Bluegill (*Lepomis macrochirus*) Length and Condition in Undisturbed and Human Disturbed Lakes

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Abstract

Human disturbance on inland lakes has the potential to reduce the size and negatively impact the condition of bluegill (*Lepomis macrochirus*) fish. Previous literature has found that both lakeshore construction and angling can reduce bluegill size structure and condition, a ratio of weight to length. I investigated three lakes in northern Wisconsin and the Upper Peninsula of Michigan to evaluate whether human disturbance reduces bluegill size. Two of the lakes, Tenderfoot and Bay, have human disturbance, and one lake, Crampton, has no disturbance. Tenderfoot is subject to high fishing pressure and has some lakeshore construction, Bay has low fishing pressure and no lakeshore construction, and Crampton, being the undisturbed lake, has neither. All lakes varied significantly in bluegill size, but the undisturbed lake had smaller bluegill length (Crampton lake, mean 81 mm, median 73 mm) than either of the disturbed lakes (Tenderfoot, mean 145 mm, median 145 mm; Bay lake, mean 190 mm, median 200 mm). It is unclear whether human influence had an effect on Bay and Tenderfoot size distributions. Human disturbance did not explain the small bluegill size of Crampton. Likely, a variety of environmental factors interacted to produce the observed sizes, with an unknown amount of human influence on Bay and Tenderfoot. Future research could determine whether human influence, ecological and physical processes, or a combination of both led to the observed differences.

Introduction

Bluegill (*Lepomis macrochirus*) are a vital species of fish in the lakes of the eastern United States. They are a popular target of anglers as well as a critical link in the food chain for larger sport species like northern pike (*Micropterus salmoides*), walleye (*Sander vitreus*), muskellunge (*Esox masquinongy*), smallmouth bass (*Micropterus dolomieu*), and largemouth bass (*Esox lucius*). In an undisturbed environment, bluegill populations are only affected by natural pressures like water clarity, predator types and abundances, and lake size. In human disturbed areas, however, bluegill face different circumstances. The predators that feed on them may be at a lower population than in an undisturbed lake due to fishing by anglers. Spawning beds and lake shore habitat may be disturbed by construction and boating activities. Bluegill themselves could be fished by humans in a disturbed lake. These differing circumstances could have large impacts on a bluegill population, changing size distributions, fish conditions, and other aspects. Bluegill size in particular is important to anglers, as larger bluegill provide more food per catch, and small bluegill are often hard to consume. A lake with healthy, large-sized bluegill would thus be more beneficial to anglers than a lake with small bluegill. Having large bluegill in a population increases production of eggs and young fish (Drake et al. 1997). Increased egg and young production in bluegills can increase recovery from angling, raise bluegill population size, and provide more food for predator fish like largemouth bass and northern pike. The larger population sizes of bluegill and predator fish could provide more opportunities for fishing, both for recreation and consumption.

Previous studies have focused on the impact of human activities on bluegill size distribution. Shoreline construction appears to negatively impact the size and condition of bluegill. Schindler et al. (2000) found that bluegill exhibited lower sizes and productivity in Michigan lakes that had high levels of lakeshore construction. The bluegill were 2.3 times less productive in heavily disturbed lakes, the productivity measured through growth rate and population size structure. Bluegill in habitats with diverse underwater plants grew faster than bluegill in other areas (Tomcko and Pereira 2006). The diverse plant communities could possibly be degraded by shoreline construction, leading to a reduced growth rate and maximum size. Thus, bluegill in disturbed areas would likely have smaller lengths and appear to be poor condition, as they would have access to less spots for feeding and hiding from predators.

Harvesting of bluegill, especially for large individuals of the species, also seems to have a detrimental effect on bluegill size and condition. Testing on Wisconsin lakes found that bluegill shifted towards smaller sizes after angling was enacted on a previously undisturbed lake (Goedde and Coble 2011). In another study (Rypel 2015), bluegill size increased when the bag limit on the fish was decreased. The decreased harvest of the fish likely resulted in fewer large fish being taken, leading to a recovery of a larger population. Implementation of a minimum size limit (200 mm) in Nebraska lakes with no previous size limit showed a small increase in bluegill size, although the effects varied depending on the productivity of the lake. Exploitation seemed to decrease the size of bluegill in lakes in one Minnesota study (Parsons and Reed 1998). When the harvest limit of bluegill in eight Minnesota lakes was decreased from 30 to 10 fish per day, mean length increased significantly (Jacobson 2005). Large bluegill size was partially attributed to low fishing intensities in two Michigan lakes (Schneider 1998). Bluegill parental males (those that build and defend nests) were found to be smaller in lakes with high intensity fishing, and "cuckold" males (males that "cheat" and fertilize eggs being released into nests of the parental males) possibly increase in proportion when fishing intensity increases (Drake et al. 1997), leading to lower successful egg rearing. Beard and Kampa (2011) found that bluegill across the country decreased in size from 1967 to 1991, possibly due to the impacts of fishing. In general, the literature agrees that intensive fishing of bluegill often leads to smaller fish sizes.

Modeling on simulated bluegill populations provides a non-invasive way to study the effects of fishing on bluegill size structure. Beard and Essington (2000) modeled effects of angling on fish sizes and found that the size of harvestable fish was smaller on fished lakes than unfished lakes. Another model for bluegill size and harvesting regulations (Beard et al. 2011) found that decreasing the bag size of fish and limiting the harvest of very large fish did not significantly increase fish size, while closing harvest during the spawning season led to a small increase in size. In Florida, modeling of size structure of bluegill predicted that minimum size limits would increase their size structure. Field testing of the limits determined that natural mortality was a larger factor determining the quality of the fish than fishing mortality (Crawford and Allen 2006).

Human impacts on size structures of fish populations have also been investigated in other fish species. The degree to which fish respond to size selective harvesting depends on the species. In zebrafish (*Danio rerio*), harvesting fish of large size decreased their overall body size (Uusi-Heikkila et al. 2015). Random harvesting and selection of small fish resulted in little change in body size. Bluegill may demonstrate similar trends as zebrafish, shifting to lower population size structure when large individuals are harvested (anglers usually keep larger fish for consumption). However, zebrafish and bluegill are only distantly related species, so the effects could differ greatly from zebrafish to bluegill.

To investigate the effects of fishing and shoreline construction on fish size, I collected bluegill from lakes in northern Wisconsin and the Upper Peninsula of Michigan. I hypothesized that bluegill in lakes with no shoreline construction or fishing would be significantly larger and in better condition ("fatter", a higher weight to length ratio) than bluegill in lakes with shoreline construction and fishing. In addition, bluegill would be significantly longer on lakes with low fishing and shoreline construction than on lakes with high fishing and shoreline construction. As previous research has shown, shoreline construction can negatively impact the productivity of a lake (Schindler et al. 2000, Tomcko and Pereira 2006). The decreased production could result in slower growth rates, smaller fish, and “thin” fish (a low length to volume ratio). Fishing on bluegill populations would likely remove the largest individuals in lakes without size restrictions. Smaller bluegill would remain, and continued fishing could lead to a population wide shift towards egg production at earlier ages and smaller size (Uusi-Heikkila et al. 2015), further reinforcing the small size and weights of the bluegill. The majority of previous literature seems to point in this direction, finding that bluegill on unfished lakes or lakes with maximum sizes and/or bag limits had larger individuals (Goedde and Coble 2011, Rypel 2015, Parsons and Reed 1998, Jacobson 2005, Drake et al. 1997).

Methods

I selected three lakes on the property of the University of Notre Dame Environmental Research Center (UNDERC), located on the border between Wisconsin and the Upper Peninsula of Michigan, for bluegill collection. Crampton, the first lake, has no fishing and shoreline construction. Bay, the second lake, has no shoreline construction and low fishing pressure. Tenderfoot, the third lake, has some areas of human shoreline construction and high fishing pressure. Data for fish weight and length on Crampton was provided by the National Ecological Observatory Network, consisting of the weights and lengths of 241 bluegill collected from three fyke nets on the lake on June 1, 2019. I collected bluegill on Bay and Tenderfoot via angling, fyke nets, and minnow traps, beginning collection on June 12, 2019, and ending collection on July 13, 2019. I checked the fyke nets and minnow traps daily and moved them between each collection date to provide a more random sample. For each fish, I recorded the length in millimeters and the weight in grams and then released it back into the lake. I decided that I would only use fyke net data on Bay and Tenderfoot to keep data consistent between my sampling and the Crampton data, giving me a sample size of 77 bluegill on Bay and 127 bluegill on Tenderfoot. I determined and graphed the mean and median bluegill weight and length for each lake and created a boxplot and histogram for the length data. I ran a one-way ANOVA and a pairwise test to determine if the bluegill from each lake varied significantly in length. Additionally, I ran a Welch ANOVA test (which does not assume equal variances) with pairwise comparison and a non-parametric Kruskal-Wallis chi squared test with a pairwise Wilcox test to confirm that the results were significant. To see if there was a difference in fish condition, I created scatter plots of the length and weight and added trend lines. All of the statistics, the boxplot, and the histogram were done in R commander; all other figures were created in Microsoft Excel.

Results

Bluegill on Bay lake had the largest length (mean 190 mm, Figure 1; median 200 mm, Figure 2), followed by bluegill on Tenderfoot (mean 145 mm, Figure 1; median 145 mm, Figure 2) and Crampton (mean 81 mm, Figure 1; median 73 mm, Figure 2) lakes. Bluegill on all three lakes varied significantly in their lengths (Table 1, one-way ANOVA: F value=519, df=2, p value= $< 2 * 10^{-16}$; Table 2, pairwise test: Crampton and Tenderfoot p value= $< 2 * 10^{-16}$, Crampton and Bay p value= $< 2 * 10^{-16}$, Bay and Tenderfoot p value= $< 2 * 10^{-16}$; tested at p value significance level of 0.05). The Welch ANOVA with pairwise comparison, Kruskal-Wallis chi squared test, and pairwise Wilcox test all exhibited similar levels of significance to the original ANOVA and pairwise tests (Tables 3-6). Length and weight showed a very close relationship on all three lakes, and the condition varied only very slightly between lakes (Figure

5). Weight followed a similar trend to length, with fish on Bay being on average the heaviest (mean 137 g, Figure 6; median 142 g, Figure 7), followed by fish on Tenderfoot (mean 50 g, Figure 6; median 44 g, Figure 7) and Crampton (mean 9 g, Figure 6; median 5 g, Figure 7) lakes.

Discussion

While the bluegill population's size structure did vary significantly between lakes, the differences among populations did not support my hypothesis. I expected that Crampton, the non-disturbed lake, would have the largest bluegill, followed by the Bay and then Tenderfoot, the disturbed lakes. Instead, I found that Crampton had the smallest bluegill, with Bay having the largest fish and Tenderfoot having intermediate-sized fish. Thus, the impact of human influence on these three lakes is unclear. There could be a relationship associated with Bay and Tenderfoot, as they did follow the hypothesized order, with the less disturbed Bay lake having larger fish than the more disturbed Tenderfoot (Bay mean length 190 mm, Figure 1, Tenderfoot mean length 145 mm, Figure 2). This could be indicative of lower human impact resulting in larger recorded fish size. With less fishing, large fish would be removed from the water less frequently, possibly leading to the observed size difference. This would agree with much of the previous literature (Goedde and Coble 2011, Rypel 2015, Parsons and Reed 1998, Jacobson 2005, Drake et al. 1997), which found that less disturbed lakes had larger fish. The lower amount of shoreline construction on Bay lake could result in higher quality habitat for bluegill foraging and reproduction, leading to faster growth rates and larger sizes. Previous literature (Schindler et al. 2000, Tomcko and Pereira 2006) also associates increased shoreline construction with decreased bluegill size and quality. However, as Crampton, the undisturbed lake, did not have the largest fish, the relationship cannot be confirmed. Fishing and lakeshore construction cannot explain the size of bluegill on Crampton; something besides human disturbance is resulting in the small size observed. Further interpretation of the human impact on these three lakes would be difficult, as my study has a limited scope and contains no replicates.

Other explanatory factors for the observed fish sizes include environmental and physical components. One factor could be the presence or absence of predatory fish on the three lakes. On Tenderfoot, multiple species of predatory fish exist, with smallmouth bass, largemouth bass, northern pike, muskellunge, and walleye all being present (UNDERC 2019, Aquatic Habitat Descriptions). The abundance of predators likely limits the amount of bluegill in the lake, preventing the fish from becoming overcrowded (Garling 2002). However, the presence of large predators like northern pike and muskellunge may limit the amount of extremely large bluegill. These large fish may have the ability to swallow large bluegill, keeping large bluegill from escaping predation and preventing an abundance of very large (~200 mm) bluegill. Conversely, on Crampton lake, there are few predators that would be able to eat bluegill (Michael Cramer pers. comm. 2019, NEON 2019). The absence of predators on Crampton may result in an overabundance of bluegill and a stunting of bluegill size. When there are too many bluegill in a lake, they have access to less resources per fish, possibly leading to slower growth rates and smaller body size (Garling 2002). On Bay lake, the main bluegill predator present is largemouth bass, with small numbers of pike and smallmouth bass also present (UNDERC 2019, Aquatic Habitat Descriptions). Largemouth bass likely prevent stunting of bluegill populations on the lake, but they are also likely not able to eat very large bluegill, as the bluegill could not physically fit through their mouths. This would account for the small number of bluegill in the 0-150 mm range found on the lake and large amount of ~200 mm bluegill collected (Figure 4). The small bluegill would be eaten by the largemouth bass. However, any fish that survived long enough to obtain a size of ~200 mm would escape predation by largemouth bass, leading to their retention within the population. This could possibly relate to a study by Schneider (1998), who found large bluegill in a lake with the main predator being largemouth bass.

Another factor is competition within the bluegill trophic level. Bluegill generally eat aquatic insects, zooplankton, and algae (Mecozzi 2008), a diet that is shared by similar sized fish like white crappie (*Pomoxis annularis*), black crappie (*Pomoxis nigromaculatus*), yellow perch (*Perca flavescens*), rock bass (*Ambloplites rupestris*) and pumpkinseed (*Lepomis gibbosus*). On Tenderfoot lake, crappie, yellow perch, rock bass, pumpkinseed, and bluegill are all present (UNDERC 2019, Aquatic Habitat Descriptions). These species would all compete for the same food resources, leading to less food available for bluegill to eat. Less available food could result in slower growth rates and the smaller sizes observed in the fish on the lake. Bay lake has bluegill and a small amount of perch (UNDERC 2019, Aquatic Habitat Descriptions). Bluegill in Bay likely have less competition for food, as the only competition they face is a small population of yellow perch and themselves. They could have access to more food per individual, allowing them to grow more quickly and reach large sizes. Crampton lake contains perch and bluegill, so the amount of competition on the lake may be lower than Tenderfoot (NEON 2019).

Lake size, shape, and nutrient level are other possible factors in shaping bluegill size. Crampton is small (0.2581 sq km) and has few bays (UNDERC 2019, Crampton Lake Bathymetric Map), Bay is of a medium size (0.673 sq km) with many bays (UNDERC 2019, Bay Lake Bathymetric Map), and Tenderfoot is the largest lake (1.9424 sq km), with fewer bays. (UNDERC 2019, Tenderfoot Lake Bathymetric Map). Tenderfoot, with its large size, could possibly support more food resources for bluegill. Crampton, on the other hand, may have less food due to its small size (Shoup 2007). Lake size would explain why Tenderfoot has larger bluegill than Crampton, but would not explain Bay's medium size and largest fish. However, there is a positive correlation between shoreline irregularity and fish size. Bay, with its irregular shore, may have a large amount of protected littoral habitat for bluegill to spawn and feed in, giving them ample food, protection from predators, and faster growth rates. Tenderfoot and Crampton, with less shoreline variation, may have less optimal littoral habitat, leading to smaller bluegill. Nutrient levels also could have an impact. Tenderfoot is eutrophic (high in nutrients and productivity, personal observations), while Bay lake is more oligotrophic (low in nutrients and productivity, personal observations). Crampton is also oligotrophic (NEON 2019). The high nutrient levels on Tenderfoot would explain the lake having larger fish than Crampton. Fish on Tenderfoot could have access to more phytoplankton and zooplankton resulting from high nutrient levels, letting them obtain larger sizes. However, Bay lake, with its large sized bluegill and low nutrient levels, would defy this explanation.

Most likely, the size structure of the bluegill is due to a variety of environmental factors, with no one factor strictly determining the size of a bluegill. In addition, the factors likely interact with each other, making it difficult to measure precisely what ultimately contributes to the bluegill size in each lake. Human disturbance on Bay and Tenderfoot is unclear, but perhaps it interacts with other factors to help create the size distributions observed.

Interestingly, the condition of fish (the ratio of length to weight) seems to follow a similar trend between all three lakes (Figure 5). This may indicate that all of the fish have access to similar and adequate food resources, leading to the same general "thickness" regardless of lake. It could also just be that bluegill do not exhibit a response in terms of "thickness" or condition even if different environmental factors are present. They may simply grow slower in the absence of abundant food, reaching larger lengths and weights at an older age instead of becoming "fat".

There are a fair number of limitations to my study. First, I did not have replicates for my lakes. One could consider Bay and Tenderfoot lakes replicates of human disturbed lakes, but the lakes have differing levels of human impact. Crampton, the only non-disturbed lake, has no replicates. This severely limits the interpretive power of the study, making it hard to describe any wide-ranging effects of human disturbance on lakes. I can only say with a level of certainty how human impacts affect Bay, Tenderfoot, and Crampton; further postulation on human effects are difficult or impossible. Fyke nets, the collection method I utilized, are known to select for a certain subset of the population (Sullivan 2019). Specifically, Fyke nets select towards the larger end of a population, as smaller members can swim through the holes in the nets, skewing results. I used only fyke nets in my study, which cuts down on variables associated with using multiple methods of collecting. However, I may be missing out on small bluegill that the fyke nets do not collect, leading to data that is not representative of the true bluegill populations in my studied lakes. Collection dates are another issue. The Crampton data was all collected in early June, and my data was collected between early June and July. Bluegill grow throughout the summer (Mecozzi 2008), possibly making the measurements in Crampton artificially smaller than the measurements in Bay and Tenderfoot. If I was able to collect all my fish in early June, I would have been able to eliminate this variable. However, with my collection dates spread out over two months, I cannot know for sure if the fish collected on Bay and Tenderfoot are larger due of summer growth or because of other environmental factors. Finally, the method I used for weight collection, a handheld spring scale with a clip to attach the fish to, was rather imprecise. If a fish flapped around during recording of weight, the scale would bounce up and down multiple times and often land on a weight different than the originally observed weight. This was not too much of an issue, as even with the imprecise weight measurements, conditions of the fish appeared to be similar regardless of weight (Figure 4). However, if I had used weight as my main indicator of fish size, this could have been a problem.

Future studies could build upon my study in a number of ways. First, replicates of human disturbed and undisturbed lakes could be utilized, preferably three or more lakes per condition. This would allow for a wider scope of interpretation. More fish could be collected per lake using multiple methods. This would allow for both testing of a larger proportion of the population as well as a comparison between testing methods. Lab studies could use artificial ponds with the same conditions, with some ponds having no bluegill removed and other ponds having removal of large fish. This would isolate variables associated with field studies and determine if angling has an effect in a controlled environment. The same artificial pond setup could be manipulated using shoreline construction, simulating human shoreline disturbance. A comparison of fish data sets provided by state resource departments and statistics on angling and lakeshore construction could contribute to the field and lab studies. Investigations into the environmental factors of each lake I studied could help determine why the lakes were so significantly different in bluegill size.

In conclusion, it seems unlikely that human disturbance has a large effect on the size and condition of bluegill in Crampton, Tenderfoot, and Bay lakes. The lakes differ significantly, but not in the order that I hypothesized. Much more likely, a combination of many environmental effects, paired with a much-reduced human impact, determine the size of bluegill on the three lakes. Hopefully, future research can more thoroughly study the impacts of humans on the size and condition of bluegill. This research, combined with appropriate policy actions, will ensure both the quality of bluegill and associated species in lakes and the satisfaction of the anglers who catch these fascinating fish.

Acknowledgements

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Tables

Table 1. One-way ANOVA test on bluegill from Crampton, Tenderfoot, and Bay lakes. N(Crampton)= 241, N(Tenderfoot)=127, N(Bay)=77.

Data type	Df	Sum sq	Mean sq	F value	P value
Main data	2	816497	408249	519.9	$< 2 * 10^{-16}$
Residuals	442	347097	785		

Table 2. Pairwise analysis of one-way ANOVA test on bluegill from Crampton, Tenderfoot, and Bay lakes. N(Crampton)= 241, N(Tenderfoot)=127, N(Bay)=77.

Lakes compared	Estimate	Standard error	T value	P-value
Crampton and Tenderfoot	63.239	3.073	20.58	$< 2 * 10^{-16}$
Crampton and Bay	-108.997	3.668	-29.71	$< 2 * 10^{-16}$
Bay and Tenderfoot	-45.758	4.047	-11.30	$< 2 * 10^{-16}$

Table 3. One-way Welch ANOVA test (no assumption of equal variances) on bluegill from Crampton, Tenderfoot, and Bay lakes. N(Crampton)= 241, N(Tenderfoot)=127, N(Bay)=77.

F value	Numerator df	Denominator df	P value
437.7	2.00	170.71	$< 2.2 * 10^{-16}$

Table 4. Pairwise analysis of one-way Welch ANOVA test (no assumption of equal variances) on bluegill from Crampton, Tenderfoot, and Bay lakes. N(Crampton)= 241, N(Tenderfoot)=127, N(Bay)=77.

Lakes compared	P-value
Crampton and Tenderfoot	$< 2 * 10^{-16}$
Crampton and Bay	$< 2 * 10^{-16}$
Bay and Tenderfoot	$< 7.4 * 10^{-16}$

Table 5. Kruskal-Wallis chi-squared test (non-parametric ANOVA test) on bluegill from Crampton, Tenderfoot, and Bay lakes. N(Crampton)= 241, N(Tenderfoot)=127, N(Bay)=77.

Chi square value	df	P value
287.81	2	$< 2.2 * 10^{-16}$

Table 6. Pairwise Wilcox test (non-parametric ANOVA pairwise test) on bluegill from Crampton, Tenderfoot, and Bay lakes. N(Crampton)= 241, N(Tenderfoot)=127, N(Bay)=77.

Lakes compared	P-value
Crampton and Tenderfoot	$< 2 * 10^{-16}$
Crampton and Bay	$< 2 * 10^{-16}$
Bay and Tenderfoot	$< 2 * 10^{-16}$

Table 7. Summary statistics for bluegill from Crampton, Tenderfoot, and Bay lakes.

N(Crampton)= 241, N(Tenderfoot)=127, N(Bay)=77.

	Mean length (mm)	Median length (mm)	Standard deviation length (mm)	Mean weight (mm)	Median weight (g)	Standard deviation weight (g)
Crampton	81.3278	73	24.75717	9.440456	4.8	15.17869
Tenderfoot	144.5669	145	26.67524	49.59843	44	32.15251
Bay	190.3247	200	37.62682	137.1299	142	62.82326

Figures

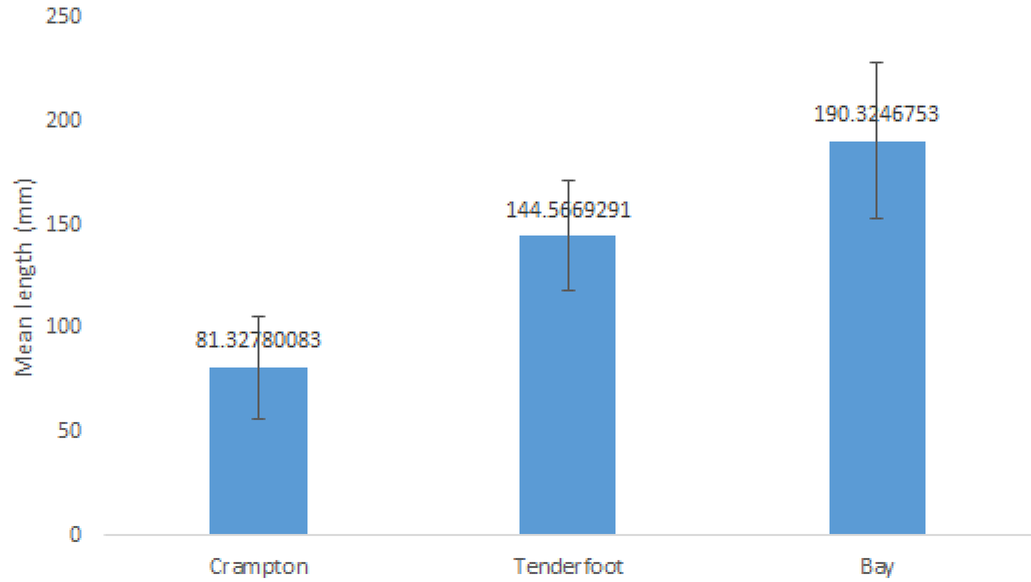

Figure 1. Mean lengths (mm) of bluegill in Crampton, Tenderfoot, and Bay lakes. Data was collected between June 1 and July 13, 2019. N(Crampton)=241, N (Tenderfoot)=127, N(Bay)=77.

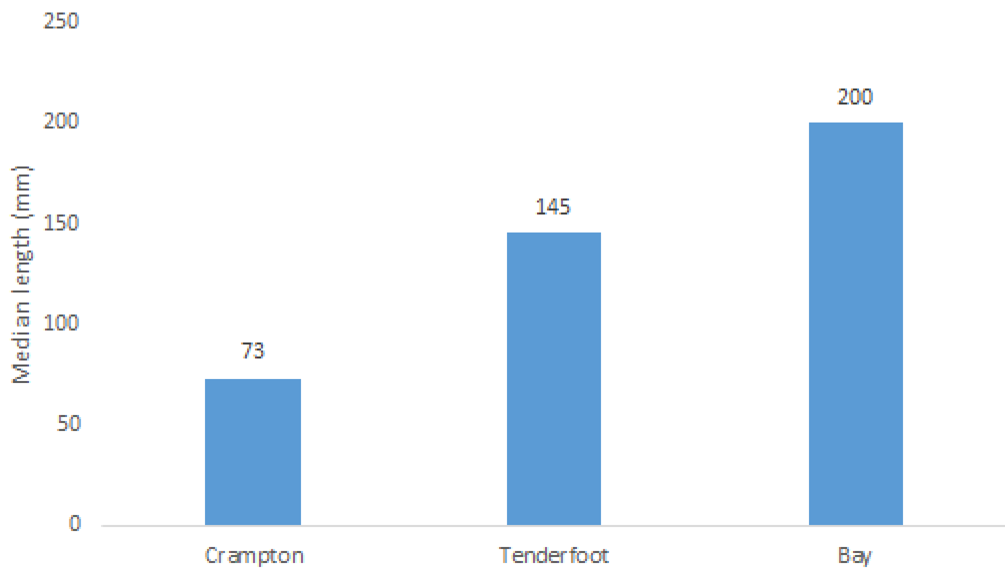

Figure 2. Median lengths (mm) of bluegill in Crampton, Tenderfoot, and Bay lakes. Data was collected between June 1 and July 13, 2019. N(Crampton)=241, N (Tenderfoot)=127, N(Bay)=77.

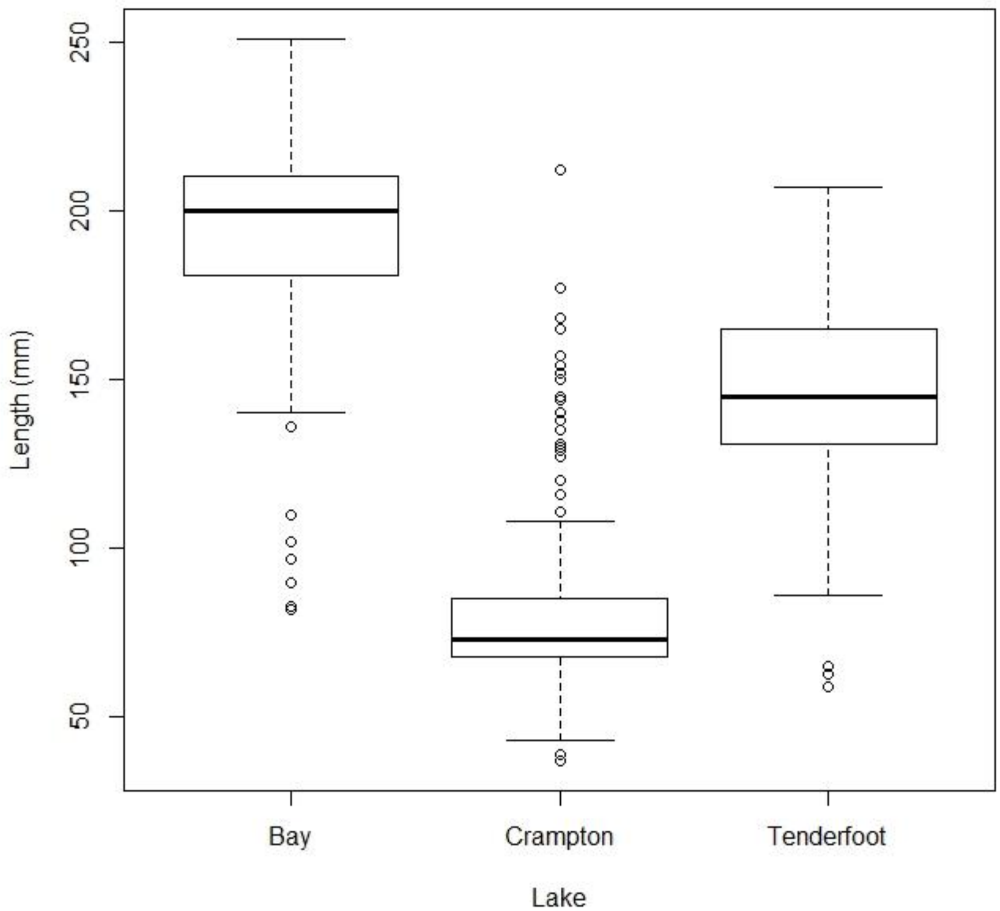

Figure 3. Boxplot of bluegill length (mm) from Crampton, Tenderfoot, and Bay lakes.

N(Crampton)= 241, N(Tenderfoot)=127, N(Bay)=77.

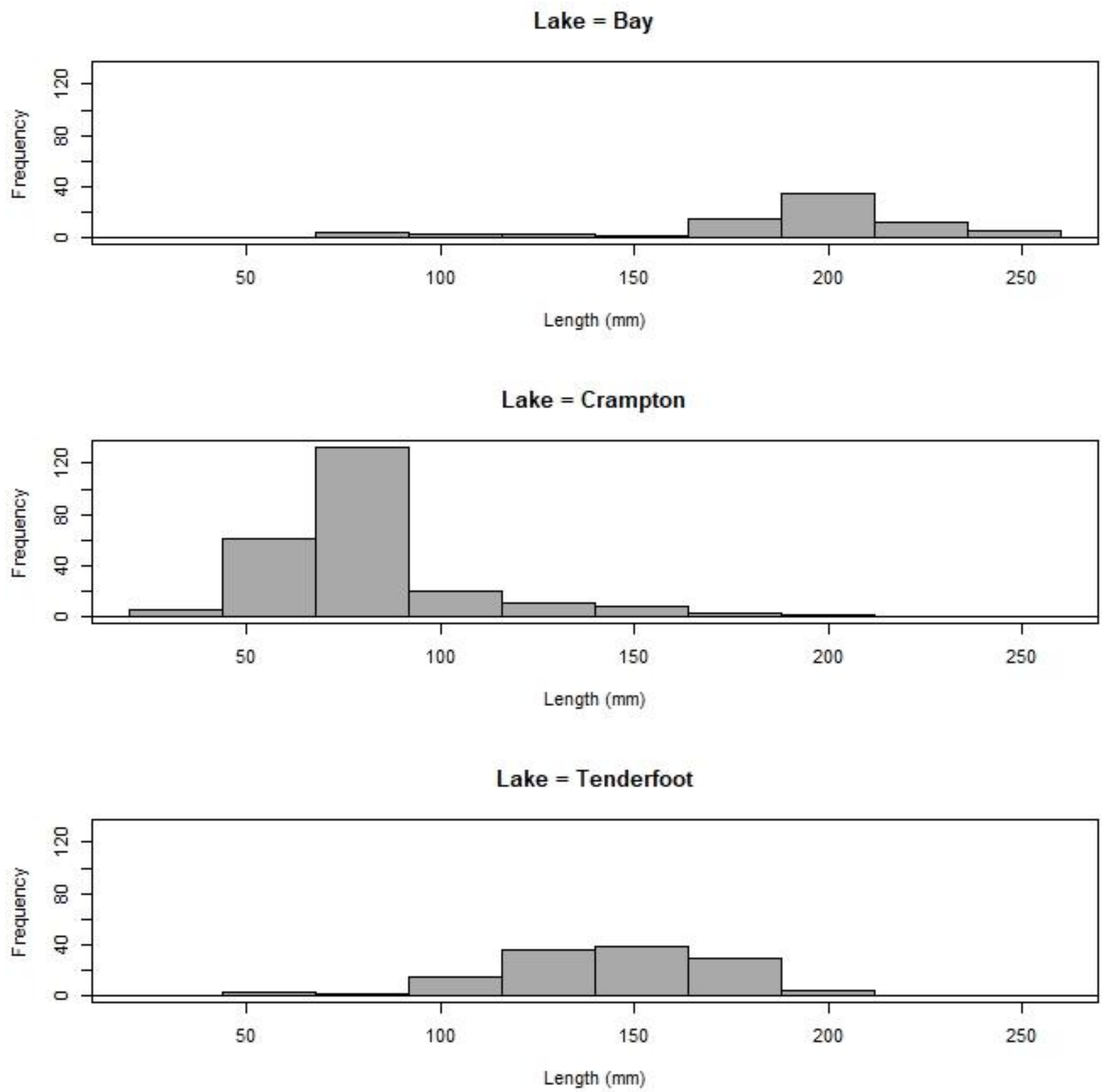

Figure 4. Histogram of bluegill length (mm) from Crampton, Tenderfoot, and Bay lakes.

N(Crampton)= 241, N(Tenderfoot)=127, N(Bay)=77.

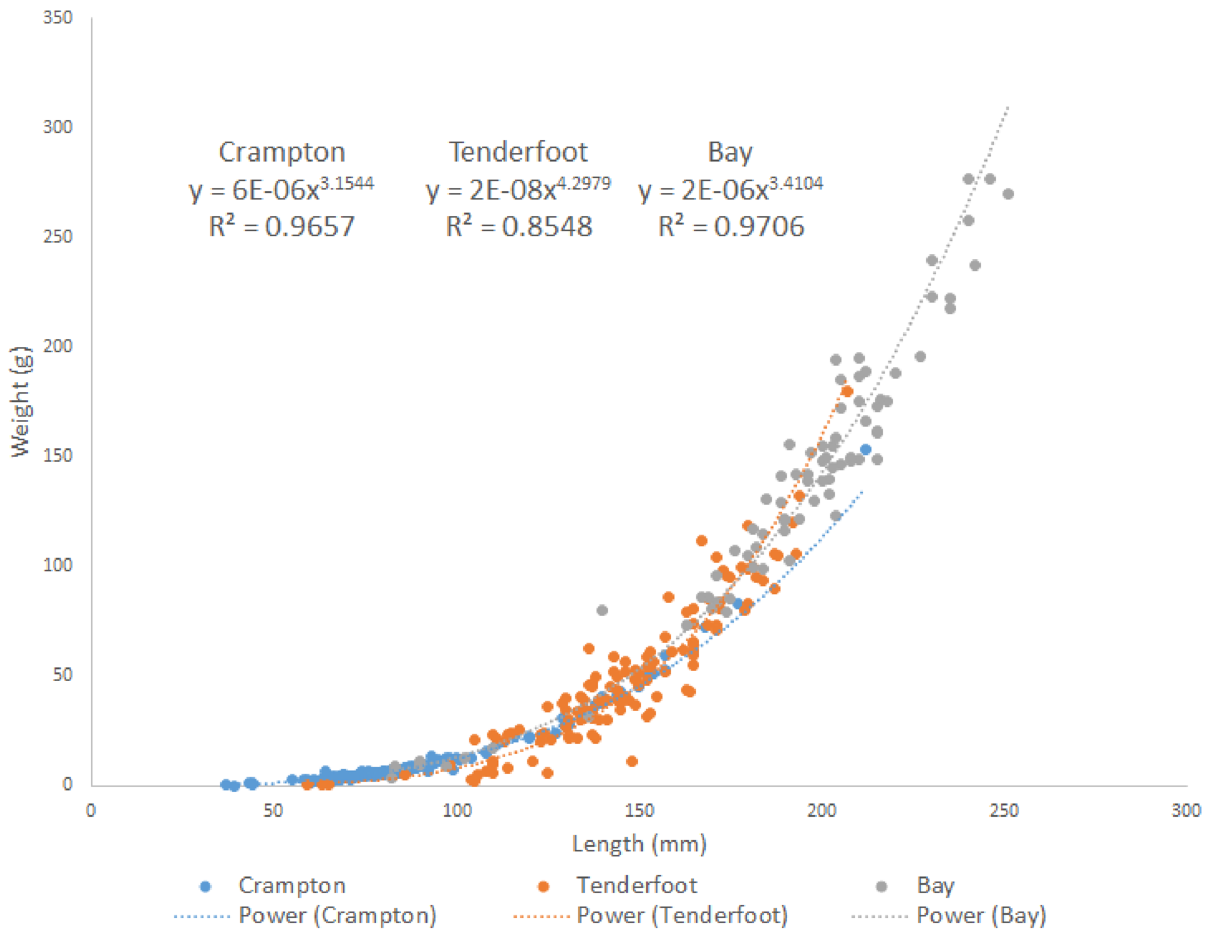

Figure 5. Scatterplot with trendlines depicting length (mm) and weight (g) of bluegill collected on Crampton, Tenderfoot, and Bay lakes. Data was collected between June 1 and July 13, 2019. N(Crampton)=241, N (Tenderfoot)=127, N(Bay)=77.

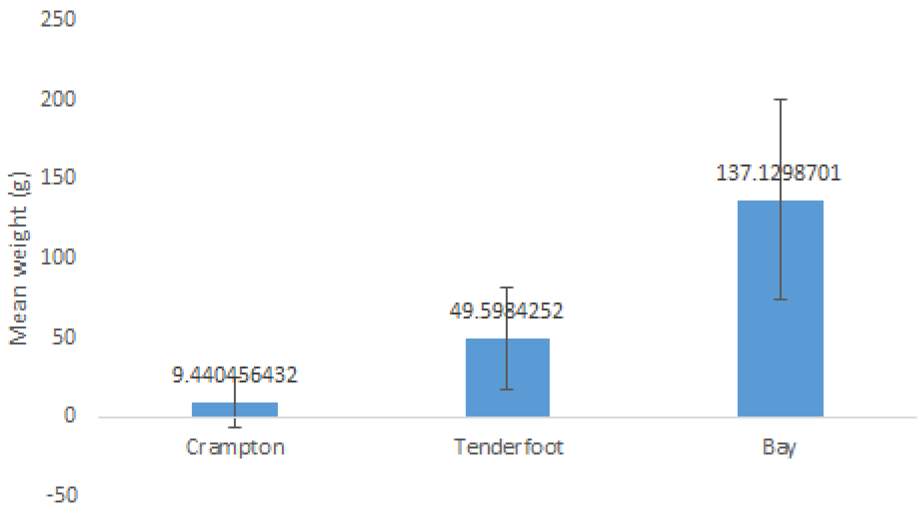

Figure 6. Mean weights (g) of bluegill in Crampton, Tenderfoot, and Bay lakes. Data was collected between June 1 and July 13, 2019. N(Crampton)=241, N (Tenderfoot)=127, N(Bay)=77.

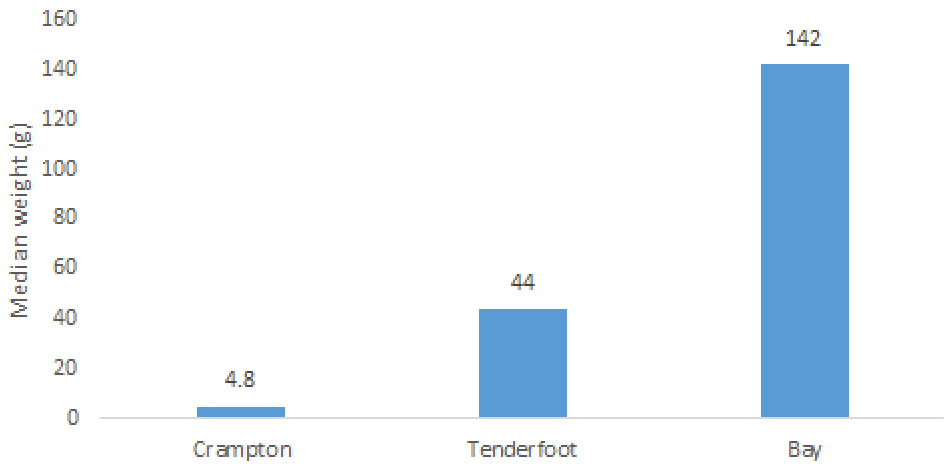

Figure 7. Median weights (g) of bluegill in Crampton, Tenderfoot, and Bay lakes. Data was collected between June 1 and July 13, 2019. N(Crampton)=241, N (Tenderfoot)=127, N(Bay)=77.

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