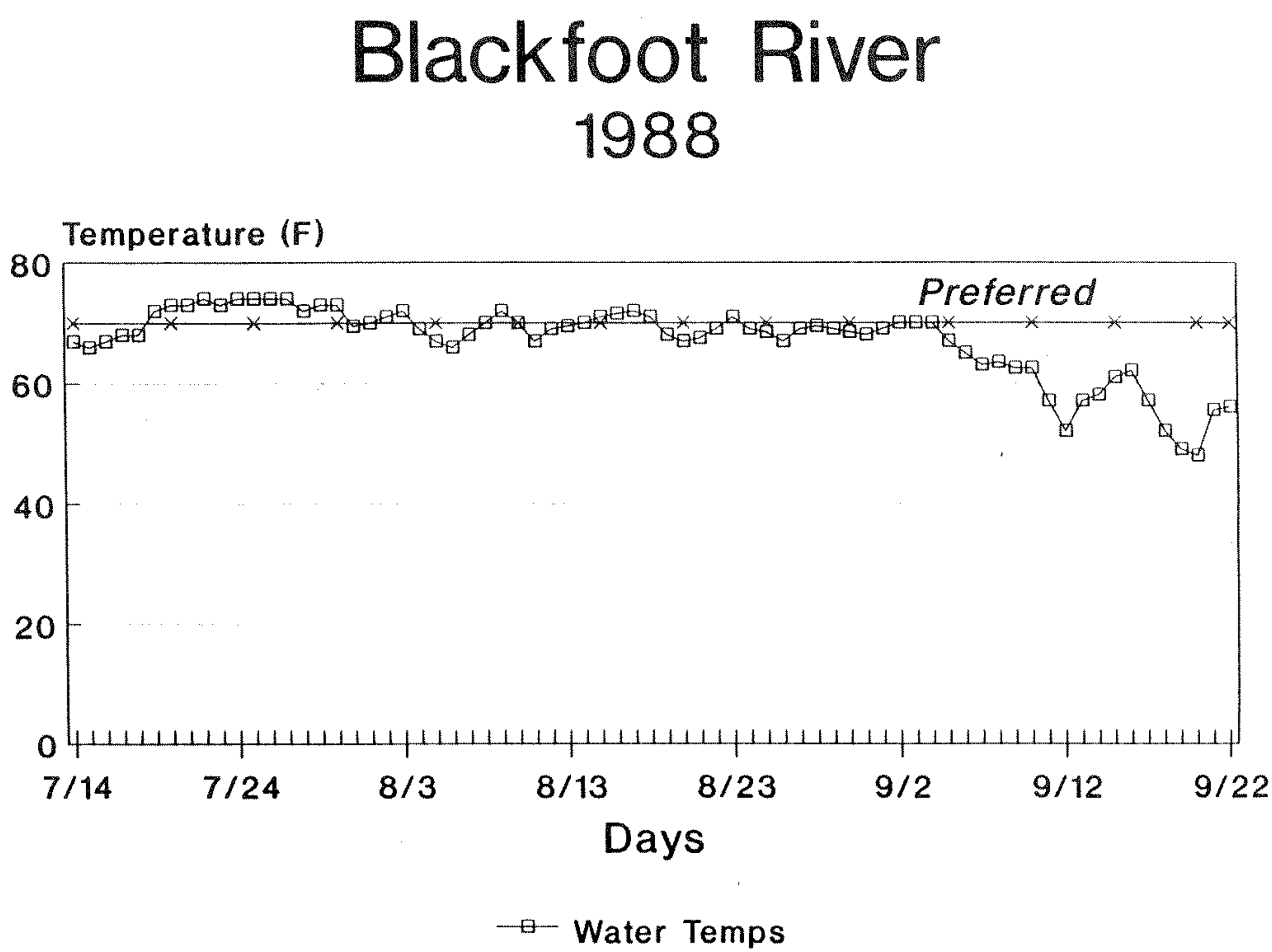


Figure 12. Surface water temperatures for Blackfoot River, Montana for 1988. The "preferred" water temperature for smallmouth bass is indicated.

are needed for a more thorough assessment of suitability for smallmouth bass. Available data, however, suggest that further study should be conducted.

Summary of Systems under Consideration

The importance of adequate temperature conditions must be recognized with any fish introduction. Optimum water temperatures for smallmouth bass are from 78-82°F. As indicated, growth is reduced about 50% at 72°F from that of optimum for juveniles and adults. Growth of smallmouth bass appears good within Noxon Reservoir, actually in excess of that in the Snake River. The present rapid growth, however, will probably decrease once the population matures and growth probably will be similar to that observed in the Snake River.

The most critical aspect of water temperature, however, is that of affecting year-class strength. In the northern part of the native range, year-class strength is correlated with water temperature. Numerous authors implicated the importance of water temperature, from Virginia to Ontario. Less than optimum water temperatures will result in variable year-class strength; during warmer years, stronger year-classes will be produced that will support the fishery. Cooler years will result in weak year-classes with no significant contribution to the fishery. Low water temperatures will also result in slow growth. However, if natural mortality were low as estimated (@ 14%), and bass have the potential to exceed 12-15 years of age, larger bass would occur in the population.

RECOMMENDATIONS

Region 1

Highest Potential	Proposed Action
1. Flathead Lake	Consider Introduction
2. Lower Flathead River	Consider Introduction

High Potential	
1. Loon Lake (Lincoln County)	Collect/ Interpret Water Quality Data
2. Lake Five (Flathead County)	Collect Substrate/Cover Data
3. Blue Lake (Flathead County)	Collect Temperature Data
4. Pleasant Valley Fisher River	Collect Water Quality Data
5. Stillwater River	Collect Water Quality Data

Low Potential

1. Horseshoe Lake (Lincoln County)
2. Horseshoe Lake (Lake County)
3. Loon Lake (Lake County)
4. Upper Thompson Lake (Lincoln County)
5. Little Bitterroot Lake
6. Dog Lake
7. Lake Blaine (Flathead County)

Region 2

Highest Potential	Proposed Action
1. Blackfoot River	Collect/Interpret Water Temperature Data-if Favorable Consider Stocking
2. Bitterroot River	Collect/Interpret Physical Habitat Data and Refine Water Temperature Data
3. Clark Fork River	Collect/Interpret Physical Habitat Data and Refine Water Temperature Data
4. Clearwater River	Collect Additional Physical/Chemical Habitat Data
5. Lake Alva	Collect/Interpret Water Quality Data
6. Lake Inez	Collect/Interpret Water Quality Data

Low Potential

1. Seeley Lake
2. Salmon Lake

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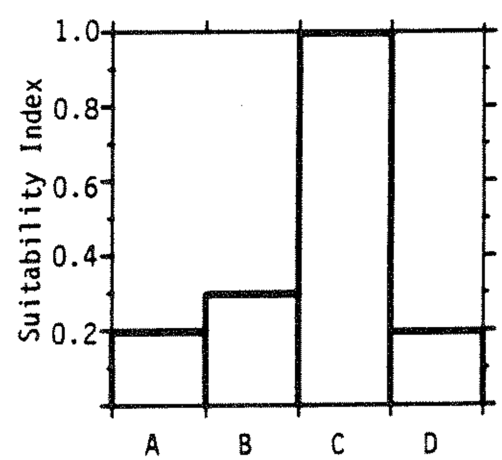
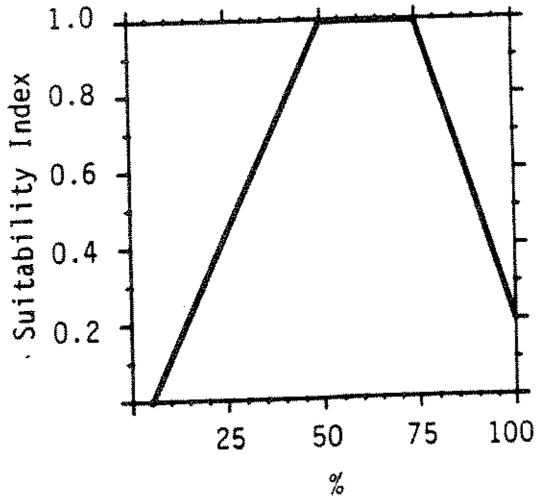
Appendix Table 1. Suitability index (SI) graphs for smallmouth bass mode variables (Edwards et al. 1983).

Suitability Index (SI) Graphs for Model Variables

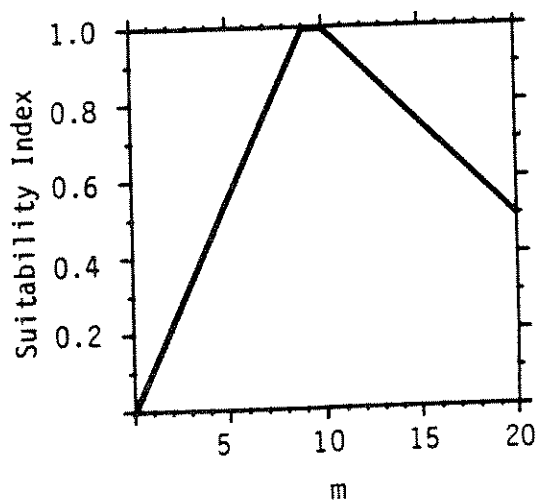
This section contains suitability index graphs for the 15 variables described above and equations for combining the suitability indices for these variable indices into a species HSI using the component approach. Variables may pertain to either a riverine (R) habitat, a lacustrine (L) habitat, or both.

Habitat	Variable		Suitability Graph
R,L	V_1	Dominant substrate type within pool, backwater (R), or shoal area (L). A. Silt and sand (< 0.2 cm) and/or rooted vegetation B. Pebble (0.2-1.5 cm) C. Gravel, broken rock (1.6-2.0 cm), and boulder with adequate interstitial space D. Bedrock	

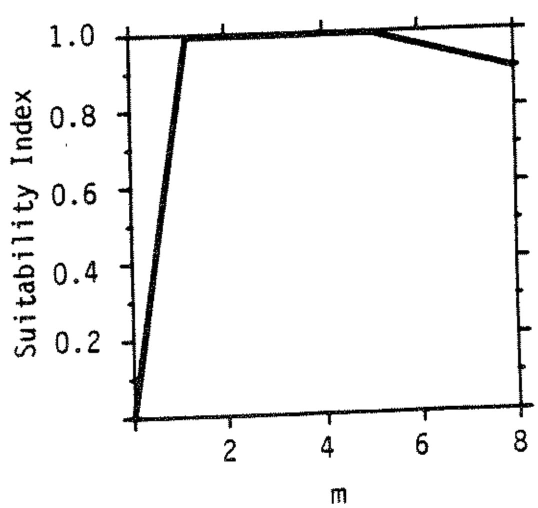
R V_2 Percent pools.



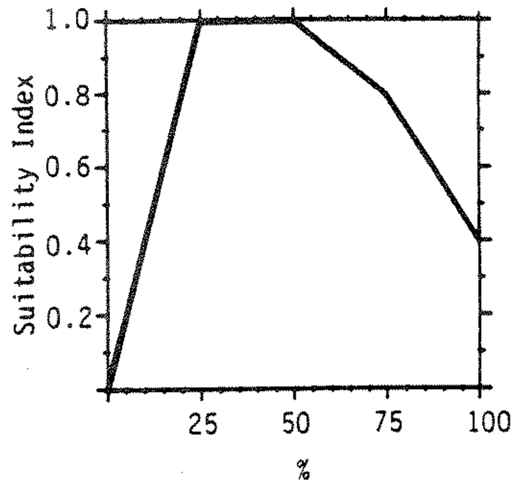
L V_3 Average depth of lake or reservoir during midsummer.



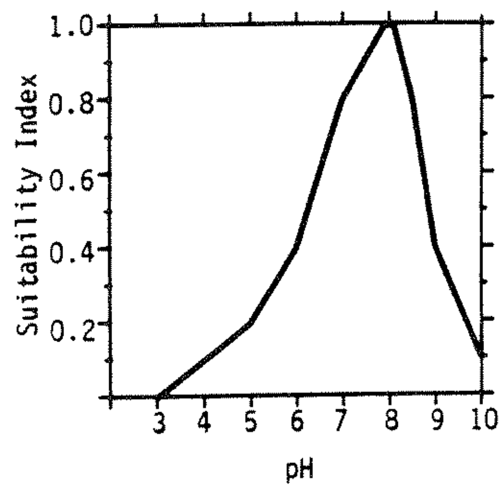
R V_4 Average depth of pools during midsummer.



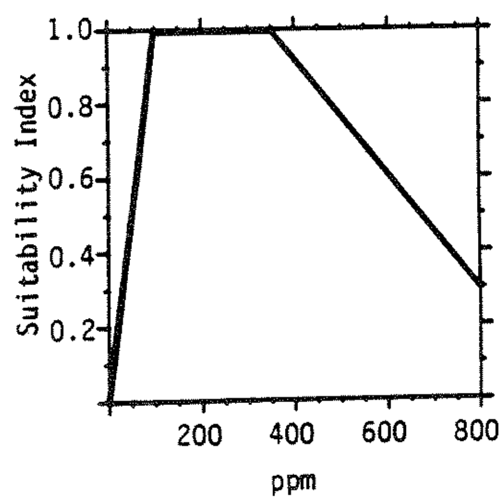
R,L V_5 Percent cover in the form of boulders, stumps, dead trees, and crevices (adults) or vegetation and rocks (fry).



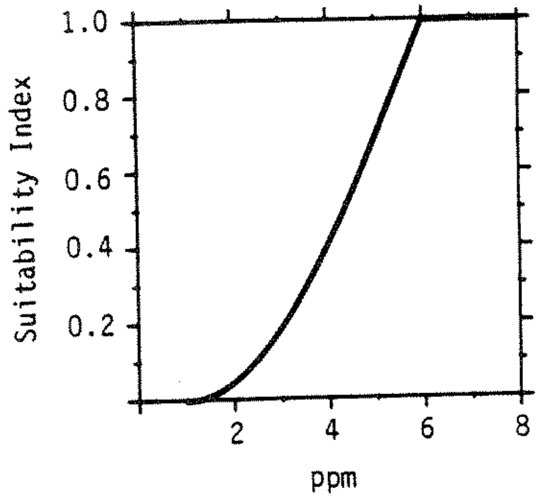
R,L V_6 Average pH level during the year.



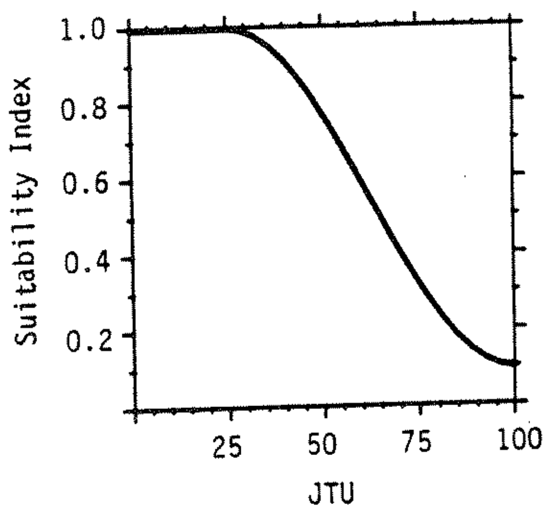
L V_7 Average TDS level during the growing season (May to October).



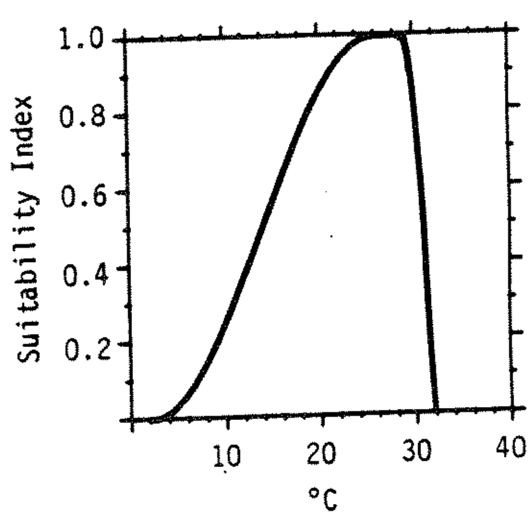
R,L V_8 Minimum dissolved oxygen level throughout the year.



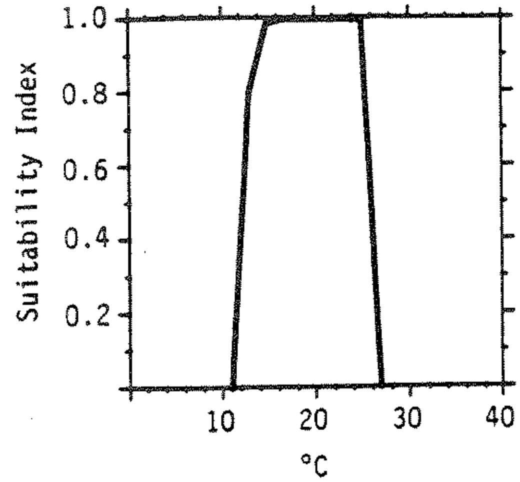
R,L V_9 Maximum monthly average turbidity level during the summer.



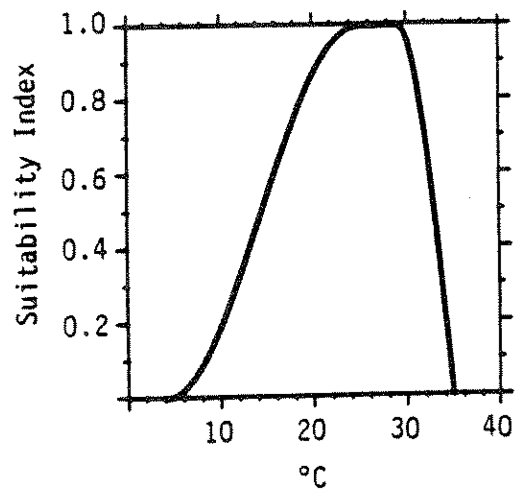
R,L V_{10} Water temperature in selected habitat during the growing season (May to October) (adults).



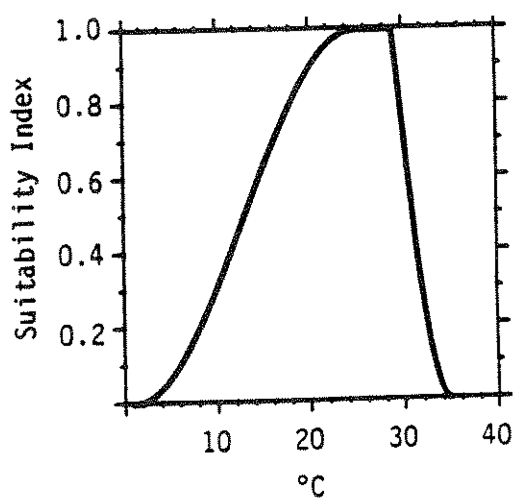
R,L V_{11} Water temperature in selected habitat during spawning and for 45 days afterwards (embryo).

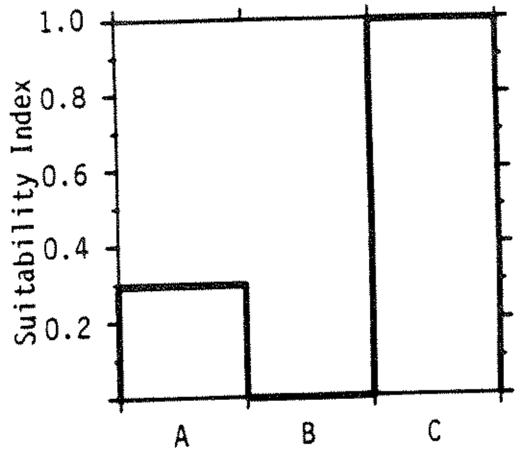
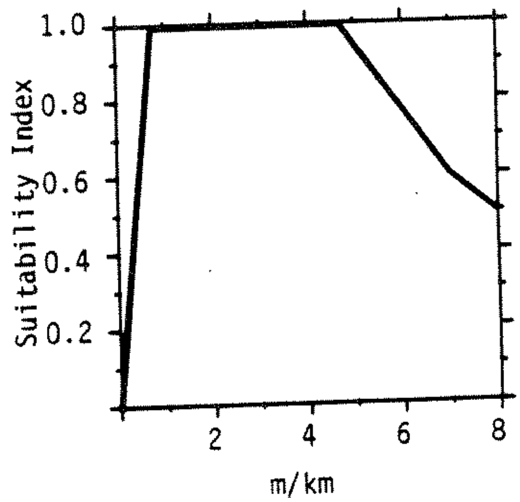


R,L V_{12} Water temperature in selected habitat during the growing season (May to October) (fry).



R,L V_{13} Water temperature in selected habitat during the growing season (May to October) (juvenile).



R,L	V_{14}	Water level fluctuations during spawning and for 45 days after spawning. A. Rapid rise during spawning (1-2 m) B. Rapid fall during spawning or afterwards (.5-1 m) C. Slow rise previous to spawning (.5-1 m) with stable levels during spawning and afterwards	
R	V_{15}	Stream gradient within representative reach.	

Riverine Model

These equations utilize the life requisite approach and consist of five components: food; cover; water quality; reproduction; and other.

Food (C_F).

$$C_F = (V_1 \times V_2 \times V_5)^{1/3}$$

Cover (C_C).

$$C_C = \frac{V_1 + V_2 + V_4 + V_5}{4}$$

Water Quality (C_{WQ}).

$$C_{WQ} = \frac{V_6 + V_8 + V_9 + 2\,[(V_{10} \times V_{12} \times V_{13})^{1/3}]}{5}$$

Except, if V_{10}, V_{12}, or V_{13} is ≤ 0.6, then C_{WQ} equals the lowest of V_{10}, V_{12}, V_{13} or the above equation where the lowest of V_{10}, V_{12}, or V_{13} is substituted for $(V_{10} \times V_{12} \times V_{13})^{1/3}$ in the equation.

Reproduction (C_R).

$$C_R = (V_{11}^2 \times V_{14} \times V_1 \times V_5 \times V_8 \times V_9)^{1/7}$$

Other (C_{OT}).

$$C_{OT} = V_{15}$$

HSI determination

$$HSI = (C_F \times C_C \times C_{WQ} \times C_R \times C_{OT})^{1/5}$$

Or, if C_{WQ} or C_R is ≤ 0.6, the HSI equals the lowest of the following:

C_{WQ}; C_R; or the above equation.

Sources of data and assumptions made in developing the suitability indices are presented in Table 1.

Sample data sets using the riverine HSI model are in Table 2.

Lacustrine Model

This model utilizes the life requisite approach and consists of four components: food; cover; water quality; and reproduction.

Food (C_F).

$$C_F = (V_1 \times V_3 \times V_5)^{1/3}$$

Cover (C_C).

$$C_C = \frac{V_1 + V_3 + V_5}{3}$$