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Inlet Management in Massachusetts with an Aim to Address Shoreline Erosion

S. W. Kelley[1]; J. S. Ramsey[2]; and H. E. Ruthven[3]

[1]Applied Coastal Research and Engineering, Inc., 766 Falmouth Rd., Suite A1, Mashpee, MA 02649. E-mail: skelley@appliedcoastal.com
[2]Applied Coastal Research and Engineering, Inc., 766 Falmouth Rd., Suite A1, Mashpee, MA 02649. E-mail: skelley@appliedcoastal.com
[3]Applied Coastal Research and Engineering, Inc., 766 Falmouth Rd., Suite A1, Mashpee, MA 02649. E-mail: skelley@appliedcoastal.com

ABSTRACT

Due to a variety of unique regulatory restrictions, designers of engineered solutions to coastal erosion in Massachusetts often are required to develop innovative projects that make the best use of limited resources. Three recent inlet management projects in southeastern Massachusetts provide useful examples of the competing interests that shape the engineering design process. The results of working together with the environmental regulatory community were efforts that led to balanced and unique solutions that enhanced barrier beach function as storm protection and habitat for the long-term. Because of endangered species habitat issues at all three locations, the effectiveness and sustainability of the enhancements needed to be unequivocally demonstrated to the permitting agencies.

INTRODUCTION

Three recent inlet dredging efforts in southeastern Massachusetts demonstrate the typical non-engineering challenges that must be addressed in order to design a project that will achieve the intended goals for inlet management and adequately address regulatory concerns related to habitat issues. The locations of the three inlets are mapped in Figure 1: Ellisville Harbor in Plymouth, Mill Creek in Chatham and Cotuit Bay inlet in Barnstable. The dredged volumes of these projects vary in order of magnitude from 1,000 cubic yards (Ellisville) to 100,000 cubic yards (Cotuit Bay). Though the engineering of these projects was straightforward, in each case the final plan was greatly influenced by environmental concerns not related to engineering that arose during the permitting process.

In southeastern Massachusetts, permitting concerns that are most often raised for dredging projects are related to important commercial marine species as well as endangered and protected species habitat (e.g., piping plover, common tern, horseshoe crab, winter flounder and sea duck), and/or designated coastal resource types (e.g., barrier beach and coastal bank resource areas). Further, projects that require dredging in areas with no historical record of a licensed navigation channel are considered improvement dredging and require the additional demonstration that the project is designed to have no adverse impacts on bottom topography, sediment transport processes, water circulation and marine productivity. Two of the systems described here had no existent historical record of dredging (Ellisville and Mill Creek). Though a series of historically dredged channels do exist at Cotuit Inlet, this fact did not simplify environmental permitting, since a sub-aerial sand spit (a barrier beach resource) had accreted across this channel. In this case, the regulatory concerns required that the barrier resource of the accreted spit have precedence over the historic navigation channels.

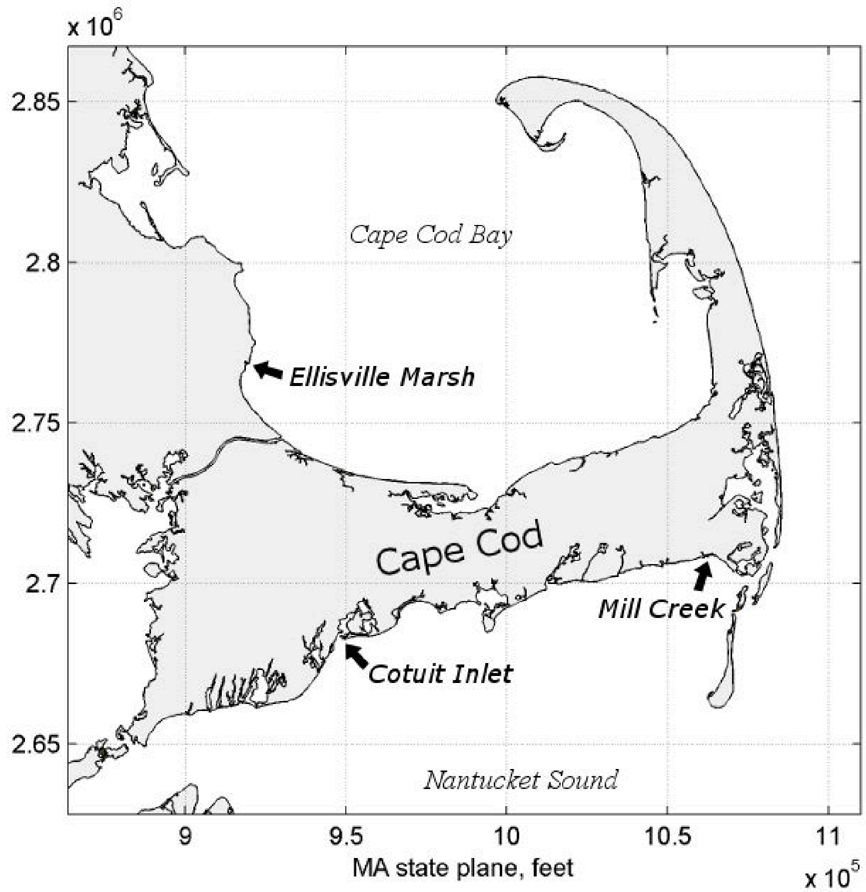

Figure 1. Locus map of the three inlet systems.

ELLISVILLE HARBOR

The inlet of the 70-acre salt marsh system at Ellisville historically served as a harbor of refuge since the 17th century. With a mean tide range of about 10 feet, the natural channel would only be accessible during the higher stages of the tide. The inlet channel likely was historically maintained; however, official records of these occasional efforts do not exist, as the work pre-dated the environmental and regulatory process.

In 1985, the state purchased the land bordering the north side of the inlet. Shoaling problems at Ellisville began after the 1991 “no name” storm when a spit began to grow across the inlet channel. By 1995 the spit had grown 1600 feet to the southwest (Figure 2), to the point where the southern tip of the spit closed in on the seaward tip of a groin in that area. By 2000, the inlet channel effectively had become pinned by the groin, which began to act as a jetty and caused the inlet channel to meander into the coastal bank at the landward base of the groin (Figure 3). The tidal efficiency of the inlet degraded as the inlet meandered into the bank. This evolving condition resulted in a decreased tide range in the marsh and degradation of the marsh plain, since it became continuously waterlogged.

The steady erosion of the coastal bank endangered several properties, though a single homeowner took on the original task of arresting the intensifying threat from the tidal channel. A plan was developed in 2001 that would relocate the inlet channel to its pre-1991 storm position by making a simple cut, requiring approximately 1,000 cubic yards of dredging through the barrier spit. Two years passed before permission was granted to dredge the channel in November of 2003.

The main issues that were addressed during the regulatory review were related to disputed land ownership, piping plover habitat, and the state designated Ellisville Area of Critical Environmental Concern (ACEC). The parcel of land north of the marsh is maintained by the state as Ellisville Harbor State Park. Initially, the state park made claims on the spit, but this claim was successfully refuted. The claim that the area of proposed channel dredging fell within the designated ACEC was also successfully refuted, as it was shown to be within the "footprint" of a historically designated channel. Regulations prevent dredging and hard coastal engineering structures within ACECs. Owners of the endangered properties were prevented from constructing a revetment to protect the eroding bluff because these parcels unequivocally are within the designated Ellisville ACEC.

Figure 2. Evolution of Ellisville Marsh inlet, prior to relocation (1995 and 2003) and after the new inlet channel was cut in December 2003 (2005 and 2015).

Endangered species concerns at the spit were raised due to the area being a popular off-road vehicle (ORV) access area. The inlet channel in its pre-2003 cut configuration naturally provided a barrier to ORV activity on the spit, and also acted to reduce public access to the active piping plover nesting habitat area. With the channel cut, the physical barrier would be lost as it was expected that the spit would eventually move landward and fill in the defunct channel. In order to address these habitat concerns, the final plan required the establishment of access control measures, including a secure gate that would be used to completely bar vehicle access to the habitat area.

Final regulatory approval for the project was granted in November 2003, for a one-time cut of the channel. The beneficial effects of the relocated channel were immediately seen with the halting of erosion at the coastal bank and also a 2-foot drop in mean low water (MLW) in the marsh, with a related increase in the total tide range. The drop in MLW was enough to allow the marsh to drain properly, resulting in the re-emergence of marsh grass (Ransey, *et al*., 2006). Monitoring of the marsh after the channel cut showed an increase in *Spartina alterniflora* of 14.3 acres, or a 170% increase in coverage compared to before the cut. In 2008 a notice of project change was filed in order to acquire a 10-year dredging permit, which allows for periodic maintenance of the inlet.

The good-faith effort to accommodate regulatory concerns in the final dredging plan for Ellisville demonstrated to the oversite agencies (primarily the Natural Heritage & Endangered Species Program of the Massachusetts Division of Fisheries and Wildlife) that inlet relocation could be an effective method of maintaining and preserving endangered species habitat. The good example of Ellisville aided the permitting of similar succeeding projects.

MILL CREEK

Situated along the relatively protected shoreline of northeast Nantucket Sound, Mill Creek, in the Town of Chatham, experienced a similar sudden spit growth across the systems only inlet. The 78-acre estuary has a mean tide range of about 3.5 feet, and is split into two main embayments: the lower reach near the inlet is a broad marsh, while the upper reach is a kettle pond (Taylors Pond) which connects to the lower system via a 60-foot-wide and 1300-foot-long tidal creek.

Figure 3. Condition of the eroded coastal bank in 2001, at the point of maximum landward excursion of the Ellisville Marsh inlet.

Analysis of historical shoreline movement showed that the area is dynamic, with maximum long term erosion rates of about 4 ft/yr (Kelley, *et al*., 2010). The shoreline updrift (west) of the

Mill Creek inlet is influenced by a groin field and a jetty located at the town line with Harwich, 5,500 feet to the west. These structures have restricted the transport of material to the Chatham south shore. The west Mill Creek jetty was an effective block to littoral transport until after 2005 when the groin compartment updrift of the jetty finally became filled to capacity, and the jetty began to bypass sand. This resulted in the rapid formation of the spit seen in the 2007 aerial photo presented in Figrue 4.

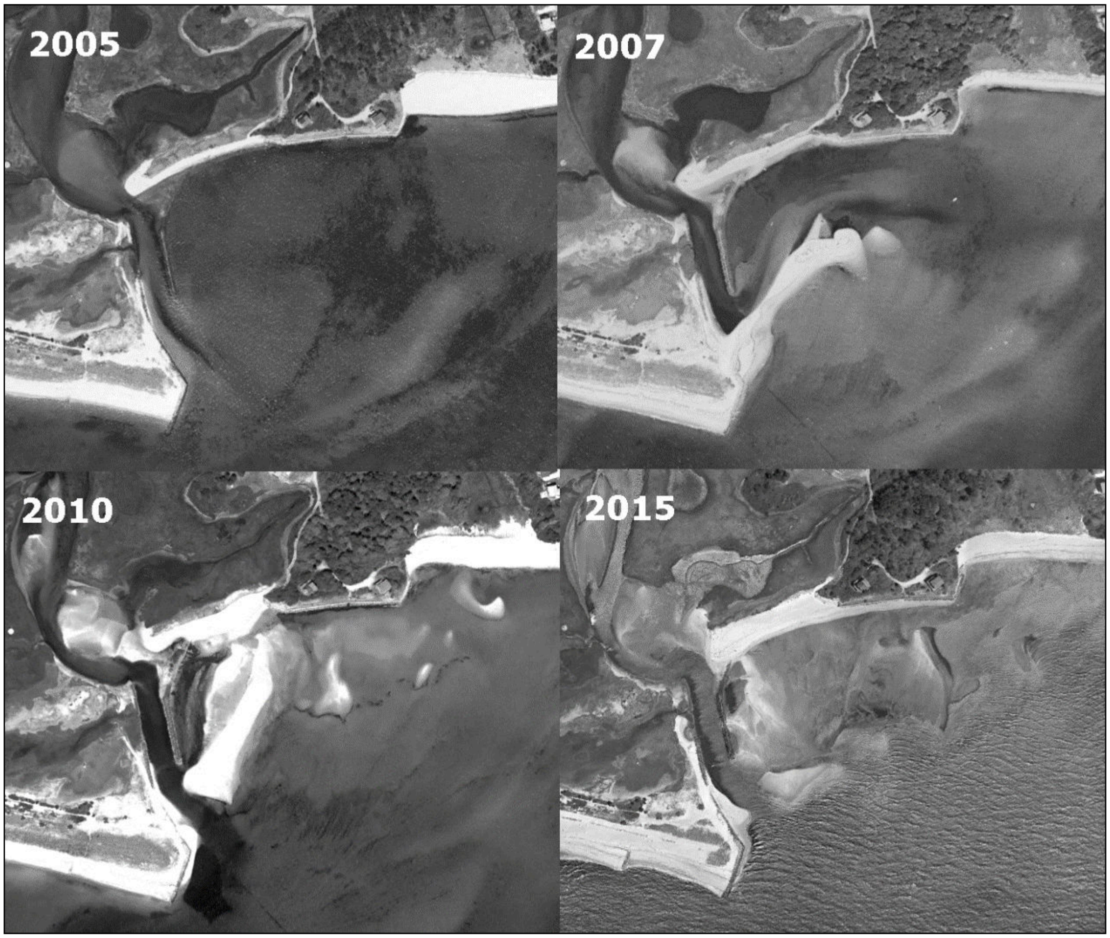

Figure 4. Evolution of Mill Creek Inlet before inlet cut (2005 and 2007) and after (2010 and 2015).

Hydrodynamic modeling of the system showed that the tide range was reduced by 10% by 2007 (Kelley, *et al*., 2007). In addition, water quality in the creek system was degraded as a result of the spit's influence on tidal exchange. Mill Creek had historically been a key area utilized by the Town's shellfish propagation program, but post-spit formation tidal conditions greatly impaired the ability of the Creek to support this effort.

The final permitted plan developed by the Town's Coastal Resources Department incorporated improvement dredging through the spit, including an offshore sand impoundment basin. The total volume permitted to be dredged from the inlet, including the impoundment, was 12,900 cubic yards. The plan also included an innovative provision for dredging 7,600 cubic yards from the updrift barrier beach (the last two groin compartments adjacent to the updrift inlet jetty) to create additional sand impoundment capacity. The updrift beach excavation is designed to enhance shorebird habitat by extending the slope of the beach face through the dune, which increases the area available for foraging and nesting. As historical accretion of the updrift fillet has occurred, dense dune vegetation has provided stability, but this vegetation inhibits the use of this beach/dune area by piping plovers.

The inlet and offshore impoundment were dredged in 2010; however, the updrift beach impoundment was not constructed at that time. Sand from the channel was used to nourish the shoreline at the base of the east jetty (downdrift), which had been flanked due to the highly eroded condition of this area, and also to fill a downdrift area identified as a useful feeder template for the farther downdrift shoreline (Kelley and Ramsey, 2000). Following the initial channel dredging, the updrift impoundment cut and habitat construction have been made, as can be seen in the 2015 aerial photo presented in Figure 4.

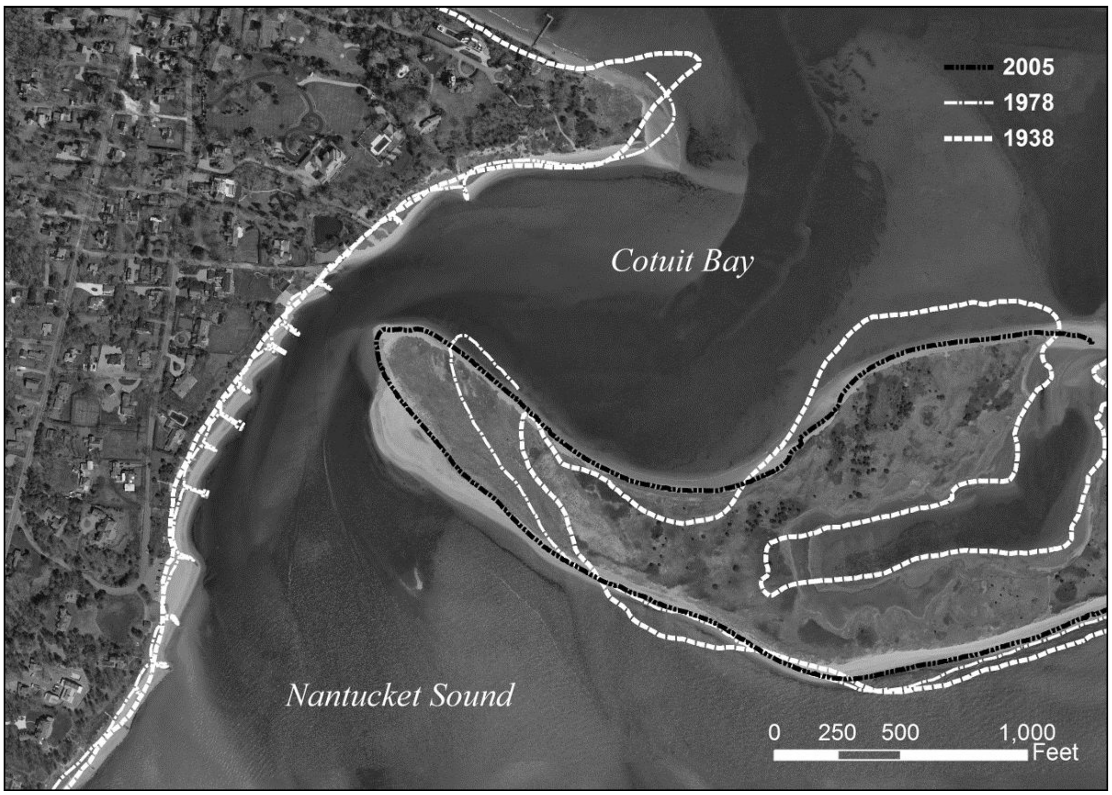

Figure 5. Evolution of the Sampsons Island shoreline. Historical shorelines are plotted on the 2014 USGS aerial photo of the Cotuit inlet vicinity.

COTUIT INLET

Cotuit Bay inlet is one of two inlets of the Three Bays estuary in Barnstable. Three Bays is a 1,250-acre embayment system on Nantucket Sound with a mean tide range of three feet. Presently, the narrowest section of the inlet channel between the mainland and Sampsons Island is 230 feet wide. Before the 1940's, Cotuit Bay Inlet had been an 800-foot-wide entrance. The narrowing of the channel has become a safety concern due to the heavy recreational use of the inlet and the resulting close proximity of boating traffic and non-navigation related use of the area (e.g. swimming).

The first official record of the inlet being dredged is from 1934. Over the ensuing 80+ years, a spit extending from Sampsons island has been allowed to grow into the inlet channel (Figure 5). Following the 1934 dredging, nonperiodic maintenance of the inlet channel occurred in 1947 and 1967. In both of the follow-on projects, the channel edge was moved progressively westward (Figure 6). No major dredging of the inlet channel has occurred since 1967.

The Sampsons Island together with Dead Neck (collectively referred to by the acronym DNSI) has historically been a productive shorebird area, but has recently experienced a decline in successful nesting activity (Parsons, 2014). The decline is attributed to the effects expanding vegetation and erosion of the beach in different areas of DNSI. Monitoring data show that nesting activity has been most successful in the period immediately following nourishments placed on Dead Neck in 1985 and 1999.

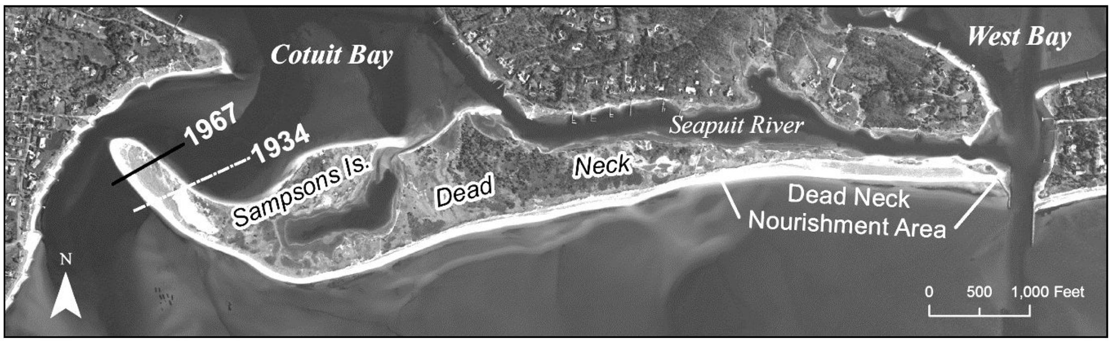

Figure 6. Setting of Sampsons Island and Dead Neck between Cotuit Bay inlet and West Bay inlet. The edges of the 1934 and 1967 dredged channels are indicated across the Sampsons Is. spit. The nourishment area that will use the material dredged from the spit is also indicated. 2005 Mass GIS aerial photo.

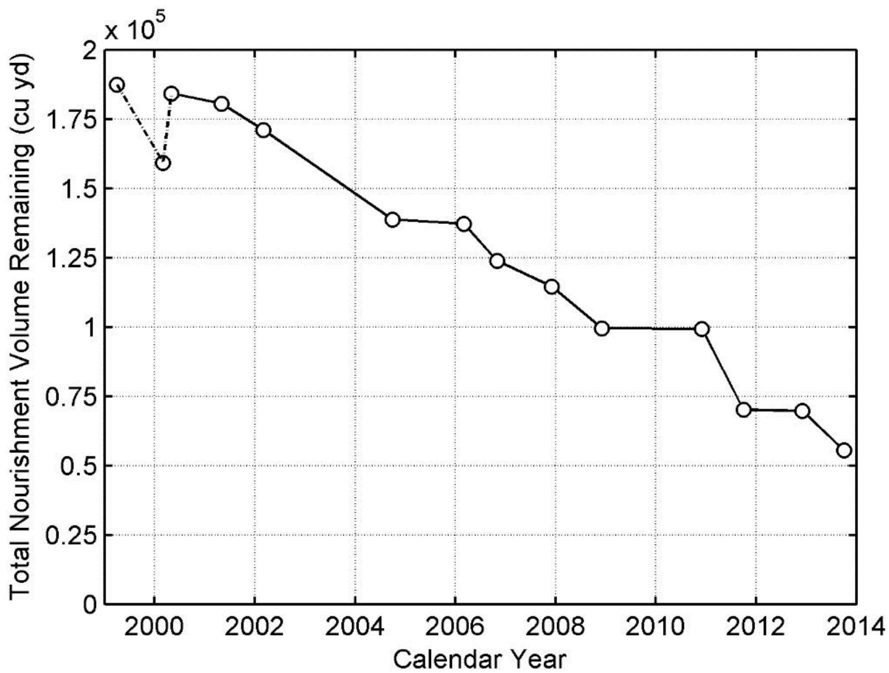

Figure 7. Volume remaining of 1999-2000 nourishment of Dead Neck, as surveyed quasi-annually.

In addition to the documented shorebird habitat loss, the eastern end of Dead Neck has lost up to 100 feet of beach width since 2000 (Ramsey and Simmons, 2013). A 210,000 cubic yard nourishment was completed on the eastern end of Dead Neck in 2000. Since then, the quasiannual monitoring of the 2,000-foot-long nourishment template (Figure 7) shows that the fill has lost an average of 11,700 cubic yards per year. The template volume remaining at this time is less than one quarter of the original volume, and indicates that the fill is past the end of its design life.

A plan was developed that would address the issues of habitat decline, the continued growth of the Sampsons Island spit into Cotuit inlet, and the eroded condition of the Dead Neck nourishment template. The owners of the properties that comprise DNSI (Mass Audubon and Three Bays Preservation, Inc.) proposed that 500 feet of the Sampsons Island spit be dredged and that material be placed in the Dead Neck nourishment template. This back-passing project would have a dredge cut volume of 234,000 cubic yards. The plan would widen the inlet to the limit of the 1934 channel over a span of five years, while providing material that would be used at the eastern end of DNSI for shore protection and habitat construction.

The need for the sand contained within the accreting spit is more urgent since other possible sources are either depleted or unavailable due to regulatory restrictions. Since the 1990's, the primary sand source for Dead Neck nourishments has been material dredged from navigation channels in the Three Bays area. This present project requires much more volume than is available from channel maintenance at this time. In addition, offshore sources are essentially prohibited due to Barnstable County regulations that prevent sand mining in depths less than 66 ft, which is considered sea duck feeding habitat.

In response to feedback from the permitting agencies concerned about the size of the project, the project was scaled back. The plan is now to dredge 134,000 cubic yards of sand from the Sampsons Island spit, which will widen the inlet to the limits of the 1967 channel. Dredging will occur over three years. As part of the overall management plan developed with Mass Audubon for DNSI, 11,400 cubic yards of material will be used for the restoration and creation of specific habitat sites distributed around the island. 20,000 cubic yards will be used for dune restoration. The remaining available volume will be used to fill the nourishment template with a maximum beach slope of 1:15 (v:h) that is intended to provided additional endangered bird species habitat (as suggested by Maslo*, et al*., 2010).

CONCLUSION

In the case of the three inlet systems described above, it was only after large-scale inlet shoaling caused a variety of adverse impacts (e.g., severe coastal erosion, degradation of salt marsh and estuarine habitat, and navigation safety concerns) that management plans were developed. The hazards that developed added a sense of urgency to the situation that helped project proponents and regulators to focus and achieve a consensus that resulted in effective management plans that feature wildlife stewardship in their core goals. In each case, the good faith effort to address endangered species concerns helped to create a plan acceptable to all stakeholders, and which ultimately lead to the restoration of degraded habitat.

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