Statewide Management Plan for Largemouth and Smallmouth Bass

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August 17, 2017

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Introduction

Largemouth (*Micropterus salmoides*) and smallmouth bass *(Micropterus dolomieu)* (collectively referred to as "black bass") are two of the most popular recreational fish species targeted by resident and non-resident anglers in Vermont waters (Connelly and Knuth 2010). Their popularity compels consistent, scientifically sound, and socially acceptable fisheries management that utilizes tools such as data collection, regulations, and habitat management to optimize the fishing experience for Vermont's bass anglers. To that end, the Vermont Fish and Wildlife Department's (VTFWD) Bass Management Team has collected, compiled, and analyzed data; reviewed the scientific literature; and had many discussions to develop this Statewide Management Plan for Largemouth and Smallmouth Bass. This document includes an overview of black bass biology, summaries of data collected from Vermont's bass fisheries, descriptions of bass fishery management issues relevant to Vermont, and descriptions of potential fisheries management actions that could be used to sustain and improve bass populations to provide quality bass fishing opportunities in Vermont.

The primary purposes of this plan are to:

- Assist VTFWD fisheries biologists with the implementation of sound and consistent management strategies for the protection or enhancement of bass populations and the recreational fisheries they support.
- Provide an educational resource for anglers, Fish and Wildlife Board members, legislators, media and the general public on a variety of bass fishery management issues.

This largemouth and smallmouth bass management plan should be considered a working document, subject to change as warranted by changes in environmental or social pressures as well as advances in bass fishery management techniques.

Statement of Need

Both in Vermont and nationwide, fishing for largemouth and smallmouth bass is more popular than ever. According to the 2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation, largemouth and smallmouth bass are the most popular freshwater fish species in the country. More than 10.6 million anglers spent 171 million days in 2011 targeting black bass (U.S. Department of the Interior 2011).

In Vermont, black bass fishing has steadily increased in popularity in recent decades. In 1990, largemouth and smallmouth bass were the 3rd and 5th most preferred fish species of resident Vermont anglers, but in 2010, they were the 2nd and 4th most preferred fish species, with 18% and 10% of Vermont resident anglers naming these species as their preferred target (Connelly and Knuth 2010). During that same period, the percentage of resident open water anglers targeting largemouth bass increased from 60% to 66%, and the percentage targeting smallmouth bass increased from 64% to 71%. Resident and non-resident anglers spent an estimated 957,241 days in pursuit of largemouth and smallmouth bass in Vermont waters during the 2009 open water season (Connelly and Knuth 2010).

Competitive bass fishing tournaments have also increased in popularity both in Vermont and across the country. Noble (2002) reported an increase of over 300% in the number of tournaments held in the United States and Canada during the past 25 years, and the number of permits issued for bass-specific tournaments on Vermont waters has increased from 25 in 1996 to a high of 192 bass tournament permits issued in 2012.

As the popularity of bass fishing in Vermont increases, so does the scrutiny of bass management strategies applied to these fisheries. Different user groups have different motivations for fishing, which may lead to conflicting desires. Many anglers place a high value on fishing for sport and strictly practice catch-and-release angling, while others are harvest-oriented and employ fishing to place healthy food on the table for their family. An increase in participation in open water bass tournaments can lead to conflicts such as crowding and space issues at public access areas, as well as on the water. Careful consideration of the biological and social implications of bass management options will be necessary to meet the desires of our diverse angling public.

Angling is not the only way that humans can affect bass fisheries. Humans can have both positive and negative effects on aquatic habitat, thereby influencing the bass populations that are dependent on these habitats. Aquatic plants, which provide important spawning, nursery and cover habitats, may be removed by humans when their abundance interferes with other recreational or aesthetic values. The removal of trees, woody shrubs and natural grassy vegetation and the establishment of manicured lawns along shorelines can negatively impact fish habitat through shoreline erosion, siltation, nutrient run-off and resulting algae blooms and water quality degradation (VTANR 2013). Manipulation of water levels in reservoirs can affect bass directly by interfering with spawning and indirectly by decreasing aquatic vegetation and prey abundance. Humans can also serve as vectors for non-native aquatic species and pathogens that could negatively affect bass populations. Our ability to sustain quality bass fisheries into the future is dependent upon the protection and enhancement of aquatic habitats.

Because of the unprecedented popularity of recreational fishing as well as competitive bass fishing in Vermont and increasing challenges in protecting bass habitat, a Statewide Management Plan for Largemouth and Smallmouth Bass is needed to help direct and guide future management activities, such as data collection, regulation implementation, and habitat management to ensure the quality of bass fishing currently enjoyed across Vermont can be sustained or improved in the future.

The Statewide Management Plan for Largemouth and Smallmouth Bass aims to:

1. Utilize abundant bass assessment data, outside research and Vermont angler opinion data to formulate management strategies that will protect bass resources and meet angler desires;
2. Promote consistency in management on a statewide basis;
3. Address frequently raised bass management issues; and
4. Serve as a public educational resource on bass management issues.

Department Mission

"The conservation of fish, wildlife, plants, and their habitats for the people of Vermont."

Fish Division Goals

- Protect, conserve, enhance and manage all fisheries resources and habitats, and provide a diversity of quality fishing opportunities.
- More closely align fisheries management with public desires and the ecology of Vermont's waters.
- Optimize public fishing access to state waters.
- Through education, promote public awareness and support for fishery resource conservation.

Bass Biology

Black bass is a collective common name used to refer to the any or all of the six centrarchid (sunfish) species occurring in North America that are assigned to the genus *Micropterus*. Two species, largemouth bass and smallmouth bass, are native to Vermont and have long been valued as sportfish here. Reports of the Vermont Fish Commissioners dating from the 1800s sometimes make mention of Oswego bass and Potomac bass which are synonymous to largemouth and smallmouth bass, respectively.

Largemouth Bass

Distribution

The largemouth bass is native to the North American continent with a range encompassing the St. Lawrence-Great Lakes, Hudson Bay (Red River), and Mississippi River basins from southern Quebec to Minnesota and south to the Gulf of Mexico; in the Atlantic Slope drainages from Florida north into Virginia; and Gulf Slope drainages from southern Florida into northern Mexico (Page and Burr 1991). The species has been introduced widely beyond its native range. Naturalized populations now exist in all states, except for in Alaska (Fuller et al. 1999).

Specific to Vermont, the natural range of largemouth bass (i.e. pre-European settlement) is believed to have been limited to Lake Champlain, but since then, it has expanded nearly statewide including the Connecticut River, Hudson River, and Memphremagog-St. Francis River drainages (Langdon et al. 2006; MacCrimmon and Robbins 1975). The primary mechanism for its range expansion in the state has been intentional translocations and stocking, both legal and otherwise. Bass were being spread by private citizens well before the State of Vermont embarked on stocking the species in waters outside of its native range in the state (about 1875). Figure 1 illustrates the current distribution of largemouth bass populations in Vermont but excludes the many small private ponds scattered throughout the state with introduced populations. Riverine populations in Vermont are generally confined to reaches accessible from Lake Champlain and the Connecticut River upstream to the first natural or artificial barrier. In Vermont, largemouth bass are known to occur in 129 public lakes and ponds and sections of 13 rivers and streams.

Taxonomists recognize two subspecies of largemouth bass. The dominate subspecies, northern largemouth bass (*M. s. salmoides)*, has the broadest distribution and is the one found in Vermont.

The natural range of the other subspecies, Florida largemouth bass (*M. s. floridanus)*, is Florida, Alabama, Georgia and southern South Carolina (Bailey and Hubbs 1949).

Habitat

Largemouth bass inhabit warm water areas of small, shallow lakes; shallow bays of larger lakes; and less commonly large, slow rivers (Scott and Crossman 1973). Optimum lake and pond habitats have areas of extensive shallow water (i.e. ≥25% of the surface area ≤20 ft (6 m) in depth; Stuber et al. 1982). Substrate can vary, but usually consists of mud, organic debris, sand, gravel, or hard consolidated clay (Trautman 1957). Rocky substrate, preferred by smallmouth bass, is used less frequently by largemouth (Scott and Crossman 1973). Abundant aquatic vegetation and other cover structures (logs, stumps, rocks) are important in maintaining the overall integrity of aquatic ecosystems and in supporting diverse, healthy and abundant fish communities (Crowder and Cooper 1979; Savino and Stein 1982). For example total vegetation cover may affect recruitment of age-0 and age-1 bass as well as food consumption (Miranda et al. 1996). At northern latitudes bass need access to deep water for overwintering and may be require as much as 40-60% of the lake surface area should have depths greater or equal to 20 feet (6 m; Stuber et al. 1982).

Water temperature is critical for defining habitat suitability for bass. Temperature preferences and tolerances may vary based on fish size or age, acclimation conditions, and location within the species' range. Largemouth bass can tolerate a wide range of temperatures with an optimum range of 55 to 80°F (12.8 to 26.7°C; Piper et al. 1982). At water temperatures below 50°F (10.0°C) bass become inactive (Emig 1966) and may exhibit physiological stress above 86°F (30.0°C; Johnson and Charlton 1960).

Largemouth bass growth is reduced at dissolved oxygen concentrations less than 8 ppm (Stewart et al. 1967). Avoidance behavior is exhibited at <4 ppm (Burleson et al. 2001) and levels less than 1 ppm can result in death (Moss and Scott 1961). For successful reproduction, largemouth bass require the water to be in the pH range of 5 to 10 (Emig 1966; Buck and Thoits 1970).

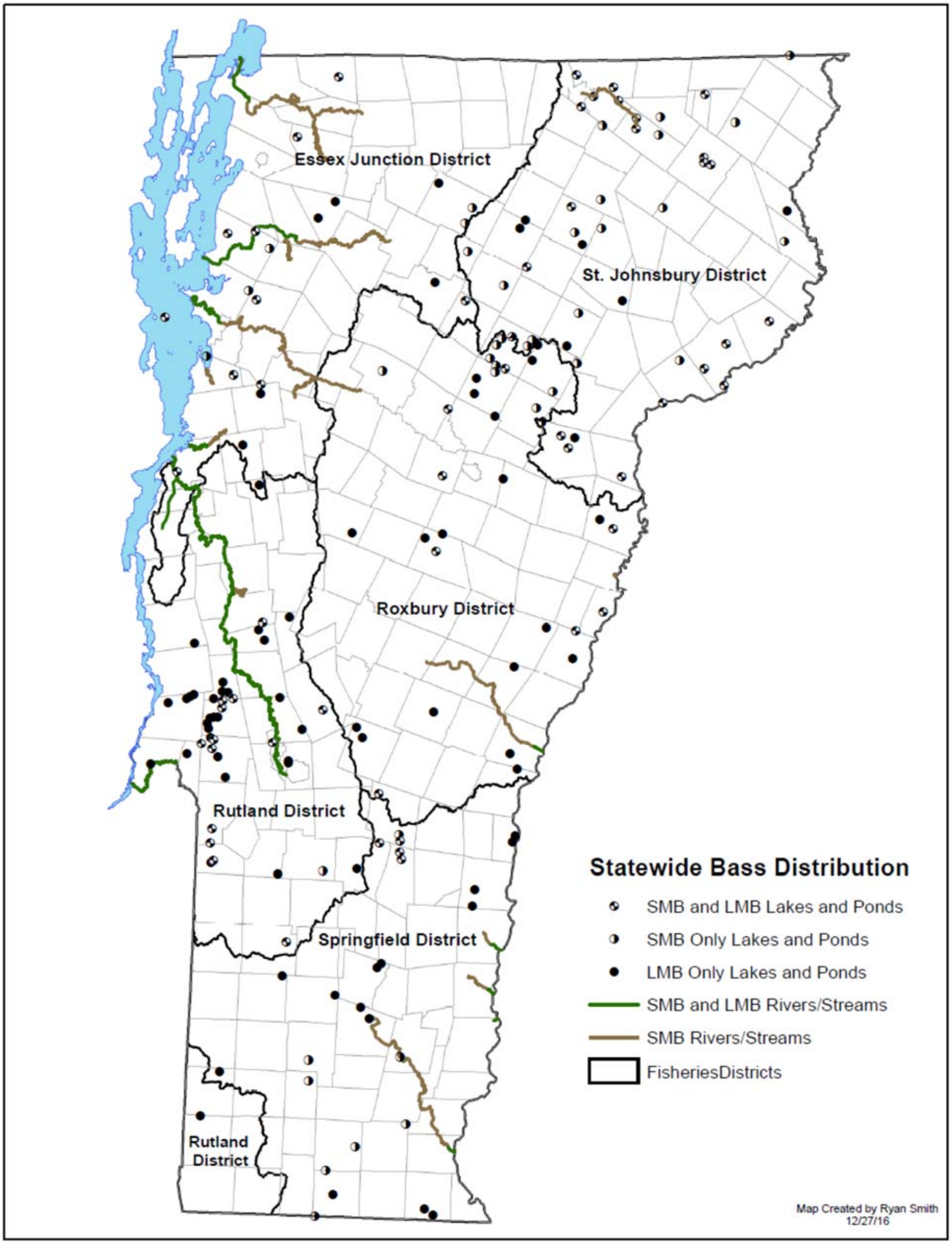


Figure 1. Current distribution of largemouth and smallmouth bass populations in Vermont public waters.

Reproduction and Early Development

Largemouth bass spawn in the spring when water temperatures warm to about 60°F (15.6°C). In Vermont, spawning typically occurs between late May and late June. Because of year-to-year variation in water temperatures, the timing of bass spawning is variable. Male bass perform nest site selection and construction and provide all parental care to incubating eggs and fry. Nests are usually located in shallow littoral areas where water depth is in the range of 1 to 4 feet (0.3 to 1.2 m; Heidinger 1975), although spawning may also occur at somewhat greater depths. Nests are usually located near protective cover (e.g. slopes, boulders, ledges, submerged vegetation; Miller and Kramer 1971). Gravel is the preferred spawning substrate but other materials are used, including mud, sand and cobble. The male prepares the nest by sweeping away silt and organic debris to expose the underlying substrate. Nests may measure 2 to 3 feet (0.6 to 0.9 m) in diameter (Miller and Kramer 1971).

Once a nest has been constructed, the male lures a female into it where the eggs are released and fertilized and settle to the bottom of the nest. This may be repeated several times and spawning ends when the female departs either to deeper water or to locate another mate. A female largemouth bass may produce 13,000 to 30,000 eggs per pound of body weight (Laarman and Schneider 1985; Piper et al. 1982). Once spawning has concluded, the male assumes all care of the eggs, fanning them with his fins to deliver fresh water and remove wastes and sediments. He also guards the eggs and fry from predators, such as sunfish and yellow perch. The eggs hatch within 72 to 96 hours depending on water temperature. At about 10 days of age the fry are free-swimming, at 13 days the yolk-sac is absorbed, and within another six days the fry must begin feeding on their own. During this time, the male protects the schooling fry from predators. By the end of the second or third week, the young bass disperse and must fend for themselves.

Diet

Largemouth bass are carnivores and will consume just about anything they can catch. Young bass measuring 8 to 19 mm total length feed almost exclusively on crustaceans; at 20 mm they begin to include insects in the diet; at 50 mm very small fishes may be consumed; and at 100+ mm fish become a substantial part of their food intake (Miller and Kramer 1971; Scott and Crossman 1973). The diet of adult largemouth bass is mainly fish, although worms, mussels, snails, frogs, crayfish, and large insects may be eaten (Emig 1966). Even small rodents, birds, and snakes will be taken if the opportunity should arise.

Bass have been observed to consume rainbow trout with total body lengths measuring up to 70% of that of the bass (K. M. Cox, VTFWD, personal communication). The size of a forage fish capable of being swallowed by a bass, correlates to the maximum body depth of the prey fish and the maximum mouth width of the bass (Emig 1966). Fish are swallowed head first. According to Bennett (1962), a bass must consume 1% of its body weight per day to maintain weight and condition.

Age and Growth

Several structures can be used to estimate the age of bass, including scales, fin rays, fin spines, and otoliths. Otoliths (or "ear stones") are generally regarded as the most reliable structures for estimating fish age, but the removal of these bones requires that the fish be killed. Of the structures that can be removed from fish without killing them, fin spines may provide the most accurate and precise age estimates for bass (Welch et al. 1993; Morehouse et al. 2013), which is why VTFWD currently uses dorsal fin spines to assign ages to bass. In brief, the method for determining fish age from a spine involves viewing a thin cross-section of the spine under magnification and counting growth rings, which are made annually (Figure 2). The method is analogous to determining the age of a tree by counting its growth rings. While VTFWD has large amounts of historic bass age data derived from scales, these data are not included in this plan because scale ages tend to underestimate ages of older fish.

Largemouth bass can live as long as 23 years (Green and Heidinger 1994). Of the 376 largemouth bass that have been assigned an age by VTFWD staff using dorsal spines, the oldest fish was 16 years, but they are likely to live beyond that age in Vermont waters. The state record largemouth bass was caught from Lake Dunmore in 1988. The fish weighed 10.25 lbs. and measured 25 inches in length.

Growth rate of any fish species is affected by many factors including water temperature, water quality, habitat quality, food availability, and various stressors. Largemouth bass growth rate is variable in Vermont, but length at age of Vermont's largemouth bass is typically less than the North American median (Figure 3, Appendix I-A). Slower growth of largemouth bass in Vermont waters can be attributed to longer winters and cooler temperatures relative to the majority of the North American range. Vermont's largemouth bass generally reach the minimum legal length (10") between ages two and four. North American largemouth bass typically reach sexual maturity when they reach 10 to 12 inches (Claussen 2015), which could take anywhere from two to seven years for largemouth bass in Vermont.

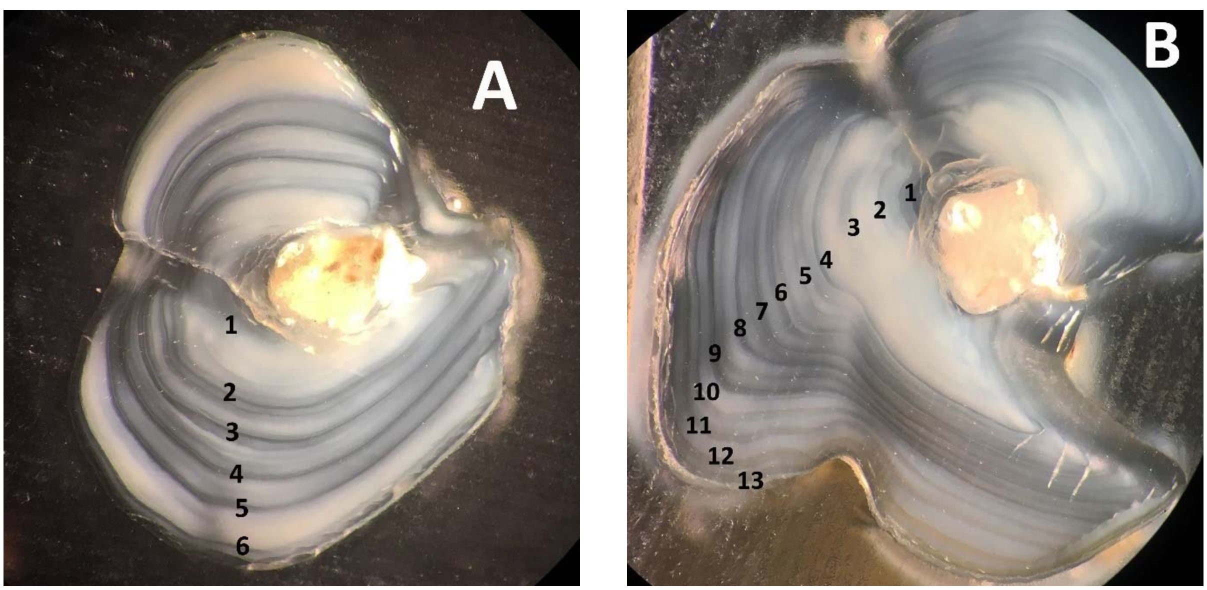


Figure 2. Magnified view of dorsal spine cross-sections showing annuli. (A) shows a dorsal spine from a 6-year-old smallmouth bass measuring 15.7-inches in length collected from Lake Champlain in 2012. (B) shows a dorsal spine from a 13-year-old largemouth bass measuring 18.8-inches in length, collected from Lake Champlain in 2012.

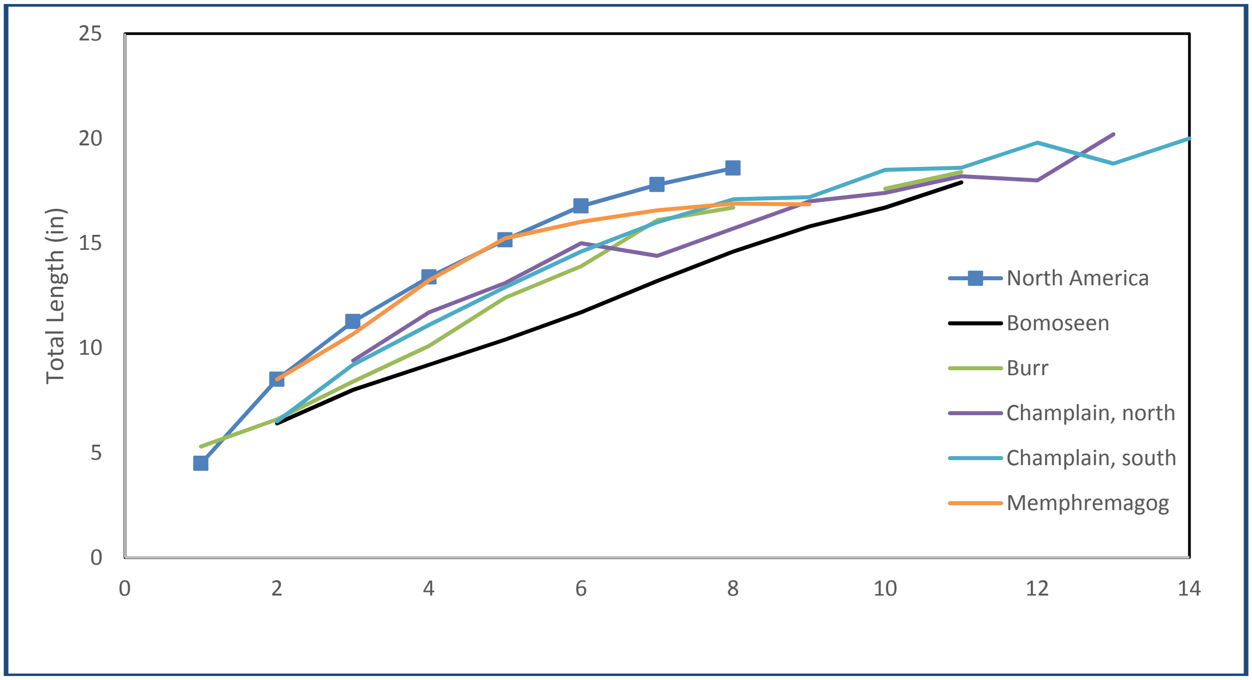


Figure 3. Length (in) at age for largemouth bass from across North America (Jackson et al. 2008) and from four Vermont waters. Total length for North America is the median value of mean length at age for many individual populations. Total length for Vermont waters is the mean length for each age. Age data for North American populations came from a variety of hard parts, while all Vermont age data were derived from dorsal spines. Jackson et al. (2008) excluded older age classes to minimize potential aging errors.

Gabelhouse (1984) used data from across North America to develop standard length categories for several freshwater species including largemouth and smallmouth bass (Table 1). These length categories are utilized by VTFWD biologists when examining Vermont bass data. No "trophy" largemouth bass have ever been observed during sampling by VTFWD personnel, and largemouth bass greater than 20 inches are rarely observed. Since the start of the Vermont Master Angler Program in 2010, only two largemouth bass entries greater than 25 inches have been accepted, but many largemouth bass greater than 20 inches are entered every year. The upper end (Trophy and Memorable) of the Gabelhouse length categorization may not be appropriate for Vermont due to the slower growth rates observed here. For this reason, VTFWD uses a minimum length of 18 inches for the largemouth bass "memorable" size category.

Table 1 - Length categories (in) for largemouth and smallmouth bass (Gabelhouse 1984).

Species	Stock	Quality	Preferred	Memorable	Trophy
LMB	8	12	15	20 (18)*	25
SMB	7	11	14	17	20

*****_Gabelhouse (1984) set 20 inches as the memorable size for largemouth bass, but for the purposes of this plan, memorable size is 18 inches for Vermont waters._

Smallmouth Bass

Distribution

Smallmouth bass are native to North America with a range encompassing the St. Lawrence-Great Lakes, Hudson Bay (Red River), and Mississippi River basins from southern Quebec to North Dakota and south to northern Alabama and Georgia, and west to eastern Oklahoma (MacCrimmon and Robbins 1975; Page and Burr 1991). The species has been naturalized in all states, with the exceptions of Florida, Louisiana and Alaska (Fuller et al. 1999).

The native range of smallmouth bass in Vermont was restricted to Lake Champlain (Langdon et al. 2006; MacCrimmon and Robbins 1975), but introductions into other waters of the state began sometime in the 1870s. Currently, the species is found in suitable habitats nearly statewide (Figure 1), including 93 public lakes and ponds, and sections of 17 rivers and streams. Smallmouth bass, unlike largemouth bass, are rarely successful when introduced to small private ponds, where habitat conditions are less suitable for this species' reproduction and survival.

Habitat

Smallmouth bass prefer for cool, flowing streams, and large, clear lakes (Emig 1966). Hubbs and Bailey (1938) describe lakes best suited for smallmouth bass to be greater than 100 acres (40 hectares) in size, with water depths greater than 30 feet (9 m), and that stratify seasonally. Preferred lake habitats have gravelly, rocky littoral zones, little to no aquatic vegetation, and deep water for bass to access during periods of summer high water temperatures and for overwintering. In lakes, smallmouth bass are often associated with rocky shoals and ledges. Streams providing favorable habitat have beds dominated by gravel and rock, riffles and deep pools, cover or refuge structure (e.g., rocks and large wood), and moderate water velocities (Edwards et al. 1983; Emig 1966; Hubert and Lackey 1980).

Water temperature appears to be the most important factor affecting smallmouth bass distribution throughout the year. Smallmouth bass have cooler temperature requirements than largemouth bass. The preferred summer water temperature is near 70°F (21°C), although individuals have been observed at times in water temperatures exceeding 90°F (32.2°C; Coutant 1975). The optimum temperature for growth appears to be near 78.8°F (26°C), with peak growth occurring in the range of 78.8 to 84.2°F (26 to 29°C) and no growth occurring above 95°F (35°C; Coutant 1975). In response to increasing temperatures, bass typically leave shallow habitats for cooler waters available in deeper parts of the lake. With the onset of fall and declining water temperatures, at 50°F (10°C) smallmouth bass become lethargic and feed less (Coutant 1975).

Reproduction and Early Development

Smallmouth bass usually become sexually mature at 3 to 4 years of age (Emig 1966). Reproductive behavior is similar to other centrarchids, including largemouth bass, in that the male carries out nest site selection and construction and provides all parental care to developing eggs and fry. Turner and MacCrimmon (1970) observed Ontario smallmouth bass commencing nest building and spawning in early June when water temperatures ranged from 59 to 64.4°F (15 to 18°C). In Vermont waters, beginning of spawning activity is variable from year to year depending on water temperature and depth. Generally, the earliest spawning occurs in early

May. Depth of spawning has been reported in the range of 0.8 feet to 12 feet (0.3 to 3.6 m; Hubbs and Bailey 1938), although it has been observed to occur as deep as 20 feet (6.1 m, Coble 1975; S. P. Good, VTFWD, personal communication). Preferred sites are sheltered from wind and wave action with sand, gravel and/or rock substrates and with some cover structure in the vicinity, such as large boulders or logs (Neves 1975; Scarola 1973). Nests are shallow basins excavated in the substrate and have an average diameter of 2 feet (0.6 m) (Neves 1975). A female is coaxed into the nest, where she releases between 1,000 and 10,000 eggs, depending on her size and whether all the eggs she is carrying are spawned in a single nest (females may spawn over multiple nests; Coble 1975; Neves 1975). After egg fertilization and completion of all spawning activity, the female either retreats to deep water or locates another mate. The male assumes complete parental care over the eggs and hatchlings, warding away predators and fanning the eggs to provide fresh water and keep the nest clear of sediments and organic matter. Depending on water temperature, the eggs hatch in 2 to 10 days, as sac-fry and continue to development in the nest for an additional 6 to 7 days (Neves 1975; Scarola 1973). At 11 days of age, the black fry are capable of "rising" off the substrate, where they form a tight school that occupies the nest site for another week (Scarola 1973). During this time and for up to an additional two weeks, the male continues to guard the young from predators and maintains the school until the young bass (about 1 inch in length) disperse and are free of any parental care.

Diet

Smallmouth bass consume a variety of organisms, aquatic and terrestrial, including invertebrates (e.g., insects and crayfish), amphibians and fishes. Diet is primarily dependent on bass size and age. At first, zooplankton is consumed by young-of-the-year, followed by insects and other small macroinvertebrates, and eventually larger prey items including fish and crayfish (Coble 1975, Emig 1966, Scarola 1973).

Age and Growth

Smallmouth bass are known to live to at least 15 years of age (Brewer and Orth 2015). Of the 280 smallmouth bass that have been assigned an age by VTFWD staff using dorsal spines, the oldest fish was 14 years. The state record smallmouth bass was caught from Lake Eden in 2003. The fish weighed 6.81 lbs and measured 23 inches in length.

Smallmouth bass growth rate is variable in Vermont, but length at age is typically similar to the North American median (Figure 4, Appendix I-B). Vermont smallmouth bass typically reach the minimum legal length (10") between ages two and four. Smallmouth bass can be sexually mature at lengths as small as 8 inches, but they are more likely to begin spawning when they exceed 10 inches (Ridgeway et al. 1991, Dunlop et al. 2005).

Vermont smallmouth bass fit the Gabelhouse (1984) size categories very well (Table 1). "Trophy" smallmouth bass exceeding 20 inches are infrequently observed during VTFWD fisheries sampling, however many smallmouth bass in this size category are reported to the Master Angler Program every year.

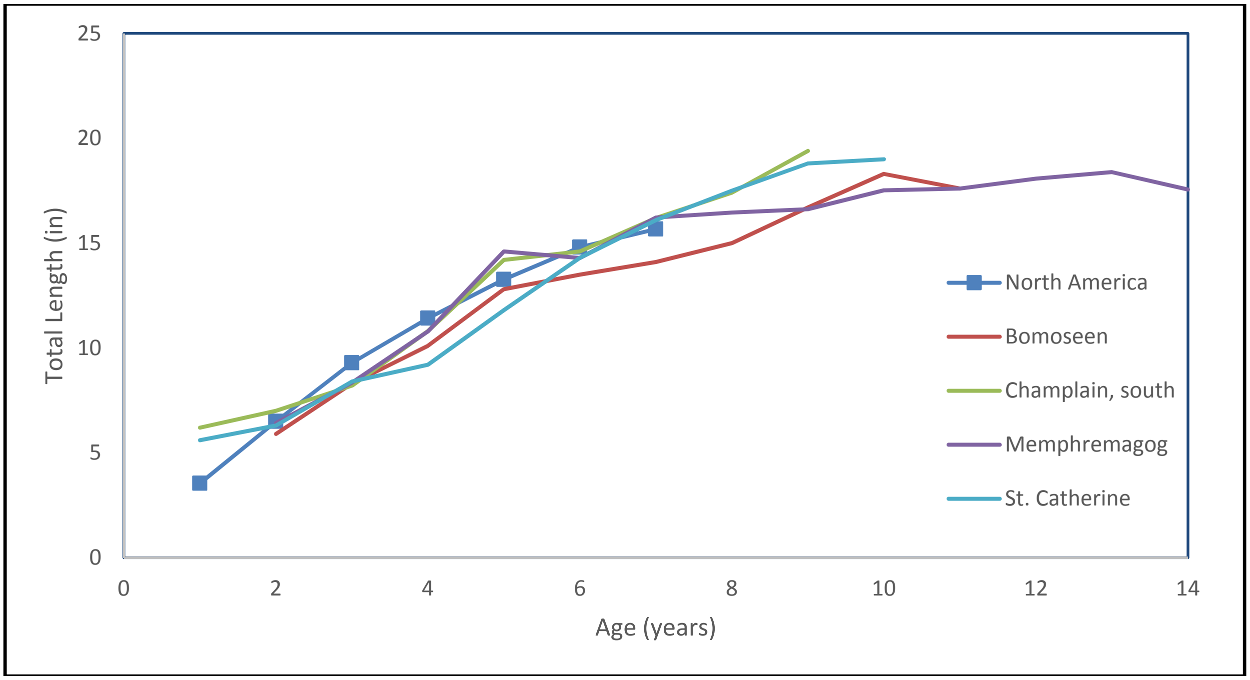


Figure 4. Length (inches) at age for smallmouth bass from across North America (Jackson et al. 2008) and from four Vermont waters. Total length for North America is the median value of mean length at age for many individual populations. Total length for Vermont waters is the mean length for each age. Age data for North American populations came from a variety of hard parts, while all Vermont age data were derived from dorsal spines. Jackson et al. (2008) excluded older age classes to minimize potential aging errors.

Fish Community Interactions

An analysis of fish species richness in 56 Vermont lakes and ponds having largemouth bass populations or sympatric smallmouth bass populations found that 50% of the waters have northern pike (*Esox lucius*); 63% white sucker (*Catostomus commersoni*); 64% rock bass (*Ambloplites rupestris*); 71% pumpkinseed (*Lepomis gibbosus*); 84% golden shiner (*Notemigonus crysoleucas*); 89% brown bullhead (*Ameiurus nebulosus*); and 96% yellow perch (*Perca flavescens*). Fourteen other species were also identified but occurred in fewer than 40% of the lakes and ponds. Some of these species include: chain pickerel (*Esox niger*), 39%; bluegill (*Lepomis macrochirus*), 18%; fallfish (*Semotilus corporalis*), 16%; common shiner (*Luxilus cornutus*) and banded killifish (*Fundulus diaphanus*), 7%. Lakes with only smallmouth bass or sympatric with largemouth bass numbered 60. Species richness was similar in that golden shiner, brown bullhead and yellow perch occurred at the greatest frequencies, i.e. 78%, 90% and 97%, respectively. Other species in descending order of occurrence were white sucker, 72%; pumpkinseed, 67%; chain pickerel, 62%; and rock bass, 48%.

Small-bodied littoral fish species, particularly cyprinids, are not well represented in these lakes. Presence and abundance of small-bodied species can be affected by piscivory, habitat complexity, species distributions and may be an artifact of sampling method. The introduction of bass species into waters to which they are not endemic may very well alter fish communities from what existed previously. As a case in point, prior to largemouth bass being introduced to

Stoughton Pond, Windsor County in 1987, the fish community was, in descending order of abundance, comprised of white suckers, yellow perch, brown bullheads, common shiners, and golden shiners. Currently, common shiners are rarely observed in Stoughton Pond, while white suckers and golden shiners continue to be common although not nearly as abundant as they were before the bass population and fishery became established. Predation of fish by other fish is a significant factor affecting the structure of fish communities in lakes and streams (Jackson et al. 2001; MacRae and Jackson 2001). MacRae and Jackson (2001) assessed fish assemblages in small lakes in central Ontario with and without smallmouth bass and found reduced abundance of some species, particularly small-bodied species, in lakes with smallmouth bass.

Manipulation of bass abundance and size structure for the purpose of managing fish community structure, enhancing fishing opportunities, and developing quality sport fisheries has long been recognized and widely practiced. H. S. Swingle began work at Auburn University in Alabama in the 1930s to develop methods for effectively managing fish populations (i.e. simple fish communities) in farm pond environments. Through his research, the concept of fish population "balance" was developed based on a series of ratios comparing the abundance of predatory fishes (e.g., largemouth bass) to prey species (e.g., bluegill; Nielson 1999; Swingle 1950). Since then, other assessments of aquatic community structure and balance have been developed [e.g., proportional stock density (PSD; Anderson and Weithman 1978)], principally to manage fish populations for satisfactory fish harvests. The concepts of predator-prey balance are most useful in the management of small ponds with simple fish communities and are generally not applicable to Vermont's public waters.

Pathogens and Parasites

Several pathogens and parasites are of particular importance to the management of healthy bass populations and fisheries in Vermont waters. Largemouth bass virus (LMBV) is an iridovirus that infects adult largemouth bass and other centrarchid species with infections, sometimes resulting in high mortality (Grizzle et al. 2003). LMBV was first isolated from bass in a Florida lake in 1991. The first documented LMBV fish kill event occurred in Santee-Cooper Reservoir, South Carolina in 1995. Since its discovery, LMBV has been detected in 18 other states, including Vermont. In 2002, largemouth bass sampled from the Lake Champlain population tested positive; however, to date no fish kill episodes attributed to LMBV have occurred in the state.

Viral hemorrhagic septicemia virus (VHSV) has not yet been detected in Vermont. Nine fish species (3 cool/warm water; 6 cold water) were evaluated for susceptibility to VHSV infection. Largemouth bass ranked second after muskellunge (*Esox masquinongy)* followed by yellow perch (*Perca flavescens)* (Kim and Faisal 2010).

Bass tapeworm (*Proteocephalus ambloplites)* is an endemic parasite infecting both largemouth and smallmouth bass. The adult stage of the worm inhabits the digestive tract of the parasitized fish; however, the plerocercoid stage migrates to internal organs, including ovaries, causing tissue damage that can negatively affect reproduction (Scott and Crossman 1973).

Bass Population Assessment and Fisheries Status

VTFWD has a long history of fish sampling, going as far back as the 1930s, however, more modern boat electrofishing techniques have only been in use since 1988. Between 1988 and 2015, bass populations have been sampled by boat electrofishing on more than 500 occasions on 100 waterbodies. Three main types of data that have been collected during these bass electrofishing surveys. First, is the number of bass in each size category (Table 1). These data are used to calculate relative stock densities, which provide a numerical summary of the length-frequency distribution of the population (Anderson and Neumann 1996). The second type of data, which is closely related to the first, is the catch-per-unit-of-effort (CPUE) in bass per hour for each of the different size classes. The third type of data is the relative weight, which gives an idea of the condition, or plumpness, of the bass.

One of the department's goals for the management of bass fisheries is a high angler catch rate of bass in the quality, preferred, and memorable size classes. Thus, electrofishing CPUE of these size classes is one of the best measures of a quality bass fishery and of successful bass management. For all the bass sampling data collected in Vermont since 1988, the 75th percentiles of largemouth bass CPUE for the quality, preferred, and memorable size classes are 23, 8, and 1.6 bass per hour (Figure 5). The 75th percentiles of smallmouth bass CPUE for the quality, preferred, and memorable size classes are 13, 6, and 1 bass per hour. The 75th percentile of CPUE for both species combined in those three size categories are 30, 12, and 3.

Electrofishing catch rates for the three size categories vary widely across the state (See Appendix II – A-I). Most of this variation can be attributed to water chemistry and habitat. Waters in the southern part of the state tend to have higher catch rates of largemouth bass, while smallmouth bass catch rates tend to be higher in the north (Figures 6 through 8).

Electrofishing catch rates can vary widely from year to year (Figure 9). Variation in catch rate can indicate an actual variation in bass abundance, but it can also be related to variation associated with the sampling method, such as water clarity, water temperature, and the skill of the electrofishing crew. Given the potential for variability in the sampling technique, several years of data may be necessary to accurately characterize a waterbody's bass fishery.

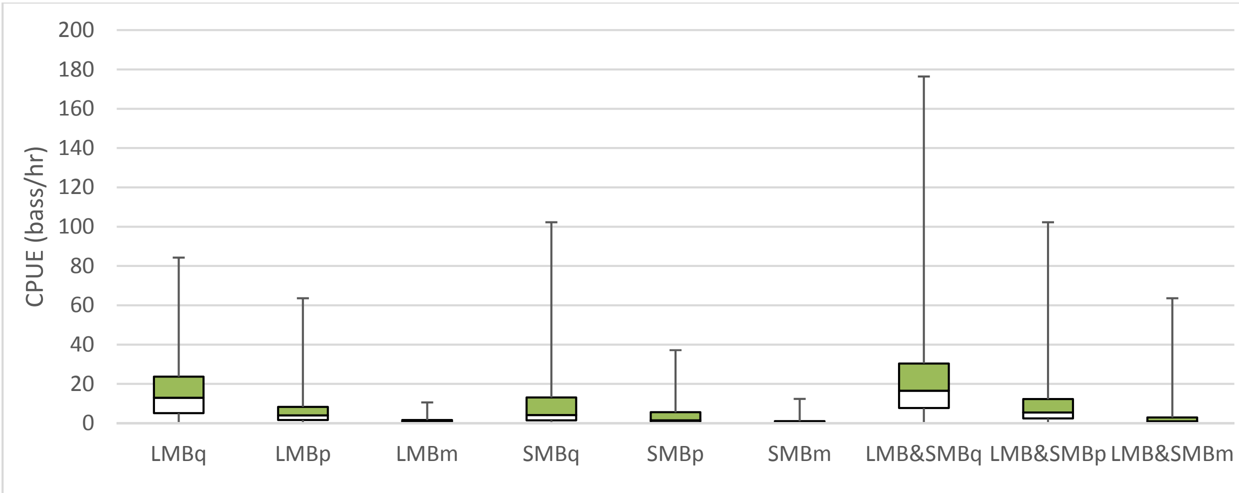


Figure 5. Boxplot of catch-per-unit-of-effort (CPUE) in bass per hour for largemouth bass (LMB), smallmouth bass (SMB), and both species combined in three different size categories [quality (q), preferred (p), and memorable (m)] for 557 boat electrofishing events in Vermont from 1988 to 2015. Error bars show the maximum values. Top of box is the 75th percentile. Bottom of box is the 25th percentile. Middle line is median (50th percentile).

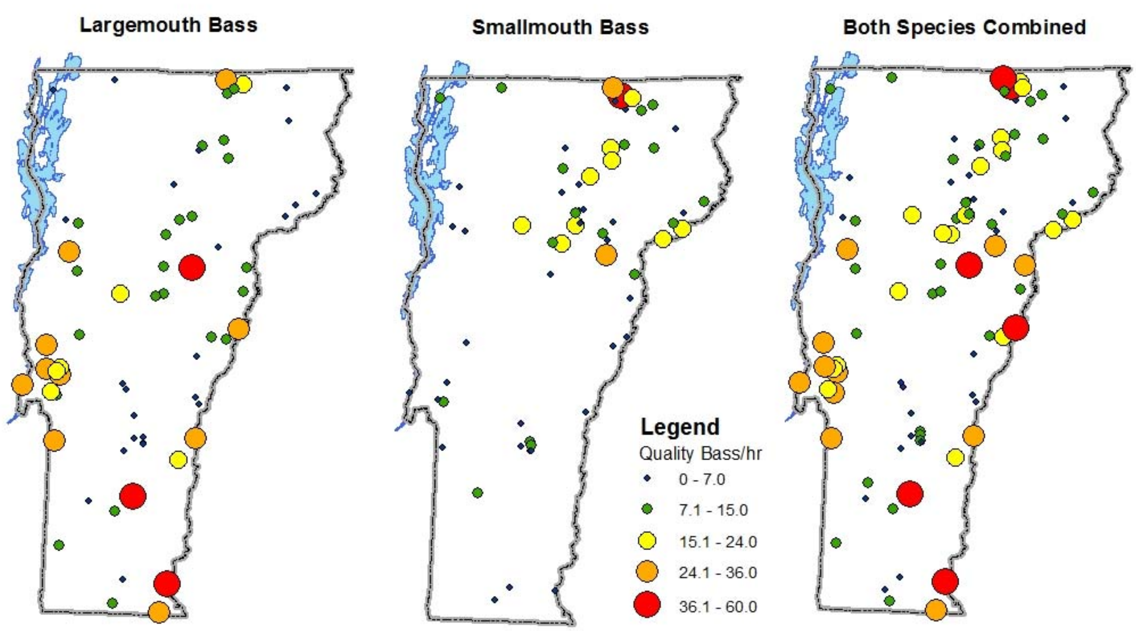


Figure 6. Geographic display of the average electrofishing catch rate of quality largemouth (≥ 12") and smallmouth bass (≥11") during spring and summer electrofishing surveys on 91 Vermont waters from 1988 to 2015.

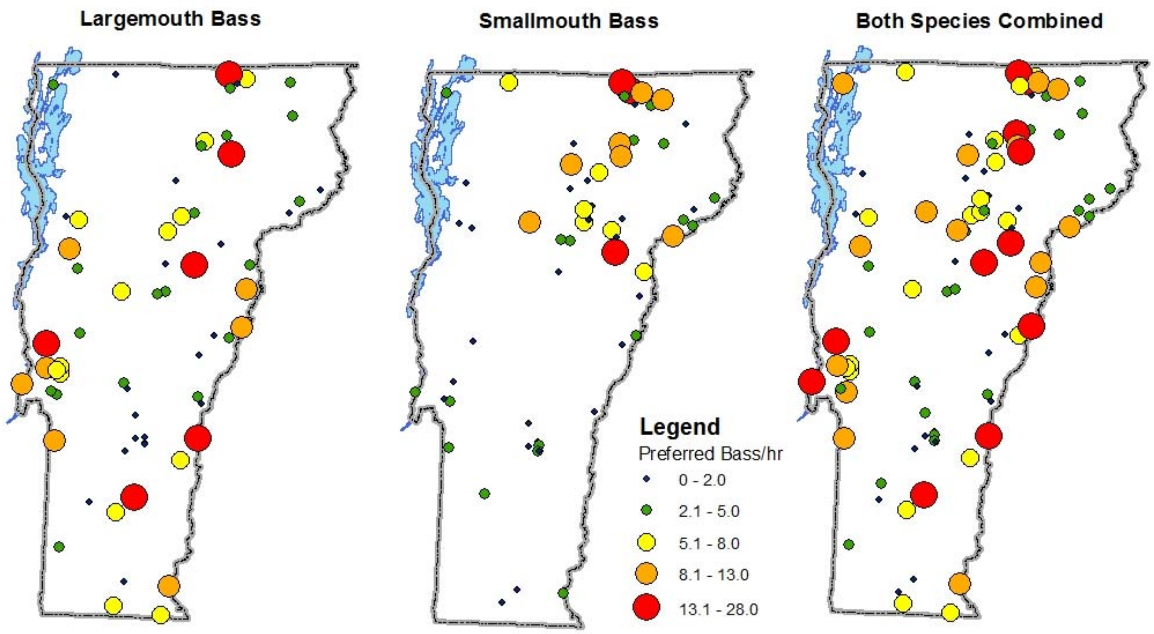


Figure 7. Geographic display of the average electrofishing catch rate of preferred largemouth (≥ 15”) and smallmouth bass (≥14”) during spring and summer electrofishing surveys on 91 Vermont waters from 1988 to 2015.

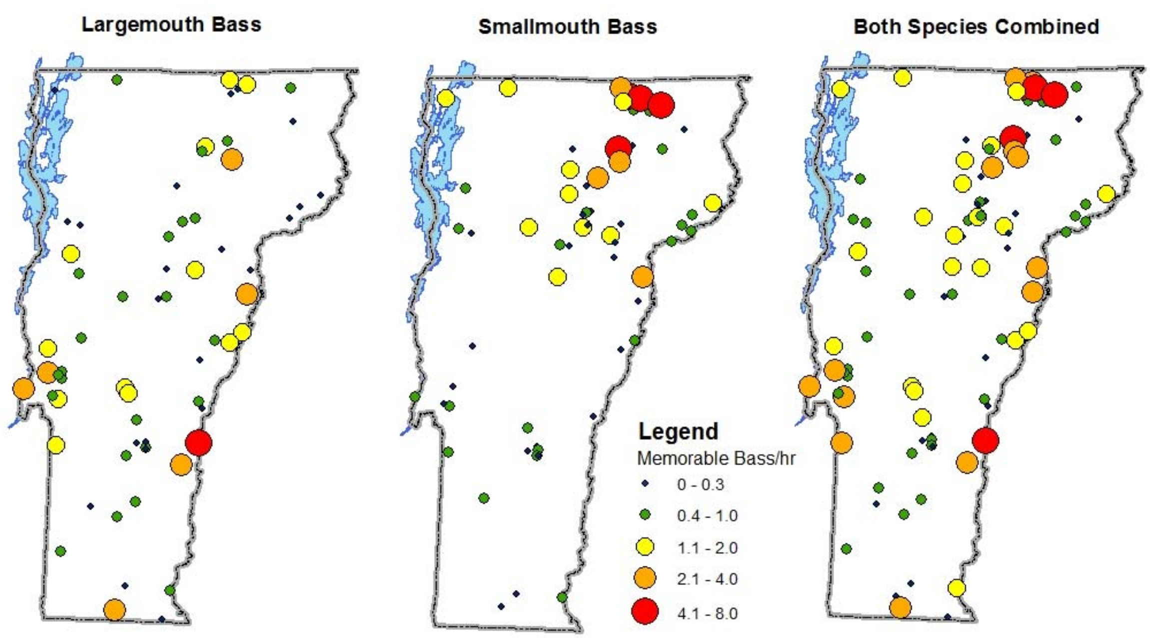


Figure 8. Geographic display of the average electrofishing catch rate of memorable largemouth (≥ 18”) and smallmouth bass (≥17”) during spring and summer electrofishing surveys on 91 Vermont waters from 1988 to 2015.

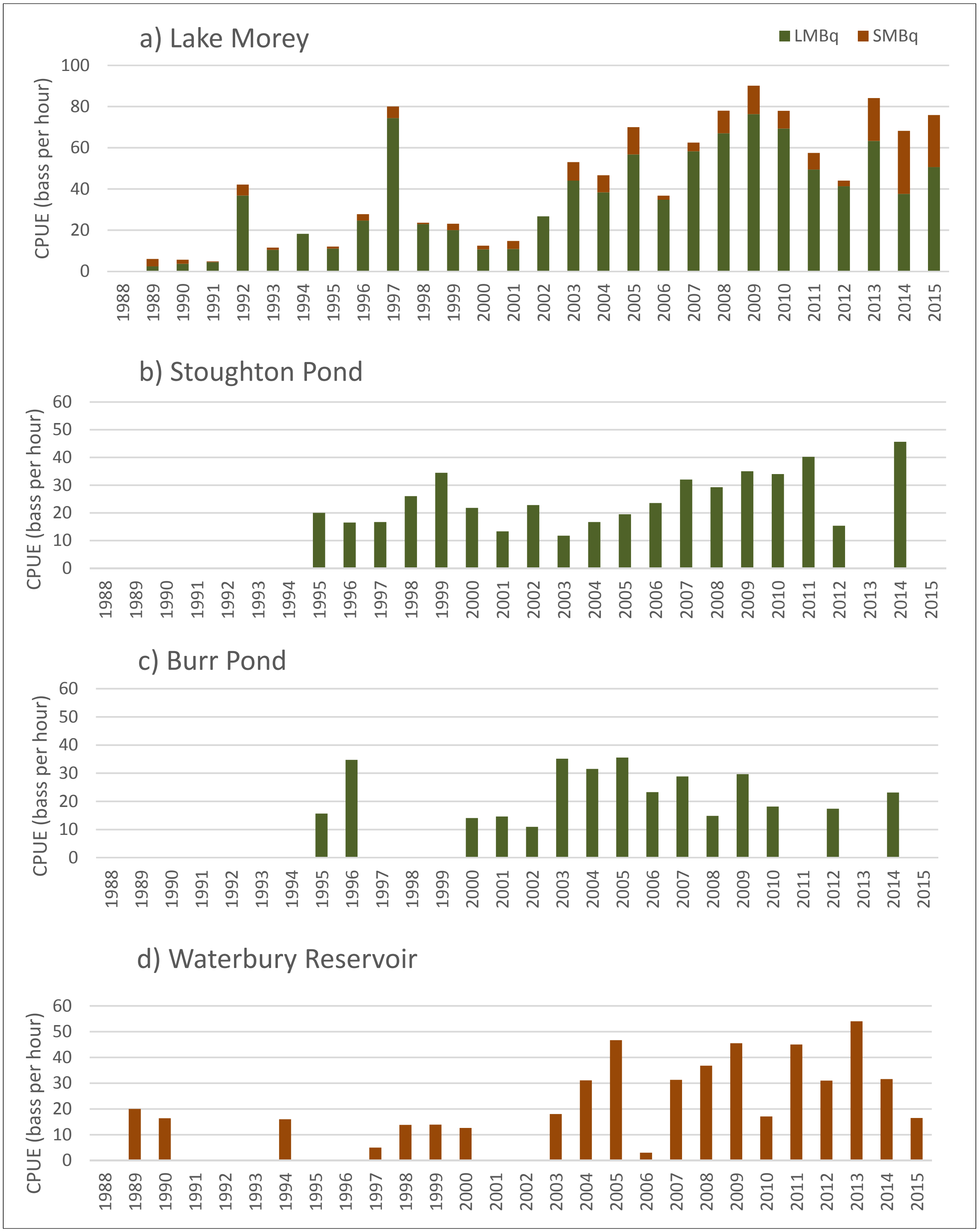


Figure 9. Electrofishing catch rate of quality size largemouth (LMB) and smallmouth (SMB) bass for four lakes in Vermont from 1988 to 2015. Largemouth bass are in green. Smallmouth bass are in brown. Quality size is ≥ 12” for LMB and ≥ 11” for SMB.

River Fisheries

Many of the larger tributaries of Lake Champlain and the Connecticut River support smallmouth bass populations and fisheries (Figure 1). Creel surveys on the White River found smallmouth bass represented a small percentage of the fish caught (≤ 5%) (Claussen 1987, Claussen 1993, Claussen 1995). For the Winooski River between Bolton Dam and Richmond, smallmouth bass represented a much higher percentage of total catch (27%) but no harvest was observed (Kirn 2001). It was suggested that the lack of harvest may be due to the small size of individual fish caught. In both of these waters, the bass populations represent a self-sustaining river population. In lower sections of Lake Champlain tributaries (lake to first barrier) a spring smallmouth bass spawning run occurs. While harvest is currently closed, many of these rivers support popular catch and release fisheries for anglers actively targeting smallmouth bass.

Due to the strong preference of largemouth bass for lake-based habitats, they are rarely observed in river reaches that have noticeable current. They do inhabit some of the state's large, low gradient rivers, especially those areas that are immediately upstream of a lake or that provide large areas of off-channel still-water habitat (Figure 1). Fish sampling and creel survey data are generally lacking for rivers that support largemouth bass fisheries, but many largemouth bass caught from Connecticut River setbacks have been entered into the Master Angler Program.

Management

Vermont Regulation History

Vermont has long recognized the importance of bass and has offered them protection for many years. One of the earliest mentions of bass protection occurred in the *1877 Biennial Report of the Fish Commissioners of the State of Vermont*. In this report the commissioner provided multiple recommendations including gear restrictions (hook and line only) and suggested that bass should be offered the same protection against illegitimate modes of capture as the 1874 Act passed for trout and salmon. Shortly after those recommendations occurred, an act was passed that allowed the harvest of bass only caught by hook and line with a 10-inch minimum length. Additionally, the season was closed in the spring to protect bass during spawning. During this same period, black bass (smallmouth and largemouth) were actively being stocked into many Vermont lakes. In some cases, individual lakes were even closed to bass harvest in an effort to protect the recently introduced bass (Years: 1885 to 1889).

The 10-inch minimum length has been constant for more than 130 years, but creel limits have evolved. During the late 1800s, creel limits did not exist, but in 1903, a 24-fish per day (individual) or 36-fish per boat (two or more anglers) limit was established. In 1929, the limit was reduced to 10 fish per day and in 1981 it was reduced to 5 fish per day where it remains to this day.

Bass seasons have been relatively constant over the years with minor adjustments in the season opener. The season opener historically ranged from May 1 to July 1 and is currently set to the second Saturday in June. In 1966, a limited ice fishing season for bass (and trout and salmon) was experimentally established on eight Vermont lakes. In 1974, this ice fishing season was expanded from eight to more than 40 lakes.

Historically, bass were protected from targeted angling during the spring, but in recent years (since 1991), a spring catch and release season was created. This season requires the use of artificial lures and flies to minimize hooking injury. The spring catch and release season remained constant until 2013, when it was expanded. Currently, the open water catch and release angling season runs from December 1 to the Friday before the second Saturday in June on waters open to angling.

A summary of the historic regulations and list of all current bass regulations can be found in Appendix III.

Regulation of Angler Harvest

Fishing regulations for bass include creel limits, length limits, season closures and gear restrictions. While harvest regulations are applied for a variety of biological, social and political reasons (Everhart and Youngs 1975; Isermann and Paukert 2010; Radomski et al. 2001), the following must occur to be effective in protecting or altering a fish population:

- Fishing mortality (harvest and hooking mortality) must be a significant component of the total mortality of a population; and
- Regulations must address specific fish population and fisheries characteristics of the target water; and
- Angler compliance must be high.

General regulations are applied statewide and are intended to provide a broad measure of protection for a given species or address social concerns. Wide variations in fish population characteristics, recreational fisheries, geographic location and annual environmental conditions often limit the effectiveness of these regulations in providing adequate protections.

Specialized regulations are tailored to the specific biological and fisheries characteristics of an individual or group of similar waters with the intent of producing a specific response in the fish population (e.g., increase density, larger sizes, etc.). Special regulations often utilize a combination of creel and length limits and may include catch and release regulations, gear restrictions or seasonal closures. While these targeted regulations may be more effective in improving bass abundance and/or size structure, conflicting angler interests and added complexity of regulations may limit their acceptance, implementation and compliance (Isermann and Paukert 2010; Page and Radomski 2006; Radomski et al. 2001).

Creel Limits

Creel limits set the number of fish that can be legally harvested in a single day by an individual angler. Creel limits are widely regarded as largely ineffective in reducing the total harvest of fish over the course of the season, as few anglers actually catch and keep their full limit (Isermann and Paukert 2010; Radomski et al. 2001; Cook et al. 2001; Noble and Jones 1999).

Creel limits are often used to more equitably spread the harvest among a greater number of anglers (Fox 1975), although Radomski et al. (2001) submit there is no evidence to support this theory. Creel limits can provide socially acceptable restrictions on the amount an individual angler can harvest in a day and may provide a measure of success for anglers (Fox 1975; Cook et. al. 2001). Cook et al. (2001) suggest that creel limits may over-exaggerate the biological capacity of waters and negatively impact angler satisfaction if too difficult to attain. They recommend creel limits be based upon a reasonable expectation of catch that more anglers can achieve. Finally, creel limits may serve to remind anglers that fisheries resources are finite (Radomski et al. 2001) and serve to instill a conservation ethic. Paukert et al. (2007) reported all 48 states within the continental United States maintained statewide creel limits ranging from two to 10 bass per day.

The current statewide creel limit for largemouth and smallmouth bass (combined) in Vermont is five per day and has been in effect since 1981 when it was reduced from 10. Statewide angler surveys conducted in both 2000 and 2010 revealed more than 60% of Vermont resident anglers support the current creel limit on inland waters and on Lake Champlain (Connelly and Knuth 2010). Ice anglers (64%) showed a somewhat higher level of support than open water only anglers (59%). Of the 22% of Vermont residents that disagreed with the current creel limits in 2010, 81% supported lower limits (average recommendation = 3.4). Non-resident anglers were less supportive of the current creel limit (48% agree, 29% disagree) with 93% of those opposed supporting lower limits (average recommendation = 4.1).

Recommendation. As creel limits primarily address social considerations and recent statewide angler surveys indicate general support for current regulations, there are no compelling reasons to consider changes to the statewide general creel limit at this time. In addition, the current five fish limit is not an unrealistic goal for most Vermont bass fisheries and therefore should not negatively influence angler satisfaction.

Length Limits

Length limits have been shown to be effective in altering bass population abundance and size structure when appropriately applied to specific population and fishery characteristics and where harvest is significant (Gablehouse 1984; Martin 1995). Length limits include minimum, protected slot, harvest slot and maximum length limits.

Minimum length limits require the release of all fish below a specified length and can be used to protect fish until they reach sexual maturity or a desired size. While positive improvements in bass fisheries have been documented following the implementation of minimum length limits (Jacobs et al. 2002; Wilde 1997; Novinger 1984), if used in abundant populations with high recruitment, negative impacts to growth and size structure may occur (Carline et al. 1984; Novinger 1984). In a review of largemouth bass evaluations, Wilde (1997) concluded that minimum lengths were effective in increasing angler catch rates, but not improving size structure. In Vermont, angler and electrofishing catch rates and size structure improved following implementation of a 14-inch minimum length limit for largemouth bass in Lake Morey in 1991 (Kirn 1996), however, changes in the aquatic plant and fish community, including the establishment of Eurasian watermilfoil and bluegill during this period, confound evaluating the true effect of the length restrictions.

Protected slot limits allow harvest of smaller fish in populations exhibiting high densities and slow growth, in an attempt to reduce intraspecific competition and improve growth rates (Gabelhouse 1987; Isermann and Paukert 2010). Fish are protected within a specific length range and are again available for harvest when they exceed the upper threshold of the protected slot. In a review of 42 studies, Wilde (1997) concluded that slot length limits have generally been successful in restructuring largemouth bass populations by increasing population size and the proportion of larger fish. Likewise, Buynak and Mitchell (2002) and Jacobs et al. (2002) also reported improvements in bass fisheries protected with protective slot limits. Some studies, however, have reported failures with this approach because anglers were not willing to harvest small bass in sufficient numbers to elicit bass population responses (Gablehouse 1984; Martin 1995). In these situations, slot length limits function as higher minimum length limits. This was also the case in Vermont where a 10 to 12-inch protected slot limit was applied to very dense populations of largemouth bass in Kent Pond and Baker Pond (Kirn 1997).

Harvest slot limits allow harvest within the defined slot, while protecting fish below and above the slot range. Harvest slot limits have been used to protect long-lived species such as sturgeon and paddlefish, presumably to protect recruitment of young and adult spawners. Population modeling of harvest slot limits consistently resulted in increased harvest while maintaining a more natural age structure, conserving reproductive capacity of larger fish and increasing angler catches of trophy fish than more traditional minimum length limits (Gwinn et al. 2013). Acceptance of such regulations for bass fisheries may be difficult, particularly by tournament anglers, as larger fish are required to be released.

Maximum length limits allow harvest only below a defined maximum length. Carlson and Isermann (2010) found these regulations were largely effective in increasing the proportion of fish above the maximum length. They suggest that maximum length limits are best applied to populations comprising smaller fish with moderate growth and moderate fishing activity. These regulations provide an alternative to protected slot limits where harvest of smaller size classes is warranted to improve size structure. As with harvest slot limits, it is likely that bass tournament anglers would oppose maximum regulation options unless an exception to the immediate release of larger bass is granted for tournaments (Jacobs et al. 2002).

Vermont's current minimum length limit is 10 inches for largemouth and smallmouth bass, except for rivers, where no length limit applies. This limit has been in existence since 1884 when other protections for bass were implemented. While the original intent of the 10-inch limit is unclear, it does very little to protect reproductive capability of bass (VTFWD 1989) or fishing quality. In addition, very few Vermont anglers would consider harvesting bass below 10 inches (Connelly and Knuth 2010; Kirn 1997).

Where length limits are applied to improve fishing quality it is important to recognize angler opinions of desirable bass sizes. The 2010 Vermont Angler Survey indicates that the average "smallest keeper size" was 11.4 inches while only 28% and 32% of resident anglers would keep a largemouth bass or smallmouth bass, respectively, at the size of the current statewide minimum length limit of 10 inches (Connelly and Knuth 2010).

Approximately 33% of resident anglers and 57% of nonresident anglers report that they do not keep bass. This proportion has steadily increased during the 20 years covered by the 1991, 2000 and 2010 statewide angler surveys. Resident anglers reporting that they do not keep bass increased from 12 to 13% in 1991, to 25% in 2000, and to 33% in 2010. Similarly, nonresident anglers reported releasing bass with rate increases from 20 to 22% in 1991, to 45% in 2000, and to 57% in 2010. These higher rates of catch and release fishing can have a significant influence on the effectiveness of future harvest regulations.

Angler opinions on quality sizes for largemouth and smallmouth bass can be used to craft regulations which focus on improving fishing quality. The 2010 Vermont Angler Survey indicates that a 16-inch largemouth bass and 14-inch smallmouth bass were considered quality size by at least two-thirds of resident anglers (Connolly and Knuth 2010).

Recommendation. The current statewide minimum length limit of 10 inches provides neither biological nor social benefits but no changes are proposed. As described above, length limits function best when tailored to specific bass population and fishery characteristics. While increasing the statewide minimum length limit may conceivably benefit some fisheries, it may negatively impact others. Extensive monitoring of bass populations in Vermont rarely shows length distributions indicative of excessive harvest. In these cases, specialized regulations specific to these bodies of water would be a more appropriate management strategy but this must be balanced by the desire of anglers to have consistent statewide fishing regulations that are easier to understand.

Season Restrictions

Closed seasons are among the oldest fisheries regulations and are often used to protect fish prior to or during spawning, or when fish are concentrated and vulnerable to harvest (Isermann and Paukert 2010; Quinn, 2002; Noble and Jones 1999). Historically closed seasons also enabled law enforcement to shift focus to hunting activities (Noble and Jones 1999), while some states have retained the concept of season openers to generate angler excitement and license sales (Isermann and Paukert 2010).

Largemouth and smallmouth bass exhibit predictable spawning behaviors which make them vulnerable to angling (Siepker et al. 2009; Suski and Phillipp 2004). While removal of spawning bass from their nest has been shown to reduce fry production (Siepker et al. 2009; Phillipp et al. 1997; Ridgeway and Shuter 1997), effects on population levels and fishing quality remain undocumented (Siepker et al. 2009; Quinn 2002). For example, in Wisconsin, Mraz (1964) reported no negative impacts to a largemouth bass fishery with an earlier season opener and elimination of length limits.

Quinn (2002) reported that only 20 states continue to utilize closed seasons for black bass, with most occurring in the northern states. Fisheries managers in these states were less concerned with the recruitment of young bass than with the potential reduction in fishing quality if large adult bass are harvested during the spawning season. This concern was voiced when Vermont implemented its statewide spring bass fishery in 1989: *"Specifically, we are concerned that a disproportionate number of large bass may be harvested during early spring, impacting fishing quality throughout the remainder of the season.* (VTFWD 1989)" It is for this reason that immediate release of bass was required during the early spring season, as was the use of artificial flies and lures to reduce potential hooking mortality.

In Vermont, there are three distinct bass fishing seasons:

- Open Water Season: *Second Saturday in June through November 30.*

  This season protects bass from harvest during the majority of the spawning season in most years, although annual and geographic variation in the timing of spawning can be substantial in Vermont. Therefore, in some years when bass spawning is delayed, little protection may be afforded in some waters.

- Catch and Release Season: *December 1 through the Friday before the second Saturday in June.*

  An early catch and release season was implemented in 1989 to expand angling opportunities while limiting the potential for negative impacts to bass populations. This early season was aligned with the traditional trout fishing season and allowed anglers to fish during the spawning season, while requiring immediate release and the use of artificial flies and lures. In 2013, the start of the catch and release season was extended from the second Saturday in April to December 1 and continues until the start of the open water season. The expanded season provides additional angling opportunities during the occasional early spring when conditions allow access to Vermont lakes and ponds.

- Ice Fishing Season (select waters): *Third Saturday in January through March 15.*

  Ice fishing for bass, trout and salmon was first implemented in Vermont in 1966 on eight lakes and was deemed a "desirable regulatory fisheries practice on Vermont's large two-story lakes" and recommended further expansion (Stewart 1966). In 1974 a total of 40 lakes greater than 100 acres were opened to ice fishing for bass, trout and salmon, although these regulations have not been uniformly applied throughout the state. It is assumed that the ice fishing date range was based upon social factors and the likelihood of safe ice conditions rather than a biological rationale.

Vermont's bass fisheries consist of an early spring catch and release season, and both an open water season and ice fishing season (select waters) where harvest is allowed. Understanding angler effort, fishing characteristics and motivations during these seasons will be important to developing future bass management strategies. Throughout the 1990s, substantial efforts were made to conduct angler creel surveys during the open water and ice fishing seasons on several Vermont lakes and ponds supporting bass fisheries. These surveys provide a means to compare fishing effort and bass catch and harvest among the three seasons.

Open Water vs. Ice Fishing

Open water anglers account for the vast majority of the annual catch and harvest of both largemouth and smallmouth bass (Table 2). Not only is the open water season for bass approximately three times longer than the ice fishing season, but open water catch rates are also substantially higher.

Catch and harvest rates were much higher for largemouth bass than smallmouth, particularly during the ice fishing season. Low vulnerability of smallmouth bass during the winter is further supported by five years of ice fishing creel surveys on Waterbury Reservoir, a productive smallmouth bass lake, where no harvested smallmouth bass were observed in 1126 angler interviews. Likewise, three ice fishing creel surveys on Harriman Reservoir yielded a total harvest of 7 smallmouth bass from 1829 angler interviews.

Ice anglers were more focused on harvesting largemouth bass than their open water counterparts and therefore accounted for a larger share of the annual harvest than is represented by their catch (Table 2). Open water anglers on average harvested 41% of the largemouth bass they caught while ice anglers harvested an average of more than 80%. While ice fishing season accounted for an average of only 15.8 % of the annual catch, it comprised 36.3% of the annual harvest for largemouth bass.

Table 2. Comparison of catch and harvest statistics for open water and ice fishing seasons in waters where full season creel surveys were conducted in the same year.

Species/Season	Catch/Angler Hour (range)	Harvest/Angler Hour (range)	% Total Estimated Catch (range)	% Total Estimated Harvest (range)	% of Bass Harvested (range)
Largemouth Bass					
Open	**0.21** (0.09-0.27)	**0.068** (0.056-0.078)	**85.0** (74.7-90.3)	**68.2** (61.7-73.8)	**41.0** (29.8-50.0)
Ice	**0.067** (0.05-0.089)	**0.051** (0.044-0.066)	**15.8** (9.9-25.3)	**36.3** (26.2-44.3)	**80.2** (69.9-88.0)
Smallmouth Bass					
Open	**0.079** (0.023-0.19)	**0.017** (0.00-0.02)	**96.1** (100-82)	**80.9** (62.1-100)	**30.6** (6.4-56.5)
Ice	**0.003** (0.00-0.012)	**0.002** (0.00-0.007)	**3.9** (0-18)	**9.1** (0-37.9)	**36.5** (0.0-69.6)

Vermont resident anglers appear generally satisfied with ice fishing for bass on selected lakes and ponds as currently allowed. The 2010 statewide angler survey reported only 13% of respondents did not support ice fishing for bass while 58% indicated they somewhat or strongly agreed with this season (Connolly and Knuth 2010). Ice anglers indicated a higher level of strong support than open water anglers (34% vs. 19%).

Lake Champlain has never been opened to ice fishing for bass, although it provides ice fishing for trout and salmon. When asked if they would support ice fishing for bass, 31% of Vermont resident anglers responded *"No"* while 46% somewhat or strongly supported the concept. Open water anglers were more strongly opposed (37%) to an ice fishing season for bass on Lake Champlain than ice anglers (25%).

The tendency of ice anglers to be more harvest oriented should be considered when developing future fishing regulations. Expanding ice fishing season opportunities to new lakes should consider the potential for additional harvest, particularly for largemouth bass, and its associated biological and social implications. Fisheries managers should also be aware that acceptance and implementation of specialized regulations requiring more restrictive harvest regulations may be more difficult where ice fisheries currently exist.

Early Spring Catch and Release Season

The early spring bass season requires immediate release of bass due to concerns of potential overexploitation of quality-sized bass during the spawning season when bass locations are predictable and nesting behaviors increase vulnerability to angling. Full season creel surveys conducted on Lake Bomoseen (1992), Lake Champlain (1999) and Lake Morey (1995) showed higher catch rates during the early spring in one of three waters for largemouth bass and smallmouth bass (Table 3). Information on the relative size distribution of the catch between the two seasons is not available due to the immediate release requirement of the spring fishery.

Table 3. Catch rates (fish per hour) for largemouth and smallmouth bass from full season creel surveys on three waterbodies.

Waterbody	Year		Catch and Release Season	Open Water Season
			Largemouth Bass	
Lake Bomoseen	1992		0.417	0.210
Lake Champlain	1999		0.203	0.361
Lake Morey	1995		0.177	0.296
			Smallmouth Bass	
Lake Bomoseen	1992		0.140	0.160
Lake Champlain	1999		0.106	0.076
Lake Morey	1995		0.024	0.066

Changes in the popularity of bass fishing in Vermont and angler behaviors, as described elsewhere in this report, point to the need for updated angler creel surveys. Increased angler participation in bass fishing, as well as a significant trend towards catch and release fishing, may substantially alter conclusions drawn from these 15- to 20-year-old angler creel surveys.

Recommendation. The current bass season allows for catch and release angling from December 1 through the beginning of the open water season in mid-June, when harvest is allowed through November 30. This season structure generally provides protection to spawning bass from harvest except in waters where spawning is delayed due to geographic location or environmental conditions. To provide full protection for all waters in all years would likely require delaying harvest until July 1, which would likely be unpopular with anglers. As long-term monitoring of bass populations does not suggest trends of declines in quality measures which can be attributed to season length or the early spring catch and release season, no change in the current season structure is recommended at this time. Further addition of waters open to ice fishing for bass should be evaluated on a case-by-case basis considering angler desires and the potential for impacts to bass populations and overall fishing quality.

Gear Restrictions

The application of terminal tackle restrictions is often applied in conjunction with specialized length limits or catch and release regulations in an attempt to maximize survival of released fish (Noble and Jones 1999). Reviews of hooking mortality studies have identified hooking location as the most critical factor affecting mortality of released fish (Bartholomew and Bohnsack 2005; Wydoski 1977), where fish hooked in the esophagus, gills, stomach and other vital organs experience substantially increased mortality. These reviews also report the use of natural baits and J hooks (vs. circle hooks) increase the risk of deep hooking and associated mortality. Other findings from these studies include:

- Depth of capture, warm water temperatures and extended playing and handling times were significant mortality factors.
- Cutting the line on deeply hooked fish greatly increased survival.
- Barbless hooks had marginal survival benefits vs. barbed hooks.
- Fish size and hook size were not significant mortality factors.
- Too few studies were available to adequately assess the effect of treble hooks vs. single hooks.
- Hooking mortality studies, which often involve releasing fish into holding pens, may underestimate mortality due to unnatural protection from predation during the recovery period.

The survival of released fish is a key assumption of special length and other regulation strategies requiring the release of hooked fish. However, the use of gear restrictions (artificial flies and lures) are not generally favored by Vermont resident anglers as only 23% supported their use in the 2010 statewide angler survey (Connelly and Knuth 2010). In addition, enforcement and compliance with gear restrictions for bass may be compromised in waters where natural baits are allowed for other species. As gear restrictions may be difficult to impose, angler education on proper handling and release techniques should be provided where fishing regulations require the release of a portion of the catch.

Recommendation. The current gear restrictions that are in effect during the catch and release bass season are recommended to remain because they reduce hooking mortality and are generally accepted by the angling public. Further application of gear restrictions may be appropriate for certain special regulation situations and should be considered on a case-by-case basis.

General Regulations

A comprehensive listing of current Vermont general and specialized bass regulations can be found in Appendix IV.

Specialized Regulations

Specialized regulations intended to improve specific bass fisheries have been sparingly used in Vermont. In 1991 a 14-inch minimum length limit was applied to largemouth bass in Lake Morey following several years of poor recruitment and dramatic declines in spring electrofishing catch rates (Kirn 1996). In an attempt to increase the abundance of quality-sized bass in Baker Pond and Kent Pond, regulations for angler harvest of abundant small (<10-in) largemouth bass were liberalized through implementation of a 10- to 12-inch protected slot length limit, an increase in the daily creel limit from 5 to 10, and a limit of one bass greater than 12 inches in 1993 (Kirn 1997). More recently, catch and release regulations were applied to previously unfished ponds to avoid rapid depletion of quality-sized bass, including Berlin Pond (Kirn 2014) and Stiles Pond (Kratzer 2014).

Vermont resident anglers generally support the use of specialized regulations for improving bass fisheries in some waters, although support for specific regulations varies. The most recent statewide angler survey showed resident anglers supported the use of length limits (56%) but were less interested in the use of lower creel limits (34%), catch and release (29%) or artificial flies and lures only (23%) regulations (Connolly and Knuth 2010). Resident open water anglers and ice anglers had similar opinions of the regulation options, while nonresident anglers tended to be more supportive of all special regulation options.

Recommendations. The application of specialized regulations should be considered where biological and fishery characteristics of the water or groups of waters suggest changes to harvest regulations will result in improved fishing quality through alterations in bass size structure or densities. For fishing regulations to be effective, angler harvest must be a significant component of total fishing mortality and released bass must have a reasonable chance of survival. Angler acceptance and compliance will also be important considerations in developing regulation strategies, along with the desire to have regulations be consistent and easy to understand.

Specialized regulations should target improvement in specific size classes of bass based upon angler opinions of quality sizes. The 2010 statewide angler survey suggests at least two-thirds of resident anglers would consider 16-inch largemouth bass and 14-inch smallmouth bass to be quality size (Connolly and Knuth 2010). Fisheries managers should also strive to develop a suite of regulation options to target specific biological and fishery characteristics to minimize the number and complexity of regulations (Jacobs et al. 2002).

Interjurisdictional Waters

Several Vermont waters are jointly managed by other states or Canadian provinces (e.g., Lake Champlain, Lake Memphremagog, Connecticut River). While coordination and consistency in regulations among jurisdictions is desirable, organizational and political realities may limit this ability.

Bass Tournaments

Across North America, bass tournaments have gained in popularity. One study estimated that bass tournament fishing had increased by 300% during the past 25 years (Noble 2002). This increase prompted many state and provincial agencies to create bass management plans and formalize tournament requirements. Vermont has also experienced an increased interest in bass tournaments. In 1996, Vermont started issuing permits for fishing tournaments held on Vermont waters. The State of Vermont defines a tournament as an activity where individuals pay an entrance fee and compete for a prize based on the size and/or number of fish caught (*10 VSA 4613*). While these permits include multiple types of tournaments, a large portion of them are for bass. In 1996, the first year they were available, 25 permits were issued for bass tournaments. Most bass tournament permits were issued to out of state clubs and focused on four water bodies: Lake Champlain (36%), Lake Bomoseen (20%), Connecticut River (16%) and Lake St. Catherine (16%).

In 1997, Vermont experienced its first large-scale, nationally recognized bass tournament. Bass Anglers Sportsmen Society (B.A.S.S) had their "Top 100" tournament on Lake Champlain out of Mallets Bay. Just two years later, B.A.S.S. held another, "Top 150" tournament also out of Mallets Bay. In 2001, 114 bass tournament permits were issued. In 2012 this increased to 193 bass tournaments with a focus on five waterbodies: Lake Champlain (71%), Connecticut River (9%), Lake Bomoseen (7%), Lake St. Catherine (4%) and Lake Memphremagog (4%). Clearly, most of the expansion is related to the Lake Champlain bass fishery. Lake Champlain has been highly ranked by many fishing organizations, and the World Fishing Network described it as "perhaps the best lake in all of North America for both quality largemouth and smallmouth bass."

The 2010 statewide angler survey included questions related to angler opinions on specific fisheries management issues. Anglers were asked to rate the issue of fishing derbies/tournaments (other than "kids" derbies). In this survey, 62.5% of Vermont residents and 52.8% of non-residents considered fishing derbies/tournaments as "Not a problem" (Connelly and Knuth 2010).

While the opinion survey suggests tournaments are not a problem, the VTFWD recognizes the increased popularity of bass tournaments and has taken some basic actions to minimize user conflicts. To minimize access area conflicts, the department only allows one tournament group to use an access area on a given day. The department also does not issue permits during the youth waterfowl hunting weekend.

In 2009, the department expanded the bass tournament report form in an effort to gain additional biological information. Based on the submitted reports for tournaments in 2014, 10,958 bass were weighed-in, resulting in a total weight of 30,785 pounds. These bass had an average weight of 2.8 pounds.

Recommendations. The department should continue the current permitting program and review access area usage on a regular basis for possible user conflicts. The department should also continue to assess angler opinions regarding fishing tournaments/derbies through periodic statewide angler surveys.

If resources allow, the department should continue to expand bass assessments on lakes which annually experience multiple bass tournaments. Finally, the state should periodically evaluate tournament permitting process/conditions in light of bass assessment data, angler survey data or user conflicts, adjusting process/conditions as appropriate.

Introductions of Bass and their Forage

The popularity of black bass among Vermont's anglers has been abetted by the expansion of their range throughout the state through both government-sanctioned and illegal introductions during the last 150 years. While the current distribution of black bass includes many public and private waters across the state, bass and forage fish introductions are still important management tools. The purpose of this section of the Statewide Management Plan for Largemouth and Smallmouth Bass is to summarize past introductions of black bass and their forage, summarize potential benefits and risks of future introductions, review current regulations and policies related to fish introductions in Vermont, and recommend procedures for future introductions of black bass and their forage in waters of the state.

Past Introductions

Most of the fish introductions that occurred during the last 150 years were not well documented, but the department has records of government-sanctioned bass stockings dating back to the 1870s. Interestingly, some of the earliest bass introductions in Vermont were motivated by a desire to control pickerel populations: "In our opinion, the Black Bass should be introduced into all the pickerel ponds of the state, (being the only variety of fish that will exterminate the pickerel) and which affords us a more wholesome and delicious food than the poor, unsavory fish which have so rapidly multiplied in our waters" (Edmunds and Goldsmith 1874). A recent largemouth bass stocking by VTFWD occurred in 1996 in West Hill Pond, and a recent VTFWD smallmouth bass stocking was 1989 in Wrightsville Reservoir. The methods used to introduce bass to new waters were often not well documented, but it appears that the typical method was to simply collect various sizes of bass, ranging from fry to adult, from lakes and ponds with abundant populations, and to transport them to new waters.

Documentation of forage fish introductions seems to be even less complete. There are historic records of yellow perch and rainbow smelt (*Osmerus mordax*) stockings, but it is not clear what the intentions were. Since 1980, the only time the department has stocked a fish specifically for the purpose of providing bass forage was in 2005, when pumpkinseed were introduced into Kent Pond.

Potential Benefits of Bass and Forage Fish Introductions

The first and most obvious benefit of black bass introductions is to expand fishing opportunities for these species. While no new reservoirs have been created in Vermont in the last several decades, creating a bass fishery in newly constructed reservoirs was clearly an important motivation of past black bass introductions. Introductions into new reservoirs usually resulted in self-sustaining populations and nearly all large reservoirs in Vermont now support one or both species of bass. Another important motivator has been to provide quality angling opportunities in natural waters that previously lacked a popular fishery. Waters may lack quality angling opportunities because the species that are present are not popular with anglers or because the abundance and size structure of the existing fish community does not provide for sufficient catch rates of quality or "keeper" sized fish. Some recent examples of newly created bass fisheries in natural lakes and ponds include Sabin and Bliss Ponds.

Another potential goal of black bass introductions is increased predation on over-abundant, stunted forage fish. For example, this was one of the main motivations for introducing largemouth bass to Stoughton Pond (Cox 1988). Several studies outside of Vermont have attributed reduced abundance and/or increased growth rates of sunfish and yellow perch to predation by black bass (Gabelhouse 1984; Guy and Willis 1990; Olive et al. 2005; Lippert et al. 2007; Schultz et al. 2008; Michaletz et al. 2012).

Another rational for black bass introductions is their potential for self-sustainability. Many of the trout fisheries in Vermont's lakes, ponds and the large, warmer rivers are dependent on annual stocking, which is a costly, albeit valuable management practice. Often these trout fisheries are unsustainable primarily due to a lack the suitable habitat needed for all life stages. In contrast, many of Vermont's lakes and ponds and large, warmer rivers can support all life stages of one or both black bass species, making annual stocking to maintain Vermont's bass fisheries unnecessary.

In some cases, forage fish introductions can improve existing bass fisheries. Bass living in waters that lack sufficient forage may exhibit poor growth and condition (Michaletz et al. 2012). In some situations, the introduction of one or more forage species can improve the bass population's size structure (Swingle 1949), thereby improving angler satisfaction. Kent Pond is the most recent example of a deliberate introduction of bass forage. In 2005, pumpkinseed were introduced and became quickly established. Annual monitoring of the largemouth bass population indicates gradual improvement in size structure, with more fish becoming recruited to larger size classes (VTFWD unpublished data).

Potential Risks of Bass and Forage Fish Introductions

While bass and forage fish introductions are useful tools for fisheries managers, they could potentially have irreversible, negative effects on existing fisheries. Fisheries managers should carefully consider all potential outcomes of an introduction before deciding to proceed. Potential unintended consequences include competition and predation with existing species, introduction of diseases or parasites, introduction of new genes to an existing population, and creation of a new source population for potential unauthorized spreading by anglers. Managers should consider these potential consequences not only for the receiving water but for any other waters into which the introduced fish might be able to migrate if they escape the receiving water.

Black bass introductions can affect existing fisheries through competition with other predators. For competition to occur there could be two or more species using the same limited resource, or the species may interact directly i.e. by eating each other. Diet overlap alone does not guarantee that competition will occur between two predators because the prey resource may not be a limiting factor. Nevertheless, black bass diets can overlap with walleye (Fayram et al. 2005; Wuellner et al. 2010), northern pike (Soupir et al. 2000), and salmonids (Hodgson et al. 1991; Jackson 2002; Vander Zanden et al. 2004). Diets of largemouth and smallmouth bass can also overlap with each other (Olson and Young 2003). Juvenile black bass diets can also overlap with juveniles and adults of smaller-bodied fishes such as sunfish and yellow perch. Black bass are known to be strong competitors with brook trout in ponds (Bonney 2006), and therefore should never be introduced to ponds with wild brook trout populations.

Because black bass adults are usually fish predators, they can affect existing fisheries. Bass are known to prey on juvenile walleye (Santucci and Wahl 1993; Fayram et al. 2005), northern pike (Wahl and Stein 1989), and salmonids (Zimmerman 1999; Fritts and Pearsons 2004). Largemouth and smallmouth bass can also prey on each other, and may exhibit cannibalism (Clady 1974; Garvey et al. 1998). Black bass can have dramatic effects on small-bodied fishes, even to the point of eliminating them from a waterbody (MacRae and Jackson 2001; Jackson 2002; Vander Zanden et al. 2004; Steinhart et al. 2007). Golden shiners disappeared from Miller Pond a few years after largemouth bass were introduced (VTFWD unpublished data). In general, bass should not be introduced to waters that support rare, small-bodied species such as blackchin, blacknose, and bridle shiner, which are listed among the Species of Greatest Conservation Need in Vermont. As mentioned earlier, black bass predation can result in reduced abundance of sunfish and yellow perch, which may be a management goal if it results in faster growth rates and improved sized structures (Gabelhouse 1984; Guy and Willis 1990; Olive et al. 2005; Lippert et al. 2007; Schultz et al. 2008; Michaletz et al. 2012).

Fish that might be introduced to a water to serve as forage for an existing bass population also have the potential to compete with existing fish species and to prey on existing fish and invertebrate species. Careful research on a potential forage fish and the existing fish and invertebrate community of the target water should occur before considering introducing a new forage fish. The new forage fish should be low on the food chain (i.e. primarily a planktivore or insectivore) to minimize energy loss from the foodweb.

Introduction of diseases or parasites, such as largemouth bass virus or bass tapeworm, is another potential risk of bass and forage fish introductions. There is no way to guarantee that diseases and parasites will not be transferred along with the fish that are being moved from one water to another, but precautions can be taken to minimize the risk. Any potential donor population should be screened for diseases and parasites. Populations with heavy disease or parasite loads or populations that have a known disease or parasite that is not present in the receiving water should not be used. Minimizing the distance between donor and receiving waters and selecting a donor water within the same watershed will also help to minimize the risk of introducing novel diseases or parasites to the receiving water.

The genetics of existing bass and forage fish populations in the receiving watershed should also be considered when choosing a donor population. While most of the bass populations in Vermont have been established within the past 150 years, it is possible that there could be some genetic differentiation among populations throughout the state. Choosing a donor population within the same watershed as the receiving water should help to minimize the threat of introducing new genetic material into any populations already established in the receiving watershed.

Finally, establishment of new black bass fisheries can potentially encourage and aid further unauthorized introductions by the public. First, a newly established bass population could potentially reduce the distance that anglers would have to transport bass between waters, thereby making it more tempting and easier for anglers to spread bass to other waters in the area. Second, introducing any fish species to a new water can potentially send the message to the public that introducing fish species to new waters is always a good idea, and they may be emboldened to try it themselves. Any attempt to introduce bass or their forage to new waters must be accompanied with public outreach that makes it clear that this management decision was only made after carefully considering all potential benefits and risks.

Current Regulations

Three statutes, two Fish and Wildlife Board regulations, and one commissioner's rule currently apply to the introduction of fish to waters of the state and to private ponds. In brief, the public can legally only stock brook, brown, or rainbow trout into private ponds, and a permit from the department may be required, depending on the numbers of trout stocked. The public cannot legally introduce any fish species into public waters.

Process for Bass and Forage Fish Introductions

The VTFWD Commissioner or his/her duly authorized agents can legally introduce species other than trout or salmon into waters of the state. A fisheries biologist that desires to introduce black bass or their forage to a water will follow the procedure outlined in the *Vermont Fish and Wildlife Fisheries Division Internal Review Guidelines for Fish Population Introduction Proposals,* signed 4/2/2013 by Division Director Eric Palmer or the most recent version of this document, the major points of which are included in the process outlined below.

1. Fisheries biologist identifies a need for bass or forage fish introductions.
2. Fisheries biologist prepares a written proposal for review by the VTFWD Bass Team and VTFWD Fish Health Program. The proposal should include:
    a. Goal and objectives of proposed introduction
    b. Status of existing fisheries in receiving water
    c. Characteristics of proposed donor water(s)
    d. Disease and parasite testing plans developed in cooperation with VTFWD Fish Health Program
    e. Potential for escape and spread from the receiving water
    f. Potential social concerns for and against proposed introduction
    g. Plan for subsequent evaluation
3. If Bass Team approves, proposal is edited and presented to the Fish Division.
4. The Fish Division may or may not recommend that a public meeting take place.
5. With Fish Division Director approval, the fisheries biologist coordinates with VTFWD fish health biologist to perform thorough disease and parasite screening of the proposed donor population(s) and possibly the receiving water.
6. Fisheries biologist captures fish from donor water and transports fish to receiving water.
7. Fisheries biologist monitors receiving water to determine whether population becomes established and objectives are met.

Bass Habitat Management

While statewide populations of largemouth and smallmouth bass are strong, healthy, and provide high-quality angling opportunities in many waters, several threats that put bass habitat at risk are routinely encountered by department fisheries biologists tasked with managing these populations for quality recreational angling opportunities. These threats include aquatic vegetation control, shoreline development, and water level manipulation. The department works diligently, primarily through permit review processes, to ensure that fisheries concerns are addressed to protect bass habitat from these threats.

Near-shore dwelling warmwater fish species, including largemouth bass of all life stages, are heavily reliant on abundant and structurally complex aquatic habitat such as aquatic vegetation and submerged coarse woody habitat (Crowder and Cooper 1979; Crowder and Cooper 1982; Weaver et al. 1997; Curtis et al. 2015). Although smallmouth bass are less reliant on submerged aquatic vegetation than largemouth bass, both species are susceptible to changing habitat features including loss of vegetative cover, declining recruitment of coarse woody habitat, and fluctuating water levels such as winter drawdowns.

Importance of Aquatic Vegetation

Aquatic vegetation plays a vital role in maintaining the overall integrity of aquatic ecosystems and in supporting diverse, healthy and abundant fish communities in Vermont lakes and ponds. Numerous studies have documented the importance of aquatic vegetation to the health and well-being of warmwater fish communities (Crowder and Cooper 1979; Savino and Stein 1982; Durocher et al. 1984; Paukert and Willis 2002), although others have shown that excessive vegetation can be detrimental to fish growth and fishing quality in some situations (Mitzner 1977, 1978; Bettoli et al. 1993). Optimal vegetative coverage for largemouth bass ranges from 40 to 60% of the total surface area of a waterbody. Waterbodies with limited areas of open water and vegetative cover greater than 60% of the surface area can negatively impact fish population size structure due to reduced foraging success for adult fish and increased survival of young fish due to lack of predation pressure, resulting in overabundance and stunting (Savino and Stein 1982; Carpenter and Lodge 1986; Bettoli et al. 1992; Valley et al. 2004; Nagid et al. 2015).

Evaluating the quality of vegetative habitat for bass can be unintentionally over-simplified however, if relying solely on measurements of optimal percent coverage of aquatic vegetation (Hoyer and Canfield 2001). In addition to the vegetation–to–open water ratio, the structural complexity of the aquatic plant community is also an important component of high-quality bass habitat. Complex habitat is often described in the literature as being “patchy,” meaning vegetated areas comprise plant species that vary in height and volume (stem/leaf arrangement), providing both vertical and horizontal cover. Quality patchy habitat is also defined as being scattered clumps of submerged aquatic vegetation with areas of open water (opening in the plant canopy can be as small as 12 inches or up to many feet), creating edges. Structurally complex habitat provides a variety of microhabitats which support a more abundant, diverse, and healthy fish community (Tonn and Magnuson 1982; Eadie and Keast 1984; Engel 1987; Bryan and Scarnecchia 1992; Valley and Bremigan 2002a; Pratt and Smokorowski 2003).

Weaver et al. (1997) found that structural complexity of aquatic vegetation, not simply vegetation abundance, was a major factor in fish community diversity and species composition, and provided particularly high-quality habitat for young-of-year fish. Chick and Mclvor (1994) found that distinct microhabitats created in a structurally complex stand of aquatic vegetation provided optimal foraging areas for a wide range of juvenile game and forage fish species, partly due to the diverse community of aquatic invertebrates that were found to colonize on the vegetation. Hosn and Downing (1994) reported that littoral fish species spend more than 80% of their time in stands of aquatic vegetation.

Importantly, quality fish habitat can include non-native aquatic plant species (i.e. Eurasian watermilfoil [EWM] *Myriophyllum spicatum* or curly-leaf pondweed *Potamogeton crispus*), and plant structure is often more important than total plant coverage or species present. For example, an area of lake bottom with 100% coverage of a low-growing aquatic plant species such as chara (*Chara sp.)* provides much less habitat value to fish than the same 100% coverage of a canopy species such as Eurasian watermilfoil (Valley et al. 2004).

All life stages of largemouth bass rely on aquatic plants for protection from predation and as foraging areas to hunt and consume invertebrates and prey fish (Annett and Dibble 1996; Dibble et al. 1996). Juvenile largemouth bass are particularly dependent on areas of submerged aquatic vegetation, and alteration or loss of this habitat may reduce bass growth, overwinter survival and recruitment to the adult stock. Furthermore, loss of critical habitat for any single largemouth bass life stage could ultimately limit growth of the entire population (Annett et al. 1996).

Successful largemouth bass reproduction and survival has been shown to increase with abundance of aquatic vegetation and decrease with reduced plant abundance (Annett and Dibble 1996). Maceina et al. (1995) estimated growth and survival of age-0 largemouth bass in relation to the presence or absence of aquatic vegetation and found that the density of age-0 fish was 18 times higher in vegetated versus unvegetated littoral habitats. Interestingly, age-1 recruitment was enhanced in areas dominated by EWM. Other studies in Florida found that sub-adult and harvestable sized largemouth bass abundance increased as hydrilla (*Hydrilla verticillate)* spread to 40- to 60-percent coverage of waterbody surface area, but declined drastically following hydrilla control efforts that brought the total percent vegetative cover below 20% lake wide (Hoyer and Canfield 1996; Maceina 1996).

Aquatic Vegetation Control

Although aquatic vegetation is one of the most important natural components of bass habitat, supporting species diversity, abundance, and quality population structure, conflicts often exist between various lake users over the need for and extent of aquatic vegetation control.

Eurasian watermilfoil has been the most common target of many vegetation control programs in Vermont, although "nuisance" levels of native aquatic plant species such as lily pads (*Nymphaea sp.)* and pondweed (*Potamogeton sp*.) have also been controlled in the past. Negative opinions of aquatic vegetation, native or non-native, have been somewhat exacerbated by shoreline development contributing to erosion, overland run-off, sedimentation and nutrient loading, which can lead to increased plant growth (VTANR 2013).

While EWM provides value as fish habitat and attracts anglers who prefer to fish in or near aquatic vegetation (Wilde et al. 1992; Slipke et al. 1998), EWM's ability to quickly out-compete some native plant species, form dense stands, and grow to depths of up to 20 feet has caused impacts, in some instances, to other recreational uses such as swimming and boating in near-shore areas. As a result, chemical and mechanical vegetation control programs have been implemented on a number of Vermont waters during the last 30 years.

The large-scale control of aquatic vegetation in Vermont lakes and ponds can pose a direct threat to bass habitat, particularly if diverse, structurally complex native plant communities do not re-establish quickly, or if repetitive control efforts keep aquatic vegetation suppressed over long periods.

Despite the negative connotations of non-native aquatic plant species like EWM and curly-leaf pondweed, when they exist as part of a diverse plant community or grow in patches with areas of open water, these species can provide value as quality fish habitat (Engel 1995; Pratt and Smokorowski 2003) without negatively impacting fish populations (Weaver et al. 1997; Olson et al. 1998; Valley and Bremigan 2002b) and support high-quality recreational angling opportunities.

Recommendations. Eradication, total control, or even significant long-term suppression of well-established non-native species is usually impossible (Simberloff 2003, 2005; Vander Zander et al. 2010; Caplat et al. 2012), or too costly and labor-intensive to be done effectively (Pagnucco 2015). Aquatic nuisance species plant control efforts in Vermont should focus on alternatives that consider all recreational uses, while avoiding significant and widespread losses of fish habitat.

Aquatic vegetation control efforts should:

- Focus on reducing the spread of invasive aquatic plants;
- Focus only on non-native aquatic plant species and not on native species;
- Be approved only in areas that directly and significantly impact certain recreational uses. For example, heavily infested lake areas immediately surrounding public and private docks, boat ramps, boating channels, or beaches and swimming areas;
- Avoid whole-lake treatments. Emphasis should be on localized, small-scale control;
- Avoid areas far offshore, along undeveloped shorelines where it is not in conflict with other recreational uses, or areas where it is not impeding boat traffic or access to waterfront properties.

Occasionally, the early discovery of a new non-native aquatic plant infestation can provide an opportunity for complete eradication before the species becomes well-established and widespread. In such instances, a more aggressive control strategy would be encouraged if there's reasonable potential for success.

Shoreline Development

Protecting terrestrial vegetation surrounding Vermont's waterbodies is critical for providing high water quality and fish habitat. Removing trees, woody shrubs and natural grassy vegetation and establishing manicured lawns along shorelines can negatively affect fish habitat through shoreline erosion, siltation, nutrient run-off and resulting algae blooms and water quality degradation (VTANR 2013). Naturally vegetated shorelines filter run-off pollution, stabilize shoreline soils, and directly contribute to fish habitat by allowing the natural addition of fallen trees and branches, known as coarse woody habitat (CWH). Additionally, leafy canopy from shoreline trees and shrubs keep water temperatures cooler by shading the surface and provide leafy material to the water where it ultimately serves as food for invertebrates.

Numerous studies have documented the importance of CWH in lakes and its function as habitat for fish and the aquatic community in general (Newbrey et al. 2005; Schneider and Winemiller 2008, Czarnecka 2016). CWH functions similarly to submerged aquatic vegetation by providing cover and protection, spawning surfaces, and areas that colonize with beneficial algae and algae-grazers in the form of aquatic invertebrates, which in turn provide a food source to forage fish, panfish, and juvenile game fish species (Lewin et al. 2004; Sass et al. 2006, 2006b; Biro et al. 2008; Helmus and Sass 2008; Lawson et al. 2011; Sass et al. 2012).

Shoreline development often results in a decrease in coarse woody habitat when waterfront property owners remove "unsightly" fallen trees from the water and thin or remove shoreline vegetation, preventing future recruitment. Research has shown that developed shorelines typically have less CWH than undeveloped shorelines (Christensen et al. 1996), resulting in decreased fish habitat quality and changes to local fish distribution, abundance, and growth rates (Bryan and Scarnecchia 1992; Schindler et al. 2000; Ahrenstorff et al. 2009; Gaeta et al. 2014).

Recommendations. Shoreline development is regulated in Vermont through *29 V.S.A. Chapter 11 - Management of Lakes and Ponds*, which is administered by VTDEC through the Shoreland Encroachment Permit Program. This permitting requirement has been recently bolstered by the passing of Act 138 Vermont Shoreland Protection Act, during the 2012 Vermont legislative session. Department fisheries biologists participate in the review of permit applications, and submit comments to VTDEC that help protect fish habitat and fishing opportunities.

Department review of shoreline development activities should:

- Actively participate in the review process for all permit processes and submit appropriate comments to protect aquatic and riparian habitats
- Work to conserve, protect and restore riparian vegetation and coarse woody habitat
- Work with private shoreline landowners to improve understanding of the benefits of proper management of riparian areas

Permit Review Guidance and Policy Resources:

- Guidance for Agency Act 250 and Section 248 Comments Regarding Riparian Zones. (VTANR 2005).

    - http://anr.vermont.gov/sites/anr/files/co/planning/documents/guidance/Guidance%20for%20Agency%20Act%20250%20and%20Section%20248%20Comments%20Regarding%20Riparian%20Buffers.pdf
- The Vermont Shoreland Protection Act: A Handbook for Shoreland Development (VTANR 2015).
    - http://dec.vermont.gov/sites/dec/files/wsm/lakes/docs/Shoreland/lp_ShorelandHandbook.pdf
- Riparian Management Guidelines for Agency of Natural Resources Lands. (VTANR 2015).
    - http://fpr.vermont.gov/sites/fpr/files/About_the_Department/Rules_and_Regulations/Library/Riparian%20Final%20Guidelines%20%28signed%20copy%29_resized.pdf
- Riparian Buffers and Corridors, Technical Papers. (VTANR 2005).
    - https://anrweb.vt.gov/PubDocs/DEC/WSMD/rivers/docs/EducationalResources/rv_RiparianBuffers&CorridorsTechnicalPapers.pdf
- Native Vegetation for Lakeshores, Streamsides and Wetland Buffers. (VTDEC 1994).
    - http://dec.vermont.gov/sites/dec/files/wsm/lakes/Lakewise/docs/pl_native-veg.buffer-manual.1994.pdf

Water Level Manipulation

Water level manipulation has been used widely across the United States to achieve a variety of goals and objectives including flood control, hydropower generation, property protection, aquatic vegetation control, and fish management.

Water level manipulation is sometimes used in fisheries management as a habitat management tool. For example, seasonal water level manipulation in reservoirs can be used to promote the growth of, or allow the artificial planting of, terrestrial vegetation for fish habitat. Water levels are drawn down in the late summer and fall, and vegetation is planted or allowed to develop in the dewatered areas. The reservoir is then slowly flooded in the spring, and the resulting inundated vegetation provides spawning and nursery habitat and fertile foraging areas for a variety of fish species (Bennett 1971; Strange et al. 1982; Beam 1983; Ratcliff et al. 2009). Water level manipulations for fish habitat such as this usually occur in artificial reservoirs with low productivity that do not support natural aquatic vegetation. Additionally, projects such as these generally do not occur in the northern United States, including Vermont, because winter climates do not allow the growth of vegetation during typical drawdown periods.

Lake drawdowns can also be used to control nuisance aquatic vegetation, particularly in cold climates. To achieve this purpose, water levels are generally lowered in the late fall and held at low levels through the winter months. This exposes areas of the lake bottom in the littoral zone to drying and freezing, which kills aquatic plants. Winter drawdowns for aquatic vegetation control usually target non-native invasive plant species such as EWM when recreational uses of the waterbody such as swimming and boating, or access to shoreline properties have been severely impacted due to dense vegetation growth.

Although relatively easy and inexpensive for some reservoirs, the department does not support the use of winter drawdowns to control nuisance levels of aquatic vegetation because long-term control is generally unachievable with this method, and the potential negative impacts to non-target species outweigh the short-term benefits of nuisance plant control. Many invasive plant species such as EWM and hydrilla grow in water much deeper than what can be affected by a feasible drawdown, and so these plants can quickly reinvade the dewatered littoral zone following re-flooding (Haller and Shireman 1984; Nagid et al. 2015). Cook (1980) also noted that water drawdowns to control aquatic vegetation often fail in locations that have heavy snowfall, which insulates the exposed lake bottom, decreasing the plant's exposure to freezing temperatures.

In addition to a general lack of long-term effectiveness, winter drawdowns can have large and long-lasting negative impacts to non-target, desirable native aquatic plant species as well as fish, frogs, turtles, mussels and aquatic invertebrates.

A major experimental winter drawdown was conducted in Vermont over the winter of 1988–1989 on Lake Bomoseen in Rutland County to attempt control of nuisance levels of EWM. The lake level was lowered 3.8 feet, exposing 314 of the lake's 2,364 acres of bottom. The lake was held at that level from the end of October 1988 through mid-April 1989. In the nearshore areas that were exposed by the drawdown, EWM decreased by 88%. However, the drawdown had no effect on EWM in water deeper than 4 feet, and most EWM documented in Lake Bomoseen prior to the drawdown occurred beyond the 7-foot depth contour (VTANR 1989).

While the drawdown had little impact on EWM in the Lake Bomoseen, the negative effects to non-target organisms were significant. The drawdown impacted species that require stable water levels such as beaver and muskrat, restricting their access to winter food supplies and exposing them to adverse weather and high predation rates. Freezing of sediments also resulted in high levels of mortality for species that overwinter in the lake-bottom, with documented declines in littoral zone populations of frogs, salamanders, turtles, snails and aquatic insects. Freshwater mussels were eliminated from the littoral zone. Finally, the abundance of native aquatic vegetation in the lake declined by 50%, while species diversity declined by 40%. The impacts to fish by the Lake Bomoseen drawdown were difficult to measure because only a single year pre-drawdown data was collected (VTANR 1989).

While winter drawdowns in Vermont for nuisance aquatic plant control have been rare, drawdowns happen annually in several lakes and ponds across the state for hydropower generation and flood mitigation. Water levels are slowly lowered over the course of the winter to generate electricity, with snowmelt and spring rains refilling the reservoir in the spring.

Several Vermont water bodies experience manipulated water levels (Table 5). The magnitude of Vermont drawdowns varies widely, from a few feet to 40 feet and may occur on a short-term cycle (daily) or a longer cycle. These types of drawdowns are more damaging to fish habitat, fish, and other aquatic life, than winter water drawdowns for aquatic vegetation control, because they occur regularly and dewater areas of lake bottom, thus eliminating the opportunity for vegetative fish habitat to grow and remain established.

Table 5. Example of water drawdowns across Vermont.

Waterbody	Town	Water Level Fluctuations & Drawdowns
Arrowhead Mountain L.	Milton	Apr. 1 – Jun 23, 1 ft variation; 2.5 ft rest of year; FERC Licensed Hydro
Ball Mountain Res.	Jamaica	30-foot winter drawdown; non-FERC licensed
Clyde Pond	Derby	Dec. 16 – Jul 15 - 1 ft variation; Jul 16 – Sept 30, 2 ft variation, Oct 1 – Dec 15, run-of-river; FERC Licensed Hydro
Comerford Reservoir	Barnet	Dec. 16 – Jul 15, 1 ft variation; Jul 16 – Sept 30, 2 ft variation; Oct 1 – Dec 15, run-of-river; FERC Licensed Hydro
Green River Reservoir	Hyde Park	6-10 ft winter drawdown; 1 ft variation May – Nov; FERC Licensed Hydro
Harriman Reservoir	Whitingham	35-ft winter drawdown; Apr 1 – Jun 15 - rising or stable levels; FERC Licensed Hydro
Molly's Falls Reservoir	Cabot	10-15 ft Dec-March winter drawdown; refill Mar – May; non-FERC licensed
Moore Reservoir	Waterford	40 ft winter drawdown, rising level through May 21; 2 ft variation through Jun 30
Somerset Reservoir	Somerset	13 ft winter drawdown; rising level through May 1; +/- 3" through Jul 31

Recommendations. Before engaging in water level manipulation efforts, the state should actively participate in the review process for hydroelectric dam and reservoir operations such as Vermont 401 Water Quality Certifications, Dam Safety Permits and Federal Energy Regulatory Commission (FERC) licensing, to ensure that fisheries and fish habitat considerations are represented. The state should also require permit conditions that maintain a stable pool to protect bass reproduction and aquatic habitat.

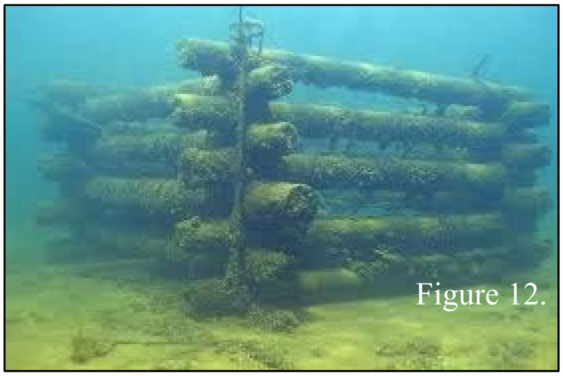
Habitat Enhancement

Sustainable and productive bass populations in lakes and ponds as well as rivers and streams are dependent upon habitat quality and quantity. Habitat quality is determined by physical parameters (e.g., temperature, clarity, color and turbidity), chemical composition (e.g., dissolved gases, organic materials, minerals, nutrients), and geomorphic characteristics (e.g., composition and distribution of substrate components, depth, volume, bottom slope/channel gradient, and current velocity). Another critical component of habitat is cover or shelter structure (Figures 10, 11), characterized by Binns and Eiserman (1979) as structural features "that allow [fish] to avoid the impact of the elements [environmental events such as strong water currents and turbulence] or enemies [predators]."

Figure 10 and 11. Fish habitat structures. Engbretson Underwater Photography / www.underwaterfishphotos.com. *Used with permission.*

In the 1930s, following earlier extensive application of habitat improvement methods in streams, fisheries managers began attempting to improve fish habitat in lakes. Aquatic and riparian habitats had become degraded by watershed alterations, such as deforestation and agriculture, and by the encroachment of lakeside resort and seasonal cottages, which resulted in the removal of large woody habitat and aquatic plant beds to enhance swimming and boating (Hubbs and Eschmeyer 1938). Restoration of habitat structure was promoted as a means of increasing environmental carrying capacity for targeted game and forage fish species. In 1938, Carl Hubbs and Ralph Eschmeyer of the Michigan Department of Conservation's Institute in Fisheries Research published the first handbook of its kind giving practical guidance to fisheries managers for improving fish habitat in lakes: *The Improvement of Lakes for Fishing: A Method of Fish Management*. Since then, habitat enhancement structures, such as those described by Hubbs and Eschmeyer, have been used in both natural lakes and ponds and artificial impoundments to manage sport and forage fish populations; however, the effectiveness of these improvements have rarely been evaluated to empirically demonstrate their benefits. Nonetheless artificial habitat structures continue to be popular with some state and federal fisheries managers and with private interests (Nielsen 1993). The goal of cover enhancement is typically to increase the abundance and size distribution of target fish species through improved recruitment, survival and growth, ultimately resulting in increased angler catch rates (Johnson and Stein 1979).

Fish habitat structures may be categorized as natural and artificial. Natural or native structures include natural boulders, aquatic vegetation beds, and naturally recruited large wood and brush from forested shorelines. Artificial structures may consist of natural or manmade materials used to emulate the function of natural structures and include evergreen trees, wooden pallets, tire bundles, brush piles, log cribs (Figure 12), stumps and whole trees, half-logs (Figure 13), stake beds, rock piles, spawning boxes, gravel and cobble, cinder and cement blocks, car bodies, hay bales, floating objects, mid-water reefs, and a variety of commercially produced fish attraction devices (Fish Hab™, AquaCrib®, Fish 'N Trees®, Sphere™ , AquaMats ®; Bolding et al. 2004).



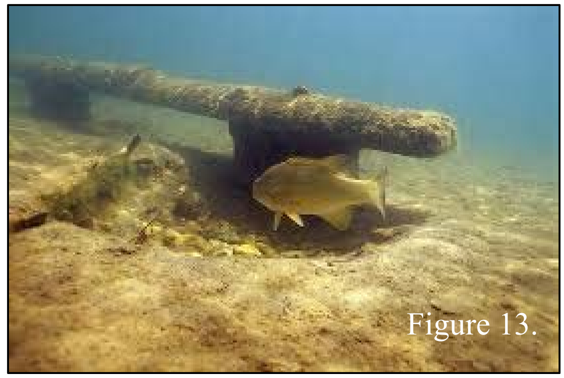


Figure 12 and 13. Fish habitat structures. Engbretson Underwater Photography / www.underwaterfishphotos.com. *Used with permission.*

During preparation of this plan, fisheries managers serving as bass and/or warmwater project leaders for the eight Northeastern state agencies (Maine Department of Inland Fisheries & Wildlife; New Hampshire Fish & Game Department; Massachusetts Division of Fisheries & Wildlife; Connecticut Inland Fisheries Division; Rhode Island Division of Fish & Wildlife; New York Division of Fish, Wildlife & Marine Resources; New Jersey Division of Fish & Wildlife; and Pennsylvania Fish & Boat Commission) were canvased about the use of artificial habitat structures for managing bass and panfish populations within their respective state waters. Responses were received from six agencies. In summary, only Pennsylvania has a program, in existence for 20 years, to provide assistance to individuals, organizations, and other state and federal agencies to manage habitat improvement projects in commonwealth lakes and impoundments. A few of the other responding state agencies may have experimented with the placement of artificial habitat structures in a few waters, but these respondents almost all agree that unless a particular lake or pond is devoid of habitat structure, there is little to no benefit to adding it. None of the responding agencies have used artificial structures to enhance bass habitat in rivers and streams. Pennsylvania has few natural lakes and ponds, therefore artificial lakes and impoundments make up most of the public waters managed for sport fisheries, and most of these lack habitat structure necessary for sport and forage fish production and survival. The goal of the Pennsylvania Fish & Boat Commission's Lake Fish Habitat Improvement Program (LFHIP) is "To bring about positive change to the fishery through altering physical features of an individual impoundment to a point where 30 to 50 percent of the entire impoundment contains structures." They define structures as "any physical element – native, natural or artificial – that provide cover for aquatic animals" (Houser 2007). To this end the LFHIP has designed and installed artificial structures going by such names as porcupine cribs, vertical plank structures, post cluster structures, felled shoreline trees, black bass nesting structures, rubble humps or reefs, and Christmas tree structures.

The application of artificial structures can have benefits to bass and other aquatic biota where cover is in limited supply. The addition of artificial structures into waters already having optimum levels of well distributed natural cover (e.g. large wood, rock and aquatic vegetation) may be of little or no benefit to increasing habitat carrying capacity and fish production. On the other hand, artificial ponds and impoundments that lack natural structure, such as excavated earth impoundments devoid of underwater topographic structure and/or dead wood resulting from inundated woodlands, may be good candidates for enhancement. Generally, Vermont's lakes and ponds are not deficient in natural structure important to bass and other aquatic organisms. Most of the standing waters in Vermont are natural lakes and ponds that offer one or more forms of natural structure such as stands of aquatic vegetation, large boulders, and large woody material recruited from forested shorelines.

While it is not clear that artificial structures consistently result in larger numbers of the species and sizes of fish that are desirable to anglers, artificial structures have been demonstrated to significantly increase angler catch rates by concentrating fish (Bolding et al. 2004). In other states, artificial structures have been purposely used as fish attractants to increase angler catch rates for certain structure-oriented sport fish, such as largemouth and smallmouth bass, rock bass, bluegill, pumpkinseed and crappies. However, the potential for structures to congregate sport fish and increase angler catch rates leading to overfishing has been raised (Wege and Anderson 1979; Walters et al. 1991; Bolding et al. 2004; Wills et al. 2004). Other potential negative consequences of artificial structures include aesthetic impacts, creation of navigation hazards, leachates from artificial materials, and stunted growth in overabundant fish populations.

Recommendations. Because artificial structures are no substitute for natural habitats, department staff need to be actively involved in the permitting processes for aquatic nuisance control (10 V.S.A. Chapter 50, Subsection 1455), lake encroachment (29 V.S.A. Chapter 11) and shoreland (10 V.S.A Chapter 49A, Subsections 1441–1449) to minimize littoral and riparian habitat impacts, such as aquatic vegetation removal, beach development and expansion, and removal of lakeshore woodlands. Additionally, placing artificial habitat structures in state waters should not be promoted or encouraged due to the lack of long-term benefits and potential negative impacts they can create. When the angling public inquires for department assistance or endorsement of efforts to add artificial habitat structures to state waters, they should be informed of the limitations of such management actions and benefits of natural habitats. Additions of artificial habitat structures should only be endorsed in cases when it can be demonstrated that natural habitats are so limited as to have negative consequences for fish populations and fishing.

This project was made possible by fishing license sales and matching Dingell-Johnson/Wallop-Breaux funds, available through the Federal Aid in Sport Fish Restoration Act.

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Appendices

APPENDIX I – A. Largemouth Bass Growth

Appendix I-A - Length (in) at age for largemouth bass from across North America (Jackson et al. 2008) and from nine Vermont waters. The North American data are the median values of the mean length at age for n different populations. Jackson et al. (2008) excluded older age classes in order to minimize potential aging errors. Sample size for Vermont waters is the number of largemouth bass that were assigned to each age group. Age data for North American populations came from a variety of hard parts, while all Vermont age data were derived from dorsal spines.

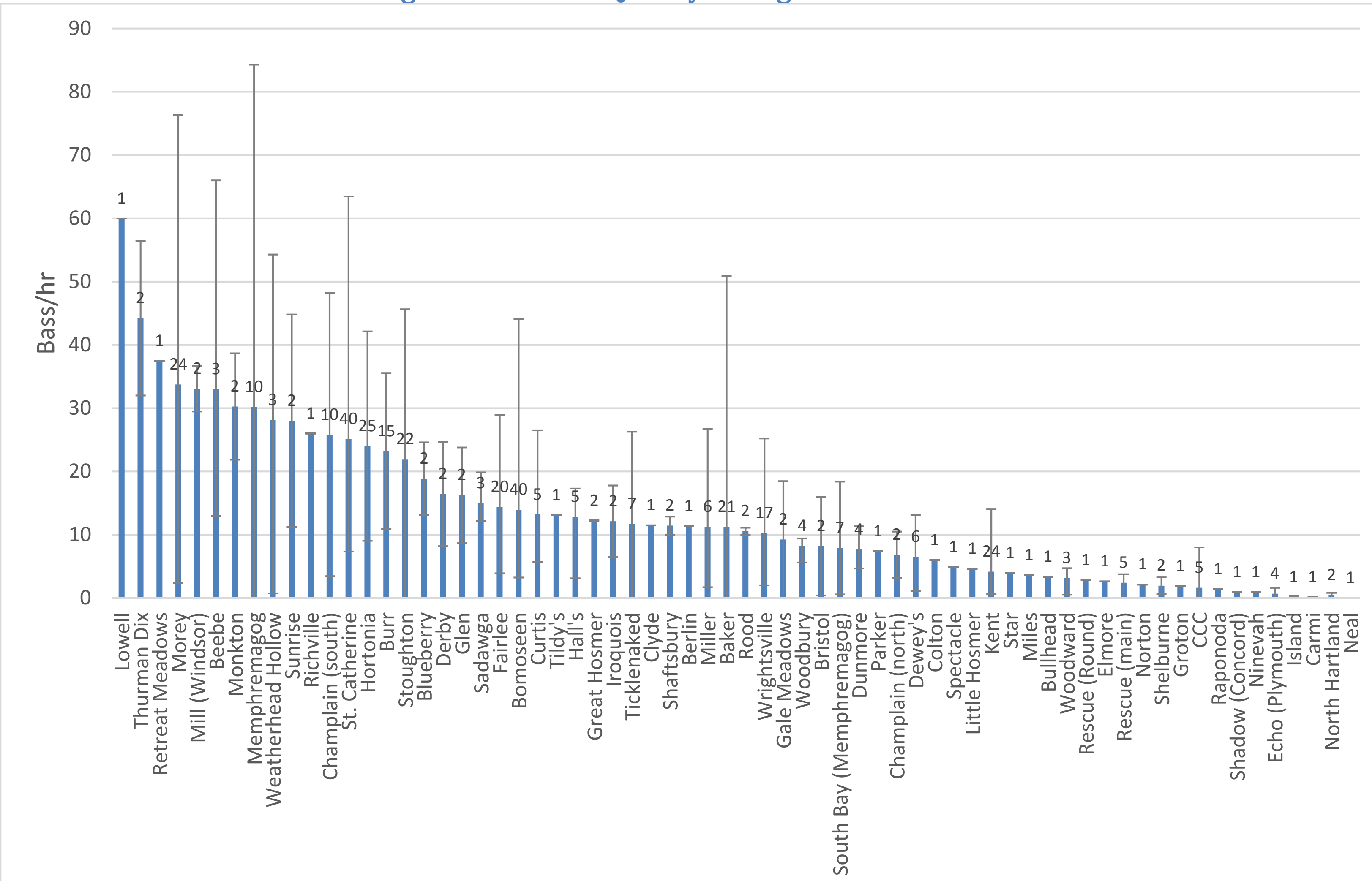
	North America 1958-2006		Berlin 2012		Bomoseen 2012		Burr 2012		Chittenden 2012		Champlain, north 2012		Champlain, south 2012		Hortonia 2012		Memphremagog 2012-2014		St. Catherine 2012		Ticklenaked 2012-2014	
Age	Median	n	Mean	n	Mean	n	Mean	n	Mean	n	Mean	n	Mean	n	Mean	n	Mean	n	Mean	n	Mean	n
1	4.5	147					5.3	2														
2	8.5	147	7.1	10	6.4	3	6.6	3					6.5	10	5.3	2	8.5	6			9.7	28
3	11.3	144	10	7	8.0	6	8.4	4	12.1	3	9.4	1	9.2	7	6.7	4	10.7	10	7.6	3	12.6	11
4	13.4	137	12.5	3	9.2	3	10.1	6	15.1	1	11.7	3	11.1	7	9.2	8	13.2	4	10.2	6	15.4	11
5	15.2	131	13.1	1	10.4	3	12.4	7	15.2	2	13.1	2	12.9	5	10.4	7	15.2	5	11.7	6	17.4	1
6	16.8	110	13.9	1	11.7	5	13.9	3	16.4	2	15.0	4	14.6	6	12.7	5	16.0	4	13.8	2		
7	17.8	95			13.2	5	16.1	2	17.4	2	14.4	5	16.0	2	14.5	4	16.6	5	14.3	7		
8	18.6	73	15.6	2	14.6	3	16.7	2	19.5	1	15.7	6	17.1	2	16.1	7	16.9	3	16.5	5		
9			14.9	2	15.8	3			18.5	2	17.0	7	17.2	3			16.9	2	18	2		
10			16.6	1	16.7	2	17.6	2			17.4	9	18.5	3					18.7	1	19.0	1
11					17.9	1	18.4	1	21.0	1	18.2	3	18.6	1	18.4	3						
12											18.0	2	19.8	3	19.0	3	19.4	1	18	1		
13			18.5	1							20.2	1	18.8	1					18.9	2		
14					20.4	1							20.0	2								
15																			21.1	1		
16					21.5	16																

APPENDIX I – B. Smallmouth Bass Growth

Appendix I-B - Length (in) at age for smallmouth bass from across North America (Jackson et al. 2008) and from seven Vermont waters. The North American data are the median values of the mean length at age for n different populations. Jackson et al. (2008) excluded older age classes in order to minimize potential aging errors. Sample size for Vermont waters is the number of smallmouth bass that were assigned to each age group. Age data for North American populations came from a variety of hard parts, while all Vermont age data were derived from dorsal spines.

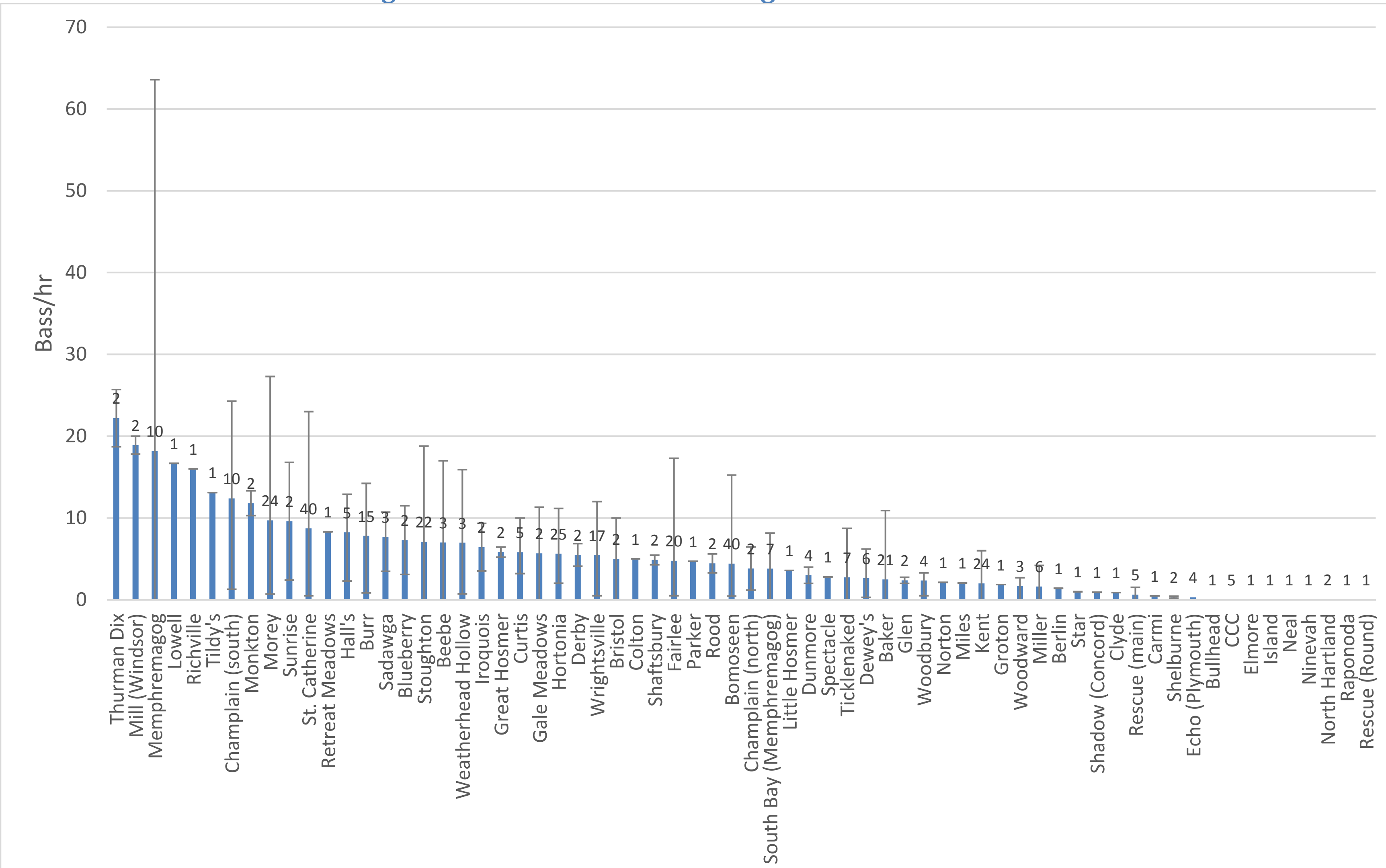
	North America		Bomoseen		Champlain, south		Memphre-magog		Salem		St. Catherine		Stiles		Ticklenaked	
	1977-2005		2012		2012		2012-2014		2013		2012		2013-2014		2012-2014	
Age	Median	n	Mean	n	Mean	n	Mean	n	Mean	n	Mean	n	Mean	n	Mean	n
1	3.5	90			6.2	1					5.6	2	6.1	1		
2	6.5	165	5.9	5	7	5	6.4	1			6.3	5	12.7	2	8.2	4
3	9.3	236	8.3	9	8.2	9	8.3	10			8.4	3	12.5	3	11.7	1
4	11.4	290	10.1	6	10.8	11	10.8	5			9.2	7	13.5	7	12.0	1
5	13.3	337	12.8	5	14.2	3	14.6	5	14.4	1	11.8	4	14.5	2		
6	14.8	376	13.5	3	14.6	6	14.3	11	15.8	4	14.3	8	15.2	5	15.6	3
7	15.7	398	14.1	3	16.2	3	16.2	10	16.9	1	16.1	8	15.5	12	16.3	1
8			15	3	17.4	2	16.5	10	16.9	1	17.5	3	15.7	12	18.7	1
9			16.7	1	19.4	2	16.6	2	18.3	2	18.8	2	14.1	4		
10			18.3	2			17.5	5			19	1	15.8	9	18.0	3
11			17.6	3			17.6	2	18.5	1			15.4	3	17.4	1
12							18.1	3	18.7	2						
13							18.4	1								
14			19.1	1			17.6	1							17.6	1

APPENDIX II – A. Electrofishing Catch Rates – Quality – Largemouth Bass



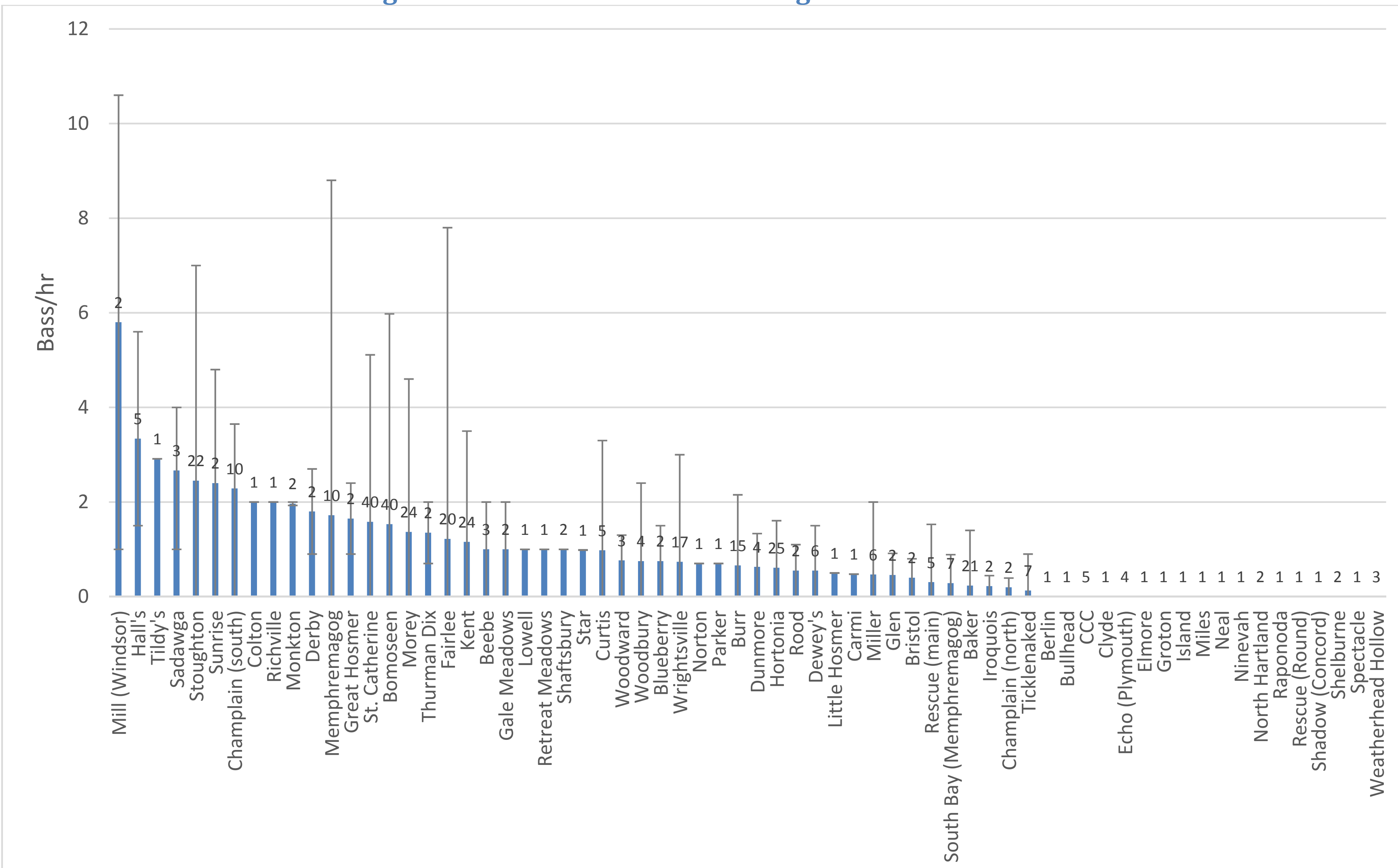
Appendix II-A. Average electrofishing catch rate of quality (≥ 12") largemouth bass during spring and summer electrofishing surveys on 66 Vermont waters from 1988 to 2015. Numbers above the bars are the number of sampling events for each water. Error bars display the minimum and maximum catch rates for each water.

APPENDIX II – B. Electrofishing Catch Rates -Preferred – Largemouth Bass



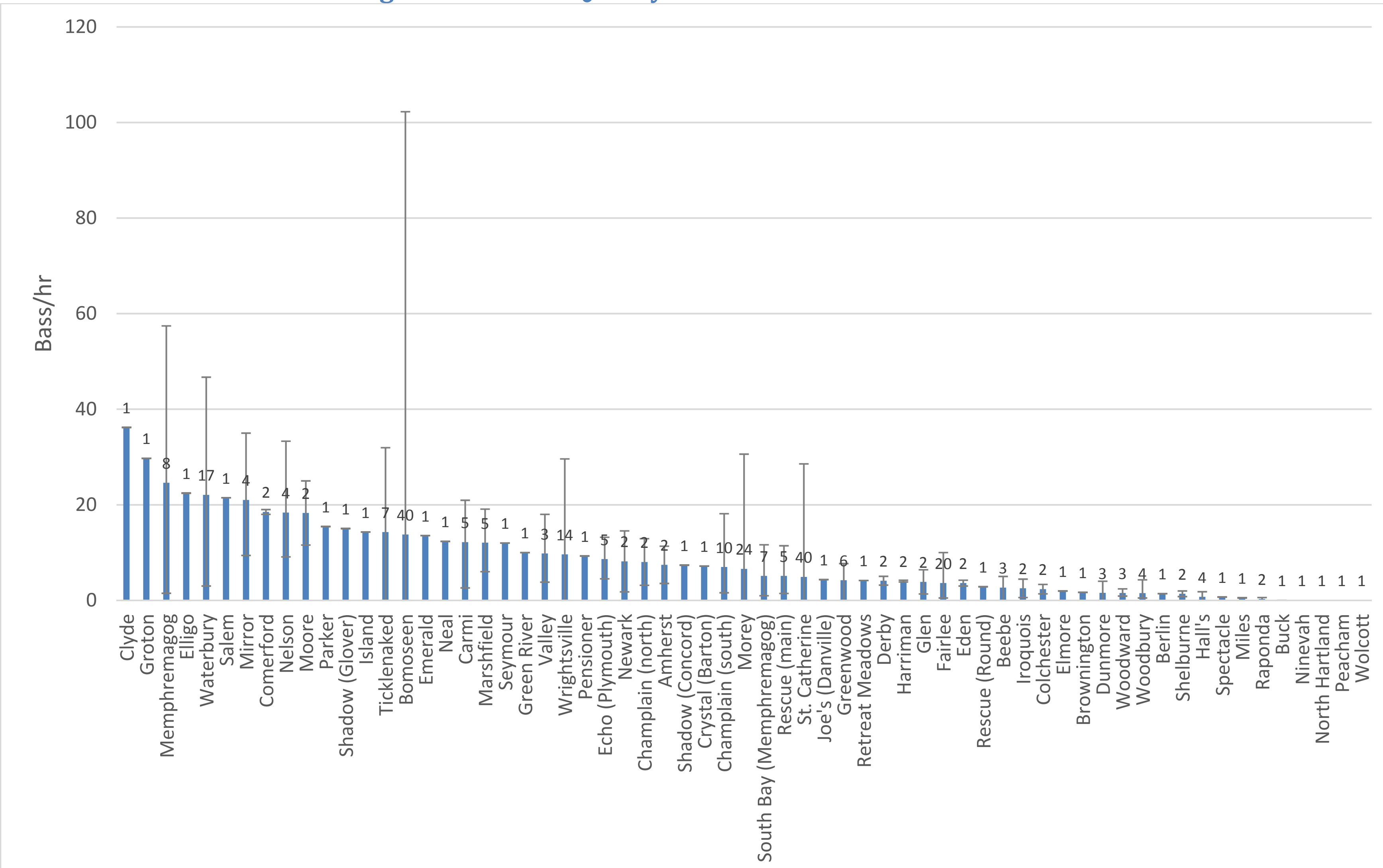
Appendix II-B. Average electrofishing catch rate of preferred (≥ 15”) largemouth bass during spring and summer electrofishing surveys on 66 Vermont waters from 1988 to 2015. Numbers above the bars are the number of sampling events for each water. Error bars display the minimum and maximum catch rates for each water.

APPENDIX II – C. Electrofishing Catch Rates – Memorable – Largemouth Bass



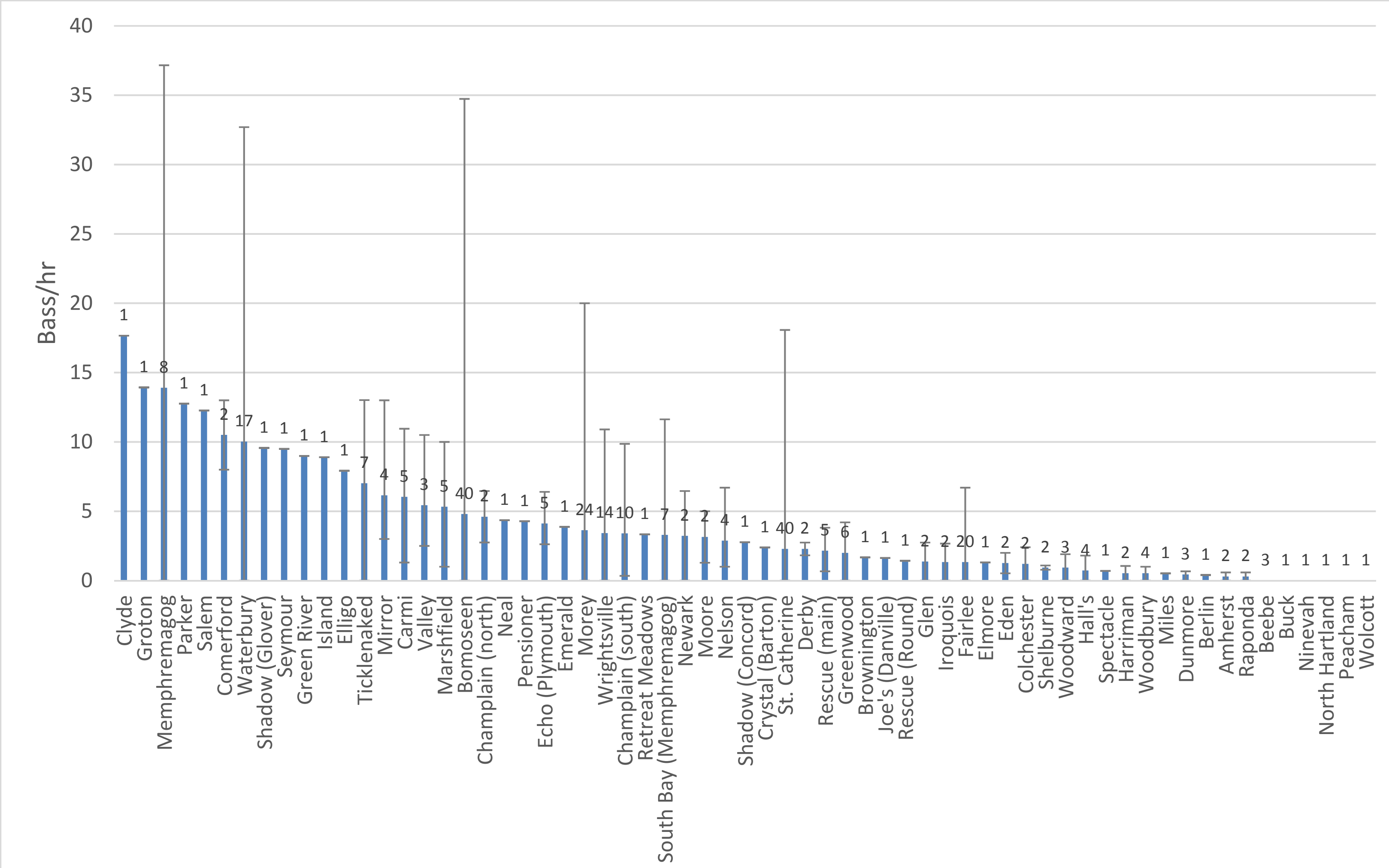
Appendix II-C. Average electrofishing catch rate of memorable (≥ 18”) largemouth bass during spring and summer electrofishing surveys on 66 Vermont waters from 1988 to 2015. Numbers above the bars are the number of sampling events for each water. Error bars display the minimum and maximum catch rates for each water.

APPENDIX II – D. Electrofishing Catch Rates – Quality – Smallmouth Bass



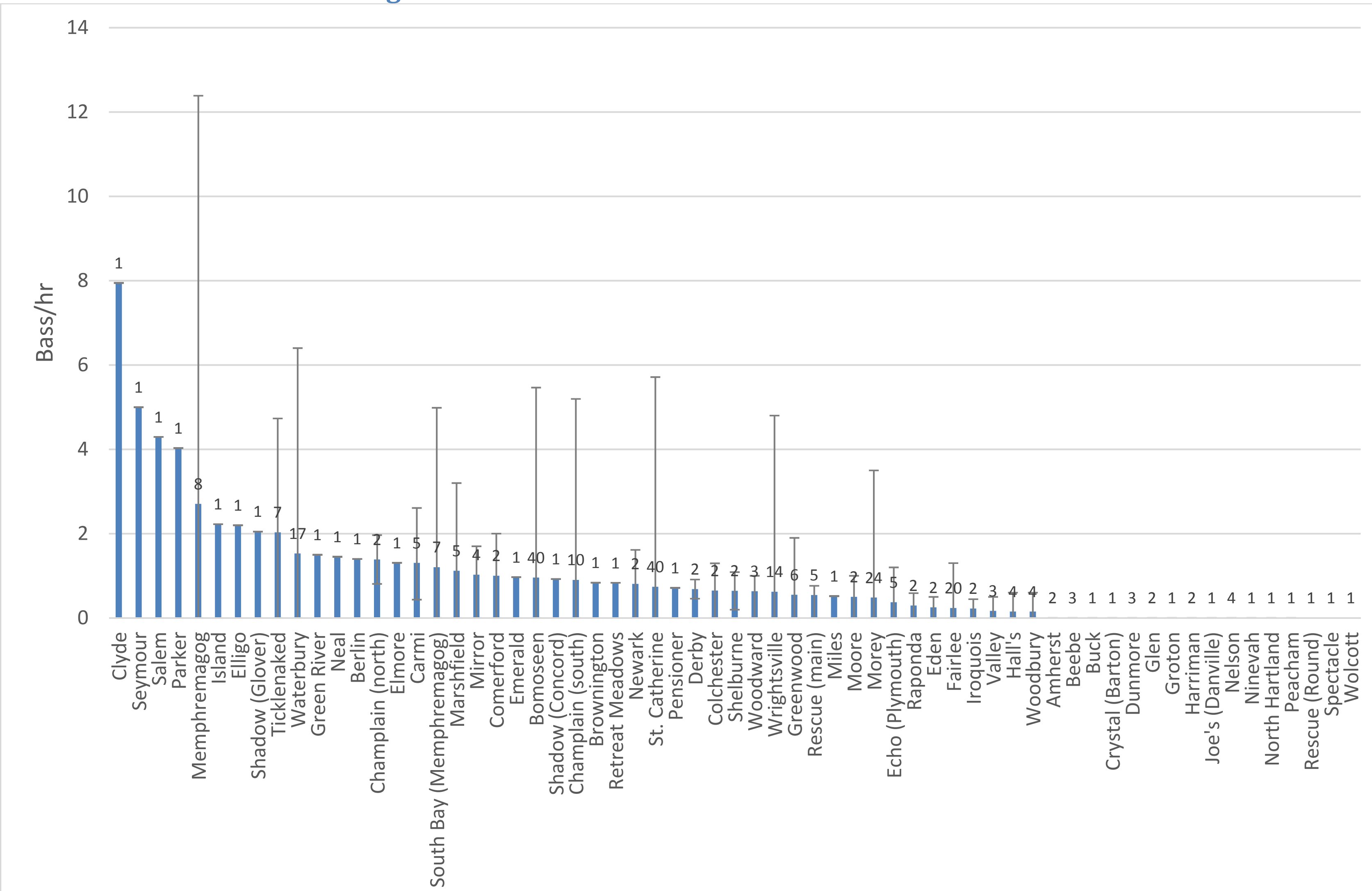
Appendix II-D. Average electrofishing catch rate of quality (≥ 11”) smallmouth bass during spring and summer electrofishing surveys on 63 Vermont waters from 1988 to 2015. Numbers above the bars are the number of sampling events for each water. Error bars display the minimum and maximum catch rates for each water.

APPENDIX II – E. Electrofishing Catch Rates – Preferred – Smallmouth Bass



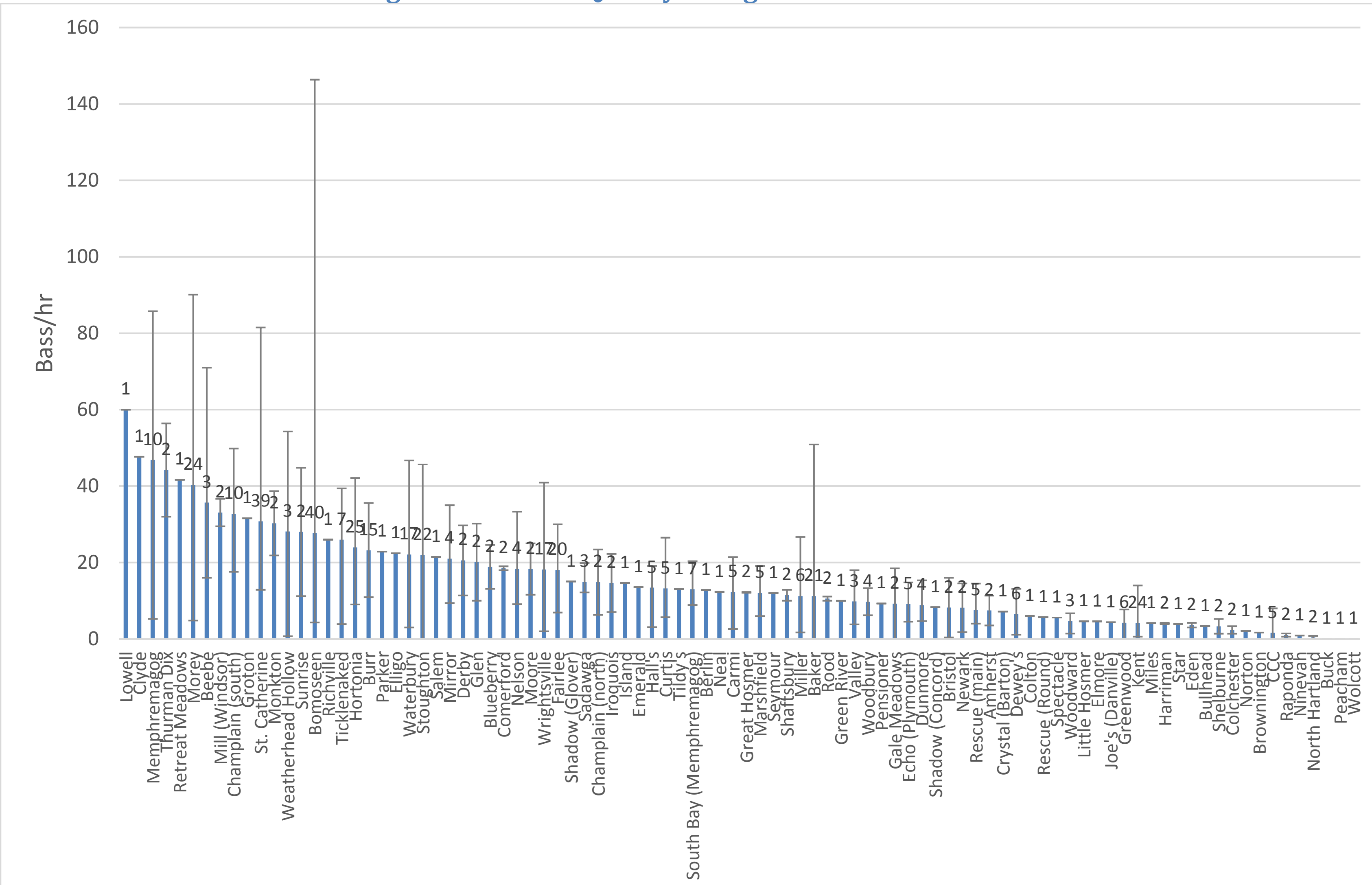
Appendix II-E. Average electrofishing catch rate of preferred (≥ 14") smallmouth bass during spring and summer electrofishing surveys on 63 Vermont waters from 1988 to 2015. Numbers above the bars are the number of sampling events for each water. Error bars display the minimum and maximum catch rates for each water.

APPENDIX II – F. Electrofishing Catch Rates – Memorable – Smallmouth Bass



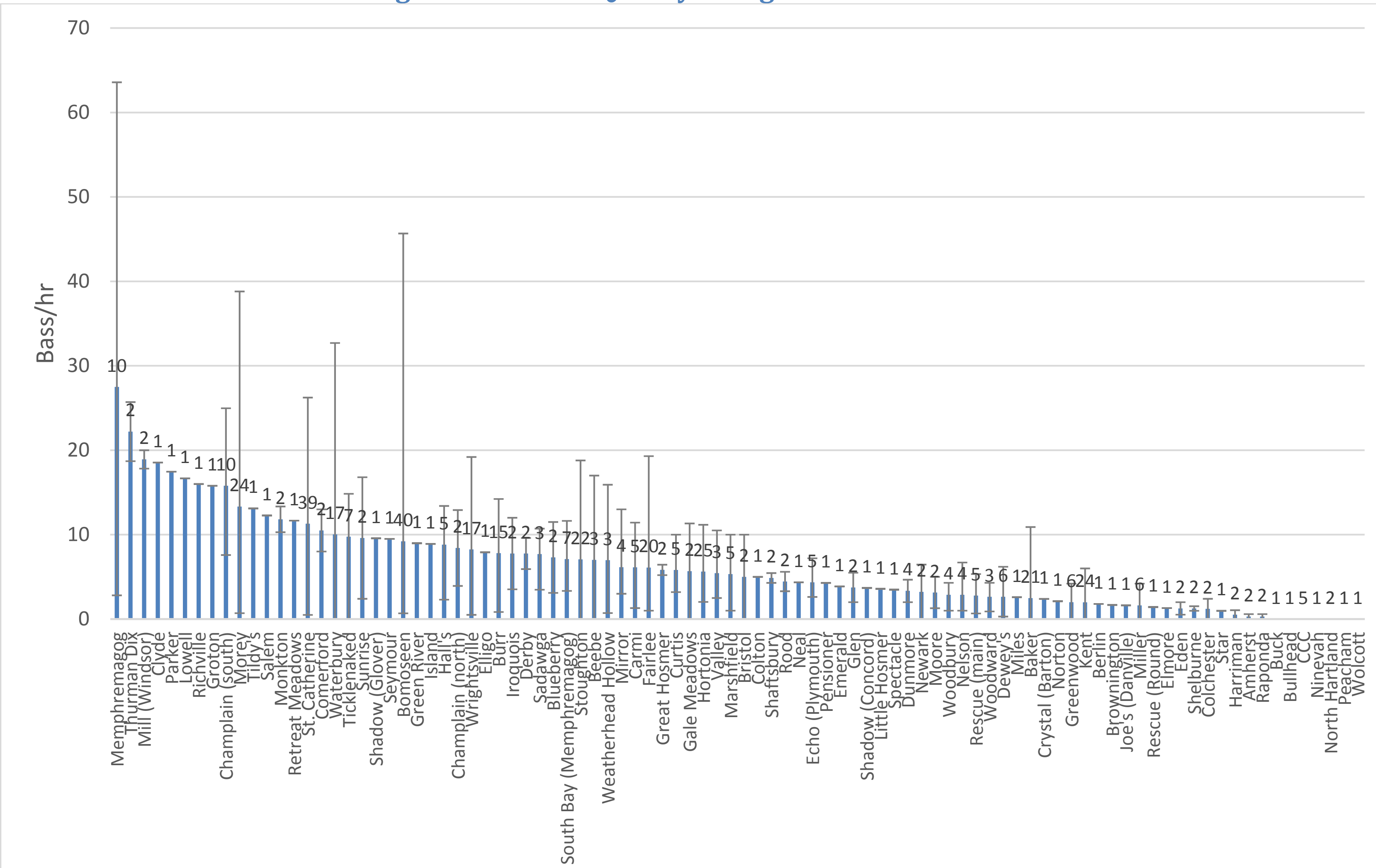
Appendix II-F. Average electrofishing catch rate of memorable (≥ 17”) smallmouth bass during spring and summer electrofishing surveys on 63 Vermont waters from 1988 to 2015. Numbers above the bars are the number of sampling events for each water. Error bars display the minimum and maximum catch rates for each water.

APPENDIX II – G. Electrofishing Catch Rates – Quality - Largemouth and Smallmouth Bass



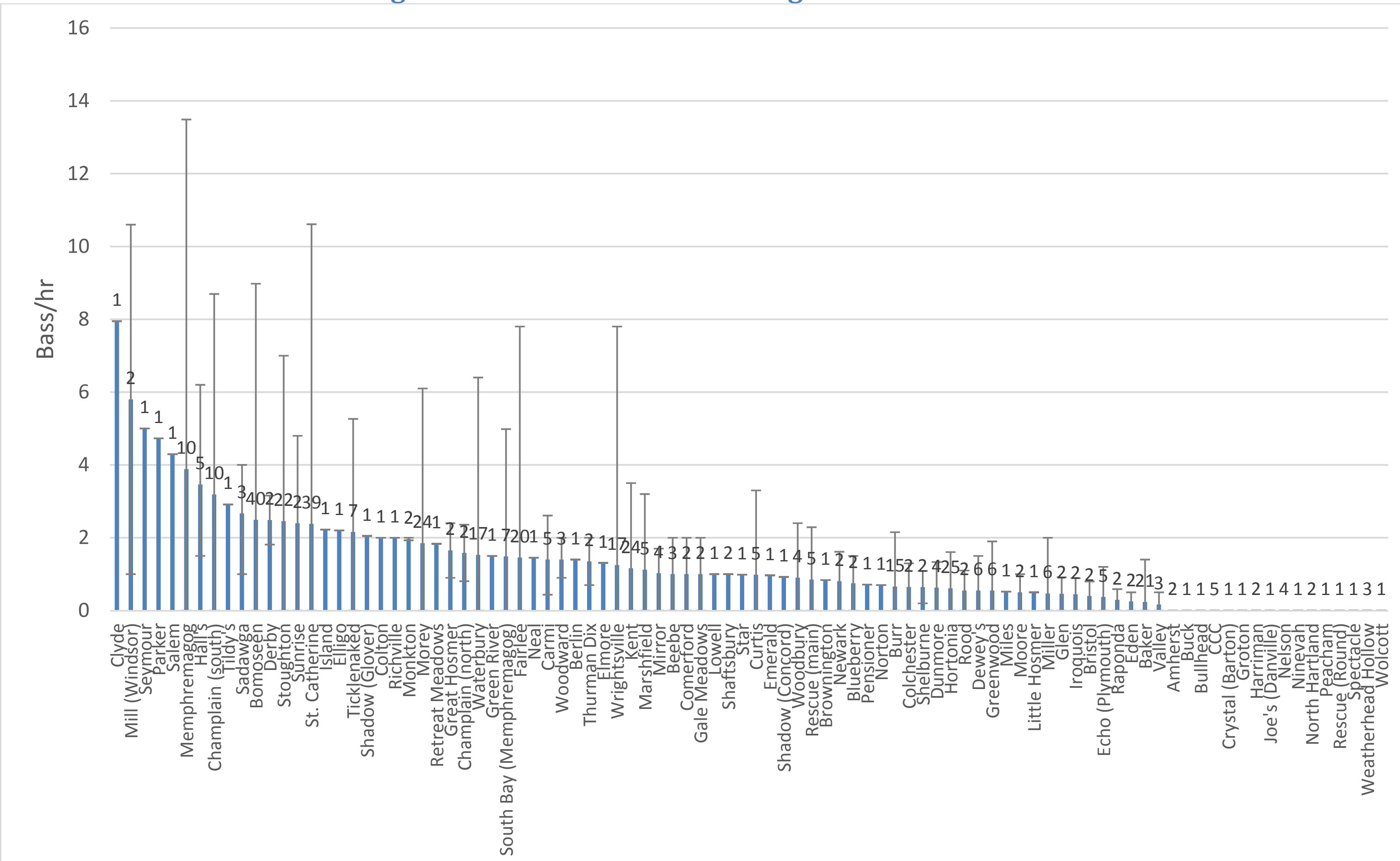
Appendix II-G. Average electrofishing catch rate of quality largemouth (≥ 12”) and smallmouth bass (≥11”) during spring and summer electrofishing surveys on 92 Vermont waters from 1988 to 2015. Numbers above the bars are the number of sampling events for each water. Error bars display the minimum and maximum catch rates for each water.

APPENDIX II – H. Electrofishing Catch Rates – Quality - Largemouth and Smallmouth Bass



Appendix II-H. Average electrofishing catch rate of preferred largemouth (≥ 15") and smallmouth bass (≥14") during spring and summer electrofishing surveys on 92 Vermont waters from 1988 to 2015. Numbers above the bars are the number of sampling events for each water. Error bars display the minimum and maximum catch rates for each water.

APPENDIX II – I. Electrofishing Catch Rates – Preferred - Largemouth and Smallmouth Bass



Appendix II-I. Average electrofishing catch rate of preferred largemouth (≥ 18”) and smallmouth bass (≥17”) during spring and summer electrofishing surveys on 92 Vermont waters from 1988 to 2015. Numbers above the bars are the number of sampling events for each water. Error bars display the minimum and maximum catch rates for each water.

APPENDIX III - History of Bass Regulation in Vermont

Year	Waterbody	Open Season	Length Limit	Bag Limit	Gear	Notes
1877	The Commissioner recommended restricting harvest method to hook and line and that the same protection against illegitimate modes of capture be accorded by the legislature to black bass that is given in the act of 1874, section 6, to trout and other fishes of the salmon family					
1881	Statewide	May 1 to Dec 31			Hook and Line only	Sec 3873, 3878
1883	Statewide	June 15 to January 31	10" min		Hook and Line only	Sec 3873, 3878
1885	Statewide	June 1 to January 31	10" min		All gear types allowed	
1889	Prospect Pond, Woodbury			Closed to Harvest (next 3 years)		Stocking Program
	Moose River - between the lower dam at East St. Johnsbury and upper dam in West Concord			Closed to Harvest (next 5 years)		Stocking Program
	Franklin Pond (Lake Carmi), Franklin	Closed to Harvest – May 1 to July 1		Closed to Harvest		Stocking Program
1895	Lake Champlain	June 15 to January 31	10" min		All gear types allowed	
1902	Lake Champlain	Open Year Round	10" min		All gear types allowed	
1903	Statewide	June 15 to January 31	10" min	24 fish/day or 36 fish/boat (2 or more anglers)	All gear types allowed	
	Lake Champlain	Open Year Round	10" min	24 fish/day or 36 fish/boat (2 or more anglers)	All gear types allowed	
1912	Statewide including Lake Champlain	June 15 to January 31	10" min	24 fish/day or 36 fish/boat (2 or more anglers)	Hook and Line only	
1929	Statewide including Lake Champlain	July 1 to January 1	10" min	10 fish/day		
1938	Statewide including Lake Champlain	July 1 to November 31	10" min	10 fish/day		
Between 1938 and 1961	Statewide including Lake Champlain	Sale of Bass Prohibited				Bass can no longer be sold
1961	Statewide including Lake Champlain	2nd Sat in June to November 30	10" min	10 fish/day		
1966	Eight Test Lakes	3rd Sat in January to 2nd Sunday in March	10" min	10 fish/day	Ice Fishing	
1974	Designated Ice Fishing Waters	3rd Sat in January to 2nd Sun in March	10" min	10 fish/day	Ice Fishing	Ice fishing in Designated waters
1974	Lake Champlain	2nd Sat in June to November 30	10" min	5 fish/day		
1981	Statewide	2nd Sat in June to November 30	10" min	5 fish/day		
	Closed Trout Water-Streams	Open when trout season open	No Min	5 fish/day		
	River and Stream open to year Round Trout fishing (C&R for trout outside of regular season).	Open when you can fish for trout (year round)	No Min	5 fish/day		

1991	Statewide	2nd Sat in April to Fri before 2nd Sat in June	C&R	0 fish/day	Artificials only	Catch and Release Season
	Lake Morey, Fairlee	2nd Sat in June to November 30	14” min	5 fish/day		Test Water at first then permanent rule.
1993	Baker Pond, Brookfield and Kent Pond, Killington	2nd Sat in June to November 30	10-12” protected slot	10 bass/day with only 1 greater than 12”		Test Water at first then permanent rule.
2012	Berlin Pond		C&R	0 fish/day		Test Water
2013	Statewide except for Seasonally Closed Waters	Dec 1 to Fri before 2nd Sat in June	C&R	0 fish/day	Artificials only	Catch and Release Season
	Stiles Pond		C&R	0 fish/day		Test Water

APPENDIX IV - Bass Regulation in Vermont

General Statewide Regulations

Catch and Release Season:

- Season: December 1 to Friday before second Saturday in June
- Bag Limit: All fish must be immediately released
- Gear: Artificial only
- Location: Most lakes and ponds in state

Regular Season:

- Season: Second Saturday in June to November 30
- Bag Limit: 5 fish
- Length Limit: 10” minimum
- Gear: None
- Location: Statewide lakes and ponds

Ice Fishing:

- Season: Third Saturday in January to March 15
- Bag Limit: 5 fish
- Length Limit: 10” minimum
- Gear: Ice fishing
- Location: Specific lakes and ponds around the state

Special Regulations

River and Stream Open to Year-Round Trout Fishing (C&R for trout outside of regular season)

- Season: No Closed Season
- Bag Limit: 5 fish
- Length Limit: None
- Gear: No open water gear restriction - Angling (No Gear Restrictions)
- Location: Large rivers with year-round trout fishing (Sections not listed)

    - Black River (Tributary to Connecticut), Lamoille River, Missisquoi River, Ompompanoosuc River, Otter Creek, Waits River, West River, White River, Williams River, Winooski River

River and Stream listed under "Seasonally Closed Waters"

- Season: Open during trout season
- Bag Limit: 5 fish
- Length Limit: None

Lakes/Ponds – Lake Morey – Special Length limits

- Bag Limit: 5 largemouth bass
- Length Limit: 14" minimum length

Lakes/Ponds – Baker and Kent Ponds - Special length limits

- Season: Second Saturday in June to November 30
- Bag Limit: 10 bass - only 1 greater than 12 inches
- Length Limit: No minimum length – 10" to 12" protected slot
- Gear: Angling (None)

Lakes/Ponds – Berlin and Stiles Ponds – Catch and Release Only

- Bag Limit: All bass must be immediately released