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Effects of Off-Road Vehicles On Beaches: A Literature Review

Supplemental Report to the Compatibility Determination for Fishing at Parker River National Wildlife Refuge

In August of 2022, Parker River National Wildlife Refuge (NWR) renewed its expired Compatibility Determination (CD) for Fishing, which discontinued recreational use of off-road vehicles (ORV) as a means to access the beach for fishing. The impacts of ORVs are discussed below to document the considerations that shaped this decision.

While use of ORVs has a long history at the refuge, erosion and beach width narrowing have accelerated since 2011. Such conditions contribute to (1) disturbance of migratory shorebird populations already in steep decline, (2) resource damage in the form of increased erosion rates, (3) safety risks to ORV users and their property, and (4) additional strains on staff resources to manage and monitor an increasingly complex program.

For some perspective, below is a brief timeline of the refuge's management of the ORV fishing program:

- Pre-2000: All beaches managed by the refuge and Sandy Point State Reservation at the south end are open to ORV fishing from approximately July through October each year.
- 2000: Sandy Point State Reservation, at the refuge's south boundary, terminates ORV use on their beaches. The 6.2 mile stretch of refuge beach remains open to ORV fishing, with over 200 permits issued annually.
- Beginning in 2011, unsafe access conditions, erosion, and beach width narrowing forces permanent closure of the southern ORV beach access point (Beach Buggy 2, or BB2).
    - Lottery permits are capped at 85 due to limited beach frontage.
    - The ORV season is reduced to 2 months (September and October), which continued through 2021.
- 2017-2018: Severe erosion nearly cancels the ORV seasons, but late-season accretion allowed for a limited number of permits (25).
- 2017-2021: Depending on year, between 25-70 permits are issued, and only 0.9-3.6 miles of beach are open to ORVs due to erosion, unsafe driving conditions, and dwindling shorebird habitat (i.e., less available space for migratory birds to share the beach with ORVs).
- 2021: Flooding of the BB1 access trail and erosion of the beach front prompts

ORV closure for 2 weeks in September as multiple vehicles required towing assistance. Staff observed resource damage of the access trail within the cranberry bog wetland.
- 2022: Due to the complications listed above and overwhelming research indicating migratory shorebird population declines, the refuge discontinued the ORV fishing program.

The ORV trail at BB1 travels adjacent to a sensitive cranberry bog and through the dunes, culminating in a steep rise over the dune to the beach (Figure 1). Flooding of BB1 has increased, with nearly 2 feet of standing water during the 2021 ORV season due to rain events. Such flooding poses safety risks to users and deterioration of sensitive wetland habitat as vehicles attempt to drive around flooded areas, thus impacting a much wider swath of habitat. In the past 2 years alone, at least 4 vehicles are known to have become stuck in this corridor alone, requiring towing assistance and response by refuge and municipal law enforcement officers.

a. b.

Figure 1. Photos from September 2021 showing ORV access challenges at the (a) BB1 access trail with over 1 foot of standing water in a sensitive cranberry bog and (b) 100 yards south of where BB1 enters the beach. While the locations pictured above are constantly changing and not always flooded, based on field observations and current research, such conditions will continue to intensify, creating adverse effects to migrating shorebirds, resource damage to the refuge, and safety risks to ORV users.

Adverse effects of ORV use on beaches are prevalent both in the near and long-term. Below is a summary of some such effects derived from the literature.

Impact to Migratory Birds:

Mengak et al. (2019) found that there are 12 significant disturbance types occurring on beaches during southward migration in the Northeast Region (Maine to Virginia). These disturbances were determined to be significant (in terms of frequency, extent, and/or effect on shorebird survival and behavior) by 50 shorebird researchers, biologists and/or managers, who also ranked them. Importantly, beach driving was ranked as the number one disturbance type affecting southward migrating shorebirds. In order of significance from highest to lowest rank, the remaining disturbance types after beach driving were dogs, direct harassment, beach raking, coastal engineering, general beachgoing, events, recreational fishing, motorized watersports, commercial fishing, unmanned aircraft, and wind-powered aircraft (Mengak and Dayer, 2020).

Off-road vehicles cause both direct and indirect disturbance to migratory birds. While some studies have found that birds respond the same (Harrington and Drilling 1996) or even less to vehicles (Klein 1993) when compared to pedestrians, Harrington and Drilling (1996) found that roosting Semipalmated Sandpipers responded significantly more to vehicles than to pedestrians on sandy beaches in the fall. Similarly, on Cape Cod, Blodget (1978) found that ORVs caused the most disturbance to roosting shorebirds in the upper beach. This may be explained by the fact that ORVs typically travel on the upper beach, the preferred roosting zone for most shorebirds, at dawn, dusk, and night hours, when shorebirds are most likely to be roosting. At the refuge, ORVs allow anglers to access more remote areas (e.g., north of lot 3) that would otherwise have low public use and thus low disturbance rates. Further, ORV users tend to remain on the beach for longer periods than pedestrians – particularly during the critical nighttime hours, when shorebirds require undisturbed roosting habitat – as the vehicle provides for additional gear, comforts, relief from the elements, and enhanced access.

Several other studies have shown reduced numbers of migrating shorebirds in response to vehicle traffic on beaches. Pfister et al. (1992) documented that vehicle presence caused Semipalmated Sandpipers and Sanderlings to alter their distribution on Plymouth Beach, Massachusetts; along with long-term declines in abundance of Short-billed Dowitchers and Red Knots that exceeded declines at comparable, less disturbed sites.

Beach driving may displace shorebirds from important habitats. One study found that ORV use reduced the proportion of shorebirds using wet sand areas on the beach (Tarr et al. 2010). This study also showed effects of disturbance over multiple sampling intervals, suggesting that shorebirds did not quickly revert to their prior activities or locations after moving away from ORVs. A study by Forgues (2010) demonstrated that with increasing distance from the beach ORV entry point, vehicle abundance decreased while shorebird abundance and richness increased. The author also found that species richness and abundance of some species (Sanderlings, Ruddy Turnstones, Willets, Black-bellied Plovers, Whimbrels) significantly declined with higher ORV frequency as did the number and size of shorebird roosts (*paragraph from:* Mengak et al., 2019, p.10).

Further, beach driving causes behavioral changes in shorebirds. Forgues (2010) found that migrants spent less time foraging and more time resting when ORVs were present. In another study, beach driving primarily affected the use of beach habitats for resting, with birds spending more time active and less time resting (Tarr et al. 2010). Tarr (2008) found that transient individuals (those who did not defend feeding territories) spent less time in the disturbed areas (i.e., where driving was present) while territorial birds tolerated the disturbance and defended their feeding territories. One study conducted in Australia found that evasive behaviors by drivers (e.g., avoiding flocks or slowing down when approaching flocks) had no affect; birds were disturbed at the same rates when vehicles took no action (Weston et al. 2014b). Another study conducted in Australia noted that increasing the separation distance between vehicles and birds was more important to reducing disturbance responses than changing vehicle speed (Schlacher et al. 2013, *paragraph from:* Mengak et al., 2019, p. 11).

The federally threatened Rufa Red Knot – listed since the last fishing Compatibility Determination (CD) was approved – uses the refuge during spring and fall migration, with peak counts occurring from mid-September to late October (USFWS 2012, ebird data). Because Red Knot use peaks during the ORV season, extra care needs to be taken, as additional stressors to this imperiled species could hinder recovery.

Coastal Massachusetts is one of the few stopover locations for Red Knots during the fall migration and Plum Island is one of the top five sites within Massachusetts. While Red Knots do not consistently use Plum Island from year to year in high numbers, the species' life history indicates that protecting flocks from human disturbance when knots are present is critical to their recovery. When combined with other factors (e.g., algal blooms, oil spills, wind energy), human disturbance, from ORVs and otherwise, exacerbates the primary threats and further reduces the subspecies' resiliency.

In addition to direct disturbance of migratory birds described above, ORVs cause negative indirect effects, through changes in beach morphology and reductions in prey (invertebrate) abundance. ORV use has been shown to directly reduce macroinvertebrate density and diversity (Schlacher et al. 2008). Steinback et al (2005) found that ORVs reduced invertebrate diversity within the wrack line (organic debris left by high tides) and reduced the amount of wrack on beaches. While species of invertebrates responded differently, their overall abundance is significantly lower on beaches with ORV use.

Much of beach life is concentrated in and around the wrack line. Bacteria, which play a vital role in breaking down organic matter, are 1,000 times more abundant in the wrack than on bare sand, but Godfrey and Godfrey (1980) found that ORVs reduced the number of bacteria present, by 50 percent, and the number of diatoms in the sand by 90 percent.

We believe the negative impacts to the wrack, and associated loss of invertebrate diversity and abundance, and loss of cover for roosting, is the greatest indirect ORV impact to shorebirds at Parker River NWR. Refuge stipulations in the 1994 and 2005 CDs stated that ORVs are not to drive over wrack, wet sand or on the toe of the dunes. However, the narrowing of the beach in recent years has made compliance impossible on many sections of the beach. As a result, ORV users typically drive over the wrack, resulting in the negative consequences listed above.

ORV use may also have adverse effects to nesting shorebirds. Although most direct effects are avoided with seasonal closures, indirect effects can occur from the resulting narrower beach and steeper foredunes, as described above. Such conditions limit available nesting habitat for Piping Plovers and Least Terns. This not only reduces carrying capacity, but also reduces productivity as birds are forced to nest on the upper beach or near the crest of the beach where they are more susceptible to flooding tides. In contrast, when beaches have a gently sloping, vegetated foredune, birds will often nest on the face or top of the dune. This slight increase in elevation and distance from the high tide reduces nest loss to flooding; the vegetation conceals the nests and chicks from potential predators; and offers shade during extreme heat.

The refuge beach is an important habitat for both breeding and migrating shorebirds. The Northern Atlantic Shorebird Plan identified protection of food resources and minimizing human disturbance as high priority management objectives (Clark and Niles 2003). By disturbing shorebirds from foraging and roosting, and by adversely affecting food resources, ORVs can cumulatively contribute to lower-weight shorebirds migrating from the Refuge; and lower-weight shorebirds are less likely to successfully complete their long-distance migrations (Harrington and Drilling 1996).

Impacts to the Dunes and associated Vegetation:

Numerous studies have shown that ORVs compact and dry out sand and reduce vegetation on the beach front (Anders and Leatherman 1987, Godfrey, Leatherman, and Buckley 1980, Godfrey and Godfrey 1980). Vehicle passes break up the (salt) crust, increase surface roughness, and move sand downslope (towards the ocean), making the beach more susceptible to erosion by wind and tides (Godfrey and Godfrey 1980, Anders and Leatherman 1987). ORV use also breaks up wrack detritus and destroys plant propagules, preventing vegetation that would stabilize and grow the dunes. The cumulative impact of ORVs can lead to loss of vegetation and halting of forward beach migration, resulting in an abrupt rather than sloping dune base; both of which leave the dune more susceptible to wave energy and erosion.

Godfrey and Godfrey (1980) reported that 50 passes of a vehicle are sufficient to stop the seaward growth of the foredune completely, leading to a scarped rather than sloping dune front. Beach grass rhizomes can grow more than 2 centimeters per day, accumulating and advancing the foredune both horizontally and vertically (Godfrey and Godfrey 1980). Vehicle passes in the foredune break up the rhizomes and dry out the root zone. Anders and Leatherman (1987a) found that even very low vehicle traffic can stop forward dune growth. In a controlled experiment on Fire Island, NY, while vegetation grew 0.20 to 0.52 meter without ORV use, the vegetation front retreated 0.45m to 1.66m on beach zones with low vehicle traffic (1 to 8 passes per week). Vegetation did show east-ward growth after a 5.5-month reprieve from experimental impacts. However, resumption at one-half the former treatment level caused significantly more erosion and vegetation retreat.

The findings from Anders and Leatherman (1987a) also demonstrate that low levels of ORV use increase dune erosion, as the impacted zones experienced sand loss while the undisturbed zone experienced considerable accumulation. The study correlates much of the erosion with vegetative loss, but the tracks created by ORVs can also affect the morphology of the beach through sand displacement and compaction (Schlacher and Thompson 2008). The amount of sand displaced increases as the number of vehicles (traffic flow) increases. However, sand displacement is most pronounced with the first few vehicles (up to 10), again demonstrating that low disturbance levels will have detrimental changes to beach topography. It is worth noting that these levels of disturbance are far less than those experienced at the refuge, with estimated vehicle passes of 40 to 80 per week.

On Plum Island, beach erosion and accretion are cyclic on an annual basis. Erosion tends to occur from October through April, mainly during Nor'easter storms, while accretion and recovery occurs from April to October. ORV use on the refuge beach during September and October dries out and displaces sand and destroys vegetation at the toe of the dunes, thus making the foredune more susceptible to beach erosion from October to April, leading to steeper dune faces. The steeper dune faces may reduce dissipation of wave energy, further accelerating dune erosion (Anders and Leatherman 1987b); presenting a problem to the long-term stability and resiliency of the refuge's dunes, especially when faced with the predicted increase of severe coastal erosion and flooding (Zhang et al. 2004) due to sea level rise and climate change.

The beach at Parker River NWR is narrow and the foredune is steep and scarped. It is uncertain whether this beach profile is a legacy of historical ORV use, or a result of natural geomorphological process. Anders and Leatherman (1987a) saw evidence of compounding impacts of storms and ORV use on beach processes when the Nor'easter of 1978 hit their study site on Long Island, NY after their initial field trials. While the entire beach retreated landward during the storm, the ORV-zone retreated 3 to 4 times as far as the control site. Furthermore, the following spring, the ORV-sites continued to show retreat while the control site showed rapid recovery from storm impacts, with average seaward growth of 1.33 meter. This westward erosion is consistent with long term erosion rates predicted by Gutierrez et al (2014) of 3.3 feet (1 m) per year along Atlantic sandy beaches.

Shoreline monitoring on the Refuge beach from 2011 to 2020 has not detected westward erosion but did document significantly higher erosion and accretion cycles on the Refuge beach (Psuty 2014). This increase in dynamic nature of beach and dune habitat is consistent with increased storm frequency and intensity, which we expect will increase based on projected climate predictions.

Many studies and models concur that with sea level rise and increased frequency of high intensity storms, rates of coastline retreat and erosion along the wave-dominated beaches of the East Coast will be many orders of magnitude greater than present (Ashton et al 2008, Knutson et al 2010, Bender et al 2010). Gornitz et al (2002) suggests that erosion rates in the New York area will triple in the 2020s; and may be 6 times greater by the 2050 decade. Kirshen et al. (2008) estimated that the recurrence interval for 100-year flooding events in Boston could increase to a frequency of every 3 years or less by the year 2050. The recent eroding storms experienced by Plum Island may be part of this increasing storm intensity and frequency pattern. With climate change, we expect to see more erosion on the Refuge beach; and impacts of ORVs to dune growth and recovery would exacerbate increased erosion, leading to an even narrower beach and steeper foredune.

Summary:

While the refuge's draft 2022 CD found fishing via pedestrian access to be an appropriate and compatible public use of the refuge, it found that ORVs detracted from the refuge's core mission of protecting shorebirds and their habitat. Therefore, the CD found fishing to be compatible with the stipulation that ORV access be discontinued. Given declining shorebird populations of the very species that depend upon the refuge as a fall stopover site, rising sea levels, lack of foraging and roosting habitat due to pervasive beach erosion, and observed resource damage due to ORVs – in addition to extensive documentation of the same in the literature – termination of the ORV program is timely and prudent. Further, the refuge offers extensive public access opportunties to anglers which do not require the use of ORVs.

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