

## DISCUSSION

### Near-shore Survey

#### Effects of Human Activities on Long-tailed Ducks

We measured the effects of human activities on Long-tailed Ducks by comparing population trends between “Industrial” and “Control” areas, and by assessing the correlation between density and human activities. In neither case was there sufficient evidence, based on models developed by Johnson and Gazey (1992), to suggest that change in density and distribution resulted from human activities. These results concur with those reported by Johnson and Gazey (1992). For example, both studies found that densities changed at similar rates between the “Industrial” and “Control” area, and that Long-tailed Duck density was not significantly related to the frequency of disturbances such as boats, low-altitude aircraft over-flights (<500 ft) or land-based human activities.

While disturbance effects on marine birds were not detected in this study, previous research has shown otherwise. For example, Common Eiders nesting on barrier islands were sensitive to low-level aircraft (Schamel 1974). Similarly, Long-tailed Ducks in Beaufort Sea lagoons showed behavioral responses (Gollop et al. 1974) and changes in distribution (Johnson 1982) resulting from human disturbances. Moreover, Johnson and Gazey (1992) reported a tendency for lower Long-tailed Duck densities on aerial transects with human activities, although this effect was not statistically significant.

Given that other studies indicate that human disturbance may impact marine birds in central Beaufort Sea lagoons, we should scrutinize the negative results in this study. Trends in sea duck populations are difficult to detect because of inherent stochasticity in populations and high standard errors in aerial survey techniques (Goudie et al. 1994). Recognizing these limitations, Johnson and Gazey (1992) cautioned that the power to detect a disproportionate change in Long-tailed Duck density is low, even if an effect actually exists. In fact, they reported that 11-12 years of monitoring would be required to detect a 12% change in relative density of Long-tailed Ducks.

A second reason why human impacts may be difficult to detect is long-term changes in habitat. Changes in availability of preferred habitat may influence shifts in Long-tailed Duck distribution. Configuration of lagoons between 1906 and 1972 suggest a net landward migration of barrier islands (Naidu et al. 1984). Moreover, some changes in barrier island structure can occur in relatively short periods of time. For example, a severe arctic storm hit the islands on 10 August, 2000 influencing distribution of marine birds and altering the size of some barrier islands (Flint et al. 2000).

Finally, human induced effects may not have been detected due to encroachment of human activities throughout the “Control” area. Thus, this area is not truly a scientific control because some limited development has occurred there. Seasonal camps in the “Control” area have served as a base for biological studies in the Maguire Islands since 1999 (Flint et al. 2000). A similar camp, however, was located in the “Industrial” area as well, thus these camps have not caused a disproportionate increase of human activity in the “Control” area during the study period.

Correlation between human activities and bird density is difficult to detect even if strong effects exist, due to low power of the ANOVA and ANCOVA models (Johnson and Gazey 1992).

Detecting human disturbance effects on birds is difficult because density and distribution is influenced by many variables, such as weather, season and locality. Moreover, disturbance events in this study were not controlled in a rigid experimental design. Absence of a controlled experiment can complicate attempts to identify the cause of change. For example, in an

investigation of disturbance effects on Long-tailed Ducks, Johnson (1982) found that movements coincided with an increase in human-induced disturbances. This period, however, occurred during a change in wind and wave patterns, making it difficult to isolate the causes of distribution change.

For these reasons, an alternative to the current test of industry effects could be a controlled experiment of disturbance on distribution patterns. Experiments of this nature were initiated in 2000 (Flint et al. 2000) and expanded in 2001 using disturbed and multiple control study sites (Lanctot et al. 2001).

#### Components of Variation

Many results from this study matched those reported by Johnson and Gazey (1992) suggesting that the components of variation in density have not changed substantially since 1991. For example, both studies found no difference in Long-tailed Duck density between the “Industrial” and “Control” areas overall. Both studies, however, did find differences among habitats in specific areas. For instance, Mainland Coastline was important to Long-tailed Ducks in the “Control” area, but not in the “Industrial” area. This result reaffirms findings from previous studies (Bartels and Zellhoefer 1982, Johnson 1982) suggesting that Long-tailed Ducks are not randomly distributed throughout the Beaufort Sea lagoons. Further, both this study and Johnson and Gazey (1992) showed that densities varied among habitats between years. On a smaller scale, densities of ducks seen on transects within habitats varied in both studies. That is, there were specific transects with consistently high densities of Long-tailed Ducks. For example, transect 191, a mainland coastal habitat transect in the “Control” area, consistently had higher densities than other transects in the same habitat and area. Finally, both studies found that wave height was negatively correlated with densities. Thus, as wave height increased, densities decreased. This relationship may be due to Long-tailed Ducks seeking shelter during periods of heavy wave action; or alternatively, could be due to waves reducing the ability of observers to see birds on the water. Although Wave height was a significant variable, it explained little of the variation in density, as seen in the nearly identical  $R^2$  estimates generated by the ANOVA (0.74) and ANCOVA (0.75) models.

#### Possible Long-term Decline in Long-tailed Ducks

While results from this study concurred with nearly all terms and covariates reported by Johnson and Gazey (1992), one important difference was a significant Year term, indicating that Long-tailed Duck density in both the Industrial and Control areas declined significantly between 1990 and 2000. Johnson and Gazey (1992) noted an apparent downward trend in 1991, but the change was not significant at the  $\alpha = 0.05$  level. Although the downward trend after 1991 was less pronounced than between 1990 and 1991, densities continued to decline in 1999 and 2000. This trend resulted in a significant Year term in this study, presumably due to the expanded sampling period (four years) and relatively low intra-year variance.

Concurrent with this downward trend in Long-tailed Duck density was an apparent shift in species composition within the near-shore study area. For example, Johnson and Gazey (1992) reported that Long-tailed Ducks made up over 91%, on average, of the marine birds sighted in the study area during the years 1977-1982, 1984, 1989-1991. The percentage, however, began decreasing in 1984, when 97% of the birds detected were Long-tailed Ducks. By 1991, the percentage had dropped to 87% (Johnson and Gazey 1992). Additional surveys in 1999 conducted by LGL Ltd. showed this percentage had dropped further to 84.5% (Noel et al. 2000). In this study we found slightly lower proportions of Long-tailed Ducks (1999- 80%, 2000- 79%). While the statistical and biological significance of these numbers has not been

assessed, this downward trend may be important in light of decreased densities of Long-tailed Ducks in lagoons and Alaskan coastal plain breeding population estimates (Mallek 2001).

Several alternatives may explain the reduction of density estimates in central Beaufort Sea lagoons. First, populations of Long-tailed Ducks on the Alaskan Arctic Coastal Plain have been monitored annually since 1986 (Brackney and King 1993, 1994, 1995, 1996; King and Brackney 1997; Mallek and King 2000; Mallek 2001) and are showing signs of a long-term downward trend. Population estimates in 2000 were the lowest in the 15-year history of the survey (Mallek 2001), and were significantly lower than the preceding 14-year mean. The central Beaufort Sea lagoons likely support many molting birds that breed locally (Johnson and Richardson 1982). Decreased density in Beaufort Sea lagoons, therefore, may reflect a general downward trend of this species along the Alaskan Arctic Coastal Plain. Second, decreased density estimates of molting Long-tailed Ducks could be due to reduced numbers of a non-local breeding population that molts in Beaufort Sea lagoons. Sea duck breeding sites may be hundreds or even thousands of kilometers from molting areas (Salomonsen 1968). For example, many Canadian breeding Long-tailed Ducks presumably join Alaskan birds to molt in the Central Beaufort Sea lagoons (Salter et al. 1980, Johnson and Herter 1989). Third, Long-tailed Ducks that historically used central Beaufort Sea lagoons may have shifted their molting grounds out of the study area altogether. Fourth, the reduction of birds seen in lagoons may be related to breeding propensity rather than a decrease in population size. For example, in years with poor reproductive success, failed breeding females may have molted in July and August in conjunction with males rather than in September after raising broods. In this circumstance, density estimates in lagoons would be elevated due to a larger proportion of birds molting during the survey period. If this alternative were true it would indicate an increase in breeding propensity between 1990 and 2000. Fifth, observed decreases of Long-tailed Duck density may reflect a shift in diurnal patterns of lagoon use. For example, if birds required more time feeding in recent years relative to 1990 (resulting from disturbance, viruses, decrease in available prey, etc.), then birds would have spent more time in the mid-lagoon where Long-tailed Ducks generally feed. This situation would result in lower density estimates because Long-tailed Ducks dive for their food where they cannot be seen by survey crews, and because they would be spread out throughout the mid-lagoon rather than concentrated along the barrier island transect where they generally roost.

The difficulty in separating these various alternatives highlights the importance of identifying the breeding locations of Long-tailed Ducks that molt in the central Beaufort Sea lagoons. Plans are in place to put satellite radios on molting Long-tailed Ducks in 2002 to help answer this question. Additionally, it is important to gain a better understanding of the effects of breeding propensity on summer molting populations, and detect long-term shifts in activity budgets.

#### Distribution Patterns in the Near-shore Survey

Long-tailed Ducks densities were high in Barrier Island habitat relative to other habitats in the study area. The elevated density in this habitat, however, is likely influenced by the study design and diurnal patterns of marine birds. For example, given the objective to monitor trends in density between years, the study protocol specifies the importance of conducting surveys as late in the day as possible in order to control for diurnal movement patterns (Johnson and Gazey 1992). Long-tailed Ducks have been shown to congregate in the lee of barrier islands in evening (Johnson 1982, Flint and Lanctot, pers obs.) whereas they feed primarily on invertebrates in mid-lagoon habitat during midday (Johnson 1982, Craig et al. 1984). Thus, high densities of Long-

tailed Ducks detected in Barrier Island transects is likely a result of time of day rather than habitat preference.

While differences occurred between habitats as a whole, density also varied among Habitat-Area strata. These differences, may be related to the varying protection each Habitat-Area stratum affords. For example, Long-tailed Duck density in Mainland Coastline habitat was highest in the “Control” area. This difference may be partly due to differences in habitat between the “Industrial” and “Control” areas (Johnson and Gazey 1992). Alternatively, differences among Habitat-Area strata may be due to food availability. Marine birds in central Beaufort Sea lagoons commonly utilize mysids and amphipods (Griffiths and Dillinger 1980). Abundance of these invertebrates, however, can vary considerably between years (Griffiths and Dillinger 1980). Fluctuations of these food sources may govern strategies birds use to distribute themselves within the lagoons.

Like Long-tailed Ducks, Common Eider concentrations were highest in Barrier Island habitat. This result is not surprising, because barrier islands are preferred nesting habitat for Common Eiders on the North Slope (Johnson 2000). Densities of this species were higher in the “Control” vs. “Industrial” areas, closely paralleling results from recent aerial surveys conducted by Noel et al. (2000). This distribution pattern is noteworthy given that the number of nests built, and nesting success parameters were essentially equal in the “Industrial” and “Control” areas (Flint et al. 2000). One explanation of this pattern is that a greater proportion of non-breeding Common Eiders use lagoons east of Prudhoe Bay, thereby increasing overall density estimates in the “Control” area.

Unlike Common Eiders, Scoters are not known to breed on the Alaskan Coastal Plain (Johnson and Herter 1989). Scoters do, however, migrate to Alaskan Beaufort Sea lagoons to molt. There we found that Scoters (predominantly Surf Scoters) were present consistently in Mid-lagoon habitat between Oliktok Point and Egg Island in the “Industrial” area. This finding, as well, was consistent with those reported by Noel et al. (2000). The affinity of Scoters to this particular stratum is striking, especially given that no other species discussed in this report used that area extensively. It is not clear why this area is favored, but bivalve mollusks are common to the diets of the three species of scoters (Savard et al. 1998, Brown and Fredrickson 1997, Bordage and Savard 1995) and may influence the unique distribution of these species.

In contrast to the sea ducks, loons were distributed throughout all near-shore habitats. Unlike sea ducks, Loons do not use Beaufort lagoons as molting sites. Rather, near-shore waters serve as important feeding locations during the critical chick-rearing period (Andres 1993). Loons that were observed in lagoons, therefore, were likely foraging for fish to deliver to chicks at inland sites. Our results matched those reported by Noel et al. (2000) who found that densities of Pacific and Red-throated Loons were not significantly different between habitats. Yellow-billed Loon density, however, was slightly higher along barrier islands than in other habitats. These differences in distribution patterns may reflect varying prey preferences of these three Loon species.

Other species varied widely in their use of near-shore waters. For example, Glaucous Gulls were ubiquitous along the Mainland Coastline and Barrier Islands. In these habitats, Glaucous Gulls were generally roosting on the water’s edge. Interestingly, Near-shore Marine habitat was used to a relatively high extent in the “Control” area. In contrast, Glaucous Gulls were conspicuously absent from Mid-lagoon habitat throughout the study area. Shorebirds too, shared the barrier islands and mainland coastline. Shorebird sightings were variable, but when detected, these birds were generally found in relatively large flocks along mudflats. Rarely were Shorebirds seen in Mid-lagoon habitat. Similarly, Northern Pintails, and Geese and Swans also

avoided mid-lagoon habitat. Instead, both groups used the mainland shoreline almost exclusively. There they were seen feeding and flying over the narrow strip of coastal salt marsh.

## **Offshore Survey**

### Components of Variation in Marine Bird Offshore Distribution

A lower proportion of variation in Long-tailed Duck density was explained by ANOVA and ANCOVA models in the Offshore surveys than in the Near-shore. This is likely due to intrinsic differences between the two surveys. For example, near-shore transects were selected in areas where birds occur in consistently high densities (Johnson and Gazez 1992), whereas offshore transects were systematically placed across a large study area. Moreover, the Offshore survey attempted to sample waters during three distinct phases of the summer, whereas the Near-shore survey concentrated on a six-week molt period when relatively stable populations of birds were present. Additionally, fewer replicates were conducted in the Offshore survey relative to the Near-shore survey. The differences in design of these surveys is due to the objectives that directed their implementation. For instance, the Near-shore survey was originally designed to measure human activity effects on densities of Long-tailed Ducks along index transects whereas the Offshore survey intended to monitor eider distribution through summer in offshore waters, an area with little prior information.

Distribution of marine birds as a whole cannot be broadly generalized. Densities varied by species and by when and where we looked. One example of this regional and temporal variability was seen in distribution patterns of Long-tailed Ducks. Long-tailed Ducks moved from deep offshore waters into protected near-shore waters at the onset of post-breeding molt in both years of the study. Movement of Long-tailed Ducks into near-shore waters during the molting period has been documented by others (Bartels et al. 1983, Bartels and Doyle 1984, Harrison 1977), and is likely due to the importance of near-shore lagoons affording protection from poor weather, and proximity to abundant prey (Johnson 1982). These characteristics can be critical to molting birds when nutritional requirements and susceptibility to predation are high (Hohman et al. 1992).

Another factor that explained some variation in distribution was the presence of ice. In particular, densities of Pacific and Red-throated Loons, and Glaucous Gulls decreased as ice cover increased. In contrast, densities of other species did not vary significantly with changes in ice cover. Other researchers found that presence of ice was not helpful in explaining variability in marine bird offshore distribution (Divoky 1979). Presumably, other components of variation in this study were more important to distribution patterns, thus the effect of ice was not detected. In this study, summer ice conditions varied between years, thus consistent patterns were difficult to detect.

## **Offshore Migration Corridor**

While densities of most marine birds were generally higher in near-shore areas, offshore waters may provide an important migration corridor for eiders. In this study, densities of King Eiders were greatest offshore during the July surveys, coinciding with the peak of post-breeding molt migration (Johnson and Herter 1989). Johnson and Richardson (1982) using a combination of aerial surveys, ground observations, and radar found that eiders may bypass the south-central portion of the Beaufort Sea by migrating westward, north of the barrier islands. Similarly, Peterson et al. (1999) found that post-breeding Spectacled Eiders migrated west, seaward of the Beaufort Sea barrier islands. Finally, an aerial survey of the Canadian Beaufort Sea showed eiders used waters as far as 115 km from shore in July (Searing et al. 1975).

Long-tailed Ducks, too, may migrate from their breeding sites to molt locations using offshore waters. Johnson and Richardson (1982) reported that coastal observations of migrating Long-tailed Ducks in the Yukon were too low to account for the numbers of birds that entered Alaskan Beaufort Sea lagoons. Thus, they suggested that the many birds were migrating over deep waters, out of sight from land. Similarly, Harrison (1977) found Long-tailed Ducks scattered throughout Beaufort Sea offshore waters up to 160 km from shore. In this study we found that Long-tailed Duck densities increased in offshore strata by late August. Presumably these birds had completed post-breeding molt and were en route to wintering areas. This assessment, however, is speculative given the “snapshot” nature of these surveys. This highlights the need for a migration study designed specifically to detect routes, turnover rates and timing of marine birds in the Central Beaufort Sea.

### **Important Areas**

The Near-shore and Offshore surveys revealed four locations in the Central Beaufort Sea important to marine birds. Harrison Bay is one area that showed relatively high densities for Scoters, King and Spectacled Eiders, and Yellow-billed and Red-throated Loons. Relatively high densities of Yellow-billed Loons and Spectacled Eiders seen in Harrison Bay may be related to the nesting distribution of these species. In general, these species nest closer to Harrison Bay than other areas in the Offshore survey area (Larned et al. 2001). Previous studies noted the importance of Harrison Bay for marine birds. For example, Harrison (1977) conducted offshore aerial surveys and found high densities of eiders in offshore waters within Harrison Bay in August. Moreover, Petersen et al. (1999) documented post-breeding Spectacled Eider concentrations in Harrison Bay. Similarly, Divoky (1984) noted that Loons were more common in the near-shore waters of Harrison Bay than in similar habitat to the east. Further, Andres (1993) showed that this area provided important feeding grounds for Loons. From his study site in the Colville River Delta, he noted regular foraging flights of Red-throated and Pacific Loons to Harrison Bay. From there they returned to nest sites bearing fish to deliver to chicks at inland nesting sites.

In contrast, our results indicate Harrison Bay had low densities of Long-tailed Ducks and Common Eiders. By chance, survey transects in Harrison Bay did not intersect Thetis Island, the single barrier island in Harrison Bay that has high concentrations of Long-tailed Ducks and Common Eiders (Johnson 1984, Schamel 1974, Johnson 2000). Thus, our density estimates of these two species are probably low in the Harrison Bay Shallow-water stratum.

Barrier Islands also had high marine bird densities, presumably because they provide important habitat for many species. These results agree with previous studies that have shown the affinity of Long-tailed Ducks and other marine birds to barrier island habitat (Johnson 1982, 1984; Johnson and Gazey 1992). The benefit this habitat provides includes protection from wind and rough water, and close proximity to abundant prey (Johnson 1982).

On a fine scale, several locations within the Beaufort lagoons stand out as particularly important. The Barrier Island habitat adjacent to the Stockton Islands had consistently high densities of Long-tailed Ducks and Common Eiders. Similarly, the Mainland Coastline between Bullen Point and Point Thomson had surprisingly high densities of Long-tailed Ducks. Finally Scoters showed a strong affinity to Mid-lagoon habitat throughout most of Simpson Lagoon. Similar patterns were reported in these three areas by Noel et al. (2000) who conducted comparable aerial surveys in 1999.

These four locations (Harrison Bay, Stockton Islands, Control Mainland Coastline, and Simpson Mid-lagoon) appear to have consistently high concentrations of select marine birds. Accordingly, care should be taken to minimize impacts of human activities in these areas.

## **Recommendations For Future Monitoring Efforts**

Continuation of the current protocol in subsequent years will help detect relative change in Long-tailed Duck densities between the “Control” and “Industrial” areas if differences truly exist. Although data on Long-tailed Duck density were collected between 1977 and 1984 within the general study area, they were not collected using a comparable protocol (Johnson and Gazey 1992) and thus cannot be used for this analysis. For example, sampling prior to 1990 did not occur in four transects within each Habitat-Area stratum. Such a design is required by the analysis protocol to test for industry effects. Johnson and Gazey (1992) recommended that industrial effects be assessed using data collected in 1990-1991 as a baseline. Comparing these results to those collected in 1999 and 2000 provided the first opportunity for detecting a relative change in density. Given the low statistical power of these tests (Johnson and Gazey 1992), however, additional data should be collected.

A long-term data set, will be beneficial only if the conditions within the study area remain constant. For example, to attribute changes in density to industrialization requires that a disproportionate level of human disturbance occur in the “Industrial” area. As mentioned earlier, the “Control” area is not a true control in that it has become exposed to human activities since 1990. In the course of this study the “Industrial” transects were exposed to 2.5 times the level of potential disturbances as were transects in the “Control” area. If human encroachment into the “Control” area increases appreciably in future years, then alternative ways to assess disturbance effects should be sought.

One alternative is to examine immediate effects of disturbance of known extent and duration on behavior and distribution of Long-tailed Ducks in a controlled experiment. An opportunity to measure disturbance effects in a relatively controlled setting will occur in August 2001 when Western Geco conducts 3D seismic tests near Spy and Leavitt Islands. The Alaska Science Center will monitor local movements of Long-tailed Ducks in response to seismic tests using radio-equipped birds and remote data collection computers (Lanctot et al. 2001).

The current Near-shore study design may be an effective way to monitor trends of Long-tailed Duck density among specific areas, but it does not provide unbiased estimates of abundance or habitat preference. For example, Mid-lagoon habitat is under-represented in the current design (Noel et al. 2000), preventing reliable expansion of density estimates throughout this habitat. Moreover, the northern edge of barrier islands is not sampled at all in the current protocol. In addition, Near-shore survey results should not be misconstrued as demonstrating habitat preference because timing and locations of sampling were not random.

If abundance estimates and a better understanding of habitat preference are deemed important and necessary for multiple species using the Beaufort Sea, then a randomized sampling design may be better suited than the current approach. Purely random transects, however, are neither safe, logistically feasible, nor economical using an aerial platform. A better alternative may be a stratified systematic survey with random starting points. With this approach, habitats would be sampled in proportion to their size regardless of predetermined concentrations of marine birds. This would provide researchers an unbiased estimate of population size.

Ideally, aerial survey protocols should standardize observers, conditions, survey platform, and altitude. Standardization, however, is difficult due to uncontrolled weather, geography, and logistics. For those reasons our aerial surveys were imperfect. While it is accepted that aerial surveys, like any sampling method, include problems of bias and precision, the aerial platform does provide an acceptable level of sampling for many management questions (Caughley 1977). Certainly it is important to minimize potential sources of bias. In this study, the use of two types of aircraft in the Near-shore survey, and variable altitude during the Offshore survey may have

increased variation. As discussed in the results section, however, these potential sources of bias are unimportant relative to other components of variation. Regardless, to obtain the best estimates of marine bird densities, special effort should be exercised to standardize data collection.

Towards that end, USFWS-Migratory Bird Management, USFWS- Regional Aviation Management, and the Office of Aircraft Services developed safe standardized operating procedures for Offshore aerial surveys in March 2001. In general, this agreement approved the continued use of twin-engine aircraft at an altitude of 45 m and speed of 180 km\hr for future Offshore survey efforts. The standard operating procedure increased the margin of safety for survey crews by implementing guidelines including specialized tests for contract pilots prior to surveys, use of primary and secondary pilots, and use of turbine engine aircraft. The continued use of a twin-engine platform at 45 m and 180 km\hr will enable future survey efforts to produce comparable data to those collected in this study.

## SUMMARY AND CONCLUSIONS

Hundreds of thousands of marine birds use the Beaufort Sea each year. Previous studies have shown that the south-central Beaufort Sea satisfies important functions for marine birds, including feeding and molting habitat, and a migratory pathway. Concerned that these functions may be compromised by progression of oil and gas development into the near-shore waters of the Beaufort Sea, MMS and USGS-BRD signed an Intra-agency Agreement to assess impacts of human activities on distribution and density of Long-tailed Ducks in Beaufort Sea lagoons. To accomplish this, USGS-BRD subcontracted the USFWS, Waterfowl Branch of Migratory Bird Management, to conduct Near-shore aerial surveys in 1999 and 2000 using existing MMS protocol (OCS- MMS 92-0060), and to compare these results with historical data in “industrial” and “control” areas. We used these data to compare relative densities between “industrial” and “control” areas and to describe the relationship between bird density and human activities.

In addition to monitoring “industrial” and “control” areas, we surveyed near-shore waters between these sites. Accordingly, we mapped distribution patterns of Long-tailed Ducks and other marine birds in an expanded near-shore area among 4 habitats from Oliktok Point to Brownlow Point.

Although Long-tailed Ducks are abundant in the Beaufort Sea, Spectacled, King and Common Eiders also comprise an important proportion of marine avifauna in the region. A poor understanding of Eider distribution in the south-central Beaufort Sea prompted us to conduct an Offshore survey in 1999 and 2000. This survey supplemented the existing protocol to sample near- and off-shore waters for Eiders between Cape Halkett and Brownlow Point up to 60 km offshore.

The specific objectives of this study were to:

1. Monitor Long-tailed Ducks and other species within and among “industrial” and “control” areas using existing protocol (OCS-MMS 92-0060).
2. Use data from 1999-2000 and data collected by Johnson and Gazey (1992) in 1990-1991 to compare Long-tailed Duck population trends between “industrial” and “control” areas, and to describe the relationship between distribution patterns and human activities.
3. Expand the Near-shore survey area to encompass habitats between the original “industrial” and “control” areas, and sample Near-shore Marine habitat from Oliktok Point to Brownlow Point to delineate small-scale distribution patterns of marine birds throughout the expanded study area.
4. Correlate variation in marine bird populations with environmental factors, human activities, and temporal and spatial variables.

5. Implement an Offshore survey that targets Spectacled (*Somateria fischeri*), Common (*S. mollissima*) and King Eiders (*S. spectabilis*).
6. Document distribution patterns of marine birds within the Offshore survey area.

Using the analysis procedures outlined by Johnson and Gazey (1992), we detected a region-wide decrease in Long-tailed Duck density within the study area between 1990-2000. This finding substantiated concerns expressed by Johnson and Gazey (1992) who detected a non-significant downward trend in Long-tailed Duck densities between 1989-1991. While densities region-wide decreased, we did not find a disproportionate decline in the “industrial” area. Similarly, survey data suggested that local disturbance events, such as boat traffic, low-level aircraft, and land-based human activities did not alter the distribution patterns of Long-tailed Ducks.

These tests may have failed to detect human effects on bird densities even if they do indeed occur. Reasons for low power of these tests include inherent stochasticity in sea duck populations, high standard errors associated with aerial survey techniques, localized short- and long-term changes in barrier island habitat, intrusion of human activities into the “Control” area, and unidentified components of variation.

The expanded Near-shore survey indicated that Long-tailed Ducks were the most abundant species in the near-shore environment. Within this area, Long-tailed Ducks densities were highest in Barrier Island habitat, particularly among the Stockton Islands. The survey protocol, however, was designed to test hypotheses of disturbance effects, not to test habitat preferences. Thus, although Long-tailed Ducks were seen in the highest densities in Barrier Island habitat, this finding should not diminish the importance of Mid-lagoon habitat where Long-tailed Ducks feed in midday. Thus, distribution patterns reported here must take into account the location of transect lines and when surveys were conducted.

In the Offshore survey, patterns of marine bird distribution were more variable than in the Near-shore survey. The greater variability in the Offshore survey can be attributed to a larger and more varied study area, a broader sampling period (early, mid, and late summer) and fewer replicates. Nonetheless, general patterns of marine bird distribution were documented. For example, Common Eider densities were highest in shallow-water areas throughout the study area, whereas King Eiders were generally found in large flocks in the deep waters of Harrison Bay. Similarly, Spectacled Eiders were seen in large flocks in Harrison Bay. Unlike King Eiders, however, Spectacled Eiders were uncommon. Offshore survey data also indicated that Common Eider densities remained relatively stable through summer, while King and Spectacled Eider densities peaked in July. The timing and location of King and Spectacled Eider concentrations supports the idea that offshore waters provide a migration corridor for post-breeding Eiders. However, given the Offshore survey is limited to two years of data, it is difficult to predict timing or routes of migrating birds.

The Near-shore and Offshore surveys indicated several areas that appear to be important to marine birds. Harrison Bay, particularly the deep-water strata, supported the highest concentrations of King and Spectacled Eiders. Moreover, this region was relatively important for Scoters, and Red-throated and Yellow-billed Loons. Barrier Island habitat, too, had the highest concentrations of Long-tailed Ducks and Common Eiders. In particular, Barrier Island Habitat among the Stockton Islands had consistently high densities of these species. Although Mainland Shoreline habitat typically had lower densities than Barrier Island habitat, the shoreline between Bullen Point and Point Thomson supported high densities of Long-tailed Ducks relative to other areas in this habitat. Finally, Scoters showed a strong affinity to Mid-lagoon habitat in western Simpson Lagoon.

The Near-shore survey protocol provides a means to monitor trends in molting Long-tailed Duck densities among specific areas and can establish relationships between distribution patterns and human activities; however, this approach is limited. For example, the protocol cannot be used to measure population abundance or habitat preference and is inappropriate to apply to other marine bird species in the near-shore environment.

One alternative that may provide a better assessment of the effects of human activity on marine birds is to measure behavioral responses to disturbances of known size and duration. Direct observations could document immediate changes in distribution within a controlled setting. Additionally, this approach may help identify what specific activities have measurable effects on birds and predict the duration of these responses. An opportunity to measure disturbance effects in a relatively controlled setting occurred in August 2001 when Western Geco conducted 3D seismic tests near Spy and Leavitt Islands.

If multi-species abundance and habitat preference information is of interest, then monitoring efforts should use a sampling design that includes systematic transects with random starting points. This approach would provide an unbiased sample marine bird density in the study area of interest.

As oil and gas development shift from on-shore to offshore sites, potential for oil spills in marine waters will increase. Modeling efforts that predict the impact of oil spills on marine birds are dependent upon an understanding of distribution patterns of these species. These models can be important tools that minimize risk to wildlife by guiding development plans and prepare for cleanup in the event of an actual spill.