

# REVISITING *Rapana venosa* IN HAMPTON ROADS, CHESAPEAKE BAY AS TBT ABATES

Melissa Southworth, Alexandria Marquardt, Nathan Otto, Michael Unger and Roger Mann  
Virginia Institute of Marine Science, College of William & Mary, P.O. Box 1346, Gloucester Point, VA 23062-1346

## Abstract

*Rapana venosa* (rapa whelk) is a large, long lived, predatory gastropod that is native to the Sea of Japan. It was discovered in Hampton Roads, VA in 1998, arriving via ballast water from the Black Sea and eastern Mediterranean. The Molluscan Ecology Program at VIMS enacted a bounty program in collaboration with local watermen to collect rapa whelks. Between 1998 and 2009, over 27,000 whelks were removed from the lower Chesapeake Bay and its sub-estuaries. Rapa whelks have a complex life history that exploits several niches in the Bay, they are voracious predators on local shellfish resources, and there is a lack of a local predator to control them for most of their lives. On prolonged exposure to tributyl tin (TBT), an active component in anti-fouling paints for ships as used in the shipbuilding and repair industry in Hampton Roads for over 40 years, female rapa whelks exhibit development of an accessory male penis, a state called imposex, with accompanying impaired sexual function. Imposex was notable in the 1998-2009 collections. A 2019-2020 survey by the Unger laboratory at VIMS (Figure 1) revisited select sites in Hampton Roads to sample for TBT. A 2021 follow up survey of imposex in a now endemic *Rapana* population, collected a total of 173 rapa whelks (SL range 54-145mm, 53 female + 36 imposex female + 84 male). The presence of all size ranges in the 2021 collections is indicative of continued reproduction and recruitment into the extant population. A comparison of imposex incidence between animals collected from 1999-2009 and 2021, show a decreased incidence of imposex in the population collected in 2021.

## Introduction

The invasion of Hampton Roads and the southern Chesapeake Bay by the gastropod *Rapana venosa* has been well documented (1 through 9). By 2009 *Rapana* was well established in the Hampton Roads region of the Chesapeake Bay, breeding annually as demonstrated by year class structure in the collections, arguably having a negative impact on local hard clam populations as demonstrated by characteristic predation signatures on shells. Hampton Roads remains a center for both shipbuilding and international shipping, activities that were associated with use of tributyl tin (TBT) anti-foulant until the cessation of its use in the United States in 2003. TBT has been reported to induce imposex in female marine gastropods, that is development of an accessory male penis, a state called imposex with accompanying impaired sexual function (10). Imposex was observed in Hampton Roads *Rapana* populations, notably so in close proximity to shipbuilding facilities (11). While TBT becomes sediment associated and sinks, it can also be both buried over time and degraded proffering an improved environment for the benthos. A 2019-2020 survey (Figure 1) by the Unger laboratory at VIMS revisited select sites in Hampton Roads that were noted for TBT presence in historical surveys. The question was posed: if TBT is abating is there a concurrent reduction in imposex occurrence in *Rapana* and over what spatial domain does this occur?

## Methods

*Rapana* were collected in 2021 from specific locations (Figure 1) by local watermen as part of a bounty program. Individuals were frozen and subsequently examined for morphometric descriptors (shell length, shell diameter, whole weight, shell weight, wet tissue weight) and dissected to identify sex (M/F) and occurrence of imposex (IF) with measurement of penis length in both M and IF individuals (Figures 2-4). Samples of foot tissue were dissected and frozen for future TBT assay.

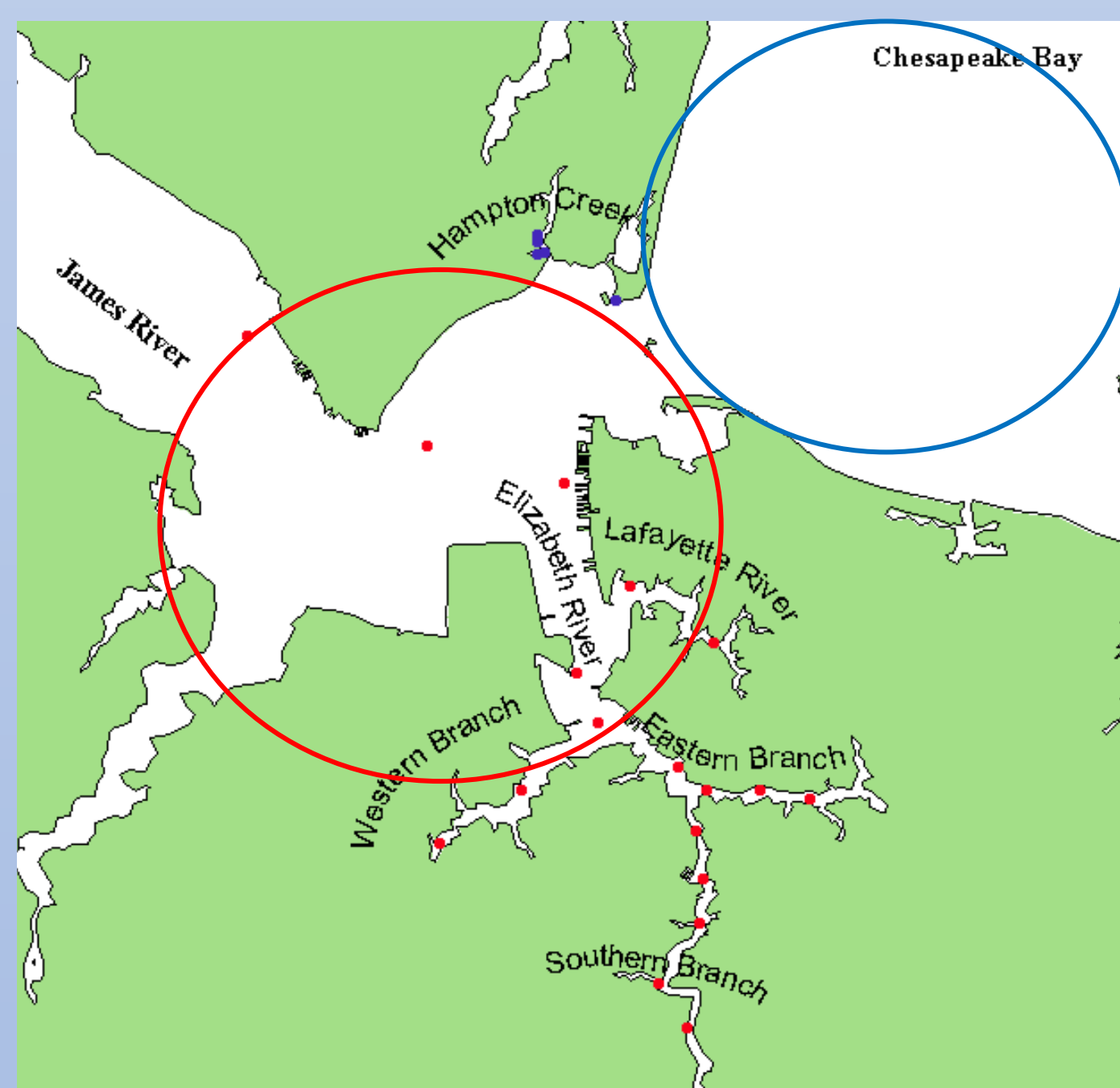


Figure 1: *Rapana* sample locations: Red circle is Craney Island/Elizabeth, Blue circle is Buckroe Beach/Oceanview  
● Sediment samples for TBT analysis

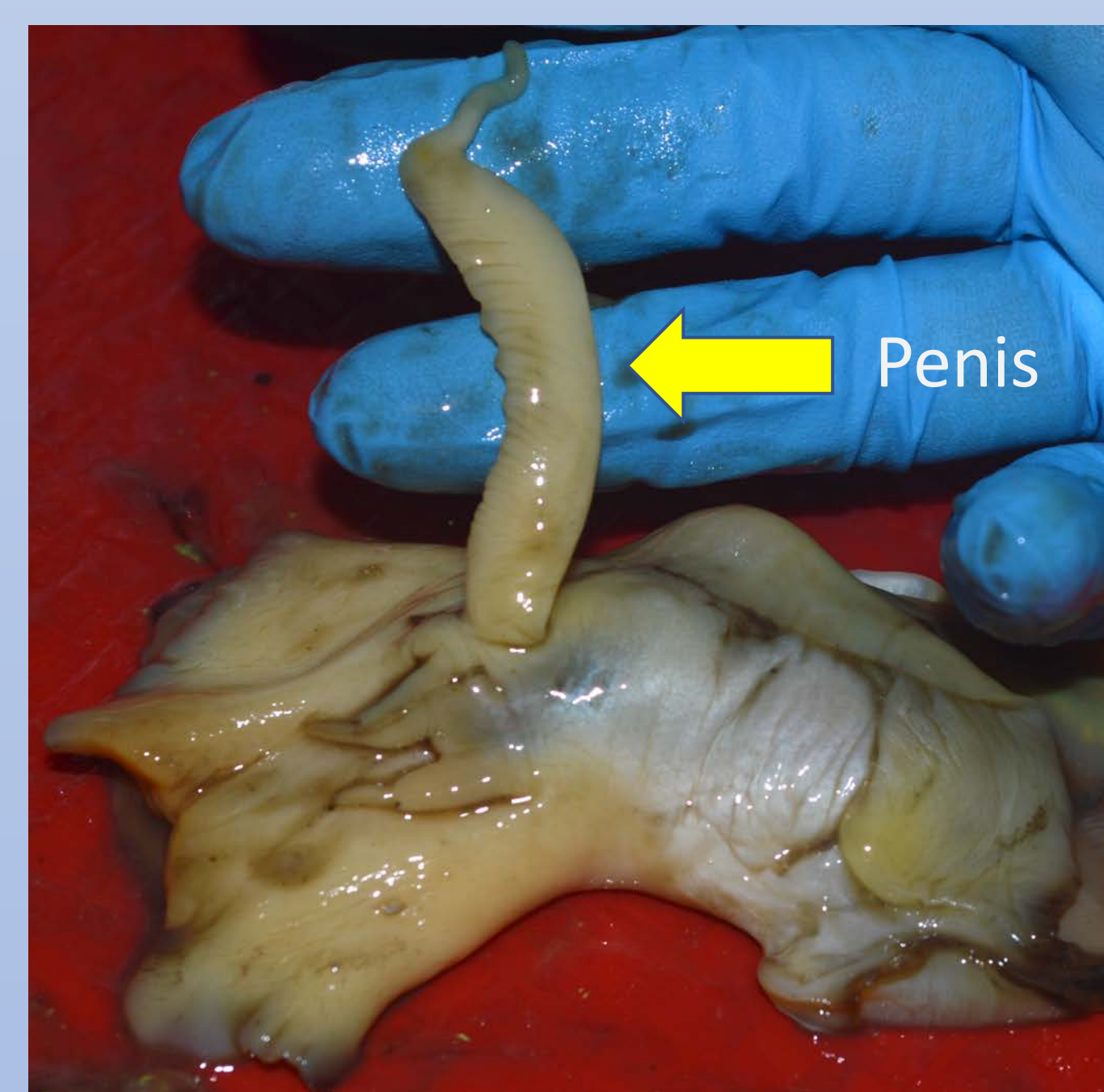


Figure 2: Male *Rapana venosa*

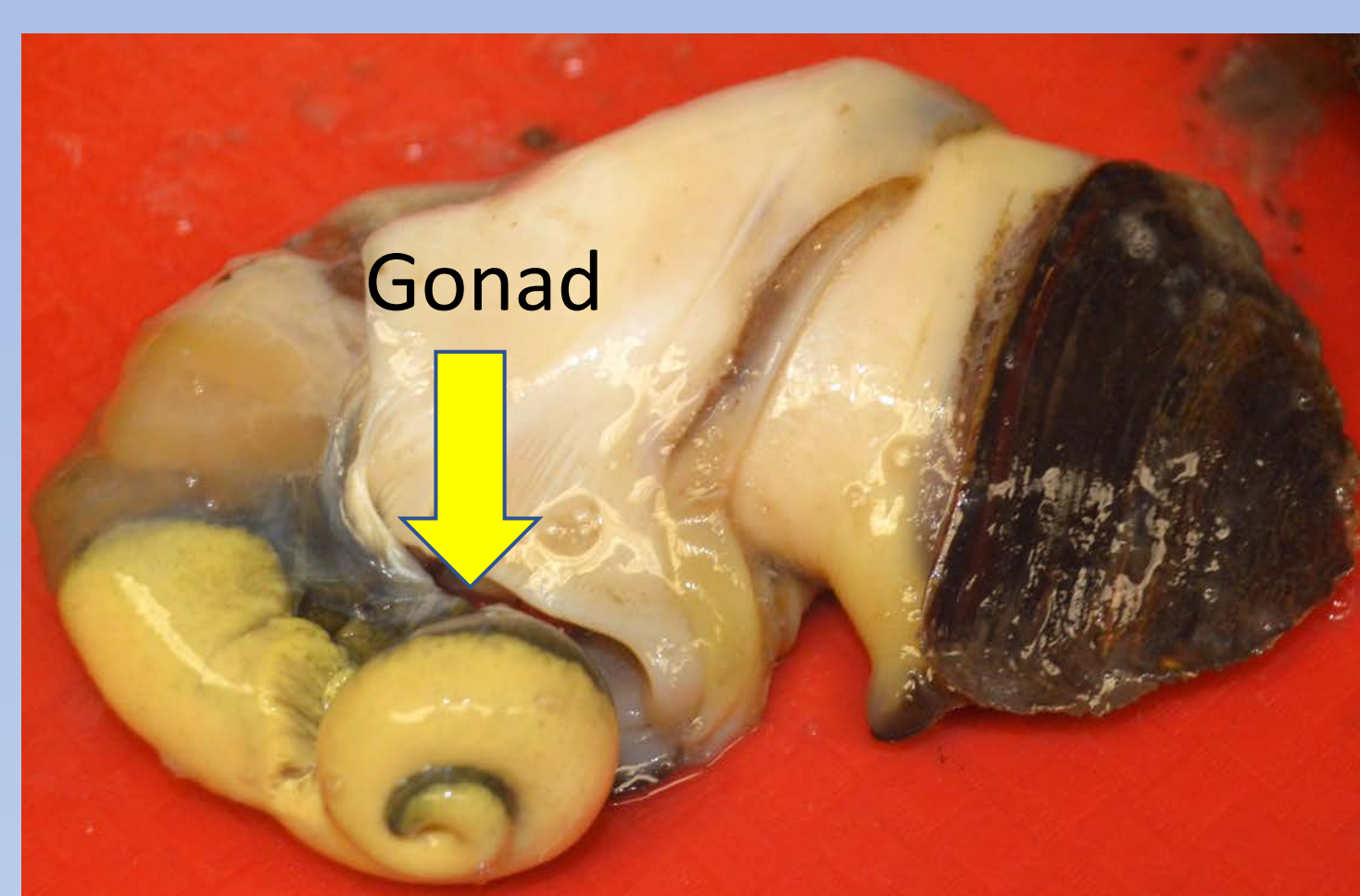


Figure 3: Female *Rapana venosa*, showing distinctive bi-coloring of gonad.

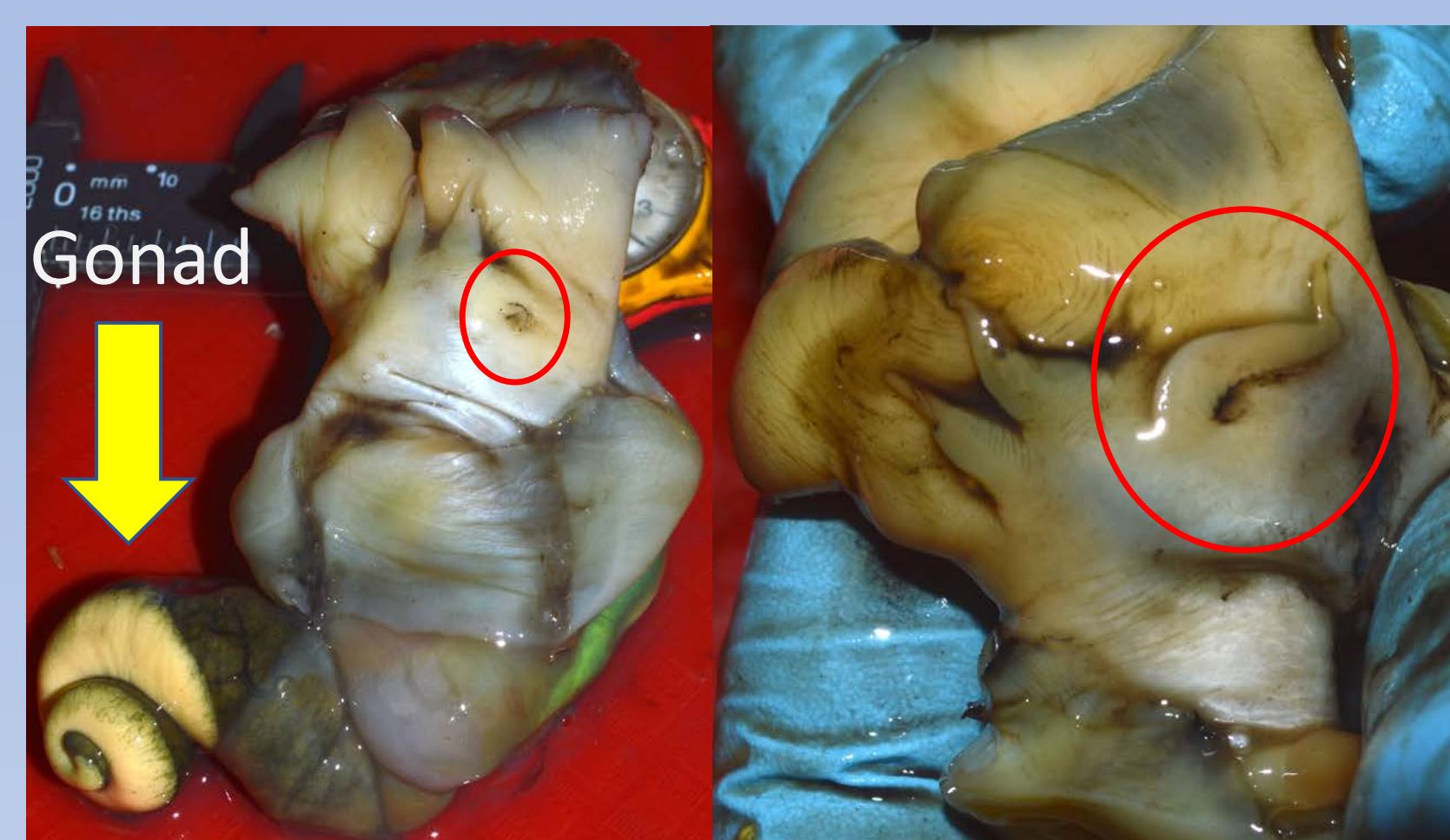


Figure 4: Imposex *Rapana venosa*, showing the distinctive bi-coloring of the gonad indicating females, but both animals are developing a penis (circled in figure).

## Results

Current results focus on total collections by region, sex ratios, and individual size. Remaining morphometric and TBT assay data will be addressed in a future publication. A total of 173 animals were collected (53 Female, 36 Imposex Female, and 84 Male) with a shell range of 54 to 145mm SL (Figure 5). IF were only found in the Craney Island/Elizabeth River location, a region in close proximity to past TBT usage in shipping associated activity. No imposex females were found within the Buckroe Beach/Oceanview sampling site. A comparison of 2021 data with data from Harding et al. (11), shows a decrease in imposex incidence and a similar trend in Relative Penis Length Index (Table 1) in the animals collected in 2021.

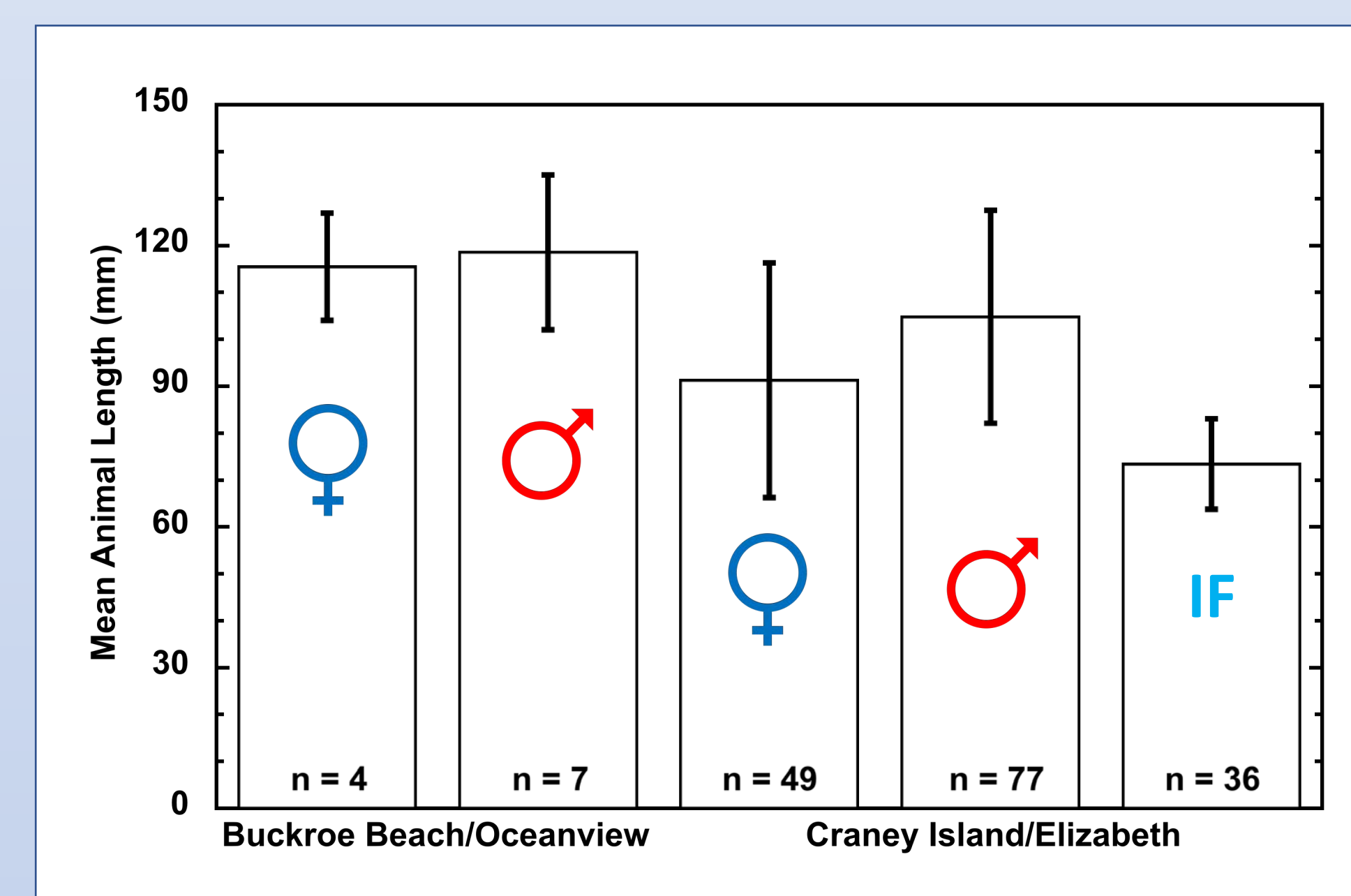


Figure 5: Average size of male, female, and imposex females collected during 2021 at the Buckroe Beach/Oceanview and Craney Island/Elizabeth sites.

Table 1: Comparison of data from Harding et al. (11) and 2021 collections. Total n is the total animals sampled each year, %IF is the percent of animals sampled that were imposex, and RPLI is the relative penis length (RPLI = (mean penis length imposex females/mean penis length males) x 100) (10).

Year	Oceanview/Buckroe			Craney Is./Elizabeth		
	Total n	% IF	RPLI	Total n	% IF	RPLI
1999	40	32.5	33.7	133	29.3	37.5
2000	106	14.2	26.9	64	23.4	38.9
2002	176	19.3	16.4	167	39.5	24.5
2005	54	11.1	10.5	95	31.6	12.6
2008	86	4.7	25.4	117	17.1	18.5
2009	59	5.1	13.3	182	13.7	26.0
* 2021	11	0.0	0.0	157	19.7	17.8

## Conclusions

The demographics of the collected individuals represent several age classes indicating that the now endemic *Rapana* population continues to reproduce with regularity. The decrease in imposex occurrence bodes well for future reproduction, but is worrisome for the continued predation pressure of the invader on native shellfish resources.

## Literature Cited

- Harding, J. M. and R. Mann. 1999. Journal of Shellfish Research. 18(1):9-17
- Mann R. and J. M. Harding. 2000. Biological Invasions. 2:7-22
- Mann, R. and J. M. Harding. 2002. Biological Bulletin. 204:96-103
- Harding, J. M. and R. Mann. 2005. Journal of Shellfish Research. 24(2):381-386
- Harding, J.M., R. Mann, and C. Ware-Kilduff. 2007. Journal of Shellfish Research. 26(1):33-42
- Harding, J.M., R. Mann, P. Kingsley-Smith, and D. Savini. 2007. Journal of Experimental Marine Biology. 352:1-11
- Harding, J. M., S. M. Gera, and R. Mann 2008. The Nautilus. 122(4):217-227
- Harding, J. M., R. Mann, and C. Ware-Kilduff 2008. Marine Biology. 155(6):571-581
- Harding, J.M. and R. Mann. 2016. Journal of Shellfish Research. 35(4):885-910
- Gibbs, P. E. and G. W. Bryan. 1987. In: Proc Oceans '87 Int Organotin symp, vol 4, IEEE, Piscataway, NJ= USA, pp 1482-1487
- Harding, J. M., M. A. Unger, R. Mann, E. A. Jester, and C. Kilduff. 2013. Marine Biology. 160:3027-3042

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