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## An Interactive Application for Tracking the Movement of the Limulus Polyphemus throughout Long Island Sound (LIS)

Ismael Youssef  
*Sacred Heart University*

Samah Senbel  
*Sacred Heart University, senbels@sacredheart.edu*

Jennifer Mattei  
*Sacred Heart University, matteim@sacredheart.edu*

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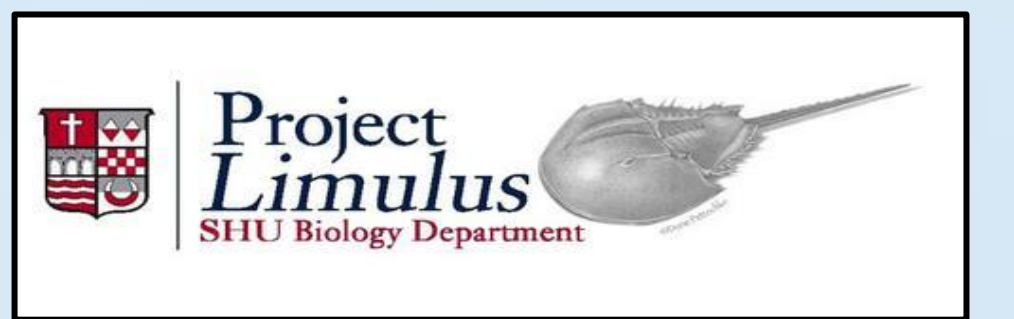
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Department of Biology, Sacred Heart University, Fairfield, CT  
 Ismael Youssef, Samah Senbel & Jennifer Mattei

## Introduction

- Commonly known as Atlantic Horseshoe Crab
- Lives in the east coast of North America
- High population density in estuaries (Long Island Sound)
- Blood used for medical purposes
  - Used to make Limulus amoebocyte lysate (LAL)
  - LAL is used for detection of bacteria
- Body used for bait
  - Used to fish American eel and whelk
- The horseshoe crabs are labeled vulnerable to extinction by the IUCN red list
- Project Limulus is a project funded by Sacred Heart University
- The Project has been ongoing for 18 years
- They have been studying and tagging Horseshoe crabs all throughout the LIS
- Have tagged and recaptured over 20,000 horseshoe crabs



Figure 1. Picture of horseshoe tag

## Results

- Using the application multiple conclusions can be made about the movement of the horseshoe crabs
- 82% of horseshoe crabs have traveled under 10 kilometers
- Very rarely did the Horseshoe crabs travel over 20 Kilometer
- 79.4% of horseshoe crabs were recaptured only once
- Generally, the number of males tagged and recaptured was double the number of females.
- When horseshoe crabs seem to travel they tend to travel to the north or east rarely to the south or west
  - This could be possibly caused by the fact that the water in the southern end of the LIS is more polluted than the water in the Northern end of the LIS

## Project Limulus Movement Analysis

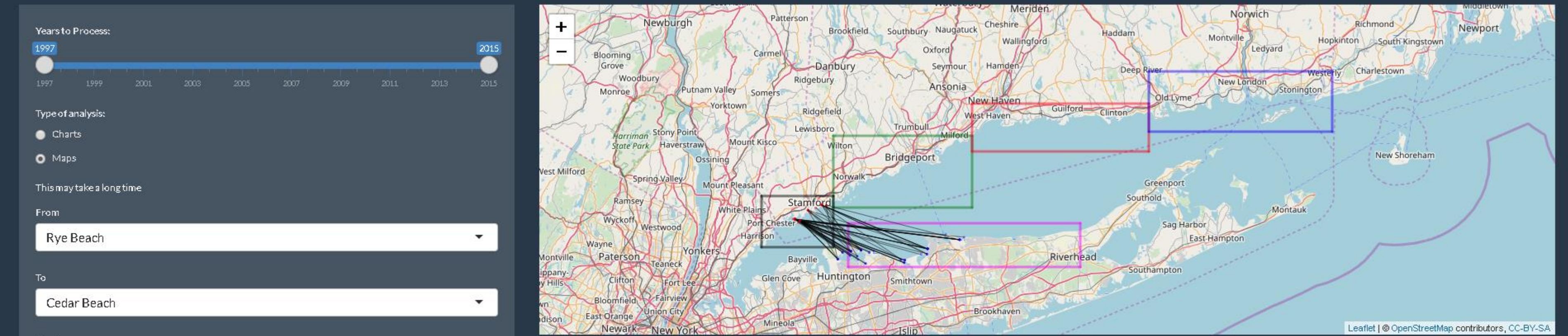


Figure 2. Screenshot of the interactive application

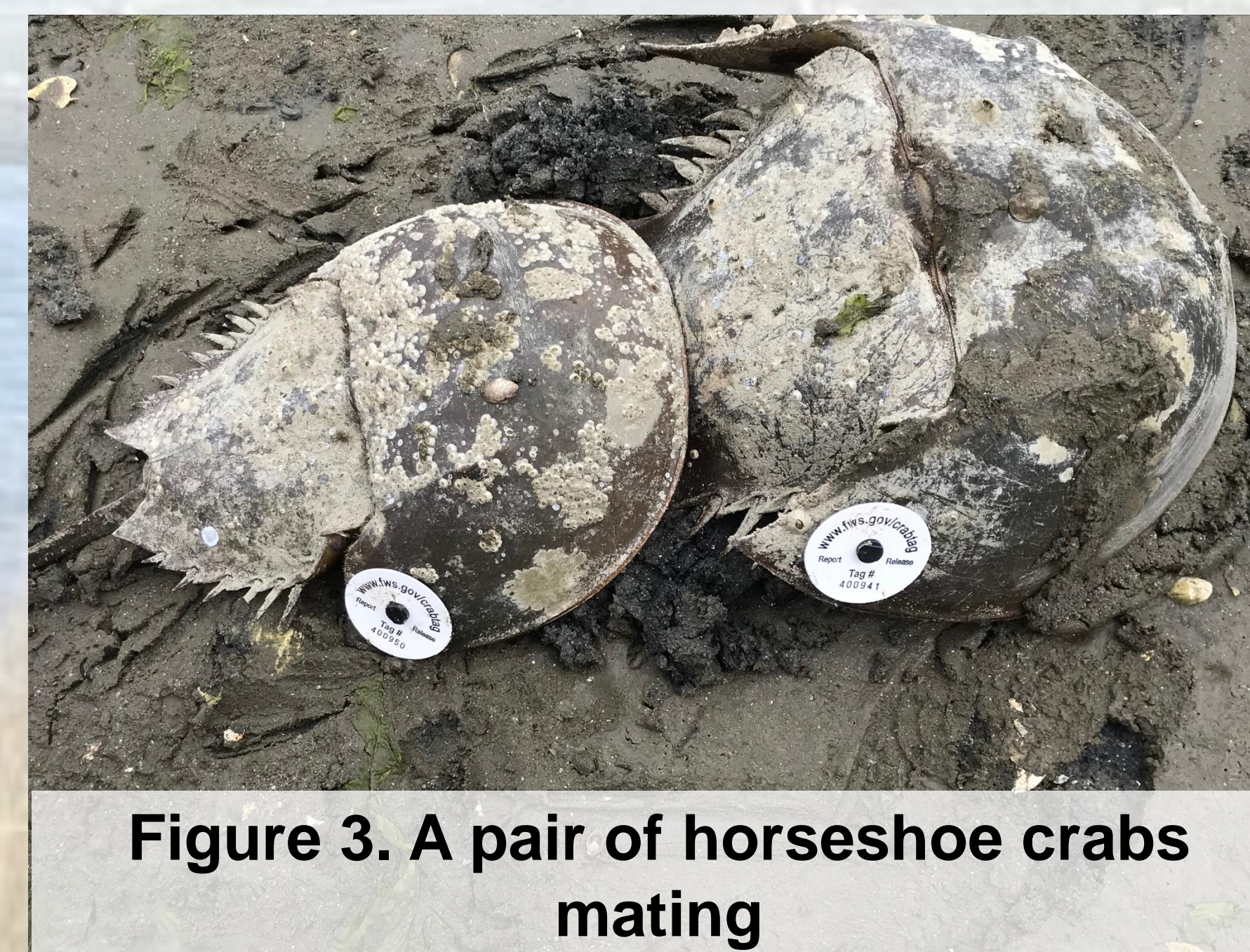


Figure 3. A pair of horseshoe crabs mating



Figure 4. Sign about reporting horseshoe crabs that are found

## Methods

- Tagging:
- Tagging was done all throughout the LIS
  - Over 20,000 Horseshoe crabs have been tagged
  - Project has been ongoing for over 18 years

- Mapping:
- R was used for data analysis
    - R is a computer coding language
    - Mainly used for data analysis and creating different types of plots and graphs
    - R was used to an interactive application that can plot maps based on the user's input
    - The Library Shiny in R was used to create the application
    - The application allows the user to pick graphs and maps to plot with different variable
    - These variable are: Distance travelled, Days between captures, Initial Longitude, Initial Latitude, final longitude, final latitude, Number of Recaps, Gender, Tag Date, Recapture Date, Tag State, Recapture state, Initial Tag region and Recapture region
    - And the user can Plot three factors at once: X-axis, Y-axis and color.

		To						
		Bluff	Sandy	Milfrd	Rye	Cedar	LI	RI
From	Bluff (3420)	3038 (89%)	137 (4%)	24 (.7%)	8 (.2%)	8 (.2%)	18 (.5%)	187 (5.4%)
	Sandy (3618)	69 (2%)	3156 (87%)	299 (8.3%)	24 (.7%)	36 (1%)	30 (.9%)	4 (.1%)
	Milford (5412)	38 (.7%)	391 (7%)	4696 (87%)	99 (2%)	127 (2.3%)	59 (1%)	2 (0%)
	Rye (1343)	9 (.7%)	22 (1.6%)	126 (9.4%)	1033 (77%)	59 (4.4%)	93 (6.9%)	1 (0%)
	Cedar (116)	4 (3.4%)	7 (6%)	15 (13%)	0 (0%)	81 (70%)	9 (7.7%)	0 (0%)
	LI (90)	0 (0%)	3 (3.3%)	6 (6.6%)	3 (3.3%)	7 (7.8%)	70 (78%)	1 (1%)
	RI (66)	1 (1.5%)	1 (1.5%)	0 (0%)	0 (0%)	0 (0%)	1 (1.5%)	63 (95.5%)

Figure 5. Movement of the horseshoe crabs between the regions

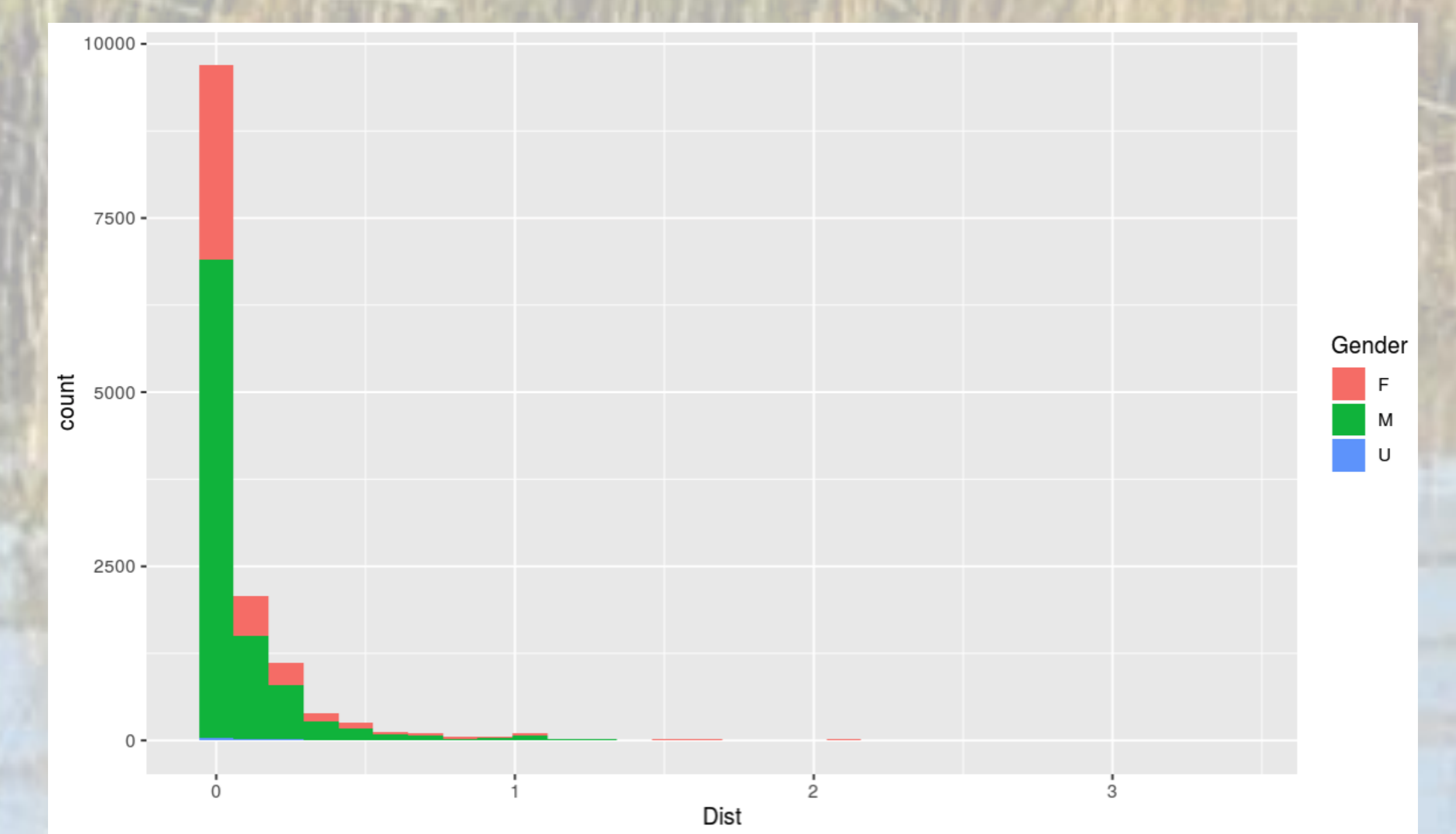


Figure 6. Distance travelled by the horseshoe crabs

## Conclusion & Future Directions

- Limulus Polyphemus is a species of horseshoe crab that inhabits the LIS
- An interactive application was created to map and graph the movement of Horseshoe crabs in the LIS using the coding language R
- Data from project Limulus was used
- Most of the moving Horseshoe crabs are moving to the north and east for unknown reasons

## References

- RCrab Shiny app, <https://senbel.shinyapps.io/RCrab/>, last accessed on Jan 1st, 2019.
- Project Limulus at Sacred Heart University Biology dept. website, <https://www.sacredheart.edu/academics/collegeofartssciences/academicprograms/biology/projectlimulus/>, last accessed on Jan 1st, 2019.
- Beekey M, and Mattei J, "The Mismanagement of Limulus polyphemus in Long Island Sound: What are the Characteristics of a Population in Decline?", Changing global perspectives on biology, conservation, and management of horseshoe crabs. Springer, 2015.



Figure 7. Tagged Horseshoe crab found in Long Island Sound