

### Waterbird Abundance

Species were placed in management guilds to evaluate the relationship between waterbird abundance and foraging patterns. A guild is a group of species that exploit resources in a similar way (Root 1967); a management guild is a group of species that respond in similar ways to anthropogenic changes to the environment (Verner 1984). Three management guilds were identified based on the way food was captured in this study: (1) surface-feeders (Northern Pintail), (2) divers (Oldsquaw), and (3) birds that both dive and feed at the surface (King Eider and Spectacled Eider). This approach provides a framework for evaluating the relative importance of different habitat factors for species with similar foraging patterns. However, the evaluation is based on abundance data only. Habitat use varies according to a variety of other factors including age, sex, and breeding stage (Weller 1988). Also, ducks may use a variety of wetlands during the nesting season (Krapu 1974).

Northern Pintail showed the greatest response to impoundments. Troy (1985) also found that pintails were more abundant in areas with impoundments. Although early thaw and greater average surface area may partially explain greater use of impoundments in early summer, the fact that pintails were also more abundant on impoundments in mid- and late summer (after water-level drawdowns in many impoundments) suggests that factors other than timing of thaw and water body size were also important in habitat selection. Specifically, surface-feeders such as pintails appear to benefit from shallower water and greater amounts of emergent vegetation characteristic of impoundments. Shallow water in particular may increase the availability of invertebrates to surface-feeding waterfowl (Murkin and Kadlec 1986). Weller (1990) indicated that maintaining water depths of 15–45 cm would benefit surface-feeding ducks like Northern Pintails because such conditions allow them to swim but still tip up for food.

Oldsquaws were consistently more abundant in natural ponds, despite ponds being available almost one week later than impoundments. This suggests that divers are closely tied to deeper water bodies, probably because they tend to nest closer to water than dabbling ducks and thus require wetlands with more stable water levels (Kaminski and Weller 1992). Payne (1992) has suggested that water depth for diving ducks should average 90–120 cm and should be deeper than for sur-

face-feeding ducks (Payne 1992). Hudson (1983) and Uresk and Severson (1988) recommended that maximum impoundment depth for divers should not exceed 1 m.

Reasons for patterns of water body use by eiders were less clear. The distribution of eiders in the oil field appeared to be more restricted than that of other species. King Eiders in particular showed a preference for natural ponds in the vicinity of DS7, where they were often observed diving.

### Waterbird Activity Budgets

Foraging times of waterbirds were similar on impoundments and natural ponds. Considering that invertebrate productivity averaged higher in measured impoundments than ponds (Kertell and Howard 1992, this study), foraging times are probably a fair indication that feeding success (number of prey caught per foraging bout) was also comparable between the two water body types. Because birds are wide-ranging vertebrates that link water bodies spatially by responding to differences in invertebrate abundance (Weller 1988), we would expect individual birds to exploit a number of water bodies but forage longer on those water bodies with the most food. Both Tufted (*Aythya fuligula*) and Ruddy (*Oxyura jamaicensis*) ducks stay on one food patch and deplete it before moving on to look for a new patch, and return to previously profitable patches more often than would be expected by chance (Tome 1988, Giles 1990). Feeding success (chironomids caught per dive) and foraging effort of young Tufted Ducks increased with increasing prey density (Giles 1990), and Kaminski and Prince (1981) found that foraging effort by dabblers was positively correlated with frequency of prey encounter. Impoundments, then, increase the number of potentially profitable foraging patches for waterfowl.

Although we did not measure water depths in 1992, more time spent diving in ponds by Pacific Loons and King Eiders and greater dive lengths by Oldsquaws and Pacific Loons in ponds were probably a function of deeper water in ponds versus impoundments. At Point Storkersen, diving was the preferred method of foraging by Oldsquaws in all but the shallowest water bodies (Bergman et al. 1977). Taylor (1986) found that Oldsquaw dive length at West Long Lake was positively correlated with water depth. For breeding Oldsquaws in West Greenland, dive duration increased with water depth (Reynolds 1987).

## Reproductive Biology of Pacific Loons

### Selection of Nest Site

Nest pond requirements of the Common Loon (*Gavia immer*) include (1) clear water for easy prey visibility, (2) adequate nest sites, (3) isolation from conspecifics, (4) protection from wave action, (5) abundant aquatic vegetation, and (6) adequate food for two young for at least two weeks (McIntyre 1983). Many of these requirements may apply equally to the Pacific Loon.

At Prudhoe Bay, Bergman and Derksen (1977) found that Pacific Loons preferred small, shallow ponds with emergent *Arctophila* and *Carex* over large, deep lakes with abrupt shores. Small, shallow water bodies with emergent vegetation contain abundant invertebrates (Bergman et al. 1977, Kertell and Howard 1992), and nest and foraging sites that are protected from wind and wave action. At McConnell River, N.W.T., average depth of 19 Pacific Loon ponds was only 52 cm (range 30–90) (Davis 1972). Pacific Loon nests located on large ponds (those protected poorly from wave action) at McConnell River were always on the lee side of points or islands (Davis 1972).

Loons selected fewer large ponds than large impoundments (water bodies greater than 10 ha in size) for nesting at Prudhoe Bay. Thus, differences in reproductive ecology may result to some extent from differences in surface area. However, the fact that large natural ponds were not commonly selected as nest sites suggests that large ponds were less suitable for nesting than large impoundments. Other studies of Pacific Loons nesting on natural ponds support this finding. For example, Pacific Loons at Point Storkersen (Bergman and Derksen 1977) selected natural ponds that were almost identical in size (3.0 ha) to those natural ponds selected in this study (2.97 ha); and at McConnell River, N.W.T. (Davis 1972), mean size of 46 nest ponds was 2.22 ha (range 0.23 to 9.54). Because large natural ponds are deeper, have more abrupt shorelines, and contain less emergent vegetation than large impoundments, they may provide fewer nest sites protected from wave action. Small impoundments, on the other hand, may be less suitable for nesting than similarly sized ponds because impoundments are shallower and more likely to expose nests to predation as they dry.

Despite the earlier availability of impoundments compared with ponds, Pacific Loons initiated nests on approximately the same date in both water body types.

According to Davis (1972), Pacific Loons may select breeding territories during late summer of the previous breeding season. Because water levels in late summer are often lower than those in early summer, particularly in impoundments, loons that select territories and nest sites on impoundments in late summer apparently must wait for spring water levels to stabilize before conditions are right for nesting on them.

### Factors Influencing Foraging Behavior

There was high interpair variation in number of foraging bouts, average length of complete bouts, total time spent foraging, and prey delivery rates at ponds and impoundments. A variety of factors may have contributed to this variability. Because we were testing a number of data collection techniques, differences were to some extent due to small sample sizes. Additional sources of variation include age and reproductive experience of adults, and differences in prey availability, prey choice, and foraging efficiency (due to physical differences such as surface area, water depth, and substrate type) among individual water bodies. Nevertheless, the fact that high interpair variation was characteristic of both natural ponds and impoundments suggests that loon pairs are probably affected by the same physical and biological factors at both water body types.

Prey delivery rates were generally greater for pairs on impoundments, suggesting that prey densities also were greater on impoundments compared with ponds. However, we lack information on prey choice and profitability, and how they influence foraging rates. Although chironomids, plecopterans, and trichopterans were most abundant in impoundments (Kertell and Howard 1992, this study), loons also feed their young zooplankton (Davis 1972, Bergman and Derksen 1977), which often occur in dense concentrations (Butler et al. 1980). Foraging rate should vary not only with food availability but also with quality of food and prey size (Hutto 1990).

Despite lack of data on food selection, our study shows that loons successfully capture prey in both ponds and impoundments despite any differences that might exist in substrate type between the two water body types. Particulate composition and organic content of the sediments are correlated with distribution and abundance of certain invertebrates (Wetzel 1983); however, even if benthic habitats in impoundments contain higher levels of peat and drowned vegetation than benthic habitats in ponds, these differences do not

appear to have influenced foraging efficiency.

#### **Factors Influencing Hatching Success**

Possible reasons for lower hatching success on impoundments than ponds include (1) differences in nest site choice, (2) greater fluctuations in water level, and (3) more frequent human disturbance. Nests on impoundments were more commonly located on mainland shorelines than nests on ponds. Throughout their range in North America, Pacific Loons prefer to nest on islands (Davis 1972, Bergman and Derksen 1977), which are visited by foxes less frequently than mainland nests (Petersen 1979). On the Yukon-Kuskokwim River Delta in western Alaska, foxes were primarily responsible for destruction of mainland nests, while avian predators caused most of the destruction of island nests (Petersen 1979). Arctic foxes were common in the Prudhoe Bay oil field in 1992 (pers. obs.).

Changes in water level affected nest success in our study and were a common cause of loon nest failures elsewhere. For Common Loons, Barr (1986) found that 33% more clutches hatched successfully in territories with water-level fluctuations less than 1.5 m, and Belant and Anderson (1991a) reported nest failure when receding water levels increased the distance of the nest to water by 3 m. Loon nests away from shorelines on land may be inaccessible to loons or more difficult to defend against predators (Gotmark et al. 1989). In a northern Wisconsin impoundment, a 20-cm water-level decline did not affect nest success, but a 12-cm water-level increase accounted for the flooding of four Common Loon nests (Belant and Anderson 1991a). Rising water levels led also to the desertion of Arctic Loon (*Gavia arctica*) nests in northern Sweden (Gotmark et al. 1989). Although Murphy et al. (1989) reported two Canada Goose (*Branta canadensis*) nests that were flooded by rising water in an impoundment at Prudhoe Bay, no instances of loon nest loss due to rising water were noted during this study. Belant and Anderson (1991b) concluded that annual water-level variations in impoundments should be minimized during brood rearing to allow reuse of optimal brood areas and minimize site loss.

Many of the impoundments we studied were located adjacent to pads where human activity is concentrated and nest locations are sometimes known to workers. Although we did not observe adult loons being forced off their nests as a result of human activity, temporary abandonment of nests may result in increased opportunities for predation by foxes or gulls,

which were common near pads in 1992.

#### **Factors Influencing Mortality of Young**

Loss of young loons was not observed during this study. Some of the chick losses may have been due to starvation of the youngest chick in the brood. Davis (1972) and Bergman and Derksen (1977) found that the youngest chick often died within two weeks of hatch due to competition for food with its older sibling.

Bergman and Derksen (1977) suggested that overland dispersal from the nest water body leaves young vulnerable to predation. However, mortality of young was lower for pairs nesting on ponds despite more loon families moving from ponds to adjacent water bodies.

Glaucous Gulls prey heavily on chicks of other birds (Johnson and Herter 1989, Barry and Barry 1990). In northwest Canada, the Glaucous Gull was the only predator species seen taking Red-throated Loon chicks; only chicks <10 days old were taken (Dickson 1993). Greatest loss of young Red-throated Loons occurred in a year when there was a significantly large number of Glaucous Gull chicks in the study area (Dickson 1992). Although predation by Glaucous Gulls was not witnessed in 1992 at Prudhoe Bay, gulls were often observed at pads, and a pair fledged three young on an impoundment with two loon families.

#### **Factors Influencing Dispersal**

In a study at McConnell River, N.W.T., Davis (1972) found that Pacific Loons with small territories were less successful than those with large territories and hypothesized that nest ponds were selected primarily for their food value. The average size of 35 territories in the McConnell River area was 3.66 ha, considerably larger than the average size (2.22 ha) of nest ponds there (Davis 1972). Consequently, 20 of the territories (57.1%) included more than one pond, and birds that nested on small ponds often moved to nearby ponds to feed. Although territory sizes were not determined for birds at Prudhoe Bay, pairs that nested on ponds (which averaged much smaller in size than impoundments) used nearby water bodies to a greater extent than pairs that nested on impoundments. Apparently, these birds expanded their territories in response to a need for more food.

#### **Comparative Habitat Quality of Ponds and Impoundments**

Pacific Loons readily nest and raise young on both impoundments and ponds, indicating that both water

body types meet their nest-site requirements. However, a problem confounding studies of loons and other large waterbirds is that, because they are long-lived, they may return year after year to the same breeding area regardless of prior reproductive success (Alvo 1986, Strong 1990). Consequently, for Red-throated and Common loons, survival of young to fledging is considered as perhaps the best indicator of local short-term environmental conditions (Strong 1990, Dickson 1992). According to Strong (1990), nearly fledged young indicate suitable nesting habitat, adequate food supply, and acceptable levels of human disturbance throughout the nesting period.

This study ended in early August when young Pacific Loons were approximately 7–21 days old ( $X = \sim 15$  days at both ponds and impoundments); fledging occurs 43–53 days after hatch (Parmelee et al. 1967). As indicated earlier, number of young per nesting pair averaged 0.63 for ponds and 0.41 for impoundments at this time. Nilsson (1977) determined that the Arctic Loon in Sweden would need to produce 0.4–0.5 fledged young per nesting pair per year to maintain its population level. Thus, to more accurately assess habitat “quality”, future studies of Pacific Loons in arctic Alaska should include observations of nearly fledged young.

## CONCLUSIONS

Results show that the impoundments we studied in 1991 and 1992 contain abundant emergent vegetation and a well-developed invertebrate community with a variety of invertebrates important to waterbirds. Although there was high variability among individual ponds and impoundments, impoundments on average contained higher biomasses of chironomids and oligochaetes and higher numbers of plecopterans, trichopterans, and gastropods than natural ponds of similar size. We suggest that ongoing thermokarst and

subsidence, acting in association with seasonal water-level drawdowns, may be responsible for continued nutrient release and relatively high invertebrate productivity in some impoundments 10–20 years after their initial creation.

More ducks were observed on the impoundments than on the natural ponds, and although there were differences in methods of foraging, ducks and Pacific Loons foraged similar lengths of time on impoundments and ponds. However, individual species and guilds varied in the extent to which they responded to impoundment productivity, likely as a result of impoundment sizes, water regimes, or habitat characteristics (e.g., amount of emergent vegetation). Compared with ponds, shallower water and more emergent vegetation in impoundments appear to have encouraged greater use by surface-feeders relative to divers, and changes in water level apparently led to lower reproductive success for Pacific Loons.

Studies explaining how waterbirds respond to different wetland habitats and mitigation techniques have been numerous and reflect a current public interest in wetlands. A major conclusion of waterbird studies is that, because waterbird species vary in the extent to which they respond to different wetlands and wetland habitats, modification of wetland habitats may benefit some species at the expense of others. At Prudhoe Bay, wetland modification designed to increase use of impoundments by divers (e.g., maintaining stable water levels) may negatively impact populations of surface-feeders and possibly result in a decline in overall invertebrate production. Therefore, if management of impoundments at Prudhoe Bay is considered desirable to increase populations of certain species, objectives should be clearly stated and potential impacts to other species understood before mitigation strategies are implemented.

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## Appendices

Additional figures and tables are provided in the following appendices to support the information contained in the body of this report.

- Appendix A. Water bodies used for studies of waterbird use (Sites 15–19) and loon biology (Sites 20–22) in 1992, Prudhoe Bay, Alaska.
- Appendix B. Water bodies used for studies of waterbird use (Site 20) and loon biology (Sites 24, 25, 33, 34, 37) in 1992, Prudhoe Bay, Alaska.
- Appendix C. Water bodies used for studies of invertebrate production (Sites 1–4), waterbird use (Sites 21–30), and loon biology (Sites 27–32, 35, 44, 47) in 1992, Prudhoe Bay, Alaska.
- Appendix D. Water bodies used for studies of waterbird use (Sites 1,2) and loon biology (Sites 1–4, 17–19, 23, 26, 38, 42, 43, 46) in 1992, Prudhoe Bay, Alaska.
- Appendix E. Water bodies used for studies of invertebrate production (Sites 5, 6), waterbird use (Sites 9, 11–14), and loon biology (Sites 13–15, 36, 39, 41) in 1992, Prudhoe Bay, Alaska.
- Appendix F. Water bodies used for studies of waterbird use (Sites 3,4) and loon biology (Sites 2, 3, 5–7, 43) in 1992, Prudhoe Bay, Alaska.
- Appendix G. Water bodies used for studies of invertebrate production (Sites 7, 8), waterbird use (Sites 5–8, 10), and loon biology (Sites 8–15, 40, 45) in 1992, Prudhoe Bay, Alaska.
- Appendix H. Numbers of invertebrates in samples during June 1992, Prudhoe Bay, Alaska.
- Appendix I. Numbers of invertebrates in samples during July 1992, Prudhoe Bay, Alaska.
- Appendix J. Numbers of invertebrates in samples during August 1992, Prudhoe Bay, Alaska.
- Appendix K. Wetland classifications for water bodies used to determine bird abundance in 1992, Prudhoe Bay, Alaska.
- Appendix L. Water body characteristics, nest phenology, and fate of eggs and young at natural ponds in 1992, Prudhoe Bay, Alaska.
- Appendix M. Water body characteristics, nest phenology, and fate of eggs and young at impoundments in 1992, Prudhoe Bay, Alaska.
- Appendix N. Average number of foraging bouts and average length of complete bouts by Pacific Loon pairs at six natural ponds in 1992, Prudhoe Bay, Alaska.
- Appendix O. Average number of foraging bouts and average length of complete bouts by Pacific Loon pairs at six impoundments in 1992, Prudhoe Bay, Alaska.
- Appendix P. Foraging time, prey delivery rates, and estimated total prey deliveries by Pacific Loon pairs at six natural ponds in 1992, Prudhoe Bay, Alaska.
- Appendix Q. Foraging time, prey delivery rates, and estimated total prey deliveries by Pacific Loon pairs at six impoundments in 1992, Prudhoe Bay, Alaska.