

SMALLMOUTH BASS IN DOOR COUNTY

2009/2012 Population Assessments and Sport Fishery



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Executive Summary

Smallmouth bass populations in the Sturgeon Bay/Little Sturgeon Bay and Rowley Bay areas of Door County were evaluated in recent years. Data collected during these surveys suggest the populations were generally in good to excellent condition regarding abundance, fish size, and recruitment. While the recent abundance estimate specific to Little Sturgeon Bay was comparable to estimates from the two previous surveys, the length at age and overall size structure has improved considerably in all locations since they were last assessed. These increases were most notable in the Sturgeon Bay/Little Sturgeon Bay area where nearly 25% of the fish sampled were 18 inches or greater in length. Age composition structure in both populations is well distributed with multiple age classes well represented particularly for younger fish; this points to a positive future for both fisheries. The overall prominence of age-4 fish in each population was especially encouraging. Recoveries of smallmouth bass tagged in the Sturgeon Bay/Little Sturgeon Bay area indicated some modest movement but, as in past surveys, the evidence continues to suggest that smallmouth bass inhabiting this area generally do not move extensively from their home range. While the sport catch of smallmouth bass had dropped somewhat and then leveled off for a number of years during the early to mid-2000s, in recent years catch rates have increased considerably working their way among the top 10 in the time series record for Green Bay waters of Door County. Although our survey indices point to a bright future for Door County smallmouth bass populations, the continued availability of quality habitat is a concern. Historically low water levels on Lake Michigan compounded by the resulting increase in riparian dredging activity threaten to directly impact the amount and quality of habitat available to smallmouth bass. Some of the isolated smallmouth bass populations, particularly along the Lake Michigan and northern Green Bay sides of Door County, have historically been understudied and we hope to make evaluation of these populations a priority in the near future.

Introduction

Within the last two decades, the smallmouth fishery around Door County has become what could be considered “world class” both in terms of fish size and abundance. The more productive areas for smallmouth are found along the Green Bay side of Door County although viable populations exist along the Lake Michigan side as well. Smallmouth bass populations have been assessed in selected areas of Door County periodically since 1991 in order to evaluate various aspects of the population dynamics of this very popular sport fish. Most recent assessments were conducted in Little Sturgeon/Sturgeon Bays (2009) and Rowley Bay (2012). Sampling began in late April and lasted well into May. The last comprehensive smallmouth surveys in these areas occurred in 2004. Herein we report results from recent population assessments and sport creel surveys. We also draw references to historical data to illustrate changes in the population over time.

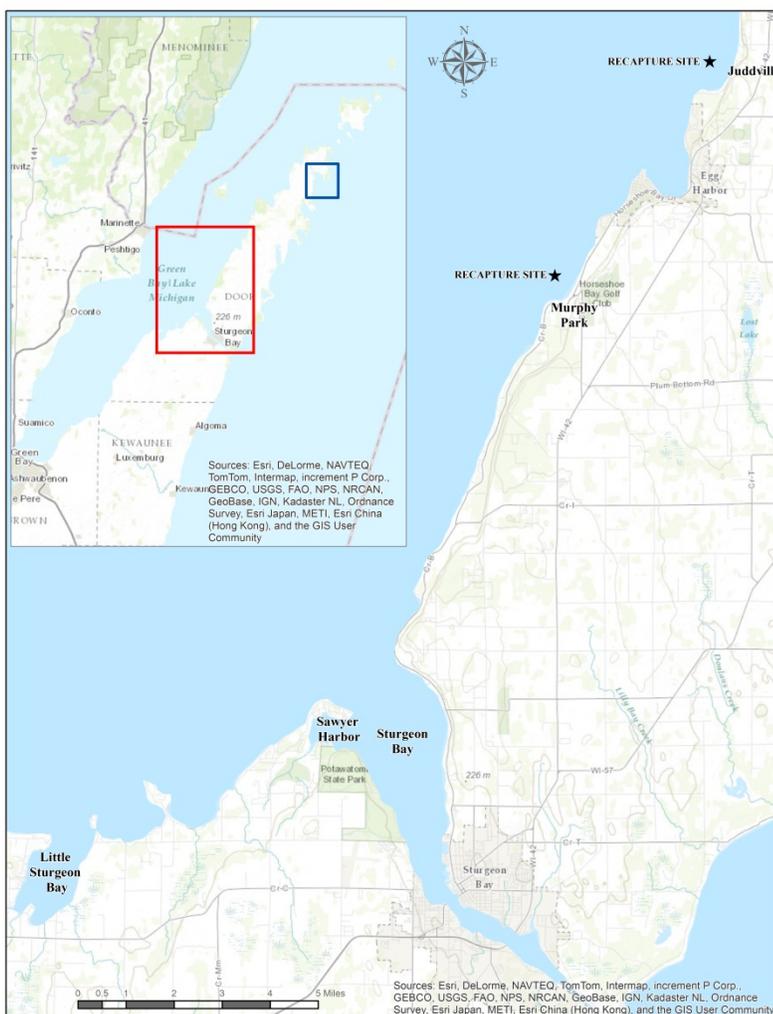
Methods

Little Sturgeon/Sturgeon Bays

Fyke nets were set in Little Sturgeon Bay and Sturgeon Bay beginning April 28, 2009 and were permanently removed after the third week in May. (Nets were removed from the water during weekends.) Nets (2-3 per site) were lifted and fish removed every 24 hours and were fished for a total of 71 net nights. Due to weather incurred limitations, our ability to fish nets on the main bay of Sturgeon Bay was limited and therefore the sampling was relegated to the more protected area of Sawyer Harbor, an embayment of Sturgeon Bay (Figure 1). Data collected from smallmouth bass included total length measured to the nearest millimeter (converted to inches) and a subsample of scales used for ageing. Scales were sampled from the left side of the fish, near the tip of the relaxed pectoral fin just below the lateral line. The majority of the fish were tagged along the left side, just below the dorsal fin with a yellow plastic tag (Floy Tag®) which held a unique ID number and the address of the Sturgeon Bay fisheries office. Fish health was also evaluated by examining for any external lesions. All other gamefish were measured and non-gamefish were identified to species, counted, and released.

An adult smallmouth population estimate (approximately age-5 and older fish) was calculated for Little Sturgeon Bay using the Chapman Modification of the Schnabel Method. Because only a small portion of Sturgeon Bay was sampled, only a population estimate for Little Sturgeon was performed. Furthermore, a larger number of recaptures from the Little Sturgeon area allowed for a more precise estimate. However, for size and age composition/structure analysis, fish from Little Sturgeon and Sturgeon Bay were combined given the habitat and forage conditions are similar between the two sites.

Figure 1. Locations for smallmouth population assessments on Door County peninsula. Red inset box outlines Sturgeon Bay area sampling and tag recovery area and the box is expanded in the large map. Blue inset box represents location of Rowley Bay survey site in Door County.



During October, 2008, Sturgeon Bay staff began receiving reports from anglers describing a noticeable proportion of smallmouth bass with very pronounced lesions on various parts of the body, particularly from Green Bay waters of northern Door County. Reports generally characterized the lesions as being circular in nature and reminiscent of a lamprey wound. Similar reports were received during the early part of the 2009 season. During our 2009 survey we recorded the incidence and details of these lesions for fish captured though likely not all affected fish were recorded.

Rowley Bay

Fyke nets were set in Rowley Bay May 8, 2012 and fished periodically until May 31, 2012 for a total of 21 net nights. Nets were lifted and fish removed every 24 hours. Nets were not fished during weekends. Weather conditions limited the amount of effort that was expended for this assessment. Data collected from smallmouth included total length measured to the nearest millimeter (converted to inches) and a subsample of scales used for ageing. A sub-sample of fish was weighed. From this sub-sample, an estimated mean weight by length bin was calculated from a regression equation. All fish were given a top caudal fin clip after being processed to avoid duplicate sampling and to potentially calculate a population estimate. Fish were evaluated for any external lesions. All other gamefish were measured and non-gamefish were identified to species and counted. No population estimate was conducted for this survey due to the restricted period of assessment and limited number of recaptures.

Creel Survey

The sport fishery for smallmouth has been assessed annually in the outlying Door County waters since the 1970s through the use of a randomized angler creel survey. The creel season begins with the May opener and typically runs thru mid-October and survey sites include most popular access points along the Door County shoreline. Standard creel survey interview data are collected including effort, catch, harvest, biological data (length, weight, marks/tags) and angler demographics (Masterson and Eggold 2013).

Results

Age Composition

Little Sturgeon/Sturgeon Bays

The smallmouth bass sampled in Little Sturgeon and Sturgeon Bays in 2009 ranged from 4 to 14 years of age and at least 6 year classes were well represented, age-4 to age-9 (Figure 2). Most notably, the prominence of age-4 fish in the sample suggests there was a strong 2005 year class, whereas it appears age-4 fish in the 1996 and 2004 surveys did not make up a large component of the population at the time. (However, these data should be interpreted cautiously as this may also be an artifact of changing catchability for younger fish as a result of increasing growth rates or changing maturation schedules - see growth results and discussion section later in report) The 2009 age compositions also differ from the previous assessment years in that the year classes are more evenly distributed in the population. Specifically this contrasts 2004 where apparently stronger classes of age-5 and age-6 fish made up 60% of the catch and in 1996 where age-7 and age-8 fish made up close to 50% of the catch. Fish from the strong year classes in 1998 and 1999 (5 and 6 year olds in the 2004 survey) were still relatively well-represented in the 2009 survey as 10 and 11 year olds, making up over 10% of the population.

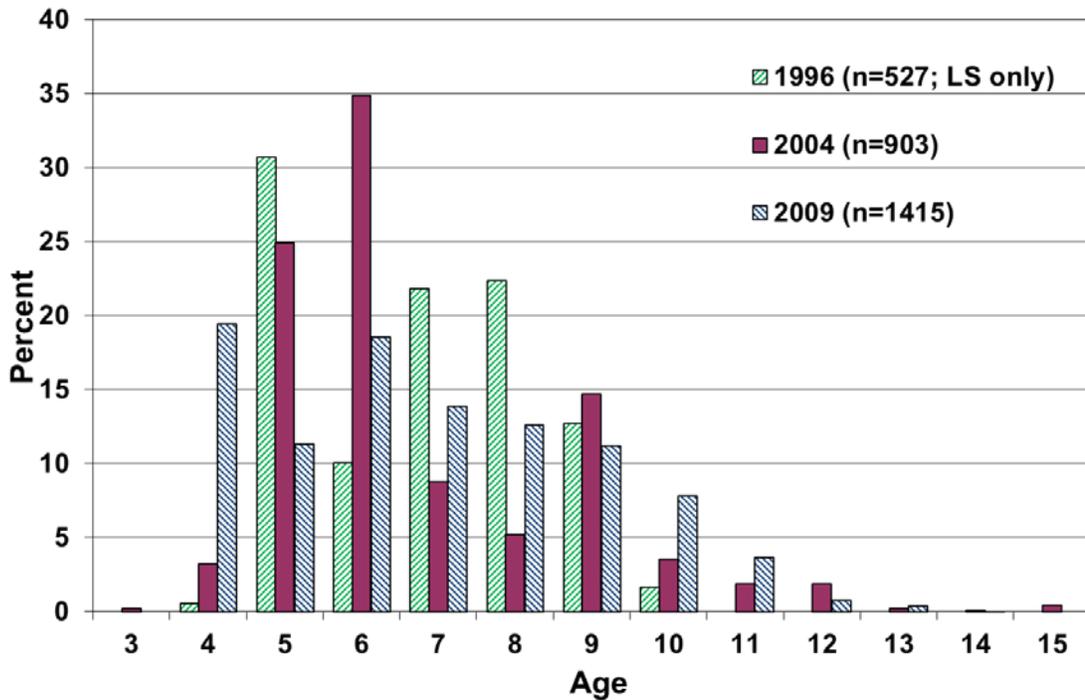


Figure 2. Age composition of smallmouth bass from 1996, 2004, and 2009 spawning surveys in Little Sturgeon Bay and Sturgeon Bay.

Rowley Bay

The smallmouth bass sampled in Rowley Bay in 2012 ranged from 3 to 16 years of age and at least 5 year classes were well represented, age-4 to age-8 (Figure 3). Most notably, the prominence of age-4 fish in the sample suggests there was a strong 2008 year class, whereas it appears age-4 fish in the 1996 and 2004 surveys did not make up a large component of the population at the time. (However, as with the 2009 Little Sturgeon/Sturgeon Bay survey, these data should be interpreted cautiously as this may also be an artifact of changing catchability for younger fish as a result of increasing growth rates or changing maturation schedules - see growth results and discussion section later in report) The 2012 age compositions also differ from the previous assessment years in that the year classes are more evenly distributed in the population, especially from age-4 to age-9. Specifically this contrasts 2004 where apparently stronger classes of age-5, age-6, and age-9 fish made up close to 60% of the catch and in 1996 where age-5 and age-7 fish made up close to 70% of the catch. Also, in contrast to the 2004 population, the proportion of fish from the 2012 survey older than age-9 drops off considerably. The differences in age composition between 2004 and 2012 may, to a certain extent, also be a result of sampling times during the spawning period (see discussion section regarding influence of water temperature).

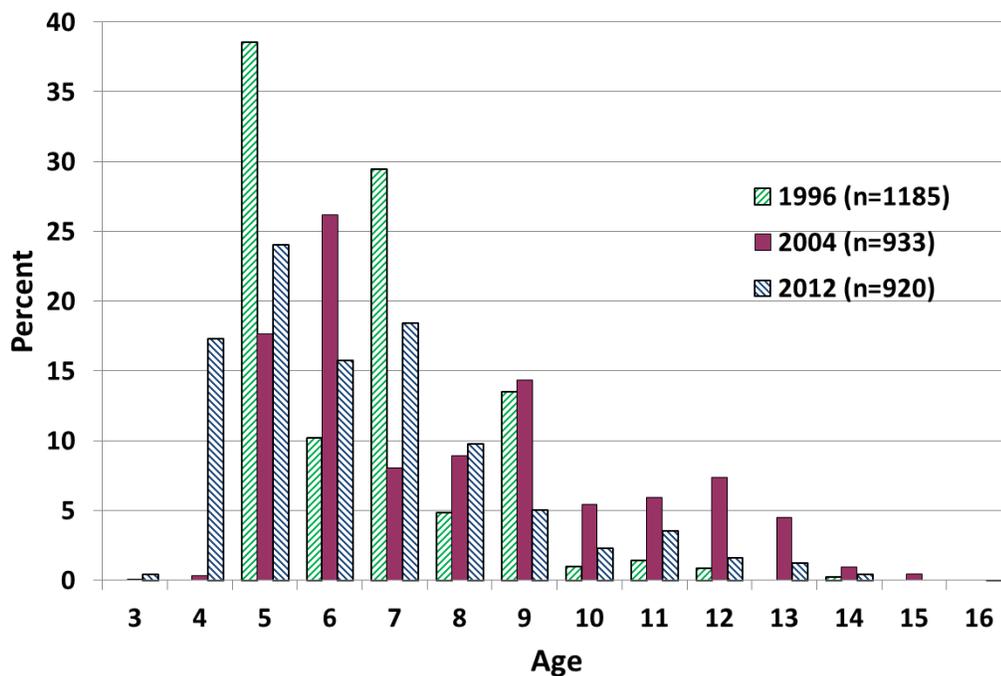


Figure 3. Age composition of smallmouth bass from 1996, 2004, and 2012 spawning surveys in Rowley Bay.

Length Composition, Growth and Weight

Little Sturgeon/Sturgeon Bays

Similar to the age composition distributions, the length composition of smallmouth bass in the Little Sturgeon and Sturgeon Bay areas during 2009 was well distributed among the overall population (Figure 4a). Fish length ranged from 12 to 22 inches and over half were between 15 and 17 inches while nearly 25% were 18 inches or greater. The 2009 length compositions suggest a shift in the overall size structure from 2004 where a large percentage (63%) were 15 inches or less and only 11% of these fish were 18 inches or greater. Indeed, the average length of a smallmouth sampled during the 2004 survey was 16.1 inches while the average fish measured 16.5 inches in 2009.

Mean length at age, as measured periodically during 1994-2009, appears to be increasing for the smallmouth population in this sampling area (Figure 5a). In fact, the average length of age-4 and age-5 fish has increased approximately 3 inches since the mid-1990s. Whereas historically a fish didn't reach the 14" legal size limit until around 7 years, the data now suggest fish on average could reach the legal limit by 5 years of age.

Rowley Bay

While the age composition in Rowley Bay in 2012 shifted to younger age classes compared to 2004, with the exception of the 18 inch length group, the percentage of fish between 14 and 20 inches was quite comparable between the two survey years (Figure 4b). Once again, this may represent the shift in size at age or changes in fish distribution due to variable abiotic conditions.

Mean length at age for Rowley Bay, as measured periodically during 1996-2012, has also been increasing for this smallmouth population (Figure 5a). However, there is generally less disparity in mean length at age for several of the age classes measured during the last two survey years (2004 and 2012). For example, while the average length of age-6 and age-7 fish increased around 2 and 1.5 inches, respectively, between 1996 and 2012, their overall average lengths were virtually the same between the 2004 and 2012 survey years. As with the Little Sturgeon/Sturgeon Bay area population in 2009, smallmouth bass in Rowley Bay that historically didn't reach the 14" legal size limit until around 7 years, now could reach the legal limit by 5 years of age.

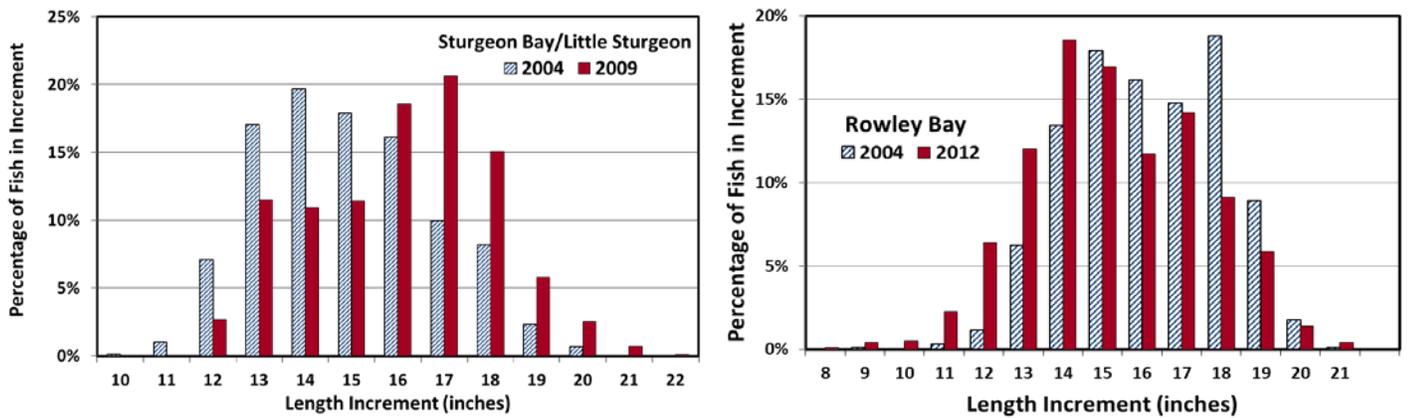


Figure 4a. Length compositions for Little Sturgeon Bay/Sturgeon Bay smallmouth bass in 2004 and 2009 survey years. Length bins are delineated by any fish that fell within a particular inch group (e.g. a fish in the 16” bin could have been between 16-16.99 inches in length). **4b.** Length compositions for Rowley Bay smallmouth bass in 2004 and 2012 survey years.

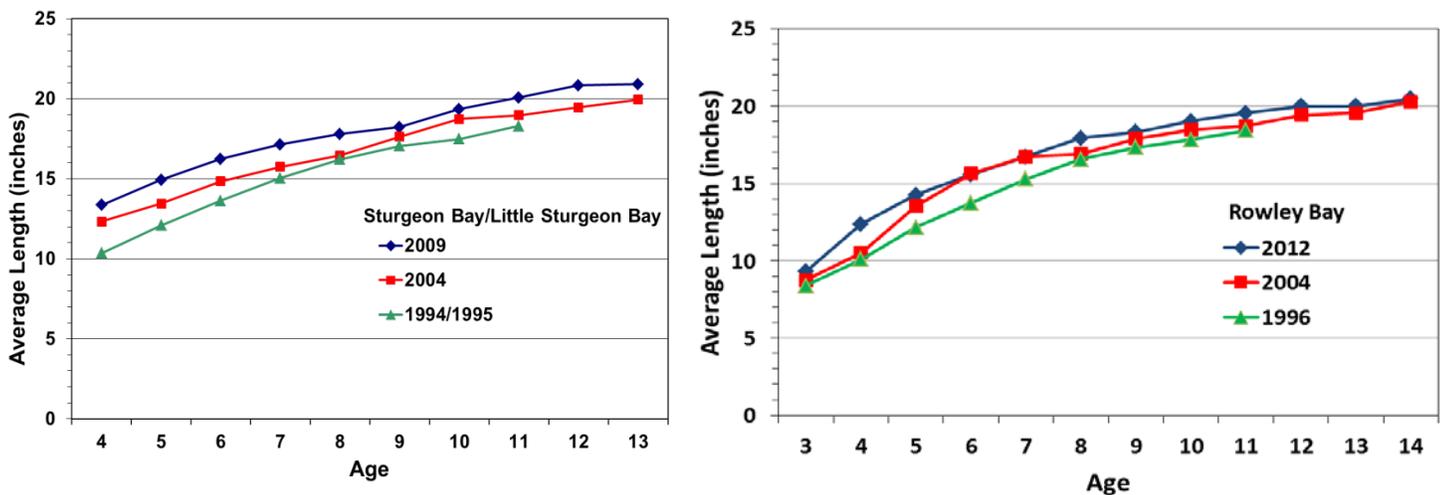


Figure 5a. Mean length (in) at age of smallmouth bass sampled during the 1994/1995, 2004, and 2009 spring spawning periods in Little Sturgeon Bay and Sturgeon Bay. **5b.** Mean length (in) at age of smallmouth bass sampled during 1996, 2004, and 2012 spring spawning periods in Rowley Bay. (Much of the sampling in 1996 was done near the mouth of the Mink River)

From the sub-sampled group of fish that were weighed in Rowley Bay (n=148), a length-weight regression formula was developed to estimate weights of fish when the length is known (Figure 6). These weight estimates are limited to pre-spawn smallmouth bass in Rowley Bay and are provided to give anglers an approximation of what a fish may weigh when the length is known. For example, a fish with a length of between 19 -19.9 inches could have a weight in the area of 4 pounds.

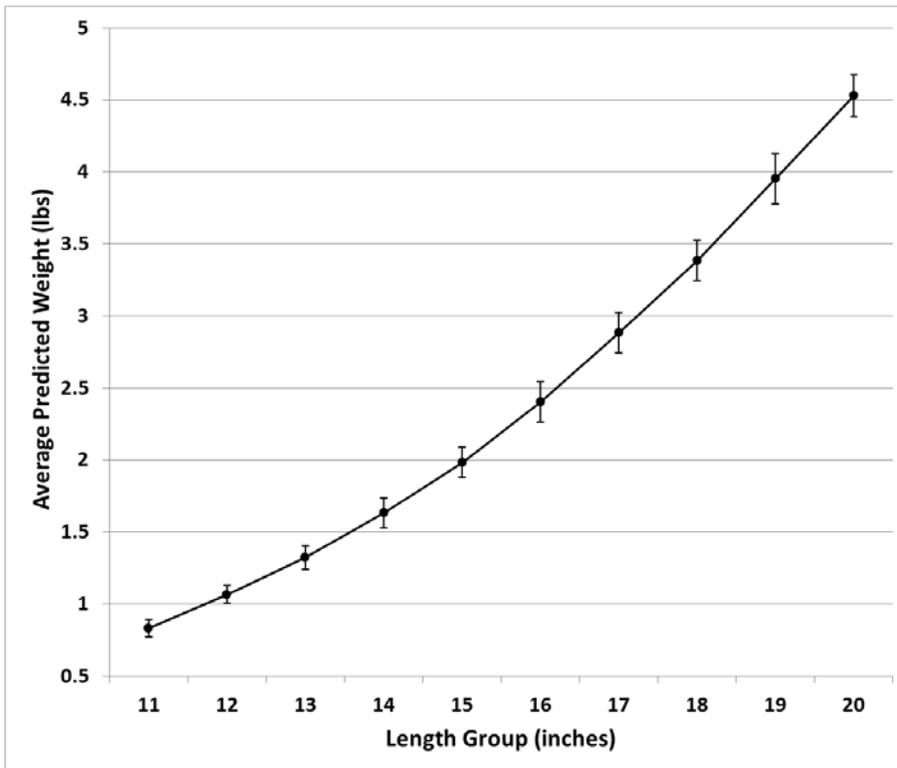


Figure 6. Average of predicted weights (+/- 1 SD) for smallmouth bass for selected length bins of fish sampled in Rowley Bay, 2012. Length bins are delineated by any fish that fell within a particular inch group (e.g. a fish in the 16” bin could have been between 16-16.99 inches in length).

Population Estimates

To estimate the number of adults in the Little Sturgeon population, only fish greater equal to or greater than 378 mm (14.9”) were used in the calculations. This is the average length of the age-5 fish in the survey results, the age at which smallmouth bass in this area are assumed to become reproductively mature; therefore the estimate includes approximately ½ the age-5 fish as part of the adult population. The population estimate of adult fish for Little Sturgeon was 8,513. This total is fairly consistent with the last two population estimates (most comparably 1994) conducted for Little Sturgeon although it increased by nearly 900 since the 2004 estimate (Table 1). The relatively large confidence intervals of these population estimates is consistent with inherent issues involving violations of assumptions in using closed population mark-recapture calculation methods to estimate open populations (such as those in Green Bay); therefore, these population estimates should be interpreted with a certain level of caution.

Table 1. Population estimates for adult smallmouth bass captured during spring assessments in Little Sturgeon Bay in 1994, 2004, and 2009.

Year	Population Estimate	95% Confidence Interval
1994	8,494	5,916 – 12,650
2004	7,641	4,678 – 13,173
2009	8,513	5,988 – 12,056

Tag Recoveries (Little Sturgeon Bay and Sturgeon Bay)

All except one of the 53 fish recaptured during the 2009 survey effort were found in the same general location (Little Sturgeon or Sawyer Harbor) as originally tagged in the survey. However, one fish tagged in Sawyer Harbor on May 8 was recaptured 11 days later in a Little Sturgeon survey net. Many tag recoveries were also reported by tournament anglers and general sport fishers. Interestingly, one fish was recaptured 3 times during the survey and a fourth time by an angler in early June. In addition to the survey recaptures, sport anglers have reported an additional 79 tag recoveries to date. Once again, the majority of the angler-caught fish were from the same general location in which they were tagged during the 2009 survey. However, several fish reported by anglers had moved a considerable distance from the tagging site, the furthest being around 15.5 miles (Table 2). A number of fish tagged in Little Sturgeon were recaptured modest distances in adjacent areas such as Riley's and Sand Bays (not listed in Table 2). Interestingly, two fish tagged on the same day in April in Little Sturgeon with consecutive tags were recaptured on the Flats area of Sturgeon Bay in 2009, though they were caught about two weeks apart (May 24 and June 7). Only a few tag recoveries were reported after 2009 supporting the premise that tag loss is fairly high in smallmouth.

Table 2. Tagging and recapture locations, dates, and approximate distance traveled for smallmouth bass that moved away from the general area in which they were tagged. Recapture year was 2009 unless otherwise noted.

Tagging Site (Date)	Recapture Site (Date)	Approximate Distance Traveled (mi)
Sawyer Harbor (May 8)	Little Sturgeon (May 19)	10
Sawyer Harbor (May 13)	Rileys Bay (June 5, 2010)	6
Sawyer Harbor (May 15)	Murphy Park (May 17)	11
Little Sturgeon (April 30)	Sturgeon Bay (May 24)	9.5
Little Sturgeon (April 30)	Sturgeon Bay (June 7)	9.5
Little Sturgeon (May 19)	Sturgeon Bay (July 22)	9.5
Little Sturgeon (May 20)	Sturgeon Bay (June 7)	9.5
Sturgeon Bay (May 12)	Juddville (5/17)*	15.5

*Fish was recaptured again on 5/29 in Sawyer Harbor

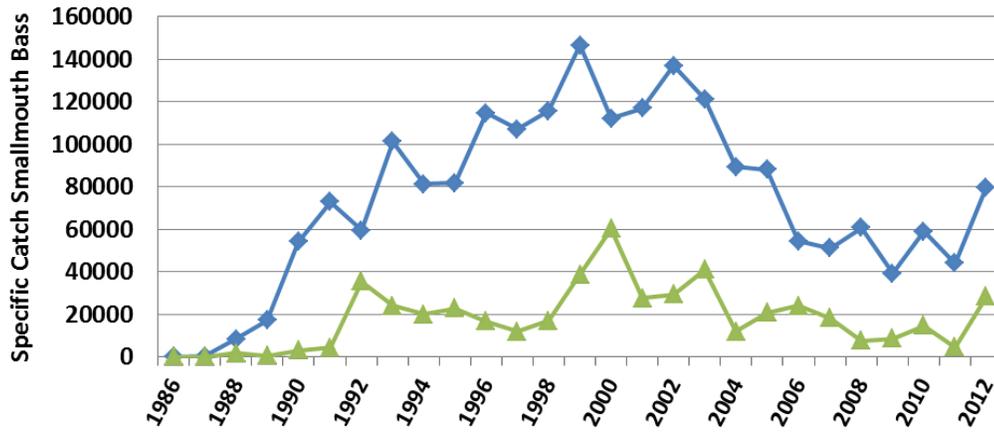
Fish Health

Though the incidence of lesions observed during the 2009 survey was not empirically compared with those of past surveys, the frequency appeared greater than what has been observed in the past. Consequently, three smallmouth bass with lesions were collected from fish registered during the 2009 spring Sturgeon Bay Open Bass Tournament and submitted to the Wisconsin Veterinary Diagnostic Lab for evaluation. One of the three fish was positive for Viral Hemorrhagic Disease (VHS). This is not the first VHS positive smallmouth bass from this area as fish submitted during 2007 also tested positive. Generally speaking, aside from the sometimes extensive lesions, the fish appeared to be in good condition and no large scale mortality incidents were reported during this time period.

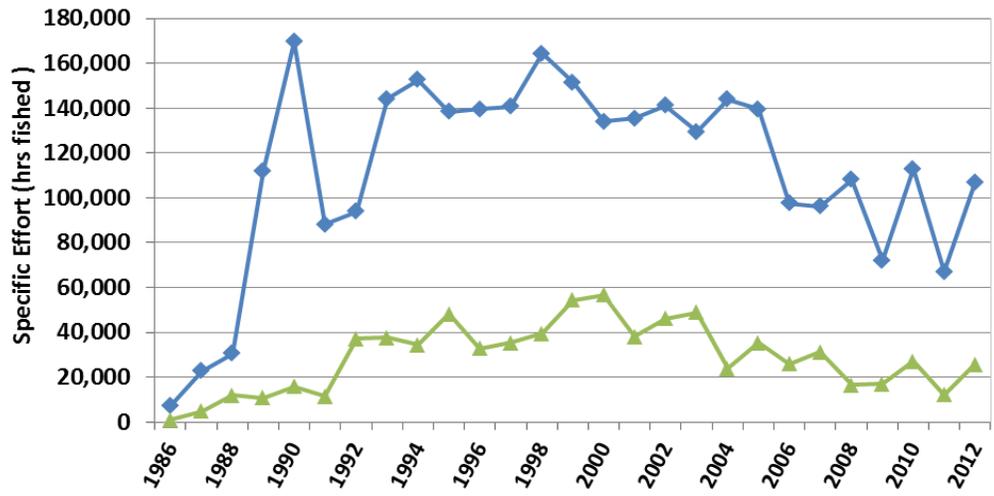
Creel Surveys

Catch and effort for smallmouth bass in Door County waters increased rapidly during the late 1980s to the 1990s (Figures 7a-c). Catch rates, as measured by anglers specifically targeting smallmouth bass, were nearly 1 fish per hour for several years in the late 1990s. Between 2003 and 2004, catch rates for smallmouth bass declined precipitously and the catch rate for the next 7 years was around 0.5 fish caught per hour of fishing. Recent creel results indicate an increase in catch rates for smallmouth bass over the last two years in Green Bay waters increasing from 0.52 fish per hour in 2010 to nearly 0.66 fish per hour in 2011 and approximately 0.75 fish per hour in 2012. There was also a large increase in catch rates for smallmouth bass in Lake Michigan increasing from about 0.37 fish per hour in 2011 to 1.1 fish per hour in 2012; this may be at least partially a result of a boat launch in Rowley Bay that became available to the public in 2012.

7a.



7b.



7c.

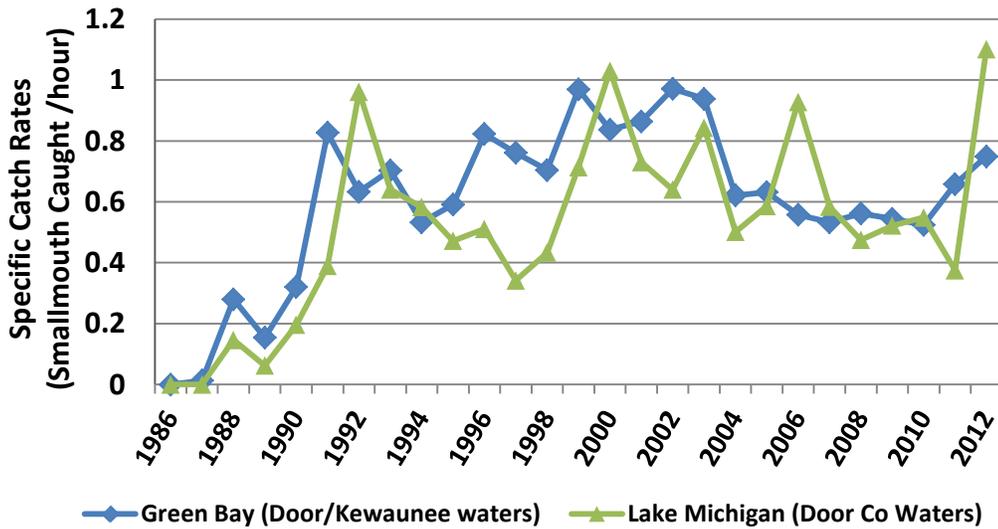


Figure 7a-c. Historical creel survey results for Door County waters of Green Bay and Lake Michigan. Catch, effort, and catch rates are specific to anglers targeting smallmouth bass.

Harvest

Between 1986 and 2004, the average annual harvest of smallmouth bass in Door County waters of Green Bay was $19,657 \pm 3024$; peaking at 45,040 in 1992 (Figure 4). Harvest was relatively high through much of the 1990s until implementation of a 14" size limit reduced it considerably in 1998. After the bag limit change, harvest remained fairly steady until it decreased sharply in 2005 to 6,664 from 12,627 fish in 2004. Since 2005 the harvest in these waters has averaged $6,586 \pm 384$ annually. Harvest in Lake Michigan waters of Door County has generally been substantially lower and the annual harvest has averaged $3,688 \pm 680$ over the same time series.

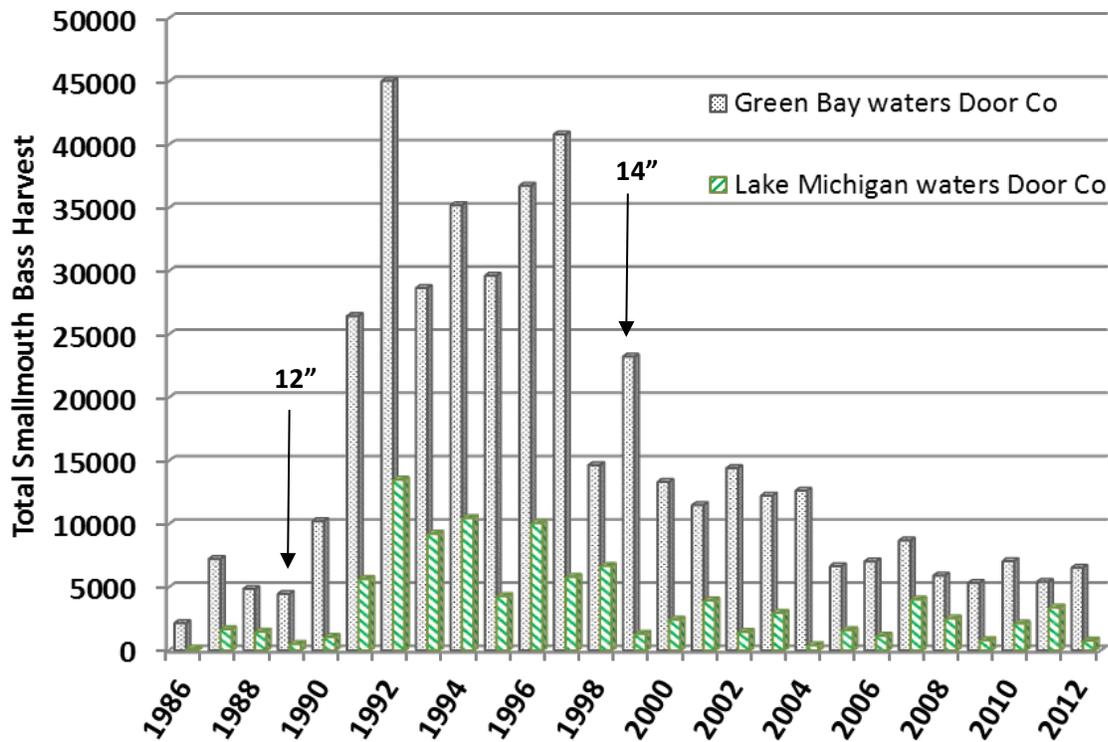


Figure 8. Smallmouth bass harvest history in Door County waters of Green Bay and Lake Michigan. Arrows indicate size limit changes in 1989 and 1999.

Discussion

Little Sturgeon/Sturgeon Bays

The results of the 2009 Sturgeon Bay area assessment suggest our smallmouth bass spawning populations appear to be doing well given their robust size (length) and age compositions. Using Little Sturgeon Bay as an indicator, recruitment into the adult population has demonstrated positive signs; adult abundance improved by approximately 1000 fish since the last population estimate and was nearly the same estimate produced in 1994. Furthermore, recruitment, as measured by the younger fish in the population, appears to have been good in recent years. Since the invasion of the round goby in the Great Lakes and the first goby record in Sturgeon Bay in 1999, their impact as a nest predator has been of great concern, particularly with smallmouth bass. Because it took several years for gobies to reach high levels of abundance throughout this area, their impact on smallmouth could likely not have been measured in our spring surveys until around 2009, at the earliest. The abundance of ages 4-6 in the 2009 survey provides a certain level of assurance that goby nest predation has not substantially limited smallmouth bass recruitment in the areas surveyed. However, as goby abundance continued to grow during the mid-2000s, the full impacts of gobies may not yet be detectable in our survey of adult fish and a level of vigilance is still necessary.

The age composition of the 2009 survey is a positive sign of a healthy smallmouth population in the area. Well distributed smallmouth age classes suggest there had been few truly weak year classes during the early to mid-2000s (Figure 2). A certain level of caution should be administered when interpreting the age composition distribution, however, as these levels can be affected by sampling dates and relevant water temperatures. However, water temperatures as measured at the surface on most sampling days for this area were fairly similar between the last two survey years. Average water temperatures during the survey in 2004 were 52.3 F (min/max: 43-63; SD: 6.63) while in 2009 the average water temperature was 55.3 F (min/max: 49-67; SD: 4.30). One reason for the higher temperatures in 2009 may have been that most of the sampling in Sturgeon Bay took place in Sawyer Harbor, while in 2004 much of the sampling was done in the larger area of Sturgeon Bay proper. With smallmouth

bass, there is an observed tendency for the larger fish to first come into the spawning areas early in the season while the younger/smaller fish generally are more prominent later in the spawn. The specific extent to which temperature and/or photo-period influence this phenomenon, is relatively unknown. The 2004 survey started a week before the 2009 survey and ran over two weeks later. The later sampling in 2004 would suggest that smaller fish would be a larger component of the sampled population. However, upon examination of the actual number (not percent composition) of fish in the length groups between the two survey years, the numbers of fish in the smaller length groups are similar between the surveys indicating we did not selectively sample larger fish in the 2009 survey but that they were legitimately in larger proportions than in 2004. In addition, the increase in size at age may be partially responsible for a change in catchability for smallmouth bass. Historically, most smallmouth bass in this area did not recruit to the fyke nets until the age of 5 likely because this is the age at which the majority of the fish reached maturation (Kroeff 1992) and possibly due to gear selectivity issues. However, considering smallmouth bass in 2009 were approximately one inch larger at age-4 than they were in 2004 and three inches larger than they were during the mid-nineties, more fish may be maturing at an earlier age; possibly resulting in a shift in the maturation schedule. Additionally, the increased growth rates may simply be making younger fish more susceptible to capture during spawning surveys (i.e. change in catchability with length). Nonetheless, the large difference in age-4 contribution to the overall composition between 2004 and 2009 (six-fold increase) speaks to positive signs in overall recruitment.

The length at age and overall size structure from the 2009 survey demonstrated some very positive signs as both indices increased considerably from previous surveys (Figures 4a and 5a). Strength of particular year class(es) can of course account for a portion of the upward shift in the overall population size structure between 2004 and 2009. However, the increasing trends in size at age provide supporting evidence that the average size of a smallmouth bass in these areas has been increasing over the last 15 years. Since the population estimates have been similar during this time period, the change in growth does not appear to be a density dependent issue (i.e. increased growth as a result of decreasing densities and less competition for food). One plausible explanation for the increased growth is the abundant forage base created by the round goby invasion within the last decade. Due to their ubiquitous nature and relatively limited movement patterns, round gobies are likely a good food source considering smallmouth bass would need to expend relatively little energy in pursuit and capture relative to the energy they receive. Furthermore, it can be hypothesized that smallmouth bass may have adapted well to feeding on gobies considering this invasive shares similar rock burrowing habits of crawfish which were likely the main pre-goby forage for bass. Ironically, a developing dilemma could be imagined when considering increasing growth rates and the effectiveness of the 14" size limit, implemented in 1998. Considering the goal of the 14" size limit was to protect fish through age-5, the age when many female smallmouth are likely becoming reproductively mature (Becker 1983), then this size limit may be becoming less effective as size at age increases. Our data indicate that the average length of an age-5 fish in 2009 was 14.9 inches while in 1994/1995 and 2004 a fish of this age measured 12.1 and 13.4 inches, respectively. Therefore, as of 2009 the 14" minimum size limit may have no longer been as effective in allowing at least one spawning event before being susceptible to harvest. However, that is based upon the assumption that maturity is based upon age and that size-at-maturity is not as substantial a contributor. If earlier maturation is dependent more upon size now, then the size limit still affords these fish some protection prior to spawning. In fact, there is some historical reference to fast growing females maturing at age-4 in parts of Lake Michigan (Becker 1983).

Tagged fish recaptures from the 2009 survey, as in past surveys (Weigert 1966), continue to suggest that smallmouth in this area generally do not move extensively and have a tendency to remain in a "home range". An overwhelming number of the fish tagged in Little Sturgeon Bay and Sturgeon Bay were recaptured in the same general locations. The movement of one individual tagged in Sturgeon Bay on May 12, recaptured May 17 in Juddville, and then recaptured again May 29 in Sawyer Harbor suggests a small number of fish may move a fair distance. The size (17") suggests this was a mature fish and was perhaps a female that spawned around the time of initial capture and then moved extensively after. Past surveys have suggested that smallmouth may have a homing tendency (Kroeff 1993). Our surveys were not designed to capture such information. However, an attempt was made to evaluate the potential for long distance homing tendencies by moving 2009 survey tagged fish that were captured in various Sturgeon Bay/Little Sturgeon Bay area locations by anglers in the Spring Sturgeon Bay Open Bass Tournament that same year (n=6). The tagged fish were moved north from Sturgeon Bay to Fish Creek on the tournament's re-stocking truck a distance of approximately 25 miles from Sturgeon Bay. However, no recaptures

were reported which is not surprising given the relatively small number of fish that were moved.

One hypothesis regarding the increased incidence of external lesions observed during the 2009 survey is that the lesions were the result of secondary infections due to a VHS-compromised immune system that allowed other bacteria to proliferate in the fishes' systems. Furthermore, since VHS is generally most active over a particular range of lower water temperatures (37 – 54° F virus grows best in fish) it's possible that the fish were able to recuperate from the challenge, to a certain extent, once water temperatures increased. At this point, it does appear that an epizootic event occurred since the level of affected fish appeared to drop after 2009 and we received few angler reports of affected fish during the years following the survey. We did not observe any large scale die-off of smallmouth bass associated with the 2009 observations. Furthermore, the 2012 Rowley Bay survey on the Lake Michigan side of Door County did not reveal this high level of affected fish.

Rowley Bay

Given the warm spring and associated higher water temperatures in 2012, our assessment likely commenced later in the pre-spawn progression than we would have preferred. Pre-spawn movement patterns into shallow water have been observed to be associated particularly with the larger fish in the smallmouth bass population. Very large catches (100 bass/net night) in the fyke nets after the first night of fishing provided evidence that the pre-spawn movement patterns were in full swing indicating we had likely missed the early portion of the pre-spawn movement into shallow water. Nevertheless, the data collected suggest the smallmouth bass spawning population appears in very good condition given the observed size and age compositions. Furthermore, recruitment of younger fish into the adult population appears to have been good in recent years. As with the Sturgeon Bay area, preliminary indications are that the impacts of the nest predating round goby are not as great as once feared. However, the establishment of gobies in this area was likely delayed by several years compared to locations in Green Bay as gobies were not detected in this area in large numbers in the 2004 survey (Kroeff et al. 2004). Therefore, fish collected in this survey may not reflect age classes that would have hatched when gobies reached the high levels of abundance now found in that area. It will be important to continue monitoring the Rowley Bay smallmouth bass population in light of the relatively recent proliferation of gobies.

The age groups of fish sampled from Rowley Bay in 2012 are generally well distributed; all adult age classes are well-represented in the population until age-8. This apparent consistent recruitment is encouraging (Figure 3). However, the overall distribution is somewhat skewed to the younger age classes as compared to earlier surveys which, again, may be indicative of the late survey start resulting in the older, earlier run fish being missed. With the earlier spring warmup in 2012, the larger (older) fish may have been more active earlier in the spring. However, water temperatures as measured at the surface on most sampling days for this area were not dramatically different than those measured in 2004, for example. Average water temperatures during the survey in 2004 were 53.5 F (min/max: 45-60; SD: 4.12) while in 2012 the average water temperature was 50.7 F (min/max: 46-56; SD: 3.50) suggesting that the water was cooler in 2012. The survey start dates for each year were one day apart in early June. Nevertheless, the spring of 2012 was unusually warm and we lack water temperature data from the weeks prior to the survey. Given the circumstances, it's difficult to determine if the shift to younger age classes in 2012 is a real phenomenon. Given the limited number of fish harvested in this area, it's unlikely that fishing mortality has major implications.

The overall size structure of fish in the 2012 survey was very encouraging with good representation between 12 and 19 inches (Figure 4a). With the exception of the 18 inch length group, the 2004 and 2012 survey years were fairly similar for this metric. Interestingly, this contrasts the observed differences in age compositions between these two survey years. The fact that growth has increased on average over the years (Fig. 5b) may partially explain this phenomenon. Many of the average lengths at age have increased ½ inches or more since the 2004 survey. Furthermore, ageing error may also partially explain these contrasting data. Ageing studies have generally indicated that ageing scales from smallmouth bass has some inherent error, particularly in aging older fish. Using otoliths (ear bones) would likely have increased ageing accuracy and precision. However, to extract otoliths the specimen must be sacrificed and therefore we accepted a certain level of ageing error for the older fish. The overall increase in length at age over the course of the last three survey years in Rowley Bay somewhat mirrors the trend for this metric in the Sturgeon Bay area (Figure 5a). However, while the mean lengths at age between these two

sites followed one another very closely during the 1996 survey and most year classes in 2004, the Sturgeon Bay area smallmouth bass have generally outpaced growth rates for Rowley Bay in recent years. For example, while smallmouth bass on average grew to 15 inches by year five in Sturgeon Bay area sites, an age-5 fish in Rowley Bay averaged about 14.24 inches, in 2012. While comparing size at age of fish that were sampled several years apart is not an ideal comparison, the data provide some insight into differential growth rates between the two populations and that growth rates for the two sites have demonstrated an increasing trend over the last 15-20 years. Like the Sturgeon Bay/Little Sturgeon Bay population, though not as extreme, the dilemma regarding the effectiveness of the 14" size limit exists for Rowley Bay as well. Our data indicate that the average length of an age-5 Rowley Bay smallmouth bass in 2012 was 14.25 inches while in 1996 and 2004 a fish of this age measured 12.2 and 13.6 inches, respectively. Therefore, as of 2012 the 14" minimum size limit may no longer be as effective in allowing at least one spawning event before being susceptible to harvest. However, as mentioned earlier, that is based upon the assumption that maturity is based upon age and that size-at-maturity is not as substantial a contributor. If earlier maturation is dependent more upon size now, then the size limit still affords these fish some protection prior to spawning.

Due to conditions limiting the collection of accurate fish weights (e.g. boat instability, wind), these data are rarely collected in the field. However, during the Rowley Bay survey we had the opportunity to collect weight information on shore on two sampling dates from a portion of the fish sampled in the survey. From this sample we were able to generate an estimated weight based on length (Figure 6). These weights should be taken as rough estimates based on the limited samples and dates; this can introduce biases such as disproportionate sampling of males/females or limitations on size groups. However, these estimates can give anglers, within a certain level of confidence, an idea of how much a smallmouth bass within a particular length group might weigh at this time of year.

Creel Survey

Catch rates for smallmouth bass in Door County waters of Green Bay have shown some interesting trends during the time series captured by our creel surveys. Of particular interest is the large drop in the catch rate between 2003 and 2004 (Figure 7c). Creel survey protocol remained the same throughout this period ruling out a methodological source of error. At first glance it would seem that these catch rates reflect a drop in smallmouth bass abundance. However, unlike a situation where a strong year class recruits into a fishery and dramatically increases catch rates, it's difficult to imagine a situation where such a large drop would reflect reduced abundance; especially given little change in harvest in Door County waters over that period. An abrupt decline in abundance would be more typical with shorter lived species (e.g. yellow perch) than a longer lived species such as smallmouth bass. Furthermore, the limited number of population abundance estimates from fishery-independent sources between 1994 and 2004 suggest smallmouth bass abundance has been fairly stable. The data suggest that smallmouth bass abundance within a particular component of the population could have partially impacted catch rates during the mid-1990s to mid-2000s (e.g. age-5 and age-7 fish made up nearly 70% of 1996 survey age composition) though that's not likely the main reason. Perhaps a better explanation may be a result of changes in the Bay ecology. Increased water clarity likely stemming from large numbers of Dreissenid mussels may have driven fish further offshore and reduced catchability, especially for shore anglers. Further, the abundance of round gobies may have affected smallmouth bass feeding habits and made them less inclined to take what the angler has to offer. These reduced smallmouth bass catch rates may have been a factor in the subsequent reduction in angler effort over ensuing years (Figure 7b). The relative stability of catch rates between 2004 and 2010 indicate that whatever the factor responsible, it was consistently measured over time. Recent increases over the last two years in smallmouth catch rates may be indicators of strong recruitment in several age classes as measured in the 2009 survey or perhaps changing angling tactics.

Harvest level for smallmouth bass is often tied to changes in minimum size limits. Interestingly, the large reduction in harvest between 2004 and 2005 does not mirror the trend for catch rates which decreased a year earlier (Figure 8). However, an artifact of our creel survey design is that if only a small number of anglers are actually interviewed, then one or two interviews can have a strong effect on the results. This may explain why the drop in harvest was not measured immediately. Of further interest is that although catch rates have been increasing over the last two years, harvest has remained fairly constant. This may be a reflection of the established "catch-and-

release” mentality associated with bass anglers.

Summary and future outlook

Evidence from our 2009 and 2012 surveys indicate the smallmouth bass populations in the Sturgeon Bay/Little Sturgeon Bay areas and Rowley Bay on Lake Michigan proper are generally in good to excellent condition regarding abundance, size, and recruitment. Younger age classes are well represented indicating the future fishery outlook is bright. Although there has been some variation over time, sportfishing opportunities now abound with excellent catch rates and recently reported weights of fish in the 7 to 8 lb. range (Sturgeon Bay Open Spring Tournaments). These trends are expected to continue for the near future. There are, however, some management needs and concerns that should be addressed to ensure future robust smallmouth bass populations in Door County waters of Green Bay and Lake Michigan.

1) More consistent smallmouth bass population monitoring and assessment of additional areas would greatly benefit smallmouth bass management. Because of the extensive smallmouth habitat around the Door County area, timely surveys of the populations are difficult to achieve. One future management priority will be to establish a rotation of survey sites where possible. Northern Door county sites in the areas between Egg Harbor and Sister Bay are rarely evaluated primarily due to the difficulty in effectively sampling the sites. However, efforts should be made to conduct index surveys of these areas. It may be practical to conduct spring electrofishing indexing of some of these areas that do not lend themselves to fyke netting. The areas around Washington Island have not been surveyed in since 1997. The areas within ¼ mile of the town of Washington Island have a size limit regulation that is different than the rest of Door County (12” min) and the area should be evaluated to determine how well this regulation is performing. In Door County waters of Lake Michigan, smallmouth populations can be found in the bays including and north of Baileys Harbor. Aside from the Rowley Bay area, these bays to the south have not historically been evaluated and should be a priority as well.

2) Invasive species still remain a threat to smallmouth bass and other populations. Although we are cautiously optimistic that the impact of round gobies on smallmouth bass recruitment may not be as extensive as once feared, given the short timespan that gobies have been a part of the Green Bay and Lake Michigan ecology it would be prudent to continue vigilant monitoring of the populations.

3) Recent record low water level observations in Lake Michigan are cause for concern given the loss of nearshore fish habitat that can result from these changes. Water levels during the course of 2013 began to show signs of rebounding from these historical lows although the average water level for 2013 was still approximately 1.5 feet below the average for the period of record (<http://www.glerl.noaa.gov/data/now/wlevels/levels.html>).

4) Dredge permit applications have substantially increased over the last two years due to recent low water levels in Lake Michigan. Door County in particular has seen a substantial increase in applications in recent years. This increased dredging activity could result in further habitat loss with implications to various life stages of not only smallmouth bass, but other fish species as well.

5) One point of controversy has been the potential population-level impacts of the movement of large numbers of smallmouth relocated from their “home range” as a result of catch-hold-release fishing tournaments in this area. Future research priorities include a need to investigate the presence and/or level of genetic distinction between the various populations around Green Bay and Door County waters of Lake Michigan. Due to the relatively limited movement patterns of smallmouth bass, the potential for significant genetic differences between these populations exists. The need is great for this information as management decisions are often made based upon the genetic “uniqueness” of particular populations so this information could benefit future management strategies. A related research priority involves an empirical evaluation of the specific range of movement of some of the smallmouth bass populations in Door County waters of Green Bay including testing for homing tendencies. A study design incorporating the latest technological advances in acoustic telemetry may be very beneficial in answering whether fish remain in their newly relocated areas, and to what extent; as well as whether fish that are in their assumed home range generally remain in this area. This type of telemetry study has the potential to provide information in

answering a variety of other life history questions as well. External funding would need to be obtained as both the genetic and movement studies have the potential to be costly and could not be supported with our standard operational project funds.

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