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The effect of human activities on migrant shorebirds: successful adaptive management

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SUMMARY

The effect of human disturbance on migrant birds is a conservation issue of international importance, as is determining if disruption has long-term population effects. Disruptions can occur during migration, wintering, breeding and foraging. Thousands of shorebirds migrate through Delaware Bay (Atlantic Coast of North America) in a four-week period each spring; this is the largest concentration of shorebirds in the continental USA. Ecotourists come to see them, creating the potential for disruption. Data available on shorebird/human interactions at a migratory stopover over a 20-year period were used to describe the interactions of shorebirds and people from 1982--2002 and examine trends in human disruptions and shorebird behaviour during this time. The rate of disruptions caused by people increased during the 1980s, declined slightly by the early 1990s, and declined sharply by 2002. The decline in human activity along the beach was directly related to the conservation efforts of the New Jersey Endangered and Nongame Species Program, New Jersey Audubon, and others interested in preserving the shorebirds. In the 1980s, birdwatchers concentrated on the beaches on which it was easy to walk and which had the highest shorebird counts, because there were no restrictions on human behaviour. During this time, the average disturbance duration was over 10 min, regardless of the type of intruder, and shorebirds were often disrupted for over 40 min hr^{-1}. Even though the number of disruptions declined over the study period, the percentage of shorebirds that flew away (and did not return within 10 min) did not change during the 1980s, and increased in 2002. The average time that shorebirds were disrupted per hour by people declined during this period (mainly because there were fewer people on the beaches). The Endangered and Nongame Species Program placed signs on shorebird foraging beaches, restricted access, built viewing platforms to contain ecotourists, and eventually patrolled key beaches and issued summonses for infractions. These activities were so effective that only one bird watcher disturbed the birds in 2002. Education was also vital to encouraging local residents not to walk or fish along these beaches during the spring migratory stopover, and to keep their dogs on a leash. These data support the importance of actions on the part of state agencies and conservation organizations to limit disruptions to foraging shorebirds during critical migratory stopovers, a problem faced by shorebirds in many temperate regions of the world.

Keywords: disruptions, foraging, human disturbance, migrants, shorebirds, stopover, temporal patterns

INTRODUCTION

People in diverse cultures enjoy and appreciate observing wildlife in natural settings, particularly unusual or spectacular concentrations. In the USA, thousands of shorebirds migrate through Delaware Bay during a two-week period each spring (Clark *et al*. 1993; Burger *et al*. 1997). This is the largest concentration of shorebirds in the continental USA; in a critical three-week period in late May–early June, over one million shorebirds migrate through the bay (Senner & Howe 1984; Clark *et al*. 1993). Shorebirds congregate here because of the abundance of horseshoe crab (*Limulus polyphemus*) eggs (Botton *et al*. 1994; Tsipoura & Burger 1999; Botton & Loveland 2000; Piersma & Baker 2000). Although the horseshoe crabs come up on the beach primarily at high tide, the beaches are often littered with spawning horseshoe crabs.

Fifteen species of shorebirds feed on horseshoe crab eggs in the spring, but three species of shorebirds depend more heavily on them than do other species, including red knot *Calidris canutus*, ruddy turnstone *Arenaria interpres*, and sanderling *Calidris alba* (Myers *et al*. 1987; Castro & Myers 1989; Tsipoura & Burger 1999). All the shorebirds that migrate through Delaware Bay have generally shown a decline in abundance over time (A.J. Baker, personal communication 1999; Morrison *et al*. 2001), but knots and turnstones are especially vulnerable because their foraging is more limited to Delaware Bay beaches than is the foraging of the other species (Burger *et al*. 1997). Similar habitat restrictions could occur with these same, or other species, in other migratory stopover areas.

The spectacle of shorebirds and spawning horseshoe crabs draws hundreds of bird watchers to these beaches during the

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spring migratory stopover (Burger *et al*. 1995). The beaches are also vulnerable to the usual beach activities, such as walking, jogging, fishing and dog-walking. The presence of people on beaches where shorebirds congregate in foraging flocks is likely to be disruptive.

There are four key questions with respect to the interactions of shorebirds and people. (1) Does the presence of people result in changes in shorebird behaviour? (2) Has human use of these beaches changed over the period when declines in shorebirds have occurred? (3) Is there reason to believe that human disruptions might have ecological consequences? (4) Has management of the beaches by the Endangered and Nongame Species Program of the State of New Jersey reduced the impact of ecotourists? We addressed these questions by examining data collected in 1982, 1987, 1992 and 2002 on Delaware Bay beaches.

There are social, economic and recreational costs and benefits of ecotourism involving shorebirds along Delaware Bay that extend far beyond the bird watchers and photographers themselves, including restaurants, hotels, gas stations, and birding/photographic equipment, apparel and other paraphernalia (such as books, postcards and flags). Wildlife biologists are interested in both preserving the wildlife resource, in this case migrant shorebirds, and in providing adequate and meaningful wildlife experiences for ecotourists who will presumably contribute to the local economy and to the conservation of these species in the future. Thus, it is advantageous to prevent conflicts, allow birds to forage and enhance the experience for ecotourists. Making information available on the interactions and outcomes between these two groups is important for continued conservation (Kenchington 1989). While potential predators, and competition from laughing gulls *Larus atricilla* (Burger & Gochfeld 1991) also pose a problem for the foraging shorebirds, direct human disruptions and declines in horseshoe crab eggs are the primary conservation issues (Burger & Gochfeld 1991; Burger *et al*. 1995).

The relationship between human disruptions and ecological consequences bears examination because such a relationship is usually only inferred. Gill *et al*. (1996, 2001*a*, *b*) have suggested that response to humans is not equivalent to ecological effects. They used a prey depletion model with godwits *Limosa limosa* to elegantly demonstrate that there was no evidence that human presence affected the prey supply at any spatial scale. These landmark studies are models for our understanding of the potential long-term effects of human disruptions on birds, and bear consideration in the current study. However, the foraging situation on Delaware Bay is different from the usual shorebird tidal mudflat for two key reasons: (1) shorebirds have less time to forage on a migratory stopover when individual birds may be present for only four weeks, as compared to wintering activities, and (2) the intertidal foraging habitat may be linear along the tide line, and is only 1–3 m wide on Delaware Bay. Thus foraging space is the limiting resource, and not prey (although prey could also be limiting).

Management of human/shorebird interactions

Management of the shorebird habitat along Delaware Bay varied markedly during the 20 years of this study. In the early 1980s, there were three groups of users on the beaches, namely horseshoe crab collectors, bird watchers and other people (fishers, walkers and joggers). In 1982, there was no management of the beaches, and there were no restrictions on bird watchers or others along the beaches (except for those implied by the USA/Canadian/Mexican Migratory Bird Treaties). At this time, fisherfolk who walked the beaches to collect the horseshoe crabs as bait for eel and conch also disturbed migrant shorebirds.

While there was unrestricted take of horseshoe crabs during the 1980s, by the early 1990s there were restrictions (crabs could be taken only during the night when shorebirds did not forage). In the late 1990s, the taking of horseshoe crabs from the beaches was forbidden and strictly enforced, and there were other restrictions to reduce the effect of this exploitation on the foraging shorebirds.

When bird watchers first discovered the shorebird spectacle (mid-1980s) and began to increase in numbers, local residents at Reed's Beach complained about them and their cars. In 1989, the state constructed a viewing platform and a parking lot for bird watchers to reduce the disturbance to local residents. By the early 1990s, however, it was clear that bird watchers walking along the beach could present a problem to the foraging shorebirds themselves, and the state instituted restrictions on access to the prime beaches where shorebirds foraged. Bird watchers were restricted to the viewing platforms. By 2002, the final year of this study, bird watchers were restricted to viewing platforms or the edges of beaches, interns patrolled the beaches from behind the dunes to prevent human disruptions and enforcement occurred.

METHODS

We made our observations at Reed's Beach North and South on the New Jersey side of Delaware Bay in 1982, 1987, 1992 and 2002 (Fig. 1). Additional beaches were surveyed in 1982 and 1987 to understand the potential for variation in human and avian use among beaches. Delaware Bay is located between New Jersey and Delaware, and is separated from the Atlantic Ocean by 10 km of upland habitat. Delaware Bay habitat includes sandy beaches, sod banks, and creek and river inlets, backed by tidally-flooded salt marshes (*Spartina alterniflora*). Because of concern for declining shorebird numbers, many of the beaches are closed to human activity during the migratory season, but enforcement is not complete at all beaches.

Disruptions were recorded by type and frequency at Reed's Beach at all times of the day, and at all tide times, during the peak four weeks of shorebird migration. Observations were made on 12–20 days each year, for 6–10 h per day, depending upon the tides. People who came on the beaches

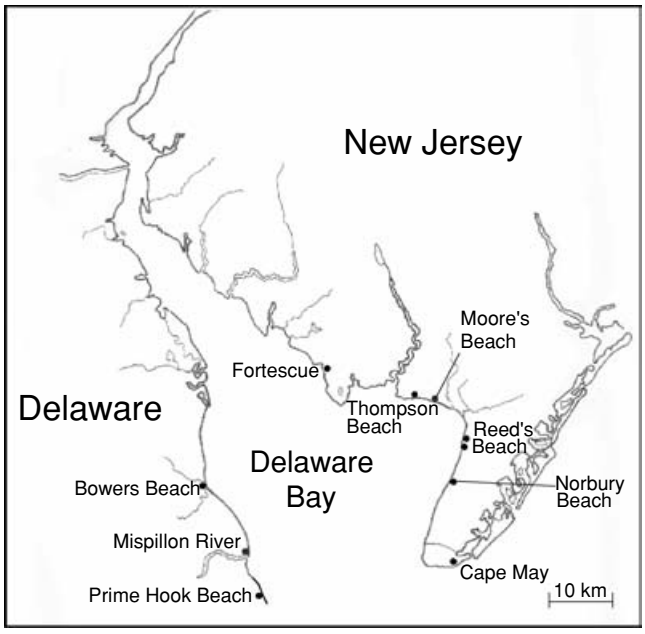

Figure 1 Map of Delaware Bay showing the major beaches where the interactions of shorebirds and people were observed in 1982, 1987–1988 and 2002.

were classified as bird watchers (holding binoculars and looking intently at the birds), walkers, fishers (with poles) and sunbathers. We also recorded the behaviour of the birds: no response (did not fly), flew and returned within 10 min, and flew and did not return within 10 min. In most cases, shorebirds in the last category flew to other beaches or flew over the water as if to cross Delaware Bay to the Delaware side.

Examination of the effect of people on shorebirds is in depth for 1982 (Burger *et al*. 1995) and 2002 (J. Burger, unpublished data 2002). J. Burger and K. Clark (unpublished data) made additional observations in 1987 and 1992. Since the number of bird watchers who walked on the beaches was highest in 1987, some of the information from that year is presented in more detail.

The data were analysed by t tests and χ^2 contingency tables, as appropriate.

RESULTS

The total number of disruptions per hour increased slightly during the 1980s, but had declined sharply by 2002 for Reed's Beach (Table 1, two-tailed $t = 4.5$, $p < 0.001$). In the early 1980s (when the shorebird concentration was first discovered by bird watchers), the percentage of people on the beaches who were bird watchers was small (8 of 428 disruptions). Walking on the beaches was the most common activity. By the late 1980s, bird watchers made up one-third of the people on the beaches (110 of 350 disruptions), but with intense management (Fig. 2, $\chi^2 = 113$, $p < 0.001$) this declined to

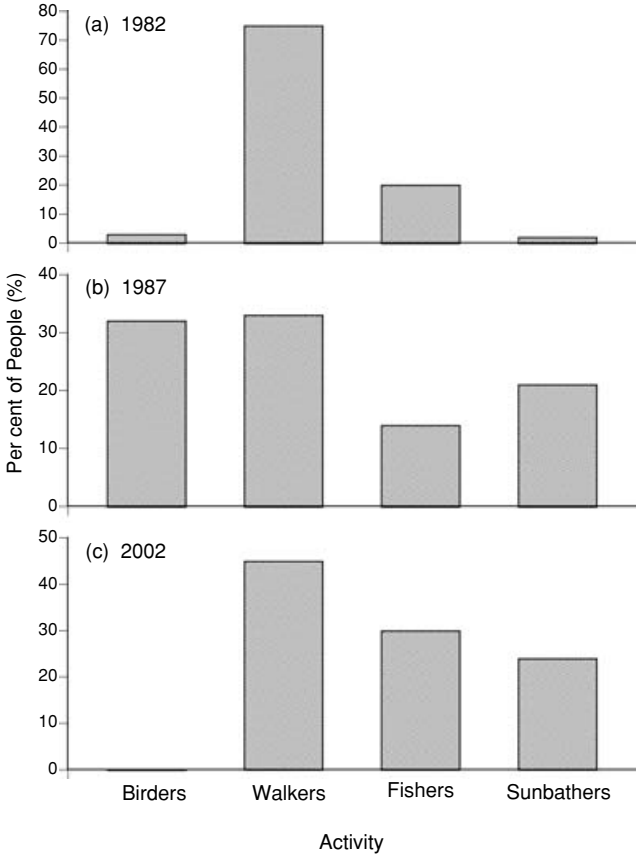

Figure 2 Activities of human intruders on Delaware Bay beaches (Reed's Beach North and South) where shorebirds were foraging in (*a*)1982, (*b*) 1987–1988 and (*c*) 2002.

Table 1 Frequency of shorebird disruptions as a function of management and horseshoe crab harvest.

Year	*Management of bird watchers*	*Horseshoe crab harvest and management*	*Mean disruption rate (hr^{-1})*	*% Bird watchers disrupting birds*	*Mean time disturbed ($min\ hr^{-1}$)*
1982	None	Unlimited take	4.7	2	32.9
1987	Restrictive signs, no enforcement	Unlimited take	5.6	30	53.0
1992	Viewing platform on Reed's Beach, no restrictions	Unlimited take, restrictions on timing of take	4.5	44	42.0
2002	Signs, viewing platform on Reed's Beach, enforcement, patrols	No harvest	0.4	0	3.6

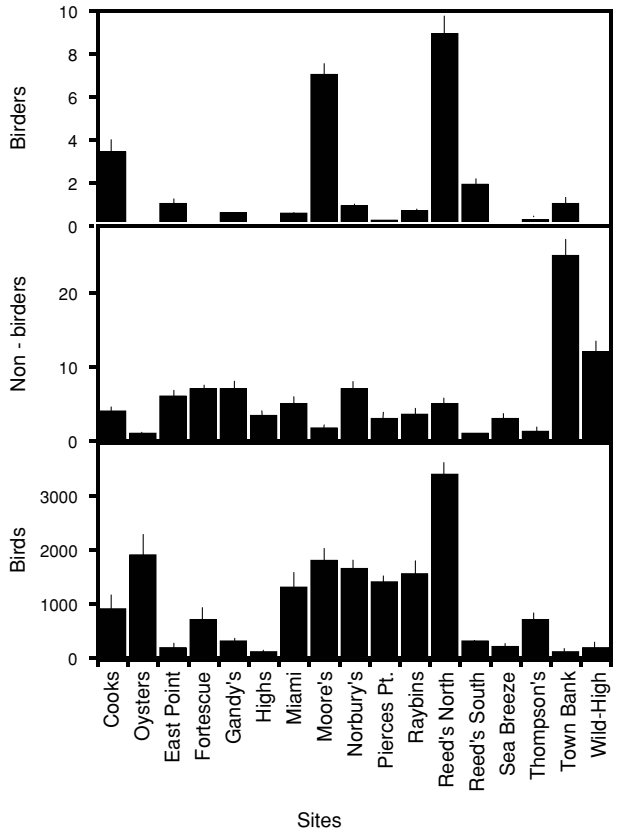

Figure 3 Total number of bird watchers and non-bird watchers on 17 Delaware Bay beaches in 1987–1988, along with peak shorebird counts.

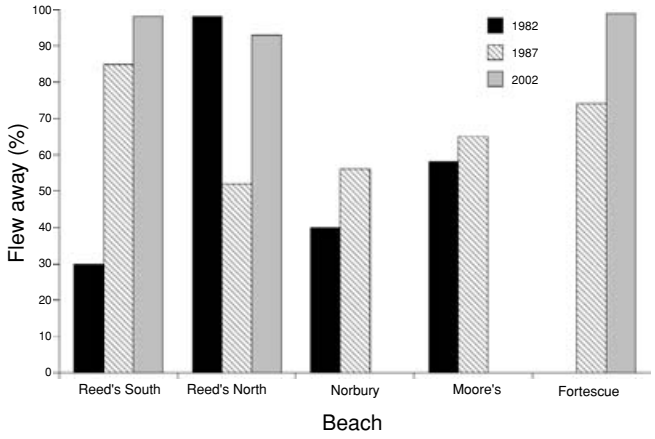

Figure 4 Percentage of shorebirds that flew away in response to human intrusions by year and beach.

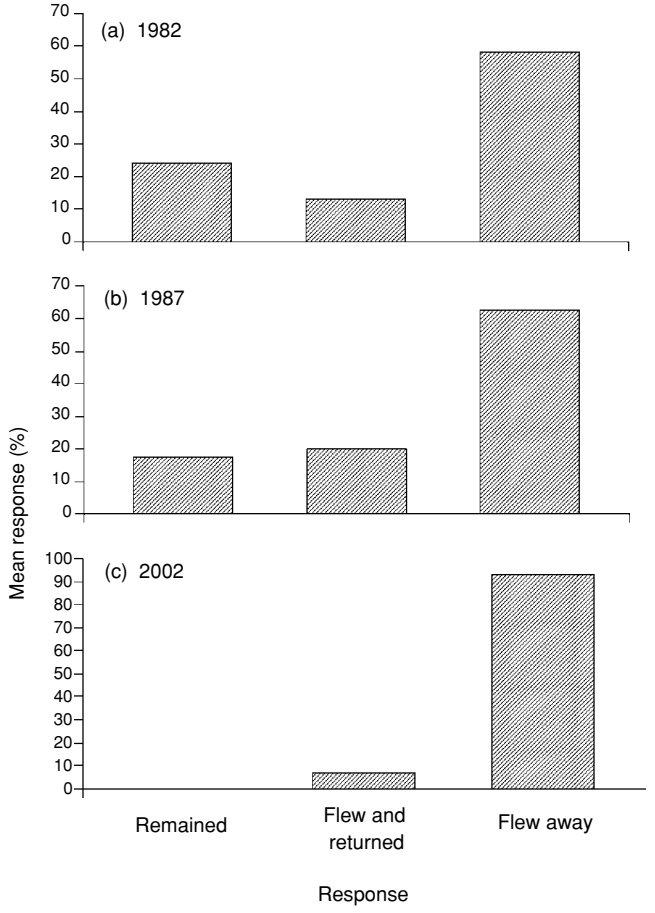

Figure 5 Mean response of shorebirds to human disruptions on Reed's Beach, Delaware Bay, in (*a*) 1982, (*b*) 1987–1988 and (*c*) 2002.

one person in 2002 (1 of 49 disruptions). Bird watchers were a significantly higher proportion of the disruptions in 1987 and 1992 than in 1982 and 2002 ($\chi^2 = 158$, $p < 0.0001$). Dogs (alone or with people), which mimic a fox or coyote predator, were present in all years, and in 2002 they constituted over 15% of disruptions.

In 1987, both the number of intruders and the types of intruders varied by beach (Fig. 3). Bird watchers concentrated on Cooks, Moore's and Reed's Beach North, which were easy to access and did not require a long walk. The potential for disruption varied among the beaches, and was not always correlated with shorebird activity (Fig. 3).

Shorebirds responded to the intrusions by remaining (continuing to forage), by flying but returning within 10 min, or by flying away and not returning. The percentage of shorebirds that flew away varied by beach (Fig. 4, $\chi^2 = 6.3$, $p < 0.016$) and year (Fig. 5, $\chi^2 = 7.5$, $p < 0.01$). For example, on Reed's Beach South the percentage that flew away increased each year, but on Reed's Beach North the percentage decreased in 1987. When Reed's Beach North and South are considered together, a higher percentage of birds flew away when exposed to a human disturbance in 2002 than did so in the earlier years. This suggests that the birds are not adapting to the presence of people by habituation. The total time per hour that foraging shorebirds were disrupted by the activities of people increased from 1982 to 1987, but declined in 2002 ($t = 6.37$, $p < 0.001$) (Table 1).

DISCUSSION

This study indicates that: (1) the rate of disruption caused by people increased during the 1980s, declined slightly by the early 1990s, and declined sharply by 2002; (2) the number of bird watchers disturbing the birds decreased to one by 2002; (3) in the 1980s, bird watchers tended to concentrate on the beaches that were easy to walk to and had the highest shorebird counts; (4) in the 1980s, the average disruption was over 10 min, regardless of the type of intruder, and shorebirds were often disturbed for over 40 min hr^{-1}; and (5) the percentage of shorebirds that flew away (and did not return within 10 min) remained the same during the 1980s, but increased in 2002.

The decrease in the rate of occurrence of people on the Delaware Bay beaches is a direct result of management by the Endangered and Nongame Program of the State of New Jersey. When the number of bird watchers began to increase in the mid-1980s, partly because of increased publicity in birding magazines, the Program placed signs on shorebird foraging beaches, restricted access, built viewing platforms to contain ecotourists, and eventually patrolled key beaches and issued summonses for infractions. The New Jersey Audubon Society also implemented an extensive educational programme aimed at bird watchers, reinforcing the importance of not disturbing foraging shorebirds during migration. Education was also vital to encouraging local residents not to walk or fish along these beaches during the spring migratory stopover, and to keep their dogs on a leash. These restrictions have not been followed all the time, as some residents (and others) still allow their dogs free access to the beaches. While previous studies on Delaware Bay have indicated that dogs can be an important disturbance (Burger 1986; Burger *et al.* 1995), work in 2002 indicated that they are currently the prime and most important factor disturbing the shorebirds at protected beaches along Delaware Bay (J. Burger, unpublished data 2002).

While the number of disruptions caused by people declined from the 1980s to 2002, the number of bird watchers walking on the beaches declined to one, largely because of educational programmes, signage and viewing platforms, and peer pressure. The number of bird watchers on the beaches in 1982 was low; this was before bird watchers learned of the major concentrations of shorebirds on the Bay. The numbers of bird watchers increased in the mid-1980s because of an abundance of popular accounts (Dunne *et al.* 1982; Myers 1986, 1989). The increase in bird watcher numbers was followed by restrictions on their use of the beaches by the Endangered and Nongame Species Program.

The decline in migrant shorebirds using Delaware Bay then received considerable attention in the popular press and in birding magazines. The combination of viewing platforms, education and enforcement curbed the behaviour of bird watchers, especially on beaches that are patrolled. Bird watchers still congregate at the beaches with the largest concentrations of shorebirds, where the likelihood of an 'unusual' or 'rare' bird is highest, but they remain off the beaches themselves and view the birds through binoculars.

With the elimination of crab pickers from the beach and intertidal waters, and the severe reduction in disruptions by bird watchers, the shorebirds were disrupted for far less time (less than 5 min hr^{-1}, compared to over 50 min hr^{-1} in the mid-1980s). This allowed shorebirds to spend more time foraging actively. Since many of the species nearly double their weight in the two–three weeks they spend on Delaware Bay (Castro & Myers 1989; Tsipoura & Burger 1999) during good food years, any reduction in the available time for foraging could be severe. There is controversy surrounding the ability of these shorebirds to double their weight; data from the Endangered and Nongame Program suggest that some species of shorebirds are no longer doubling their weight in the allotted stopover time (L. Niles, unpublished data 2004).

The effect of intruders including humans and dogs on the beaches can be disruptive, especially when human activity is intense, or people are on the beaches for long periods of time. The percentage of birds flying away completely in response to human activity remained the same during the 1980s, and increased in 2002, indicating that the birds were not habituating. Birds were disturbed for less total time in 2002 compared to the 1980s.

CONCLUSIONS

The data from this study clearly show that there is a relationship between human activity on Reed's Beach and shorebird foraging. Birds flew away and did not return to forage in response to 58% or more of the human disruptions. The studies of Gill and colleagues on godwits (Gill *et al.* 2001*a*; Smart & Gill 2003) have suggested that such human disturbances might not have long-term ecological consequences. These elegant studies rather convincingly showed that for wintering godwits, human disturbance did not alter their access to prey, as shown by prey-depletion models. The case with migrant shorebirds that forage on a limited area around high tide (in the case of Delaware Bay, a horizontal range of only 1–3 m) may differ somewhat from this. We suggest that when migrant shorebirds have a limited period of time at a stopover place, with limited foraging space, behavioural disruptions during foraging have consequences in terms of needed weight gain.

The management implications are clear. Shorebird foraging is disrupted by the presence of people and dogs on their foraging beaches, and they respond by flying away. When there were no restrictions (in the 1980s), the birds were disturbed for over half of the time. When there were disruptions on all beaches, the shorebirds often returned to the same beaches. When most beaches were protected (2002), the shorebirds had nearby beaches to move to when they were disrupted. The management of the beaches by the Endangered and Nongame Species Program has been effective in removing the vast majority of disruptions from the beaches on the New Jersey side of Delaware Bay. Horseshoe crab eggs make up 50–90% of the diet of all the migrant shorebirds on Delaware

Bay (Tsipoura & Burger 1999). Since there is a decline in the availability of eggs for foraging shorebirds (Botton & Loveland 2000), it is desirable to reduce human activity as much as possible so that the birds can have sufficient uninterrupted time to obtain enough horseshoe crab eggs to gain sufficient weight for their northward migration and subsequent breeding in the Arctic. There is currently some evidence that some shorebirds are leaving Delaware Bay without gaining as much weight as they did in the 1990s (A.J. Baker, personal communication 1999; L. Niles, unpublished data 2004). If this proves to be the case, then human disturbance may be a prime cause for concern.

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