Salinity and Water Level Effects on Red Mangrove (*Rhizophora mangle*) Propagule Establishment

NICOLAS ALVAREZ, SAMANTHA CARCAMO, OMAR LOPEZ

BIOTECH @RICHMOND HEIGHTS HIGHSCHOOL

INTRODUCTION

Red mangroves (*Rhizophora mangle*) are abundant in forested coastal wetlands of the southeastern United States. They provide key ecosystem services:

- Storm protection and shoreline stabilization
- Improved water quality
- Habitat and nursery grounds for marine organisms
- Long-term carbon storage

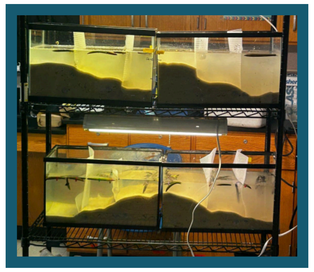
- Coastal ecosystems are rapidly changing due to sea-level rise and increasing temperatures.
- Successful establishment is critical for seedling survival and long-term forest recruitment.
- Mangroves are displacing tidal marsh plant communities (Krauss et al., 2011).
- In the dwarf mangrove community, the effects of salinity and water depth and size on propagule establishment remain unclear.

PROBLEM STATEMENT

- How do **size, salinity and water depth** (independent variables) influence the **Establishment and Root Growth** (dependent Variables) of Dwarf Red Mangrove (Rhizophora mangle) propagules during early development?

HYPOTHESIS

- We predict that higher water levels and higher salinity will have lower propagule establishment, root mass and number, and that smaller propagules will have lower establishment, root mass, and number than larger ones.



DATA ANALYSIS

Data Analysis Establishment:(N=162)

- Both **propagule size and water depth** had significant effects on establishment (Table 1 and Fig.1 & Fig.2)
- Table 1 . Results of Establishment 3 Way ANOVA

Factor	Sum Sq	Df	F value	Pr(>F)
salinity	0.2490	1	2.1228	0.15379
size	0.8189	2	3.4912	0.04113 *
water.depth	0.7942	2	3.3860	0.04494 *
salinity:size	0.1523	2	0.6491	0.52851
salinity:water.d	0.3004	2	1.2807	0.29020
size:water.d	0.1811	4	0.3860	0.81722
salinity:size:water.d	0.0576	4	0.1228	0.97338

- **Data Analysis Root Mass and Number:** (N=128) three-way factorial ANOVA showed **Root Mass** was affected by **Salinity, Size,and the interaction of both Salinity and Size.(Fig3)**
- water depth had no significant effect on root mass. Root Number no sig.. Table 2.Salinity,Size and Water Depth effects on Root Mass

Factor	Sum Sq	Df	F value	Pr(>F)
Salinity	**0.010465**	**1**	**5.8765**	**0.01702 ***
Size	**0.012530**	**2**	**3.5181**	**0.03313 ***
Water_D	0.004277	2	1.2008	0.30498
Salinity: Size	**0.013309**	**2**	**3.7369**	**0.02699 ***
Salinity:Water_D	0.002916	2	0.8187	0.44373
Salinity:Water_D	0.002916	2	0.8187	0.44374
Salinity:Water_D	0.002916	2	0.8187	0.44375

FIG 1. MEAN PERCENT ESTABLISHMENT BY SIZE

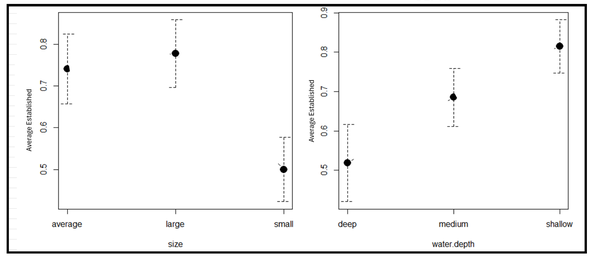


FIG 2.MEAN PERCENT ESTABLISHMENT BY WATER DEPTH

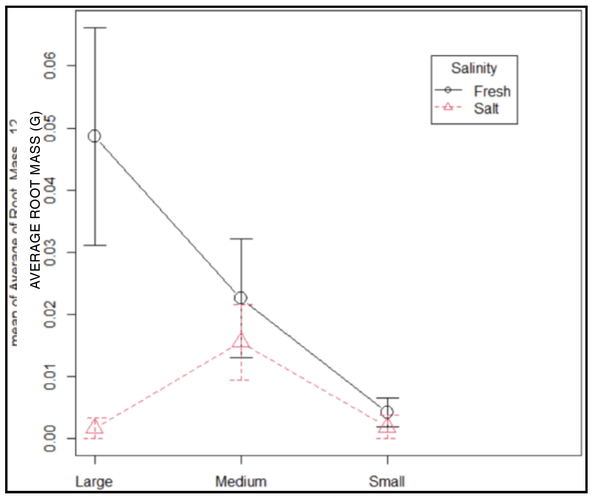


FIG. 3. AVERAGE ROOT MASS BY SALIITY AND SIZE.

CONCLUSION

- **Water depth and propagule size were the primary factors influencing Dwarf Red Mangrove (*Rhizophora mangle*) propagule establishment**. Salinity was not a significant effect on establishment.
- Across all propagule sizes, establishment was greater in shallow water than in deeper water.
- Smaller propagules had lower establishment compared to Average and Large propagules.
- Ewe 2009 reported similar results that larger propagules have greater establishment rates. We believe the greater energy reserves and density of the larger propagules may be the reason for the higher establishment.

- **Size and salinity both had an effect on root mass.**
- Root mass was greater in larger propagules grown in freshwater compared to saltwater. Small propagules had low root mass regardless of salinity.
- Contrary to expectations, water depth did not significantly affect root mass.
- Freshwater conditions may reduce stress on root growth, supporting mangrove expansion into freshwater marshes.

PROCEDURES

- We set up six ten-gallon fish tanks: three tanks (35 ppt salt water) and three tanks (0 ppt) freshwater. We used aquarium grade salt. Salinity was measured using a refractometer.
- Each tank was divided into three sections, each representing a different water level, which were kept at 21cm. Rinsed sand was added to create the following depth conditions: Shallow: 5cm Medium: 11cm Deep: 17cm
- Nine wild dwarf red mangrove propagules: three large, three medium, and three small were placed in each section per tank.
- Propagule size classes were defined as large (>5 cm) and small (<3.5 cm), with medium sizes in between.
- Propagules were weighed on digital scale before placement. To track individuals, groups of propagules were marked using colored zip ties:
- Shallow: purple, yellow, unmarked; Average: green, blue, unmarked ;Deep: black, red, unmarked.
- One grow light operating on a 10-hour light cycle was used for every two tanks.
- Propagules were monitored every four days for sinking and establishment in the sand
- N= 162 propagules were measured and weighed. Establishment was measured from Oct 4-28, and root mass and number from Oct4-Dec 19, 2025.
- We define establishment as a propagule that had sunk to the bottom with the tip of its stem inserted into the sand.
- All observations were recorded in a field notebook and later entered into Google Sheets.
- Wet Root Mass was measured by cutting off roots and weighing
- To analyze the effects of propagule size, salinity, and water depth on establishment, we performed a three-way factorial ANOVA using R Studio version 4.5.2

APPLICATIONS

- Propagule size and planting depth are key considerations for mangrove restoration
- Using larger propagules (>5 cm) and shallower planting depths may enhance establishment success and seedling recruitment in Dwarf Red Mangrove communities.
- These findings inform effective mangrove restoration strategies under changing coastal conditions.

ACKNOWLEDGEMENTS

- Steve Oberbaur PhD from Florida International University and FCE-LTER for providing Red Mangrove propagules
- Kevin Whelan National Park Servoce for statistical help in R
- Christina Whalen Biotech @Richmond Heights Science teacher as our mentor.