# Nest Sites of Seabirds on Dredge Islands in Coastal Louisiana

**Paul L. Leberg,** *Department of Biology, University of Southwestern Louisiana, Lafayette, LA 70504*

**Patrick Deshotels,**[1] *Department of Biology, University of Southwestern Louisiana, Lafayette, LA 70504*

**Sandra Pius,** *Department of Biology, University of Southwestern Louisiana, Lafayette, LA 70504*

**Michael Carloss,** *Louisiana Department of Wildlife and Fisheries, 2415 Darnall Rd., New Iberia, LA 70560*

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*Abstract:* Dredge islands are an important but relatively unstudied habitat for seabirds on the northern coast of the Gulf of Mexico. We characterized nest sites of Forster's terns (*Sterna forsteri*), least terns (*S. antillarum*), gull-billed terns (*S. nilotica*) and black skimmers (*Rynchops niger*) on dredge islands in the Atchafalaya Delta Wildlife Management Area in Louisiana. With the exception of the least tern, seabird use of the islands has increased over the last 5 years. Generally, dredge islands were used only during the first nesting season following their creation. Forster's terns nested on clumps of dead water hycacinth (*Eichornia crassipes*); nest sites of the other 3 species were relatively devoid of dead vegetation. Both least and gull-billed terns nested on substrates that contained shell while avoiding nearby patches of sand. The nest sites of black skimmers were very similar to surrounding habitat, and nest location may have been more influenced by the presence of gull-billed terns than by substrate composition.

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Up to 90% of the seabird species in the family Laridae are colonial breeders (Lack 1968). Their nests often consist of 3 to 5 eggs laid in shallow depressions in existing substrates. The primary nesting habitats for many of these species, which include beaches, barrier islands, and sand bars, are often threatened with disturbance or destruction by human activities (Buckley and Buckley 1977). Dredge islands have become important nesting sites for seabirds, providing pro-

[1] Present Address: Louisiana Department of Wildlife and Fisheries, 2415 Darnall Rd., New Iberia, LA 70560.

tection from predators as well as humans (Soots and Parnell 1975). These islands may become even more important to seabirds as other traditional nesting habitat is lost to development (Buckley and Buckley 1977).

The Atchafalaya Delta is the most actively building delta in the Gulf of Mexico. The growth of the delta is the result of sediments being deposited by the Atchafalaya River. Because the river is an important shipping lane, these sediments are frequently removed by dredging. The material from these dredging operations has been used by the Louisiana Department of Wildlife and Fisheries to create a series of dredge islands on the Atchafalaya Delta Wildlife Management Area (ADWMA).

A 1990 survey found that the dredge islands in the Atchafalaya Delta supported nesting colonies of approximately 1,000 pairs of black skimmers and 150 pairs of gull-billed terns (Martin and Lester 1990); these were the largest nesting colonies of the 2 species in Louisiana. More recently, both Forster's and least terns have nested on the dredge islands. Seabird use of dredge islands has been documented in several studies (Soots and Parnell 1975, Chaney et al. 1978), but there have been few attempts to quantify the characteristics of nest sites in these important habitats.

Because of the apparent importance of these dredge islands to seabird populations on the northern coast of the Gulf of Mexico, we examined population trends and quantified nest site characteristics of the 4 species nesting on the ADWMA. This information will be useful in evaluating the potential value of a dredge island as nesting habitat for these species. Knowledge of nesting habitat is important for the management of colonial seabirds and is especially critical in the case of the least tern which is declining in many areas (Thompson and Slack 1982, Kotliar and Burger 1986).

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## Methods

The ADWMA is located at the mouth of the Atchafalaya River in St. Mary Parish, Louisiana. Seabird colonies frequently relocate each year as new dredge islands become available in the delta. Since 1990, these colonies have been censused to determine the number of nesting birds utilizing dredge islands in the area. Surveys of islands were conducted once per year between 18 May-8 July 1990–1995. Simple counts of birds nesting in individual colonies were obtained from aerial surveys in every year except 1991. In every year but 1990, estimates from aerial surveys were supplemented with data collected while walking across the dredge islands. Surveys were conducted by one of us (M. Carloss), with the exception of 1990 (Martin and Lester 1990).

In 1993 we examined nest site characteristics on T-Pat's Island, which had received a recent deposit of dredge material and was readily accessible by boat. This island is approximately 0.6 km in diameter and is located about 5.5 km south of the ADWMA headquarters. Dominant plants on the higher areas (1–2 m) were *Panicum ancepts* and several species of goldenrod (*Solidago* spp.). Lower portions of the island were dominated by *Spartina dichotimoflorum.*

We established 4 sampling plots on the island in June. Plots were variable in size and were located near centers of nesting colonies. The nests of Forster's terns were located in 2 discrete clusters that we sampled with a 20 x 20 m plot and a 10 x 10 m plot. Results of comparisons of nests to randomly selected sites were similar for these 2 plots, so they were combined for all analyses presented here. Two separate 20 x 20 m plots were used to sample the least tern colony and a mixed-species colony of gull-billed terns and black skimmers. These plots were established to study spacing patterns of nests; this work is ongoing. While not necessary for making nest site characterizations we report here, these plots defined the areas in which we evaluated substrates at nests and random sites within each colony.

Immediately after most of the chicks in the colony had fledged, we sampled characteristics of the nest substrate. A 70 x 70 cm grid was centered over the top of a nest. We chose this distance because it appeared to be the approximate area around the nest that was most actively defended by a nesting bird. Intersection points on the grid occurred every 11.67 cm for a total of 49 points. A nail was dropped vertically at each intersection and the first substrate contacted by its point was identified. Substrates were typically placed into 1 of 3 categories: sand, shell, and dead vegetation. These 3 categories accounted for >90% of the materials at grid intersections. At least 20 randomly chosen nests of Forster's terns, gull-billed terns, and black skimmers were sampled for substrate characteristics. Only 12 nests of least terns were located in the sampling plot, so all were sampled for substrate composition.

To determine if the substrates of nests were different from those of the surrounding habitat, the sampling grid was also placed at random locations within each plot. The number of randomly sampled locations was 20 in both the Forster's tern and gull-billed tern-black skimmer plots and 10 in the least tern plot. For both the grids located over nests and at random points, the number of grid intersections over a given substrate category was divided by 49 to estimate the proportion of the grid covered by the substrate.

We used Analysis of Variance (ANOVA) with Tukey's method for multiple comparisons to test the hypothesis that the mean proportion of a substrate was not different among the nests of the 4 species (SAS Inst. 1985). We also used ANOVA to compare the mean proportions of a substrate of the randomly chosen sites among the 3 colonies. We used *t*-tests to compare the proportion of a substrate at nest sites of a species to the randomly selected sites in its colony. Because the dependent variables were proportions and because the variances were not always homogenous among the samples being compared, we also analyzed the data with the non-parameteric Kruskal-Wallis and Mann-Whitney-

Wilcoxon tests. These tests are analogous to the ANOVA and *t*-tests, respectively. The same null hypotheses were rejected using non-parametic and parametric tests when statistical significance was assessed at the 0.05 level. Therefore, we present only the results of the parametric tests.

One potential bias in our analysis of nest site characteristics is the addition of materials to the nest scrapes, a behavior noted in several terns (Chaney et al. 1978, Martin and Zwank 1987). To assess this potential bias, we divided the sampling grid that was placed over each nest into 2 parts: the 24 sampling points located around the periphery of the grid and the 25 interior sampling points. The periphery of the grid was clearly outside of the nest scrape and was probably representative of the nest substrate prior to any modification by the bird. The proportion of each substrate type in the periphery and interior of the nest sites were compared to the substrates at the randomly selected sites within each colony using *t*-tests. If the results of these 2 comparisons were the same, it would suggest that substrates were not substantially modified by nesting birds. However, if the composition of the nest scrape differed from the composition of points on the periphery of the sampling grid, relative to the random samples of substrate, it would suggest that the birds were modifying the nest scrapes to the point that our analysis of nest substrates would be biased.

Two additional aspects of the statistical analysis seem worthy of comment. First, a grid intersection could only be occupied by 1 substrate type, so comparisons of nest substrates among species are not completely independent. In other words, if the nests of least terns had a much higher proportion of a substrate than did the other 3 species, the least terns would be expected to have relatively lower proportions of the other substrate components. Second, our replicates were either nest sites or random locations within a colony, and not replicate colonies of the same species. Therefore, our results relate directly to only the nest substrates of the 3 colonies located on T-Pat's Island. Extension of the results to a more generalized comparison of substrate characters for the species on all dredge islands would require the sampling of replicate colonies.

## Results

There were approximately 320 pairs of Forster's terns, 50 pairs of least terns, 300 pairs of gull-billed terns, and 1,200 pairs of black skimmers nesting on T-Pat's Island during 1993. As this was the first and last year birds have nested on the island, it is impossible to discuss population trends within the colony. Annual surveys indicated that between 1990–1995 seabirds have nested on 2–4 islands per year in the ADWMA, with most islands being used for only the first year following their creation. Older islands were used only after fresh dredge materials were deposited on their surface. Trends over all the dredge islands suggest that nesting activity in the ADWMA is increasing for 3 of the seabird species (Fig. 1). The number of nesting least terns is low but appears to be relatively stable over the last 5 years. The total numbers of pairs of nesting

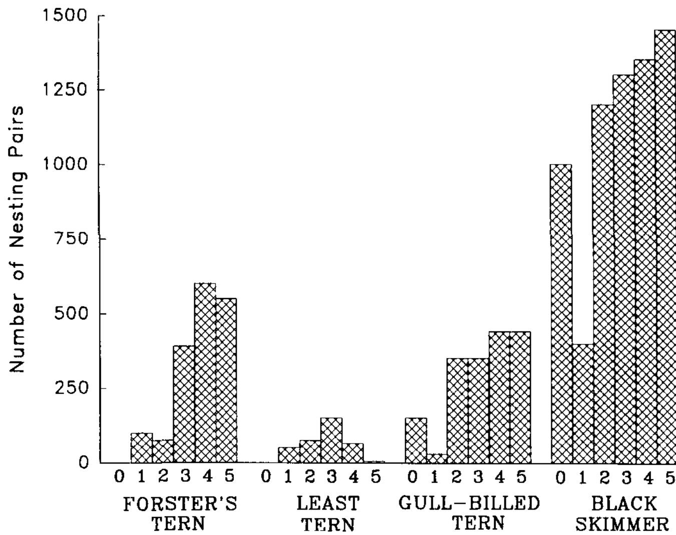


**Figure 1.** Numbers of breeding pairs of 4 species of seabirds nesting on dredge islands during 1990–1995 (0–5, respectively) in the Atchafalaya Delta Wildlife Management Area, St. Mary Parish, Louisiana. Estimates of numbers of nesting birds were made from boats, aircraft, and by walking through the colonies.

seabirds for the years 1990–1995 were 1,115, 580, 1,700, 1,975, 2,455, and 2,445, respectively.

The most common substrate in Forster's tern nests was clumps of dead water hycacinth that accumulated at the drift line (Fig. 2). Birds appeared to select this nesting material; the portion of dead vegetation at nest sites was significantly higher than at random sites located in the colony ($P < 0.0001$, Fig. 2). Sand was the most frequent substrate in the colony, but it was seldom recorded as a nest substrate ($P < 0.0001$, Fig. 2). When only the periphery of the sampling grid was examined, there was still significantly less sand around nests than at random sites in the colony ($P \leq 0.008$); however, differences in water hycacinth were no longer significant ($P = 0.084$). Samples of substrate taken within the interior of the grid contained more sand and less dead vegetation than the random sites ($P < 0.01$).

Shell was significantly more frequent in the substrate of nests than random sites in the least tern colony (Fig. 2, $P = 0.002$). Conversely, sand was rare at these nest sites relative to the random sites ($P = 0.004$). These same differences in substrate between the random and nest sites were significant when the analysis examined only data of the outer or inner portions of the sampling grid ($P < 0.05$).

The substrate of gull-billed tern nests tended to have more shell and less sand than random sites in the sample plot (Fig. 2, $P = 0.005$ and $P = 0.004$, respectively). The substrates of nests of black skimmers in the same plot did not differ from the random sites for either shell ($P = 0.274$) or sand ($P = 0.281$).

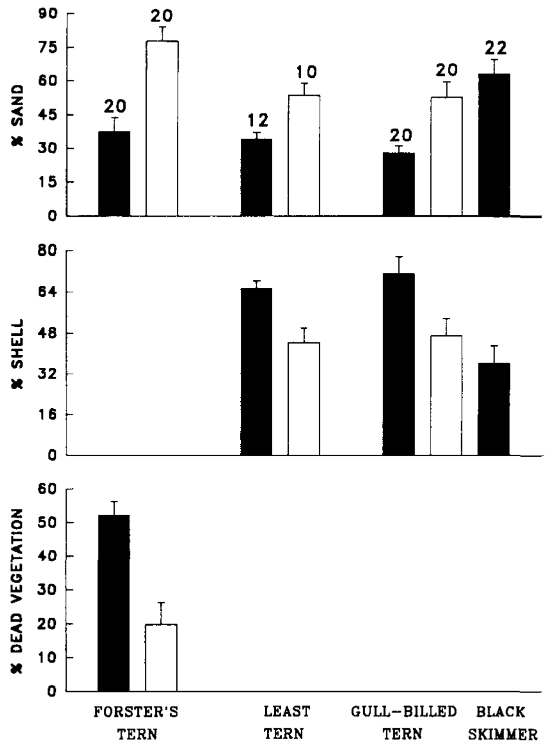


**Figure 2.** Percentages of dead vegetation (A), sand (B), and shell (C) at nest sites of 4 colonial seabirds on dredge islands in the Atchafalaya Delta Wildlife Management Area, St. Mary Parish, Louisiana. Closed and open bars represent the characteristics of nest sites and nearby randomly-selected sites, respectively. Sample sizes are located above the standard error bars on the uppermost graph.

Restricting comparisons of substrates from the random sites to either of inner and outer portions of the sampling grid around the nest sites of these two species had no significant effects on our results.

Examination of the substrate of the random sites in the sample plots provides a comparison of the habitat used by each species for its colony. Dead vegetation was found only in the Forster's tern colony (Fig. 2, $P < 0.0001$). Sand was more common, and shell was rarer, in the Forster's tern colony, relative to 2 other colonies ($P < 0.0001$).

Substrates differed among the nest sites of the 4 species. Only Forster's terns utilized dead vegetation as a nest substrate (Fig. 2, $P < 0.0001$). The frequency of sand in black skimmer nests was significantly higher than in the nests of the 3 species of terns ($P < 0.001$). Nests of the least and gull-billed terns both had higher frequencies of shell in their substrates than did the nests of Forster's terns and black skimmers ($P < 0.0001$).

## Discussion

Annual surveys suggest that the dredge islands of the Atchafalaya delta support large, and apparently growing, populations of 3 of the 4 seabirds. Numbers of least terns, a species whose status is of concern over large portions of its range (Thompson and Slack 1982, Kotliar and Burger 1986, Alleng and Whyte-Alleng 1993), changed little after an initial increase in the number of nesting pairs from 1990 to 1991. The development of dredge islands at the Atchafalaya Delta has probably had a major effect on local seabird populations as the nearest large colony of any of these species is over 65 km away. In addition, a 1993 statewide survey found that the numbers of black skimmers and gull-billed terns nesting in the ADWMA were at least an order of magnitude larger than other colonies of these species in Louisiana.

These surveys should be considered as only rough indices of bird abundance, rather than as complete censuses of all nesting birds. The date of the survey varied over almost a 2-month period, making it likely that peak nesting activity of at least one of the species was missed each year. Even with these qualifications, the survey results support the impression of area biologists that the size of the seabird colonies in the ADWMA is increasing.

Seabird use of the dredge islands in the Atchafalaya Delta differs from the temporal patterns documented for similar islands in North Carolina (Soots and Parnell 1975). In the ADWMA large colonies were only found on islands that had been covered with dredge materials 4–9 months prior to the nesting season; a few least terns would nest on islands that are 2 years old. In North Carolina, terns did not use dredge islands until the second year after they were created. Skimmers would occasionally nest on recently created islands, but they were more likely to use older islands that where also inhabited by terns. In another difference from Louisiana, Soots and Parnell (1975) estimated that gull-billed and least terns used an island for an average of 4 years; skimmer colonies persisted for an average of 7 years. We believe the very rapid growth of vegetation occurring on dredge islands in the Atchafalaya Delta explains the short duration of use of the birds of individual islands. By an island's second year, vegetation is thick enough to impede foot travel and severely reduce visibility at ground level.

Because most of the nest and colony characteristics we evaluated varied among our study plots, it appears that manipulations of these features have the potential to affect the use of dredge islands by terns and skimmers. Of the 4 species studied, only Forster's terns nested near the island's drift line. Common substrates in this area were sand and dead vegetation; no shell was found in the colony. The nests of Forster's terns were located on clumps of dead water hycacinth; dead vegetation was absent from the nests of the other seabirds. The traditional nesting sites of this species are piles of dead vegetation in marshes or on natural marsh islands (Martin and Zwank 1987, Storey 1987, Hall 1989). Although this tern has been reported to nest on dredge islands (Chaney et al. 1978, Martin and Zwank 1987), Portnoy (1977) found that only 0.8% of the Forster's terns in Louisiana nested on dredge islands. During the statewide survey in 1993, this number had increased to 12%.

High water and waves are a major source of nest loss in this species (Bergman et al. 1970, Chaney et al. 1978). The location of the colony near the drift line made the Forster's tern nests subject to flooding during unusually high tides.

During our study, there was a storm tide high enough to cover the entire colony. The placement on the nests on clumps of dead vegetation, 5–15 cm high, may increase their survival during periods of high water. Additionally, the clumps of vegetation may float during periods of high water, again protecting the nests. Patches of *Spartina,* which is often found around the nests, may function to hold the piles of dead plant material together during a storm (Martin and Zwank 1987). Further investigations are needed to evaluate these possibilities.

Managers might be able to increase the survival of Forster's tern nests by placing piles of dead vegetation farther above the drift line. If the Forster's terns occupied these higher sites, it is possible that nest losses during high water would be decreased. Compared to nests located in marsh habitats, Hall (1989) reported that nests located on islands were less susceptible to wave damage. However, it is possible that the species derives some benefit from nesting near drift lines. For example, the presence of *Spartina* might be an important feature of nest site selection, perhaps by providing hiding places for chicks. We did observe unused clumps of water hycacinth on other areas of the island, suggesting this habitat was not limited on T-Pat's Island. The ability of managers to manipulate the location of Forster's tern colonies and influence nest success needs further study.

There was no difference in substrate characteristics between random sites from the least tern and gull-billed tern-black skimmer colonies. Substrates were composed of roughly equal proportions of sand and shell and there was little dead vegetation in these colonies. Unlike the Forster's tern colony, these birds nested on the highest point of the island. These areas occurred near the outlet of the pipe used to deposit dredge materials. During the dredging operation, sand and silt particles flow away from the outlet with the water and start to collect as the water slows down. Shell and larger, heavier particulates do not flow with the water and as a result they collect near the outlet. Dredging outlets are often moved during dredging, creating patches on these islands that are covered by layers of shell.

There were no differences between the nest site characteristics of least and gull-billed terns. The nest sites of these 2 species had high frequencies of shell relative to randomly chosen sites, or the nest sites of black skimmers and Forster's terns. High elevation, sparse vegetation, and a mixture of shell and sand are characteristics of least tern and gull-billed tern colonies that have been studied elsewhere (Soots and Parnell 1975, Chaney et al. 1978, Thompson and Slack 1982, Grant and Paganelli 1984, Kotliar and Burger 1986). There are several reasons why these terns might have preferred shell over sand as a nest substrate. First, shell may simply co-occur with increased elevation (Kotliar and Burger 1986), but this would not explain why nest sites contained more shell than did nearby random sites. Second, shell may help retard vegetation growth, providing the birds increased fields of vision. Third, shell may also be cooler than sand, reducing water loss in tern eggs (Grant and Paganelli 1984). Fourth, birds may nest on shell to avoid sand containing large amounts of silt, which can adversely affect egg survival (Thompson and Slack 1982, Carreker 1985). Finally, shell might provide a more cryptic background for eggs (Kotliar and Burger 1986). We are evaluating these explanations for the preference of terns for shell substrates, but regardless of the outcome it appears that shell is an important feature of nest sites of terns.

Relative to the gull-billed terns nesting in the same colony, black skimmers nested on substrates that contained more sand and less shell. There was no difference in substrate composition between skimmer nests and nearby random sites. The biggest determinant of skimmer nest choice appears to be the presence of terns, and not substrate cues. Close associations between black skimmers and common terns (*Sterna hirundo*) have been reported on the Atlantic Coast (Gochfeld 1978), and a similar association appears to occur between black skimmers and gull-billed terns in colonies in the ADWMA. Black skimmers might benefit from aggressive mobbing of predators by terns nesting nearby (Burger and Gochfeld 1990); this hypothesis is currently being tested for the skimmer-tern association in the ADWMA. Regardless of the reason black skimmers tend to nest next to terns, if shell is important for promoting the use of dredge islands by gull-billed terns it may be an equally important habitat feature for skimmers.

In addressing the role of substrate preferences in the selection of colony and nest-site locations we needed to evaluate the possibility that the birds were modifying their nest substrates. Terns will occasionally modify nest scrapes if adequate substrates are not available (Chaney et al. 1978, Martin and Zwank 1987). For the least terns, gull-billed terns, and black skimmers, results of comparisons of substrates from the periphery and interior of the sampling grids to those at randomly selected sites were similar. On T-Pat's Island, nest sites of these species did not appear to be modified, suggesting that even if birds were changing nest scrape composition, this effect was small compared to the effects of nest site choice. For the nests of Forster's terns, substrates on the periphery of the sampling grid contained a significantly lower frequency of water hycacinth than did substrates closer to the nest scrape. This suggests that Forster's terns added water hycacinth to the nest scrape, perhaps removing it from the periphery of the nest site. Alternately, these terns may have nested on preexisting clumps of hycacinth that were sometimes smaller than our sampling grid. This is a distinct possibility as there were many piles of hycacinth present, most of which were not used as nests. Even if some of the Forster's terns added water hycacinth in their nests, this does not diminish the possibility that the ready availability of this material is an important habitat component for this species.

The substrates used by least terns, gull-billed terns, and black skimmers might be determined by both their nesting sequence and the availability of shell. In coastal Louisiana, least terns establish their nests first. On T-Pat's Island, as well as on another island currently being studied (T. Mallach and S. Pius, pers. commun.), these birds nested on substrates with a high shell composition. These small terns were fairly aggressive and actively prevented gull-billed terns and black skimmers from entering their colony. Gull-billed terns nested next, and selected high shell substrates if they are available, as was the case on T-Pat's Island. On another island, least terns occupied all available patches of shell, and gull-billed terns established their colony on nearby sand substrates (S. Pius and T. Mallach, pers. commun.). On both islands, black skimmers chose their nest sites last and with little regard to nest substrate. At first skimmers nested in and among the gull-billed terns, but expanded to areas outside the tern colony as nest sites became limited.

This pattern of nesting sequence raises 2 questions if it is found to be consistently repeated on other dredge islands. First, if gull-billed terns can bring off successful clutches when nesting on sand, why did they appear to prefer a shell substrate on T-Pat's Island? Second, would black skimmers nest on substrates with more shell if these sites were not already occupied by terns? Both of these questions are currently being evaluated.

Shell may have other important, but indirect benefits of making dredge islands suitable for tern and skimmer colonies. For example, shell increases the stability of dredge islands by offering resistance to wind and rain erosion (Soots and Parnell 1975). Shell may also benefit nesting seabirds by retarding vegetation growth.

Because of the short duration of usefulness of individual islands to seabirds, terns and skimmers would probably abandon the ADWMA if dredging activity ceased. In general, dredging and deposition practices appear to be capable of sustaining a suitable abundance of seabird habitat on the ADWMA; however, water conditions in the lower Mississippi River drainage can greatly affect the availability of dredge materials. For example, low water levels this past year had made it questionable that there would be enough dredge material to create sites useful to seabirds in 1996. A potential solution to variable supplies of dredge materials may be to create a more permanent site for colonies of the gull-billed terns, least terns, and black skimmers. This might be accomplished by covering an island's surface with a layer of shell, making plant growth difficult. Addition of a layer of shell might also increase the attractiveness of a dredge island to these species. We are currently conducting an experiment to evaluate the effectiveness of a supplemental deposit of shell as seabird nesting habitat.

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