George Smith, Rachel Kang, and Clinton Arriola in the Tred Avon River.

Tracking Zombie Crabs

The Chesapeake Bay Parasite Project

November 16, 2017 By Monaca Noble

Record Turnout and Enthusiasm!

If I had just one word to describe this year's sampling season it would be enthusiasm. Enthusiastic volunteers, interns, and staff made this season a success - in research results, education, and fun.

This fiscal year, 161 volunteers participated in the project, contributing over 1,500 hours. This included both long and short-term volunteers and two school groups who participated in October and April. For our June and August events, participation increased with 13 more people and 391 more hours than 2016, reaching a combined total of 1162 hours.

This year we began bimonthly sampling sites to track crabs and parasites through the fall, winter and spring. We also started larval (plankton) surveys in the Rhode River to measure crab and shrimp abundance and distribution.

Increased participation allowed us to expand our data collection with more sampling events than ever before! We saw many new faces and welcomed back many returning volunteers.

Whether you've been with us for years or are just starting out, it's been a real pleasure getting to know you. Your contributions to this project are essential and appreciated. Thank you!

Our Project

If you turn over a submerged log, peek under a dock, or look inside an oyster basket, you might find tiny mud crabs scampering around. Mud crabs are less than

Seasonal Sampling

Winter sampling provided new and surprising discoveries.

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Decapod Larval Survey

Zoea is the scientific term for larval crabs and our 2017 Rhode River survey measured their distribution and abundance.

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an inch across and live in shallow water habitats like around oyster shells, woody debris, and submerged structures.

There are several species of mud crab in Chesapeake Bay, but the white-fingered mud crab (*Rhithropanopeus harrisii*) is probably the most abundant crab in Maryland waters. Finding 50 to 100 crabs on a single log or a grab of oyster shells isn't unusual.

The Marine Invasions Lab has been studying mud crab populations in Maryland since the 1990s to understand what controls their abundance and distribution. One aspect of our research focuses on the parasitic barnacle *Loxothylacus panopaei* (Loxo), which infects mud crabs. Loxo was introduced to Chesapeake Bay in the 1960s from the US Gulf of Mexico, probably with oyster imports. We're interested in the effects of Loxo on mud crabs and how this changes through time.

We are currently measuring mud crab populations and Loxo prevalence in five waterways in Maryland - the Rhode, West, Tred Avon, and Patuxent (near Broomes Island) Rivers - and Rock Hall Creek.

We catch the crabs using small plastic crates filled with dead oyster shells called crab collectors. The crates provide an attractive habitat for mud crabs. Each crate is set out for two months allowing adequate time for crabs to colonize. The majority of our sites are surveyed in June and August, but a few are sampled bimonthly throughout the year. These surveys have revealed large fluctuations in crab and Loxo population size as well as other interesting discoveries.

The Making of a Zombie

From the 2016 Newsletter

The introduced parasite, Loxo, is turning native mud crabs in Chesapeake Bay into zombie nursemaids. Tiny female Loxo larvae use a dart-shaped injection stylet to inject embryonic cells into the crabs. These cells grow into a mature parasite that wraps

around the crab's nervous system. The parasite assumes complete control over the host crab, controlling major functions such as molting and reproduction as well as compromising the crab's immune system and eliminating the crab's ability to reproduce.

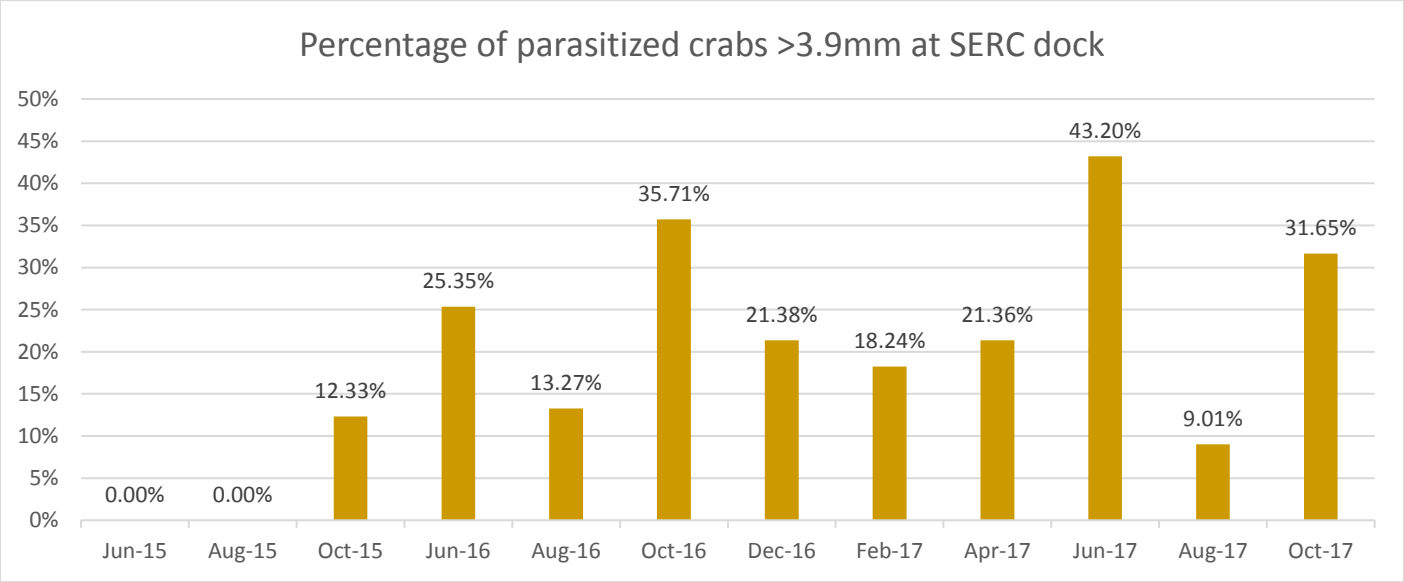
When the parasite is ready to reproduce it produces a large sac, called a virgin externa, which protrudes through the crab's abdomen. Male parasites are attracted to the virgin externa. When they locate the opening in the externa they use their stylet to inject trichogon cells. These cells develop into testes that fertilize eggs within the sac (externa). Once the parasite has grown its testes, full reproduction is triggered. The sac, now a mature externa, triples in size to hold thousands of larvae. Under the right conditions Loxo can produce a new brood of larvae every five or six days!

Who takes care of all these parasite larvae? The zombie nursemaid does. The infected crab tends to the sac of the parasite like a female crab looks after her eggs. But since the parasite targets both genders, male crabs also mother the larval parasites.

To trick the male crabs into tending to her young, the parasite feminizes the male crabs. She does this by changing his behavior and giving him a wide apron, just like a female crab. Having a wider apron helps him hold the huge sac protruding through his abdomen.

Most infected crabs have only a single sac to support, but some have several. If a crab has multiple sacs, it usually has two or three, but six sacs on a single crab have been reported.

Do multiple sacs mean multiple parasites? Genetic analysis has only been done on a few crabs, but early results point to multiple parasites rather than multiple sacs from a single parasite. For the crab, this might be like multiple puppeteers fighting for control over a single puppet.



The percentage of parasitized crabs at the SERC dock averaged across the collectors at each sampling point.

Seasonal Sampling

Serendipity at a show-and-tell event in late October 2015 led to the addition of bimonthly sampling in the Rhode and West Rivers starting in October 2016.

The number of parasitized crabs in the summer of 2015 was too low to be detected in the field. So when we set out a couple collectors in the fall of 2015 for a show-and-tell event, we weren't expecting to have parasites to show the attendees. But as we were going through the shell at the event - explaining that we probably weren't going to see any parasites - we spotted an infected crab, then another, and another. We were astonished. There were so many parasitized crabs that people wondered if we'd seeded the collectors for the show-and-tell, but we hadn't.

Where were all these parasites in June and August? What happened in the environment between August and October to trigger reproduction and an upsurge in parasite frequency? We had a lot of questions, but few answers. When we sampled again in June and August of 2016, the parasitized crabs were plentiful at nearly every location.

We knew from our long-term data set that the Loxo parasite was abundant in some years and nearly absent in others. But the timing of parasite reproduction wasn't clear. We didn't know when they started to appear or disappear from the system or what the trigger might be.

In August 2016, we selected three sites to sample every other month throughout the year, two sites in the Rhode River and one in the West River. Bimonthly sampling was done to allow crabs time to recolonize the collectors between the collection periods.

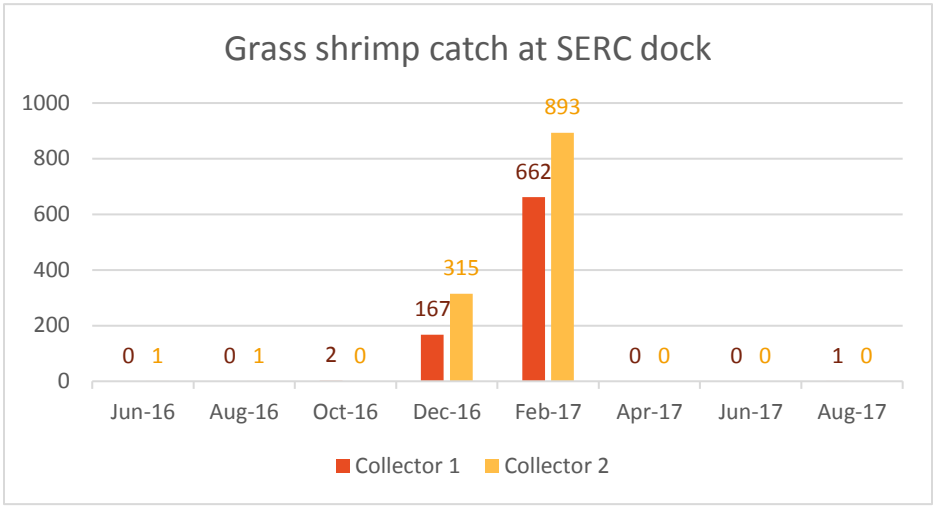
The above graph shows the percentage of infected mature crabs, or crabs over 3.9mm in size, collected at the SERC dock, one of three sites surveyed bimonthly. For crabs under 3.9mm in size, we are unable to easily determine if they have been infected or not.

From this small sample, we see that Loxo was present throughout the winter and seemed to be reproducing based on the presence on mature externa. We are looking forward to seeing the results from this winter's survey.

Grass Shrimp Galore!

One surprising discovery of winter sampling was grass shrimp in our collectors – hundreds of them. In the summer, grass shrimp live in shallow nearshore environments. But in the winter they move into deeper water. Our crab collectors are set at about 1 meter deep. It

A net full of grass shrimp found in the crab collectors in the winter.



The number of grass shrimp caught in the mud crab collectors at the SERC dock.

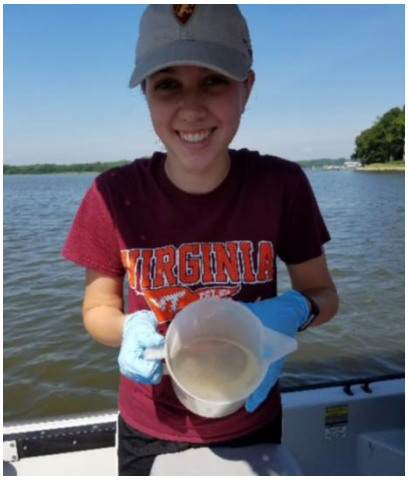
turned out that wintering grass shrimp seek refuge on oysters, as we caught hundreds in December and February. Finding them in such high numbers was a fun surprise and will provide a good opportunity for the people looking at parasites in grass shrimp to assess the parasite load on wintering shrimp this season.

Decapod Larval Survey

In May 2017, we started a new survey in the Rhode River. Every other week on the full and new moons, we collected plankton samples from five locations in the Rhode River. We then counted all of the larval decapods in the samples. Decapods are the taxonomic group of animals that includes crabs and shrimp. Our aim was to determine the abundance and distribution of larval decapods, especially mud crabs and grass shrimp, and how this changes over time.

Several long-term volunteers contributed to the survey. One of their many tasks was to remove, count and measure any jellyfish caught in the net. The presence of ctenophores (comb jellies) and jellyfish made it difficult for us to sort through the samples in the lab, and by the end of the summer we had devised a jellyfish removal system to rid ourselves of this gooey problem.

We'll be able to share some these results in next year's newsletter.



Volunteer Eileen Cover removing, measuring, and counting jellyfish.

Future Plans

October 21st was the first of the 2017/2018 seasonal survey. Students from South River High School along with several other volunteers came out to help. We found a lot of parasites in both the West and Rhode Rivers. This year we added three new sites to seasonal survey, creating three sites in each river. Volunteers participating in the winter will be happy to know that we'll be processing these collectors indoors during cold weather.

We will continue this research again in 2018. We'll be setting out the collectors in April in preparation for our June and August sampling events. We expect to start the decapod larval survey in May. We look forward to working with our long-term volunteers and new participants in the coming year.

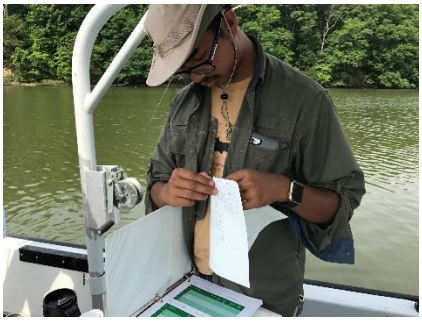
Meet our 2017 Interns

As our project has grown so has our need for a larger support team in the field. In addition to our core staff, this year's field events were supported by four interns and four long-term volunteers, two of whom volunteered all summer as part of an internship program through their high school. We simply could not accomplish as much as we do without their support.

Bios for staff, Eileen Cover, and Gee Gee Lang are in the 2016 newsletter.

Our field team from Left to right - Jennifer Ascencio, Shannan Stafford, Maria Sharova, Jose Cuevas, Alison Cawood, Monaca Noble, and Clinton Arriola. Not shown George Smith, Carolyn Tepolt, Rachel Kang, Martin "Joey" Miller, Eileen Cover, and Gee Gee Lang.

Jose Cuevas



Jose was this year's Chesapeake Bay Parasite Project intern in the Marine Invasions Lab. He has a B.A. in Marine Science from the University of San Diego. In addition to all of his project responsibilities, he created a methods training video for the project that we'll be using next summer.

"Producing the methods training video presented a cerebral challenge in science communication and the Parasite Project itself was a wonderful way for me to exercise my marine science skills. I loved being at SERC over the summer, and the chance to work with so many amazing citizen scientists made it even better."

Jose was supported through the Smithsonian Woman's Committee.

Clinton Arriola

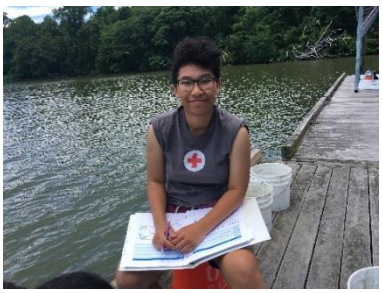
Clinton graduated with a B.S. in Biology from Temple University. During his Marine Invasions internship he's been involved with research in community ecology and predator-prey interactions of nearshore fishes, the decapod larval survey, and the Chesapeake Bay Parasite Project.

"It's incredible to see the interest that the volunteers have in collecting high-quality data and being a part of the scientific process."

Clinton was supported by SERC's Marine Invasions Lab.

Shannan Stafford

Shannan was a summer citizen science intern. She is a Political Science and Psychology major at Bryn Mawr College in Bryn Mawr, Penn.



Jennifer Ascencio

Jennifer was a summer citizen science intern. She is a senior at Chapman University in Orange, Calif., majoring in Environmental Science & Policy.

"Having citizen volunteers play such an active and important role in the mud crabs project is very exciting to see. It was a wonderful thing to be a part of."

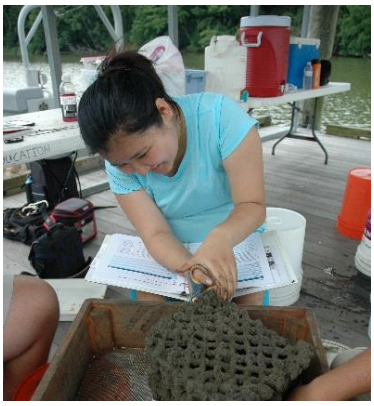
Jennifer and Shannan were supported through the Research Experiences for Undergraduates (REU) program through the National Science Foundation.

Martin "Joey" Miller

"It's amazing for me to discover the magnitude of what this parasite's effect is on a mud crab."

Joey is a senior at Southern High School where he is the Southern High Signature Design Program Ambassador. He grew up in Galesville, Md., and has his commercial crabbing license. Joey has been completing a high school internship as a volunteer at SERC this summer and fall working on several projects, including the Chesapeake Bay Parasite Project. Joey plans to major in Environmental Science at Salisbury University.

Rachel Kang



"I started with the mud crab project in the summer of 2015. Watching the project grow to what it is now is extraordinary. Being able to help fellow volunteers and interns was a grateful opportunity. In the lab, there are always new things to learn. I am so thankful to Monaca for allowing me to help with all aspects of the project."

Rachel volunteered in the lab and the field in 2015 and 2017. She graduated from South River High School in May of 2017. After graduating, she volunteered nearly full-time through the summer. This fall she started her first year of college. Rachel is a budding scientist and a talented artist.

Partners

This project would not be possible without the support of our many partners. We'd like to give special thanks to the Cooperative Oxford Laboratory and Patuxent Environmental & Aquatic Research Laboratory, and the many marina and dock owners who have hosted our research on their property. Finally, we give a huge thank you to all our volunteers!

Support Us

Our project operates on a lean budget. To sustain our vibrant citizen science program, which engages over 150 people per year to advance knowledge and discovery, we could use help in the following areas:

- Purchase of salinity loggers. Although it appears changes in salinity affect crab and Loxo populations, we lack the necessary instruments to measure rapid changes at our field sites.
- Replacement of general supplies for use by citizen scientists in the laboratory and field. These must be replaced each year.

- Travel support to attend conferences / workshops in order for interns and staff to present results. We have transformed the mud crab survey into a successful citizen science effort and sharing the results will encourage others to develop citizen involvement in their research.
- Publication costs, to publish our key findings, using this as a model system of high-quality data collected through citizen science.
- Supporting summer student internships.

If you are interested in providing financial support for our project, please send a check payable to the Smithsonian Environmental Research Center, noting "For Chesapeake Bay Parasite Project" in the memo line, to:

Christine Buckley
Smithsonian Environmental Research Center
647 Contees Wharf Road
Edgewater, MD 21037

If you prefer to donate online, go to https://serc.si.edu/ and click the DONATE button in the upper right of the page. In order for your gift to go directly to the Chesapeake Bay Parasite Project, we kindly ask that you send an email to BuckleyC@si.edu to let her know you just made an online donation to SERC and would like the funds used in support of the Chesapeake Bay Parasite Project.

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Wish List

Items	Price
HOBO salt water conductivity/salinity data logger	$750 each, 5 needed
General supplies – rope, collectors, cable ties, buoys, etc. $1500	$1500
Student intern	$5,000
Conference travel	$2,000
Publications	$2,000

THANK YOU!

Rachel Kang and Jose Cuevas pulling in a collector.

Kallan Benson, Jennifer Ascensio, and Kara Ogburn processing a sample at the Patuxent Environmental & Aquatic Research Laboratory (PEARL) in Broomes Island, Md.

George Smith and Monaca Noble rinsing down the plankton net.

Students from South River High School processing a sample on the SERC dock.

Carolyn Tepolt and the winter sampling crew in Galesville.

Gee Gee Lang and Jennifer Ascensio deploying a collector.