NESTING SUCCESS AND PRODUCTION OF GREATER SANDHILL CRANES DURING EXPERIMENTAL PREDATOR CONTROL AT MALHEUR NATIONAL WILDLIFE REFUGE, OREGON, 1982-83

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Abstract: Greater sandhill cranes (*Grus canadensis tabida*) nest commonly on Malheur National Wildlife Refuge, Oregon, but depredations by common ravens (*Corvus corax*) and coyotes (*Canis latrans*) contributed substantially to low recruitment during the 1970's. An experimental predator removal study was initiated in 1982 to determine if nesting success and recruitment would increase if predator populations were reduced. We monitored 120 crane nests located in 2 treatment areas (ravens and coyotes removed, and only ravens removed) and 1 control area (40 nests per area). Nesting success between the 2 predator control areas differed significantly during the 2-year study, but not between either predator control area and the area where no predators were removed. Two years of predator removal did not sufficiently reduce the number of predators in the study area to increase nest success to a level that would maintain a stable nesting population.

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The Central Valley Population (CVP) of greater sandhill cranes is 1 of 5 populations of this subspecies. Because of its small size and low productivity, the CVP has been classified as a sensitive population, receiving high priority for management by the U.S. Fish and Wildlife Service in the Pacific Flyway. Most cranes of the CVP nest in southcentral and eastern Oregon and in northeastern California. Malheur National Wildlife Refuge (NWR), Harney Co., Oregon, is the most important nesting area for the CVP (Littlefield and Thompson 1979; Littlefield 1982, 1989; Stern et al. 1987).

Depredations by common ravens and coyotes on sandhill crane eggs and unfledged young at Malheur NWR were believed to have contributed substantially to the low number of chicks fledged (Littlefield and Thompson 1987). Of 674 crane nests monitored during 1966-81, 48.5% were destroyed by predators. Annual mortality of crane chicks for 11 years (1970-81) averaged 84.8% (C. D. Littlefield, unpubl. data).

Reduction of annual cattle grazing on Malheur NWR after 1973 improved nesting habitat and resulted in increased nest success (Littlefield and Paullin 1990), but the percentage of fledged chicks in the autumn population has averaged only about 6% since then (1974-81). The number of nesting crane pairs peaked at 236 in 1975 and declined to 214 in 1982 and 1983.

This paper reports on an experimental predator control study conducted at Malheur NWR in 1982 and 1983 to test the effectiveness of (1) common raven control alone for improving sandhill crane nest success, and (2) simultaneous coyote and raven control on crane nest success and recruitment. This paper summarizes results of the 2-year study.

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STUDY AREA

Malheur NWR includes more than 72,000 ha of interspersed meadows, marsh, and shrub-covered uplands, the latter dominated by sagebrush (*Artemisia* spp.). Most sandhill crane nesting occurs in emergent vegetation in depressions in the meadows (Littlefield and Ryder 1968) of the narrow Blitzen Valley. The valley is surrounded by rimrocks that provide nesting sites for common ravens.

Common ravens are abundant throughout the Malheur NWR and adjacent areas (Littlefield and Thompson 1987).

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More than 1,300 ravens have been counted at winter roost sites in the area. Coyote densities are unknown, but observations by refuge staff and others indicate that coyotes are generally abundant. Coyote predation on sandhill crane eggs was less than that by ravens or raccoons (*Procyon lotor*), but coyotes, unlike ravens, kill crane chicks (Littlefield and Lindstedt 1992).

Ravens and coyotes are common on the refuge during the period when cranes are nesting. Each year a pronounced post fledging movement of ravens onto the refuge occurs in late May and early June, when nesting of many other avian species peaks (Stiehl 1978, Littlefield and Thompson 1987). Coyotes are commonly encountered during the crane nesting period (April-June), but numbers increase in late July after meadows dry and hay mowing activities begin (C. D. Littlefield, unpubl. data).

The 8,153-ha Raven Removal Study Area (RRSA) was located in the southern Blitzen Valley (Fig. 1). Common ravens were killed in this area. A Raven and Coyote Removal Study Area (RCRSA) located in the Double-O area on the western portion of the refuge was 7,976 ha. A Control Study Area (CSA), 7,494 ha in size, was established near the center of the Blitzen Valley where no experimental predator management occurred. The CSA was about 8 km from the RRSA, and the RCRSA was about 26 km northwest of the CSA (Fig. 1). Study sites were selected on the basis of predator populations and the number of nesting crane pairs. The RRSA had the greatest number of nesting crane pairs on the refuge, whereas the RCRSA had the highest predator densities and lowest crane nest success from 1978 to 1982 (C. D. Littlefield, unpubl. data).

METHODS

Common ravens were killed with DRC-1339 (3 chloro-p-toluidine hydrochloride), a selective toxicant that is not lethal to mammals or raptorial birds at dosages lethal to ravens (Decino et al. 1966, Larson and Dietrich 1970). In 1982, common raven control was conducted from 12 February to 10 June in the RRSA and 25 February to 14 June in the RCRSA. A total of 7,335, 1-cm^3 meat baits treated with 7.5 mg/kg of DRC-1339 (Larsen and Dietrich 1970) was placed on carcasses of mule deer (*Odocoileus hemionus*), black-tailed jack rabbit (*Lepus californicus*), pronghorn (*Antilocapra americana*), and carp (*Cyprinus carpio*) between 12 February and 16 April 1982. Depending on carcass size, 5 to 50 meat baits were used daily per carcass. From 16 April to 14 June, 1,828 chicken eggs, injected with 1 ml of 10% solution of DRC-1339 in water, were placed throughout the RRSA and the RCRSA. Usually, 4 injected eggs were placed in each artificial nest. All known common raven nests were examined annually by the refuge staff. In 1982 and 1983, 42 raven nests were surveyed, and activity and fates were determined. Most of the nests were on or adjacent to the 3 study areas.

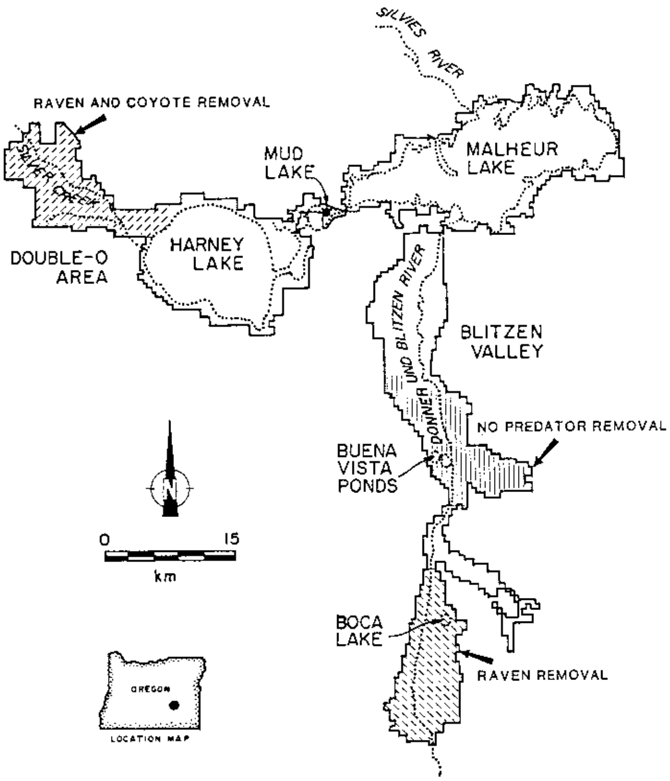

Fig. 1. Location of 3 study areas for evaluation of predator removal on sandhill crane nest success and production, Malheur National Wildlife Refuge, Oregon, 1982-83.

Coyotes were removed from the RCRSA between 2 December 1981 and August 1982 by aerial gunning from a helicopter and by trapping. Removal in 1982 was most intense in the spring and only minor control took place after May. In the RCRSA, Animal Damage Control (ADC) personnel and private trappers removed 214 coyotes during the 2-year period. Of 147 coyotes killed in 1982, only 8 were taken during summer. However, coyotes were seen regularly on all study areas during summer. In 1983, 67 coyotes and 1 red fox (*Vulpes vulpes*) were removed. Red foxes were previously unrecorded from Malheur NWR. Nearly all coyotes were killed before summer. One or 2 coyotes were seen daily in August, but their numbers were fewer than in August 1982 (C. D. Littlefield, unpubl. data).

From 25 February through 21 May 1983, 3,685 chicken eggs treated with DRC-1339 were placed in the RRSA and the RCRSA. Dosages were the same as in 1982. Coyotes were removed from the RCRSA by trapping and aerial gunning from November 1982 through 31 July 1983. Only 1 helicopter flight was made in 1983 compared to 3 in 1982.

Searches for greater sandhill crane nests were conducted from 13 April through 27 May 1982 and 15 April through 20 May 1983. Searches were continued until 60 active crane nests (20 per study area) were found. Most nests were located during ground searches, but some were spotted from fixed-winged aircraft and helicopter. Egg incubation stage was estimated by the flotation method described by Westerskov (1950). Nests were reexamined after the estimated hatching date and nest success determined (success = at least 1 hatched egg). Predators were identified by examining the nest and egg remains (Sooter 1946, Einarson 1956).

To assess crane productivity, ratios based on counts of adult and young sandhill cranes (age class based on plumage) were attempted from ground surveys conducted from 21 to 25 September 1982 and from 22 to 28 September 1983. Annual production was calculated as:

$$\frac{\text{No. of young}}{\text{No. of young} + \text{No. of breeding adults}} \times 100\%$$

Young were counted on refuge grain fields where they concentrated during feeding in September, before most migrant cranes had arrived. Grain fields were present in or near all 3 study areas, so production per study area was usually possible to determine, particularly in the RRSA and the RCRSA.

RESULTS AND DISCUSSION

Common Raven and Coyote Removal

Although the number of common ravens killed during the study was not determined, populations were greatly reduced, especially on predator removal areas. At Malheur NWR traditional raven nests are generally occupied year after year. By May 1983 none of 20 known traditional raven nests near the predator removal areas was active. Near the CSA, 4 of 8 traditional raven nesting sites were used in 1982 and 3 were active in 1983, indicating that some ravens from that area were killed by treated baits set out in 1 of the predator removal areas.

Nest Success and Predation-1982

A total of 60 (20 per study area) greater sandhill crane nests was examined in 1982 (Table 1). Thirteen (65%) of 20 nests in the RRSA were successful. Coyotes destroyed 2 nests, ravens destroyed 1, and the others were lost to undetermined predators. Of the 20 nests examined in the RCRSA, 12 (60%) were successful. Destruction of 8 nests was attributed to common ravens (3), raccoons (2), coyote (1), and undetermined predators (2).

Table 1. Success of greater sandhill crane nests after predator removal, Malheur National Wildlife Refuge, Oregon, 1982-83 (*n* = 20 nests examined in each study area per year).

	1982		1983	
Study area	No.	%	No.	%
Raven Removal (RRSA)	13	65	9	45
Raven and Coyote Removal (RCRSA)	12	60	16	80
Control (CSA)	14	70	13	65

The highest nesting success in 1982 was in the CSA (70%). Destruction of 3 nests was attributed to ravens, and another 3 nests were destroyed by undetermined predators. Water management in the untreated area was different than in the other 2 study areas in 1982. By mid-April water was abundant in most of the crane nesting habitat of that area and remained relatively deep throughout the spring and early summer. Coyote activity in that area likely was reduced because of the deep water.

Average nest success in 1982 ($n = 60$) was 65%, ranging from 60% to 70%, but was not significantly different among the 3 study areas ($\chi^2 = 0.44$, $P > 0.05$). Common ravens destroyed 7 clutches, coyotes 3, raccoons 2, and unknown predators 9. Nesting success, however, was higher in all study areas when compared to the 16-year (1966-81) average (C. D. Littlefield, unpubl. data): 43.9% for RRSA ($n = 460$ nests), 50.0% for RCRSA ($n = 34$), and 45.9% for CSA ($n = 137$).

Unfortunately, irrigation was delayed on a portion of the crane nesting habitat until mid-May in the RRSA. Delayed irrigation facilitated hunting of marsh and meadow habitat by coyotes while crane nesting was in progress. In addition to the 2 nests known to have been destroyed by coyotes, we believe the 4 nests attributed to unknown predators likely were destroyed by coyotes.

Nest Success and Predation-1983

Sixty crane nests (20 per study area) also were examined in 1983 (Table 1). Success was only 45% in the RRSA for the 20 nests examined, but 3 nests were lost to flooding and 1 was abandoned. Ample water was available after mid-April, but breached dikes prevented water stabilization in some areas; the Blitzen River overflowed in late May, flooding 3 monitored nests. Fortunately most clutches already had hatched when the flooding occurred. No nest losses were attributed to ravens, but raccoons destroyed 3, coyote 1, and undetermined predators 3.

In the RCRSA, 80% of the 20 nests examined were successful. One clutch was lost to a common raven, 1 to a coyote, 1 to a raccoon, and 1 was abandoned.

Sandhill cranes achieved 65% nest success (13/20) in the CSA. Most nest sites had water by mid-April, and cranes initiated nesting shortly after their territories received water. Most nesting was completed before high water from local streams inundated much of the area. Common ravens destroyed 2 nests, coyotes 2, raccoon 1, undetermined predator 1, and 1 was abandoned.

Nest success was significantly different among the 3 areas in 1983 ($\chi^2 = 9.13$, $P \leq 0.05$). The RCRSA had significantly higher nest success than the RRSA ($\chi^2 = 7.30$, $P \leq 0.01$). Success was not significantly different between the RRSA and the CSA ($\chi^2 = 0.92$, $P < 0.05$) or between the RCRSA and the CSA ($\chi^2 = 2.30$, $P < 0.05$). In all 3 areas combined, raccoons destroyed 5 nests, coyotes 4, ravens 3, and undetermined predators 4. Three nests were flooded, 2 were abandoned, and 1 contained infertile or addled eggs.

Nesting Summary, 1982-83

Nest success in the RRSA averaged 55%. In this area only 1 nest was destroyed by ravens in 2 years. Undetermined predators destroyed 7 nests, raccoons 3, and coyotes 3.

In the RCRSA nest success averaged 70%. Four clutches were lost to ravens, 3 to raccoons, 2 to coyotes, and 2 to unknown predators. Nest success in the CSA averaged 68%. Common ravens destroyed 5, coyotes 3, unknown predators 3, raccoons 1, and 1 was abandoned. For 120 nests monitored during the 2-year study, overall nest success averaged 64%.

Differences in nest success among the 3 study areas were not statistically significant during the 2-year study ($\chi^2 = 2.25$, df=5, $P > 0.05$). However, where both common ravens and coyotes were removed, nest success during the second year was 80%. This was the highest success rate since the 1940's, when predators were routinely killed throughout Malheur NWR.

Productivity

Data on productivity were inconclusive because crane pairs with chicks from outside the study area moved onto the grain field before brood counts were conducted in both 1982 and 1983. Therefore, the actual number produced in the study area was not determined. However, of the 25 chicks produced on or adjacent to the refuge in 1982, only 2 were fledged from the 93 crane pairs in the RRSA and 1 from the 27 pairs in the RCRSA. In 1983, 39 young were fledged, including 4 from the RRSA and 5 from the RCRSA. Of the young cranes hatched on Malheur NWR in 1982 and 1983, 90.1% and 84.8%, respectively, died before fledging, primarily from predation.

The length of this study was to be 3 years, but funding was not provided for the final year. Malheur NWR encompasses a large area where predators are abundant. Under such circumstances predator removal may have to take place for more than 2 years before there is a significant increase in sandhill crane nest success or recruitment.

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USE OF DREDGED MATERIAL TO CONSTRUCT WINTER WHOOPING CRANE HABITAT

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Abstract: Aransas National Wildlife Refuge (ANWR) and nearby coastal marshes serve as the winter home for the only natural flock of whooping cranes (*Grus americana*). In recent years shoreline erosion and the subsequent loss of wintering habitat have been observed on the refuge adjacent to the Gulf Intracoastal Waterway (GIWW). In 1988 the U.S. Army Corps of Engineers (USACE) District, Galveston, Texas, and U.S. Fish and Wildlife Service (USFWS) entered into an informal agreement to attempt to slow shoreline/habitat loss on the refuge. Efforts to curtail habitat loss have included armoring the most erosive reaches with temporary concrete erosion control structures and using articulated concrete mats to armor severely eroded reaches. Most recent efforts have been directed at determining if dredged material removed from the GIWW during routine channel maintenance could be used to construct winter crane habitat. One experimental site was constructed in 1991 by Mitchell Energy Corporation and 2 in 1993 by USACE. Current plans call for the long-term monitoring of the sites to determine the relative success of the habitat creation effort. A comprehensive biomonitoring program is being developed by researchers at the USACE Waterways Experiment Station (WES) to track the long-term development and to characterize habitat conditions and wildlife use of the experimental sites.

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Key words: Aransas National Wildlife Refuge, dredged material, ecological monitoring, *Grus americana*, habitat creation, whooping cranes.

The establishment of ANWR in 1937 helped protect and conserve the wintering habitat of the whooping crane. In the winter of 1938, the whooping crane population was estimated at 29 individuals and only 2 small flocks survived in the wild. During the past 57 years the population has increased slowly to total 158 individuals in the 1995 winter (T. V. Stehn, unpubl. data). The protection, conservation, and management of the wintering grounds at Aransas is and will continue to be paramount to survival of the species in the wild.

The GIWW is a federal navigation canal 38 m wide by 4.7 m deep for waterborne commerce located between Texas and Florida; it was constructed through Aransas in 1944. Construction of the GIWW, past dredged material disposal practices, and shoreline erosion created a net loss of 465 ha of whooping crane habitat at ANWR (Ramirez et al. 1988). Net losses inside the critical habitat from 1930 to 1986 have amounted to 841 ha, equaling an 11% loss in a study corridor 1,830 m wide centered on the GIWW (Sherrod and Medina 1992).

Critical habitat on the wintering grounds adjacent to the GIWW is being lost to erosion at a rate of 1.0-1.6 ha annually (Stehn 1987, USACE 1988) with total losses at ANWR exceeding 93 ha (Stehn 1987). Rate of shoreline erosion is 0.7-1.2 m per year along some of the more erosive reaches (Stehn 1987, USACE 1988). Since 1940, the GIWW shoreline has receded approximately 28 m on either side of the channel (Stehn 1987).

Loss of critical habitat in these areas represents a potentially threatening situation to the survival of the species on the refuge because of the proximity of winter crane territories to the GIWW. In winter 1994-95, 19 of 46 (41%) of the total adult crane territories adjoined the GIWW (Stehn 1995). Exact cause and rate of shoreline/habitat loss are presently unclear, but loss is believed to be caused by natural wave (fetch) and current action, wakes thrown up by marine traffic using the GIWW, and, to some extent, past dredged material disposal practices (Stehn 1987, Zhang et al. 1993). This paper describes efforts taken to (1) stop habitat loss on the wintering grounds caused by shoreline erosion and maintenance dredging disposal practices, (2) create additional marshlands for whooping cranes by using dredged material, and (3) formulate long-term plans for the ecological monitoring of the created marshes.

STUDY AREA

The GIWW passes through 68 km of whooping crane critical habitat in areas regularly used by wintering cranes. This includes an 11-km reach by the Welder Flats Coastal Preserve next to Shoalwater Bay and a 19-km reach through the ANWR between Aransas and San Antonio Bays (Fig. 1). Dredged material was used to create habitat in Mesquite and San Antonio Bays adjacent to ANWR.

RESULTS AND DISCUSSION

Shoreline Erosion

The USFWS and USACE-Galveston conducted several activities from 1989 to 1992 aimed at stopping or slowing erosion of critical whooping crane habitat. The most significant of these was the initiation of an on-going study under

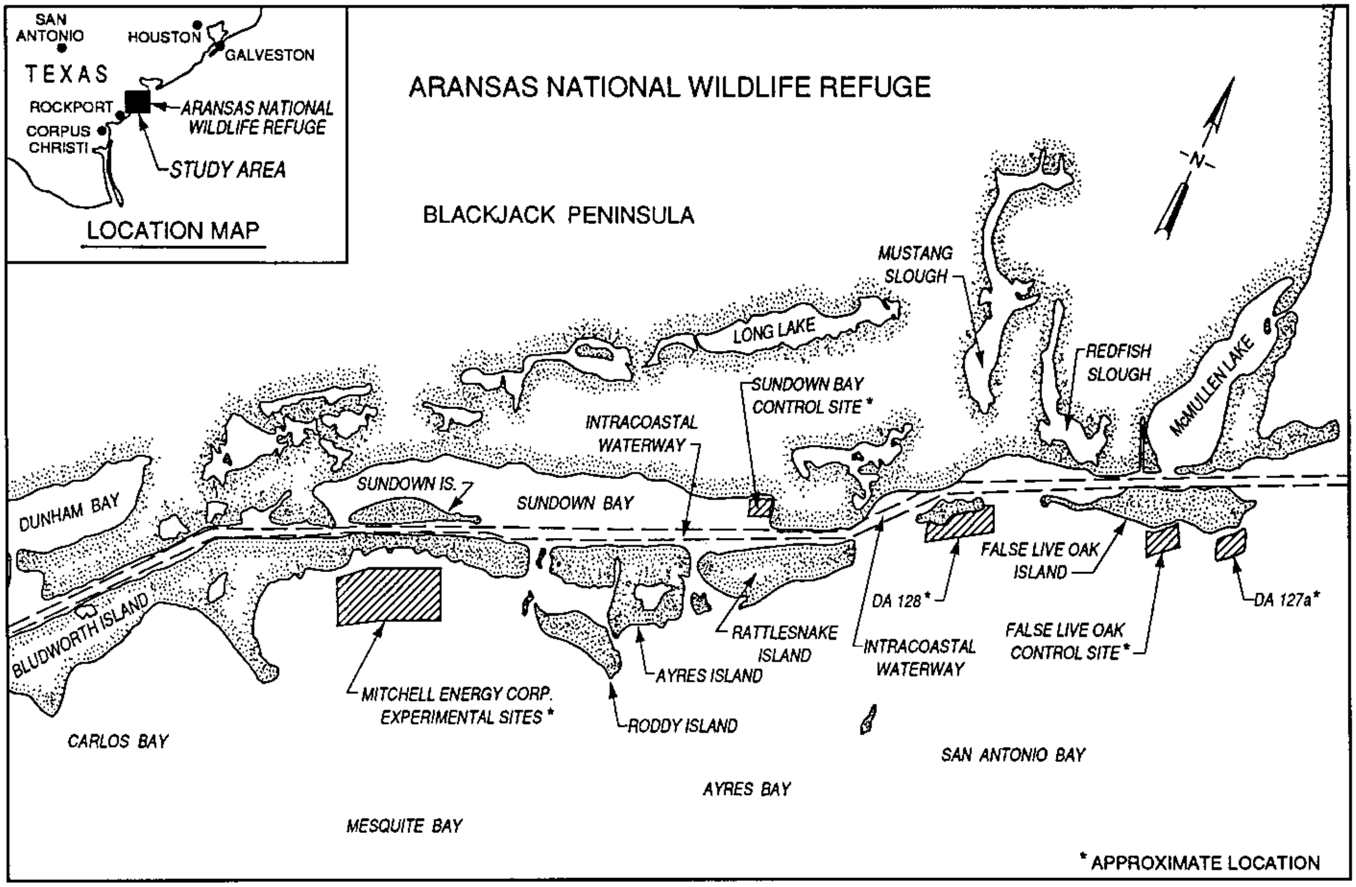

Fig. 1. Location of study sites for evaluation of use of dredged material to construct winter habitat for whooping cranes along the Gulf Intracoastal Waterway, Aransas National Wildlife Refuge, Texas.

Section 216 of the 1970 Flood Control Act, which is investigating the feasibility of relocating the GIWW to a different route. Temporary erosion control measures (e.g., concrete bag retaining walls, posting signs within the confines of the refuge urging boat operators to operate at speeds which would produce little or no wakes) were initiated in 1989 as a stopgap measure on several of the more erosive reaches (i.e., those that would be irreversibly modified before the completion of the Section 216 study). Approximately 2,652 m of erosive shoreline were protected from 1989 to 1992 by use of more than 57,000 bags of cement in a huge volunteer effort involving government, private corporations, and hundreds of individuals.

In May 1993 an agreement was reached between the USFWS and USACE-Galveston, which called for the armoring of some to the more erosive reaches with technology regularly used by USACE on inland waterways. By 1995 approximately 5,486 m of shoreline had been protected with articulated concrete mats laid on geotextile fabric. Mats were anchored/linked with polyester cables which allow the mats to move and conform to existing land features. Current plans call for the armoring of an additional 610 m annually until the Section 216 study is completed and implemented.

Creation of Habitat from Dredged Material

More permanent solutions to the problem of habitat loss included investigating the use of dredged material removed from the navigable channel during routine, scheduled maintenance to (1) construct additional winter habitat and (2) construct erosion control structures for protecting existing habitat. In 1989 a cooperative study between USACE-Galveston, USFWS-ANWR, and WES was begun to survey the area to determine the feasibility of using dredged material removed from the GIWW during routine channel maintenance to protect some of the more erosive reaches. The goals of the initial study were to (1) characterize vegetation and wildlife use on some of the more erosive reaches and (2) conduct the preliminary engineering studies to determine the feasibility of using dredged material in a beneficial manner to construct additional winter habitat. A 50-year dredged material disposal plan is being developed cooperatively between the USFWS and USACE-Galveston. This plan will call for use of dredged material to create an additional 653 ha of winter habitat.

The first large-scale attempt to create winter whooping crane habitat with dredged material was undertaken in 1991 by the Mitchell Energy Corporation (MEC). A 5.3-ha site was constructed on the bayside of Bludworth Island (Fig. 1) by use of material removed as part of a dredging operation (channel establishment) in the Mesquite Bay area. The site was planted with species native to the Texas Coastal Bend. In 1993, MEC constructed a 3.6-ha site which adjoined the original construction effort. Both sites were protected with articulated concrete mats connected with polyester cables. One-year monitoring on the first site indicated ground coverage of approximately 99% and 89% for low and high marsh species, respectively (C. Belaire, Belaire Consulting, Inc., Rockport, Tex., unpubl. data). Smooth cordgrass (*Spartina alterniflora*) was the dominant species on the low marsh areas of the project and saltmeadow cordgrass (*S. patens*), saltgrass (*Distichlis spicata*), seaside paspalum (*Paspalum vaginatum*), and saltwort (*Batis maritima*) dominated the drier, high marsh areas. Preliminary observations suggest that the MEC wetland is maturing well, and whooping cranes were observed in the created habitat 4 times from 1991 to 1994 (2 cranes in January 1991, 5 cranes in March 1993, 2 cranes in November 1994, and 2 cranes in December 1994) (T. V. Stehn, unpubl. data).

A fisheries study of the created Mitchell habitat compared with natural marshes, seagrass beds in shallow bays, and unvegetated shallow bay bottom showed the new marsh to benefit fisheries (Rozas et al. 1994). Salt marsh and seagrass habitats supported significantly greater densities of most species. Therefore, replacing open bay bottom with marsh and seagrass habitats should have a positive effect on most species that were dominant in the study area. Even though some open bay habitat will be lost by creating new marsh, the area replaced by marsh is small relative to the total area of open bay habitat in the vicinity, and species that use shallow unvegetated bottom will likely find suitable habitat near constructed marshes (Rozas et al. 1994). If marshes that are functionally equivalent to natural marshes can be constructed, the increased benefit of enlarging the habitat area for fishery and forage species that use marsh systems should outweigh the loss of open bay habitat (Rozas et al. 1994).

In summer 1993, the USACE-Galveston began construction of 2 additional sites by using material obtained from ongoing dredging operations in the area. The 2 sites were located east of False Live Oak Point (Disposal Area [DA] 127a) and east of an unnamed dredged material island across from the opening to Mustang Slough (DA 128) (Fig. 1). The False Live Oak 9.3-ha site was contained within an earthen levee. Three openings were constructed through the levees to facilitate water exchange on the site and a riprap breakwater (stone) was constructed around the bay side to protect the developing marsh from fetch. The second 8.5-ha site, DA 128, was constructed at an existing dredged material disposal site and armored with large diameter, geotextile grout tubes filled with dredged material. Experimental sites were planted in 1993 by consultants under contract to the USACE-Galveston with native salt marsh species common to the intertidal marshes of the Texas Coastal Bend. Both sites were allowed to consolidate and dewater for 2 years while plans for the long-term ecological monitoring of the sites were developed by personnel from USFWS-ANWR, USACE-Galveston, and WES.

Long-term Monitoring

Biologists from the USFWS-ANWR, the USACE-Galveston, and the WES have developed a long-term program aimed at monitoring 3 biological aspects of the experimental sites. Monitoring data will be used to evaluate the success or failure of the habitat creation effort and to provide information for scientists and engineers charged with future habitat creation efforts. Long-term ecological monitoring of the project area will involve sampling efforts to assess (1) the development of vegetation on the experimental sites, (2) the use of the experimental sites by avian species, and (3) macrobenthic and invertebrate abundance and composition on experimental sites.

Control sites include open bay habitat in San Antonio and Sundown Bays and saltmarsh on the north end of Sundown Bay (Fig. 1). These natural communities will be compared with the created marshes and open bay habitats that existed prior to marsh creation.

Vegetation

Development of vegetation on the experimental sites will be monitored annually during the study by use of remotely sensed data and conventional field sampling techniques. Habitat types will be manually delineated on aerial photos and digitized into a Geographic Information System (GIS) for spatial analyses. Percent coverage of the various habitat elements/components (e.g., open water, planted vegetation, bare ground, tidal flats, and tidal channels) will be determined for each year of the study and used to track the development of the vegetation on the experimental sites.

Avian Use

Avian use of the experimental sites will be monitored bimonthly on both control and experimental sites. Composition and abundance of avian species will be determined for comparisons of avian diversity. Two fixed-width transects have been established on the control and experimental sites to identify (1) and tally all avian species occurring on each site, (2) how the sites are being used (e.g., feeding, loafing, or resting), and (3) what habitat types (e.g., tidal flats, open water, or low marsh) within the sites are being used. Richness and evenness indices will be calculated and used to compare avian diversity on the sites and evaluate whether the experimental sites are mimicking the control sites.

Macrobenthos/Invertebrates

Quarterly macrobenthic/invertebrate sampling will be aimed at (1) investigating taxonomic composition, taxa richness, and total abundance of macrobenthic/invertebrate species on control and experimental sites and (2) determining if the types and numbers of macrobenthic/invertebrate species on and around experimental sites are similar to those found on control sites. Taxonomic composition, taxa richness, and total abundance (animals per m^2) will be estimated for each of the sites (experimental and control) and used to determine if significant differences exist.

The 2 main concerns that will be addressed in our field sampling are (1) are macrobenthic and infauna abundance and composition on an experimental site comparable to macrobenthic and infauna abundance and composition on a control/existing site, and (2) how did the loss of open water, shallow bay habitat affect macrobenthic and infauna abundance and composition (how many and what kinds of species did we impact by building the experimental site?). Primary efforts will be directed towards the macrobenthic component (e.g., fish, crabs, and shrimp) because of its importance to wintering cranes as a potential food resource.

Permanent macrobenthic trap stations were established during summer 1995 and permanently located by use of a Global Positioning System. Macrobenthic/invertebrate data will be collected quarterly and will involve the use of 1.5- × 1.5-m portable drop nets, a 7.5-cm PVC cylindrical push corer/sampler, and commercial crab traps. We will run 3 drop net traps per site per day and trap for 4 consecutive days each quarter. This design will provide us with a minimum of 12 samples per site per quarter (36 total samples per quarter) and 144 samples per year.

We have established 27 permanent infauna sampling points on the 3 study sites. Infauna samples will be collected with the push corer, processed through a 0.5-mm sieve, and preserved in the field. Identification and analysis of macrobenthic and infaunal samples will be done by invertebrate biologists in the Coastal Ecology Group of the Environmental Laboratory at WES.

Crab Abundance

Crab abundance and distribution on the 3 sites will also be monitored quarterly with commercially available crab traps. Four permanent trap sites were established in August 1995 on each of the 3 study sites to determine the species, size, and numbers of crabs that will be available to wintering cranes. Crab traps were baited with raw chicken each morning and checked once daily for 4 consecutive days. Crabs were identified to species, sexed, measured, and released back on the site at the end of each day.

Home Range

Another important aspect of the study will involve use of observation data collected by ANWR biologists to calculate winter home range and territory size for cranes using the refuge. Observation data will be digitized into a GIS and used to calculate home range/territory size and shape according to several accepted methods. Vegetation sampling (i.e., species dominance, species frequency, vegetation height, density, and coverage) within home ranges/territories and core areas will be conducted in the third and fourth years of the study to contribute to an understanding of the structural characteristics of winter habitat. Intensive field sampling within home ranges/territories will provide insight into the structural characteristics of winter habitat and provide a model/template to guide future habitat creation efforts.

Preliminary Field Sampling

Preliminary analysis of drop net data collected in summer 1995 suggests that a diverse assemblage of species (vertebrate and invertebrate) is already present on the study sites. Dominant species on the 3 sites included white shrimp (*Penaeus setiferous*), grass shrimp (*Palaeomenetes pugio*), and blue crabs (*Callinectes sapidus*). Analyses of drop net data indicated that DA 128 had the largest number of species (7) but the DA 127a site had the highest number of individuals (86). The Sundown Bay control site had the fewest species (5) but the greatest number of white shrimp. DA 127a had the greatest number of crabs (23).

Analyses of infauna data indicated that the Sundown Bay control site had the greatest number species (9) and the greatest number of individuals (20). Species identified in infauna samples from the 3 sites included clam worms

(*Nereis succinea*), an amphipod (*Ampelisca abdita*), polychaete (*Laeonereis culveri*), lunar dove shell (*Mitrella lunata*), mud shrimp (*Callianassa* spp.), polychaete worms (Capitellidae), unidentifiable polychaetes, blue crabs, shrimp (*Acetocina [Retusa] caniculata*), dwarf surf clam (*Mulinia lateralis*), and tube-building worm (*Diopatra cuprea*).

Sixty-nine blue crabs were captured on the 3 study sites during the sampling period. Crab abundance was greatest on the DA 128 site (31) and least on the Sundown Bay control site (13). Twenty-five blue crabs were trapped on DA 127a during the sampling period.

CONCLUSIONS

Development of the MEC sites appears promising and the sites appear to be progressing as expected (T. V. Stehn, unpubl. data). Information obtained from data collected on both the MEC and USACE sites in subsequent years will be used to better understand seasonal and annual developmental variation among the sites. Baseline data collected in the first year of this study will be used to make comparisons among sites and years to gain insight into the development of the experimental sites and ultimately to evaluate the success/failure of the habitat creation effort. Data collected as part of this study will also be used to determine the feasibility of conducting similar efforts in the future. We hope that USFWS and USACE researchers can establish some fundamental design criteria that can be used to guide future habitat creation efforts. A successful habitat creation effort at Aransas would provide much needed winter habitat for the wild whooping crane population and would benefit both the USFWS by identifying a mechanism for protecting erosive shoreline and the USACE-Galveston by confirming a cost-effective mechanism for the safe, beneficial use of dredged material.

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