SCDNR MARINE RESOURCES RESEARCH INSTITUTE STATE REPORT.

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Contact: Dr. Peter Kingsley-Smith, Senior Marine Scientist, Marine Resource Research Institute, South Carolina Department of Natural Resources (SCDNR), 217 Fort Johnson Road, Charleston, SC USA 29412;
E-mail: kingsleysmithp@dnr.sc.gov; Tel. No.: 843-953-9840.

Update on research on the Island apple snail, *Pomacea maculata*.

In July 2018, the SCDNR Crustacean Research and Monitoring Section was awarded funding from the USFWS State and Interstate Aquatic Nuisance Species Management Plan Program (SIANSMP) in part to conduct a research project entitled "Assessment of the current distribution of the island apple snail, *Pomacea maculata*, in West Ashley and its potential to invade the estuarine habitats of the Ashley River, South Carolina" (PI: Kingsley-Smith, P.R.). For this project, biologists will re-survey a system of stormwater ponds in a suburban neighborhood in West Ashley, SC which was previously surveyed by SCDNR biologists in 2015 (see Gooding et al. 2018). Since that time, multiple hurricanes, tropical storms, and an extreme cold weather event in January 2018 have occurred in this area, all of which could have impacted the distribution and abundance of the *P. maculata* populations in this location. Furthermore, this neighborhood is located less than 3 km from the ecologically-important Ashley River, such that determining the current status of these *P. maculata* populations is important in assessing the potential risk of their invasion of the Ashley River.

Four stormwater ponds in the West Ashley area were surveyed in October 2018. All ponds surveyed contained established populations of *P. maculata* (a total of 360 adults and 1,939 egg clutches were counted across the four ponds). These numbers indicate increases in abundance estimates in all four ponds compared to the surveys conducted in 2015 at a similar time of year. Field surveys for this project will continue through the fall of 2018 and spring/summer 2019.

The following manuscripts on the island apple snail, *Pomacea maculata* (derived from the College of Charleston M.S. research conducted by Elizabeth Underwood) have been submitted for publication:

Underwood, E.B., Darden, T.L., Knott, D.M. & Kingsley-Smith, P.R. Salinity tolerance of invasive island apple snail, *Pomacea maculata* (Perry, 1810), hatchlings in South Carolina, USA. *Journal of Shellfish Research* (in review).

Underwood, E.B., Darden, T.L., O'Donnell, T.P. & Kingsley-Smith, P.R. Population genetic structure and diversity of the invasive island apple snail, *Pomacea maculata* (Perry, 1810), in South Carolina and Georgia, USA. *Journal of Shellfish Research* (in review).

Invasive crayfish research in South Carolina.

Investigation of the recent spread and dispersal patterns of the red swamp crayfish, *Procambarus clarkii*.

The SCDNR Crustacean Research and Monitoring Section recently received funding from the USFWS SIANSMP as well as a 3-year award from the USFWS State Wildlife Grant Program (start date: October 1st 2018) to address questions related to the recent spread of *Procambarus clarkii* in the state, impacts of *P. clarkii* on native crayfish species, and dispersal patterns of *P. clarkii* in the northeastern part of the state in the Waccamaw and Pee Dee River drainages. Surveys conducted by SCDNR biologists during the current reporting period in the coastal plain of South Carolina and North Carolina have shown multiple new records of *P. clarkii* in areas where native crayfish species, including priority conservation species such as the Waccamaw crayfish, *Procambarus braswelli*, were previously observed. Researchers are concerned that *P. clarkii* is displacing native crayfish species throughout this region. As part of the USFWS State Wildlife Grant Program-funded project, SCDNR researchers will seek to better understand the potential dispersal pathways leading to the recent expansion of *P. clarkii*. Population genetic structure

both within and among watersheds that have been invaded by *P. clarkii* will be investigated using microsatellite genotyping techniques. Genetic microsatellite markers have been shown to be highly effective at distinguishing human transport from post-introduction dispersal events in *P. clarkii* (Yi et al., 2018).

Figure 1 (above). The invasive red swamp crayfish, *Procambarus clarkii*. (Photo courtesy of Elizabeth Underwood, SCDNR).

Figure 2 (above). The native Waccamaw crayfish, *Procambarus braswelli*. (Photo courtesy of Elizabeth Underwood, SCDNR).

2) Investigation of potential recent geographical spreads and new invasions by the invasive virile crayfish, *Faxonius virilis* and rusty crayfish, *Faxonius rusticus.*

Two non-native species of crayfish, *Faxonius virilis* and *Faxonius rusticus* (both formerly in the genus *Orconectes*) are currently established in North Carolina only a few miles from the North Carolina-South Carolina border in the Broad River and Catawba River watersheds, yet not previously reported in South Carolina. In July 2018, SCDNR biologists, in collaboration with the Catawba Indian Nation, surveyed a region of the Catawba River located on the Catawba Indian Nation Reservation and collected specimens of *Faxonius virilis*, **confirming the presence of this invasive species for the first time in South Carolina**. With recently acquired funding from the USFWS SIANSMP, SCDNR biologists will survey stream, wetland, and lake habitats in the Broad and Catawba River watersheds, near the North Carolina-South Carolina border, for both *F. virilis* and *F. rusticus* to gain a better understanding of the current distribution of these species and their potential impacts on native species. This research effort, led by Dr. Michael Kendrick and Elizabeth Underwood, will also continue to engage the Catawba Indian Nation to help them to monitor their reservation lands for these invasive species of crayfish.

Figure 3. *Left*: Recent dipnet sampling efforts to collect native and non-native crayfish species. *Right*: The virile crayfish, *Faxonius virilis* (https://nas.er.usgs.gov/queries/FactSheet.aspx?speciesID=215).

Research into the hybridization of redeye bass and Alabama bass in South Carolina.

The redeye bass (*Micropterus coosae*) in the Savannah Basin, also known as Bartram's Bass, is one of three priority species included in the National Fish and Wildlife Foundation (NFWF)'s Native Black Bass Initiative (NBBI), and has been listed as a species of highest concern in SCDNR's State Wildlife Action Plan (SWAP). This listing is primarily due to the effects of hybridization with the Alabama Bass (*M. henshalli*), which was introduced into the reservoir systems in the Savannah River basin in the 1980s. Since then, hybridization between the two species in the reservoirs has been documented in the field and confirmed by genetic analysis.

In recent years, SCDNR biologists have captured Alabama Bass and hybrid individuals in riverine habitats upstream of the reservoirs, while pure *M. coosae* individuals are increasingly confined to smaller rivers. While previous work by the SCDNR has documented that *M. coosae* populations are diminishing due to introgression with *M. henshalli*, key questions remain regarding the extent of this process in tributary streams. As part of the NBBI, the SCDNR Marine Resources Research Institute's Population Genetics Team is collaborating with SCDNR Wildlife and Freshwater Fisheries and Clemson University

staff and students to address the following key questions to fill knowledge gaps and inform management decisions aimed at securing self-sustaining pure populations of *M. coosae*: i) To what extent are lotic systems serving as refugia for pure *M. coosae* populations, and if any, where are these located? ii) What is the spatial extent of the *M. henshalli* invasion? iii) What is the frequency of hybrids in lotic systems and is their occurrence the result of in-stream spawning in those systems or upstream movement from reservoirs? iv) Can any of these patterns be predicted by geographic and/or habitat features?

During summers of 2017 and 2018, snorkel surveys were performed in eight tributaries to the upper Savannah to quantify nesting microhabitat use of redeye bass and egg samples were collected for quantitative PCR (qPCR) genetic analysis at 160 nests detected. Genetic analyses of eggs and individuals have been completed from 50 of those sites which revealed that *M. coosae* were present at 33 sites with hybrids present at 21. Preliminary analyses to predict species and hybrid distributions indicate that pure *M. coosae* individuals prefer sites with greater than 68% forested cover. However, in less forested watersheds, there is a higher probability of pure *M. coosae* individuals at sites with greater bank slopes and increased distance from reservoirs. In all watersheds, sites closer to reservoirs were less likely to harbor pure *M. coosae*. These results suggest a potential trade off may be occurring between land cover and dispersal for facilitating the spread and hybridization of invasive *M. henshalli*.

During the past summer, the SCDNR Marine Resources Research Institute's Population Genetics Team has been collaborating with FLWRC staff to transition from the use hydrolysis probes to microsatellite-based identification of hybridization in these species. The microsatellite markers will improve our capabilities to resolve species interactions as well as provide conservation genetic information on gene flow, genetic diversity, and effective population size in these endemic populations. Work on the optimization and testing of the marker panel in our lab is ongoing and anticipated to be completed early next spring.

Update on reports of Asian tiger shrimp (*Penaeus monodon*) in the GSARP region.

Table 1. Number of Asian tiger shrimp *P. monodon* reported to the USGS Aquatic Nuisance Species database by state and by year between 2005 and 2017.

	NC	SC	GA	FL	PR	AL	MS	LA	TX	All states
2005	0	0	0	0	0	0	0	0	0	**0**
2006	5	0	0	0	0	1	0	0	0	**6**
2007	1	1	0	1	0	0	0	1	0	**4**
2008	8	6	4	2	0	1	0	0	0	**21**
2009	14	15	3	1	0	5	3	4	0	**45**
2010	2	20	1	2	0	0	0	7	0	**32**
2011	329	144	3	25	0	28	16	128	5	**678**
2012	21	64	55	41	1	3	14	8	1	**208**
2013	4	100	193	30	0	0	6	0	0	**333**
2014	1	63	0	5	0	5	5	1	0	**80**
2015	4	16	5	7	0	41	17	9	3	**102**
2016	0	2	0	3	0	23	5	1	0	**34**
2017	0	10	0	2	0	0	0	0	0	**12**
2018	**0**	**15**	**0**	**2**	**0**	**0**	**1**	**0**	**0**	**10**
All years	**389**	**456**	**264**	**121**	**1**	**107**	**67**	**159**	**9**	**1580**

Researchers at the SCDNR Marine Resources Research Institute (MRRI) remain interested in improving our understanding of the invasion of the South Atlantic Bight and Gulf of Mexico by the Asian tiger shrimp, *Penaeus monodon*. With that said levels of reporting and concern over this species continue to decline since their peak in 2011, (see Table 1 above). SCDNR Wildlife Biologist I Elizabeth Gooding remains the point of contact for reports and specimen collections of this invasive species from South

Carolina. The total number of *P. monodon* reported to date from SC is 456 specimens, with a size range of 61 to 330 mm TL. The cold weather in January 2018 may have negatively affected *P. monodon* in SC waters, given its Indo-West Pacific native range. In addition, both state (January 9th) and Federal (January 17th) waters were closed to trawling, in an effort to protect any overwintering white shrimp (*Litopenaeus setiferus*) from commercial fishing mortality, reducing the opportunity for commercial trawl catches of *P. monodon* during the spring of 2018. The first tiger shrimp report in 2018 did not occur until July 11th. The first seven reports all consisted of reports of single individual tiger shrimp caught aboard small vessels or from the shore, with locations ranging from Georgetown, SC to Hilton Head, SC. Only five of those specimens were donated to the SCDNR ranging in size from 63-222mm total length. In addition, the most recent and only commercial report consisted of eight tiger shrimp caught off Cape Romain and Bulls Bay, SC, one of which appeared to exceed the typical size range (250-280 mm TL) of these offshore-derived specimens collected by commercial shrimp trawlers (see Figure 4 below).

Figure 4. Asian tiger shrimp, *Penaeus monodon* collected by a commercial trawler (Miss Georgia) off Cape Romain and Bulls Bay, weighing 26oz in total.

Update on eel swimbladder parasite research.

The following manuscript was submitted to the journal *Management of Biological Invasions* this month: Jamison, M.M., Arnott, S.A., De Buron, I., Kingsley-Smith, P.R., Spanik-Hill, K. & Watson, A.M. Development of a qPCR tool for the environmental detection of *Anguillicoloides crassus*, an invasive pathogenic parasite in the American eel, *Anguilla rostrata*.

Literature Cited

Gooding, E. L., A. E. Fowler, D. M. Knott, R. T. Jr. Dillon, T. Brown, M. R. Kendrick & P. R. Kingsley-Smith. 2018. Life history and phenological characteristics of the invasive island apple snail *Pomacea maculata* (Perry, 1810) in stormwater retention ponds in coastal South Carolina, USA. *Journal of Shellfish Research* 37:229-238.

Yi, S., Li, Y., Shi, L., Zhang, L., Li, Q., & Chen, J. (2018). Characterization of population genetic structure of red swamp crayfish, *Procambarus clarkii*, in China. *Scientific Reports* 8(1):5586.