**Oyster propagation**

As part of our daily environmental education programs, we currently generate about .5 m3 of broken oyster shell (a mixture of live and dead oysters) with our students in an oyster laboratory experience which we currently use to reseed our near shore oyster habitat. We will use shell to seed the oyster reef balls and promote new oyster growth on them. “These structures give oyster spat a place to settle and grow. If there is not an abundance of wild oyster spat, people sometimes “seed” the structure by releasing live oyster spat obtained from local hatcheries to supplement wild oyster deficiencies”. (Wallace & Camp, 2022) Since many of the broken oysters are still alive and they are from this area they will continue to reproduce. They will produce spat and attract new spat to them and the oyster reef balls.

Due to its geographic location at the leading edge of an estuary, Durney Key experiences more variable salinity levels over time. This could lead to many of the oysters not being able to tolerate the salinity change. We will use oyster clutches found on oyster beds closest to Durney Key to seed the oyster reef balls so they are more likely to survive.

1. Wallace, C., Camp, E., & Smyth, A. (2022, March 28). *OYSTER HABITAT RESTORATION AND SHORELINE PROTECTION*. FOR376/FR446: Oyster Habitat Restoration and shoreline protection. <https://edis.ifas.ufl.edu/publication/FR446>

Scientists call oysters estuarine "ecosystem engineers"—organisms that create, modify, maintain, and otherwise alter habitat for themselves or other organisms. Oysters serve this function in coastal systems because they build large reefs that provide ecologically valuable habitat (Jones et al. 1997). Worldwide, oyster populations have declined by an estimated 90% from what they were a century ago due to over-harvesting, loss of quality habitat area, and disease (Beck et al. 2011). Florida oysters have also declined. For example, Naples Bay has experienced an 80% loss in oyster reefs since 1950, while oyster reef habitat has decreased by 99% in southeast Florida (zuErmgassen et al. 2012: Schmid et al. 2006) and by66% in the Big Bend region of northwest Florida (Seavey et al. 2011). This publication describes why oyster reefs may be a particularly efficient way to protect shorelines from erosion caused by boat wakes or storms and identifies the costs and benefits of using oysters in this way. (Wallace & Camp, 2022)

Overall, oyster reefs can play a major role in preventing shoreline erosion and may enhance coastal resiliency to sea-level rise in addition to providing environmental benefits. Sea-level rise and climate change will affect the 76.5% of Floridians that are coastal residents, living in counties directly adjacent to the Atlantic Ocean and the Gulf of Mexico (NOAA 2020). Projections predict that sea level will rise between 26 and 88 cm by 2100. Floridians will face increased vulnerability to storm surge inundation as well as shoreline and dune loss. Coastal property owners may want to consider investing in oyster shoreline protection as an alternative to bulkheads or other human-made infrastructure. One hectare of oyster reef returns on average $860 per year in shoreline protection benefits and a maximum of value of $85,988 over 20 years (Grabowski et al. 2012). In total, protecting a shoreline with oysters can provide at least $13,571 per hectare per year of environmental benefits with the average value being $23,274. Therefore, homeowners should consider installing oyster living shorelines as an investment in erosion protection and ecosystem services. For more information on the permitting process for installing a living shoreline see: <https://edis.ifas.ufl.edu/sg187>.

Human activities could pose a risk to our long-term success. Weather and sea level rise, hurricanes and tropical storms are a potential threat and could shift or deposition large amounts of sediment. Temperature, salinity, depth, and pH can change seasonally, preventing oysters from attaching to the oyster reef balls or creating an inhospitable habitat for spat. The mean high tide mark will be monitored, and firm substrate prioritized to determine best reef ball placement over time and reduce settling. In addition, shell will be supplemented to continue to provide viable habitat for spat and clutch formation

A dirt patch with plants and a wooden fence

Description automatically generated with medium confidence

**Oyster reef balls and Oyster propagation**

Reef Balls are shaped to optimize protective void spaces for fish, and include features such as rough surface textures to enhance oyster settlement and other sessile organisms. Holes designed to create whirlpools help bring nutrients to animals and plants living on the Reef Ball surface. Our reef balls will be transported to Durney Key and shoreline areas where we have fast boat traffic to help prevent erosion. Reef balls will be winched into place from the research pontoon boat. We will experiment with different marine concrete designs and test their effectiveness as a substrate for new oyster growth along with other sessile marine organisms. “In South Carolina, scientists are testing the efficacy of "oyster castles" — concrete, shell, and limestone blocks — assembled on the shoreline to grow new oyster reef”. (Chowdhury, 2019)

Our objective is to reduce erosion from boat wake. Oyster reef balls act as a breakwater for boat wake. A study of oyster reef balls was conducted on Kutubdia Island, the southeast Bangladesh coast of India. Oyster reef balls slowed down waves, reduced erosion by 50% and promoted shoreline plant growth. “the sedimentation rate is significantly higher in all reef sites than controls, confirming the morphological effect of the breakwater reefs.” (Chowdhury, 2019)

As part of our daily environmental education programs, we currently generate about .5 m3 of broken oyster shell (a mixture of live and dead oysters) with our students in an oyster laboratory experience which we currently use to reseed our near shore oyster habitat. We will use shell to seed the oyster reef balls and promote new oyster growth on them. “These structures give oyster spat a place to settle and grow. If there is not an abundance of wild oyster spat, people sometimes “seed” the structure by releasing live oyster spat obtained from local hatcheries to supplement wild oyster deficiencies”. (Wallace & Camp, 2022) Since many of the broken oysters are still alive and they are from this area they will continue to reproduce. They will produce spat and attract new spat to them and the oyster reef balls.

A close-up of a tree stump

Description automatically generatedA group of people standing in a shallow body of water

Description automatically generated

Florida Fish and Wildlife commission recommend artificial reefs as a way to protect shorelines.

A screenshot of a computer

Description automatically generated

As sands shift or oyster reef balls settle, we may need to adjust, move or add additional reef balls to continue to act as a breakwater. It is also possible that oysters may not settle on these oyster reef balls due to the salinity level around the island is on average at the maximum tolerance level of the Eastern Virginian Oyster (25ppt). Oysters are present on rocks along the Northwest end of the island but there are very few. The island has a lot of recreational use, and it is possible that some of the public might not agree with what we are doing and may move the oyster reef balls. We will post signage on the island to educate the public about our efforts.

Due to its geographic location at the leading edge of an estuary, Durney Key experiences more variable salinity levels over time. This could lead to many of the oysters not being able to tolerate the salinity change. We will use oyster clutches found on oyster beds closest to Durney Key to seed the oyster reef balls so they are more likely to survive.

1. Chowdhury MSN, Walles B, Sharifuzzaman SM, Shahadat Hossain M, Ysebaert T, Smaal AC. Oyster breakwater reefs promote adjacent mudflat stability and salt marsh growth in a monsoon dominated subtropical coast. Sci Rep. 2019 Jun 12;9(1):8549. doi: 10.1038/s41598-019-44925-6. PMID: 31189886; PMCID: PMC6561949. <https://www.nature.com/articles/s41598-019-44925-6>

Summary: Coastal habitats play a critical role in coastal adaptation strategies as they can reduce the vulnerability of coastal communities to natural hazards like flooding, eroding shorelines and sea level rise[1](https://www.nature.com/articles/s41598-019-44925-6#ref-CR1),[2](https://www.nature.com/articles/s41598-019-44925-6#ref-CR2),[3](https://www.nature.com/articles/s41598-019-44925-6#ref-CR3),[4](https://www.nature.com/articles/s41598-019-44925-6#ref-CR4). These habitats include coral reefs[5](https://www.nature.com/articles/s41598-019-44925-6#ref-CR5), reef-forming bivalves[6](https://www.nature.com/articles/s41598-019-44925-6#ref-CR6),[7](https://www.nature.com/articles/s41598-019-44925-6#ref-CR7),[8](https://www.nature.com/articles/s41598-019-44925-6#ref-CR8),[9](https://www.nature.com/articles/s41598-019-44925-6#ref-CR9), dense vegetation of kelps and seagrasses[10](https://www.nature.com/articles/s41598-019-44925-6#ref-CR10),[11](https://www.nature.com/articles/s41598-019-44925-6#ref-CR11), salt marsh vegetation[12](https://www.nature.com/articles/s41598-019-44925-6#ref-CR12),[13](https://www.nature.com/articles/s41598-019-44925-6#ref-CR13),[14](https://www.nature.com/articles/s41598-019-44925-6#ref-CR14) and mangroves[15](https://www.nature.com/articles/s41598-019-44925-6#ref-CR15),[16](https://www.nature.com/articles/s41598-019-44925-6#ref-CR16),[17](https://www.nature.com/articles/s41598-019-44925-6#ref-CR17),[18](https://www.nature.com/articles/s41598-019-44925-6#ref-CR18). They have the capacity to reduce flow and dampen wave energy through their physical structures and by doing so, they trap and stabilize sediments, allowing to keep pace with sea-level rise by natural accretion and growth[13](https://www.nature.com/articles/s41598-019-44925-6#ref-CR13),[19](https://www.nature.com/articles/s41598-019-44925-6#ref-CR19),[20](https://www.nature.com/articles/s41598-019-44925-6#ref-CR20),[21](https://www.nature.com/articles/s41598-019-44925-6#ref-CR21),[22](https://www.nature.com/articles/s41598-019-44925-6#ref-CR22),[23](https://www.nature.com/articles/s41598-019-44925-6#ref-CR23). Moreover, they offer additional ecosystem services including: (1) water quality regulation[24](https://www.nature.com/articles/s41598-019-44925-6#ref-CR24),[25](https://www.nature.com/articles/s41598-019-44925-6#ref-CR25); (2) ecosystem succession[26](https://www.nature.com/articles/s41598-019-44925-6#ref-CR26),[27](https://www.nature.com/articles/s41598-019-44925-6#ref-CR27); and (3) fisheries production[28](https://www.nature.com/articles/s41598-019-44925-6#ref-CR28),[29](https://www.nature.com/articles/s41598-019-44925-6#ref-CR29),[30](https://www.nature.com/articles/s41598-019-44925-6#ref-CR30). The use/design of sustainable ecosystems that integrate human society with related natural habitats for the benefit of both is called ecological engineering[31](https://www.nature.com/articles/s41598-019-44925-6#ref-CR31),[32](https://www.nature.com/articles/s41598-019-44925-6#ref-CR32),[33](https://www.nature.com/articles/s41598-019-44925-6#ref-CR33). It provides opportunities to combine engineering principles with ecological processes to reduce environmental impacts of man-made infrastructure[34](https://www.nature.com/articles/s41598-019-44925-6#ref-CR34).

2. Wallace, C., Camp, E., & Smyth, A. (2022, March 28). *OYSTER HABITAT RESTORATION AND SHORELINE PROTECTION*. FOR376/FR446: Oyster Habitat Restoration and shoreline protection. <https://edis.ifas.ufl.edu/publication/FR446>

Summary: As the climate continues to change, coastal areas and people who live there face increasing risks from erosion and wave damage. The impacts of climate change are made worse by declines in natural oyster reefs, which historically provided some natural protection. However, oysters can be restored for the specific purposes of protecting shorelines. Intended for coastal property owners and local governments that must make decisions about protecting shorelines in the face of a changing climate, this publication describes the practicality and cost-effectiveness of using oysters in this way.

3. Beck, Michael & Brumbaugh, Robert & Airoldi, Laura & Carranza, Alvar & Coen, Loren & Crawford, Christine & Defeo, Omar & Edgar, Graham & Hancock, Boze & Kay, Matthew & Lenihan, Hunter & Luckenbach, Mark & Toropova, Caitlyn & Zhang, Guofan & Guo, Ximing. (2011). Oyster Reefs at Risk and Recommendations for Conservation, Restoration, and Management. BioScience. 61. 107-116. 10.1525/bio.2011.61.2.5.

Summary: Native oyster reefs once dominated many estuaries, ecologically and economically. Centuries of resource extraction exacerbated by coastal degradation have pushed oyster reefs to the brink of functional extinction worldwide. We examined the condition of oyster reefs across 144 bays and 44 ecoregions; our comparisons of past with present abundances indicate that more than 90% of them have been lost in bays (70%) and ecoregions (63%). In many bays, more than 99% of oyster reefs have been lost and are functionally extinct. Overall, we estimate that 85% of oyster reefs have been lost globally. Most of the world's remaining wild capture of native oysters (> 75%) comes from just five ecoregions in North America, yet the condition of reefs in these ecoregions is poor at best, except in the Gulf of Mexico. We identify many cost-effective solutions for conservation, restoration, and the management of fisheries and nonnative species that could reverse these oyster losses and restore reef ecosystem services.

Oyster reefs have the potential as eco-engineers to improve coastal protection. A field experiment was undertaken to assess the benefit of oyster breakwater reefs to mitigate shoreline erosion in a monsoon-dominated subtropical system. Three breakwater reefs with recruited oysters were deployed on an eroding intertidal mudflat at Kutubdia Island, the southeast Bangladesh coast. Data were collected on wave dissipation by the reef structures, changes in shoreline profile, erosion-accretion patterns, and lateral saltmarsh movement and related growth. This was done over four seasons, including the rainy monsoon period. The observed wave heights in the study area ranged 0.1–0.5 m. The reefs were able to dissipate wave energy and act as breakwaters for tidal water levels between 0.5–1.0 m. Waves were totally blocked by the vertical relief of the reefs at water levels <0.5 m. On the lee side of the reefs, there was accretion of 29 cm clayey sediments with erosion reduction of 54% as compared to control sites. The changes caused by the deployed reefs also facilitated seaward expansion of the salt marsh. This study showed that breakwater oyster reefs can reduce erosion, trap suspended sediment, and support seaward saltmarsh expansion demonstrating the potential as a nature-based solution for protecting the subtropical coastlines.(Chowdhury, 2019)

Scientists call oysters estuarine "ecosystem engineers"—organisms that create, modify, maintain, and otherwise alter habitat for themselves or other organisms. Oysters serve this function in coastal systems because they build large reefs that provide ecologically valuable habitat (Jones et al. 1997). Worldwide, oyster populations have declined by an estimated 90% from what they were a century ago due to over-harvesting, loss of quality habitat area, and disease (Beck et al. 2011). Florida oysters have also declined. For example, Naples Bay has experienced an 80% loss in oyster reefs since 1950, while oyster reef habitat has decreased by 99% in southeast Florida (zuErmgassen et al. 2012: Schmid et al. 2006) and by66% in the Big Bend region of northwest Florida (Seavey et al. 2011). This publication describes why oyster reefs may be a particularly efficient way to protect shorelines from erosion caused by boat wakes or storms and identifies the costs and benefits of using oysters in this way. (Wallace & Camp, 2022)

Native oyster reefs provide many ecosystem services (figure 3) including water filtration, food and habitat for many animals (e.g., fish, crabs, birds), shoreline stabilization and coastal defense, and fisheries (reviewed in Grabowski and Peterson 2007, NRC 2010). (Beck, 2011)

**Constructed oyster breakwater reefs**

Oyster reefs were often constructed by using shell derived materials, forming either piles of loose shell or in bags or filling gabions with loose shell[27](https://www.nature.com/articles/s41598-019-44925-6#ref-CR27),[73](https://www.nature.com/articles/s41598-019-44925-6#ref-CR73),[74](https://www.nature.com/articles/s41598-019-44925-6#ref-CR74). In a dynamic and high energy coast, like the study site, more robust reefs are needed with high vertical relief to avoid smothering by sediments and less physical damage to the deployed structure during the monsoon season[6](https://www.nature.com/articles/s41598-019-44925-6#ref-CR6). Three oyster reefs were constructed on a tidal mudflat of Kutubdia Island using precast concrete rings. Each of concrete ring was 0.8 m in diameter, 0.8 m high, and 0.05 m thick with four holes in them[50](https://www.nature.com/articles/s41598-019-44925-6#ref-CR50), a structure similar to reef balls[75](https://www.nature.com/articles/s41598-019-44925-6#ref-CR75). Each reef contained 41 concrete rings, each placed in two rows next to each other, resulting in 20 m long reefs (Fig. [7](https://www.nature.com/articles/s41598-019-44925-6#Fig7)). These reefs were deployed parallel to the coastline (~0.5 m above mean lower low water, MLLW) as wave-break structures to attenuate wave energy. About 50–70 cm of the rings were exposed to the air or water depending on the season and tidal phase, while rest of part (i.e. bottom side) were sunk in mud after deployment at the experimental site. Prior to the deployment of the reefs, ECOBAS project used the concrete rings on the intertidal mudflat adjacent to the experimental site (at the same tidal exposure) for two years to allow oyster larvae settlement and grow[50](https://www.nature.com/articles/s41598-019-44925-6#ref-CR50). During the first year, settlement of oysters was low (<100 spat m−2). However, successful spat fall (>300 spat m−2) was observed in year two, when rings covered with high densities of oysters *S. cucullata* (~1200 individuals m−2; size class 5–47 mm shell length) and other marine organisms such as barnacles, sea anemones, gastropods and polychaetes. The overgrown rings were transported to the experimental site in March 2016 and termed as “oyster breakwater reefs”. A terminology OysterBreaktm was also used for a similar experimental setup in Vermilion Cove, Louisiana, USA[27](https://www.nature.com/articles/s41598-019-44925-6#ref-CR27) (La Peyre *et al*., 2017). Top 50 cm of the reef substrates were covered with as thick as ~10 cm layer of live and dead oysters, while the dynamic bottom part (30 cm) was occupied by various benthic epifauna, mostly reef forming polychaetes, *Sabellaria* sp. (Fig. [8](https://www.nature.com/articles/s41598-019-44925-6#Fig8)). (Chowdhury, 2019)

Overall, oyster reefs can play a major role in preventing shoreline erosion and may enhance coastal resiliency to sea-level rise in addition to providing environmental benefits. Sea-level rise and climate change will affect the 76.5% of Floridians that are coastal residents, living in counties directly adjacent to the Atlantic Ocean and the Gulf of Mexico (NOAA 2020). Projections predict that sea level will rise between 26 and 88 cm by 2100. Floridians will face increased vulnerability to storm surge inundation as well as shoreline and dune loss. Coastal property owners may want to consider investing in oyster shoreline protection as an alternative to bulkheads or other human-made infrastructure. One hectare of oyster reef returns on average $860 per year in shoreline protection benefits and a maximum of value of $85,988 over 20 years (Grabowski et al. 2012). In total, protecting a shoreline with oysters can provide at least $13,571 per hectare per year of environmental benefits with the average value being $23,274. Therefore, homeowners should consider installing oyster living shorelines as an investment in erosion protection and ecosystem services. For more information on the permitting process for installing a living shoreline see: <https://edis.ifas.ufl.edu/sg187>. (Wallace & Camp, 2022)

The condition of oyster reef ecosystems is poor and the challenge in revitalizing native oyster reefs is great, but we have identified many reasonable actions that can be expanded across local to regional to global scales. Actions recommended to reverse this decline and enhance oyster reef condition include improving protection; restoring ecosystems and ecosystem services; fishing sustainably; stopping the spread of nonnatives; and capitalizing on joint interests in conservation, management, and business to improve estuaries that support oysters. Estimates of oyster reef abundance and condition across many bays and ecoregions provide a baseline for setting much-needed and realistic goals for restoration and conservation and for evaluating the progress in meeting them. (Beck, 2011)

It demonstrates that oyster reef balls help prevent erosion from waves and the monsoon cycles show it even could be effective during our tropical storms and hurricanes. Both areas have similar tidal patterns and organisms that attach to the oyster reef balls. The objective and goal is to reduce erosion and this study proves this can be done even in rough conditions.

Human activities could pose a risk to our long-term success. Weather, sea level rise, hurricanes, and tropical storms are a potential threat and could shift or deposition large amounts of sediment. As sands shift or oyster reef balls settle, we may need to adjust, move or add additional reef balls to continue to act as a breakwater. Sea level rise could make our efforts unattainable. Higher sea levels would prevent our breakwater from working properly and could erode more of the island. Temperature, salinity, depth, and pH can seasonally change, preventing oysters from attaching to the oyster reef balls.

The mean high tide mark will be monitored, and firm substrate prioritized to determine best reef ball placement over time and reduce settling. In addition, shell will be supplemented to continue to provide viable habitat for spat and clutch formation.

A wooden bridge over water

Description automatically generated



**Living vs dead oyster count**

Using a 5-meter transect line and a 1-meter squared quadrat we will count living and dead oysters visible on the surface of rocks and oyster clutches.

Just count what you can see. If you pick up the rock place it down the same way you found it and only count what you can see looking straight down at it.

A close up of a shell

Description automatically generated

Living oysters have two shells.

A group of oyster shells

Description automatically generated

Dead oysters will be partially open or only have a half shell.

Belt transects will be used to estimate the distribution and population of oysters and oyster clutches on oyster beds in our estuary. The belt transect method is similar to the line transect method but gives information on abundance as well as presence, or absence of species. Similar local counts have been used to observe oyster density. “on each sampling date at each site, we counted live and dead oysters within temporary belt transects marked using stakes and string. Each transect was 15.4 cm wide and as long as the site footprint (generally 21 m). We counted within three transects that were spaced evenly across the square (ends were 5.34, 10.68 and 16.02 meters from northeast and southeast corners), and were oriented parallel to the east and west sides of the squares, which is also along a gradient moving away from the inlet. Transects were formed by placing vertical “H” shaped iron stakes (providing attachment points for strings) at each end of a transect, and running tightened nylon string between the corners so that a 15.4 cm wide belt transect was formed approximately 5 –10 cm above the substrate. Metric tape measures were laid along these transects with 0 at the farthest point from each inlet. Using click-counters, live and dead oysters were then counted within each 2.5 m section of the transect. Dead oysters were defined as having two valves that were clearly open with no evidence of a living oyster within. All size classes were counted including live and dead spat. Only oysters that could be distinguished visually from above or to the side were counted: oysters on the undersides of clumps were not counted, and clumps were not picked up. The temporary belt transects were removed after each sampling event”.