Our Awesome Interns – Ruth Dickey-Chasin, Emily Anderson, and Lakeisha Thompson

In Search of Zombie Crabs

The Chesapeake Bay Parasite Project

Annual Newsletter

October 21, 2016 Written By Monaca Noble

Mud Crabs and Parasites

The white-fingered mud crab (*Rhithropanopeus harrisii*) is probably the most abundant crab in Maryland waters of the Chesapeake Bay. These crabs are small in size (< 1 inch across) and occur in shallow waters --- scampering around oysters, fallen logs and woody debris, and under docks and other submerged structures. It is not unusual to find 50-100 of these crabs on a single log or a grab of oyster shells!

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 is a recent arrival and was introduced to Chesapeake Bay in the 1960s from the US Gulf of Mexico. Our research explores the effects of Loxo on mud crabs and how this changes through time. As part of this research, we routinely measure Loxo prevalence throughout Maryland, including sites on the Eastern Shore, southern Maryland, and central Maryland near the Smithsonian Environmental Research Center (SERC).

For our research, we regularly survey crabs using "crab condos", which are simply small plastic crates filled with dead oyster shells. Crab condos provide attractive habitat, which mud crabs colonize quickly. Every June and August, we survey two-month-old condos to measure mud crab and Loxo populations. These surveys have revealed large fluctuations in crab and Loxo population size. Additional laboratory experiments underway by our team (page 5) suggest that temperature and salinity play an important in population dynamics and also that some crabs are resistant to infection.

The Making of a Zombie

Learn how the parasite takes over the crab and uses it to tend its larvae.

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Future Plans

Plankton sampling for mud crab larvae is a big addition to be added in 2017.

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The Making of a Zombie

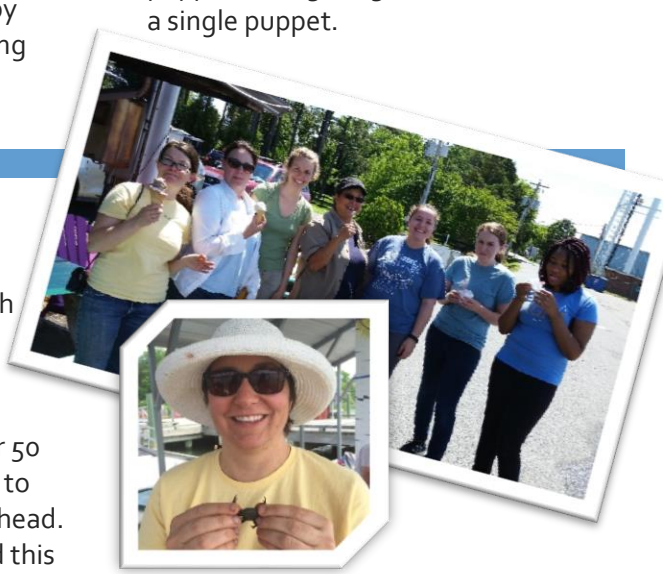
The introduced parasite, Loxo, is turning native mud crabs in Chesapeake Bay into zombie nursemaids. Tiny female Loxo larvae use a dart-shaped injection stylet to inject embryonic cells into the crabs. These cells grow into a mature parasite that wraps around the crab's nervous system. The parasite assumes 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 two testis that fertilize eggs within the sac (externa). Once the parasite has grown its testis, 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? While genetic analysis has only been done with a few crabs, 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.



Our Team

The project is run by a dedicated group of staff, interns, and volunteers. As the project has grown in size, so has our need for assistance in running the program in the field and in the lab. Our 2016 team included six staff members – Dr. Gregory Ruiz, Monaca Noble, Dr. Alison Cawood, Maria Sharova, Dr. Carolyn Tepolt, and George Smith - one full-time intern, Emily Anderson, and two interns, Ruth Dickey- Chasin and Lakeisha Thompson who helped in the field. We also had a group of volunteers that each put in over 50 hours in the lab and/or the field to help keep the project moving ahead. We couldn't have accomplished this without Gee Gee Lang, Pavan vindra, Eileen Cover, and William Brewer.

A feminized male mud crab with a mature parasite.

Alison Cawood and Maria Sharova count and identify fish from the crab collectors.

Ruth Dickey-Chasin, Gee Gee Lang, and Alison Cawood sort through a crab collector at the SERC dock

Ms. Gam's science students from Loudoun School spent the morning sorting crabs with us.

Highlights from 2016

This summer marked the first year of a more intense sampling effort. In the past we focused on a large area with few crab condos at each sampling site. One goal of the new survey is to understand the localized distribution and periodicity of the parasite. Thus, we reduced our sampling area but greatly increased the number of crab condos at each site. The total number of condos this year increased from 40 to 66. A second goal of the new survey was to look at the crab condos as mini habitats and measure other species unitizing them, such as fish.

The new sampling sites are the Rhode River (Edgewater), West River (Galesville), Tred Avon River (Oxford), Patuxent River (Broomes Island), and Rockhold Creek (Deale). These sites were selected based on the results of the long-term survey.

Citizen Scientists

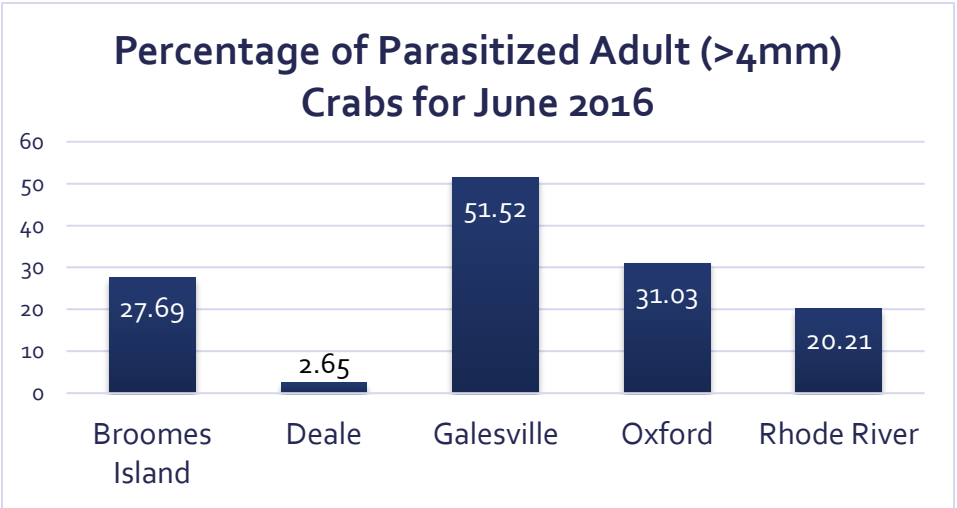
This summer was the third year that the survey has been run as a citizen science project. We had a great field season. For the June and August field component, 119 people contributed 771 hours to the project! That's a new project record! Plus, we had an intern and four great lab volunteers. Our lab citizen scientists contributed 160 hours and counting! The increased participation was especially important this year given the increased sampling effort.

Parasites

This was a big year for the Loxo parasite. We detected Loxo in adult crabs at all five sites. Galesville, Broomes Island, and Oxford had the most parasites. Galesville is a new site this year, but the parasite is routinely found at Broomes Island and Oxford, and often nearly absent in the Rhode River and Deale except in periodic high parasite years like 2016.

Fish

We recorded a total of 3660 fish in the crab condos. The most common fish were naked gobies (*Gobiosoma bosci*), which made up 80% of the total catch, followed by skilletfish (*Gobiesox strumosus*) (9%) and stripped blenny (*Chasmodes bosquianus*) (7%). Grass shrimp (multiple species) and American eels (*Anguilla rostrate*) were caught



sporadically and oyster toadfish (*Opsanus tau*) were found in Oxford during the August survey. The number and species of fish varied by site. Our biggest catch was from Big Island in the Rhode River where we caught 112 gobies in a single condo. Overall we caught 1438 more fish in August than in June.

New Discoveries

We caught the invasive Asian shore crab *Hemigrapsus sanguineus*, in our Oxford collectors. This is not a new discovery for Chesapeake Bay, but is a first for the mud crab project, which has been collecting crabs in Oxford for 16 years. This shore crab is most abundant in rocky intertidal habitats and has a salinity tolerance between 10 and 61 ppt. The salinity at Oxford was 14ppt, which is close to their lower tolerance limit.

Our Team

Volunteers

William Brewer started in the lab sexing crabs and looking for parasites in November of 2015. Bill was charming and interesting and we were honored to work with him. He volunteered through July 2016 and was great at asking tough questions about our research. Sadly, Bill died on July 25th at the age of 94.

He was a WWII vet, a lawyer at NOAA, a sailor, and much more. We miss hearing his stories every Wednesday afternoon.

Gee Gee Lang is a retired engineer who started volunteering in November 2015. She grew up in Hawaii but spent much of her career in California. She's doing retirement right - she's busy gardening, going to the opera, taking classes at the community college, including genetics, French, and yoga. Here's her bio in her own words.

"I began chasing crabs along the sandy beaches of Hawaii as a child. When playing hooky from my college coursework in Chemistry and Engineering in Oregon, I stalked the elusive, swift-footed, Pacific razor clam. After working most of my adult life in California, I bade farewell to the cold water loving, Dungeness crab of the Pacific to happily embrace the tiny mud crab studied by the wonderful community of scientists and researchers at SERC."

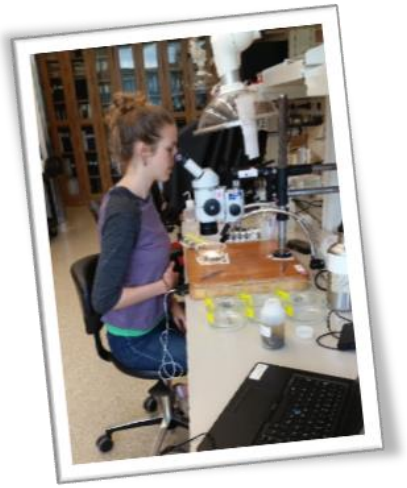
Eileen Cover started volunteering in July. She is a recent graduate of Oakland Mills High School in Columbia, MD and is taking a gap year before starting her undergraduate career at the University of Maryland. When Eileen is not looking for crab parasites, she is rehearsing and performing with the Teelin Irish Dance Company as well as taking classes in hip hop, tap, and tai chi at the community college.

Pavan Ravindra is a high school student from Columbia, MD. He volunteered for nearly every field day in 2015 and upon reaching his 16th birthday he started a high

school internship project on mud crabs with mentor Carolyn Tepolt. In 2016, he joined the field team to help retrieve the crab collectors and collect data. Fun fact: Pavan is excellent at the Rubik's Cube, and is among the fastest in the country. Yep, there is a competition for this.

Interns

Emily Anderson was the mud crab project's first full-time intern. Emily grew up in Middlebury, VT. She graduated from the University of Maine in May with a degree in Ecology and Environmental Sciences with a concentration in Ecosystem Ecology. Her past work included fish barotrauma, forest ecology, and bat biology. She is currently exploring her interests through workshops and community classes while saving money in the hopes of spending a year travelling before attending graduate school.



"Working on the mud crab project gave me a glimpse of what the research of the future may look like: accessible to people of all backgrounds, where those without an advanced degree in a scientific field can provide meaningful contributions. My time on this project taught me not just about conducting research, but also about what it means to be a part of a diverse scientific community."

Ruth Dickey-Chasin was one of this summer's citizen science interns. She attends Smith College, in Massachusetts where she studies American Studies and French and plans to graduate in 2017. She is pursuing a concentration in environmental studies and hopes to study the relationships between people and their environments.

Lakeisha Thompson was a citizen science intern working in the Global Change Research Wetland, but she did many other projects including helping us in the field in June and August. Lakeisha is attending Westley College in Dover, Delaware where she studies arts and music.

Staff

Dr. Gregory Ruiz is the principle investigation on the project and head of the Marine Invasions Lab. Greg's interest in Loxo started with his research on mud crabs in the Rhode River in the 1990s. Greg and Dr. Mark Torchin (Smithsonian Tropical Research Institute) started the long-term mud crab survey in 2003. Greg has a Ph.D. in zoology from the University of California in Berkeley.

Monaca Noble has been the project lead since 2013 and was instrumental in turning the long-term survey into a citizen science project. Monaca has a Master of Science from Portland State University in Oregon and has been in the Marine Invasions lab since 2005.

Dr. Alison Cawood joined the team shortly after coming onboard as SERC's Citizen Science Coordinator in 2014. Alison has a Ph.D. in Oceanography from Scripps Institution of Oceanography, University of California in San Diego. She handles volunteer recruitment and management.

Maria Sharova joined the team in 2015 and helps manage volunteers, and much more, for the project. Maria has a Bachelor of Arts in Anthropology from the University of Maryland in College Park and has been the Citizen Science Program Assistant since 2015.

Dr. Carolyn Tepolt is a Postdoctoral Fellow in the Marine Invasions Lab and has been using genomics to understand how mud crabs are adapting to the invasive parasite Loxo. She has been an important asset both in terms of scientific guidance and project management. Carolyn has a Ph.D. in Biology from Stanford University in California.

George Smith joined the project as our boat captain in 2015 when additional sites were added to the survey. George will take the lead on the next big project expansion in 2017 when we start plankton sampling to measure larval recruitment in the Rhode River. George is a 19 year veteran of the Invasions lab. He has a Master of Science from the University of Connecticut in Storrs, CT.

Long-term Collaborators

Dr. Amy Fowler is a SERC research associate who has been contributing to this research for many years. Amy has a Ph.D. from Auckland University in New Zealand. She is currently an Assistant Professor at George Mason University in Fairfax, Virginia.

Dr. April Blakeslee is a SERC research associate who is conducting related surveys in several areas along the East Coast and has been contributing to this research for many years. April has a Ph.D. in Zoology from the University of New Hampshire in Durham. She is currently an Assistant Professor at East Carolina University in Greenville, NC

Dr. Mark Torchin started the long-term mud crab survey in 2003 while a SERC Postdoctoral Fellow and has been contributing to the project ever since. Mark has a Ph.D. from the University of California, Santa Barbara. He is a staff Scientist in Marine Ecology at the Smithsonian Tropic Research Institute in Panama.

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!

Future Plans

We had a very successful year of sampling. Next year we plan to continue working in our new sites but will add bimonthly sampling at three of our sites to look at the seasonality of the parasite and starting in May 2017, we'll add a plankton survey.

We know that Loxo is prevalent in some years and nearly absent in others. We are hoping bimonthly sampling will give us a better idea of when, and perhaps why, the parasite disappears from the system. Our first bimonthly sampling event is October 19, 2016. Students from the Journey School in Ashton, MD will be helping with this mini survey.

Plankton sampling to begin in May 2017! Join us for a new science adventure.

Another big addition to the survey is monthly plankton sampling to look at larval recruitment. We'll conduct this survey in the Rhode River with plans for expanding it to the other four locations if resources allow. This survey will run from May through September. We welcome long-term volunteers with Smithsonian badges to participate. If you are interested please contact Alison Cawood (Cawooda@si.edu).

Support Us

Our project operates on a lean budget. To sustain our vibrant citizen science program, which engages >100 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 affects 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 our results. We have transformed the mud crab survey into a successful citizen science effort and we'd like to share the results to encourage others to increase citizen involvement their research.
- **Publication costs**, to publish our key findings, using this as a model system of high-quality data collected through citizen science.
- **Supporting a summer student internships**, for students to conduct marine biology research with us.

If you are interested in providing financial support for our project, please send a check made payable to SERC and add "For Chesapeake Bay Parasite Project" in the memo line, and mail 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 on the DONATE button in the upper right side 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. THANK YOU!

Wish List – Please Contribute

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