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Dredged Material as a Tool for Management of Tern and Skimmer Nesting Habitats

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PURPOSE: This technical note was written at the request of the U.S. Army Engineer Research and Development Center (ERDC), Environmental Laboratory (EL) following a presentation made by the senior author at a workshop coordinated by American Bird Conservancy (ABC) working with ERDC, held February 1–4, 2005 at Jekyll Island, Georgia (Guilfoyle et al. 2006). The ERDC and ABC hosted a series of three workshops dealing with coastal Corps activities and bird conservation. The Jekyll Island workshop covered the South Atlantic Coast, essentially from the Virginia-North Carolina border to south Florida. Subsequent workshops covered the North Atlantic and Gulf Coasts. Workshop objectives were to expand capabilities of the Corps to contribute to various bird conservation plans, to make the bird conservation community aware of opportunities that exist through working with the Corps, to address and hopefully reduce some areas of conflict, and to improve interagency and organization cooperation for bird conservation in these coastal regions. This report, which provides guidance on how to create and manage dredged-material islands as early-successional bird habitat, supports the objectives and was funded from a research work unit under the Corps of Engineers Dredging Operations and Environmental Research (DOER) Program titled, "Reducing conflicts between coastal engineering projects and bird habitat needs." (http://el.erdc.usace.army.mil/dots/coastalbirds.html).

BACKGROUND: Navigable waterways and channels in the United States are maintained at appropriate depths through the process of dredging. This is primarily the responsibility of the U.S. Army Corps of Engineers (USACE), and to a lesser extent the State Ports and Departments of Transportation. The material removed during dredging projects can be used to create, restore, and maintain early successional habitats preferred by most species of terns and some solitary beach-nesting shorebirds (e.g., plovers and American Oystercatcher [*Haematopus palliates*]). In most cases, dredged material placed on islands can provide nesting habitat that is equal to or even better than natural sites.

The use of dredged material by nesting waterbirds has been documented for decades, but it was not until the 1970's that the overall importance of dredged material sites to nesting waterbirds was realized (Buckley and Buckley 1974; Soots and Parnell 1975a, 1975b; Parnell and Soots 1978, 1979; Soots and Landin 1978). Studies of waterbirds during the 1970's revealed that 50–90 percent of the nesting sites in key Atlantic and Gulf Coast States were on dredged material (Landin and Soots 1977). In North Carolina, studies by J. Parnell and R. F. Soots, Jr., in the

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mid-1970's found that 76 percent of all ground-nesting waterbird colonies (terns, skimmers, pelicans, and gulls) were on dredged material sites (Parnell and Soots 1979).

Studies in the 1970's and 1980's resulted in a more complete understanding of the importance of dredged material sites to nesting waterbirds and the characteristics of dredged material islands that were used by nesting waterbirds (Erwin et al. 2003). The studies showed that not all dredged material sites are the same and that nesting waterbirds clearly preferred sites that were undiked and more closely resembled natural islands (Parnell and Soots 1979; Soots and Parnell 1975b; Parnell et al. 1986a). Soots and Parnell (1975b) mapped the seral stages of plant succession on dredged material islands and provided estimates of the useful life of an island to waterbird species. It was during this time that changes in the manner in which dredged material was placed on islands and the impact of the changes on waterbirds was recognized (Soots and Landin 1978; Parnell et al. 1986b.

This report discusses the use of dredged material by ground-nesting waterbirds, specifically nesting terns and skimmers, and the characteristics of dredged material deposits that are suitable for terns. The importance of active management, the need for periodic replenishment, and the importance of multi-stakeholder cooperation are also discussed. The observations and recommendations herein are based largely on more than two decades of experience with waterbirds and shorebirds along the coast of North Carolina.

Terns and Skimmers. Black Skimmers (*Rynchops niger*) and 10 species of terns breed along the Atlantic and Gulf coasts of the United States. The most widely distributed of the terns and the species most apt to use dredged material sites for nesting are Caspian Tern (*Sterna caspia)*, Royal Tern (*Sterna maxima*), Sandwich Tern (*Sterna sandvicensis*), Gull-billed Tern (*Sterna nilotica*), Common Tern (*Sterna hirundo*), and Least Tern (*Sterna antillarum*). These terns and Black Skimmers prefer early succession habitats consisting of bare sand, sand/shell, or sand/gravel substrate or sparse (<15 percent cover) vegetation. These species usually avoid sites with moderate to dense vegetation, a substrate of fine sand, sites with mammalian predators, and/or sites with chronic or excessive human disturbances. Forster's Terns (*Sterna forsteri*) also breed at a few sites along the Atlantic and Gulf coasts, and occasionally nest on dredged material islands with marsh or wrack present.

The North American Waterbird Conservation Plan includes the following information regarding the conservation status of terns and Black Skimmers that breed along the Atlantic and Gulf Coasts: High Concern: Gull-billed Tern, Roseate Tern, Arctic Tern (*Sterna paradisaea*), Least Tern, Black Skimmer; Moderate Concern: Royal Tern, Forster's Tern, Sooty Tern (*Sterna fuscata*); Low Concern: Caspian Tern, Common Tern; Not currently at risk: Sandwich Tern (Kushlan et al. 2002). Additional information regarding the conservation status of terns and Black Skimmers is presented in regional waterbird conservation plans, which are available at www.waterbirdconservation.org.

Dredging and Placement of Dredged Material. One of the greatest benefits to terns from dredging is the creation and maintenance of nesting habitats on islands. Islands created with dredged material can mimic their natural counterparts and provide excellent habitat for most tern species.

Dredged material islands can sometimes offer better nesting conditions than natural islands or beaches. They are often remote and lack mammalian predators. They are typically only accessible by boat, which reduces, but does not eliminate, the potential for human disturbances. And a key advantage of dredged material islands is that they are often higher in elevation than natural islands, which reduces the chances of flooding during severe weather events.

At the same time, there are potential disadvantages of dredged material islands. Dredged material islands require periodic deposits of sand, typically every 3–7 years, to maintain their size and appropriate seral stage. This is especially true for sites with early successional habitat required by most tern species. Islands constructed in open water where an island or emergent shoal did not previously exist can experience rapid erosion, shortening the useful life of the site. The process of dredging and disposal of dredged material can cause localized increases in turbidity, resuspend contaminants in sediments, degrade or eliminate submerged aquatic vegetation, cover shellfish, impact finfish spawning sites and other fishery habitat, and cover or remove intertidal habitats that are important for migrating and wintering shorebirds.

Another potential disadvantage and important consideration is that creating man-made islands could be viewed as a mitigation tool for practices that destroy or degrade stable, natural habitats. This could result in more loss of natural habitats over time, especially early successional habitats, unless these habitats are permanently protected, actively managed, and periodically replenished to maintain suitable conditions for nesting terns and skimmers. Furthermore, budgetary constraints and increased pressure to place sand on barrier beaches for beach widening and the protection of real estate (the same sand that once went to islands for the benefit of birds) could jeopardize the future of dredged material nesting sites that have historically supported significant populations of terns and skimmers.

Nevertheless, dredged material islands can and do provide excellent habitat for terns. These man-made islands, together with natural islands and beach nesting sites, are essential to terns in many states (Erwin 1980; Erwin et al. 2003).

In planning for the creation or restoration of tern nesting sites with dredged material, one must consider the following: location, possible need for a dike, size, elevation, shape, substrate, and the implementation of a long-term maintenance, management, and monitoring plan.

Location. The presence of mammalian predators will discourage most tern species from nesting. Sites considered for creation or restoration should have a natural or man-made barrier to predators. The most effective barrier is open water with a deep channel or tidal flow. A large expanse of open water between mainland or beach and a nesting site will also discourage, but not prevent, visits by people and their pets. At least 2 km of open water at mean low tide, preferably with a deep channel and tidal flow, separating a potential nesting site from mainland or other predator source is sufficient to reduce the chance of both predators and people visiting the site.

The presence of previously existing islands or shoals, the history of shoaling in the area, the stability of local channels, and the availability of a regular source of dredged material for island replenishment should also be considered. Islands created in open water where no island or shoal previously existed, or in areas where channels may move, can experience rapid erosion from tides, shifting channels, and/or storms. Also, regardless of location, dredged material islands

need periodic maintenance to maintain early succession habitats that are suitable for terns and skimmers. This can be easily accomplished with regular deposits of suitable dredged material (see "Succession and Useful Life for Terns and Skimmers"); thus, a nearby source of dredged material is advantageous.

Fish-eating birds, such as terns, can create conflicts at fish hatcheries, aquaculture facilities, and with at-risk fish populations (Collis et al. 2002; U.S. Fish and Wildlife Service (USFWS) 2005). Terns, when present at aquaculture facilities, are often subjected to lethal methods of control (Hunter et al. 2006). Therefore, the creation or restoration of tern and skimmer nesting sites in the vicinity of fish hatcheries, aquaculture facilities, or in the vicinity of at-risk fish populations should be avoided.

Lastly, terns and skimmers usually return to nest on islands where they previously had success. Thus rebuilding a former nesting island will normally attract terns faster than building an island in a new location. Occasionally, new, abandoned, or replenished dredged material islands with suitable habitat for nesting terns and Black Skimmers may go unused for one or more seasons. In such a case, social attraction (the use of decoys and recorded vocalizations) can be used to lure nesting terns and Black Skimmers to an island. This technique is described in Kress (1983) and Kress and Hall (2002). Social attraction has been used successfully to attract nesting terns to suitable nesting sites along the northeastern U.S. coast (Kress 1983; Kotliar and Burger 1984; Kress and Hall 2002) and along the North Carolina coast,[1] among other places.

Diked vs. Undiked Islands. Several studies have compared waterbird use of diked and undiked dredged-material islands (Parnell and Soots 1979; Soots and Parnell 1975a, Parnell et al. 1986a, 1986b). All have concluded that undiked islands are most suitable for nesting terns. While terns will occasionally use diked islands, most species will avoid nesting on fine substrate typically found in diked islands. Dredged material within diked islands is also more susceptible to flooding and many species will usually avoid nesting within the dike itself. There are certainly exceptions, but many diked sites that are regularly used by nesting terns more closely resemble undiked islands than a typical diked island.

Islands without a dike resemble an inverted cone with one or more domes, depending on how many times the outflow pipe was moved during disposal (Figure 1). On a typical undiked island, effluent exits the outflow pipe and is allowed to flow toward the water, resulting in the creation of a gentle slope from dome to water. This is the type of island most preferred by nesting terns. Two or three domes will produce some protection from strong winds, and terns often utilize these saddle areas between domes.

[1] Personal Communication, 2005, S. Cameron, Biologist, North Carolina Wildlife Resources Commission, Stella, NC.

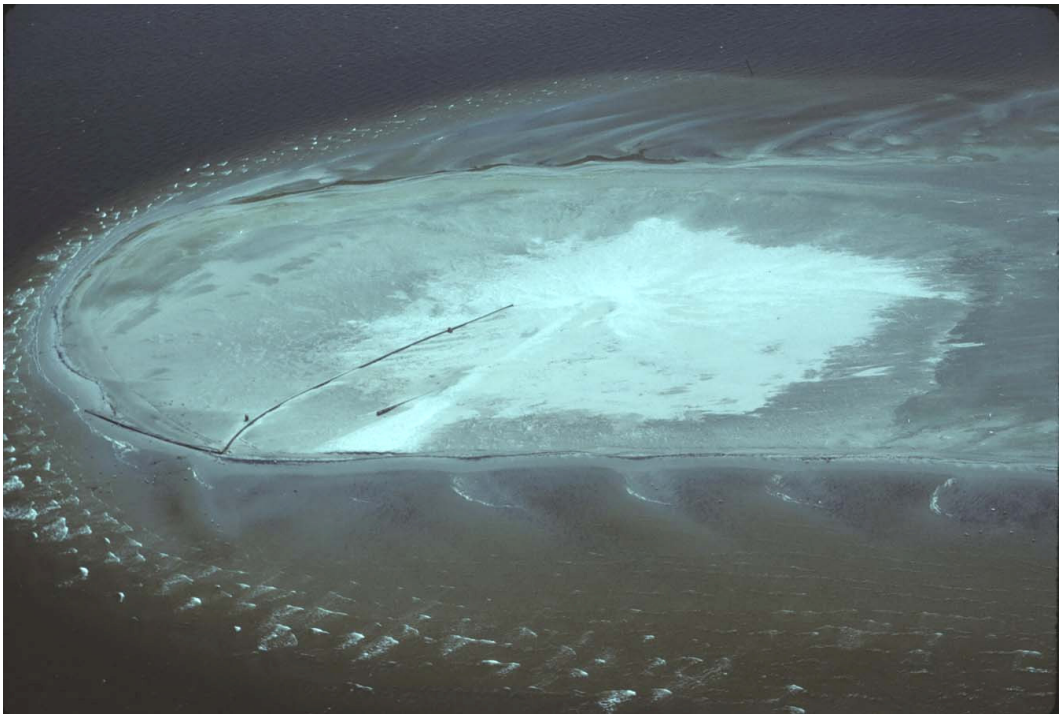

Figure 1. An undiked dredged material island with a single dome and a fresh deposit of dredged material.

The Wilmington District of the USACE has developed a disposal technique called the "control-of-effluent" method, which results in an island that has features of an undiked island and most of the benefits of placing dredged material within a diked island. When used, it can be very successful in creating or restoring tern nesting habitat and reducing impacts to surrounding submerged aquatic habitats or emergent wetland vegetation. The "control-of-effluent" method of disposal is aptly named because the slurry of water and dredged material exiting the outflow pipe is channeled to the desired location via small, temporary berms (Figure 2). The berms are constructed prior to initiation of dredging and usually surround most of the disposal area. A bulldozer or other earth shaping equipment is used to direct the effluent, eventually guiding it to an open area within the berm, avoiding areas of high environmental concern. The temporary berms are then graded to the desired slope when the pumping of dredged material has been completed. The grading of the temporary berms should be directed away from the new deposit of dredged material. Otherwise, seeds, roots, and rhizomes that were present when the berms were constructed will be redistributed over the fresh dredged material, which will rapidly increase vegetation on the island.[1] "Control-of-effluent" has been the standard method used by the Wilmington District since the early 1970's for the deposition of dredged material on estuarine islands.

[1] Personal Observation, 2005, Walker Golder, Deputy Director, Coastal Office and Sanctuaries , National Audubon Society, North Carolina State Office, Wilmington, NC.

Figure 2. Control-of-effluent method used in North Carolina to restore tern nesting habitat and maintain grassy habitat used by nesting pelicans.

Slope. A dredged material island is rarely a perfect, inverted cone-shaped feature. Most often it consists of a lower drift ridge and swale, an upper drift ridge and swale, a steeper slope leading to the dome, and the dome itself (Figure 3, Soots and Parnell 1975b). Soots and Parnell (1975b) defined slope as the rise in elevation from the upper swale to the dome. A gentle slope of 30:1 (a rise of 1 m over a linear distance of 30 m) has been recommended for ground-nesting waterbirds (Landin 1986; Chaney et al. 1978).

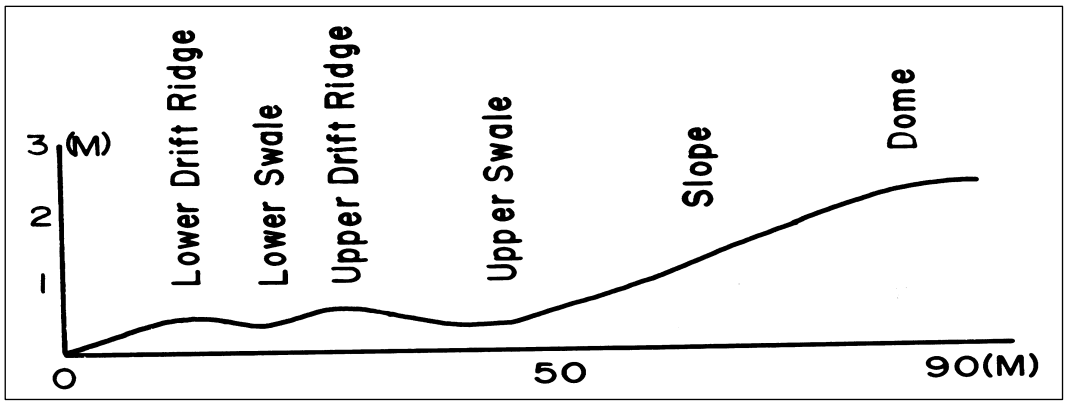

Figure 3. Topography of an undiked dredged material island (from Soots and Parnell 1975b; Figure 1, page 19).

Ideally, one could place the exact amount of dredged material on a site to maintain an island's size and slope that would be perfect for nesting waterbirds, and then maintain this size and slope throughout the life of the island. But rarely does this idealistic scenario work perfectly. Most often and especially for restoration of early successional habitat on an existing island, slope becomes a factor of the maximum allowable (permitted) size of an island or disposal area and the amount of dredged material available for the site. Therefore, flexibility is required to ensure that a site receives a new deposit of dredged material when needed and the site remains suitable for nesting waterbirds. To maintain suitable tern nesting habitat, at least one side of the island should have a gentle slope and suitable substrate. Islands with steeper slopes leading to an upper, flat or gently sloping terrace or dome can be suitable as long as the nesting area has the appropriate substrate. In such a case, the slope leading to the terrace should be no steeper than 10:1, and no slope on the island should be greater than 3:1. On islands with steeper slopes, terns will usually nest on the area between the lower drift ridge and the upper swale, or on the dome itself.

Substrate. Substrate comprised of at least 90 percent sand, often called "beach quality" sand, sand/shell, or sand/gravel is suitable for terns. Terns tend to avoid nesting on fine-grained substrate with a high percentage of silt or clay. Even fine-grained sand will blow and shift very fast when not mixed with shell, coarse sand, or held in place by vegetation. If the dredged-material is "beach quality," any silt and much of the fine, powdery sand will blow away after several months leaving coarser material behind for good nesting substrate. Too much fine-grained material may take many months to stabilize and is subject to the erosive forces of wind and wave action. Newly deposited "beach quality" sand will usually settle within two or three months, depending on local conditions, resulting in coarse substrate, which makes for better drainage and camouflage for eggs and young. The stability of a site with fine-grained material can be increased by the deposition of coarse dredged material over the fine substrate (Landin 1986).

Island Size, Elevation, and Shape. Island size and elevation are important considerations. Landin (1986) recommended that islands be no less than 2 ha and no more than 20 ha, primarily for ease of maintenance, management, and attractiveness to mammalian predators. Large dredged material islands, defined by Landin and Soots (1977) as those over 8 ha, often have more diverse habitats and can be less desirable for tern and skimmer nesting sites. Maintenance of early-successional habitats for nesting terns can be more difficult at sites where maintenance dredging is infrequent or the amount of dredged material available for an island is limited. Islands with well-developed grassland or shrub thicket habitats may become attractive to predatory birds or mammals.

Elevation is also an important consideration. Islands that are low can be susceptible to overwash or partial flooding during late spring or summer storms. Islands that are high in elevation may have slopes that are too steep for nesting terns and the higher elevation substrate may remain unsettled for a long period of time. Landin (1986) recommended 1–3 m as ideal elevation for dredged material islands, with higher elevations suitable if the dredged material is coarse sand. In 2001, the mean elevation of undiked dredged material islands used by terns in North Carolina was 3.91 m (SD = 2.97, n = 16); for natural islands it was 0.89 m (SD = 1.59, n = 46) (North Carolina Wildlife Resources Commission (NCWRC) 2005).

The shape of a dredged material island is probably of little importance to nesting terns as long as the site has suitable conditions for nesting terns.

Shoreline Stabilization. Shoreline stabilization is not recommended for islands or beaches that will be created or restored for nesting terns and skimmers. Royal and Sandwich tern chicks usually form a crèche (adult care of another's offspring) 2–3 days after hatching and prefer access to the water's edge (Shealer 1999; Buckley and Buckley 2002). Chicks of other tern species sometimes move to the water's edge prior to fledging (Parnell et al. 1995).[1] If an island is stabilized with sand bags or rip-rap, tern chicks may attempt to make their way to an intertidal beach during low tide and then be swept away during high tide or by large boat wakes. Tern chicks may tumble into crevices of a rip-rap stabilized shoreline.

Stabilization with submerged, emergent, or upland vegetation presents a different set of problems for nesting terns. Planting vegetation will likely increase the rate of plant succession on an island, thus reducing the useful life for nesting terns. Vegetation can attract nesting gulls, which can become significant predators on nesting terns and may cause terns to abandon an otherwise suitable nesting site. Stable vegetation may attract predatory and non-predatory mammals, which may be able to overwinter on an island. Finally, the presence of submerged and emergent vegetation may reduce the ability to deposit new dredged material on a site, thus jeopardizing the maintenance of a site for nesting terns.

Succession and Useful Life for Terns and Skimmers. Dredged material islands undergo a predictable pattern of plant succession, which largely determines the habitat available for nesting terns. Soots and Parnell (1975b) mapped plant succession on undiked dredged material islands along the North Carolina coast (Figure 4).

Habitat management is often required after year 5 to maintain a site in an early seral stage, which is required for most species of terns. The most effective and longest lasting means of maintaining early successional habitat is by periodic renourishment with a fresh deposit of dredged material (Figure 5). Other methods of vegetation management can be used to establish early successional habitat. They include removal of vegetation by hand, machinery, or chemicals; or covering vegetation with sand or landscape fabric. Based on experiments on North Carolina dredged material islands, these methods are temporary and usually last for only one season.

The useful "life" of an island can vary locally and regionally. Table 1 provides general guidelines for use of dredged material islands by nesting terns (Soots and Parnell 1975b).

[1] Personal Observation, 2005, David Allen, Biologist, North Carolina Wildlife Resources Commission, Trenton, NC, and Walker Bolder, Deputy Director, Coastal Office and Sanctuaries, National Audubon Society, North Carolina State Office, Wilmington, NC.

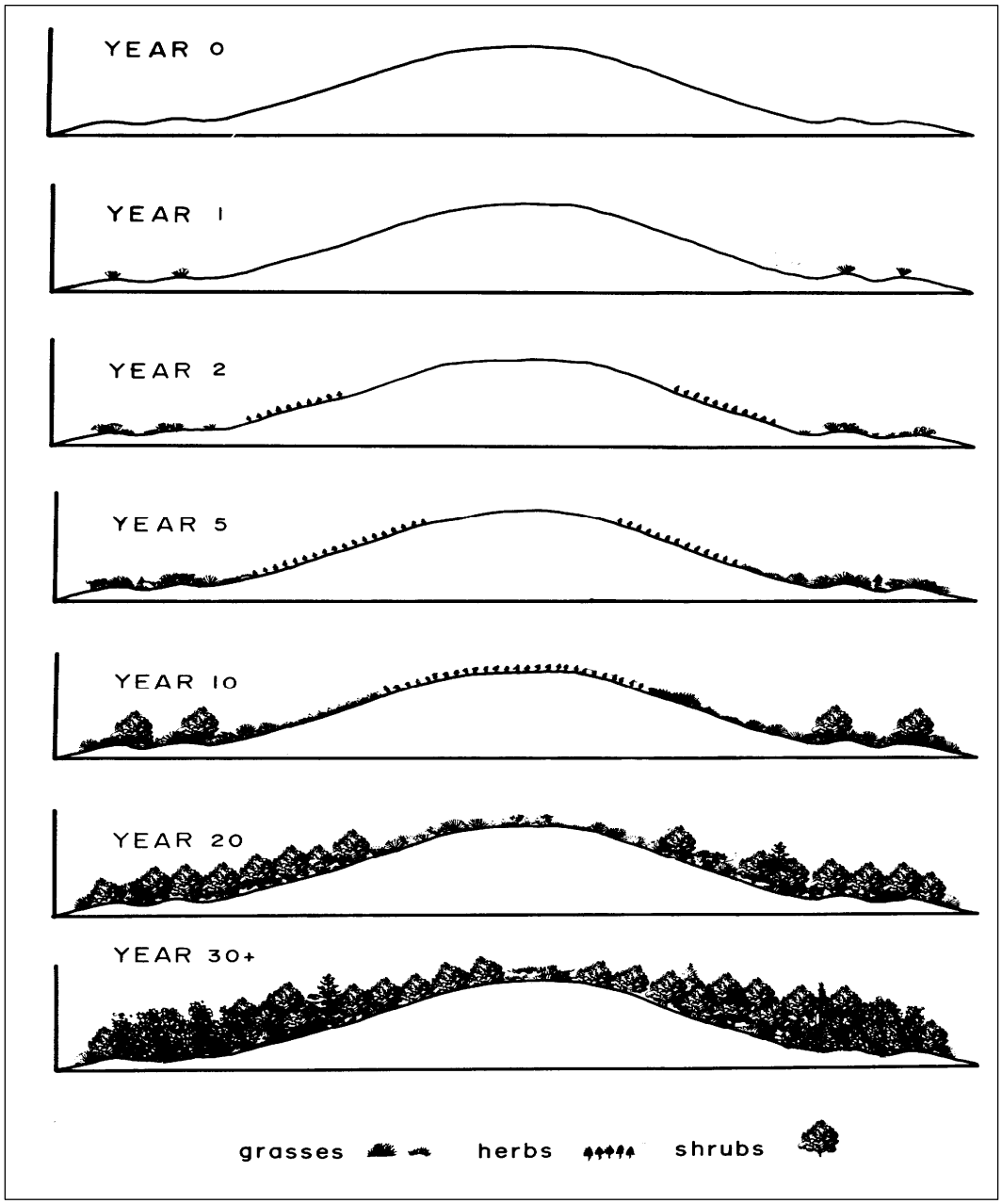

Figure 4. Plant succession on dredged-material islands (from Soots and Parnell 1975b; Figure 2, page 23).

Figure 5. An undiked dredged material island less than1 year after deposition of sand (top) and an undiked dredged material island approximately 12 years after deposition of sand (bottom).

Table 1
Age and Useful Duration of Use of Dredged Material Islands by Terns and Skimmers in North Carolina[1]

Species	Age at first use (yrs)	Estimated Use (yrs)
Royal and Sandwich Tern	1–2	4–7
Gull-billed Tern	2	4
Common Tern	2	6
Forster's Tern[2]	3	2+
Least Tern	1–2	4
Black Skimmer	1	7

[1] Adapted from Soots and Parnell (1975b; Table 1, page 57) and revised based on additional information not available at the time of their publication.
[2] Highly variable. Depends on presence of wrack or marsh.

Timing. Timing of disposal of dredged material is just as important as the quality of material being placed on potential nesting sites. Placing dredged material on potential nesting sites while birds are courting, incubating, feeding chicks, or anytime prior to all chicks fledging will cause abandonment of the site and would likely violate state and federal laws. Placing dredged material on sites while birds are actively nesting must be avoided.

The dredging window (i.e., the period when excavation of sand by dredging and the disposal of that sand is permitted) varies locally and regionally according to regulations imposed by State and Federal agencies. Therefore, the appropriate time for a dredging project must be determined for each specific locality. Dredged material should be deposited on a potential nesting site at least four weeks prior to the first arrival of nesting birds; eight to twelve weeks is preferred. This will give the substrate time to dry out and stabilize prior to the arrival of nesting birds. It will also allow time for the site to be posted and other appropriate management measures to be implemented.

Management and Monitoring. Most dredged material islands require active management to be suitable for nesting terns. While these islands are often remote and only accessible by boat, they can become popular areas for passive and active recreational activities, especially those located near population centers. These activities often peak during the warmer months of the year, which typically coincide with nesting activity by terns and skimmers. Therefore, dredged material islands require active management and regular monitoring to prevent or discourage human disturbances. With each dredged material island supporting or potentially suitable for nesting terns and skimmers, a management, monitoring, and maintenance plan should be developed and implemented by an appropriate agency or non-governmental organization with demonstrated experience in waterbird management.

The most effective means of managing disturbances is to close the site during the period when terns occupy the site. This can be accomplished with posts and signs to prohibit entrance or confine pedestrians to walkways, dikes, or observation areas.

Erwin (1989) measured the response of breeding terns, skimmers, and wading birds in North Carolina and Virginia to the approach of walking human intruders, and recommended the following setback distances for established colonies: 100 m for Least Terns and Royal Terns, and 200 m for Common Terns. Early in the nesting cycle (i.e., first arrival at colony sites, courtship, and nest building), colonial waterbirds can be very sensitive to disturbances. Erwin recommended an additional 100-m setback during this period: 200 m for Least Terns and Royal Terns, and 300 m for Common Terns. Rodgers and Smith (1995) conducted a similar study in Florida and recommended setback distances of 180 m for mixed-species tern-skimmer colonies.

Delineating buffer zones between birds and potential human disturbances is important and an effective means of reducing disturbances at nesting, resting, and foraging areas. Visible, readable, and clearly worded boundary signs are important to successfully reduce disturbances. Boundary signs stating "Entry Prohibited," "Area Closed," or "No Trespassing, No Landing" are appropriate. Boundary signs with suggestive or vague language, such as "Please do not disturb the birds" or "Bird Nesting Area" are much less effective. Signs should be placed at locations and distances so that all visitors encounter a sign regardless of their approach (Hunter et al. 2006). Erwin (1989) recommended that signs be erected 3 weeks prior to the arrival of nesting birds and that signs should be spaced 50 m apart around the entire nesting area. Closer spacing (10–15 m) is required for high traffic areas.[1] Signs on posts should be approximately 1.75 m above ground level (Hunter et al. 2006).

Sites that are easily accessible to the public may require the addition of clearly marked rope or string between signs and posts. Short (5–8 cm) pieces of brightly colored flagging tied to the string or rope every 4–5 m greatly increase the visibility of the string or rope. This creates a psychological barrier, sometimes called "symbolic fencing," that can be very effective at reducing disturbances.

Signs and rope/string alone are not sufficient without enforcement. The temporary or permanent closure of a site for the protection of terns and skimmers requires enforcement of the closure. Regular patrols by uniformed wardens, rangers, or law enforcement officers are most effective at reducing disturbances. Assistance from trained volunteers working closely with a management agency or organization can also be a very effective means of preventing disturbances at publicly accessible sites especially public beaches.

Nesting sites should also be monitored regularly by a trained biologist to assess the condition of the site and habitats, document species and numbers of nesting birds (following standard protocols), assess threats or potential threats, and develop plans for the long-term maintenance of the site and/or habitats.

Education and raising public awareness, combined with the management measures mentioned so far, are the last important components of a management plan for human disturbances. All too often, visitors are unaware of the harm to eggs or chicks that can result from untimely disturbances. And sometimes, especially on beaches, visitors simply do not believe that birds

[1] Personal Observation, 2005, Walker Golder, Deputy Director, Coastal Office and Sanctuaries , National Audubon society, North Carolina State Office, Wilmington, NC.

actually nest on sand. Local informational and educational displays, signs, brochures, tours, talks, and similar outreach tools can be used successfully to reduce human disturbances.

DISCUSSION AND CONCLUSIONS: Success of tern and skimmer habitat projects on dredged material sites depends on cooperation among regulatory and resource agencies (state and federal), non-governmental organizations, and other stakeholders. This cooperative relationship should be established long before a project is initiated. To facilitate this cooperation, some states and areas within states have developed working groups or committees that meet regularly to discuss dredging, birds, project design, and other issues related to birds and dredging. North Carolina, for example, has the North Carolina Colonial Waterbird Management Committee. Also in North Carolina, representatives from resource agencies and non-governmental organizations actively participate in USACE District dredging coordination meetings. Tampa Bay, Florida has a Migratory Bird Protection Committee to discuss, among other things, issues related to dredging and birds.

Opportunities for tern and skimmer habitat creation and restoration with dredged material likely exist at many sites along the southeastern United States coastline, especially on state and federal lands, non-governmental conservation lands, and through partnerships with private landowners. Identifying opportunities for tern and skimmer habitat restoration on dredged material islands should be a priority in all coastal states. In some areas, existing islands could be altered to provide specific habitats required by these birds. Sites that currently do not provide suitable habitats for them should be reviewed for their potential as restoration sites. Similarly, opportunities for the creation of tern and skimmer habitats should also be explored.

RECOMMENDATIONS: Based on the information contained in this technical note, the following recommendations are made:

- USACE Districts with operations that affect waterbirds or shorebirds should develop a Cooperative Agreement of Memorandum of Understanding with the appropriate State agencies (wildlife, natural resources, marine fisheries, etc.) to ensure coordination of actions to enhance the natural resource benefits of dredged material disposal.

- Sites considered for creation or restoration should have a natural or man-made barrier to predators. The most effective barrier is at least 2 km of open water with a deep channel or tidal flow.

- Construction of permanent dikes around sites created or restored for nesting terns should be avoided. Undiked islands and those where control of effluent method of disposal is used are preferred.

- Deposition of dredged material should be completed at least four weeks prior to the first arrival of nesting birds; eight to twelve weeks is preferred.

- Substrate should be at least 90 percent sand, often called “beach quality” sand, sand/shell, or sand/gravel.

- A gentle slope of 30:1 is desirable for terns and no slope on the island should be greater than 3:1; elevation should be 1–3 m; size should be 2–5 ha.

- Shoreline stabilization is not recommended for tern and skimmer nesting sites.

- A long-term management plan should be developed and implemented on all sites where dredged material is used to create or restore habitats for nesting birds and the management plan should be implemented by an appropriate agency or organization with demonstrated experience in waterbird management.

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