Crabbing Responsibly at Barnegat Bay (C.R.A.B.B.)

Survey Report

Submitted by the MATES CRABB Team:

<u>Class of 2020</u>
Emily Corcoran
Matthew Currie
Tyler Grant
Joseph Kim
Madison Linton
Melissa Restrepo
Mary Serviss

<u>Class of 2021</u>
Alessandro Barlotta
Molly Lada
John Philip Ostapovich
Lexi Pereira

Advisor: Dr. John Wnek
Correspondence: projectterrapin@gmail.com

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Center for Research and Applied Barnegat Bay Studies

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Abstract

"We used to be able to catch and keep more (blue) crabs in the past" is a comment that we received when discussing crabbing practices at Barnegat Bay, New Jersey. As a result of comments like this one, a team of 11 students at the Marine Academy of Technology and Environmental Science (MATES), Manahawkin, NJ in 2018 developed and implemented a survey to examine crabbing practices. The initiative Crabbing Responsibly at Barnegat Bay (CRABB) examined the knowledge of local recreational crabbers through a series of questions focusing on crab size regulations, locations, and economic aspects of crabbing. There was also a component of the project that focused on the perception of crabbing currently and future predictions. Of the approximately 1000 respondents, results were analyzed by gender, age, and municipality. Overall, there were a high percentage of individuals who did not know recreational crab size regulations and identification of crab sex. The survey also showed that recreational crabbing is important both economically and culturally at Barnegat Bay, NJ, but we need to conduct more education and outreach to ensure the viability of blue crabs.

Introduction

The Barnegat Bay Watershed is one of the most prominent and valuable ecosystems in New Jersey. Due to the constantly increasing population in Ocean County, tourism is also steadily increasing (Kauffman and Cruz-Ortiz 2012). Additionally, the economic value of the ecosystem is important because of its recreational, habitual, and touristic use. Some activities that occur throughout the Barnegat Bay Watershed include fishing, clamming, and crabbing. Crabbing in particular, is a prominent recreational and commercial activity in Barnegat Bay, responsible for nearly a third of all marine fishing in the state of New Jersey (Blue Claws 2018).

Some regulations that have been mandated for New Jersey blue crabbing include throwing back all egg carrying, female crabs, keeping only hard-shelled crabs measuring 4.5 inches (114 mm) in width (point-to-point) or larger, and removing crab pots after a certain amount of time (NJ Marine Digest 2019).

As with any recreational activity, the level of involvement can be based on recreational sales of crabbing gear to, actively, capturing crabs. Greater development is a result of people who want to be immersed in the coastal ecosystem, but contribute greater anthropogenic inputs, There is a high demand for housing and commercial businesses in the area (Cabrales, Racuyal, & Manoza 2015). Due to the constantly increasing population in Ocean County, tourism is also steadily increasing (Kauffman and Cruz-Ortiz 5). Additionally, the economic value of the ecosystem is important because of its recreational, habitual, and touristic use. With more people, comes a greater demand for resources; thus, if crabbing regulations are ignored the negative impact on future crab populations may reach a point that the species cannot recover. This would not only negatively impact the crabbing industry, but could impact the entire Barnegat Bay ecosystem. Therefore, it is critical that those who capture blue crabs are knowledgeable about regulations in New Jersey ("Blue Claws" 2018).

A plethora of equipment and baits are used when crabbing. According to the NJDEP Division of Fish and Wildlife bunker and chicken necks are the most popular baits used (2018). Other baits used for crabbing include any form of fresh fish or mollusks, such as razor clams. Equipment and methods used to crab are hand lines, crab traps, and crab pots. With this comes investment in crabbing as both a hobby and food source.

Crabbing Responsibly at Barnegat Bay, or C.R.A.B.B, is a team of students from the Marine Academy of Technology and Environmental Science (MATES) that was formed to survey local residents and those that crab at Barnegat Bay about their crabbing practices and perceptions in order to draw relationships between the past, present, and future trends in blue crabbing. The C.R.A.B.B. Team (referred to as "CRABB" throughout) will assess current recreational crabbing practices and analyze results to make conservation recommendations to help sustain blue crab populations, and the viability of crabbing practices. In 2006 and 2007, the New Jersey Department of Environmental Protection conducted a survey about blue crabs (NJDEP 2008). The outcomes of those survey years were an impetus for the CRABB Team survey that analyzes behaviors in recreational crabbing habits, as well as the general crabbing attitudes of the residents at Barnegat Bay, NJ. The results of the survey can help identify differences in attitudes and perceptions surrounding "crabbing", as well as crabbing practices in both 2006 and 2007, compared to 2019.

The Survey

With assistance from Ms. Lynette Lurig of the New Jersey Department of Environmental Protection and Mr. Christopher Claus of the Ocean County Parks Department, a survey consisting of 23 questions was compiled in both paper and electronic format. The C.R.A.B.B. Team first developed a survey consisting of questions (see appendix 1) chosen to gauge a participant's level of interest in crabbing, knowledge of state-imposed regulations, and crabbing practices and preferences. The survey was designed to reveal what equipment is most commonly used, which crabbing sites are most popular, and the general level of knowledge of crabbing regulations. The survey was developed as a paper and electronic format using "Google Forms", which was posted publicly through multiple social media outlets: Instagram ®, Reddit ®, and the Blue Crab Forum. A flyer (Figure 1) was developed in order to spread awareness of the ongoing survey and posted in popular areas and/or distributed during local functions (i.e, fishing club activities). The team also attended public events related to fishing, MATES outreach, and public programs with paper versions of the survey for people to complete on site. The goal was to reach 1,000 survey respondents in order to achieve enough data so that generalized, representative, and unbiased conclusions could be drawn (New Jersey Department of Environmental Protection 2008). The C.R.A.B.B. Team entered the completed surveys into an electronic data system which also contained the electronic version of the survey.

C.R.A.B.B.

***C**rabbing **R**esponsibly **A**t **B**arnegat **B**ay*

Do you enjoy recreational crabbing at the Barnegat Bay?

If so, please consider filling out a quick 5-10 minute survey about your crabbing habits!

Students at the Marine Academy of Technology and Environmental Science (MATES), Manahawkin, NJ, are conducting a research project centered around trends in recreational crabbing at the Barnegat Bay, as well as the future of crabbing.

To complete the survey, you can visit the web link below, or scan the code below using your mobile device!

https://goo.gl/forms/37gnXAtUN7dS7ueV2

For more information or assistance, you can contact the team by email: **projectterrapin@gmail.com**

Figure 1: The flyer used to describe the objective of the C.R.A.B.B. project, as well as how to access the survey online.

Our intention was to include commercial aspects into the survey; however, only the recreational crab surveys were used due to the sheer lack of the availability of commercial crabbers taking the survey. The focus of the project moved toward the recreational aspects of crabbing. Some of the questions on the recreational survey ranged from age and gender questions to economic aspects of crabbing per year, and questions about practices and knowledge of crabbing regulations.

Survey Distribution

Paper surveys were conducted at various crabbing locations throughout the spring and summer 2019. The survey was distributed at multiple events throughout the Barnegat Bay Watershed area throughout the year at some of the following events: MATES Open House, Island Beach State Park (multiple events throughout the year), NJ Wildlife Expo, Chowderfest at Long Beach Island, as well as in various online locations: the Blue Crab Forum, Instagram ® , Facebook (r), and Reddit ®. We also advertised the survey at local crabbing docks, and crabbing supply businesses.

Specific Survey Distribution Venues

Surveys were distributed at Jenkinson's Turtle Appreciation Day on April 27, Walk for Turtles on May 11 at John C. Bartlett Jr. Park (Berkeley Island Park), Ocean Fun Day on May 18 at Island Beach State Park, Island Beach State Park - School Hatchling Release on May 31, Sedge Island Marine Conservation Zone Day on June 15 at Island Beach State Park, Bunker Challenge Crabbing Contest at Traders' Cove Park on July 20, B, Barnegat Bay Day at the LBI Foundation on July 11, NJ WildExpo at Collier's Mill in Jackson on September 7, Island Beach State Park Beach Plum Festival on September 8, as well as Chowderfest on October 6.

Survey Overview

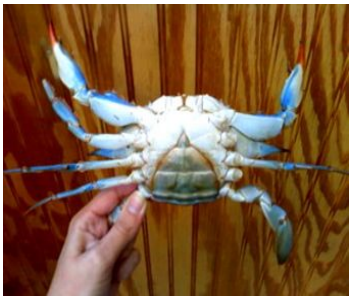
After all 1,024 responses were collected, survey responses were analyzed ranging from understanding of blue crab size regulations, to identification of crab gender. Some of the questions included "correct" and "incorrect" responses, as the goal was to limit subjectivity in responses (see Appendix 1). Along with the raw data collected, we allowed for comments, which we were able to separate into basic categories based on the subject matter. Comments deemed to be "negative" included responses relating to the lack of availability of crabs, the general decrease in the population of crabs over the years, the lack of interest in crabbing and lack of knowledge of the crabbing regulations by the general public (most notably with the younger generation). If there was a negative response regarding the environment such as "pollution", this was also noted. Comments deemed to be "positive" were essentially the opposites of the aforementioned comments, including those that related to increases in the crab populations, increases in the interest in crabbing in the general public, knowledge of crabbing regulations, and improving environmental conditions along with a general environmental awareness by crabbers. Comments considered "neutral" were categorized as those that showed "no differences" between past and present crabbing practices, and comments in the not-applicable ("N/A") category. Other neutral responses included those that "did not know" if there were any differences in crabbing over the years, those that did not specify the differences, those that did not answer the question, or those that submitted an inappropriate response.

Analysis

We focused on the following categories of responses as they were the most appropriate for blue crab conservation and practices at Barnegat Bay as well as economic and general comments related to crabbing practice…

A. **Minimal recreational size regulation of blue crabs (overall responses, age and gender)**

B. **Identification of the survey photo for sex of blue crab (Figure 2 below, mature female blue crab by respondents' age and gender)**



C. **Crabbing likelihood and crabbing platforms (places to crab)**

D. **Economic aspects of crabbing, equipment, bait and travel time to crabbing locations**

E. **Investment in crabbing (see explanation below)**

F. **Age of crabbers and crabbing equipment**

G. **Overall comments (positive and negative)**

Data was reported as percentages and raw participant values. Statistical analyses were performed using an ANOVA with an alpha of 0.05 or less dependent on the survey results.

Investment in crabbing calculations (explanation)

The responses of a subset of the survey population, those determined to have a "higher demonstrated interest in crabbing", were analyzed by using the following classification based upon the frequency respondents reported crabbing: 5 times or less per season being "less-invested" crabbers, which were considered "casual crabbers". Since a question about the amount of money invested in crabbing was recorded in ranges, the middle of the ranges chosen was used for statistical analysis. In terms of the respondents' knowledge of crabbing regulations, a score of 0, 1, or 2 was assigned for each response to quantify a respondent's knowledge of regulations, which was based on correct identification of the female blue crab (visual survey question) and the minimum capture size regulation of 4.5" for hard crabs (point to point). Scatterplots were created to demonstrate potential trends found after using a linear regression analysis. The results were reported as "highly invested crabbers" versus "casual crabbers" and assigned a knowledge score that was an average per participant per municipality.

Results

There were 1024 surveys that were analyzed with varying responses to questions as some were left unanswered. Results were reported based on answered questions which will be reported as those areas of the survey most pertinent to blue crab regulations with the greatest impact on conservation. Results are reported by survey age distribution, gender and/or residents living within or outside the Barnegat Bay watershed.

Table 1: Age distribution of responses that included the percentage of respondents who properly identified the correct gender of the blue crab in the survey (n=1006) and the percentage of respondents (n=785)who selected the correct minimum size requirement for a regulation recreational blue crab in New Jersey.

Age Range	Correct Response Percentage Crab Sex (n=1006)	Correct Response Percentage Crab Regulation Size (n=785)
< 18	**61.6**	**18.2**
18 - 29	**65.8**	**36.5**
30 - 39	**82.0**	**49.3**
40 - 49	**75.6**	**36.1**
50 - 59	**73.9**	**41.7**
60 - 69	**78.2**	**37.7**
70 - 79	**87.8**	**55.3**
80 - 89*	**85.7**	**66.7**
90 and above*	**100**	**NR**

*Low number of responses in this age group

Blue crab recreational, minimal size for "keeper" crabs

Based on the overall responses (1024) there were a high number of people who responded that there is "no regulation size (Figure 3). However, there was an equal distribution of people who responded with regulation sizes above and below the current 4.5" (114 mm) minimum size to keep blue crabs. A majority did know the regulation size, but there were a good number of respondents who knew there was a regulation size, but didn't know what it was (Figure 3). There was a positive correlation between the age of survey participants and the percentage of the age group who were able to correctly state the legal size of a keeper crab in New Jersey (Figure 4), 4.5 inches . In the under 18 category, 18.2 % of respondents correctly and 66.7% in the 80 - 89 year age group (ANOVA, $p < 0.0001$; Table 1).

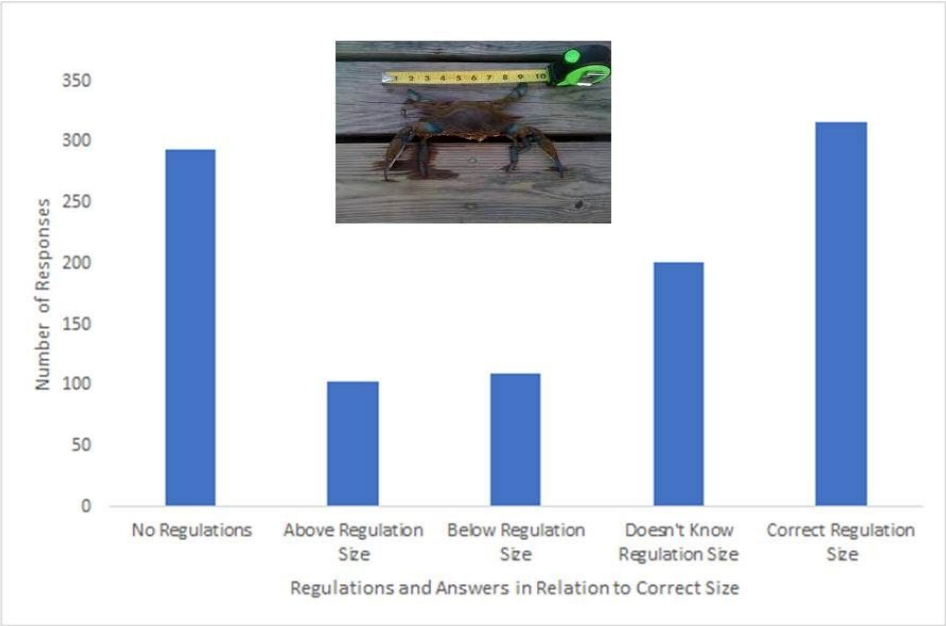


Figure 3. Raw number of responses to the regulation keep size for recreational blue crabs in New Jersey based on the survey responses (n=1024).

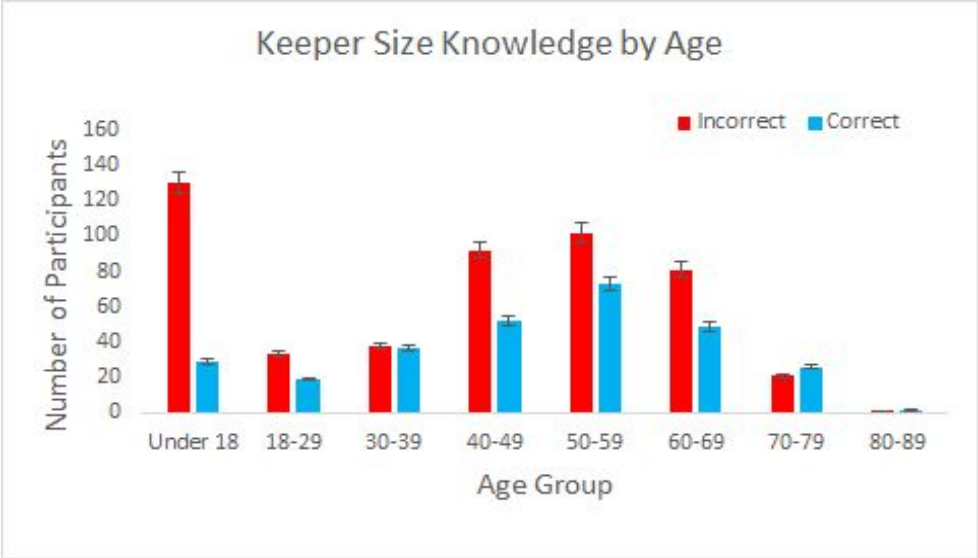


Figure 4. Breakdown on age distribution on the knowledge of the minimal blue crab capture size regulation (4.5 inches or 114 mm; n=785).

Blue crab sex determination responses

The total number of participants who responded to the "sex determination" question are displayed below (Figure 5). There was a positive correlation between the age of the survey participants and both the percentage of the age group who were able to correctly identify the sex of the female crab shown in the photograph in the survey (Figure 6). The correct response ranges were 61.6% (under 18) to 100% (90 year and older; Table 1).

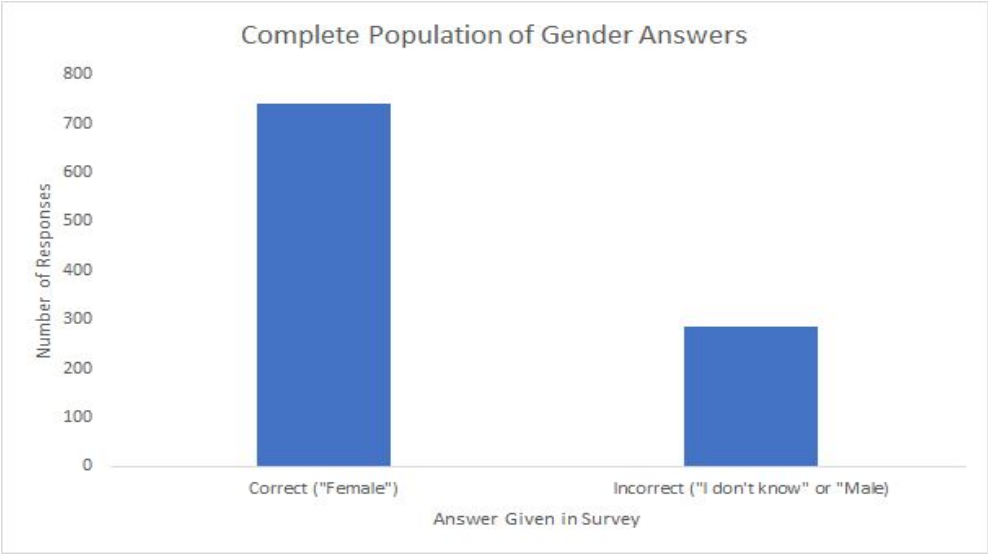


Figure 5. Total survey responses (n=1006) identifying the correct gender of the mature female blue crab (Figure 2). "Male" or "I don't know" responses were grouped as "incorrect".

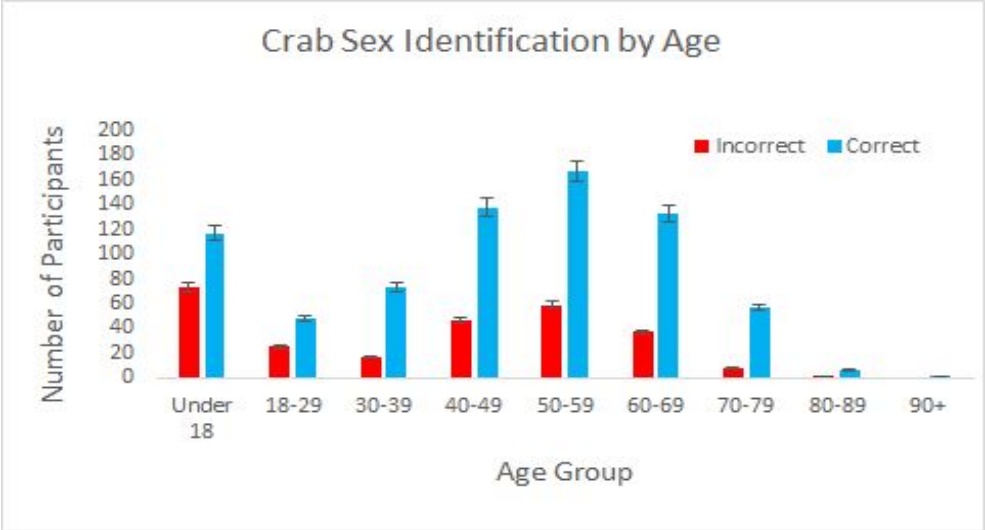


Figure 6. Number of participants (n=1006) in age categories with correct versus incorrect responses for the gender of the pictured female blue crab in the survey.

In terms of survey responses by gender, male respondents were more likely to select the correct response (~80%) as compared to female respondents (~70%). However, females were more likely to respond to the "did not know" option approximately twice as much as male respondents (Figure 7).

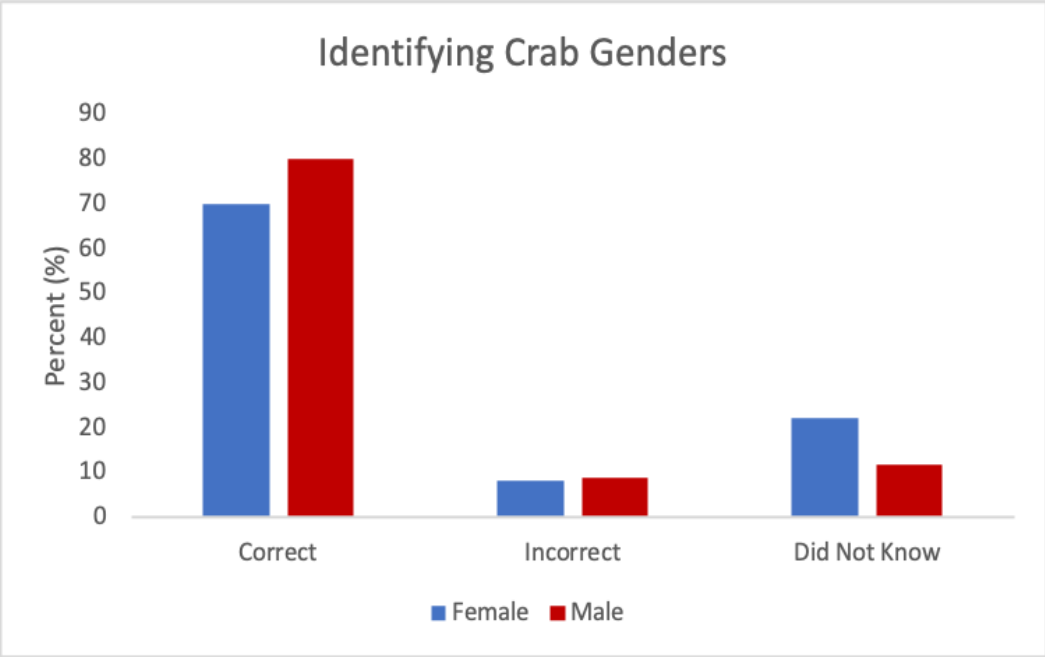


Figure 7. When determining the gender of the mature female blue crab, males were more likely to select the correct response as compared to females. However, females were more likely to respond to the "did not know" option (female n=554, male = 447).

Crabbing likelihood and crabbing platforms

This analysis of frequency of crabbing shows that females are more likely to crab 1 to 2 times a season whereas males crab 3 to 5 times a season (Figure 8). A majority of the responses were between 1 and 5 times per year based on the 1024 survey results. When surveying about the actual crabbing areas used, both males and females used docks as their primary crabbing location with females preferring it more than men. Boats were the second- most popular crabbing platform. Other responses included responses that we could not discern a crabbing practice.

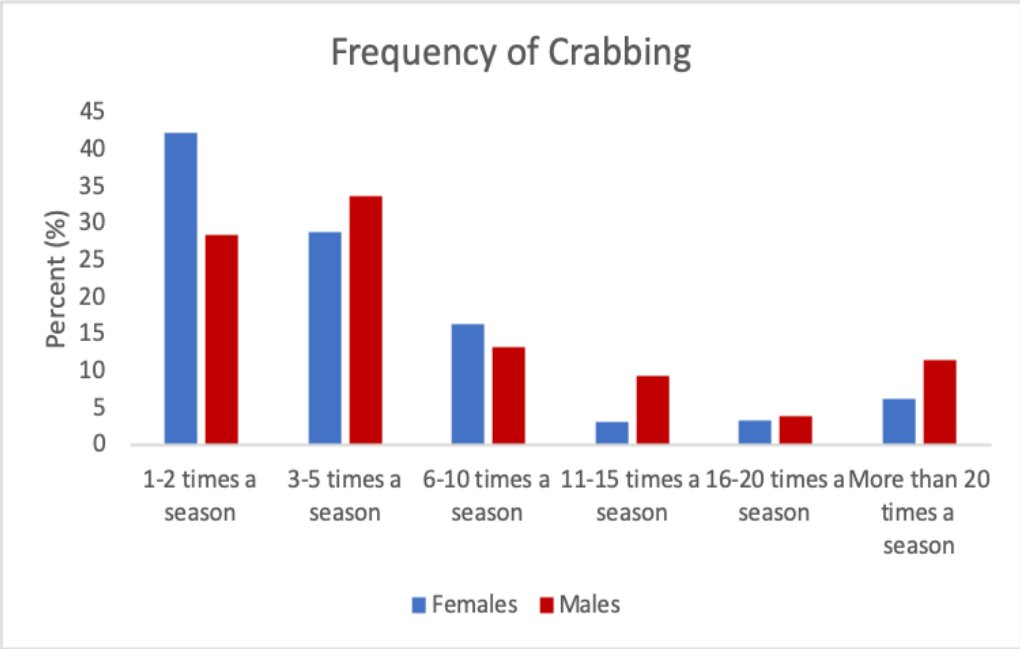


Figure 8. Responses based on frequency of crabbing each year based on the survey survey total (n=1024).

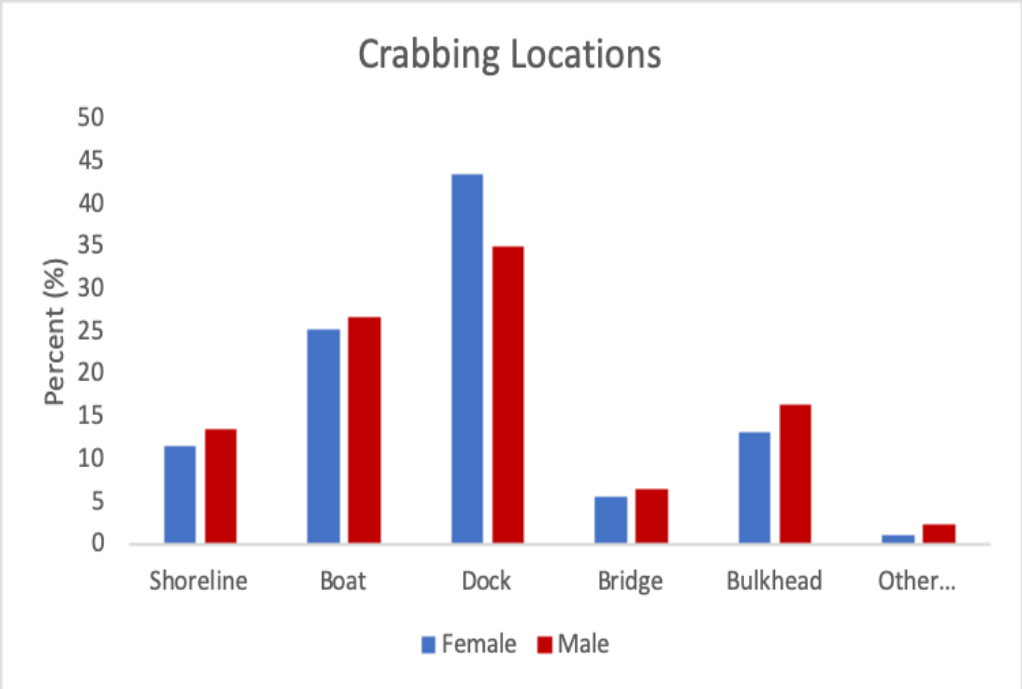


Figure 9. A higher percentage of all respondents prefer to crab along docks and aboard boats (female n=554, male = 447).

Economic aspects of crabbing, equipment, bait and crabbing locations

The total money reported invested in crabbing was $94,352.50 annually by our survey respondents (n=959; Figure 10). The areas that spent the most money annually on crabbing according to the survey were Ocean Township, Lavalette, and outside Ocean County with investments averaging $87.50, $74.61, and $65.28, respectively. In contrast, the areas that reported spending the least on crabbing per respondent per year, on average, were Eagleswood, Mantoloking, and Bay Head with values of $2.50, $24.17, and $25.00 (Figure 11).

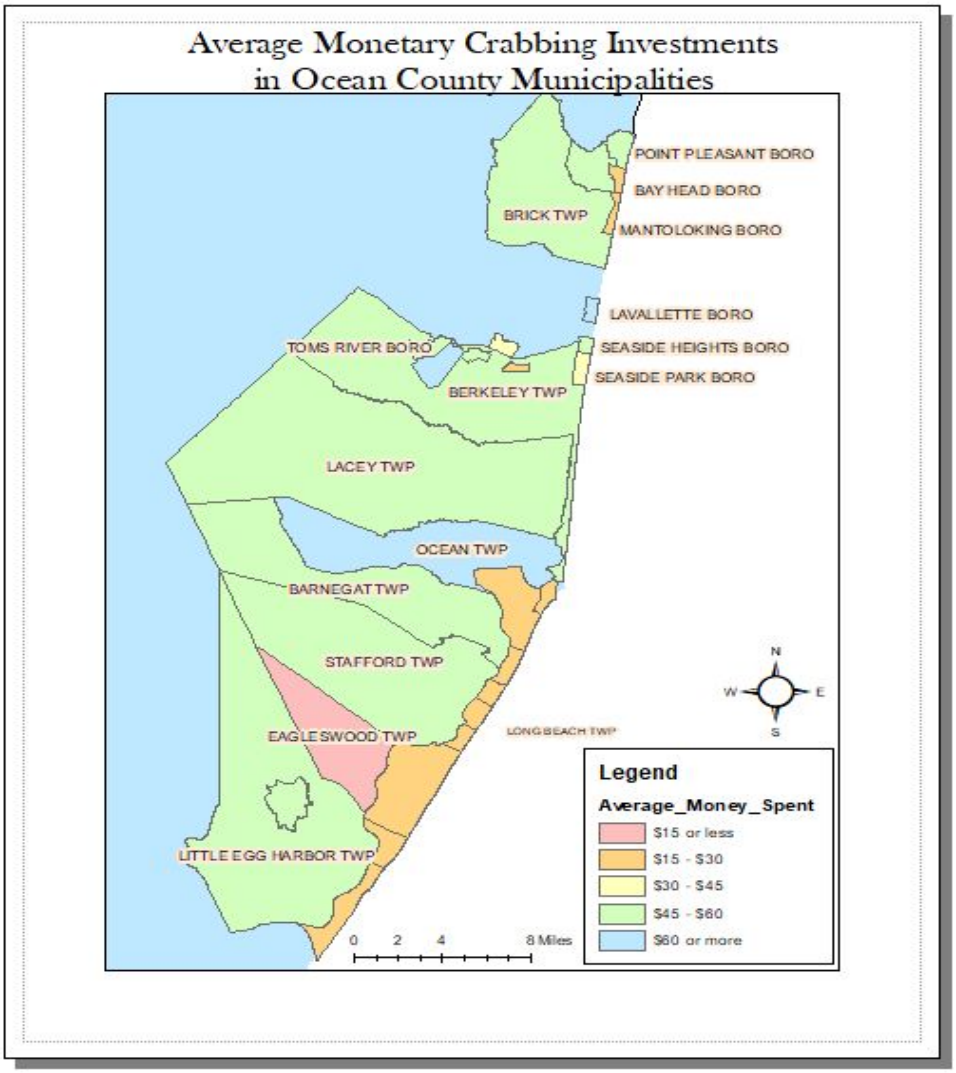


Figure 10. Overall distribution map of money spent by respondents per municipality per year (*map created by Mary Serviss)*.

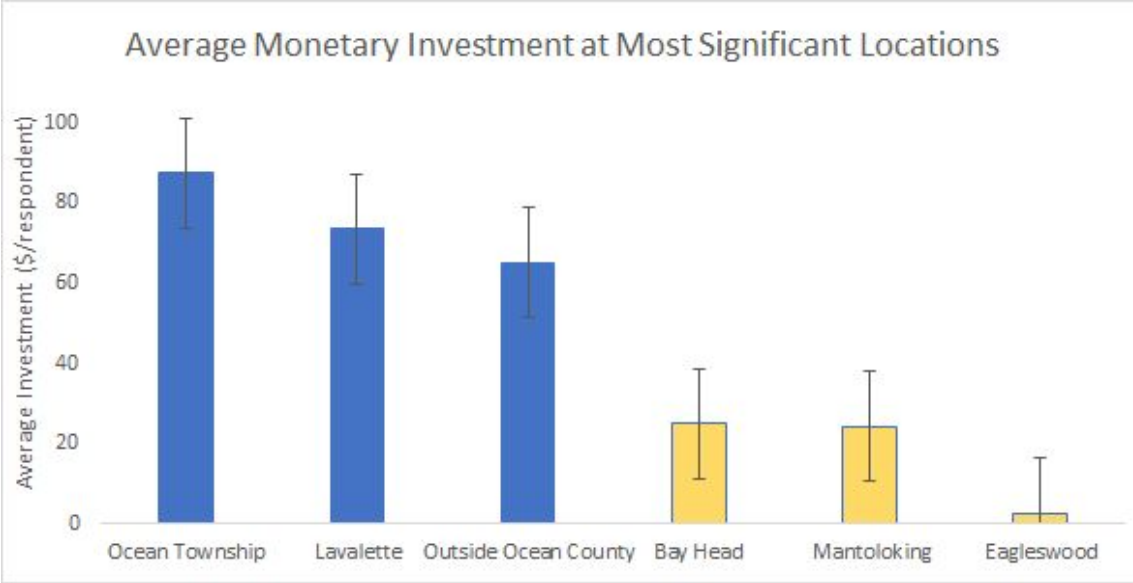


Figure 11: The top three (blue) and bottom three locations (yellow) in terms of amount of money spent on crabbing annually are compared (n=959; error ± 5%).

The equipment used to crab included hand lines with dip nets, crab traps (collapsible) and crab pots (overnight crab pots sometimes called Maryland traps). Overall, there was a consistent trend amongst the age groups in terms of recreational capture methods (Figure 12). We did not include a category for "scaping" which is net-only capture in vegetated areas.

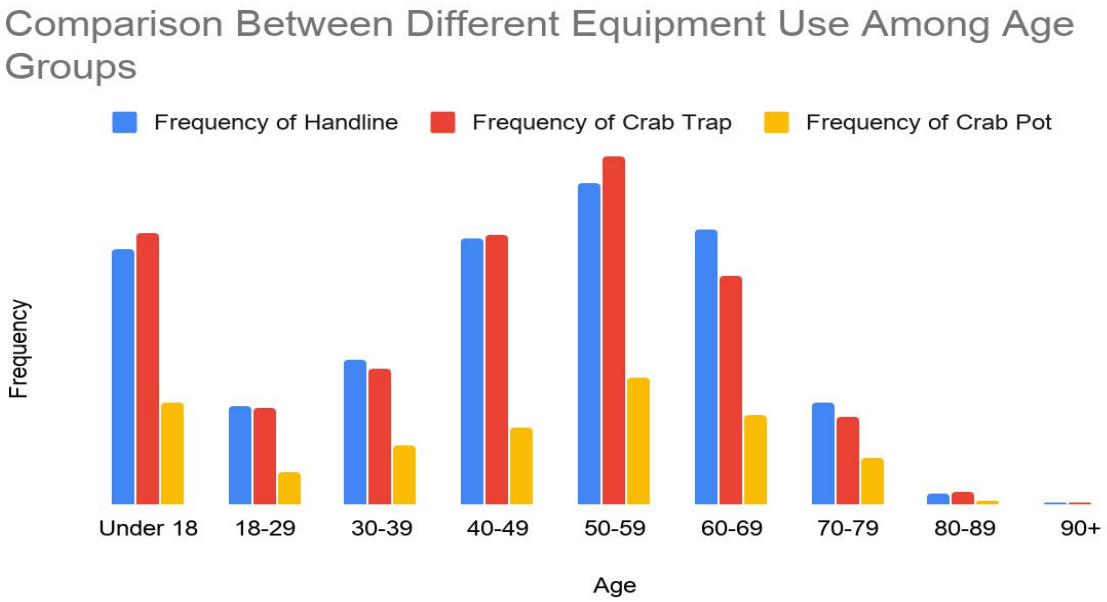


Figure 12. Frequency (number of responses) of age groups using hand lines (blue), crab traps (red) and crab pots (yellow). Results indicate that crab traps and hand lines were not different, but crab pots were used significantly less.

Bait was reported as fish (including Atlantic Menhaden - bunker) and chicken and other meat. The results indicate that bunker and fish were used slightly more often than chicken or meat (~39% versus ~34%). Also there were a number of respondents who used a combination of crab baits. Some reported that they used "razor clams" as a bait that fell under "meat" (Figure 13).

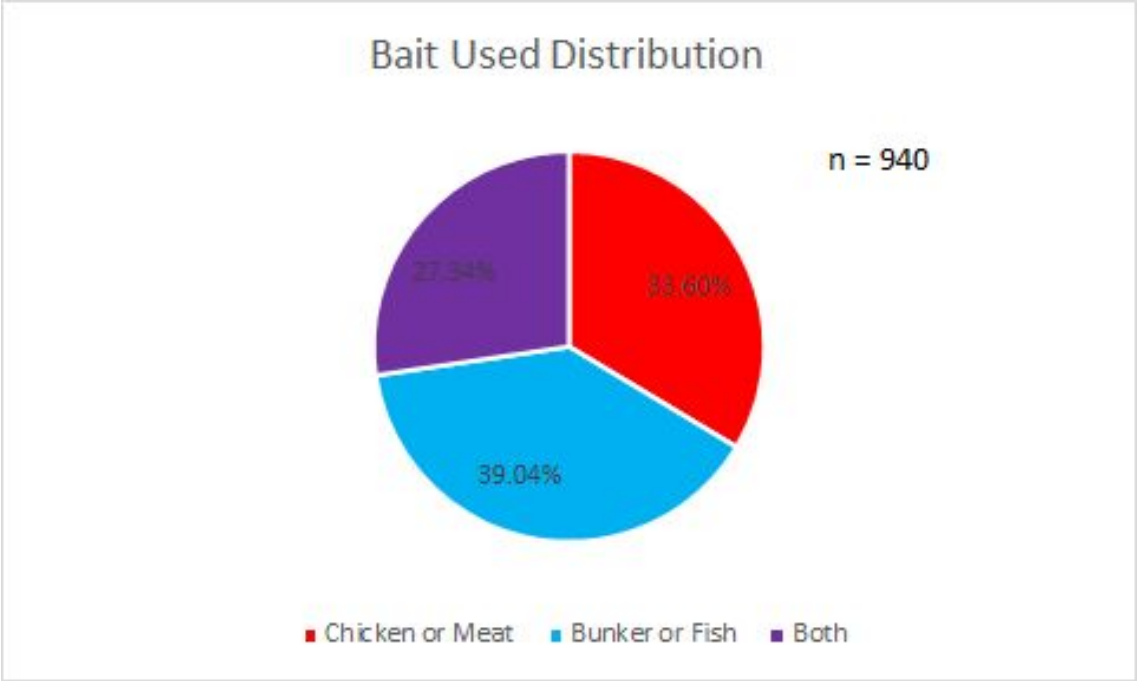


Figure 13. Bait used categorized as bunker/fish (light blue), chicken or meat (red) or both bait types (purple). There were no differences in the bait types used.

Travel time to crabbing locations ranged between <10 minutes and greater than 2 hours, which was broken down by gender. There were no differences between genders in terms of responses; however there were significant differences between the times that respondents traveled to crabbing locations ($P<0.05$) with the <10 minutes option being selected most often and 10 - 20 minute being selected next. However, we were not able to delineate between those that may have included their travel to stay at the shore and not the actual time from where they were staying to actually go crabbing. We estimate that some respondents travel great distances for a "day trip" to crab, but cannot account for 2 or more hours as accurate for a crabbing outing (Figure 14).

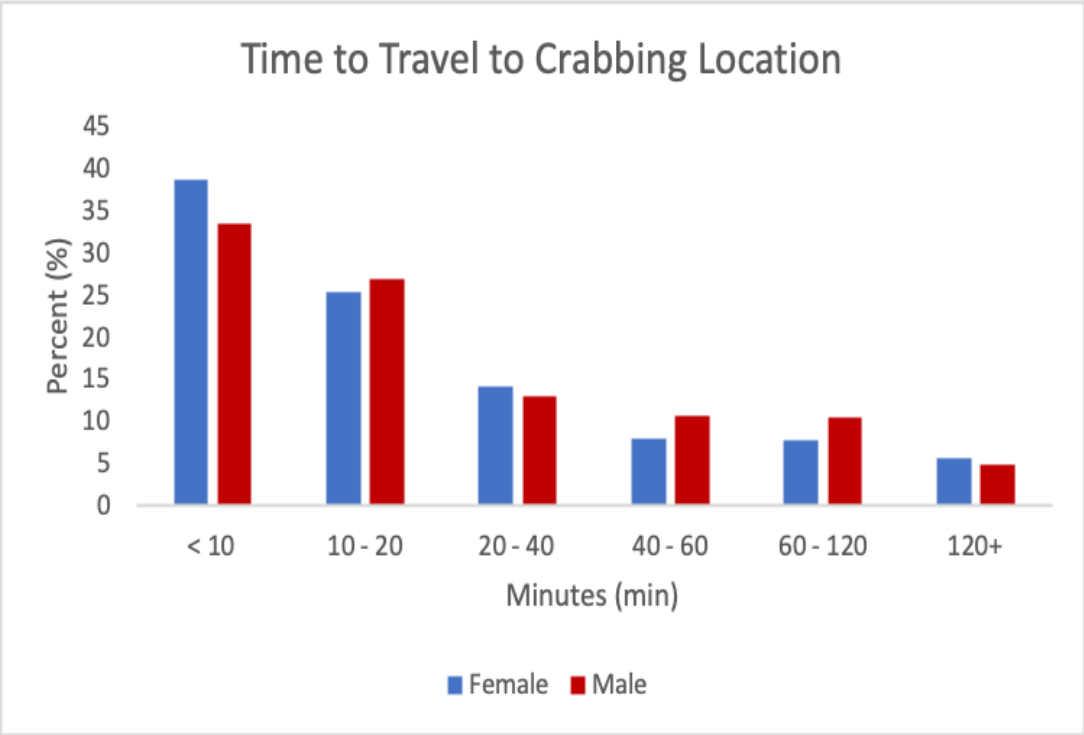


Figure 14. Female respondents chose to crab more often within a 10 minute travel time over males, but slightly more males were more likely to travel within 20 minutes than females to crabbing locations (female n=554, male = 447).

Knowledge and investment in crabbing

Once separated into categories, there were a total of 268 crabbers that qualified as "highly invested" and 462 that qualified as "not highly invested" or "casual crabbers" (total 730). Other respondents may not have given enough suitable answers that could be used to judge either way. The areas with the most knowledgeable crabbers that demonstrated high investment are Mantoloking (score of 2), "outside Ocean County" (score of 1.83), and Island Heights (score of 1.75). The least knowledgeable areas from which high interest crabbers originated are Seaside Park (score of 1.25), Waretown (score of 1), and Point Pleasant (score of 1) (Figure 15). For the casual crabbers data, the most knowledgeable crabbers come from Waretown (score of 2), Pine Beach (score of 2), and Ocean Gate (score of 1.5). In contrast, the least knowledgeable come from Lavallette (score of 0), Manasquan (score of 0), and outside Ocean County (score of 0.85) (Figure 16). Overall, respondents labeled highly invested crabbers had a total knowledge score of 72.5%. Respondents in the more casual crabbing category received a knowledge score of 54.4% when standardized and compared with each other.

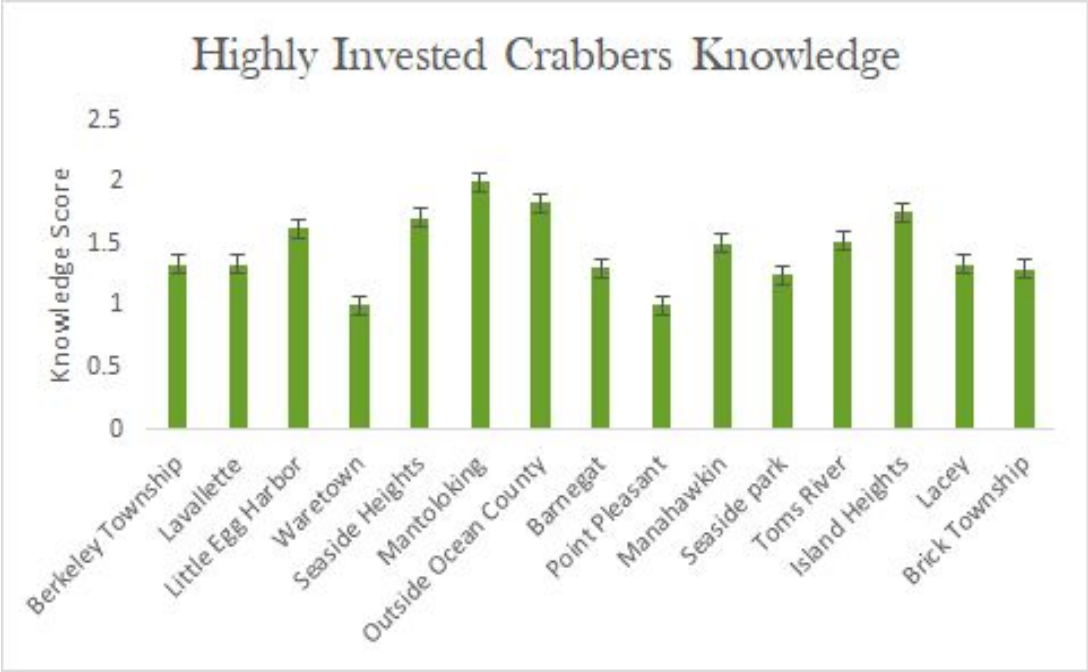


Figure 15. Average knowledge score for those "highly invested" in crabbing by location (n=268, +/- 5% error). Mantoloking had the highest score.

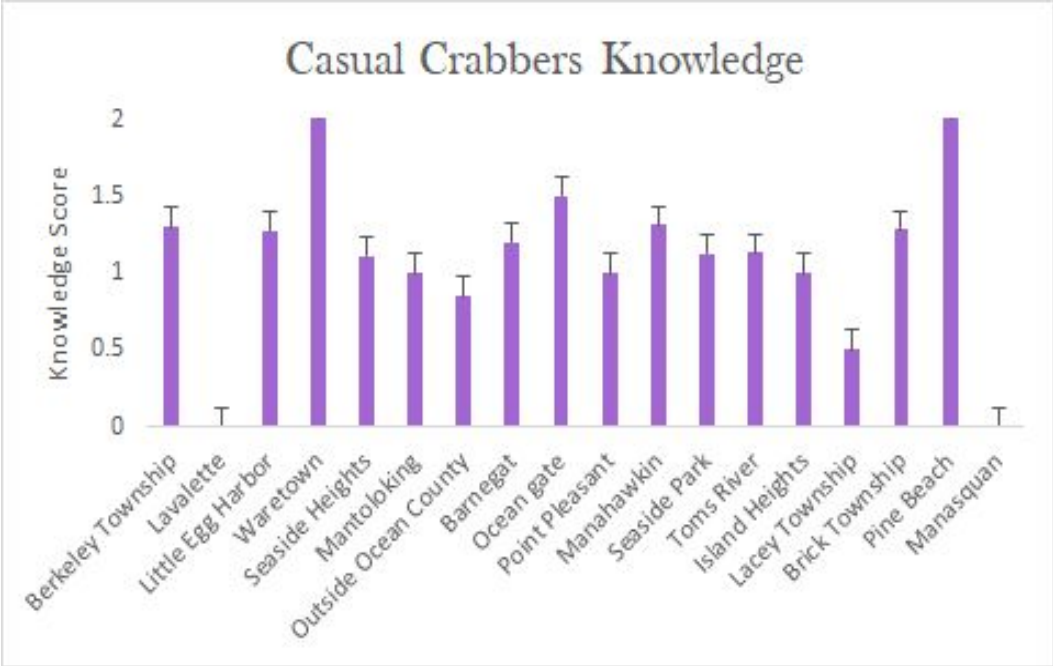


Figure 16. Average knowledge score for those "casual crabbers" by location (n=462, +/- 5% error). Waretown and Pine Beach had the highest scores.

Age of crabbers and crabbing equipment used

Seemingly, among all age groups the handline was the most popular and the crab pot was the least popular. This could be due to the pure simplicity of the handline compared to other methods. Crab pots are typically left overnight, requiring commitment to the activity, in which not many crabbers have, especially within the younger generations. As time persists, generational gaps grow larger, therefore impacting the manner in which society performs. It is shown that older age groups tend to prefer to use handlines; while, younger age groups tend to prefer crab traps (Figure 17). Crab traps are typically more convenient to catch crabs, catering to the young; handlines are more time-consuming and necessitate focus.

Interestingly enough, within the worldwide population of crabbers, crab pots are the most popular (Figs. 18 - 20), yet the results of this survey suggest that crab pots are the least preferred ("Crabbing For Hard Shell Crabs" 2018). This could be attributed to the area that the survey was conducted in and the availability of crab pots versus other methods of crabbing. The use of equipment could have been better based upon the location of crabbing, as different townships offer different settings.

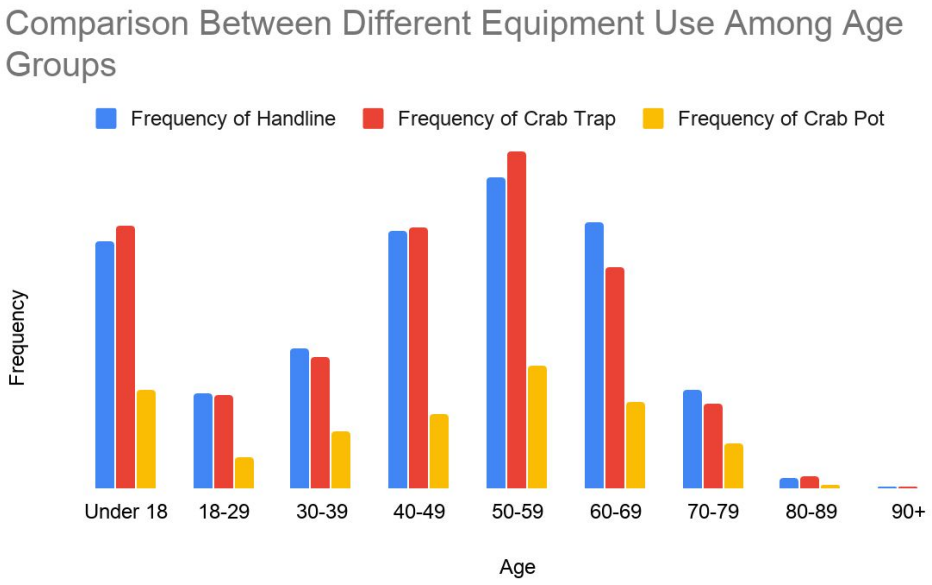


Figure 17: The bar graph demonstrates the comparison between the use of handlines, crab traps, and crab pots among each age group that responded in the C.R.A.B.B. survey.

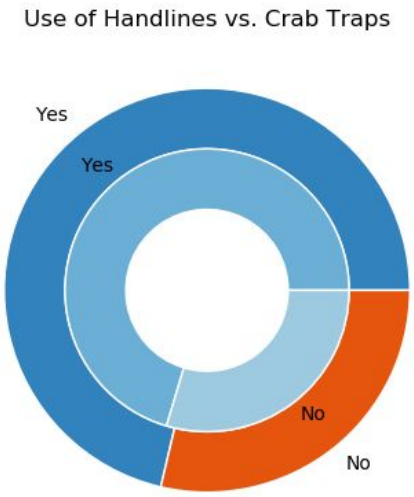


Figure 18: The doughnut chart demonstrates the comparison between the use of handlines (outer circle) and crab traps (inner circle) within the entire population of respondents of the C.R.A.B.B. survey.

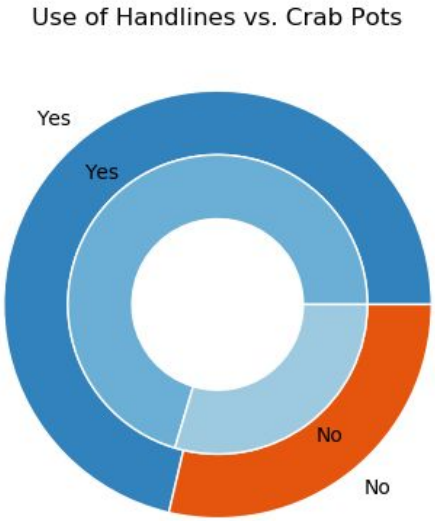


Figure 19: The doughnut chart demonstrates the comparison between the use of handlines (outer circle) and crab pots (inner circle) within the entire population of respondents of the C.R.A.B.B. survey.

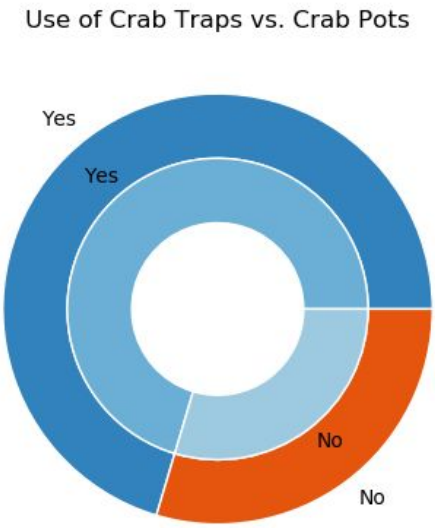


Figure 20: The doughnut chart demonstrates the comparison between the use of crab traps (outer circle) and crab pots (inner circle) within the entire population of respondents of the C.R.A.B.B. survey.

Overall Survey Comments

We received 1024 surveys to analyze and a goal was to determine perceptions in crabbing. Overall, there were a total of 434 negative comments, 94 positive, 164 neutral or no change, and 359 which people completely didn't answer or the answers didn't pertain to the question. One of the questions, "Do you think crabbing has changed over time? If so, how? Specifically, in terms of the quality of crabbing or people's general interest in crabbing?" provided the following feedback (Figure 21).

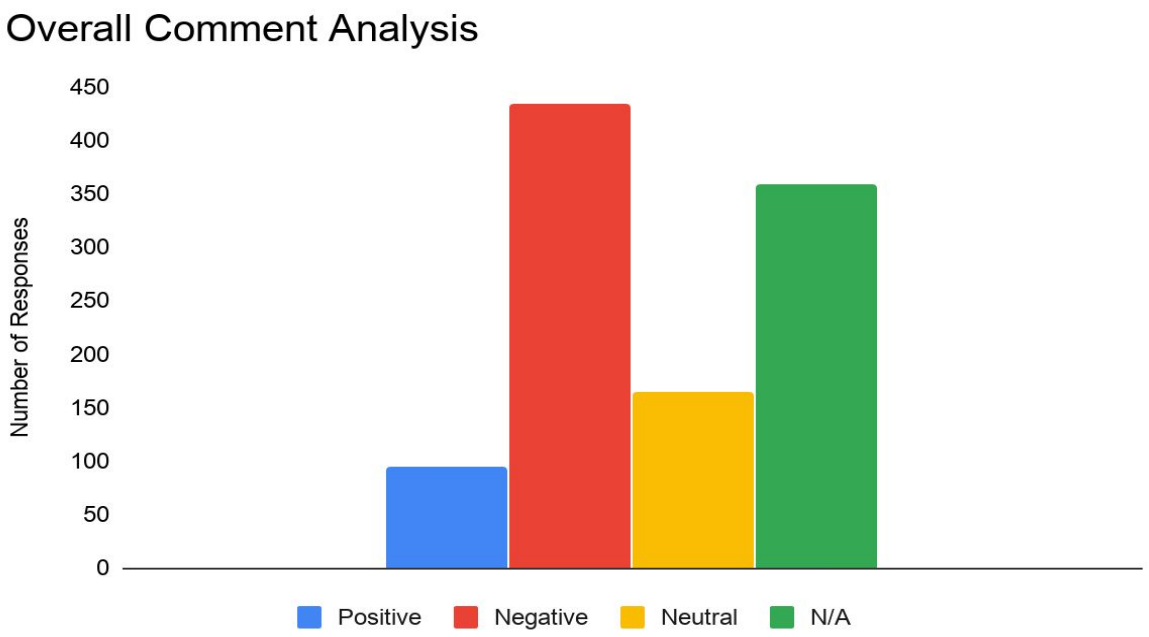


Figure 21. There was a significantly higher overall negative perception of changes in crabbing over time (n=1024). Not applicable were those that did not respond as they may have had limited crabbing experience.

In terms of the responses, we assessed the areas that the survey respondents focused their outlooks including the crabbing regulations, their level of continued interest, the crab population itself, the environment and other responses that did not fit within a category (other). We presented the data on scales relative to the number of total respondents for each category. For the positive responses, the interest was provided the greatest result (i.e., "crabbing is a fun activity") and the environmental factors were less of a focus. The number of crabs and regulations were looked upon equally and favorably (~20 respondents for each; Figure 22).

In terms of negative aspects of crabbing, equipment was a concern for some of the respondents and added as a category, whereas there were too few responses on the positive survey outcomes to categorize it. For the negative survey results, blue crabs were the greatest concern (future populations and sizes). To note, some of the responses include people's concern about those that are taking non-regulation sizes (Figure 23).

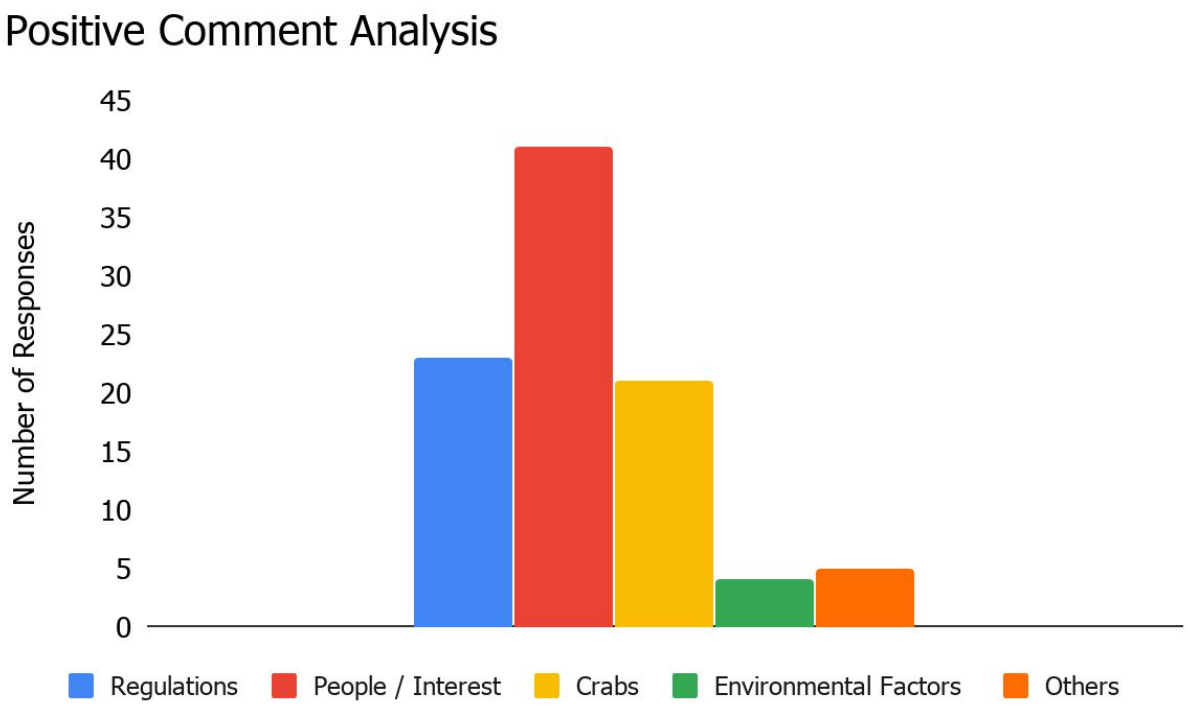


Figure 22. Actual number of respondents with positive comments (n=94), categorized (please note the scale). People and interest were the most favorable aspect of recreational crabbing.

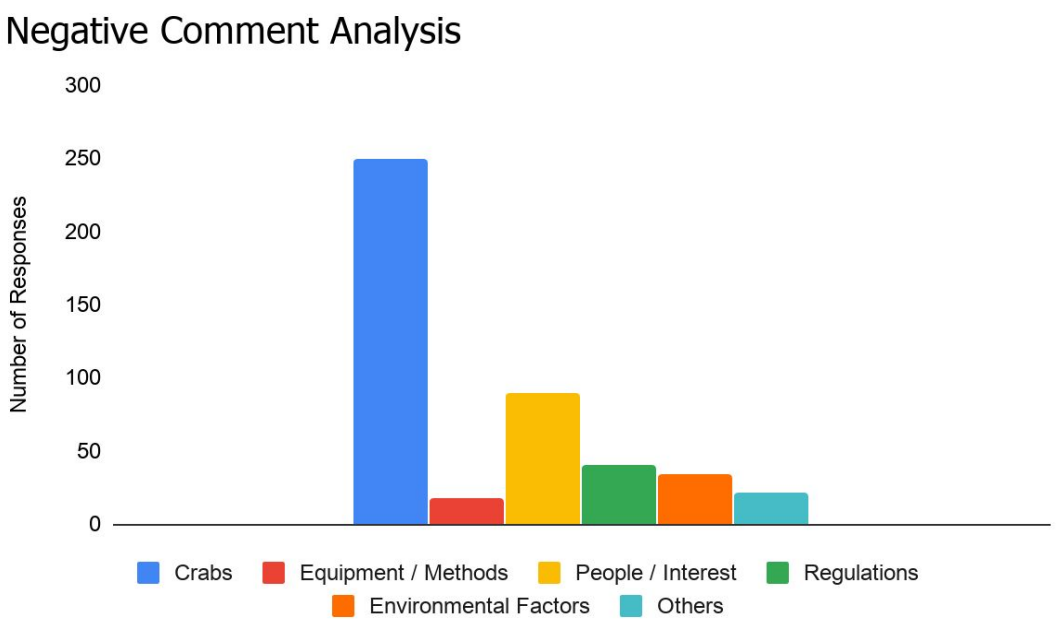


Figure 23. Actual number of respondents with negative comments (n=434), categorized (please note the scale). Future crab captures and lack of regulation size crabs (~250 respondents) were some of the negative comments. Also, interest (~100 responses) is a concern for the future.

The overall trend in the survey data between those that used their identity and those that were anonymous were similar (no statistical difference, showing those using their identity, Figure 24). We wanted to evaluate the validity of the survey between named respondents and anonymous respondents to determine any differences in the trends of the answers.

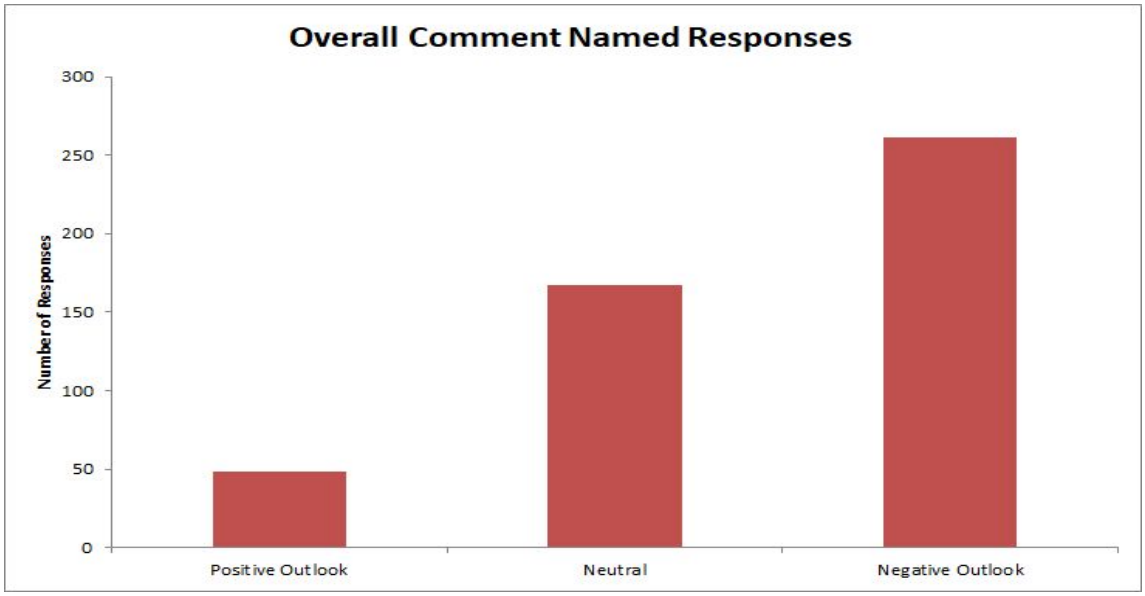


Figure 24. Overall outlook for those that completed the survey using their identity (n=450).

Discussion

Overall, there are a little over 1000 respondents to the survey (n=1024), which provided us our target sample size. However, we feel the responses were skewed toward those that may be more vested in the environment (i.e., MATES students and others under 18 that responded). However, the results provided us with some areas to focus on in terms of addressing the future and perceptions of crabbing.

Minimal recreational size regulation of blue crabs (overall responses, age and gender)
There was a positive correlation between the age of the respondent and the ability to correctly identify the legal size of a keeper, hard crab (4.5"or 114 mm) in New Jersey (Figure 4) up through the age of 50-59. There were less respondents in the older age categories which accounts for the trend. However, despite the positive trend, in all cases, the number of those in each age category that incorrectly reported the minimum size requirement were greater than those that did in almost all of the age categories, which is alarming (Figure 4). The disparity with those under 18 having the highest percentage of incorrect answers to the regulation questions is most likely due to experience and the fact that they are mostly crabbing with family members, who may have a better idea of the regulations. However, a high percentage of those under the age of 18 taking the survey were MATES students who were more likely to know about recreational crab size regulations based on their background education. The ability of older

crabbers to know the size regulation also has to be due to experience in the field. Some crabbing locations even have signs posted that state the N.J. laws, which leads to an increase in familiarity.

Blue crab sex determination

The variable with the strongest correlation to age was the ability to identify a female crab. This is likely due to the fact that the sex of a blue crab can be visually identified by viewing the "apron" of the crab, located on its underbelly, and as crabbers grow more experienced, identifying a crab's gender becomes easier for them (Figure 2). This results in older crabbers who have spent a larger portion of their lives being able to identify a female crab with ease. It seems that a majority of all survey respondents knew the sex of the mature female blue crab that was pictured in the survey with at least a two to one ratio of correct versus non-correct responses (Figure 5). However, there were still approximately 300 respondents who (~30%) of those surveyed that did not know the sex of the crab, which could have a negative effect on conservation practices if mature female blue crabs are taken out of Barnegat Bay (i.e, reduction of females in Chesapeake Bay; Chesapeake Bay Foundation 2008). Those in the 40 - 59 age ranges (Figure 6) seemed to be able to identify the sex of the crab more effectively than other age groups; however this may be due to the fact that these respondents had more crabbing experience and were more likely to participate in the survey.

Crabbing likelihood and crabbing platforms (places to crab)

A majority of our respondents crabbed between 1 and 5 times per year (on average), with most (combined male and female) selecting 1 - 2 times per year. As a result, there needs to be an effort to make these crabbers more aware of the regulations at the crabbing locations. According to our analysis, they would be considered "casual" crabbers. Although, individually, there may not seem be an effect on the crab population itself by a crabber not following the regulations; however, with a majority of recreational crabbers only crabbing 1 -2 times per year, the collective negative impact on the blue crab population can be realized if a majority do not follow the regulations.

Capture of crabs from a dock seems to be the standard "land-based" capture area as expected (Figure 9). The next choice was from a boat and "bulkhead" was selected as the third-most popular option. We feel that there could have been confusion between dock and "bulkhead", but it shows that "walled" shoreline areas are the most convenient for crabbing which support the 2006 survey conducted for the NJDEP (NJDEP 2007). . This shows that crabbing on boats is popular and the boat rental business is an important stakeholder to reach with any pertinent blue crab conservation efforts. However, according to a New Jersey study conducted in 2007, out of 76 respondents that used boats, 69 were private boats and only 7 were rental boats (NJDEP 2008). Additionally, public docks are important to promote responsible crabbing practices and should be identified as a follow-up to this study.

Economic aspects of crabbing, equipment, bait and travel time to crabbing locations

In terms of economic breakdown, the greatest frequency of money spent on crabbing per year was between 10 and 25 dollars (n=255). The next most selected amount was between 25 and 50 dollars annually (n=214; Figure 25 below). We analyzed 959 respondents who provided

feedback on the amount of money spent per year. Two respondents reported that they spent over $1000 per year on crabbing, which may include boat rental and fuel costs. Economically, this clearly shows the economic reach of crabbing. However, a far majority of respondents spent $50 or less on crabbing per year (n=655).

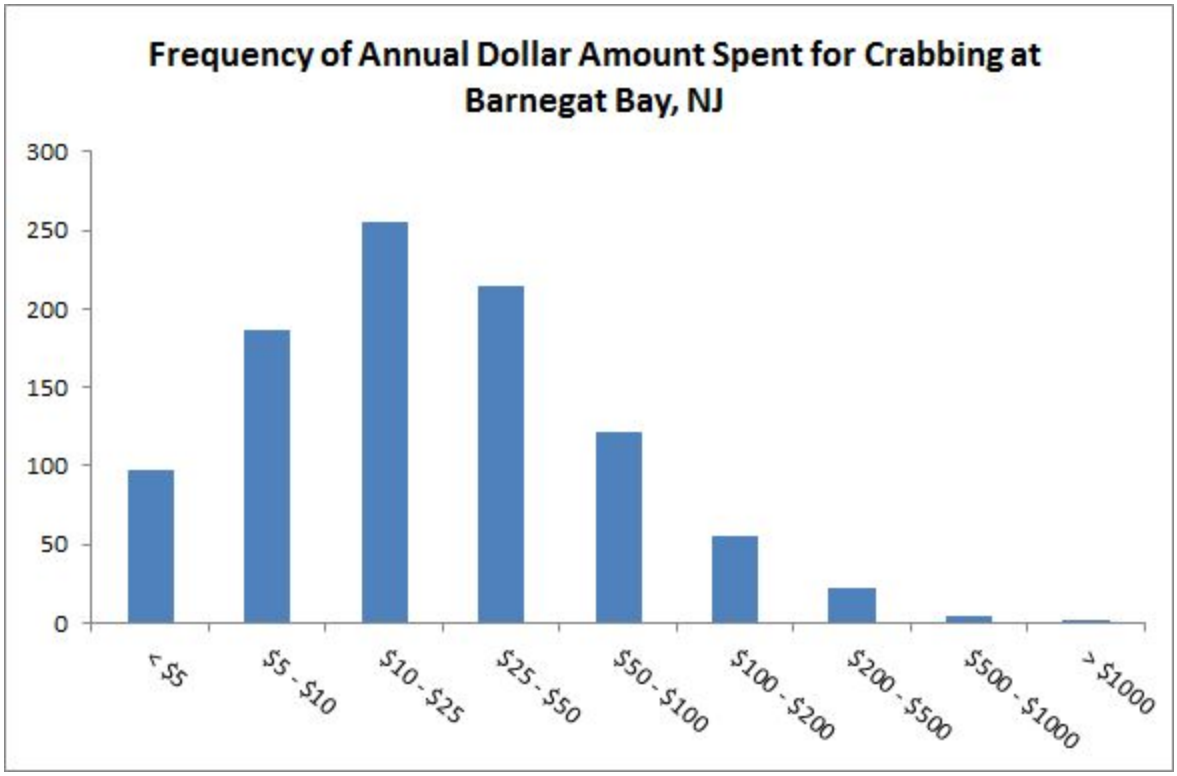


Figure 25. Frequency of responses to the amount of money spent annually for crabbing at Barnegat Bay, NJ (n=959).

Both men and females are more likely to travel to their crabbing location if it is less than 10 minutes away, although as travel time increases, there is a tendency for males to travel for a longer time to their location (only ~5% more men than females; Figure 14). It is important to take into account that some survey takers may have interpreted this question as time of traveling and staying at a location like a hotel or a relative's house, which may have led to answers in the 120+ minute range. Based on the results of this survey, it is more likely that residents will travel within 20 minutes to a crabbing location within their residence.

It seems that those in the 60 - 79 ages prefer the hand line capture method over traps with those between 60 - 69 showing the greatest difference in any method between hand lines and crab traps.. Those in the 30 - 39 age group slightly favored the hand line capture method as well. However, the hand line versus crab trap method seemed equal throughout without a statistical difference overall. It was interesting to note that those in the 18 and under category reflected similar capture methods as those in the 50 - 59 age category, which may reflect the same practices as a parent. In reviewing the data, there was an equal ratio of crab pot usage in relation to the other means of crab capture in each age category (except 90 +). The age group under 18 showed the same ratio; however, it may be a result of crab pots at their homes, and not their own

practice, which also supports the same response to those in their parent's age categories.
In terms of the bait used, it seems that bunker and fish were used only slightly more than the chicken or meat (39% vs. 34%). In our survey, we included "razor clam" in the meat analysis, but this option was negligible in terms of a category. There are a number of crabbers that use both bait (bunker/fish and chicken), which seems to be a standard practice (NJFWS 2019).

Investment in crabbing

For analytical purposes, demonstrated interest, or involvement, was determined based on the capture activity and/or economic investment that survey respondents reported. Those who demonstrated the highest level of crabbing frequency and involvement were those that had the greatest investment, and may have had the greatest impact on blue crab populations if regulations were not followed. Crabbers that were determined as more dedicated according to the amount of money they invest and how often they crab overall scored higher in terms of their knowledge on sex and size crabbing regulations by 2.17 points. This result is favorable because it suggests that as people become more involved with the practice, they are more likely to be aware of, and hopefully follow, crabbing regulations. As these people are the ones who have the greatest impact on the state of Barnegat Bay, it is crucial that they are aware of updating regulations ("Blue Claws" 2018). The fact that crabbers from outside Ocean County were among the least knowledgeable casual crabbers indicates that regulations being posted at popular crabbing sites could be useful as tourists are unaware of conscientious crabbing practices. Island Heights likely had a high knowledge score because **"crabbers reported adequate signage noting crabbing regulations at various crabbing locations"**. Although the total amount of survey responses was a little over 1000, the amount of responses from each area varied greatly. The low amount of responses from particular areas such as Little Egg Harbor and Tuckerton could have skewed the results of data (Figure 11), which is mitigated by listing the top and bottom three results, rather than just one from each end (Littler 2018).

Overall Survey Comments (see Appendix 3 for some selected survey responses)

For the positive comments, there were 5 subcategories. Many people described how regulations have increased and people are more likely to follow them. The majority of the positive comments had to do with the overall interest in crabbing: out of 94 comments there were 41 that highlighted interest as their main factor in crabbing (Figure 22). Some respondents stated that their interest in crabbing has increased over the past years and more people are beginning to crab. There weren't many positive comments pertaining to the abundance of crabs; however, those comments that did focus on the crab aspect stated that "the size of the crabs have gotten bigger". Lastly, there were very few comments that spoke favorably of the environmental conditions in Barnegat Bay.

For the negative comments, there were 6 subcategories, with 5 being the same as the positive comment categories and one pertaining to equipment and methods, with people elaborating on the negative aspects of certain crabbing tools and methods of obtaining blue crabs. For example, one response was that "many people were using crab pots and overnet equipment which catch unnecessary amounts of crabs". It is clear that most negative responses related to the crab such as decreases in the crab population and decreases in the size of the crabs over time, meaning that many crabs were less than the New Jersey legal recreational minimum size of 4.5 inches, with

249 out of 434 responses focusing on this aspect (Figure 23).

In terms of negative responses, the second most selected category was "interest" with 90 responses out of 434 showing that they believe that "the interest in this activity has diminished" (Figure 23). The other responses, which related to a lack of regulation adherence and worsened environmental conditions (i.e., water quality) had similar response frequencies. Other negative comments included that "there was a lack of knowledge about crabbing regulations in the general public (most notably with the younger generation)". There was a comment that declining water quality may be an issue for the future of less available crabs, but the fact that this was selected by ~30 respondents. It is important to note that 5 respondents who felt that crabbing had a more positive future, selected that the environment, Barnegat Bay, is showing improvement. We've included Figure 26 (below) that may help to explain the negative perception of crabbing:

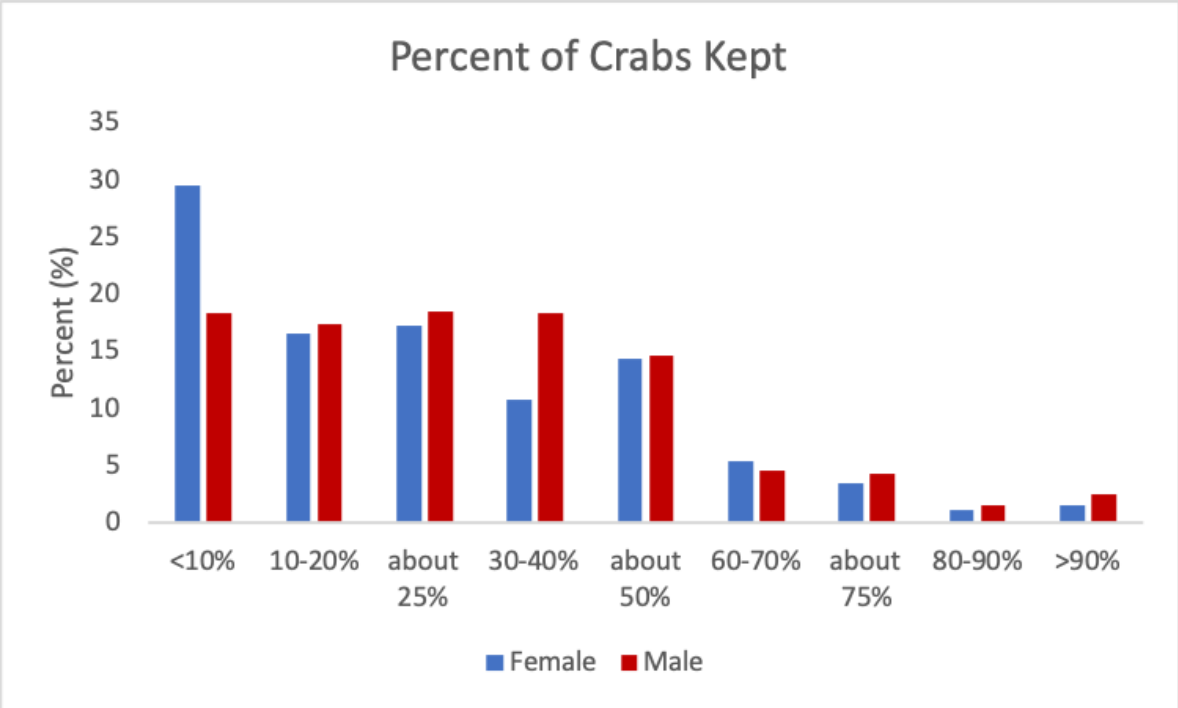


Figure 26. Based on the respondents who reported the approximate percentage of blue crabs that they were able to keep (legal size or greater), there were a significantly lower number of people who were able to keep more than 50% of the crabs captured. In fact, women reported that they were able to keep <10% of their catch more often than other percentages.

Females answered that they were able to keep less than 10% of crabs by a landslide. Men scored equally in keeping less than 10% through 40%. It is also important to note that as the percent of crabs kept increasing, males were more likely to keep more crabs than females. We feel that this may be due to the fact that females who responded to this survey tend to crab 1-2 times per year versus males (3 - 5 times). Which means that crabbing earlier in the season and/or one day with less legal-sized crabs can skew this data. The key is that collectively, male and females combined there is still a greater percentage of crabbers that can only keep ~10% of what they

catch. We feel that this enhances that negative perception of crabbing in terms of interest and the perception of "crabs". It also may tell a story about the availability of larger blue crabs within the population and the fact that commercial-style crab pots may have an impact on capturing larger crabs. This survey focused on recreational crabbers, but we still had responses from each age category that listed commercial-style crab pots as a means of crabbing.

These comments and the data collected from this survey suggest that more signage or advertisements encouraging crabbing regulation knowledge would be helpful in ensuring regulations are followed (Cabrales, Racuyal, & Manoza 2015). We thought the older age groups would be more aware of and active in responsible crabbing habits and practices. The significant p values found for all parameters using statistical analyses indicated that each age category had significantly different answers to each question ($P<0.05$). Despite its shortcomings, this survey may have been helpful in spreading awareness of regulations to get crabbers thinking of the implications behind the choices they make while crabbing.

Conclusion

The results of this survey suggest that more signage focusing on blue crab capture regulations would be helpful in increasing a crabbers' likelihood to engage in conscientious practices, especially those that are not local residents. In addition, this survey may have been helpful in misperceptions about crabbing regulations and we were able to spread awareness of regulations during the survey process. Overall, it was found that the older survey participants were more aware of responsible crabbing practices, reenforcing the sentiment that the older generations should educate the younger generations about how to crab in a sustainable and responsible way. It also shed light on the fact that blue crabbing has a positive impact on the local economy and is a part of our local culture. We recommend a survey of commercial crabbers, and expanding this survey to include more participants and to conduct more field surveys at known public crabbing locations. The following recommendations are a result of this study…

+Promote the size regulations for blue crabs through more signage and blue crab measuring stations at known crabbing locations (Figures 27 & 28, and Appendix 2 below)
+Reach out to all crabbing retail businesses (i.e., bait and tackle shops, boat rentals, and marinas with information.
+ Promote the NJ Marine Digest through all partner organizations and make electronic links available on partner electronic and social media sites.
+Conduct random crab surveys to collect measurements and take numbers of crabs at popular crabbing locations.
+ Produce educational material that is catered toward those age groups and genders addressed in this survey including a blue crab tutorial.
+Work with the Ocean County Parks, NJ State Parks and other stakeholders to develop and promote responsible crabbing programs.
+Work with the Fisheries Division of NJ Fish and Wildlife to identify the use of commercial-style crab pots (crab pot licenses).
+Develop an "app" to measure legal-sized blue crabs in New Jersey.

Figure 27. Blue crab gauge that is the minimal size for a NJ Recreational "keeper". "If it fits in, it goes back in". These are installed at John C. Bartlett Jr. Park in Bayville, NJ

Additional recommendations

+Based on surveying some of the more popular crabbing areas at Barnegat Bay, we recommend that all signage include a bilingual component so that reach can be maximized in crabbing locations (Figure 28 below).
+Be sure that all crabbing regulations are visible to the general public.

Figure 28. Crabbing regulation signs displayed at the public docks in Barnegat Township in English and Spanish (right).

Acknowledgements

The authors want to acknowledge the Ocean County Vocational Technical School (OCVTS) and its Marine Academy of Technology and Environmental Science (MATES) for their support of this project. We thank Ms. Lynette Lurig, NJ Department of Environmental Protection and Mr. Christopher Claus for their valuable input to our team throughout the entire process. Distribution was conducted through school and Project Terrapin social media accounts. We especially thank Ms. Erin Murphey for helping us to reach our goal! Also, thank you to the MATES PTSO, parents and our MATES partners for sharing our survey so that we could get the necessary responses.

CRABB Team at the Jacques Cousteau National Estuarine Research Reserve on February 28, 2020 as part of a presentation of their survey findings to state officials and stakeholders.

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Appendix 1: Survey used as part of the study

C.R.A.B.B. Recreational Survey

A team of high school students from MATES are aiming to gather information regarding crabbing trends with the goal of preserving crabbing for generations to come. They are part of the Crabbing Responsibly at Barnegat Bay initiative. This survey will begin with some background information and should take approximately 5-10 minutes. All responses can be kept anonymous. Thank you for your time.

First and Last Name (Optional)

_____ _____

Age

___ Under 18
___18 – 29
___30 – 39
___40 – 49
___50 – 59
___60 – 69
___70 – 79
___80 - 89
___90 +

Gender

__Male
__Female
__Other

How many years have you been crabbing?

___Less than One Year
___1 -2 years
___3 -5 years
___5 – 10 years
___10 – 20 years
___More than 20 years

In which region(s) do you frequently go crabbing? (Choose all that apply)

___Little Egg Harbor/Tuckerton
___Barnegat
___Manahawkin
___Toms River
___Brick Township
___Seaside Heights
___Island Heights
___Point Pleasant
___Berkeley
___Outside Ocean County
___Other

In which season(s) do you typically go crabbing? (Choose all that apply)

___Spring
___Summer
___Fall
___Winter

How long do you typically travel to go crabbing?

___Less than 10 minutes
___10 – 20 minutes
___20 – 40 minutes
___40 minutes – 1 hour
___1 – 2 hours
___More than 2 hours

Where do you typically crab from?

___Shoreline (without a beach)
___Boat
___Dock
___Bridge
___Bulkhead
___Other

How frequently do you crab?

___1 – 2 times a season
___3 – 5 times a season
___6 – 10 times a season
___11 – 15 times a season
___16 - 20 times a season
___More than 20 times a season

How much time do you generally spend crabbing on a typical day out?

___Less than 1 hour
___1 -2 hours
___3 -4 hours
___5 -6 hours
___7 or more hours

Who do you typically go crabbing with? (Choose all that apply)

___No one else
___Friends
___Coworkers
___Children
___Grandchildren
___Parents
___Grandparents
___Significant other
___Siblings
___Other

What bait do you typically use when crabbing? (Choose all that apply)

___Chicken
___Bunker
___Razor Clams
___Other

What method do you use to crab? (Choose all that apply)

___Handline

___Crab traps

___Crab pots (overnight)

____Other

What is the sex of this blue crab?

___Male
___Female
___I don't know

How many crabs do you usually catch per outing?

___0 – 5 crabs
___Half a dozen to one dozen crabs
___1 – 2 dozen crabs
___3 - 5 dozen crabs
___5 – 10 dozen crabs
___More than 10 dozen crabs
___Other

What percentage of crabs are you usually able to keep? (due to size and gender)

___less than 10%
___10 – 20%
___about 25%
___30 – 40%
___about 50%
___60 -70%
___about 75%
___80 – 90%
___more than 90%

Does this amount change seasonally of monthly? If so, when or how? Answer here

_____

_____

What type of measuring device do you use? How do you measure?

_____

_____

Is there a measuring device available for public use where you crab?

___Yes
___No
___Other

Is there a regulation regarding the minimum size of the crabs that are allowed to be kept where you crab? Is so, what is it?

_____

_____

When crabbing, do you often find that others follow crabbing regulations?

___Yes, I have never seen a crabber ignore regulations
___More often than not, crabbers follow regulations
___There is an equal number of crabbers that do and do not follow regulations
___More often than not, I see crabbers who do not follow regulations
___No, I have never seen someone following crabbing regulations

How much money do you generally spend per year on crabbing supplies and any related materials (including gas)?

___Less than 5 dollars
___5 – 10 dollars
___10 – 25 dollars
___25 – 50 dollars
___50 – 100 dollars
___100 – 200 dollars
___200 – 500 dollars
___500 – 1000 dollars
___More than 1000 dollars per year
___Other

Do you think crabbing has changed over time? If so, how? Specifically, in terms of the quality of crabbing or people's general interest in crabbing?

_____

_____

_____

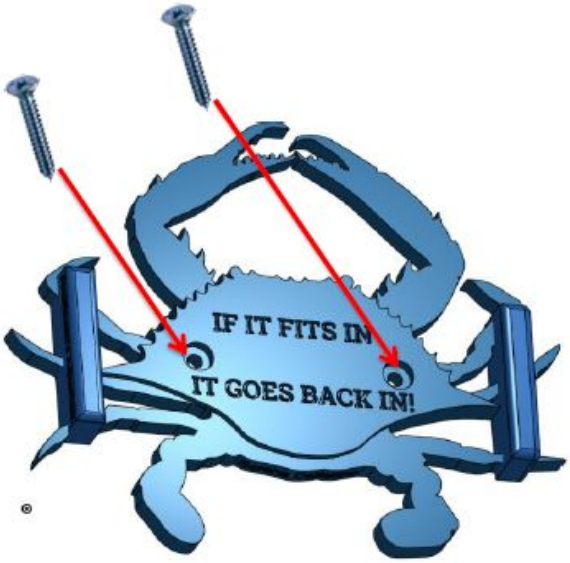
_____

_____

Thank you for your feedback. – MATES C.R.A.B.B. Team

Appendix 2

Crab Gauge Installation Instructions



Blue Crab Model

A recreational crabber can hold a crab up (backwards) to the model/size gauge & if it fits within the bars it is too small to keep, if not it is safe to keep. The design incorporates a mounting method for fastening to **the side of** a post or ledge.

Signage

You may install the signs however is convenient for you. A drill bit will work to create holes to mount the signs if a frame or other method is not being used.

Notes:

We recommend installing crabs at your most frequented crabbing spots and spacing them out. If you have any questions or concerns, please contact Serena Celestino at sc1646@scarletmail.rutgers.edu or Dr. John Wnek at projectterrapin@gmail.com.

Appendix 3: Notable selected responses from our survey

Do you think crabbing has changed over time? If so, how? Specifically, in terms of the quality of crabbing or people's general interest in crabbing?

- "It seems that more people are ignorant of the crabbing regulations. I remind them and they get angry. They think that if they catch it they can keep it. Perhaps bait shops can inform the public of the regulations."
- "YES!!! Been crabbing since the 60s... used to get bushels right off my dock.... now there are so few and most are small."
- "Yes it has changed. Smaller and less crabs in Barnegat Bay. People need to be educated on what to keep and why regulations are important. All shoreline crabbing areas (like docks) should have a measuring device and summary of regs. More checking of catches. In 30 years of crabbing, I have never seen someone from the state doing education or checking catches."
- "This would have to be the best question of all. During the 80's.The bays were filled with crabs. Bait was never needed to catch them. It wasn't until the eel grass started to die off and the water became dark and cloudy the effects became real. Areas should sectioned off to the public for restoration. "
- "Quality has dropped tremendously, so people's interest has dropped accordingly!"
- "I don't think crabbing has changed. Depending on where you live, people's interests have changed. If you're not from an area like the shoreline, you will be less likely to show your kids how to crab or how to clean and cook what you catch I believe if you went crabbing as a kid you are more likely to show your children how to crab also."