Restoration of Waterbird Habitats in Chesapeake Bay: Great Expectations or *Sisyphus* Revisited?

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Abstract.—In the past half century, many waterbird populations in Chesapeake Bay have declined or shifted ranges, indicating major ecological changes have occurred. While many studies have focused on the problems associated with environmental degradation such as the losses of coastal wetlands and submerged vegetation, a number of restoration efforts have been launched in the past few decades to reverse the "sea of despair." Most pertinent to waterbirds, restoration of submerged aquatic vegetation (SAV) beds, tidal wetland restoration, oyster reef restoration, and island creation/restoration have benefited a number of species. State and federal agencies and nongovernment agencies have formed partnerships to spawn many projects ranging in size from less than 0.5 ha to ca. 1,000 ha. While most SAV, wetland, and oyster reef projects have struggled to different degrees over the past ten to twenty years with inconsistent methods, irregular monitoring, and unknown reasons for failures, recent improvements in techniques and application of adaptive management have been made. The large dredge-material island projects at Hart-Miller Island near Baltimore, Poplar Island west of Tilghman Island, Maryland, and Craney Island in Portsmouth, Virginia have provided large outdoor "laboratories" for wildlife, fishery, and wetland habitat creation. All three have proven to be important for nesting waterbirds and migrant shorebirds and waterfowl; however nesting populations at all three islands have been compromised to different degrees by predators. Restoration success for waterbirds and other natural resources depends on: (1) establishing realistic, quantifiable objectives and performance criteria, (2) continued monitoring and management (e.g., predator control), (3) targeted research to determine causality, and (4) careful evaluation under an adaptive management regime.

Key words.—Waterbirds, Chesapeake Bay, restoration, coastal wetlands, islands.

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The living resources of the Chesapeake Bay have been the subject of folklore, literature (e.g., James Michener's novel, *Chesapeake*), navigational, commercial, recreational, and environmental interest for much of America's history. In the late 1600s, Captain John Smith exclaimed at the "huge swarms of birds and the dangers of running aground on numerous oyster bars" upon entering the Chesapeake (Ray and McCormick-Ray 2004, p. 156). Semmes (1937, in Lynch 2001) noted that "wild fowl" were so abundant that "the water was so black (with birds) that it seemed [like] a mass of filth or turf, and when they flew up there was a rushing and vibration of the air like a great storm coming through the trees while the sky over the whole creek was filled with them like a cloud." Since the early 1900s, with the rapid development of the watershed and explosive human population growth in the Bay region, most living resources have been compromised (Schubel 1986; Ernst 2003; Ray and McCormick-Ray 2004; Powledge 2005). Humans numbered about eight million in 1950, but by 2000, had grown to around 15 million, and are expected to reach about 18 million by 2020 (Ernst 2003). Concomitantly, nutrients have exploded, urban-agricultural-industrial pollutants have increased dramatically, and recreation and disturbance levels on and near the mainstem Bay and its many tributaries have spiked in recent decades (Ernst 2003; Ray and McCormick-Ray 2004; Powledge 2005).

As conditions in the Bay deteriorated, many species of waterbird declined or were displaced (Terborgh 1989; see chapters in Funderburk *et al.* 1991; Lynch 2001). Reasons point largely to qualitative and/or quantitative changes in the food base and nesting habitat. Contaminants in lower trophic level species had adverse effects on Southern Bald Eagles (*Haliaeetus leucocephalus*) and Ospreys (*Pandion haliaetus*) from the mid 1940s (World War II) until the banning of organochlorine pesticides in the 1970s with resid-

ual effects thereafter (see Rattner and McGowan 2007; Watts and Paxton 2007; Watts *et al.* 2007). Declines in submerged aquatic vegetation (SAV) from about 77,000 ha (185,000 acres) in the mid 1900s to about 29,000 ha (70,000 acres) by 2004 certainly contributed to dietary shifts of Canada Geese (*Branta canadensis*), Snow Geese (*Chen caerulescens*), Canvasbacks (*Aythya valisineria*), and a winter range shift southward of Redheads (*A. americana*) (Terborgh 1989; Haramis 1991a, b; Lynch 2001; Perry and Deller 1995). Losses of wetlands affected all species that depended either directly on marshes such as American Black Ducks (*Anas rubripes*, Krementz 1991), or on the fish and invertebrates produced by them (e.g., wading birds, see Erwin and Spendelow 1991). The dramatic oyster harvest decrease from about 40 million kg in 1900 to about five million by 1985 resulted in numerous complex ecological changes in the Bay (Ray and McCormick-Ray 2004; Powledge 2005). Oyster declines affected many benthic invertebrate communities associated with them, and as a result, the wintering waterfowl that depend upon them (Lynch 2001; Ray and McCormick-Ray 2004; Perry *et al.* 2007). Island losses in the Chesapeake Bay have been documented, with total acreage from eight major islands declining by about 1/3 from the mid 19th century to 1990 (Leatherman *et al.* 1995). In at least one case, Sharp's Island, Maryland where a hotel once stood, the entire island eroded away! With island losses come nesting habitat loss for species that require isolation from predators, such as American Black Ducks, herons and egrets, Eastern Brown Pelicans (*Pelecanus occidentalis*), Double-crested Cormorants (*Phalacrocorax auritus*), ground-nesting terns and Black Skimmers (*Rynchops niger*) (Erwin *et al.* 1993).

In spite of the temptation to conclude that the Bay's natural resources are destined for impoverishment, we are encouraged to find a number of activities are underway attempting to "turn the tide" in a better direction. Many federal agencies, including the U.S. Fish and Wildlife Service (Chesapeake Bay Field Office, hereafter FWS), National Marine Fisheries Service (NMFS), U.S. Environmental Protection Agency (US EPA), and U.S. Army Corps of Engineers (USCOE), have promoted restoration of many natural resources such as submerged aquatic vegetation (SAV), anadromous fishes (dam removals and fish ladders), oyster reefs, and island habitats to support wetlands and wildlife (e.g., USCOE's project at Poplar Island). State agencies have taken parallel measures in targeting these natural resources as well; in Virginia, the Coastal Program of the Department of the Environmental Quality, Virginia Marine Resources Commission (VMRC) and Virginia Institute of Marine Sciences (VIMS) have been leaders in restoration efforts, and in Maryland, the Department of the Environment, Department of Natural Resources (MD DNR), Maryland Port Administration (MPA) and the University of Maryland's Center for Environmental Studies (CES program) have had analogous roles. In addition, many nongovernment organizations have sponsored a number of restoration initiatives, including the Chesapeake Bay Foundation (CBF), Alliance for Chesapeake Bay, the National Aquarium in Baltimore, the Virginia Aquarium, and a variety of civic associations.

In this paper, we briefly review some of the major restoration efforts that potentially will benefit the waterbird communities of the Chesapeake Bay and coastal bays, and examine the major island development projects sponsored largely by the USCOE (Fig. 1). Our focus is on the nesting, feeding, and/or roosting habitat quality and quantity provided for waterbirds by the restoration efforts, with less emphasis on broader system effects.

METHODS

Information about SAV, oysters, and wetlands that is presented here was collected by contacting a number of resource agency and academic personnel. Much of the information was from websites, unpublished reports, and documents that had yet to undergo review. Most of the information on islands was derived from USCOE web sites, unpublished USCOE documents, progress reports from various individuals involved with the monitoring activities on the islands, as well as our own unpublished research and monitoring on Craney Island (RAB) and Poplar Island (RME). Bird information on Hart-Miller Island was obtained from E. Scarpulla, a long-time volunteer from the Maryland Ornithological Society. He initiated bird monitoring in 1996, visiting the island almost every Saturday year round, unless weather or boat limitations precluded access. He and associates hiked the

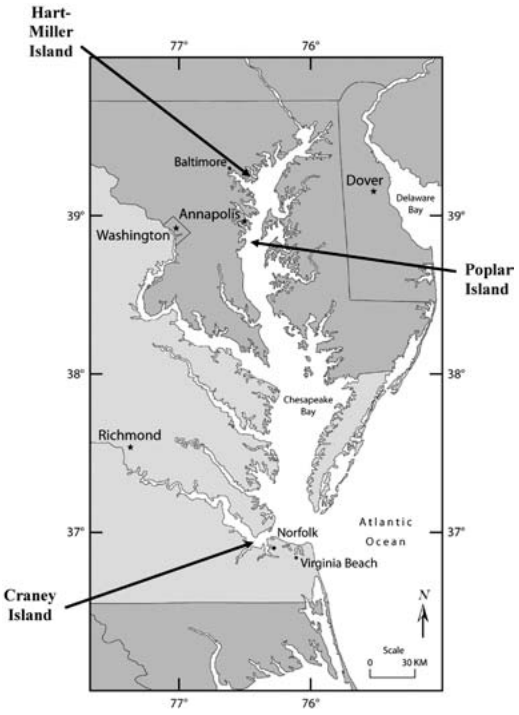

Figure 1. Locations of the three major dredged material islands in Chesapeake Bay, Hart-Miller Island, east of Baltimore, Maryland, Poplar Island, west of Tilghman Island, Maryland, and Craney Island, near Portsmouth, Virginia.

ten-km dike perimeter of the island, scanning each cell (north and south) with telescopes and estimating the total numbers of all birds observed or heard.

Poplar Island.—For the methods used for the waterbird component of the study on Poplar Island, surveys of breeding waterbirds were initiated by RME in 2002 (supplementing the efforts by Jan Reese), and from 2003-2006, a reproductive performance component was added for Least Terns (*Sterna antillarum*), Common Terns (*S. hirundo*) and Snowy Egrets (*Egretta thula*).

Surveys to estimate breeding populations were performed by visiting all potential nesting locations for waterbirds, i.e., created habitat islands, remnant islands, and sand flats within all the cells of Poplar Island (see Fig. 2) during May-July each year. An adjacent small island (north end of Jefferson Island) was also visited from 2004 to 2006 where we discovered Common Tern nesting. At least four surveys were performed on Poplar, with supplemental information on nesting provided by J. Reese. For Common and Least terns, more precise estimates of breeding pairs were needed, therefore a modified mark-recapture method was employed using three to five observers (Erwin 1979) in early June. Here, nests are marked with spray paint upon a first walk through the colony; then, a second walk through is conducted immediately, separately counting marked and unmarked nests to derive a Lincoln-Petersen Index (Erwin 1979). For subcolonies with only a small number of nests (<50), a complete nest count was conducted. This was generally done for Least Terns, but tongue depressors (markers) were employed to ensure full counts. To estimate reproductive success of both tern species, a sample of nests in each subcolony (20-30) was marked and visited at least once weekly to record egg and chick numbers. In 2003 and 2004, wire enclosures were erected around groups of Common Tern nests at two to three subcolonies, as a method to contain young and allow better estimation of chick fledging success (Erwin and Custer 1982). Because of the tendency of young to disperse widely soon after hatching, no enclosures were used at Least Tern colonies. In 2005, because of the previous years' hatching failures, fencing was deferred at the Common Tern colonies. Instead, repeated counts of large young were made at the one subcolony where renesting provided a small number of recruits. To try to document predation, a remote IR video camera system was set up in the main Common Tern colony in 2005 by FWS personnel (J. Miller and others). The camera was run at intervals over a period of several weeks in June during the nighttime hours and the images were downloaded and reviewed within several days of operation.

For egrets, a decoy experiment was attempted by J. Miller (FWS) in March 2004, whereby 20 plastic white egret decoys were purchased and placed randomly on the remaining sparse shrubs on the remnant island in cell 1. Snowy Egrets colonized the island that April 2004, and numbers of nests were estimated twice in June and July that year by four biologists. In 2005 and 2006, decoys were again used, and both Snowy and Cattle Egrets (*Bubulcus ibis*) returned. Estimates of numbers of young produced were made in two ways. In 2004, in July, a group of five biologists entered the colony (mostly large, free-running young at that point), and captured and marked young on the back with yellow felt-tipped markers. After the first marking, a second capture period ten min later was used to record the numbers of marked and unmarked birds. Then, as above, a Lincoln-Petersen Index was calculated to yield an estimate of the total of young. In 2005, due to access restrictions, multiple counts of young egrets were made from the dike using spotting scopes and binoculars on three occasions. We were unable to discriminate between Snowy and Cattle egrets using the latter method.

Osprey numbers were easier to determine, as their large nests were conspicuous on platforms, on breakwater boulders or remnant barges within cell 1. Active nests were counted at least six times from April to July both by one of us (RME) with confirmation by J. Reese.

Because of their cryptic nature, American Black Duck nests were very difficult to locate, so we depended upon getting repeated counts of broods seen during May-June from our surveys, those of J. Reese, and the FWS biologists. Thus, rough estimates of both numbers of nesting pairs as well as a reproductive measure were obtained simultaneously.

To enhance ground-nesting waterbird nesting, predator removals were conducted in 2003 and 2004. From two to four Red Foxes (*Vulpes vulpes*) were trapped and removed from April to June each year by biologists with the U.S. Department of Agriculture and/or U.S. Fish & Wildlife Service. No tracks were found near nesting colonies in either 2005 or 2006, so no trapping occurred.

Craney Island.—This site has been systematically surveyed for waterbirds, migrating and nesting, each spring and summer from 1975-2006 (by RAB and students). All potential nesting locations for waterbirds, i.e., created habitat and sand flats within the three cells of Craney Island and the shoreline outside the cells were surveyed during 15 March-1 September each year. All areas on

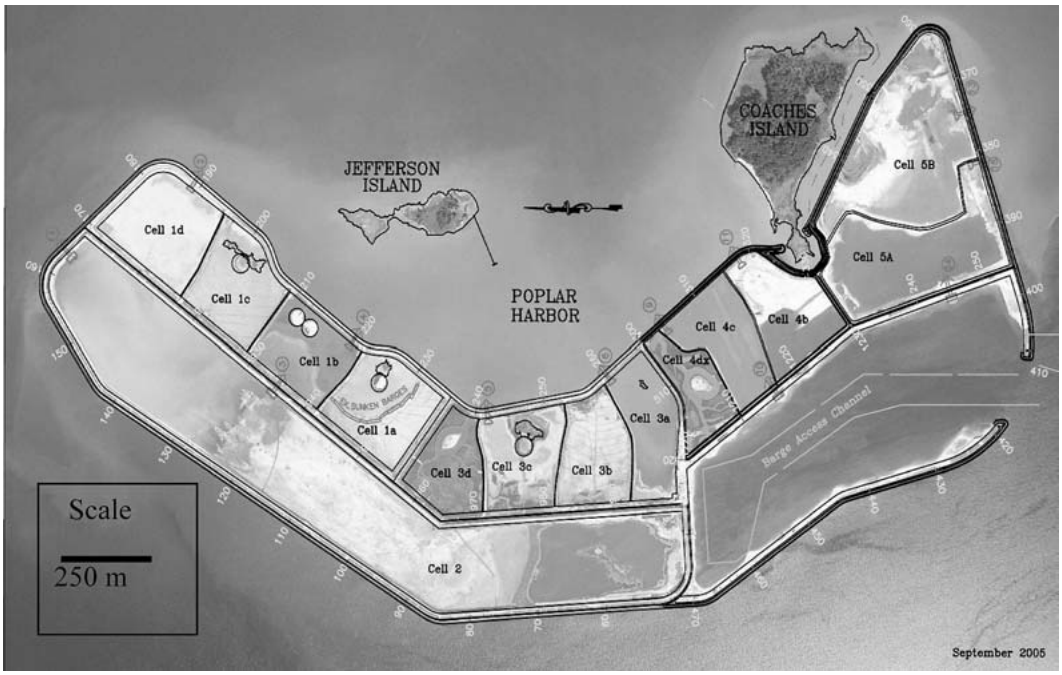

Figure 2. Schematic of Poplar Island Environmental Restoration Project, showing containment cells, habitat islands (for nesting waterbirds) within selected cells (small round features), exterior rock perimeter and sand interior cross dikes.

sites were surveyed two to three times from 15 March-30 April and twice weekly from 1 May-15 September All nesting waterbird colonies were recorded (GPS locations obtained since 1998), plotted and mapped and monitored for nesting success. For the non-waterbird species, weekly surveys were conducted throughout the year. To canvass all habitats on the island, fixed points were established and at each stop, observers recorded all species seen and heard for three minutes. This was repeated for all points to cover the entire island.

For Least Terns, a complete nest count was conducted at each subcolony to obtain an accurate number of breeding pairs. Sand color paint sticks and tongue depressors were used to mark the nest until 1985; after this, no markers were used as we suspected our marking technique attracted predators. A small straight line (15 cm) was scraped into the substrate to the north of the each nest to insure an accurate count. This simple nest marking technique did not wash away on the shell-sand substrate, did not attract mammalian predators and nests were easily relocated. The tern colonies were visited twice weekly to determine the fate of the nest. The number of eggs, number of hatched young and the number of fledged young were recorded. Evidence for any type of disturbance or depredation was observed and recorded during each visit.

Beginning in 1989 when their nesting was first documented at Craney, complete surveys for nesting Piping Plovers (*Charadrius melodus*) were conducted from 15 March until 15 June. Nesting enclosures constructed of wire were erected as needed to enhance nesting success once nests were established. Since 1998, only migrating piping plovers have been observed at Craney in the early spring and post-breeders in the late summer.

Since 1975, Black-necked Stilts (*Himantopus mexicanus*) have attempted nesting on Craney. Breeding pairs were very vocal, making their nesting presence more obvious. They concentrated in the interior of the cells on mud mounds formed by the dredge material. The nests were visited when accessible, however, some nests could only be monitored from a vehicle or at a distance because of the unstable, muddy substrate around the nest.

To attract Ospreys, four artificial platforms were erected in 1988, three of which have been used consistently over the years. In addition, three pairs of Osprey used large boulders or remnant bridge structures on site. Nests were visited when possible. Others were observed by telescope to determine the number of hatched and the number of fledged young.

To enhance nesting success of the ground-nesting waterbirds on the island, mammalian predators (Red Foxes, Raccoons, *Procyon lotor*, feral cats *Felis domesticus*, packs of wild dogs *Canis familiaris*) were observed and removed every six to eight years by USCOE personnel intermittently over the 30-year study period.

STATUS OF HABITAT RESTORATION

Submerged Aquatic Vegetation (SAV)

A large number of SAV projects have taken place in the Chesapeake Bay and in some of the Virginia coastal bays over the past 20 years especially, however, many are quite small (<0.1 ha) in area, have not carefully

documented techniques, and have high failure rates over a five-year period (R. J. Orth, VIMS, pers. comm.). In researching the status of SAV projects in the Bay region, it became apparent that there has been little Baywide coordination or updating of projects at one centralized database. VIMS maintains a website for much of their activity, the Maryland Department of Natural Resources has one that had not been updated (as of November 2005), NOAA has partial information on their projects (P. Bergstrom, NOAA, Annapolis, Maryland, pers. comm.), but many of the smaller projects orchestrated by non-government agencies (NGOs) or civic associations are not recorded and their monitoring is often not rigorous. A summary of the major projects is shown in Table 1. In Maryland, the two large projects are in the lower Potomac River (five locations totaling about 33 acres), and in the lower Patuxent River near Solomons (five sites totaling about 23 acres) (see www.dnr.state.md.us/bay/SAV/restoration.asp). In Virginia, sites are distributed from the Potomac River south to the James River in the Chesapeake, and on the Eastern Shore of Maryland and Virginia from Assawoman Bay in Maryland south to the "southern Delamarva coastal bays" including Magothy, South, Cobb, Spider Crab, and Hog Island (Orth *et al.* 2006; see VIMS annual reports on SAV at: www.vims.edu/bio/sav/). Grass beds in these southern bays have only recently been discovered and seeding experiments have gone well in recent summers (R. J. Orth, pers. comm.).

Whereas many of the early SAV plantings were from shoots, more recent evidence suggests that broadcasting seeds is more effective in developing beds over larger areas with a minimum of manpower (Orth *et al.* 2006). The major manpower need becomes one of collecting large numbers of seeds from existing productive SAV meadows.

Long-term monitoring and success of the individual projects varies a great deal. In summer 2005, survival of many small Chesapeake SAV projects was very low for unknown reasons (P. Bergstrom in Maryland, pers. comm.; R. J. Orth, pers. comm.). However, success has been higher on the ocean bays. SAV bed establishment seems to depend on a complex set of factors including water quality, interference with macroalgal mats and phytoplankton shading, distance from seed sources, and disturbances, both biogenic (bird grazing, see below) and human (e.g., clam dredging, Orth *et al.* 2002; R. J. Orth, pers. comm.).

Once large beds of SAV become established again, the prospects will improve for migrating and wintering waterfowl such as Canvasbacks and Redheads, species that were formerly much more abundant in the Bay. At the same time, threats to newly established SAV beds from the introduced Mute Swan (*Cygnus olor*) need to be reduced. This species expanded its population dramatically over the past 40 years (Perry 2004). In fact, control efforts have been underway in recent years, with egg oiling, addling, and lethal control by U.S. Department of Agriculture and both Virginia and Maryland DNR biologists. Another major threat to established SAV beds has been clam dredging. These activities leave large, long-term scarring of beds and are threats to bed sustainability when dredging is performed repeatedly (R. J. Orth, pers. comm.). Recent legislation in Maryland has resulted in some sanctuary areas being established for SAV.

Table 1. Major restoration project areas of submerged aquatic vegetation (SAV) in Chesapeake Bay and the DelMarVa region of Virginia and Maryland. Area is approximate hectare totals.

Primary area	Years	Areas (no. of sites)	Contact person or agency
Maryland—Bay	1997-2005	>5 (25 small projects; <0.5 ha); 2 large (>10 ha) projects	MD DNR SAV website
Virginia—Bay	1997-2005	2-2.5 (16 sites)	R. J. Orth, VIMS; NOAA; MD DNR
Virginia—Southern DelMarVA coastal bays	1998-2005	2 (20-27 sites)	R. J. Orth, VIMS (Orth *et al.* 2006)

Stream Restoration

Dam removal and riparian restoration along many Chesapeake Bay tributaries should provide major improvements to river quality, sediment dynamics, nutrient movement, and fisheries restoration for anadromous fish. The Chesapeake watershed leads the nation in stream restoration, with 4,700 projects undertaken since 1990, at a cost in excess of $400 million (Hassett *et al.* 2005). As direct potential benefit to waterbirds, the projects include 88 dam removals or retrofits, and 96 fish passageways (e.g., fish ladders). In spite of the large investment in funds and manpower, however, only 5.4% of the projects reported monitoring of project performance (Hassett *et al.* 2005). Of these, most (59%) were biological (e.g., sampling fish) with many fewer monitoring water chemistry or physical structure.

The anadromous herring species, White Perch (*Morone americana*), and Striped Bass (*M. saxatilis*) are often important prey for Ospreys, Brown Pelicans, and Double-crested Cormorants, and juveniles of these species may be taken by numerous species of gulls and terns from surface shoals.

Wetland Restoration

Wetlands have been largely reduced or altered throughout the Chesapeake Bay and Atlantic coasts since the early 1900s (Tiner and Finn 1986; Wilson *et al.* 2007). Beginning in the 1980s, a number of projects began at various spatial scales to attempt to reverse wetland loss, in part in response to the "No Net Loss" initiative during the George H.W. Bush administration (The Conservation Foundation 1988). In the Bay, salt marsh area declined from about 182,000 acres in 1956 down to only about 170,000 by 1989 (US EPA 1998).

Obtaining accurate, current data on all the wetland restoration projects along the Chesapeake shoreline and the Atlantic coastal bays has proven elusive. Many federal, state, and local organizations are involved and often small projects are not registered in any databases. In Maryland, the Department of the Environment (MD DOE) attempts to record most projects, but the database is incomplete (D. Clearwater, MD DOE, pers. comm.). Approximately 2,900 ha (7,000 acres) of Bay coastal wetlands had been restored from the late 1990s until 2004. This figure did not include projects whose major focus was controlling *Phragmites australis*. In addition, it did not include the newly emerging Poplar Island Environmental Restoration Project (PIERP), where two wetland cells have been planted to date (ca. 24-29 ha, or 60-70 acres), but eventually about 310 ha (750 acres) will be developed as part of the joint USCOE and Maryland Port Administration "Beneficial Use" project (see details below).

In Virginia, we were unable to get updated data from all the agencies (J. Perry, VIMS, pers. comm.). However, the Virginia Department of Environmental Quality provided information on the number of wetland permits issued and area estimates for recent years. For all wetland types (both freshwater and coastal salt marsh), 155 permits were issued in 2004, with a total of 113,100 ha (271,439 acres) under "mitigation", with a net gain of 135,535 ha (325, 284 acres; includes "preserved" acres as well as created and restored categories), and loss of 225 ha (540 acres) (C. M. Harold, Virginia DEQ, unpubl. data).

What often is lacking in both wetland and stream restoration projects is a commitment to long-term monitoring of success, or performance criteria (Hassett *et al.* 2005). In many cases, temporary breakwaters may be used, such as geotextile tubing, which have a limited lifespan. As these fail, erosion happens rapidly and correct elevations are quickly compromised resulting in death of planted *Spartina* (RME, pers. observations at Smith Island, Maryland, Fair Island in the Pocomoke River). In other cases, Canada Geese find the newly planted marshes and quickly denude the site (RME, pers. observ.).

Oyster Restoration

Since the invasion of two parasitic protozoan diseases, Demo and MSX, in the Chesapeake and on the eastern shore during the 1950s, the once-famous Eastern Oyster (*Crassostrea virginica*) population has crashed

nearly to the point of not being commercially viable (US EPA 1998; Ray and McCormick-Ray 2004). The large oyster reefs provide many important ecological functions in the Bay, including filtration of water, reduction of phytoplankton stocks, removal of pollutants, provide food for some predatory fish and snails, and the reefs serve as a stabilizing structure allowing for robust benthic communities to develop (Kennedy 1991; Ray and McCormick-Ray 2004). These communities of bivalves support large concentrations of migrating and wintering sea ducks such as Long-tailed Ducks (*Clangula hyemalis*), Black Scoter (*Melanitta nigra*), White-winged Scoter (*M. fusca*), and Surf Scoter (*M. perspicillata*) (see Perry *et al.* 2007).

Attempts to recover the oyster consist of depositing harvested shell overboard, as well as reef construction from both natural and artificial materials. Information about the restoration in Virginia can be found at: www.vims.edu/mollusc/NORM/index.htm. For Maryland, the site is at: www.oysterrecovery.org. In Virginia, the program is jointly operated by the USCOE, VIMS, NOAA, and the CBF. Since 2000, four major projects have been started involving reef construction, shell augmentation, and seeding. Two reefs are in the Great Wicomico River, two in the lower Rappahannock River, and one each in Tangier and Pocomoke Sounds. Another is pending in the Lynnhaven River.

In Maryland, the Oyster Recovery Program, directed by the University of Maryland's Center for Environmental Studies, has 37 sites in the upper Bay where more than 602 million disease free spat have been planted since 2000. These sites range, on the western upper Bay, from the Magothy River south to the Potomac, and on the eastern shore, from the Chester River south to the Nanticoke. Spat are deposited at three types of sites: sanctuaries (where no harvest is allowed and about two million spat per acre are deposited), managed reserves (delayed and limited harvest, with about one million spat per acre), and harvest bars, with no restricted harvest. The Oyster Recovery Partnership includes the University of Maryland, Maryland Sea Grant, Department of Natural Resources, NOAA, the U.S. Army Corps of Engineers, and the Maryland Watermen's Association.

Island Restoration

Hart-Miller Island, Maryland.—This large dredge material containment facility east of Baltimore, Maryland has been operated by the Maryland Port Administration (MPA) and the Maryland Environmental Services (MES) since 1984. This 456 ha (ca. 1,140 acre) site augmented two separate natural islands, Hart and Miller, and is located approximately 1.2 km south of Rocky Point County Park on the Back River Neck peninsula. Designed primarily to receive potentially toxic dredged sediments from Baltimore Harbor and the nearby channels, it is divided into two subcontainment cells, north and south cells. Recognizing the importance of the site to migratory birds and recreationists, studies (e.g., Section 1135 study) were undertaken in the late 1990s to evaluate alternative designs of habitats for the south cell (for complete copies of the 1135 report and the Value Engineering study, contact project manager C. Donovan at: cdono@menv.com). The recommended design included creation of 80 ha (200 acres) of wetlands and mudflats, ca. 33 ha (80 acres) of upland grasses and shrubs, and one 2-ha pond with a 0.4 ha (one acre) nesting island; in addition, two borrow pits were to be converted into a 6-ha (15-acre) pond. These habitats were designed to attract nesting waterbirds (e.g., Least Terns and Common Terns), as well as songbirds and migrant shorebirds and waterfowl in spring and fall. The first occurrence of the "wildlife utilization element of the monitoring plan" began November 2006 (largely conducted by FWS personnel). Active management, including wildlife control, will be much less intensive than at Poplar Island (see below), and to date has been limited to Mute Swan control (J. Harlan, MES, pers. comm.). Once the filling operations are complete, the area will eventually be transferred to the MD DNR as all environmental regulatory requirements are met (C. Donovan, MES, *in litt.*). The north cell is to continue receiving dredge material until 2009,

which will then be closed and planted mostly with grasses (M. Slatnick, MES, pers. comm.).

Largely due to volunteer efforts since 1977, 282 species of birds have been observed on, or in the vicinity of, Hart-Miller Island (E. Scarpulla, unpubl. field records). Large numbers of shorebirds use the site during migration, and many diving ducks have used the c ng species for the island. Another encouraging sign was finding about 25 pairs of the rare Coastal Plain Swamp Sparrow (*Melospiza georgiana nigrescens*). The possibility exists for a pair of Virginia Rails (*Rallus limicola*) to be breeding as well (E. Scarpulla, pers. comm.).

Least and Common terns, species of high concern to the State of Maryland, had bred in the 1980s on the island, however they have abandoned in recent years. The presence of a number of mammalian (Red Fox, *Vulpes vulpes*, Raccoons, *Procyon lotor*, and others) and avian (Great Horned Owls, *Bubo virginianus*, Peregrine Falcons, *Falco peregrinus*) predators on or near Hart-Miller will continue to depress nesting of colonial species such as Least and Common terns (E. Scarpulla, pers. comm.); to date, no predator management has occurred on the island.

Poplar Island, Maryland.—This dredge material island, a joint project of the USCOE and MPA with project coordination by MES, was planned in the early 1990s as the original Poplar Island (ca. 480 ha, or 1,100 acres in the mid-late 1800s) was rapidly eroding (down to about one ha by 1990). The original Poplar Island was nearly connected to two privately-owned adjacent islands, Jefferson Island near the north end (about one km away at present), and Coaches Island, only about 50 m from the south end.

The need to develop a second large dredge facility in the upper Bay, combined with the obvious loss of another island complex, spurred the USCOE and MPA to develop a "Beneficial Use Project" in coordination with a number of state and federal resource agencies. A 15 + year project at an original expected cost of more than $400 M, the newly renamed "Paul Sarbannes Environmental Restoration Project at Poplar Island" represents the largest Beneficial Use project in the nation by the USCOE. It is planned to contain more than 40 M cubic yards of dredge material. A 240 ha (550-acre) extension is already planned even before the original is half complete! Of the original 480 ha, the eastern half of the island, about 240 ha will be largely wetlands, creeks, pools and mudflats, while the western 240 ha will be upland meadows, shrub and forest lands. The planned extension will also be roughly half upland, half wetland or open water.

The "benefits" of a "Beneficial Use Project" pertain to fish and wildlife resources. After numerous stakeholder meetings from 1994 to 1998, the resource agency personnel reached consensus on a number of resources to receive priority as project objectives: waterbird species, wetland and SAV plants, marsh fishes, and diamondback terrapins (*Malaclemys terrapin*). The waterbird species include: Ospreys, American Black Ducks, Least Terns, Common Terns, Snowy Egrets, and Cattle Egrets. Of these, the two egret species and Ospreys were the last of the breeding species to remain on the small amount of habitat remaining on the original Poplar remnants, along with Double-crested Cormorants, a recent (since the 1980s in Maryland) Bay invader. When construction began in 1998, the noise and human activity adjacent to these remnant islands forced all of these species to relocate to other islands.

Patuxent biologists began baseline monitoring of waterbirds at several small mainland "reference" marshes near Poplar Island in 1996, but after two years of spring-summer surveys, it became obvious that the habitats were not suitable for nesting by any of our priority waterbirds. Thus, the sites did not serve as appropriate reference marshes at least for waterbirds. As pocket marshes, they were very small (<10 ha), connected to uplands and therefore susceptible to mammalian predators. This monitoring was discontinued after 2002, shifting to Poplar Island itself, and a small islet north of Jefferson Island.

Beginning in 2002, regular surveys of birds were conducted at least monthly throughout the year under contract to Mr. Jan Reese, covering all habitats within and adjacent to Poplar Island. The focus has been

on building a species list and getting estimates of numbers by location. Since 1999, 121 species of birds have been seen. A recent addition of most interest has been the Red Knot (*Calidris canutus*), with about 100 individuals seen feeding on the mudflats of one of the large cells. This species is currently being considered for federal threatened status. In winter, large numbers of scaup, Ruddy Ducks, Ring-necked Ducks (*Aythya collaris*), Tundra Swans (*Cygnus colombianus*) and many other waterfowl are found within the cells of Poplar.

A summary of the nesting populations of the primary species of concern (Table 2) reveals that the response to the new construction has been very strong, with a maximum number of terns nesting in 2003. For Common Terns, Poplar Island represents the only nesting site for the entire Maryland portion of Chesapeake Bay (D. Brinker, MD DNR, pers. comm.). American Black Ducks (that is, non-hybrid phenotypes of Mallards, *Anas platyrynchos*) were not confirmed as nesting birds until 2005 with three broods observed in May and June. After employing decoys in 2004, Snowy Egrets returned to Poplar in April 2004 and successfully nested, while Cattle Egrets returned in small numbers in 2005 (Table 2). In addition to the primary species, several "undesirable" species also nested early after construction, including Great Black-backed Gulls (*Larus marinus*), Herring Gulls (*L. argentatus*), Double-crested Cormorants (*Phalacrocorax auritus*), Mute Swans, and Canada Geese (*Branta canadensis*) (Table 3). All of these species except cormorants were subject to control either by shooting of adults (gulls, geese), or oiling/ addling of eggs (swans, gulls) by U.S. Department of Agriculture's Wildlife Services personnel.

Efforts to determine reproductive success of terns were largely thwarted in 2003 and 2004, in large part due to predation either by Red Foxes (*Vulpes vulpes*, confirmed tracks in both years in the colonies) and probably Great Horned Owls (*Bubo virginianus*). Owl feathers had been found in the Least Tern colony in cell 4 in 2003. In 2005, using a video camera setup at colony 3C the largest subcolony, the presence of owls was confirmed on 13 of 30 nights in June and July, and young Common Tern chicks were observed being carried off by an owl on at least two occasions (J. Miller, USFWS, unpubl. report).

Each year, nests were marked and we recorded hatching among Least Terns each year, but no fledged young were observed from any subcolony from 2003-2006. For Common Terns, hatching failure was nearly complete in 2003 and 2004, with fewer than five nests hatching at one colony in 2004. Generally birds abandoned the colonies due to predation. In 2003 and 2004, most of the abandonment was due to fox visitation, while in 2005, the island seemed to be fox-free. In 2005, the main Common Tern colony largely abandoned the site after repeated owl incursions, however at a small created island in cell 1B, renesting of about 40 pairs of terns occurred in late June, and eventually approximately 60 young Common Terns fledged, the first success at Poplar Island. A similar number fledged in 2006. The small (<40 nests) Common Tern subcolony on nearby Jefferson Island also failed to hatch and produce any young in 2004, 2005 or 2006.

A draft wildlife management plan is under review (P. C. McGowan, FWS, pers. comm.). This document has a significant section on predatory and other "nuisance"

Table 2. Estimates of the priority bird species surveyed during 2001-2006 at Poplar Island, Maryland (number of pairs estimated). Modified from Erwin *et al.* 2007.

Primary Species	2001	2002	2003	2004	2005	2006
Common Tern	398	380	827	809	ca. 500	ca. 500
Least Tern	35-40	40	62	50	15	35
Osprey	yes	5	6	7	5	5
Snowy Egret	0	5	0	45	ca. 60	ca. 60
Cattle Egret	0	12	0	0	5	4
American Black Duck	0	0	0	?	3	3-4

Table 3. Recruitment of undesirable avian species during 2001-2006 at Poplar Island (number of pairs estimated).[a] Modified from Erwin *et al.* in press.

Undesirable species	2001	2002	2003	2004	2005	2006
Double-crested Cormorant	0	80	405	435	740	650
Canada Goose	?	>20	C	C	C	C
Mute Swan	2	3	C	3	C	C
Great Black-backed Gull	yes	>25	C	C	C	C
Herring Gull	yes	>300	C	C	C	C

[a]The "C" indicates that USDA control measures were in effect, therefore, accurate numbers of nesting attempts were difficult to determine; however, during May 2003-2006, estimates of 200-400 adult Herring Gulls and 20-40 Great Black-backed Gulls were made by several different observers.

animals (e.g., Mute Swans and Canada Geese). To date, the only mammals to have been trapped and removed are foxes, however, Raccoons (*Procyon lotor*) and River Otter (*Lutra canadensis*) could prove to become problematic as tracks have been observed on a few occasions in recent years.

Ospreys produced an average of about one young per pair on the island over the past five years. One adult was seen with plastic netting ensnaring its talons, but continued to nest in spite of its handicap. In general two or three pairs continue to nest on the rusted remains of old barges in cell 1.

Craney Island.—The largest of the three dredged material disposal islands, Craney Island was constructed in 1957 as a 1,050-ha (2,500-acre) confined dredged material disposal site in Portsmouth, Virginia. Plans for the site were developed and approved by Congress under the River and Harbor Act of 1946. Since that time, this site has received private and public dredged material from numerous dredging projects in the Hampton Roads area. Craney does not have a management plan that specifically includes wildlife or fisheries habitat, but the managers have complied with federal laws protecting federally threatened and endangered species. In 1974, there were few management plans of any type in place and it took 14 years of patient negotiations and mutual understanding of biologist and USCOE to work cooperatively to provide some minimal nesting habitat for Least Terns.

In 1988 a Memorandum of Understanding between the USCOE and the College of William and Mary provided for the creation of habitat for, and protection of, nesting Least Terns. Craney Island activities continue under this MOU. A draft plan is under consideration to better provide for the protection of waterbirds and other wildlife. Under the current management regime, four "set aside" habitat areas associated with breakwaters were constructed in 2002. These four areas were targeted for wildlife. These areas were augmented with sand and shell substrate (90% "beach sand" quality) to provide suitable habitat for beach-nesting bird species such as Least Terns, Common Terns, Gull-billed Terns (*Sterna nilotica*) and Royal Terns (*S. maxima*).

Unlike Hart-Miller and Poplar "set aside" habitat (or wetland cell) island areas, Craney's "set aside" habitat areas serve a dual purpose. The areas target potential wildlife use and serve the additional purpose of erosion control of the perimeters along the western side. Royal Terns, Common Terns, Gull-billed Terns, Least Terns and Black Skimmers have used these areas for loafing and roosting throughout the breeding season, but to date none have nested on these areas. Brown Pelicans also roost and loaf on these areas until early June.

The Least Tern, a species of concern in Virginia, has been monitored closely now at Craney for 30 years. The Virginia population has declined statewide (Beck *et al.* 1990). Least Terns have attempted nesting at Craney since at least 1974 where they usually nest in small subcolonies (Table 4). The largest number of nesting pairs (255) of Least Terns occurred in 1988, coincidently the first year that sand-shell substrate plots were created by the USCOE. In addition, Least Tern

decoys were placed in these newly created plots. The greatest nesting activity (range from 100-255 pairs) of Least Terns occurred during the 1985-1995 period, with sharp declines after 1995 (fewer than 62 pairs every year since 1996). These declines correlated with increases in Red Fox activities on the island (RAB, unpubl. observ.).

Piping Plovers successfully nested on Craney Island from 1989 to 1997. The first nesting pair was observed in 1989. Five pairs was the highest count on site. Nesting enclosures were erected as needed to enhance nesting success. Fledging success varied over the nine-year period, but averaged more than 1.2 young fledged per pair (RAB, unpubl. data). Since 1998, migrating plovers have been observed at Craney in the early spring and again in the late summer, but no nesting has occurred. The suspected reason for this is an increase in foxes (RAB, pers. observ.), also noted above with Least Tern declines.

Black-necked Stilts have attempted nesting on site each year since the 1975. A high count of 17 adults was observed on Craney Island in May 1998. That season, six pairs were observed on territory, five nests were observed, and seven young fledged. American Avocet (*Recurvirostra americana*) adults have been observedon site throughout the breeding season in recent years, however no breeding activities were evident.

Nesting Osprey numbers varied from three to six pairs. Of the four artificial platforms erected in 1988, three pairs of Osprey have used three platforms consistently. The fourth platform has never attracted a nesting pair. In addition, three pairs of Osprey have used large boulders or remnant bridge structures on site. Four additional structures were erected in 2006. An average of two young per nest fledged from 2000-2006.

Table 4. Estimates of numbers of nesting pairs of Least Terns at Craney Island from 1975 to 2006.

Year	Number of nests
1975	75
1980	50
1985	125
1990	137
1995	135
2000	20
2005	25
2006	25

Large flocks of bird species were observed utilizing the "set aside areas" for roosting, in 2003-2005. Flocks of adult Brown Pelicans ranging from 200-500 used the area from early April until mid June. Large flocks of Royal Terns (200-300) were observed until mid May. In 2004 and 2005, a small flock of 45-50 birds remained on "set aside" sites through the breeding season. No evidence of nesting was observed. The most prevalent species flocking at Craney Island are Great Black-backed Gulls (*Larus marinus*), Herring Gulls (*L. argenatatus*), Ring-billed Gulls (*L. delawarensis*) (winter visitors), Laughing Gulls (*L. atricilla*) (breeders); this group dominated the avifauna and followed the active dredge flow. All the gull species except the Ring-billed Gull were observed during the breeding season and Herring Gulls were recorded preying on Least Tern chicks.

Weekly surveys for non-waterbird species were conducted year-round on Craney. These surveys were supplemented by observations of regular birdwatchers to Craney Island. A total of 224 species have been recorded on the facility since 1975; this includes 36 species of waterfowl, twelve species of wading birds (i.e., herons, egrets and ibises), 41 species of shorebirds and 17 species of gulls and terns. Many diverse bird species use Craney Island for wintering, migrating and for nesting and it is regionally known as a birding "hot spot".

Of all the mammalian predators (Red Fox, Raccoon, feral cats, pack of feral dogs) observed on Craney Island, foxes were the primary predator of Least Terns. In 1999, 36 Least Tern nests were destroyed by foxes in one day (RAB, pers. observ.). Mammalian predators were removed every six to eight years intermittently over the 30-year study period. The most complete and successful predator removal program was conducted in 2005. The Least Tern population also increased to 25 pairs in 2005, with similar numbers in 2006. The number of fledged young was 0.9 per nest in 2005, the highest produc-

tivity in seven years. Thus, the predator removal management program appears to be critical to the success of the tern colony.

Since 1988, through the continual efforts of the onsite USCOE Craney Island personnel, College of William and Mary (RAB and directed students), and volunteers from the Williamsburg Bird Club, Craney Island has met its dredging requirements in a timely manner as well as providing different habitat types for many migrating shorebirds, wintering waterfowl and beach-nesting birds.

The USCOE is exploring an eastward expansion of Craney Island. A total of 242 ha (580 acres) of the Elizabeth River bottom is targeted for this project. If approved, the project would not begin before 2008.

DISCUSSION

In spite of the generally negative publicity surrounding the federally sponsored Chesapeake Bay restoration program (numerous newspaper quotes in fall 2005 from the Executive Director of The Chesapeake Bay Foundation, and Powledge 2005), a significant number of positive signs are emerging in the Bay and along the ocean coast. While anoxia, turbidity, nutrient levels and pathogens in Bay waters represent chronic problems, a number of areas both in the Bay and the seaside have shown good recovery of SAV in recent years. The Severn, Magothy, and parts of Eastern Bay in Maryland, and the southern DelMarVa coastal bays especially have shown surprising recent colonization and expansion of SAV beds (R. J. Orth, pers. comm.). Oyster recovery is still an uphill battle with disease concerns, and controversy still surrounds the release of the non-native Japanese Oyster (*Crassostrea ariakensis*). A recent 30-month study began in late 2005 in Maryland and Virginia to assess in-the-field performance of *ariakensis* versus *virginianus* so it is still somewhat premature to judge the potential for this (Blankenship 2006). Stream access to anadromous fishes will continue to increase to enhance herring species and rockfish populations. Reports in 2006 in The Washington Post and local Virginia new media about changes in the large menhaden (*Brevoortia tyrannus*) processing plant operations in Deltaville, Virginia, suggest that fish extraction rates may be reduced in the future (either by plant management or legal pressure from outside), a potential benefit to Ospreys, Bald Eagles, Double-crested Cormorants, and Eastern Brown Pelicans.

In spite of whether water quality and aquatic habitat goals are met in the next one to two decades by the Chesapeake Bay Program, the most direct, immediate benefit to waterbirds we have witnessed over the past 20 years is the provision of created/restored upland habitat as a result of the development, expansion and/or altered management of the three large dredged material containment facilities. Because of the creation of temporary "wetlands" at each of the sites as material is deposited and settles, many species of shorebirds and waterfowl have been attracted to all three sites (E. Scarpulla, Hart-Miller Island, and J. Reese, Poplar Island, unpubl. reports). These sites support many species, especially during migration (shorebirds), and in winter (waterfowl). For nesting species, the results have been mixed. While priority State species of concern such as Least and Common terns have nested on all three major dredged material islands over the years, recent results are not encouraging. Both species have abandoned Hart-Miller and have had near-zero reproduction on Poplar the past four years. At Craney, Least Terns dropped from a peak of more than 250 nesting pairs in 1988 to only about 25 the past two years. Major limiting factors at all three locations appear to be mammalian and/or avian predators. Fox control has been ongoing at Poplar since 2004, but is only now being considered as part of a larger management plan for Craney. No predator controls have been initiated at Hart-Miller, although recently initiated (November 2006) wildlife monitoring may indicate that it is warranted. Control of expanding gull populations and Canada Geese on Poplar has not been controversial, however, Mute Swan control has been subject to political pressure in Maryland over the past few years (M. Mendelsohn, USCOE-Baltimore District, pers. comm.). Predator management to benefit bird conservation can be very controver-

sial and evidence can be marshaled which both supports the need for control (Erwin *et al.* 2001), or conversely, that population-level effects on birds may be minimal with control (Cote and Sutherland 1997). Our opinion is that many of the nesting islands in the Bay and along the barrier island region have been lost or compromised over the past several decades (Erwin 1996; Erwin *et al.* 1993, 2001), thus, we should institute protective measures for breeding species where it is feasible. It must be recognized, however, that where dredged material islands are large and are close to the mainland or adjacent to large wooded islands (hence, sources of predators such as foxes and raccoons), continued predator management may be necessary. The three islands discussed above all fit these criteria. Continuous monitoring and predator management are costly both in terms of funding and personnel (Erwin *et al.* 2007). Strictly from a ground-nesting bird perspective, created islands that are small and remote are more valuable as a resource than are larger islands that can harbor predators (Erwin *et al.* 1995). From the USCOE perspective however, small, low, remote islands have little capacity for dredged material deposition, thus are probably not feasible.

We find the implementation of adaptive management by both state and federal agencies to be a very positive development in wildlife and natural resource management in recent years. The recognition that scientists and managers need to work in concert with each other to design, manage, monitor, conduct research, and report on the outcome of projects is overdue and welcome, not only in the Bay region, but in all restoration programs (Walters 1986; Cairns 1988). In many restoration projects, monitoring occurs only for a few years following a procedure, e.g., marsh grass planting. We are encouraged that recently developed projects are monitored regularly over a much longer time frame. Regular reports to agencies and to the public, as well as engaging the public in restoration activities, are vital elements of a successful project.

With respect to dredged material islands in particular, as the project is completed (i.e., capacity is reached), the conservation success of these sites will only be assured if long-term cooperative agreements are developed and maintained by the interested agencies and public groups. Diplomacy with the land owner is mandatory. Habitat management and predator control require funding and long-term commitments, good communication among the groups, and public outreach (McKay, this volume). The commitment to restoration will be a test of wills of the public, scientists, and resource managers and the resilience of the Bay itself. With continued effort and a stronger public "buy-in," perhaps the plight of Sisyphus can be avoided.

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