Distribution, Demographics, and Impacts of the Island Applesnail (*Pomacea maculata*) in South Carolina: Past, Present and Future Research Efforts.

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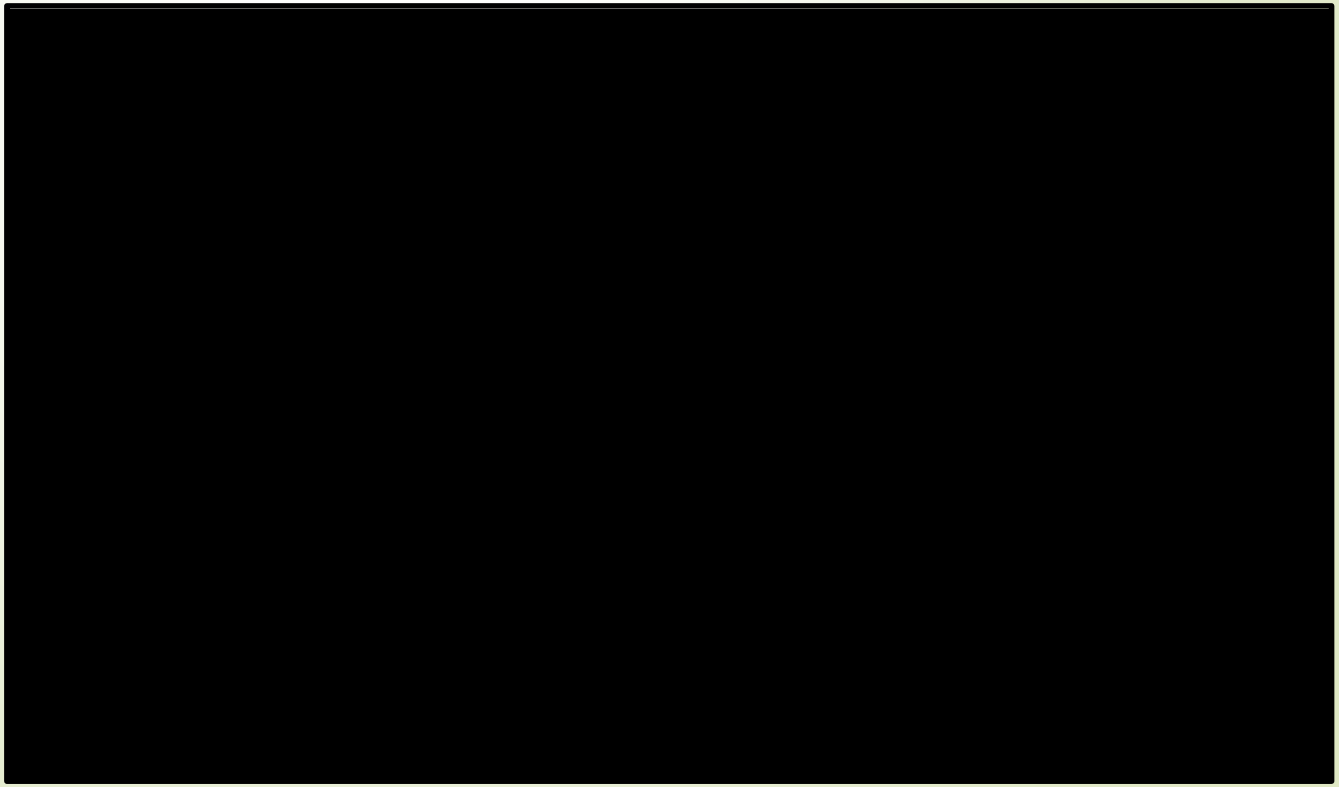
Origins and Distribution

- *Pomacea maculata* was formerly known as *P. insularum*.
- Still some debate over the taxonomy of *Pomacea* spp.
- *Pomacea maculata* is native to parts of South America.
- First reported in the U.S. in Florida in 2002.
- Now distributed throughout much of GSARP region.



Origins and Distribution

- In SC, *P. maculata* first reported in Socastee (nr. Myrtle Beach) in 2008. Currently 3 populations in SC.

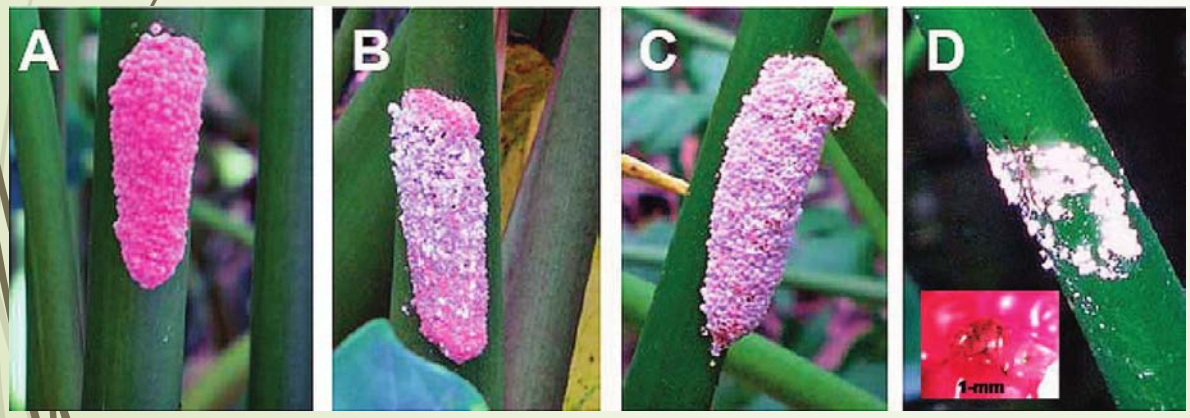

Why should I care about Island applesnails?

Diet / herbivory

- Higher rates of feeding and growth than most native freshwater snails (Baker *et al*., 2010).
- Consume a wide variety of aquatic vegetation; compete with native spp. (Morrison & Hay, 2011)
- Introduced to consume unwanted plants.
- Agricultural pests.

Early maturity / High fecundity

- Reach maturity as early as 3 months old.
- Females each deposit at least one egg mass per week from April – September (Barnes *et al*., 2008) – [although see our data later!]
- Each egg mass contains ~2000 eggs, each yielding 10-140 snails.

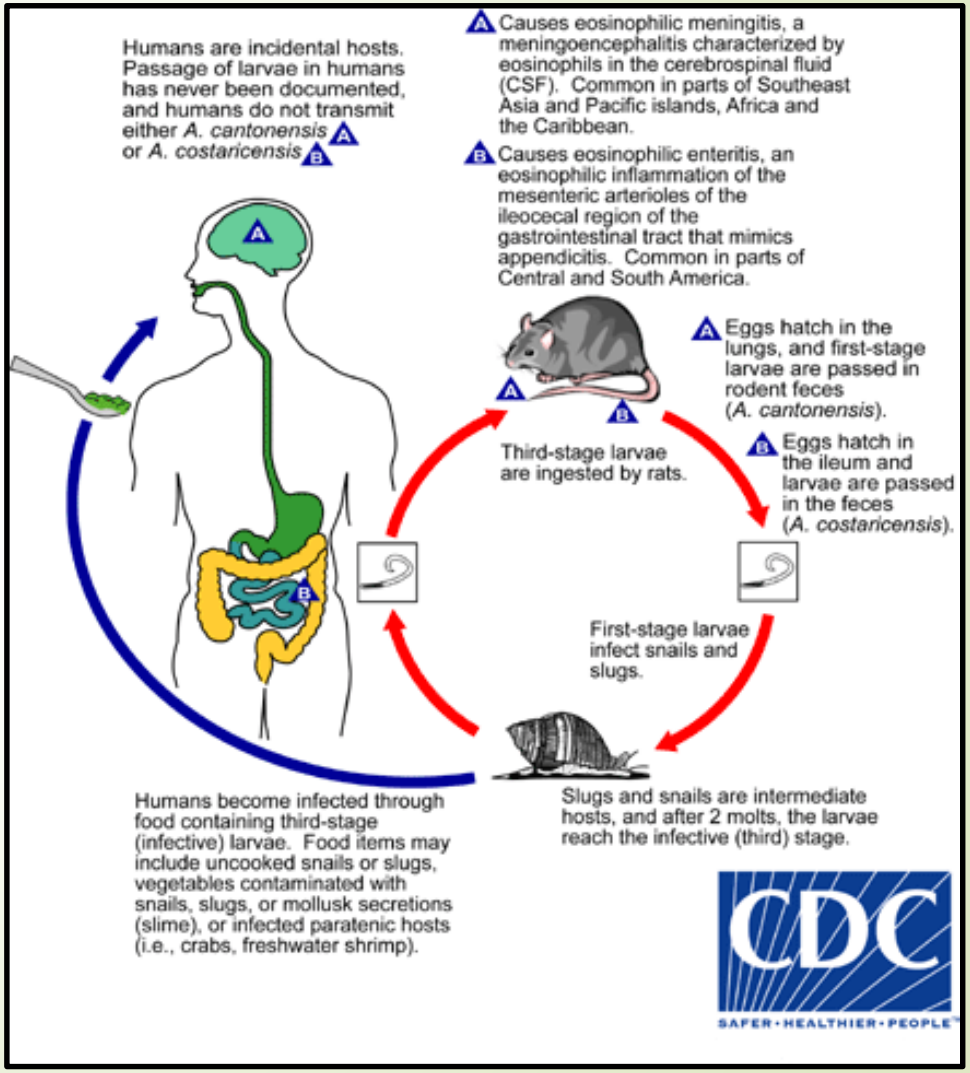


From Barnes *et al*. (2008).

Human health concern

Pomacea maculata can serve as an intermediate host for the rat lung worm parasite, *Angiostrongylus cantonensis.*

[See Teem *et al.* (2013). *Hawaii Journal of Medicine & Public Health.* Vol. 72(6):11-14.]



Recent Research Questions:

Are there additional populations of *Pomacea maculata* in *other* stormwater ponds in South Carolina, outside of the three known areas.

- Distribution Survey in 2015.

What is the seasonality of snail capture and reproductive activity (egg-laying) of *P. maculata* in SC?

- Bi-weekly Survey, West Ashley Pond, 2015-2016.

For the known populations of *P. maculata* in SC, is this invasive species present in additional ponds within those systems?

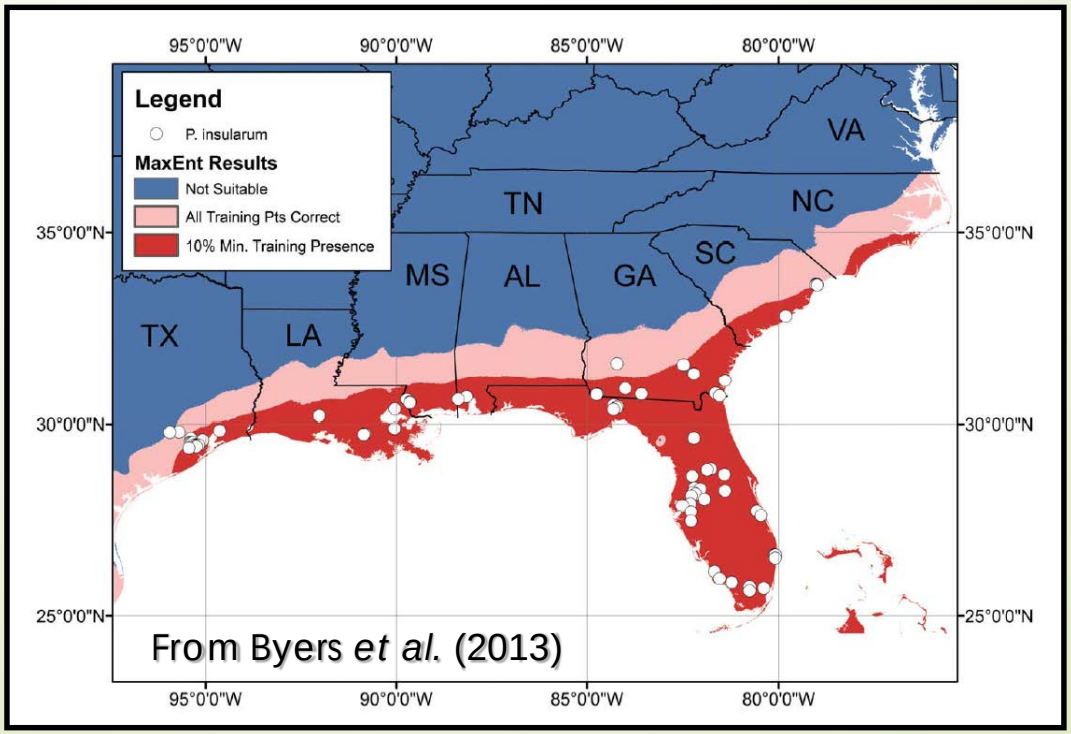
- Spread survey in 2015.

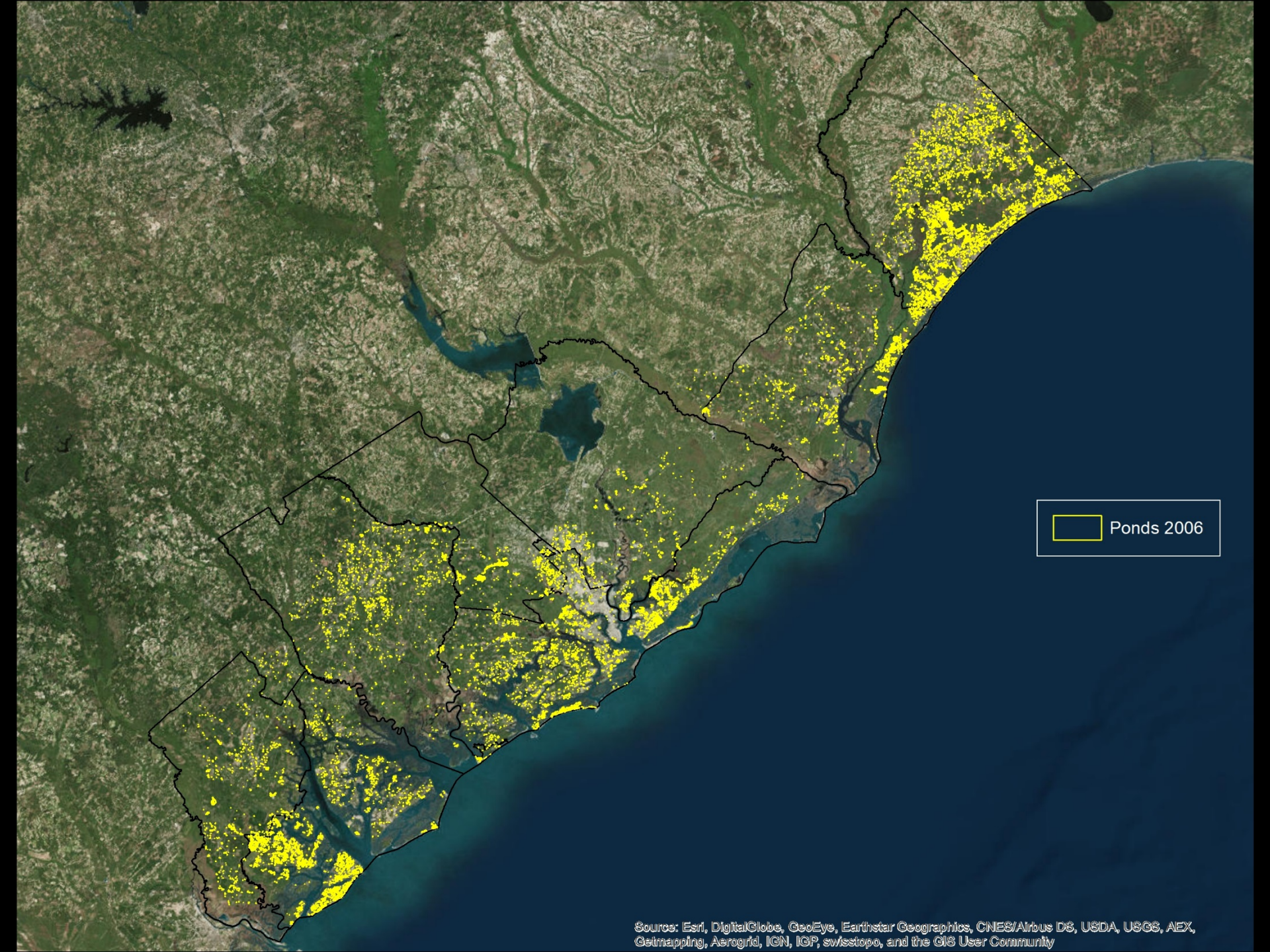
Study Sites

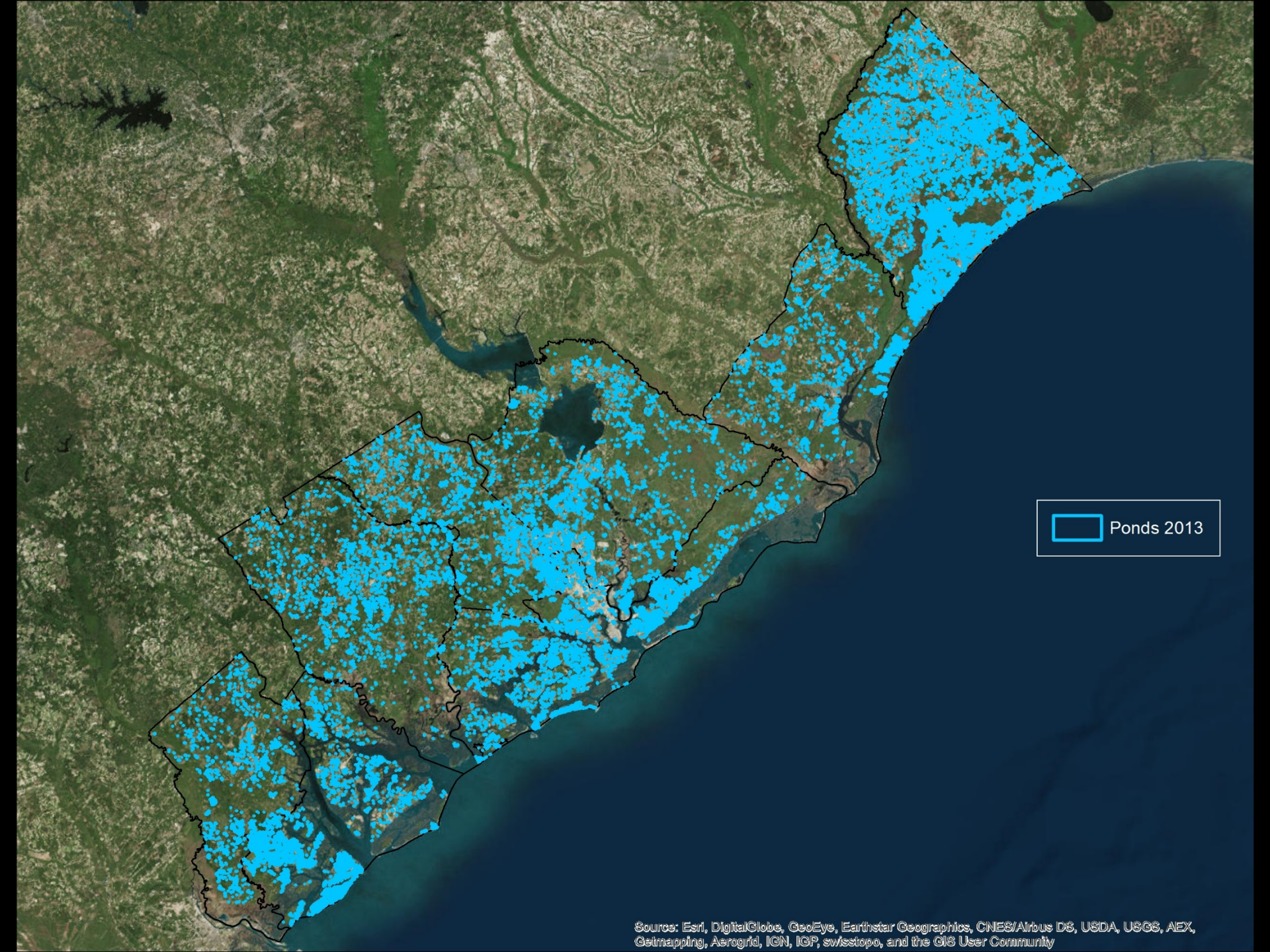
- Distribution Survey – coastal counties of SC.
- Bi-weekly Survey – West Ashley, SC pond only.
- Spread Survey – West Ashley and Myrtle Beach, SC.

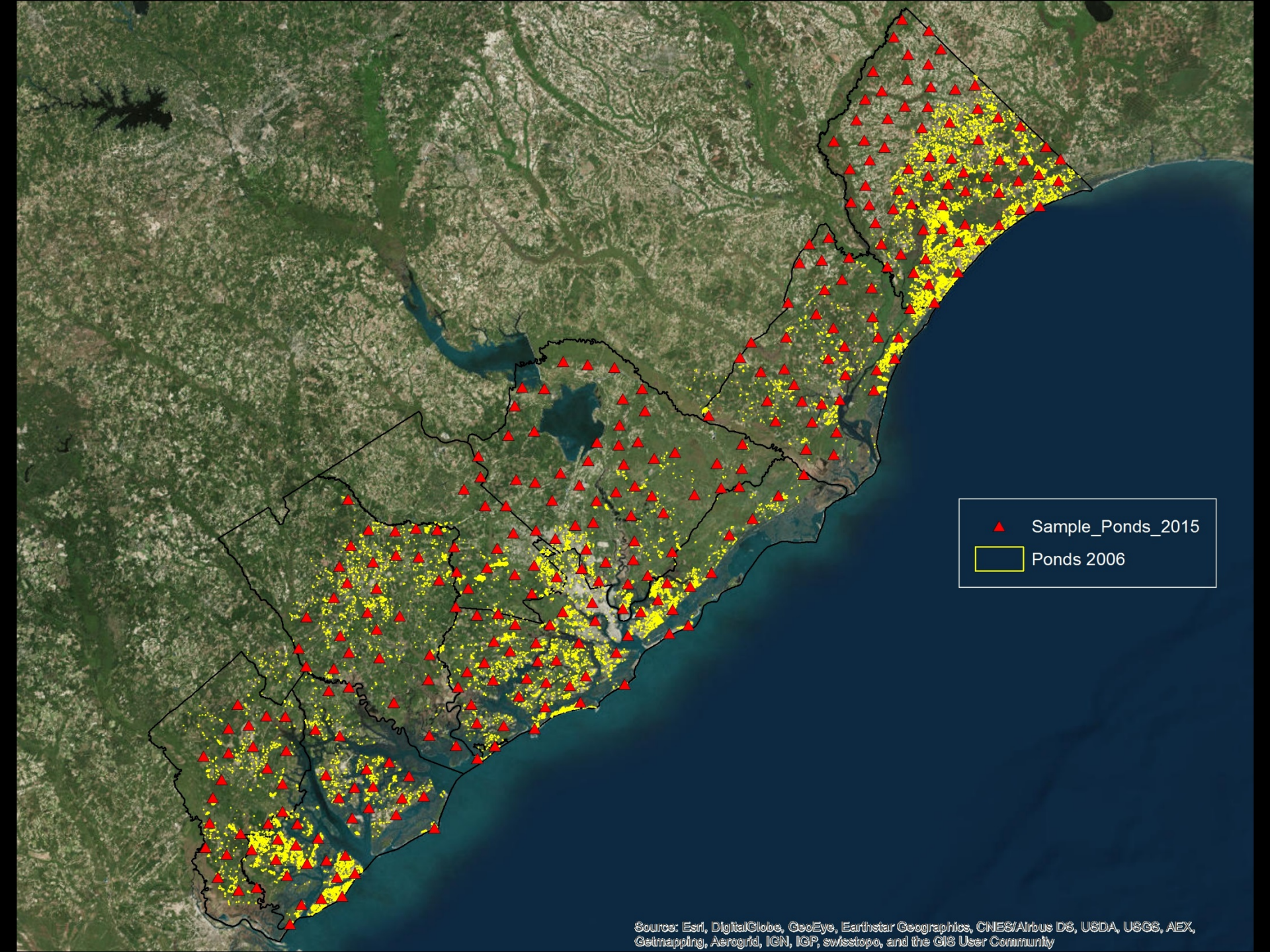
Distribution Survey

- Using Byers *et al*. (2013) model, we randomly selected 100 ponds throughout coastal SC.
- Used stormwater retention pond GIS data layer to locate ponds. Surveyed ponds on residential, commercial, and agricultural lands.




Ponds 2006
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community


Ponds 2013
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community


Sample_Ponds_2015
Ponds 2006
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Distribution Survey

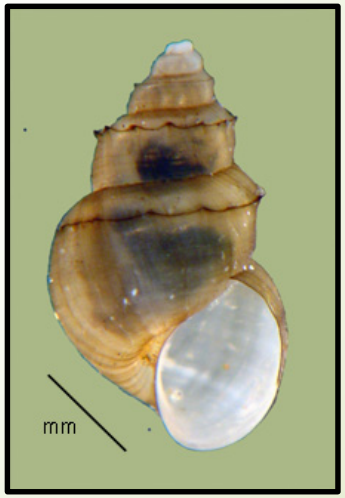
- Perimeter of pond determines the number of “rake sites” (i.e., site every 100m). A clam rake and a garden rake scrape the top 3 cm of the pond.
  - Pond perimeter surveyed for snails and egg masses.
  - Record pond characteristics (vegetation, substrates) and pond water quality.
  - Snails and egg masses are counted for each substrate type, and all accessible egg masses destroyed.

Distribution Survey

- No new *P. maculata* populations were found among the 100 randomly selected ponds. Populations may be very localized.
- 4 other invasive freshwater snail species were found on Hilton Head Island.

Bellamya japonica

Biomphalaria havanensis



Pyrgophorus parvulus

Melanoides tuberculata

Bi-weekly survey, West Ashley

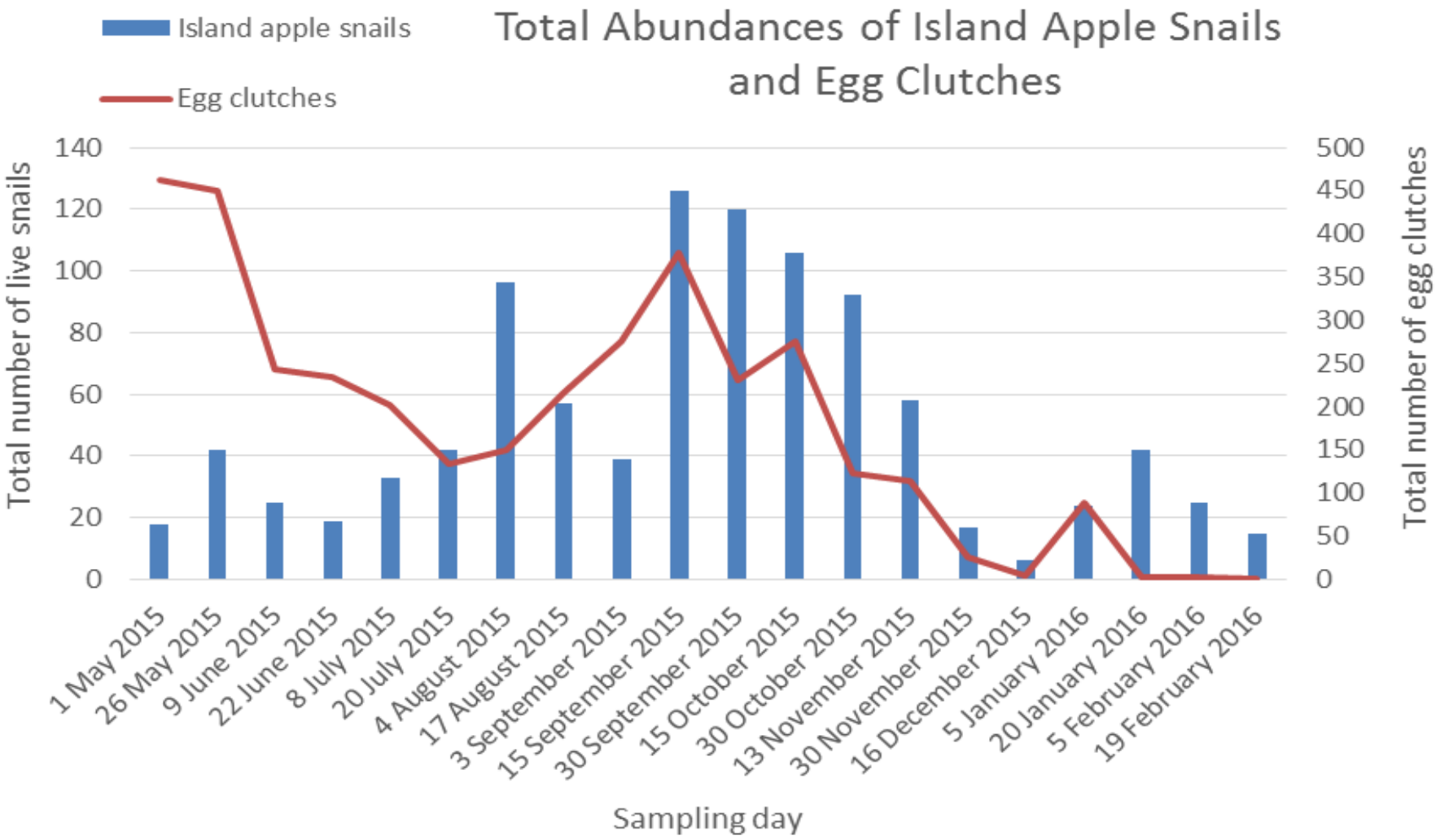
Bi-weekly survey, West Ashley

- Sampling pond in West Ashley bi-weekly (May 2015 – May 2016).
  - Visual surveys and rakings.
  - Collecting water quality data (temperature and conductivity).
  - Collecting all snails found.
  - Destroying all egg masses (and making notes on those that are not accessible).

Bi-weekly survey, West Ashley

- On the first day of this survey we collected 60+ snails (below left) and collected dozens of egg casings (below right).

Bi-weekly survey, West Ashley



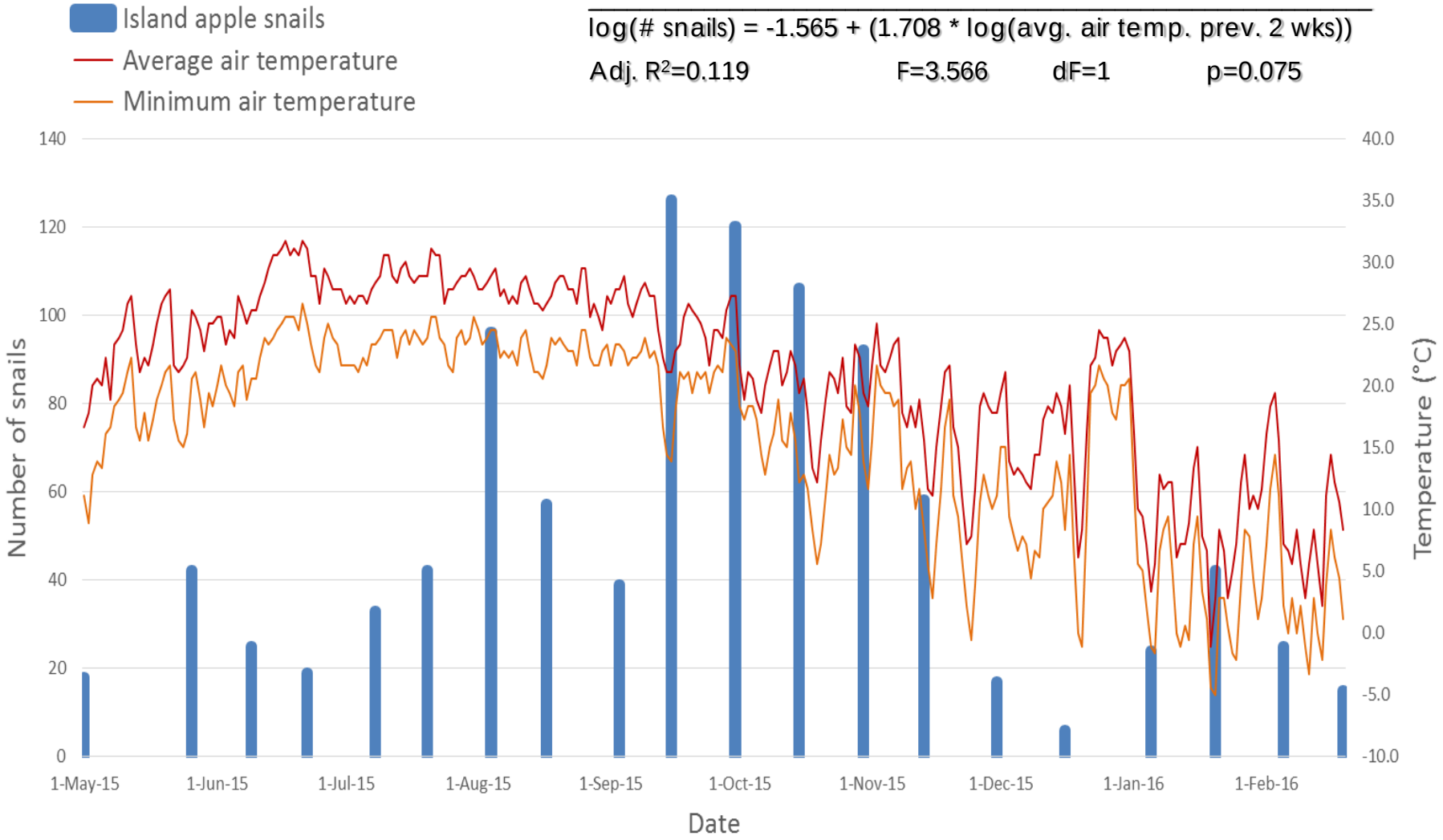
Bi-weekly survey, West Ashley

log(# snails) = -0.035 + (0.886 * log(air temp.))

Adj. R^2=0.0372 F=1.734 dF=1 p=0.204

log(# snails) = -1.565 + (1.708 * log(avg. air temp. prev. 2 wks))

Adj. R^2=0.119 F=3.566 dF=1 p=0.075



Bi-weekly survey, West Ashley

log(# egg clutches) = -7.323 + (5.064 * log(air temp.))

Adj. R^2=0.476 F=18.26 dF=1 p<0.001

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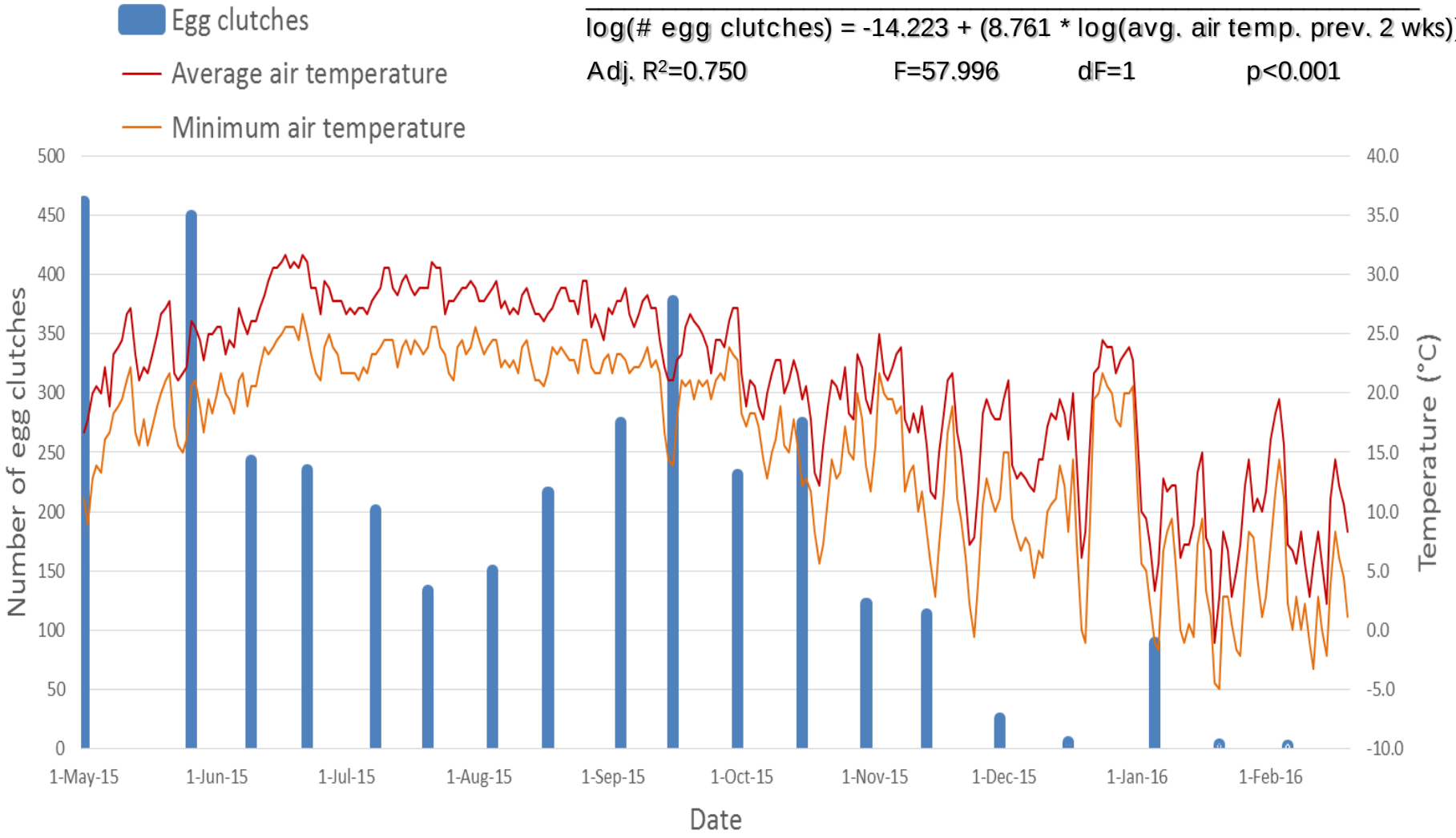
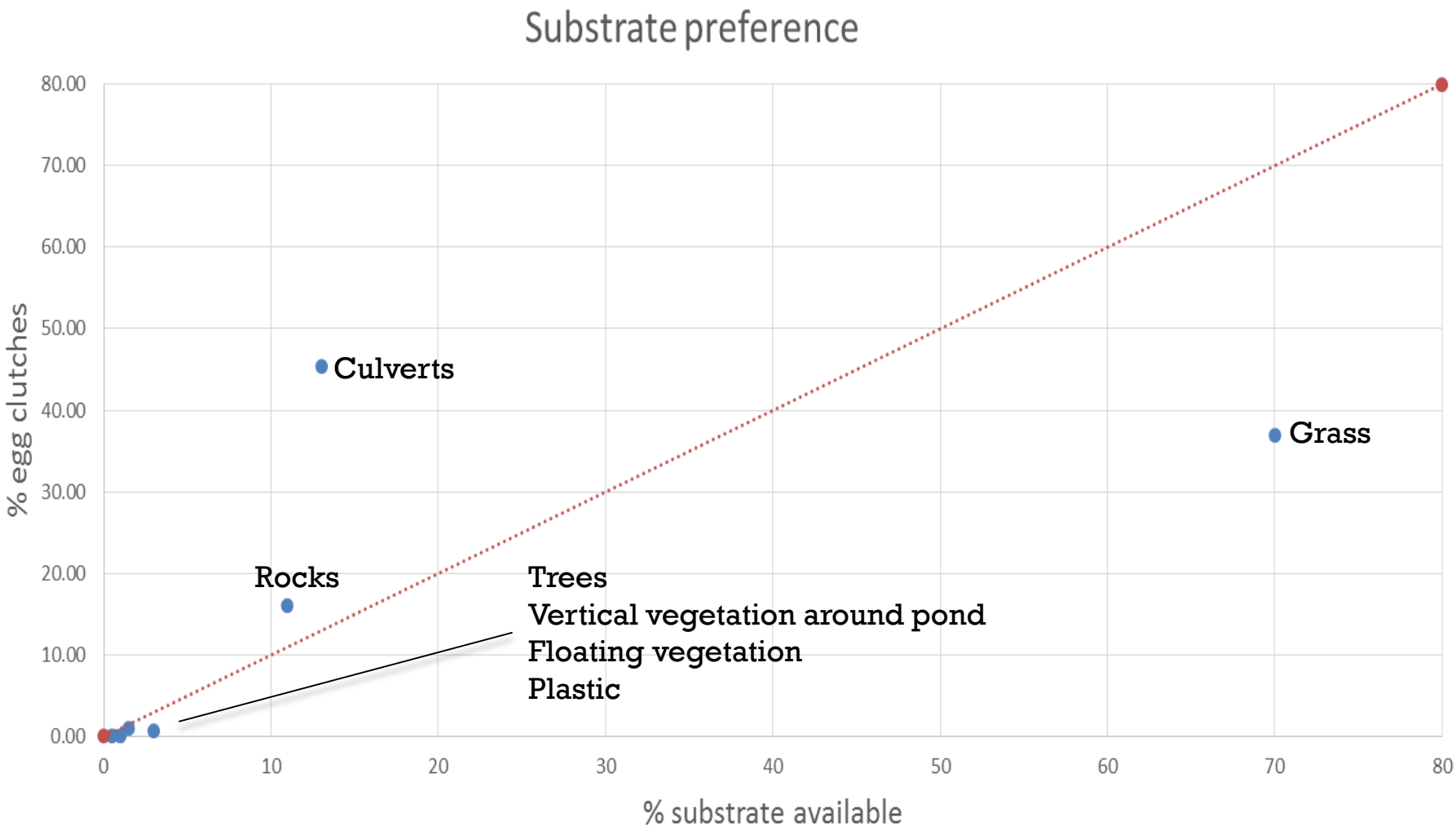
log(# egg clutches) = -14.223 + (8.761 * log(avg. air temp. prev. 2 wks))

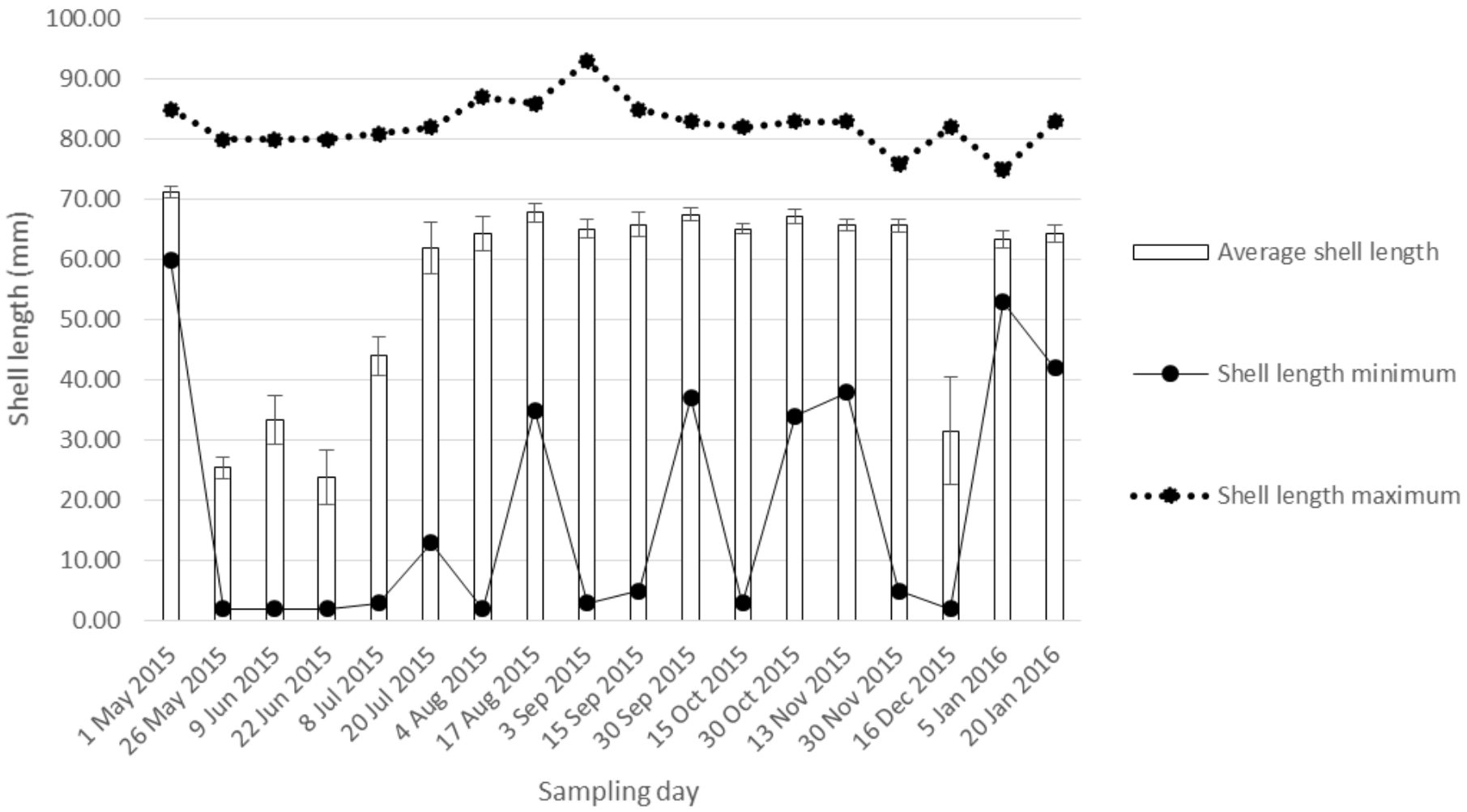
Adj. R^2=0.750 F=57.996 dF=1 p<0.001



Bi-weekly survey, West Ashley



Bi-weekly survey, West Ashley



Spread Survey

Potential mechanisms for spread

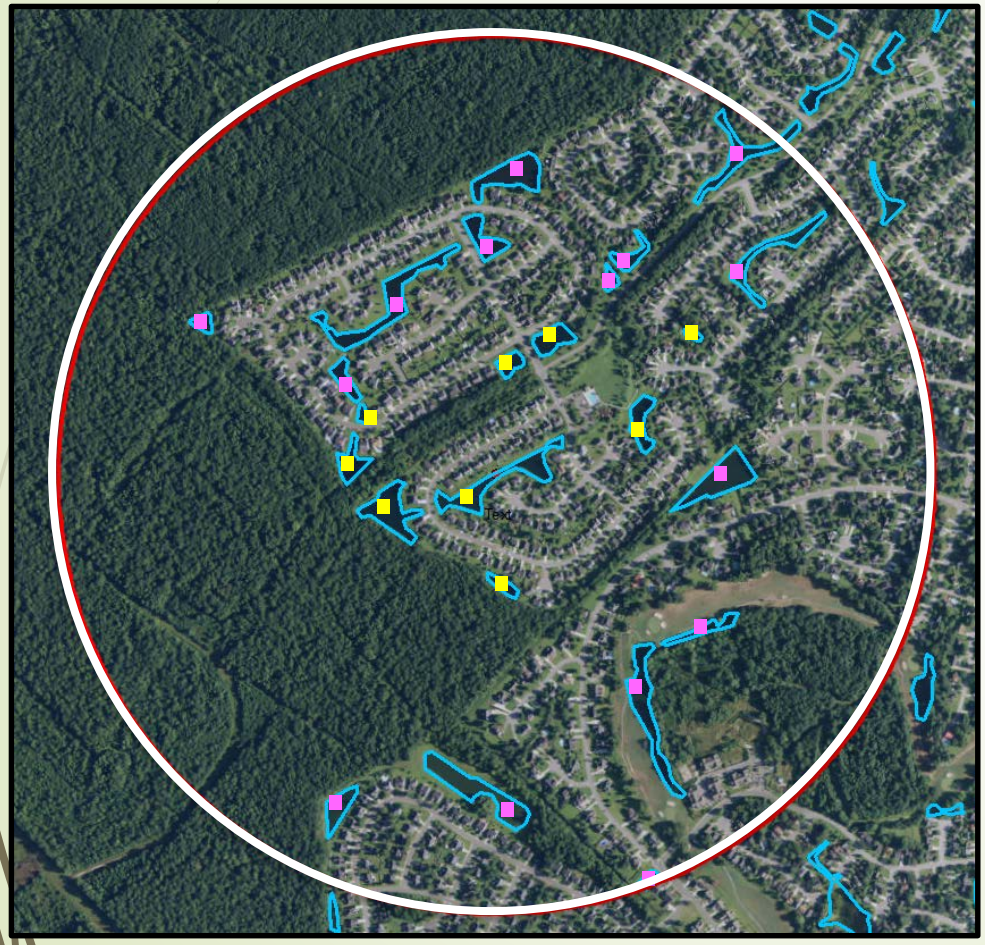
- Stormwater pond connectivity
- Predators
- New human introductions
- Flooding, large rain events

Spread Survey

[Map extracted from USGS website.]

- Surveyed all ponds within a 0.5-mile radius of known established *P. maculata* population.
- Conducted visual surveys of pond perimeters and rake site sampling.
- Surveyed 1 area in West Ashley and 3 areas in Myrtle Beach.

Spread Survey

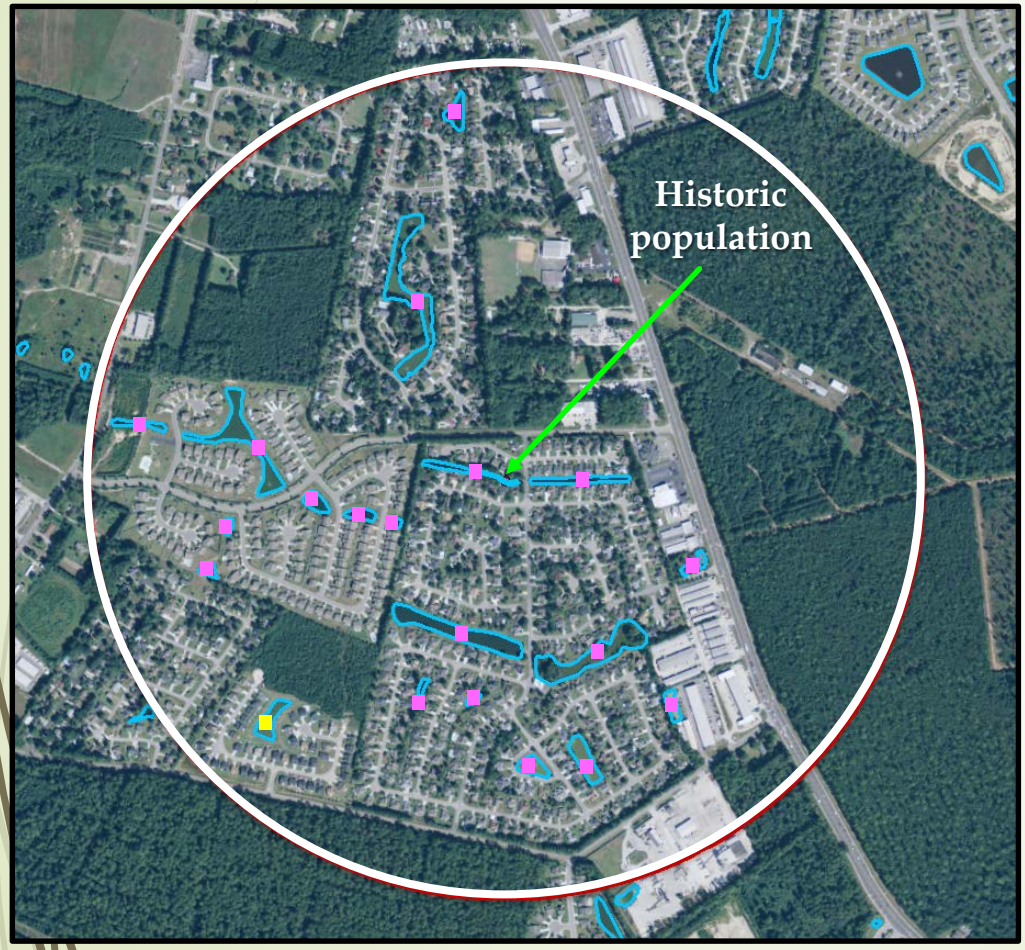


West Ashley:

- 9 of 24 ponds positive for presence of *Pomacea maculata*.

▪ = no snails observed
▪ = snails observed

Spread Survey

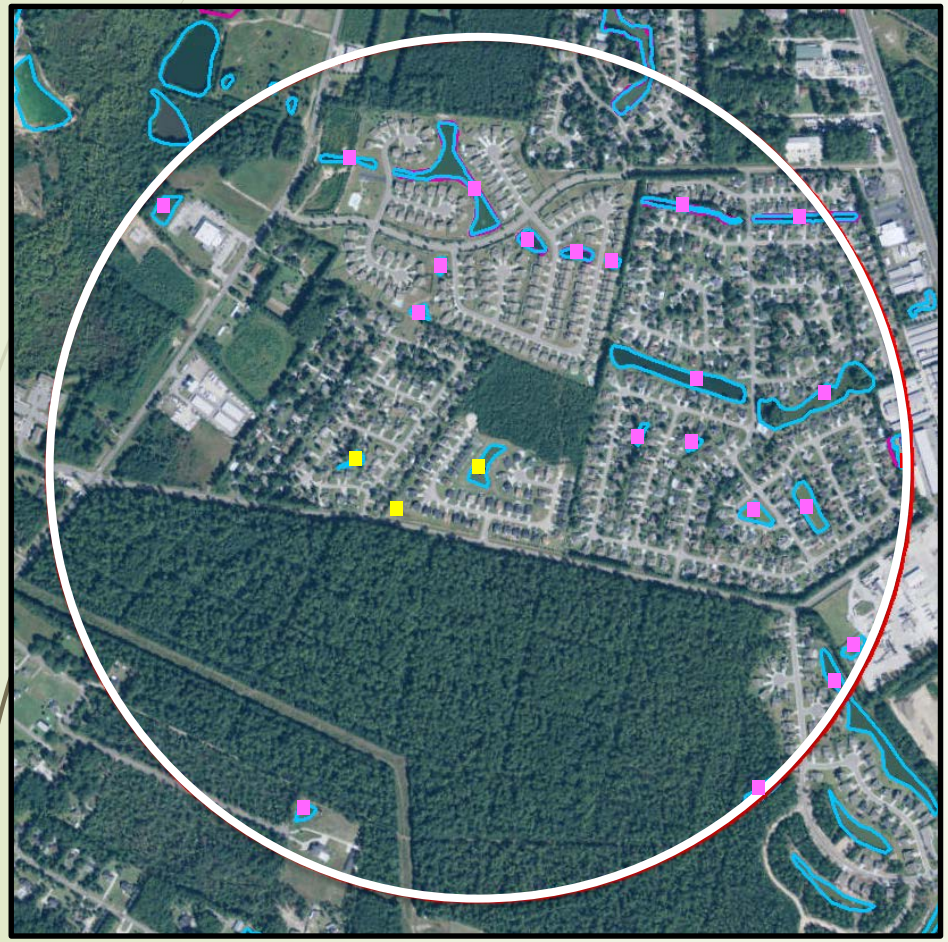


Myrtle Beach I:

- No *P. maculata* found in pond with historic population.
- Found 1 pond (out of 20 surveyed) with *P. maculata* snails and egg masses.

▪ = no snails observed
▪ = snails observed

Spread Survey

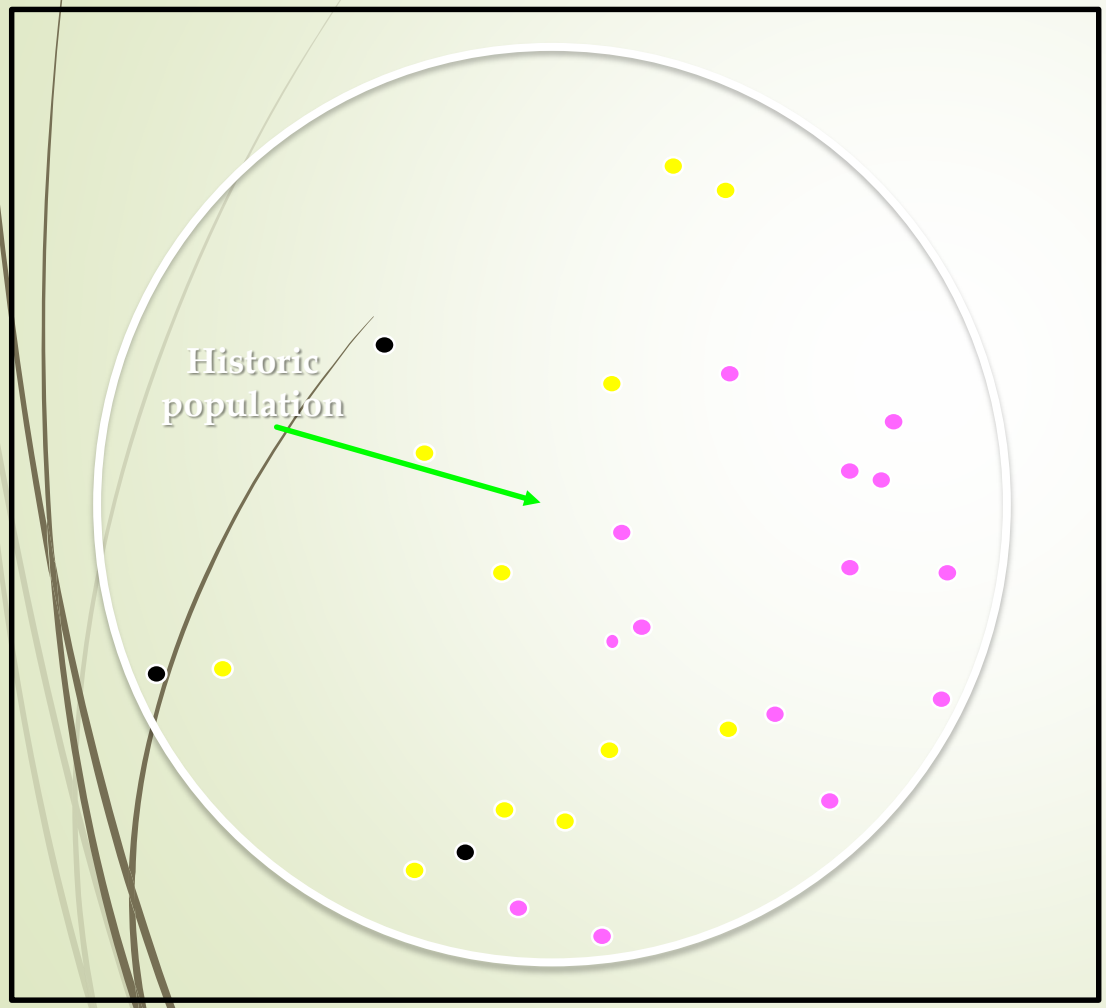


Myrtle Beach II:

- Re-centered survey area around pond where *P. maculata* were observed.
- Found 2 more ponds in survey area with *P. maculata* and its egg masses.

▪ = no snails observed
▪ = snails observed

Spread Survey



Myrtle Beach III:

- Solely a visual survey.
- 11 of 28 ponds yielded *P. maculata*.
- 3 of 28 ponds had only egg masses.
- Always egg masses present when *P. maculata* were observed.

= live snails and egg masses
= egg masses only
= no sign of snails or eggs


So what? Aren't these snails just in nasty man-made ponds?

Waccamaw River

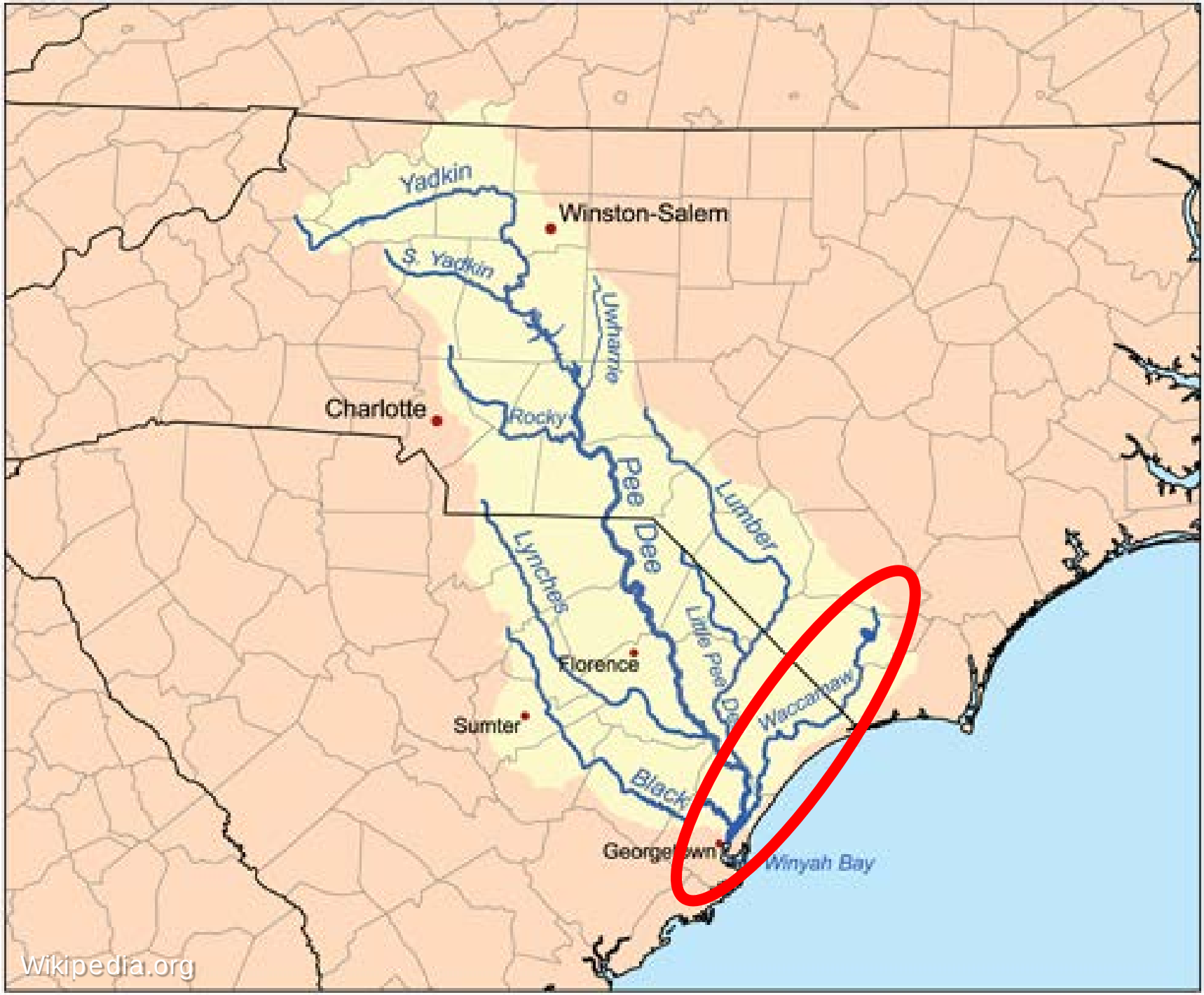
Collected March 16th 2016
by SCDNR Diadromous
Research Section

Georgetown. SC

2.07 mi

Tour Guide

1995


Yadkin
Winston-Salem
S. Yadkin
Uwharrie
Charlotte
Rocky
Pee Dee
Lumber
Lynches
Florence
Little Pee Dee
Waccamaw
Sumter
Black
Georgetown
Winyah Bay
Wikipedia.org

New Research Directions…

- Determination of presence of *Angiostrongylus cantonensis* in *P. maculata* collected in SC.
- Initial efforts focused on microscopy but we recently switched our approach to using qPCR techniques to detect parasite.
- SCDNR has expertise in qPCR that is currently being applied to *Anguillicoloides crassus*.

  [Update Tuesday afternoon!]
- qPCR protocol is already published for *A. cantonensis* (Qvarnstrom *et al.*, 2010).
- *A. cantonensis* DNA (positive control) for qPCR obtained from Dr. Qvarnstorm (CDC).
- Dissections of *P. maculata* from SC collected in 2015 are ongoing…

New Research Directions…

Photo credit: Marlene Kennedy

New Research Directions…

- Determination of snail sex ratios.

- Discussing size-at-age, reproductive maturity, and mark-recapture studies.
- Need to improve our abilities to capture snails in ponds. Baited traps, perhaps…
- Interested in physiological tolerances and diet preferences, in the context of impacts.

New Research Directions…

- New Master's graduate student!
  - Elizabeth Underwood, College of Charleston Graduate Program in MB.
  - Connection made through GSARP / Lad Akins – Elizabeth formerly worked with REEF in Bahamas.
- Initial emphasis of thesis research will be to investigate population genetic structure of *P. maculata* in SC using microsatellite markers (Chen *et al*., 2011).
- Interested in acquiring *P. maculata* tissue from other parts of its invasive range (Florida, Alabama, Mississippi, Texas).

Acknowledgements

Dr. Isaure de Buron	College of Charleston
Tiffany Brown	Unity College (NSF-REU student)
Robin Frede	College of Charleston grad student
Kelsey McClellan	College of Charleston grad student
Kristin Linesch	College of Charleston grad student
Elizabeth Underwood	College of Charleston grad student
Gary Sundin	SCDNR
Ben Stone	SCDNR
John Heinsohn	SCDNR
Danielle Draewell	SCDNR
Mike Hook	SCDNR
Dave Fuss	Horry County Government

DNR

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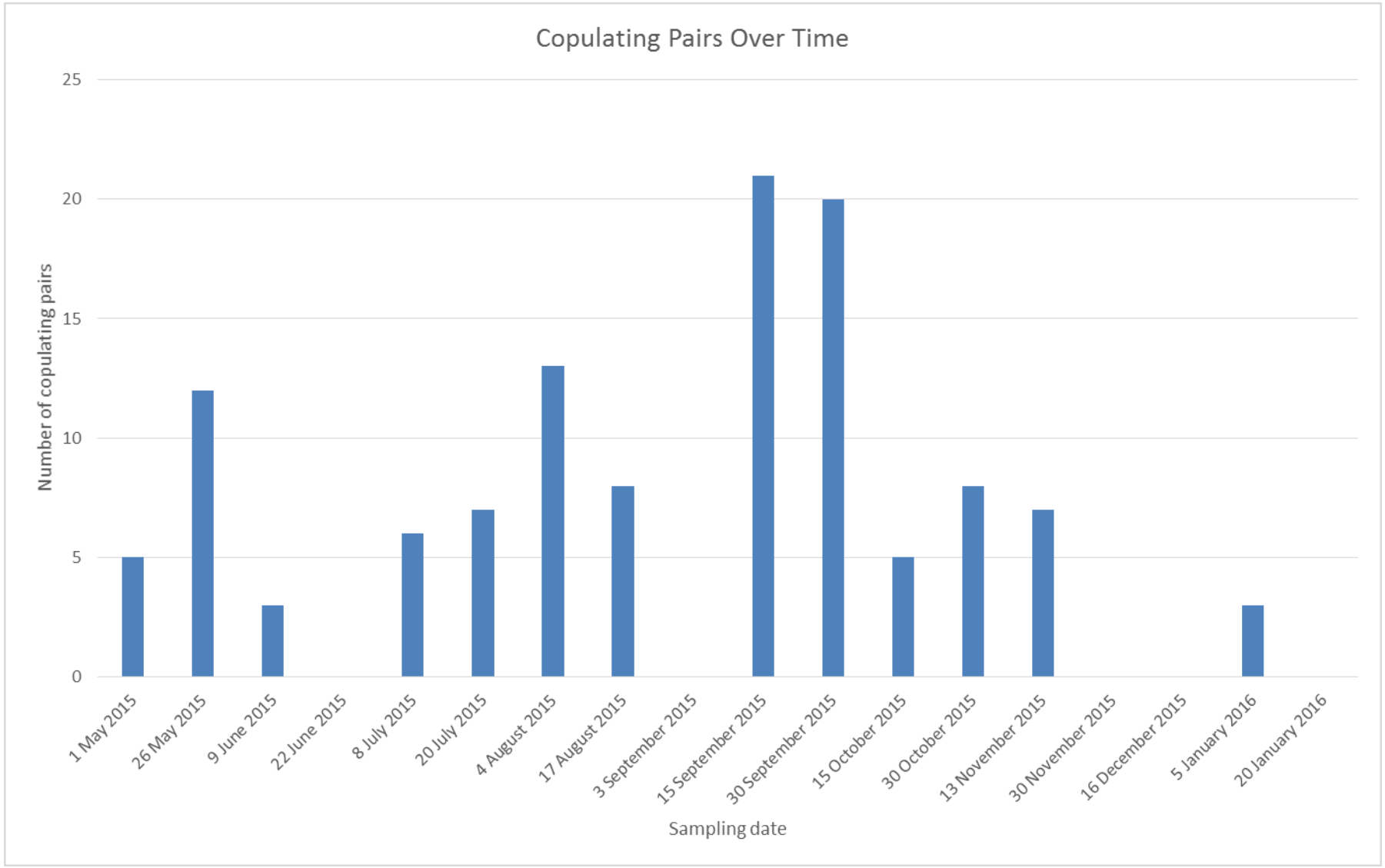
Questions?

Sampling period	# single live snails	# copulating pairs	# egg casings	Min size	Max size	Avg size
1 May 2015	8	5	462	60	85	71.17
26 May 2015	18	12	450	2	80	25.50
9 June 2015	19	3	243	2	80	33.39
22 June 2015	19	0	235	2	80	23.94
8 July 2015	21	6	201	3	81	44.03
20 July 2015	28	7	133	13	82	61.89
4 August 2015	70	13	150	2	87	64.36
17 August 2015	41	8	216	35	86	67.86
3 September 2015	39	0	275	3	93	65.13
15 September 2015	84	21	378	5	85	65.84
30 September 2015	80	20	231	37	83	67.53
15 October 2015	78	14	275	3	82	65.17
30 October 2015	58	17	122	34	83	67.22
13 November 2015	44	7	113	38	83	65.78
30 November 2015	17	0	25	5	76	65.67
16 December 2015	6	0	5	2	82	31.60
5 January 2016	18	3	89	53	75	63.30
20 January 2016	42	0	3	42	83	64.38


Copulating Pairs Over Time
Number of copulating pairs
25
20
15
10
5
0
1 May 2015
26 May 2015
9 June 2015
22 June 2015
8 July 2015
20 July 2015
4 August 2015
17 August 2015
3 September 2015
15 September 2015
30 September 2015
15 October 2015
30 October 2015
13 November 2015
30 November 2015
16 December 2015
5 January 2016
20 January 2016
Sampling date

Spread Survey – Myrtle Beach

2

1

4

3