



Environmental Impacts of Terminal Groins

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Coastal armoring - defined by NOAA as “the practice of using physical structures to prevent shorelines from coastal erosion” (NOAA - National Shoreline Service) - has been recorded to cause concerning beach and habitat loss (Dugan and Hubbard 2006, Dugan et al. 2008). Groins are the most common structure used for beach stabilization by engineers, though are “probably the most misused and improperly designed of all coastal structures” according to the Army Corps of Engineers (USACE). They are typically implemented in areas that are already experiencing severe erosion events (Audubon, 2015).

What is a terminal groin?

A groin is a hardened structure placed perpendicular to a shoreline with the purpose of preventing severe erosion (USACE). Groins are often constructed out of rock rubble, but can also be made of steel, wood, or concrete (N. Topsail Beach; NCCF, 2021). Situated perpendicular to the longshore current, groins catch sand and prevent it from being transported further along the shoreline. This leads to sand accretion on the upstream side of the groin, but results in sand depletion on the downstream side. A terminal groin is simply a groin that is placed at the edge of a barrier island or inlet area (NC Cooperative Extension, 2009).



Figure 1. Terminal groin located on the east side of Fort Macon in Carteret County, NC. Photo by Greg Rudolph.



Terminal groin vs. jetty

To an untrained eye, terminal groins and jetties may appear to be similar and serve the same purpose; however, terminal groins are often smaller in both height and length. Jetties are constructed for the purpose of navigation, whereas the sole purpose of terminal groins is to prevent severe erosion (NC CRC, 2010; NCCF, 2021).

Overwash

Overwash and barrier island rollover are natural processes that occur on all barrier islands over time. During a major storm event, storm surge waves flow over tops of sand dunes, moving sand to the landward side of the barrier island and creating overwash fans on the back side of the dunes. Over time, storm-generated overwash leads to barrier island rollover - the trend of landward movement of a barrier island (WHOI). Overwash serves an important role in maintaining barrier island health. When water washes over the dune ridge, it transports sediment and nutrients to the marshes and estuaries on the landward side of the island (NC CRC, 2010). Overwash fans, as well as the small back-side ponds created by overwash, create habitats for many important species, such as the federally protected piping plover. When overwash is prevented by terminal groins, these back-side habitats become sand and nutrient starved (NC CRC, 2010).

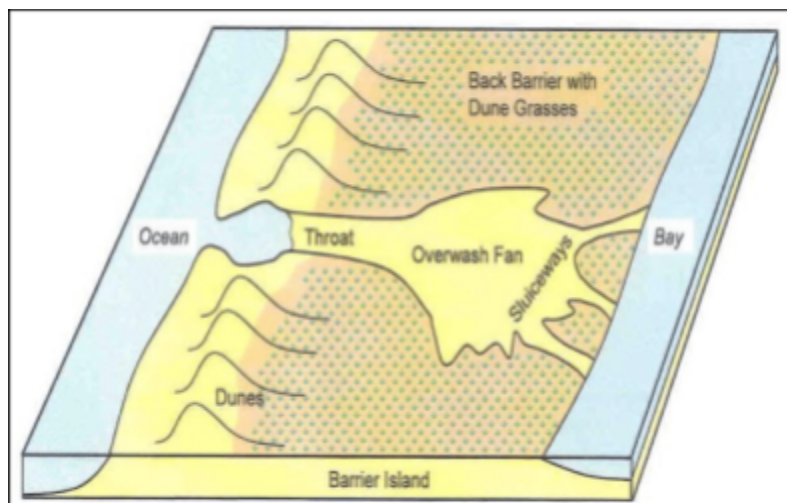


Figure 2. Overwash fan diagram (Donnelly et al. 2007).



Benthic communities



Figure 3. Ghost crab (Ocypode quadrata). Photo by Jennifer Taylor.

The primary impact of terminal groins on benthic communities is the installation of the groin on the sediment, which leads to a direct and permanent habitat loss (NC CRC, 2010). The addition of a rocky terminal groin is hypothesized to create new habitat types for benthic organisms (NC CRC, 2010), but some researchers, such as Chapman and Bulleri, warn that the introduction of this novel habitat type will likely lead to the spread of non-native and invasive species (2003). A 2008

study conducted by Dugan et al. found that “the abundance, biomass and size of upper intertidal macroinvertebrates were significantly lower on armored segments,” as compared to those on unarmored segments of the beach.

The diversity of the benthic community has direct impacts on the diversity and success of species further up the food chain, including fish, mammal, and shorebird species. Therefore, the impacts of terminal groins to benthic communities are important and should not be overlooked.

Fish

Inlets and barrier islands provide important habitats for many species of fish. The estuarine environment on the landward side of barrier islands provides a safe and protected nursery for larval and juvenile fish (NOAA Fisheries). These estuaries provide sanctuary for an estimated 80-90% of recreational fish species caught in America (APNEP). Once the fish grow to maturity, they migrate through inlets to the ocean. Inlet and nearshore habitats are diverse and abundant, providing fish species with food and shelter.

The introduction of a rocky terminal groin to a nearshore or inlet habitat provides more opportunities for food and shelter, thus increasing the biodiversity of fish species in the area - and more opportunities for recreational fishing.



Shorebirds and waterbirds

Barrier islands and inlets provide important nesting sites for many migratory shorebirds, including piping plovers, roseate terns, and oyster catchers (Audubon, 2015). Studies have shown that in locations with groins or other hardened structures, shorebird abundance and species richness have significantly decreased when compared to locations without hardened structures (Dugan et al. 2008).

The prevention of overwash and barrier island rollover by terminal groins, and subsequent shorebird habitat loss, is a major issue (NC CRC, 2010; Audubon, 2015). A 2009 report of the status of Piping Plovers emphasizes that groins impede piping plover habitat formation and regeneration by inhibiting both longshore currents and overwash from transporting sediment to nesting sites (Audubon, 2015; Hayes and Michel, 2007).

According to the Audubon Society, “loss or degradation of wintering habitat, including that associated with coastal engineering projects, is identified as a primary threat in all shorebird conservation and management planning documents” (Audubon, 2015).



Figure 4. Piping plover (Charadrius melodus). Photo by Lorraine Minns for National Audubon Society.



Sea turtles



Figure 5. Freshly-hatched sea turtle heading to the ocean. Photo from Oak Island.

Barrier island beaches serve as important sea turtle nesting sites. When a female sea turtle is ready to lay her eggs, she crawls up the beach and into the dunes, where she digs a hole and deposits her eggs (Sea Turtle Conservancy). Hard structures, including terminal groins, can potentially hinder a nesting sea turtle's access to the beach. They can also lead to false crawls, which occur when a female crawls up the beach but does not lay a nest. Once the nest hatches, a terminal groin can block hatchlings' access to the ocean. The increased biodiversity that surrounds a terminal groin can also

pose a threat to hatchlings, with a potential increase in predators lurking nearby. Finally, erosion caused by the terminal groin can lead to permanent nesting site loss (NC CRC, 2010).

Vascular plants

Seabeach amaranth is a coastal plant commonly found on barrier island beaches along the Atlantic coast (USFWS). This threatened plant resides above the high tide line on the beach front and in overwash fans (NC CRC, 2010). In studies conducted across the Atlantic coast, seabeach amaranth has been found to be more abundant on the upstream side of the terminal groin, with little to no growth immediately downstream of the groin (US FWS, 1996).



Figure 6. Seabeach amaranth (Amaranthus pumilus). Photo by Gene Neimien for USFWS.

Water quality effects

When a terminal groin is first installed, construction efforts create turbidity in the water column. This issue is often temporary, and can be somewhat mitigated by using turbidity curtains during the construction process. In some cases, toxic materials can become resuspended during installation (NC CRC, 2010). Depending on the scale of the project, turbidity levels could be harmful to fish and other marine organisms. In a 2019 study of effects of turbidity on near-shore and estuarine habitats, fish species richness and diversity were both found to decrease significantly with increased turbidity levels (Lunt & Smee, 2019). When one trophic level is negatively impacted by a change to water quality conditions, the entire food chain is affected.



Effects to humans

While most environmental effects of terminal groins are to the flora and fauna of the surrounding waters and beaches, humans are impacted by terminal groins as well. The increased biodiversity surrounding terminal groins create an optimal location for recreational offshore fishing (NC CRC, 2010). Beach access would be temporarily limited during construction, but no permanent closures would be implemented (NC CRC, 2010). There are some reports of a potential loss of aesthetic value and scenic view due to the implementation of a rock groin, as well as concerns that the groin would act as a catch-all for floating debris and trash (NC CRC, 2010; Audubon, 2015). Finally, swimmers should take care to avoid approaching any terminal groin or other hardened structure to avoid unintentional entrapment in a rip current (Liu & Wu, 2022).



Figure 7. Terminal groin at Pea Island, NC. Photo by Sam Walker.



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