2022 MAPAIS TECHNICAL REPORT

Status: Submitted (04/27/2022 11:46:36 AM)

Project: M/INV-4f

Project Title: Revisiting Rapana venosa in Hampton Roads as TBT abates

PUBLICATIONS

No user response.

RESEARCH NARRATIVE

1 Goals and Objectives

The Goals and Objectives of the effort have remained as described in the original proposal submission.

As background, Rapana venosa (rapa whelk) is a large, long lived, predatory gastropod that is native to the Sea of Japan. It was introduced (accidentally, suspected with a shipment of oysters) to the Black Sea around the end of World War II, spread naturally westward across the Mediterranean over the following 60 years, and was discovered in Hampton Roads, VA in 1998. The vector for introduction was ballast water, coal ships traveling in ballast from the Black Sea and eastern Mediterranean to terminals in Newport News and Norfolk. Rapa whelks arguably occupy a unique niche in the lower Chesapeake Bay environment – they have a salinity tolerance lower than that of large native gastropods and are too large for most native predators of gastropods found in the system. Rapa whelks live for up to 20 years and become reproductively active within two years or less. They can exploit both hard bottom (notably oyster reefs) when small, while transitioning to softer sediments and eating hard clams as they grow larger. In short they are a near ideal invader for the southern Chesapeake Bay. A bounty program was established, through a collaborative effort with local watermen, where over 27,000 whelks were collected and removed from the lower Bay and its sub-estuaries between 1998 and 2009. From these collections, a substantial knowledge of the biology of the invader was garnered. These efforts are summarized in a series of publications.

• Harding, J. M. and R. Mann (1999). Observations on the biology of the veined rapa whelk, Rapana venosa (Valenciennes, 1846) in the Chesapeake Bay. J. Shellfish Res. 18(1): 9-17

• Mann R. and J. M. Harding. (2000). Invasion of the North American Atlantic Coast by a Large Predatory Asian Mollusc. Biological Invasions. 2:7-22.

• Mann, R. and J. M. Harding (2002). Salinity tolerances of larval Rapana venosa: Implications for dispersal and establishment of an invading predatory gastropod on the North American Atlantic Coast. Biological Bulletin. 204: 96-103

• Harding, J. M. and R. Mann. (2005). Veined rapa whelk (Rapana venosa) range extensions in the Virginia waters of the Chesapeake Bay, USA. J. Shellfish Res. 381-386.

• Harding, J.M, Mann, R and Ware-Kilduff, C. 2007. The relationship between fecundity and size in a large marine gastropod Rapana venosa (Muricidae). Journal of Shellfish Research. 26(1):33-42.

• Harding, J.M. Mann, R, Kingsley-Smith, P and Savini, D. (2007). Comparison of predation signatures left by Atlantic oyster drills (Urosalpinx cinerea Say; Muricidae) and veined rapa whelks (Rapana venosa Valenciennes, Muricidae) in bivalve prey. Journal of Experimental Marine Biology and Ecology. 352: 1-11

• Harding, J. M., Gera, S. M., and R. Mann (2008). Radula morphology in veined rapa whelks (Rapana venosa, Valenciennes 1846, Muricidae). The Nautilus 122(4):217-227

• Harding, J. M., R. Mann and C. Ware-Kilduff (2008). Influence of environmental factors and female size on reproductive effort in a temperate marine gastropod Rapana venosa (Muricidae: Valenciennes 1846). Marine Biology 155(6): 571-581

• Harding, J.M. and R. Mann (2016). Habitat disturbance combined with life history traits facilitate Rapana venosa establishment in Chesapeake Bay. J. Shellfish Research. 35(4): 885-910

To summarize, 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, and slowly expanding its range northward in the Bay within limitations of salinity tolerance, while also providing, through both shipping and “hitch-hiking” on turtles, opportunities to expand its range in a southerly direction along the Atlantic seaboard.

Given the rapid growth to a size beyond the capabilities of native predators, the question was regularly posed “what can counter the progress of this invasion?” Female Rapana whelks exhibit development of an accessory male penis on prolonged exposure to tributyl tin (TBT), a class of organotin compounds incorporated as an active component into anti-fouling paints for ships for over 40 years until its global ban in September 2008. Imposex, as the term suggests, limits sexual function and thus, in the case of Rapana whelks, the ability to maintain a local invasion. TBT was used extensively in the shipbuilding and repair industry in Hampton Roads prior to it being banned, but it remained in the water and surface sediments where the majority of adult whelks buried. Strangely, the presence of a noted toxin offered hope for control of an invader. A series of publications documented imposex in Rapana, but also noted that female adults expel TBT, a lipophilic compound, with lipid rich eggs. Such actions preserve the adults and, by extension, their impact on invaded ecosystems. These publications were as follows:

• Mann, R, Harding, J.M., and E. Westcott. 2006. Occurrence of imposex and seasonal patterns of gametogenesis in the invading veined rapa whelk Rapana venosa (Valenciennes, 1846) from Chesapeake Bay, USA. Marine Ecology Progress Series. 310: 129-138.

• Harding, J. M., M. A. Unger, R. Mann, E. A. Jestel, and C. Kilduff. (2013). Rapana venosa as an indicator species for butyltin exposure over decadal and seasonal scales. Marine Biology. DOI 10.1007/s00227-013-2292-7

• Harding, J. M., M. A. Unger, E. A. Jestel, and R. Mann. (2016). Sex and site-specific trends in veined rapa whelk (Rapana venosa) tributyltin bioaccumulation: considerations for biomonitoring. J. Mar. Biol. Ass. UK. 2016 doi:10.1017/S0025315416000849

In the more than a decade since the Rapana whelk bounty program ended sedimentation has continued in Hampton Roads. Recently Dr. Michael Unger of VIMS was approached to examine the current distribution and concentration of TBT in marine waters and sediments in the Hampton Roads region. The targeted regions for sampling broadly overlap with regions for which we also have comprehensive collection demographics for Rapana whelks for the 1998-2009 period, including imposex records for a subsample of the total collection. The expectation is that TBT levels will have abated. On the other hand lowered TBT suggest lower imposex and increased reproductive activity of local Rapana whelk populations. With this as history the overall objective of the MAPAIS supported effort was to revisit Rapana abundance, demographics and imposex status in the regions of the most recent TBT assay. This effort evaluated three foci: (i) the effectiveness of the decade long, intensive bounty program in the 1998-2009 period by simply asking is there a substantial remnant population of Rapana whelks in regions of former thriving initial invaders?; (ii) assuming Rapana are still present what is the incidence of imposex in collected material?; and (iii) if imposex is declining then what is the threat of an ongoing expansion of the local Rapana population?

---

2 Accomplishments

In calendar 2021 we worked with local watermen holding crab pot licenses and who fished in the Elizabeth River, Craney Island and Buckroe/Hampton Roads Bridge Tunnel (HRBT) regions of Hampton Roads in the Lower James River. Historically the Elizabeth River and Craney Island regions were of highest local TBT concentrations whereas Buckroe and HRBT were cleaner sites. A total of 173 Rapana were collected (shell length range 54-145mm, 53 female + 36 imposex female + 84 male). No imposex was observed at the Buckroe and HRBT sites. Data are summarized in Table 1.

Elizabeth River 2001-2009 encompasses both the Craney Island- Elizabeth River and Craney Island regions for 2021 collections. The range of sizes collected in 2021 at all sites are comparable with those for the 1998-2009 period. When examined in total the 2021 collections have representation in every 5 mm shell length increment in size from 55 mm through 145 mm. This covers every year class from ~ 2 through 12 years of age based on the plots in Harding and Mann (2016). The sizes of males and females overlapped, again in agreement with earlier data. To address question (i) in the objectives - is there a substantial remnant population of Rapana whelks in regions of former thriving initial invaders? - the answer is yes, the population is well established with regular recruitment, but are there comparable signatures of TBT impact on the 2021 population members?

Harding et al (2013) summarized sizes and imposex status of rapa whelk populations in the James River system using two established (by earlier investigators) indices. These were relative penis length and relative penis volume of imposex females compared to males. The two indices give comparable results, and in the 2021 collections we focused on relative penis length where RPLI is relative penis length = (mean penis length imposex females/mean penis length males) x 100. Data is summarized in Table 2 noting that the James River data for 1998-2009 covers the entire river whereas the 2021 data is for the Craney Island region only . The RPLI for Craney 2021 is 18.80, notably on the low end of the 1998-2009 range. To address question (ii) in the

objectives - what is the incidence of imposex in collected material? – the answer is imposex is still present, but it is arguably declining in prevalence.

Assays for TBT concentration are being pursued by Dr. Unger at VIMS with other funds. The comparison have not been completed at the time of submission of this report; however, the presence of both an abundance of non-imposex females (indeed an increasing percentage of the total) and a broad size range in shell length indicates that the invader is now endemic and breeding both successfully and regularly in Hampton Roads waters.

3 Impacts/Outcomes

Question (iii) in the objectives asked - if imposex is declining then what is the threat of an ongoing expansion of the local Rapana population? There are both good and bad outcomes and messages that come from this data set. Good – the continued effort to remove TBT from the environment is reflected in improvement in the populations of benthic invertebrates that are most sensitive as demonstrated by the decreasing incidence of imposex. Bad – the invader has clearly become endemic as indicated by both the relative ease of collection and the wide range of sizes indicating multiple year class presence and successful breeding. Once established these aggressive invaders, as indicated by the 27,000 individuals collected between 1998 and 2009, are not easily removed. They are now part of the local ecosystem. As Hampton Roads continues to be a center of world maritime trade this region must now be considered a node for export of Rapana larvae to other susceptible systems at least within the Atlantic basin. As we move to prepare a final report on the project we will also build out our web page (www/vims.edu/mollusc) on Rapana into a story map.

4 Changes/Problems

Nothing to report

5 Financial Reporting

We have expended $870 in bounty payments to watermen ($5 per live whelk) plus travel fees to collect specimens. Personnel support expenditures are currently working through the VIMS accounting system. We are within all original budget targets at this time. A complete accounting will be provided with draft final reports.

6 Figures and Tables

Tables.pdf

PARTNERS THIS PERIOD

	Partner Name	Scale	Type
1	Commercial watermen	Other	Other

Notes

The local watermen who have collaborated with this project are reimbursed on a per specimen basis, but this does not cover the cost of collection. The effort is “piggy backed” on their daily workload at no set additional cost. It represents may days of vessel time which would otherwise cost hundreds of dollars per day with a total cost far exceeding the total award to the project.

P - 12 EDUCATION (P)

1 Are you reporting on Teachers or Students impacted?

2 How many teachers or students were engaged?

3 What school district(s) or other entities did they represent?

4 Note/Justification/Explanation

We have not engaged pre-K through 12 outreach in this project. In truth, this has all been stymied by COVID. The project end product would be suitable for outreach. We have historical connections to both local school districts and the Chesapeake Bay Governors School that offer options for outreach.

PRESENTATIONS, WORKSHOPS, TRAININGS, OUTREACH EVENTS (P)

1 Activity Type

Presentation

2 Date of Activity

02-28-2022

3 Number of Attendees at YOUR Presentation, Workshop or Training

500

4 Is this Informal Education?

☑ Yes

5 Description or Title of Activity

A poster at the National Shellfisheries Association meeting in San Diego 2/28/2021-3/4/2021. Title “REVISITING RAPANA VENOSA IN HAMPTON ROADS, CHESAPEAKE BAY AS TBT ABATES.” Authors: Melissa Southworth*, Alexandria Marquardt, Nathan Otto, Mike Unger and Roger Mann

6 Citation for Presentation

“REVISITING RAPANA VENOSA IN HAMPTON ROADS, CHESAPEAKE BAY AS TBT ABATES.” Authors: Melissa Southworth*, Alexandria Marquardt, Nathan Otto, Mike Unger and Roger Mann

STUDENTS INVOLVED IN PROJECT (P)

Response 1

1 First Name: Alexandria | Last Name: Marquardt | Email:

Institution

VIMS

2 Degree Sought by Student

PhD

3 New or Continuing Participant?

New

4 Check the box if the student graduated during this reporting period
☑ has/will graduate

5 Is this a graduate student that is funded by the project (or funded by match/cost share)?
No

Only answer the following questions if you answered YES to question "Is this a graduate student supported by the project?"

6 What type of project is this student working on?
Research

7 Number of calendar months effort on this project funded by Sea Grant dollars
0

8 Number of calendar months effort on this project funded by match/cost share dollars
0

9 Note/Justification/Explanation
Student funded by VIMS Fellowship

Response 2

1 First Name: Alexis | Last Name: Hollander | Email:

Institution
VIMS

2 Degree Sought by Student
MA/MS/MMA

3 New or Continuing Participant?
New

4 Check the box if the student graduated during this reporting period
☑ has/will graduate

5 Is this a graduate student that is funded by the project (or funded by match/cost share)?
No

Only answer the following questions if you answered YES to question "Is this a graduate student supported by the project?"

6 What type of project is this student working on?
Research

7 Number of calendar months effort on this project funded by Sea Grant dollars
0

8 Number of calendar months effort on this project funded by match/cost share dollars
0

9 Note/Justification/Explanation
Funded by NSF INTERN fellowhsip

Response 3

1 First Name: Jasmine | Last Name: Whelan | Email:

Institution
William & Mary

2 Degree Sought by Student
BA/BS

3 New or Continuing Participant?
New

4 Check the box if the student graduated during this reporting period
☑ has/will graduate

5 Is this a graduate student that is funded by the project (or funded by match/cost share)?
No

Only answer the following questions if you answered YES to question "Is this a graduate student supported by the project?"

6 What type of project is this student working on?
Research

7 Number of calendar months effort on this project funded by Sea Grant dollars
0

8 Number of calendar months effort on this project funded by match/cost share dollars
0

9 Note/Justification/Explanation
Student funded by NSF REU award

Response 4

1 First Name: Shijun | Last Name: Zeng | Email:

Institution
William & Mary

2 Degree Sought by Student
BA/BS

3 New or Continuing Participant?
New

4 Check the box if the student graduated during this reporting period

☑ has/will graduate

5 Is this a graduate student that is funded by the project (or funded by match/cost share)?

No

Only answer the following questions if you answered YES to question "Is this a graduate student supported by the project?"

6 What type of project is this student working on?

Research

7 Number of calendar months effort on this project funded by Sea Grant dollars

0

8 Number of calendar months effort on this project funded by match/cost share dollars

0

9 Note/Justification/Explanation

student funded by NSF Veteran REU award

VOLUNTEER HOURS (P)

1 Provide the name of the person(s) or entity providing volunteer time, and a very brief description of their type of engagement (e.g., collected water samples; gave a talk, etc.).

The local watermen who have collaborated with this project are reimbursed on a per specimen basis, but this does not cover the cost of collection. The effort is “piggy backed” on their daily workload at no set additional cost. It represents may days of vessel time which would otherwise cost hundreds of dollars per day with a total cost far exceeding the total award to the project.

2 Enter the total number of volunteer hours provided to your project by this person(s)/entity over the time of this reporting period.

2000