

GLOSSARY

Abundance—An ecological concept referring to the relative representation of a species in a particular ecosystem. It is usually measured as the large number of individuals found per sample. How species abundances are distributed within an ecosystem is referred to as relative species abundances.

Accretion—The process where coastal sediments return to the visible portion of the beach following storm erosion.

Action—Any federal activity including, but not limited to, acquiring, managing, and disposing of federal lands and facilities; facilitating human occupation or visitation; providing federally undertaken, financed, or assisted construction and improvements; and conducting federal activities and programs affecting land use, including, but not limited to, water and related land resources planning, and regulating and licensing activities.

Adaptive management—A system of management practices based on clearly identified outcomes, monitoring to determine if management actions are meeting outcomes, and, if not, facilitating management changes that will best ensure that outcomes are met or to re-evaluate the outcomes. Adaptive management recognizes that knowledge about natural resource systems is sometimes uncertain and is the preferred method of management in these cases (source: Departmental Manual 516 DM 4.16).

Adult—An organism that is fully grown or developed and capable of sexual reproduction.

Affected Environment—Existing natural, cultural, and social conditions of an area that are subject to change, both directly and indirectly, as a result of a proposed human action.

Alternate (ORV) route—A route that uses another ramp or an existing interdunal route or NC-12 to provide ORV access to an area by serving as a detour around a closed area.

Alternative, No-Action—An alternative that maintains established trends or management direction.

Anecdotal—Based on or consisting of reports or observations of usually unscientific observers.

Appropriate use—A use that is suitable, proper, or fitting for a particular park, or to a particular location within a park.

Archeological resource—Any material remains or physical evidence of past human life or activities which are of archeological interest, including the record of the effects of human activities on the environment. An archeological resource is capable of revealing scientific or humanistic information through archeological research.

Arthropod—An invertebrate that has an exoskeleton (external skeleton), a segmented body, and jointed attachments called appendages.

Anthropogenic—Resulting from the influence or actions of human beings.

Artificial lighting—Light sources produced by humans.

Backshore—The part of an ocean beach between the spring high water level and the primary dune line.

Benthic—The bottom, or relating to the bottom of the ocean or other body of water.

Berm—As used in this document refers to remnants of the man-made dune or dune ridge originally constructed in the 1930s by the Civilian Conservation Corps and the Works Progress Administration. NPS actively maintained this dune ridge until the early 1970s when NPS ended the dune stabilization policy after scientists concluded that the man-made berms constructed since the 1930s had actually served to foreshorten the seashore’s beaches and dramatically altered both the ecological and the topographical characteristics of the Outer Banks (NPS 2007f). “Berm” includes the man-made dune or dune ridge constructed to protect state highway NC-12 and interior sections of the island from ocean flooding and overwash during storms.

Best management practices—Practices that apply the most current means and technologies available to not only comply with mandatory environmental regulations, but also maintain a superior level of environmental performance. See also, “sustainable practices/principles.”

Biosphere Reserves—Found in different countries across all the regions of the world. Biosphere reserves are protected areas that are meant to demonstrate a balanced relationship between man and nature.

Bird nesting—The act of building a structure by a bird for laying eggs and sheltering its young.

Bivalves—A shell consisting of two rounded plates called *valves* joined at one edge by a flexible ligament called the *hinge*. The shell is typically bilaterally symmetrical, with the hinge lying in the sagittal plane.

Breeding activity—[See Breeding behavior.](#)

Breeding areas—Those areas that support the full suite of avian breeding activities including, courtship, territorial defense, copulation, scraping and nest building, egg laying and incubation, chick rearing and associated foraging.

Breeding behavior—Shorebird behavior that includes, but is not limited to, courtship, mating, scraping, confirmed scrapes, and other breeding or nest-building activities. [The terms breeding behavior and breeding activity are used synonymously.](#)

Breeding habitat—Habitat(s) that host the birds during territorial displaying, courtship and mating, scraping, nesting, incubation, brooding and chick foraging.

Breeding Shorebird and Seabeach Amaranth SMA—Area of suitable breeding habitat that has had multiple nests of individuals and/or multiple species of protected shorebirds, or concentrations of seabeach amaranth specimens, in more than 1 (i.e., 2 or more) of the past 5 years and is managed to minimize human disturbance during the breeding season. Focal species for Breeding Shorebird SMAs include piping plover, Wilson’s plover, American oystercatcher, least tern, common tern, gull-billed tern, and black skimmer; however, there will be ongoing evaluation of the breeding shorebird species addressed by this plan, as part of the periodic review process [described at the end of this table.](#)

Brood—The offspring, as of an animal or a bird, that are the result of one breeding season.

Buffer—A protective area or distance surrounding a sensitive resource that limits visitor access.

Bypass—A temporary route established by the park in accordance with the bypass criteria to provide ORV access during short periods of time.

Camouflaged—A method of cryptic or concealing coloration that allows an otherwise visible organism or object to remain indiscernible from the surrounding environment through deception.

Canid—The biological family of carnivorous and omnivorous mammals that includes the wolves, foxes, jackals, coyotes, and the domestic dog.

Carrying capacity—The maximum population of a particular species that a particular region can support without hindering future generations' ability to maintain the same population. A visitor, or user, carrying capacity is the type and level of use that can be accommodated while sustaining the desired resource and visitor experience conditions.

Civic engagement—Continuous, dynamic conversation with the public on many levels that reinforces the commitment of both the National Park Service and the public to the preservation of heritage resources, both cultural and natural, and strengthens public understanding of the full meaning and contemporary relevance of these resources. The foundation of civic engagement is a commitment to building and sustaining relationships with neighbors and communities of interest.

Closure—An area delineated by posts with string between them (symbolic fencing), prohibiting vehicle and/or pedestrian access.

Coastal High Hazard Area (V Zone)—The Special Flood Hazard Area that extends from offshore to the inland limit of a primary frontal dune along an open coast and any other area subject to high velocity wave action. The area is designated on the FIRM as Zone VE.

Cobble substrates—A substrate where the majority of the material is between 2.5 and 10 inches in diameter.

Compaction—The process by which a sediment progressively loses its porosity due to the effects of loading. This forms part of the process of lithification. When a layer of sediment is originally deposited, it contains an open framework of particles with the pore space being usually filled with water. As more sediment is deposited above the layer, the effect of the increased loading is to increase the particle-to-particle stresses resulting in porosity reduction primarily through a more efficient packing of the particles and to a lesser extent through elastic compression and pressure solution.

Compendium—~~A concise, yet comprehensive compilation of a body of knowledge. A compendium may summarize a larger work. In most cases the body of knowledge will concern some delimited field of human interest or endeavor. The Superintendent's Compendium is a document, updated yearly, that provides a list the special designations, closures, public use limits, permit requirements and other restrictions under the discretionary authority of the Superintendent within a park unit, as provided for in 36 CFR § 1.7 (b).~~

Consensus—Unanimous or general agreement; and secondly group solidarity of belief or sentiment. Within the context of the Cape Hatteras National Seashore Negotiated Rulemaking Advisory Committee, the Committee defined “consensus” as unanimous concurrence of the principals (members), or in the absence of the principal, his or her alternate. Members may also “abstain” or “stand aside” and not offer their consent, but refrain from blocking agreement and will thus also refrain from future negative comment or action on the consensus. Abstaining/standing aside members shall not be counted in determining if consensus has been reached.

Consent Decree—A judicial decree that sanctions a voluntary agreement between parties in dispute.

Conserve—To protect from loss or harm; preserve. Historically, the terms conserve, protect, and preserve have come collectively to embody the fundamental purpose of the NPS—preserving, protecting and conserving the national park system.

Contemporaneous—The historical timeframe that are immediately relevant to the present and is a certain perspective of modern history.

Corridor see **ORV Corridor; Pedestrian Corridor**

Council on Environmental Quality (CEQ)—Established by Congress within the Executive Office of the President with passage of the *National Environmental Policy Act of 1969*. CEQ coordinates federal environmental efforts and works closely with agencies and other White House offices in the development of environmental policies and initiatives.

Crawl—Tracks and other signs left on a beach by a sea turtle (FWC 2002).

Cultural resource—An aspect of a cultural system that is valued by or significantly representative of a culture, or that contains significant information about a culture. A cultural resource may be a tangible entity or a cultural practice. Tangible cultural resources are categorized as districts, sites, buildings, structures, and objects for the National Register of Historic Places, and as archeological resources, cultural landscapes, structures, museum objects, and ethnographic resources for NPS management purposes.

Cumulative impacts—Under NEPA regulations, the incremental environmental impact or effect of an action together with the effects of past, present, and reasonably foreseeable future actions, regardless of what agency or person undertakes such other actions (40 CFR 1508.7).

Dearth—A lack, shortage or scarcity.

Decapods—Invertebrate animals of the order Crustacea which have five pairs of legs and includes the shrimps, lobsters, crabs, etc.

Decibel (dBA)—A unit of measure of sound intensity.

Denudation—A geologic term that indicates the process by which the removal of material, through means of erosion and weathering, leads to a reduction of elevation and relief in landforms and landscapes. Exogenic processes, including the action of water, ice, and wind, predominantly involve denudation. Denudation can involve the removal of both solid particles and dissolved material. Both mechanical and chemical weathering occurs in relation to geomorphological landforms. At present the most significant processes leading to denudation include deforestation (including slash-and-burn practices of local peoples), overgrazing and certain forms of intensive farming which lead to large scale erosion. This phenomenon takes place generally by regional uplift by tectonic movement.

Derogation—See “impairment.”

Desiccation—The state of extreme dryness, or the process of extreme drying.

Desired future conditions—A park’s natural and cultural resource conditions that the NPS aspires to achieve and maintain over time, and the conditions necessary for visitors to understand, enjoy, and appreciate those resources. These conditions are identified through a park’s planning process.

Detritus—A *non*-living particulate organic material (as opposed to dissolved organic material). It typically includes the bodies or fragments of dead organisms as well as fecal material. Detritus is typically colonized by communities of microorganisms which act to decompose (or remineralize) the material.

Dredging—An excavation activity or operation usually carried out at least partly underwater, in shallow seas or fresh water areas with the purpose of gathering up bottom sediments and disposing of them at a different location.

Dune—A mound or ridge of sand or other loose sediment formed by the wind along the sea coast. The majority of dunes at the Seashore are man-made.

Ecology—The interdisciplinary scientific study of the interactions between organisms and the interactions of these organisms with their environment.

Ecosystem—A natural unit consisting of all plants, animals and micro-organisms (biotic factors) in an area functioning together with all of the physical (abiotic) factors of the environment, considered as a unit. Ecosystems can be permanent or temporary. An ecosystem is a unit of interdependent organisms which share the same habitat. Ecosystems usually form a number of food webs.

Emergence—The way complex systems and patterns arise out of a multiplicity of relatively simple interactions.

Enabling Legislation—National Park Service legislation that established a particular unit of the national Park System and set forth the legal parameters by which the respective park may operate.

Endangered species—“...any species (including subspecies or qualifying distinct population segment) that is in danger of extinction throughout all or a significant portion of its range (ESA Section 3(6)).” The lead federal agency, U.S. Fish and Wildlife Service, for the listing of a species as endangered is responsible for reviewing the status of the species on a five-year basis.

Endangered Species Act (ESA) (16 USC 1531 et seq.)—An act to provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved and to provide a program for the conservation of such endangered species and threatened species.

Environmental assessment (EA)—An environmental analysis prepared pursuant to the *National Environmental Policy Act* to determine whether a Federal action would significantly affect the environment and thus require a more detailed environmental impact statement (EIS).

Environmental impact statement (EIS)—A detailed NEPA analysis document that is prepared, with extensive public involvement, when a proposed action or alternatives have the potential for significant impact on the human environment. An EIS must meet the requirements of NEPA, CEQ, and the directives of the agency responsible for the proposed project or action.

Ephemeral pools—Temporary pools of water. They are usually devoid of fish, and thus allow the safe development of natal amphibian and insect species.

Erosion—Removal of surface material from the earth’s crust, primarily soil and rock debris, and the transportation of the eroded materials by natural agencies from the point of removal.

Escarpment—A transition zone between different physiogeographic provinces that involves a sharp, steep elevation differential, characterized by a cliff or steep slope. Usually *escarpment* is used interchangeably with scarp. A transition from one series of sedimentary rocks to another series of a different age and composition. When sedimentary beds are tilted and exposed to the surface, erosion and weathering may occur differentially based on the composition. Less resistant rocks will erode faster, retreating until the point they are overlain by more resistant rock.

Essential vehicle—Vehicles used by the National Park Service, or its agents, to conduct authorized administrative activities, such as resources management, law enforcement or other park operations, related to implementation of this plan or other applicable management plan(s) or permit(s), or as needed to respond to emergency operations involving threats to life, property, or park resources, within ~~in~~ areas that are otherwise closed to recreational ORV or visitor use.

Estuarine—Referring to the area where a water passage where the tide meets a river current; especially an arm of the sea at the lower end of a river.

Ethnographic—A methodological strategy used to provide descriptions of human societies, which as a methodology does not prescribe any particular method (e.g., observation, interview, questionnaire), but instead prescribes the nature of the study (i.e., to describe people through writing). In the biological sciences, this type of study might be called a “field study” or a “case report,” both of which are used as common synonyms for “ethnography.”

Ethnographic resources—Objects and places, including sites, structures, landscapes, and natural resources, with traditional cultural meaning and value to associated peoples. Research and consultation with associated people identifies and explains the places and things they find culturally meaningful. Ethnographic resources eligible for the National Register of Historic Places are called traditional cultural properties.

Exclosure—An enclosed area for protection or shelter from predatory animals.

Executive Order—Official proclamation issued by the President that may set forth policy or direction or establish specific duties for federal agencies in connection with the execution of federal laws and programs.

Extirpate—To destroy the whole of; exterminate.

False crawl—An aborted nesting attempt (emergence onto a beach by a sea turtle). A more correct term is “non-nesting emergence.”

Fauna—All of the animal life of any particular region or time.

Feral—An organism that has escaped from domestication and returned, partly or wholly, to a wild state.

Fledge—To bring up a young bird (chick) until it is able to fly. A *fledgling* is a young bird whose feathers and wing muscles are sufficiently developed for sustained flight.

Floodplain—Any land area susceptible to inundation by floodwaters from any source.

Flora—The first meaning, flora of an area or of time period, refers to all plant life occurring in an area or time period, especially the naturally occurring or indigenous plant life. The second meaning refers to a

book or other work which describes the plant species occurring in an area or time period, with the aim of allowing identification.

Foreshore—The area that is exposed to the air at low tide and underwater at high tide (for example, the area between tide marks). This area can include many different types of habitats, including steep rocky cliffs, sandy beaches, or wetlands (e.g., vast mudflats). The area can be a narrow strip, as in Pacific islands that have only a narrow tidal range, or can include many meters of shoreline where shallow beach slope interacts with high tidal excursion.

Geohazards—This definition implies that geohazards are widespread phenomena that are related to geological and environmental conditions and involve long-term and/or short-term geological processes. Geohazards can thus be relatively small features, but they can also attain huge dimensions (e.g., submarine or surface landslide) and affect local and regional socio-economy (e.g., tsunamis) to a large extent. In addition, human activities - for example drilling through geohazards like overpressured zones - could result in significant risk, and as such mitigation and prevention are paramount, through improved understanding of geohazards, their preconditions, causes and implications. In other cases, particularly in montane regions, natural processes can cause catalytic events of a complex nature, such as an avalanche hitting a lake causes a debris flow, with consequences potentially hundreds of miles away, or a lahar released by volcanism.

Germination—The process in which a seed or spore emerges from a period of dormancy. The most common example of germination is the sprouting of a seedling from a seed of an angiosperm or gymnosperm.

Hatchlings—A young bird or turtle that has recently emerged from its egg.

Historic breeding area—Areas used within the last 10 breeding seasons.

Hopper dredging—A self-propelled dredge having compartments in which the dredged material can be carried and dumped through hoppers.

Human disturbance—Any human activity that changes the contemporaneous behavior of one or more individuals of breeding, nesting, foraging, or roosting colonial waterbirds, piping plover, Wilson's plover, or American oystercatcher. Behaviors indicating disturbance include defensive displays; alarm calls; flushing or leaving a nest or feeding area; and diving or mobbing pedestrians, dogs, or vehicles.

Hydrology—The study of the movement, distribution, and quality of water throughout earth, and thus addresses both the hydrologic cycle and water resources.

Impairment—An impact that, in the professional judgment of a responsible NPS manager, would harm the integrity of park resources or values and violate the 1916 NPS *Organic Act* mandate that park resources and values remain unimpaired.

IMPLAN—An economic impact assessment modeling system that allows the user to build economic models to estimate the impacts of economic changes.

Incidental take—Take of listed fish or wildlife species that results from, but is not the purpose of, carrying out an otherwise lawful activity conducted by a federal agency or applicant (50 CFR 402.02).

Inlet—A narrow body of water between islands or leading inland from a larger body of water, often leading to an enclosed body of water, such as a sound, bay, lagoon or marsh. In sea coasts an inlet usually

refers to the actual connection between a bay and the ocean and is often called an “entrance” or a recession in the shore of a sea, lake or river. A certain kind of inlet created by glaciation is a fjord, typically but not always in mountainous coastlines and also in montane lakes.

Interdune blowout—Refers to the wind-swept, flat areas that lie between primary and secondary coastal dune systems.

Intertidal—The area that is exposed to the air at low tide and underwater at high tide (for example, the area between tide marks). This area can include many different types of habitats, including steep rocky cliffs, sandy beaches, or wetlands (e.g., vast mudflats).

Intertidal zone—(Also known as the foreshore and sometimes referred to as the littoral zone). The area that is exposed to the air at low tide and underwater at high tide (for example, the area between tide marks). This area can include many different types of habitats, including steep rocky cliffs, sandy beaches, or wetlands (e.g., vast mudflats). The area can be a narrow strip, as in Pacific islands that have only a narrow tidal range, or can include many meters of shoreline where shallow beach slope interacts with high tidal excursion.

Lightscape management (natural ambient)—The effective use of good design to appropriately light areas and minimize or eliminate light clutter, the spillover of light into areas where light is not wanted, and light pollution, all of which wastes energy and impacts park visitors, neighbors and resources.

Logarithmic Scale—A scale of measurement that uses the logarithm of a physical quantity instead of the quantity itself.

Misorientation—Orientation in the wrong direction. For hatchling sea turtles on the beach, travel in any direction other than the general vicinity of the ocean.

Mitigation—“Mitigation,” is defined in NPS Director’s Order 12 as a modification of the proposal or alternative that lessens the intensity of its impact on a particular resource. The definition references 40 CFR 1508.20, which states:

1. Avoiding the impact altogether by not taking a certain action or parts of an action.
2. Minimizing impacts by limiting the degree or magnitude of the action and its implementation.
3. Rectifying the impact of repairing, rehabilitating, or restoring the affected environment.
4. Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action.
5. Compensating for the impact by replacing or providing substitute resources or environments.

The term “mitigation” is used interchangeably in this plan/EIS with other terms, including “mitigation measure,” “mitigation techniques,” and “mitigation strategies.”

Mobile (precocial)—A young bird or turtle hatched or born in an advanced state of development and mobility and able to feed itself almost immediately.

Morphology—The form, structure and configuration of an organism.¹ This includes aspects of the outward appearance (shape, structure, color, pattern) as well as the form and structure of the internal parts like bones and organs.

Mudflats—Coastal wetlands that form when mud is deposited by tides or rivers. They are found in sheltered areas such as bays, bayous, lagoons, and estuaries. Mudflats may be viewed geologically as exposed layers of bay mud, resulting from deposition of estuarine silts, clays and marine animal detritus. Most of the sediment within a mudflat is within the intertidal zone, and thus the flat is submerged and exposed approximately twice daily.

Mudflats are typically important regions for wildlife, supporting a large population, although levels of biodiversity are not particularly high. They are often of particular importance to migratory birds. The maintenance of mudflats is important in preventing coastal erosion. However, mudflats worldwide are under threat from predicted sea level rises, land claims for development, dredging due to shipping purposes, and chemical pollution.

NEPA process—The objective analysis of a proposed action to determine the degree of its impact on the natural, physical, and human environment; alternatives and mitigation that reduce that impact; and the full and candid presentation of the analysis to, and involvement of, the interested and affected public—as required of federal agencies by the *National Environmental Policy Act of 1969*.

Nesting crawl—A crawl resulting from a nesting attempt in which eggs were deposited (FWC 2002).

Nesting habitat—Habitat(s) that host the birds during nesting including incubation, brooding and chick foraging.

Nestling—A bird that is too young to leave its nest.

Niche—A habitat supplying all of the necessary factors for a species existence.

Nocturnal—An animal behavior characterized by being active during the night and sleeping during the day.

Nonessential vehicle—Vehicles used by those not operating in an official agency capacity including all vehicles that do not meet the definition of an “essential vehicle.”

Off-road vehicle (ORV)—Any motorized vehicle designed for or capable of cross-country travel on or immediately over land, water, sand, snow, ice, marsh, swampland, or other natural terrain; except that such term excludes (a) any registered motorboat, (b) any fire, military, emergency or law enforcement vehicle when used for emergency purposes, and any combat or combat support vehicle when used for national defense purposes, and (c) any vehicle whose use contrary to restrictions proposed in this plan is expressly authorized by the Superintendent or the Refuge Manager under a permit, lease, license, or contract.

Organic Act (NPS)—The 1916 law (and subsequent amendments) that created the National Park Service and assigned it responsibility to manage the national parks.

ORV area—For the purposes of this plan, an ORV area is used synonymously with ORV route as defined below.

ORV corridor—An *ORV corridor* is the actual physical demarcation of the ORV route in the field. The ORV corridor on the ocean beach would be marked by posts seaward of the toe of dune or vegetation line to the high tide line.

ORV pass-through zone—An area where an ORV route would be defined to provide access to a specific area. ORV may drive through this zone to reach their destination, but may not stop or disembark passengers within this zone.

ORV route—A designated location, typically linear in nature (e.g., from point A to point B), where ORV travel may be authorized by the Superintendent, but which may be temporarily closed to ORV use to protect park resources, provide for visitor safety, or prevent user conflicts.

Overwash—Areas where water has run over or crested a berm or other structure that does not flow directly back to the ocean or lake.

Overwash fan—A fan-shaped deposit of sand, gravel or cobbles that is deposited from water that has run over or crested a berm or structure that does not flow directly back to the ocean or lake.

Park—Any one of the hundreds of areas of land and water administered as part of the national park system. The term is used interchangeably in this document with “unit,” “park unit,” and “park area.” In the context of this plan, “park” is synonymous with “National Seashore” or “Seashore.”

Pedestrian corridor—An established/marked area for pedestrian access.

Periodic review—A systematic review of data, habitat conditions, and other information to be conducted by NPS every 5 years, after storms or events that Seashore management determines to be a major modification of habitat quantity or quality, after a major hurricane, or after a significant change in protected species status (e.g., listing or de-listing), in order to evaluate the effectiveness of management actions in making progress toward the accomplishment of stated objectives. Periodic review could result in changes to the management actions in order to improve effectiveness. When desired future conditions for resources are met or exceeded, periodic review and adaptive management may allow for more flexible management of recreational use, provided adverse impacts of such use are effectively managed and wildlife populations remained stable. Where progress is not being made toward the attainment of desired future conditions, periodic review and adaptive management may result in increased restrictions on recreational use~~the attainment of desired future conditions, periodic review and adaptive management may provide for additional management including appropriate restrictions on recreational use.~~

Physiographic—(also known as geosystems or physiography) is one of the three major subfields of geography, as opposed to the cultural or built environment, the domain of human geography. Within the body of physical geography, the Earth is often split either into several spheres or environments, the main spheres being the atmosphere, biosphere, cryosphere, geosphere, hydrosphere, lithosphere and pedosphere. Research in physical geography is often interdisciplinary and uses the systems approach.

Plumage—The layer of feathers that cover a bird and the pattern, color, and arrangement of those feathers. The pattern and colors of plumage vary between species and subspecies and can also vary between different age classes, sexes, and season. Within species there can also be a number of different colour morphs. Differences in plumage are used by ornithologists and birdwatchers in order to distinguish between species and collect other species specific information.

Poaching—The illegal hunting, fishing, trapping, or eating of wild plants or animals contrary to local and international conservation and wildlife management laws.

Pollutants—The introduction of contaminants into an environment that causes instability, disorder, harm or discomfort to the ecosystem (i.e., physical systems or living organisms). Pollution can take the form of chemical substances, or energy, such as noise, heat, or light. Pollutants, the elements of pollution, can be foreign substances or energies, or naturally occurring; when naturally occurring, they are considered contaminants when they exceed natural levels.

Potential new habitat—Habitat recently created, usually by storms (e.g., overwash passes, blowouts, etc.).

Predation—Describes a biological interaction where a predator (an organism that is hunting) feeds on its prey, (the organism that is attacked). Predators may or may not kill their prey prior to feeding on them, but the act of predation always results in the death of the prey. The other main category of consumption is detritivory, the consumption of dead organic material. It can at times be difficult to separate the two feeding behaviors, for example where parasitic species prey on a host organism and then lay their eggs on it for their offspring to feed on its decaying corpse. The key characteristic of predation however is the predator's direct impact on the prey population. On the other hand, detritivores simply eat what is available and have no direct impact on the “donor” organism(s).

Predator—An organism that hunts and feeds on its prey (the organism that is attacked). Predators may or may not kill their prey prior to feeding on them, but the act of predation always results in the death of the prey.

Prenesting closure—A kind of resource closure in which an area of suitable habitat is proactively closed to ORVs and pedestrians at the start of the shorebird breeding season to provide undisturbed habitat for bird breeding activities to occur.

Preserve—To protect from loss or harm; conserve. Historically, the terms preserve, protect and conserve have come collectively to embody the fundamental purpose of the NPS—preserving, protecting and conserving the national park system.

Recent breeding areas—Areas used in the last three breeding seasons.

Research area—Area of suitable habitat set aside on a temporary or long-term basis (such as a study site or control plot) as part of a research project authorized by NPS under a research permit.

Resource closure—Any area posted as closed to all public entry in order to protect wildlife, such as breeding and foraging shorebirds and bird and turtle nests, or vegetation from human disturbance.

Riparian—Relating to or living or located on the bank of a natural watercourse (as a river) or sometimes of a lake or a tidewater.

Roosting—A resting state or period of relative inactivity employed by birds to save energy and compensate for the high metabolic rates that occur during the active part of the day. Sleeping birds often use a type of sleep known as vigilant sleep, where periods of rest are interspersed with quick eye-opening ‘peeks,’ allowing them to be sensitive to disturbances and enable rapid escape from threats.

Route [see ORV route](#)

Salinity—The saltiness or dissolved salt content of a body of water. It is a general term used to describe the levels of different salts such as sodium chloride, magnesium and calcium sulfates, and bicarbonates.

Scarified—To break a seed coat through nicking or abrasion.

Scrapes—A place where soil has been scraped away, esp. a shallow hollow formed in the ground by a bird during a courtship display or for nesting.

Sediment—Any particulate matter that can be transported by fluid flow, and which eventually is deposited. Sediments are most often transported by water (transported by wind) and glaciers. Beach sands and river channel deposits are examples of fluvial transport and deposition, though sediment also often settles out of slow-moving or standing water in lakes and oceans.

Sheetflow—Flowing water that is not confined to a channel.

Socioeconomic—The study of the relationship between economic activity and social life.

Soundscape (natural)— the aggregate of all the natural, nonhuman-caused sounds that occur in parks, together with the physical capacity for transmitting natural sounds.

Species Management Area (SMA)—Area of suitable habitat that has had concentrated and recurring use by multiple individuals and/or multiple species of protected shorebirds during the breeding season or nonbreeding season, or concentrations of seabird specimens, in more than one (i.e., two or more) of the past 5 years and is managed to reduce or minimize human disturbance. SMAs are reevaluated and redesignated every 5 years, or [after storms or events that Seashore management determines to be a major modification of habitat quantity or quality](#)~~after major hurricanes~~, as part of the periodic review process.

Subarctic—A region in the Northern Hemisphere immediately south of the true Arctic and covering much of Alaska, Canada, southern Greenland, the north of Scandinavia, Siberia, northern Mongolia and the Chinese province of Heilongjiang. Generally, subarctic regions fall between 50°N and 70°N latitude, depending on local climates.

Substrate—The earthy material that exists in the bottom of a marine habitat, like dirt, rocks, sand, or gravel.

Subtropical—The geographical zone of the Earth immediately north and south of the tropical zone, which is bounded by the Tropic of Cancer and the Tropic of Capricorn, at latitudes 23.5°N and 23.5°S.

Superintendent—The senior on-site NPS official in a park. Used interchangeably with “park superintendent,” “park manager,” or “unit manager.”

Symbolic fencing—Posts with string tied between them.

Synonym—Different words (or sometimes phrases) with identical or very similar meanings. Words that are synonyms are said to be synonymous, and the state of being a synonym is called synonymy.

Take—An act that potentially harasses, injures, or kills a protected species (FWC 2002). Take is defined differently depending on the governing legislation (i.e., Title 36 Code of Federal Regulations (CFR), *Endangered Species Act*, *Migratory Bird Treaty Act*).

“Take” as it applies to Title 36 CFR and as stated in 36 CFR 1.4 means to pursue, hunt, harass, harm, shoot, trap, net, capture, collect, kill, wound, or attempt to do any of the above.

“Take” as it applies to the Endangered Species Act and as stated in the Act Section 3.19 means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct. Harass is defined by Fish and Wildlife Service as actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding feeding or sheltering. Harm is further defined by the Fish and Wildlife Service to include significant habitat modification or degradation that results in death to listed species by significantly impairing behavioral patterns such as breeding, feed or sheltering (50 CFR 17.3).

“Take” as it applies to the Migratory Bird Treaty Act and as stated in 50 CFR 10.12, includes pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to pursue, hunt, shoot, wound, kill, trap, capture, or collect. Executive Order 13186 which calls for an MOU that has not been completed by NPS or other land management agencies defines intentional and unintentional take.

Taxon—A group of (one or more) organisms, which a taxonomist adjudges to be a unit.

Telemetry—A technology that allows remote measurement and reporting of information.

Thermal—A column of rising air in the lower altitudes of the earth’s atmosphere. Thermals are created by the uneven heating of the Earth’s surface from solar radiation, and an example of convection. The sun warms the ground, which in turn warms the air directly above it.

Traditional—Pertains to recognizable, but not necessarily identical, cultural patterns transmitted by a group across at least two generations. Also applies to sites, structures, objects, landscapes, and natural resources associated with those patterns. Popular synonyms include “ancestral” and “customary.”

Traditionally associated peoples—Social/cultural entities such as tribes, communities, and kinship units, as well as park neighbors, traditional residents, and former residents who remain attached to a park area despite having relocated, are “traditionally associated” with a particular park when (1) the entity regards park resources as essential to its development and continued identity as a culturally distinct people; (2) the association has endured for at least two generations (40 years); and (3) the association began prior to establishment of the park.

Traditional cultural property—A property associated with cultural practices, beliefs, the sense of purpose, or existence of a living community that is rooted in that community’s history or is important in maintaining its cultural identity and development as an ethnically distinctive people. Traditional cultural properties are ethnographic resources eligible for listing in the National Register of Historic Places.

Unacceptable impacts—Impacts that, individually or cumulatively, would

- be inconsistent with a park’s purposes or values, or impede the attainment of a park’s desired future conditions for natural and cultural resources as identified through the park’s planning process, or
- create an unsafe or unhealthful environment for visitors or employees, or
- diminish opportunities for current or future generations to enjoy, learn about, or be inspired by park resources or values, or
- unreasonably interfere with
 - park programs or activities, or

- an appropriate use, or
- the atmosphere of peace and tranquility, or the natural soundscape maintained in wilderness and natural, historic, or commemorative locations within the park.
- NPS concessioner or contractor operations or services.

Vehicle-free area (VFA)—An area within the Seashore that has not been designated as an ORV route. Nonessential vehicle/ORV use is prohibited in VFAs.

Viewsheds—An area of land, water, or other environmental element that is visible to the human eye from a fixed vantage point. The term is used widely in such areas as urban planning, archaeology, and military science. In urban planning, for example, viewsheds tend to be areas of particular scenic or historic value that are deemed worthy of preservation against development or other change. Viewsheds are often spaces that are readily visible from public areas such as from public roadways or public parks. The preservation of viewsheds is frequently a goal in the designation of open space areas, green belts, and community separators.

Visitor—Anyone who physically visits a park for recreational, educational or scientific purposes, or who otherwise uses a park's interpretive and educational services, regardless of where such use occurs (e.g., via Internet access, library, etc.).

Visitor experience—The perceptions, feelings, and reactions a park visitor has in relationship with the surrounding environment.

Vulnerable—A species which is likely to become endangered unless the circumstances threatening its survival and reproduction improve.

Wetlands—Wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. For purposes of this classification, wetlands must have one or more of the following three attributes: 1) at least periodically, the land supports predominantly hydrophytes; 2) the substrate is predominantly undrained hydric soil; and 3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year (Classification of Wetlands and Deepwater Habitats of the United States [Cowardin et al. 1979]).

Wrack line—Also known as a drift line, it is a line of stranded debris along a beach face marking the point of maximum run-up during a previous high tide.

REFERENCES

American Bird Conservancy

- 2005 Emergency Petition for a Rule to List the Red Knot (*Calidris canutus rufa*) as Endangered under the Endangered Species Act, 16 USC 1531 et seq. (1973 as amended) within the United States. 44 pp.
- 2008 “Government Review Confirms Red Knot and Other Imperiled Bird Candidates Should Be Listed as Endangered Species.” Accessed January 19, 2010:
<http://www.abcbirds.org/newsandreports/stories/081212.html>

Amirault, D.L., Shaffer, F., Baker, K., Boyne, A., Calvert, A., McKnight, J., and P. Thomas

- 2006 “Preliminary Results of a Piping Plover Five Year Banding Study in Eastern Canada: Support for Expanding Conservation Efforts to Non-Breeding Sites?” Proceedings of the Symposium on the Wintering Ecology and Conservation of Piping Plovers. U.S. Fish and Wildlife Service, Raleigh, NC.

Anders, F., and S. Leatherman

- 1987 “Disturbance of Beach Sediment by Off-Road Vehicles.” *Envir. Geol. and Water Sci.* 9:183–189.

Baicich, P.J., and C.J.O. Harrison

- 1997 A Guide to the Nests, Eggs, and Nestlings of North American Birds. Second edition. San Diego, CA: Academic Press.

Baker, A.J., P.M. González, T. Piersma, L.J. Niles, I.L.S. do Nascimento, P.W. Atkinson, N.A. Clark, C.D.T. Minton, M.K. Peck, and G. Aarts

- 2004 “Rapid Population Decline in Red Knot: Fitness Consequences of Decreased Refueling Rates and Late Arrival in Delaware Bay.” *Proc. Royal Soc. London* 271:875–882.

Baker, M., National Park Service (Cape Hatteras National Seashore)

- 2009a Pers. comm. via email with D. Wetmore, Louis Berger Group, Inc. (~~LBG~~[The Louis Berger Group](#)), regarding the number of sea turtle nests by species found during the years 2000 through 2005. March 16, 2009.
- 2009b Pers. comm. via email with D. Wetmore, ~~LBG~~[The Louis Berger Group](#), regarding the number of sea turtle nests by species found during the years 2000 through 2009. November 11, 2009.
- [2009c Pers. comm. via email with S. Smith, The Louis Berger Group, Inc. regarding the northernmost leatherback sea turtle nest. September 22, 2009.](#)

Barber, J.R., K.R. Crooks, and K.M. Fristrup

- ~~In press~~[2010](#) *The Costs of Chronic Noise Exposure for Terrestrial Organisms*. TREE-1176:10 pp.

References

Bent, C.

- 1929 “Life Histories of North American Shore Birds, Part 2.” *U.S. Nat’l Mus. Bull.*, Number 146, Washington, D.C.

Bergstrom, P.W.

- 1988 “Breeding Biology of Wilson’s Plovers.” *Wilson Bull.* 100:25–35.
- 1989 “Incubation Temperatures of Wilson’s Plovers and Killdeers. *Condor* 91:634–641.

Bildstein, K.L., G.T. Bancroft, P.J. Dugan, D.H. Gordon, and R.M. Erwin

- 1991 “Approaches to the Conservation of Coastal Wetlands in the Western Hemisphere.” *Wilson Bull.* 103:218–254.

Blanco, D., H.R. Goi, and G. Pugnali

- 1992 “The Importance of Punta Rasa, Buenos Aires Province, in the Migration of the Red Knot (*Calidris canutus*).” *El Hornero* 13:203–206.

Blodget, B.G., and S.M. Melvin

- 1996 *Massachusetts Tern and Piping Plover Handbook: A Manual for Stewards*. Massachusetts Division of Fisheries and Wildlife, Westborough, MA.

Brodhead, J.M., and P.J. Godfrey

- 1977 “Off-Road Vehicle Impact in Cape Cod National Seashore: Disruption and Recovery of Dune Vegetation.” *Int’l J. of Biometeorology* 21:299–306.

Broili, T., ~~National Park Service (Cape Hatteras National Seashore) Chief of Resource Management, Cape Hatteras National Seashore~~

- 2009 Pers. comm. [via email](#) with C. ~~zandy~~ Holda, Cape Hatteras National Seashore, regarding vehicle noise. September 28, 2009.

- 2010 Pers. comm. via phone with S. Hamilton, NPS Environmental Quality Division, regarding the status of seabeach amaranth at the Seashore for the 2010 season. September 23, 2010.

Brown, S., C. Hickey, B. Harrington, and R. Gill, eds.

- 2001 *The U.S. Shorebird Conservation Plan*, 2nd ed. Manomet Center for Conservation Sciences, Manomet, MA.

Brown, S., S. Schulte, B. Harrington, B. Winn, J. Bart, and M.A. Howe

- 2005 “Population Size and Winter Distribution of Eastern American Oystercatchers.” *J. of Wildl. Mgmt.* 69.

Buckley, P.A., and F.G. Buckley

- 1976 *Guidelines for the Protection and Management of Colonially Nesting Waterbirds*. National Park Service, North Atlantic Regional Office, Boston, MA.

Bureau of Labor Statistics

~~2008~~2010a “Local Area Unemployment Statistics.” Accessed ~~December 5, 2008~~August 31, 2010:
<http://www.bls.gov/lau>

2010b Quarterly Census of Employment and Wages. Accessed August 1, 2010. <http://bls.gov/cew>

~~2009~~—“Local Area Unemployment Statistics.” Accessed ~~September 2, 2009~~:
<http://www.bls.gov/lau>

Burger, J.

1987 “Physical and Social Determinants of Nest Site Selection in Piping Plover in New Jersey.”
Condor 98:811–818.

1991 “Foraging Behavior and the Effect of Human Disturbance on the Piping Plover
 (*Charadrius melodus*).” *J. of Coastal Res.* 7:39–52.

1994 “The Effect of Human Disturbance on Foraging Behavior and Habitat Use in Piping Plover
 (*Charadrius melodus*).” *Estuaries* 17:695–701.

1998 “Effects of Motorboats and Personal Watercraft on Flight Behavior over a Colony of
 Common Terns.” *Condor* 100:528–534.

Burger, J., and M.G. Gochfeld

1990 *Black Skimmer: Social Dynamics of a Colonial Species*. New York, NY: Columbia
 University Press.

Burger, J., C. Jeitner, K. Clark, and L.J. Niles

2004 “The Effect of Human Activities on Migrant Shorebirds: Successful Adaptive
 Management.” *Environ. Conserv.* 31: 283–288.

Byrne, M.W., J.M. Maxfield, and J.C. DeVivo

2009 *Migratory and Wintering Shorebird Monitoring at Cape Hatteras National Seashore,
 2006/2007*. Natural Resource Technical Report NPS/SECN/NRTR—2009/189. National
 Park Service, Fort Collins, CO.

Cairns, W.E.

1982 “Biology and Behavior of Breeding Piping Plovers.” *Wilson Bull.* 94:531–545.

California Department of Transportation (Caltrans)

1998 *Technical Supplement to the Traffic Noise Analysis Protocol*. California Department of
 Transportation Environmental Program. October 1998.

California State Lands Commission

2005 *Disposition of Offshore Cooling Water Conduits SONGS Unit 1 EIR*, Section 4.9, Noise,
 p. 4.9-3. State Clearinghouse Number SCH2004061092. June 2005.

References

Cameron, S., and D. Allen

- 2008 *2007 Survey of Nesting Colonial Waterbirds in the North Carolina Coastal Zone along with an Updating of the Colonial Waterbird Database*. Final Report to the U.S. Army Corps of Engineers, Wilmington District, NC.

Cameron, S., North Carolina Wildlife Resources Commission

- 2005 Pers. comm. with R. Podolsky, [LBG The Louis Berger Group](#), regarding Wilson's plover at Cape Hatteras. November 20, 2005.
- 2007 Pers. comm. via phone with T. Flanagan, NPS, regarding habitat enhancement / creation projects. September 21, 2007.

Cape Hatteras Business Allies

- 2009 [Draft Recreational Overview and Maps. pp. 5-8 of Addendum 4 in Negotiated Rulemaking Advisory Committee for Off-Road Vehicle Management at Cape Hatteras National Seashore; Final Report of the Proceedings submitted to the National Park Service on behalf of the Committee by Patrick Field, Robert Fisher, and Ona Ferguson, Committee Facilitators, March 20, 2009](#)

Carthy, R.R., A.M. Foley, and Y. Matsuzawa

- 2003 ["Incubation Environment of Loggerhead Turtle Nests: Effects on Hatching Success and Hatchling Characteristics." In *Loggerhead Sea Turtles* \(ed. A.B. Bolten and B.E. Witherington\), pp. 144–153. Washington: Smithsonian Books.](#)

Cave, D.

- 2010 ["A Challenge to Florida Beach Driving Tradition." *The New York Times*. September 9, 2010.](#)

Cohen, J.B., R.M. Erwin, J.B. French Jr., J.L. Marion, and J.M. Meyers

- In press 2010 [Recommendations for Management of Endangered Species at Cape Hatteras National Seashore](#). U.S. Geological Survey Open-File Report 2009-1262.

Cohen, J.B.

- 2005 "Factors Limiting Piping Plover Nesting Pair Density and Reproductive Output on Long Island, New York." Ph.D. diss., Virginia Tech University, Blacksburg, VA.

Cohen, J.B., S.M. Karpanty, D.H. Catlin, J.D. Fraser, and R.A. Fischer

- 2008 "Winter Ecology of Piping Plovers at Oregon Inlet, North Carolina." *Waterbirds* 31(3):472–479.

Cohen, J.B., E.H. Wunker, and J.D. Fraser

- 2008 "Substrate and Vegetation Selection by Nesting Piping Plovers." *Wilson J. of Ornith.* 120(2):404–407.

Collazo, J.A., J.R. Walters, and J.F. Parnell

- 1995 Factors Affecting Reproduction and Migration of Waterbirds on the North Carolina Barrier Islands. Final Report to the National Park Service, Cape Hatteras and Cape Lookout Seashores.

Cooper, S.

- 1990 “Notes on Piping Plovers Nesting at Cape Hatteras National Seashore during 1987.” *Chat* 54:1–6.

Corbat, C.A., and P.W. Bergstrom

- 2000 “Wilson’s Plover (*Charadrius wilsonia*).” In *The Birds of North America Online*, ed. A. Poole. Ithaca, NY: Cornell Lab of Ornithology. <http://bna.birds.cornell.edu/bna/species/516>

Council on Environmental Quality (CEQ)

- 1981 “Forty Most Asked Questions Concerning CEQ’s National Environmental Policy Act Regulations.” *Federal Register* 46(55):18026–38.
<http://ceq.eh.doe.gov/nepa/regs/40/40p.3.htm>.

Cowardin, L.M., ~~V. Carter, F.C. Golet, and E.T LaRoe et al.~~

- 1979 *Classification of Wetlands and Deepwater Habitats of the United States*. FWS/OBS-79/31. Performed for the U.S. Department of the Interior, Fish and Wildlife Service, Office of Biological Services, Washington, D.C.

Creef, D., Dare County Planning Department

- 2009 Pers. comm. via email with D. Wetmore, ~~LBG~~The Louis Berger Group, regarding the status of the county’s *Land Use Plan* update. February 16, 2009.

Crihfield, J.B., and H.S. Campbell Jr.

- 1991 “Evaluating Alternative Regional Planning Models.” *Growth and Change* 22(2):1–16.
DOI: 10.1111/j.1468-2257.1991.tb00544.x.

Culver S.F., C.A.G. Pre, D.J. Mallinson, S.R. Riggs, D.R. Corbett, J. Foley, M. Hale, L. Metger, J. Ricardo, C.G. Smith, C.W. Smith, S.W. Snyder, and D. Twamley

- 2007 “Late Holocene Barrier Island Collapse: Outer Banks, North Carolina, USA.” *Sedimentary Record* 5:4–8.

Dare County

- 2003 *Dare County Land Use Plan*. July, 2003.

Davis, M.B., T.R. Simons, M.J. Groom, J.L. Weaver, and J.R. Cordes

- 1999 Reproductive success, status, and viability of the American oystercatcher (*Haematopus palliatus*). Thesis, North Carolina State University, Department of Zoology, Raleigh, NC.
- 2001 “The Breeding Status of the American Oystercatcher on the East Coast of North America and Breeding Success in North Carolina.” *Waterbirds* 24:195–202.

References

Dinsmore, S., J. Collazo, and J. Walters

- 1998 "Seasonal Numbers and Distribution of Shorebirds on North Carolina's Outer Banks." *Wilson Bull.* 110(2):171–181.

Dodd, C.K., Jr.

- 1988 *Synopsis of the Biological Data on the Loggerhead Sea Turtle Caretta caretta (Linnaeus 1758)*. U.S. Fish and Wildlife Service, Biol. Rep. 88(14). 110 pp.

Dolan, R., P.J. Godfrey, and W.E. Odum

- 1973 "Man's Impact on the Barrier Islands of North Carolina." *Amer. Sci.* 61:152–162.

Drake, K.R., J.E. Thompson, K.L. Drake, and C. Zonick

- 2001 "Movement, Habitat Use, and Survival of Nonbreeding Piping Plovers." *Condor* 103(2):259–267.

Ehrhart, L.M., D.A. Bagley, and W.E. Redfoot

- 2003 "Loggerhead Turtles in the Atlantic Ocean: Geographic Distribution, Abundance, and Population Status." In *Loggerhead Sea Turtles*, ed. A.B. Bolten and B.E. Witherington, 157–174. Washington, D.C.: Smithsonian Books.

Ehrhart, L.M., and B.E. Witherington

- 1987 Human and Natural Causes of Marine Turtle Nest and Hatchling Mortality and Their Relationship to Hatchling Production on an Important Florida Nesting Beach. Final Report, Project Number GFC-84-018, Technical Report No. 1. Florida Game and Fresh Water Fish Commission, Nongame Wildlife Program, Tallahassee, FL. 141 pp.

Elias, S.P., J.D. Fraser, and P.A. Buckley

- 2000 "Piping Plover Brood Foraging Ecology on New York Barrier Island Ecology." *J. of Wildl. Mgmt.* 64:346–354.

Elliott-Smith, E., and S.M. Haig

- 2004 "Piping Plover (*Charadrius melodus*)." In *The Birds of North America Online*, ed. A. Poole. Ithaca, NY: Cornell Lab of Ornithology. <http://bna.birds.cornell.edu/bna/species/002>

Elliott-Smith, E., S.M. Haig, and B.M. Powers

- 2009 Data from the 2006 International Piping Plover Census: U.S. Geological Survey Data Series 426. 332 pp.

Environmental Systems Research Institute, Inc.

- 2002 "2000 Census Block Groups: NC." CD-ROM. ESRI Data and Maps 2002.

Erwin, R.M.

- 1977 "Black Skimmer Breeding Ecology and Behavior." *Auk* 94:709–717.
- 1979 "Species Interactions in a Mixed Colony of Common Terns (*Sterna hirundo*) and Black Skimmers (*Rynchops niger*)." *Animal Behav.* 27:1054–1062.

- 1980 “Breeding Habitat Use by Colonially Nesting Waterbirds in Two Mid-Atlantic Regions under Different Regimes of Human Disturbance.” *Biol. Conserv.* 18:39–51.
- 1989 “Responses to Human Intruders by Birds Nesting in Colonies: Experimental Results and Management Guidelines.” *Colonial Waterbirds* 12:104–108.
- ~~2005—*Management, Monitoring, and Protection Protocols for Colonially Nesting Waterbirds at Cape Hatteras National Seashore, North Carolina. USGS Open File Report 2009-1262 (2010) USGS report to the National Park Service.*~~
- Erwin, R.M., D.H Allen, and D. Jenkins
- 2003 “Created Versus Natural Coastal Islands: Atlantic Waterbird Populations, Habitat Choices, and Management Implications.” *Estuaries* 26:949–955.
- Erwin, R.M., J.D. Nichols, T.B. Eyler, D.B. Stotts, and B.R. Truitt
- 1998 “Modeling Colony-Site Dynamics: A Case Study of Gull-Billed Terns (*Sterna nilotica*) in Coastal Virginia.” *Auk* 115:970–978.
- Erwin, R.M., B.R. Truitt, and J.E. Jimenez
- 2001 “Ground-Nesting Waterbirds and Mammalian Carnivores in the Virginia Barrier Island Region: Running Out of Options.” *J. of Coastal Res.* 17:292–296.
- Federal Highway Administration (FHWA)
- 1995 *Highway Traffic Noise Analysis and Abatement Policy and Guidance*. U.S. Department of Transportation Federal Highway Administration (FHWA), Office of Environment and Planning, Noise and Air Quality Branch, Washington, D.C. June 1995. 4 pp.
- 2007 Administrative Action: Supplement to the 2005 Supplemental Draft Environmental Impact Statement and Draft Section 4(f) Evaluation NC 12 Replacement of the Herbert C. Bonner Bridge.
- Federal Interagency Committee on Noise (FICN)
- 1992 *Federal Agency Review of Selected Airport Noise Analysis Issues*. August 1992.
- Federal Register ([FR](#))
- 1985 Endangered and Threatened Wildlife and Plants; Determination of Endangered and Threatened Status for Piping Plovers. Federal Register 50:50 FR 50726–50734. December 11, 1985.
- 2001 Endangered and Threatened Wildlife and Plants; Final Determinations of Critical Habitat for Wintering Piping Plovers; Final Rule. Federal Register 66:50 CFR 36038–36143. July 10, 2001.
- 2008 Endangered and Threatened Wildlife and Plants; Revised Designation of Critical Habitat for the Wintering Population of the Piping Plover (*Charadrius melodus*) in North Carolina; Final Rule. Federal Register 73:50 CFR 62815–62841. October 21, 2008.

References

- 2009 Endangered and Threatened Wildlife and Plants: Review of Native Species That Are Candidates for Listing as Endangered or Threatened; Annual Notice of Findings on Resubmitted Petitions; Annual Description of Progress on Listing Actions. Federal Register 74:50 CFR 17. 57825. November 9, 2009.
- Flemming, S.P., R.D. Chiasson, P.C. Smith, P.J. Austin-Smith, and R.P. Bancroft
1988 "Piping Plover Status in Nova Scotia Related to Its Reproductive and Behavioral Responses to Human Disturbance." *J. of Field Ornith.* 59:321–330.
- Foley, A.M., S.A. Peck, and G.R. Harman
2006 "Effects of Sand Characteristics and Inundation on the Hatching Success of Loggerhead Sea Turtle (*Caretta caretta*) Clutches on Low-relief Mangrove Islands in Southwest Florida." *Chelonian Conservation and Biology*, 5(1): 32-41.
- Francis, C. D., C. P. Ortega, and A. Cruz
2009 Noise pollution changes avian communities and species interactions. *Current Biology*. 19: 1415-1419.
- Frazer, N.B.
1992 "Sea Turtle Conservation and Halfway Technology." *Conserv. Biol.* 6:179–184.
- Frid, A. and L.M. Dill
2002 "Human Caused Disturbance Stimuli as a Form of Predation Risk." *Conservation Ecology* 6: Article 11.
- Fussell, J. III, M. Lyons, and A.D. Barron
1990 "Birds of the Outer Banks." Version 18JUL00. National Park Service, Department of the Interior, Northern Prairie Wildlife Research Center Online, Jamestown, ND.
<http://www.npwrc.usgs.gov/resource/birds/chekbird/r4/hatteras.htm>
- Gilpin, M.E., and M.E. Soulé
1986 "Minimum Viable Populations: Processes of Species Extinction." In *Conservation Biology: The Science of Scarcity and Diversity*, ed. M.E. Soulé, 19–34. Sunderland, MA: Sinauer.
- Gochfeld, M.G., and J. Burger
1994 "Black Skimmer (*Rynchops niger*)." In *The Birds of North America*, ed. A. Poole and F. Gill. Washington, D.C.: The Academy of Natural Sciences, and Philadelphia, PA: American Ornithologists' Union.
- Godfrey, M., North Carolina Wildlife Resources Commission
2005a [Pers. comm. via email with S. Smith, The Louis Berger Group, providing information indicating that under natural conditions the average false crawl to nest ratio for loggerhead sea turtles is 1:1. October 6, 2005.](#) ~~Pers. comm. with S. Smith, LBG. October 6, 2005.~~

- 2005b Pers. comm. via email with K. Sayles, National Park Service (Cape Hatteras National Seashore), providing unpublished data regarding the annual number of loggerhead sea turtle nests in North Carolina, Cape Hatteras National Seashore, and Cape Lookout National Seashore for the years 1995 through 2004. October 4, 2005.
- 2008 Pers. comm. via email with S. Smith, [The Louis Berger Group](#)~~LBG~~, providing unpublished data regarding the annual number of loggerhead, green, and leatherback sea turtles in North Carolina, Cape Hatteras National Seashore, and Cape Lookout National Seashore for the years 1996 through 2008 (2008 data is incomplete, for the nesting season hadn't ended yet). October 3, 2008.
- [2010a Pers. comm. via email with S. Smith, The Louis Berger Group, providing the number of sea turtle nests by species in 2009 for the state of North Carolina. February 23, 2010.](#)
- [2010b Pers. comm. via email with S. Smith, The Louis Berger Group, regarding an update for the number of sea turtle nests by species in 2008 for the state of North Carolina. September 1, 2010.](#)
- Golder, W.W.
- 1985 "Piping Plovers Nesting at Cape Hatteras, N.C." *Chat* 49:69–70.
- 1986 "Piping Plovers Nesting at Cape Hatteras, N.C., in 1985." *Chat* 50:51–53.
- Goldin, M.R., and J.V. Regosin
- 1998 "Chick Behavior, Habitat Use, and Reproductive Success of Piping Plovers at Goosewing Beach, Rhode Island." *J. of Field Ornith.* 69(2):228–234.
- [Goss-Custard, J.D., and Ens, B.J.](#)
- [1984 "Interference among Oystercatchers, *Haematopus ostralegus* L. Feeding on Mussels, *Mytilus edulus* L., on the Exe Estuary." *J. Anim Ecol.* 53:217–232.](#)
- [Griffin, D., South Carolina Department of Natural Resources Marine Turtle Conservation Program](#)
- [2010 Pers. comm. via telephone with S. Smith, The Louis Berger Group regarding South Carolina protocols for relocating sea turtle nests. August 20, 2010.](#)
- Greene, K.
- 2002 *Beach Nourishment: A Review of the Biological and Physical Impacts*. ASMFC Habitat Management Series #7. Atlantic States Marine Fisheries Commission.
- Green, [C.](#), and [K. Noon.](#), [National Park Service \(Southeast Regional Office and Water Resources Division\)](#)
- 2008 Pers. comm. [via telephone with N. VanDyke, The Louis Berger Group](#), regarding a wetlands statement of findings. [February 6, 2008.](#)
- [Habib, L., E. M. Bayne, and S. Boutin](#)
- [2007 "Chronic Industrial Noise Affects Pairing Success and Age Structure of Ovenbirds *Seiurus aurocapilla*." *Journal of Applied Ecology* 44: 176-184.](#)

References

Haig, S.M., and L.W. Oring

1988 "Distribution and Dispersal in the Piping Plover." *Auk* 105:630–638.

Hanson, J., T. Wibbels, and E.M. Martin

1998 "Predicted Female Bias in Sex Ratios of Hatchling Loggerhead Sea Turtles from a Florida Nesting Beach." *Can. J. of Zool.* 76:1850–1861.

Hardgrove, M., National Park Service ([Cape Hatteras National Seashore](#))

2005 Pers. comm. [via email](#) with D. Otto, [The Louis Berger Group](#)~~LBG~~. [regarding ORV use patterns at the Seashore](#). November 17, 2005.

Harrington, B.A.

1996 *The Flight of the Red Knot*. New York, NY: W.W. Norton and Co.

2001 ~~Harrington, Brian A. 2001.~~ Red Knot (*Calidris canutus*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: <http://bna.birds.cornell.edu/bna/species/563>.

[Harrington, B.A., F.J. Leeuwenberg, S. Lara-Resende, R. McNeil, et al.](#)

[1991 "Migration and Mass Change of White-rumped Sandpipers in North and South America." *Wilson Bull.* 104: 621-636.](#)

Harrison, S., and B. Trick, NPS

2005 Pers. comm. with R. Podolsky, [The Louis Berger Group](#)~~LBG~~. September 4, 2005.

Hayman, P., J. Marchant, and T. Prater

1986 *Shorebirds: An Identification Guide*. Boston, MA: Houghton Mifflin Co.

Hecht, A., USFWS

2008 Pers. comm. via email with J. Walsh, [The Louis Berger Group](#)~~LBG~~, regarding the piping plover recovery effort. July 3, 2008.

2009 Pers. comm. via email with D. Wetmore, [The Louis Berger Group](#)~~LBG~~, regarding 2009 piping plover numbers.

~~Henson, G., J. Meekins, and K. Balancee, Cape Hatteras National Seashore~~

~~2005—Pers. comm. with LBG. September 29, 2005.~~

Hilty, S.L., and W.L. Brown

1986 *A Guide to the Birds of Columbia*. Princeton, NJ: Princeton University Press.

Hobbs, C.H., III, C.B. Landry, and J.E. Perry III

2008 "Assessing Anthropogenic and Natural Impacts on Ghost Crabs (*Ocypode quadrata*) at Cape Hatteras National Seashore, North Carolina." *J. of Coastal Res.* 24(6):1450–1458.

Hobson, W.

- 2010 “Beach Safety Campaign to Emphasize Parking Only.” *The Daytona Beach News-Journal*. August 6, 2010.

Hodgson, A.B., A.F. Paul, and M.L. Rachal

- 2008 *American Oystercatcher Nesting in Hillsborough Bay, Florida: Population Trends 1990–2007 and Management Recommendations*. Florida Coastal Islands Sanctuaries, Tampa, FL. Sovereign Lands Management Initiatives Program 2006. Tampa Port Authority, Tampa, FL.

Hoopes, M.E.

- 1993 Relationship Between Human Reaction and Piping Plover Foraging Ecology and Chick Survival. Thesis. Submitted to the Graduate School of the University of Massachusetts in partial fulfillment of the requirements for the degree of Master of Science. Department of Forestry and Wildlife Management. September 1993.

Hope, C., South Carolina Department of Natural Resources Marine Turtle Conservation Program

- 2010 Pers. comm. via telcon with S. Smith, The Louis Berger Group., regarding South Carolina protocols for relocating sea turtle nests. August 20, 2010.

Hosier, P.E., M. Kochhar, and V. Thayer

- 1981 “Off-Road Vehicle and Pedestrian Track Effects on the Sea-Approach of Hatchling Loggerhead Turtles.” *Envir. Conserv.* 8(2):158–161. Summer 1981.

Houghton, L.M.

- 2005 Piping plover population dynamics and effects of beach management practices on piping plovers at West Hampton Dunes and Westhampton Beach, New York. Diss., Virginia Polytechnic Institute and State University. 162 pp.

Howell, S.N.G., and S. Webb

- 1995 *A Guide to the Birds of Mexico and Northern Central America*. New York, NY: Oxford University Press.

Hunter, W.C.

- 2002 *Southeastern Coastal Plains–Caribbean Region Report U.S. Shorebird Conservation Plan*. U.S. Fish and Wildlife Service. September 30, 2002. Accessed December 20, 2009: <http://www.fws.gov/shorebirdplan/regionalshorebird/downloads/SECPCRRev02.pdf>

Hyde County

- 2006 *Hyde County, North Carolina CAMA Core Land Use Plan*.

Impact Assessment, Inc.

- 2005 *Final Technical Report – Volumes 1 and 2: Ethnohistorical Description of the Eight Villages Adjoining Cape Hatteras National Seashore and Interpretive Themes of History and Heritage*. November 2005.

References

InfoUSA

2008 Reference USA. Accessed 2008: <http://www.referenceusa.com/>

Industrial Economics, Inc.

1998 An Economic Analysis of Piping Plover Recovery Efforts on the Atlantic Coast. Prepared for Division of Economics, U.S. Fish and Wildlife Service, Department of the Interior.

Intergovernmental Panel on Climate Change (IPCC)

2007 *Climate Change 2007: Synthesis Report*. Contribution of Working Groups I, II, and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Core Writing Team, ed. R.K. Pachauri and A. Reisinger. Geneva, Switzerland: IPCC.

Internal Revenue Service (IRS), U.S. Department of Treasury

2005 Corporation Source Book: Data File 2005.
<http://www.irs.gov/taxstats/article/0,,id=167415,00.html>

Invasive Species Specialist Group (ISSG)

2009 ISSG Global Invasive Species Database: Impact information for *Vitex rotundifolia*. Accessed July 10, 2009:
http://www.issg.org/database/species/impact_info.asp?si=1110&fr=1&sts=&lang=EN

Jarup, L., W. Babisch, D. Houthuijs, G. Pershagen, K. Katsouyanni, E. Cadum, M. Dudley, P. Savigny, I. Seiffert, W. Swart, O. Breugelmanns, G. Bluhm, J. Selander, A. Haralabidis, K. Dimakapoulou, P. Sourtzi, M. Velonakis, and F. Vigna-Taglianti

2008 “Hypertension and Exposure to Noise Near Airports: the HYENA Study.” *Environmental Health Perspectives*. 116:329-333.

Johnsgard, P.A.

1981 *The Plovers, Sandpipers and Snipes of the World*. Lincoln, NE: University of Nebraska Press.

Jolls, C.L., J.D. Sellars, and C.A. Wigent

2004 *Restore Seabeach Amaranth, a Federally Threatened Species: Habitat Assessment and Restoration of *Amaranthus pumilus* (Amaranthaceae), Using Remote Sensing Data*. 2001. Natural Resource Presentation Program, RMP Project Statement CAHA-N-018.000, National Park Service, Final Report. 144 pp.

Kersten, M., and T. Piersma

1987 “High Levels of Energy Expenditure in Shorebirds: Metabolic Adaptations to an Energetically Expensive Way of Life.” *Ardea* 75:175-187.

Kluft, J.M., and H.S. Ginsberg

2009 *The Effect of Off-Road Vehicles on Barrier Beach Invertebrates at Cape Cod and Fire Island National Seashores*. Technical Report NPS/NER/NRTR—2009/138. National Park Service, Boston, MA. April 2009.

Kuklinski, M.L., L.M. Houghton, and J.D. Fraser

- 1996 *Piping Plover Breeding Ecology on Cape Hatteras National Seashore with Special Reference to the Effect of Temperature on Productivity*. Dept. of Fisheries and Wildlife Sciences, Virginia Tech University, Blacksburg, VA.

Lafferty, K.D.

- 2001a “Birds at a Southern California Beach: Seasonality, Habitat Use and Disturbance by Human Activity.” *Biodiversity and Conservation*, 10:1949-1962.
- 2001b Disturbance to wintering western snowy plovers. *Biological Conservation* 101:315-325.

Lande, R.

- 1988 “Genetics and Demography in Biological Conservation.” *Science* 241:1455–1460.

Landon, D. M., P.R. Krausman, K. K. G. Koenen, and L.K. Harris

- 2003 “Pronghorn Use of Areas with Varying Sound Pressure Levels.” *The Southwestern Naturalist*, 48:725-728.

~~Landry, C.~~

~~2004—Assessing the anthropogenic and natural impacts on ghost crab (*Oecypode quadrata*) populations at Cape Hatteras National Seashore, North Carolina. Thesis draft, Department of Coastal and Ocean Policy, Virginia Institute of Marine Science, College of William and Mary. August 5, 2004.~~

Lauro, B., and J. Burger

- 1989 “Nest-Site Selection of American Oystercatcher (*Haematopus palliatus*) in Salt Marshes.” *Auk* 106:185–192.

Leatherman, S.P.

- 1985 “Geomorphic and Stratigraphic Analysis of Fire Island, New York.” *Marine Geol.* 63:173–195.

Leatherman, S., and P. Godfrey

- 1979 *The Impact of Off-Road Vehicles on Coastal Ecosystems in Cape Cod National Seashore: An Overview*. UM/NPSCRU Report No. 34. 34 pp.

Lima, S.L.

- 2009 “Predators and the Breeding Bird: Behavioral and Reproductive Flexibility Under the Risk of Predation.” *Biological Reviews*, 84, 485-513

Lippson, A.J., and R.L. Lippson

- 1997 *Life in the Chesapeake Bay*. Second edition. Johns Hopkins University Press.

Loefering, J.P.

- 1992 Piping plover breeding biology, foraging ecology, and behavior on Assateague Island National Seashore, Maryland. M.S. thesis, Virginia Polytechnic Institute and State University, Blacksburg, VA.

References

Loegering, J.P., and J.D. Fraser

- 1995 "Factors Affecting Piping Plover Chick Survival in Different Brood-Rearing Habitats." *J. of Wildl. Mgmt.* 59(4):646–655.

Loegering, J.P., J.D. Fraser, and L.L. Loegering

- 1995 "Ghost Crab Preys on a Piping Plover Chick." *Wilson Bull.* 107:768–769.

Long Island Botanical Society (LIBS)

- 1992 "Seabeach Amaranth: It Survives!" In *Long Island Botanical Society Newsletter* Vol. 2, No. 6. November–December 1992.

Loomis, J.B., and D.S. White

- 1996 "Economic Benefits of Rare and Endangered Species: Summary and Meta-Analysis." *Ecol. Econ.* 18:197–206.

Lott, C.A., C.S. Ewell, Jr., and K.L. Volansky

- 2009 "Habitat Associations of Shoreline Dependent Birds in Barrier Island Ecosystems during Fall Migration in Lee County, Florida." Prepared for U.S. Army Corps of Engineers, Engineer Research and Development Center, Technical Report. 103 pp.

Lyons, M., National Park Service (Cape Hatteras National Seashore)

- ~~2005a — Pers. comm. with S. Smith, LBG. October 7, 2005.~~

- 2005b Pers. comm. with S. Smith, The Louis Berger Group ~~LBG~~, during Internal Scoping Meeting regarding seabeach amaranth and where it is normally found within the Seashore. September 28, 2005.

Majka, C.G., and F. Shaffer

- 2008 "Beetles (Coleoptera) in the Diet of Piping Plovers in the Iles de la Madeleine, Québec, Canada." *Wader Study Group Bull.* 115(2):77–83.

MANEM (Mid-Atlantic/New England/Maritimes)

- 2006 *Waterbird Conservation Plan for the Mid-Atlantic/New England/Maritimes Region.*

Manning, P.

- 2004 "North Carolina's Coastal Plain." *Audubon North Carolina – Important Bird Areas of North Carolina.*

Martin, R.E.

- 1996 "Storm Impacts on Loggerhead Turtle Reproductive Success." *Marine Turtle Newsletter* 73:10–12.

Martin, L., Hydrogeologist, Water Resources Division, National Park Service

- 2003b Pers. comm. with the Superintendent of Cape Hatteras National Seashore regarding the Hydrology of the Buxton Woods and Cape Hatteras Areas. October 23, 2003.

McGowan, C.P.

- 2004 Factors affecting nesting success of American oystercatchers (*Haematopus palliatus*) in North Carolina. M.S. thesis, North Carolina State University, Raleigh, NC.

McGowan, C.P., and T.R. Simons

- 2006 “Effects of Human Recreation on the Incubation Behavior of American Oystercatchers.” *Wilson J. of Ornith.* 118:485–493.

McGowan, C.P., T.R. Simons, W. Golder, and J. Cordes

- 2005 “A Comparison of American Oystercatcher Reproductive Success on Barrier Beach and River Island Habitats in Coastal North Carolina.” *Waterbirds* 28:150–155.

Meekins, J.

- 2005 Pers. comm—at internal scoping with ~~LBG~~The Louis Berger Group regarding nighttime ORV use at the Seashore. September 29, 2005.

Melvin, S.M., L.H. McIvor, A. Hecht, and C.R. Griffin

- 1994 “Piping Plover Mortalities Caused by Off-Road Vehicles on Atlantic Coast Beaches.” *Wildl. Soc. Bull.* 22:409–414.

Meyer de Schauensee, R., and W.H. Phelps Jr.

- 1978 *A Guide to the Birds of Venezuela*. Princeton, NJ: Princeton University Press.

Michigan State University

- n.d. Money Generation Model. <http://web4.msue.msu.edu/mgm2/default.htm>

Miller, J.D.

- 1997 “Reproduction in Sea Turtles.” In *The Biology of the Sea Turtle*, ed. P.L. Lutz and J.A. Musick, 51–81. Boca Raton, FL: CRC Press.

Miller, J.D., C.J. Limpus, and M.H. Godfrey

- 2003 “Nest Site Selection, Oviposition, Eggs, Development, Hatching, and Emergence of Loggerhead Turtles.” In *Loggerhead Sea Turtles*, ed. A.B. Bolten and B.E. Witherington, 125–143. Washington, D.C.: Smithsonian Books.

Minnesota IMPLAN Group, Inc. (MIG)

- 2004a *IMPLAN Professional, Version 2.0 Social Accounting and Impact Analysis Software: Data Guide*. Third edition. 1725 Tower Drive West, Suite 140, Stillwater, MN 55082.
- 2004b *IMPLAN System* (2004 software and 2004 North Carolina State IMPLAN data). 1725 Tower Drive West, Suite 140, Stillwater, MN 55082. <http://www.implan.com>

Molina, K.C., J.F. Parnell, and R.M. Erwin

- 2009 “Gull-Billed Tern (*Sterna nilotica*).” In *The Birds of North America Online*, ed. A. Poole. Ithaca, NY: Cornell Lab of Ornithology. <http://bna.birds.cornell.edu/bna/species/140>

References

Morrier, A., and R. McNeil

- 1991 "Time-Activity Budget of Wilson's and Semipalmated Plovers in a Tropical Environment." *Wilson Bull.* 103:598–620.

Morrison, R.I.G., and R.K. Ross

- 1989 "Atlas of Nearctic Shorebirds on the Coast of South America." *Can. Wildl. Serv. Spec. Publ.* 1(2). 2 vols. 325 pp.

Morrison, R.I.G., R.K. Ross, and L.J. Niles

- 2004 "Declines in Wintering Populations of Red Knots in Southern South America." *Condor* 106:60–70.

Moss, D., and D.P. McPhee

- 2006 "The Impacts of Recreational Four-Wheel Driving on the Abundance of the Ghost Crab (*Ocypode cordimanus*) on Subtropical Sandy Beaches in SE Queensland." *Coastal Mgmt.* 34(1):133–140.

Mrosovsky, N.

- 1968 "Nocturnal Emergence of Hatchling Sea Turtles: Control by Thermal Inhibition of Activity." *Nature* 220(5174):1338–1339.
- 1988 "Pivotal Temperatures for Loggerhead Turtles (*Caretta caretta*) from Northern and Southern Nesting Beaches." *Can. J. of Zool.* 66(3):661–669.

Mrosovsky, N., S.R. Hopkins-Murphy, and J.I. Richardson

- 1984 "Sex Ratio of Sea Turtles: Seasonal Changes." *Science* 225:739–741.

Muiznieks, B.

- 2009 Pers. comm. via email with D. Wetmore about Wilson's plover breeding. August 31, 2009.
- 2010a Pers. comm. via email with S. Hamilton, NPS Environmental Quality Division, about 2010 piping plover and American oystercatcher breeding numbers for the season. August 27, 2010.
- 2010b Pers. comm. via phone call with S. Hamilton and D. Wetmore, NPS Environmental Quality Division on August 27, 2010, providing information about the number of loggerhead, green and leatherback sea turtle nests documented at the Seashore during the 2010 nesting season as of August 27, 2010, including date of first nest laid during 2010.
- 2010c Pers. comm. via email with D. Wetmore, NPS Environmental Quality Division, providing information relating to the percentage of turtle nests relocated each year at the Seashore since 2000 and the reasons for the relocation. July 22, 2010.
- 2010d Pers. comm. via email with S. Hamilton, NPS Environmental Quality Division, and Mike Murray, Cape Hatteras National Seashore, providing information on the number of colonial waterbird nests in the 2010 breeding season. September 21, 2010.

2010e Pers. comm. via email with S. Hamilton, NPS Environmental Quality Division, comments on the internal draft FEIS regarding nonbreeding American oystercatcher numbers. October 6, 2010.

2010f Pers. comm. via email with M. Murray, Cape Hatteras National Seashore, transmitting comments on the first internal draft FEIS regarding flooding at South Point that resulted in the loss of piping plover nests. October 6, 2010.

Murphy, R.K., I.M.G. Michaud, D.R.C. Prescott, J.S. Ivan, B.J. Anderson, and M.L. French-Pombier
2003 "Predation on Adult Piping Plovers at Predator Exclusion Cages." *Waterbirds* 26:150–155.

Murray, M., NPS National Park Service (Cape Hatteras National Seashore)

2008 Pers. comm. via email with The Louis Berger Group LBG regarding the first and last turtle nests at Cape Hatteras National Seashore from 1998 through 2008.

2009a Pers. comm. via email with S. Hamilton, NPS. Subject: Vehicle Incident 2009. November 24, 2009.

2009b Pers. comm. via email with D. Wetmore, The Louis Berger Group LBG, regarding November visitation statistics. December 11, 2009.

National Audubon Society

2005 "Waterbirds: Wilson's Plover." Accessed December 23, 2008:
<http://web1.audubon.org/waterbirds/species.php?speciesCode=wilplo>

National Marine Fisheries Service and U.S. Fish and Wildlife Service (NMFS and USFWS)

1991 *Recovery Plan for U.S. Population of Atlantic Green Turtle*. National Marine Fisheries Service, Washington, D.C. 52 pp.

1992a *Recovery Plan for Leatherback Turtles in the U.S. Caribbean, Atlantic, and Gulf of Mexico*. National Marine Fisheries Service, Washington, D.C. 65 pp.

1992b *Recovery Plan for the Kemp's Ridley Sea Turtle (Lepidochelys kempii)*. National Marine Fisheries Service, St. Petersburg, FL.

1993 *Recovery Plan for the Hawksbill Turtles in the U.S. Caribbean, Atlantic Ocean, and Gulf of Mexico (Eretmochelys imbricata)*. National Marine Fisheries Service, St. Petersburg, FL.

2008~~a~~ *Recovery Plan for the Northwest Atlantic Population of the Loggerhead Sea Turtle (Caretta caretta)*. Second revision. Silver Spring, MD.

National Oceanic and Atmospheric Administration (NOAA)

2009 "Chronological List of All Hurricanes Which Affected the Continental United States: 1851–2008."
<http://www.aoml.noaa.gov/hrd/hurdat/ushurrlist18512009.txt>~~<http://www.aoml.noaa.gov/hrd/hurdat/ushurrlist18512008.txt>~~

National Park Service, U.S. Department of the Interior (NPS)

~~in prep—American Oystercatcher Report for 2008–2009. Cape Hatteras National Seashore~~

References

- 1937 Cape Hatteras Enabling Legislation. August 17, 1937.
- 1938 *Prospectus of Cape Hatteras National Seashore*. March 1938.
- 1956 *Mission 66 Prospectus, Cape Hatteras National Seashore Recreational Area*. April 1956.
- 1978a *Draft Interim Management Plan: Off-Road Vehicle Use, Cape Hatteras National Seashore*. Manteo, North Carolina. November 1978.
- 1978b *A Proposed New Plan for Management of Off-Road Recreational Vehicle Use in Cape Hatteras National Seashore*. January 1978.
- 1979 *Cape Hatteras National Seashore Environmental Analysis of Off-Road Vehicle Use with Alternatives*. Prepared by Tony Barnes, Landscape Architect, Denver Service Center. August 1979.
- 1980 *ORV Plan North District Cape Hatteras National Seashore*. Prepared by Patrick Reed, North District Ranger. October 1980.
- 1984 *General Management Plan/ Development Concept Plan/ Environmental Assessment Cape Hatteras National Seashore*.
- 1990 *National Park Service: The First Seventy-Five Years*. October 1990 (on-line book).
- 1993 "Cape Hatteras National Seashore Public Use Counting and Reporting Instructions." Counting instructions for 1993 to the present. October 10, 1993.
<http://www.nature.nps.gov/stats/CountingInstructions/CAHACI1993.pdf>
- 1997 *Cape Hatteras National Seashore Resource Management Plan*. December 1997.
- 1998 *NPS 28: Cultural Resource Management Guideline*. National Park Service Office of Policy, Washington, D.C.
- 2000a *Director's Order #47: Soundscape Preservation and Noise Management*. Accessed December 15, 2008: <http://www.nps.gov/policy/DOrders/DOrder47.html>
- 2000b 1999 Sea Turtle Breeding and Stranding Summary, Cape Hatteras National Seashore. Unpublished annual report. National Park Service, Buxton, NC.
- 2000c 1999 Colonial Waterbird Breeding Summary. Cape Hatteras National Seashore.
- 2001a *Director's Order 12 and Handbook: Conservation Planning, Environmental Impact Analysis, and Decision Making*. Washington, D.C. January 2001.
- 2001b 2000 Piping Plover Breeding Activities. Cape Hatteras National Seashore.
- 2001c 2000 Sea Turtle Summary, Breeding and Stranding Activities, Cape Hatteras National Seashore. Unpublished annual report. National Park Service, Buxton, NC. 15 pp.
- 2001d 2000 Seabeach Amaranth Survey, Cape Hatteras National Seashore.

- 2002a Outer Banks Group Parks Visitor Study, Cape Hatteras National Seashore Visitors. Visitor Services Project, University of Idaho Park Studies Unit.
- 2002b 2001 Piping Plover Breeding Activities. Cape Hatteras National Seashore.
- 2002c 2001 Sea Turtle Summary, Breeding and Stranding Activities, Cape Hatteras National Seashore.
- 2002d *Director's Order #77-1: Wetland Protection*. Washington, D.C. October 30, 2002.
- 2002e 2001 Colonial Waterbird Breeding Summary, Cape Hatteras National Seashore.
- 2003a *Cape Hatteras Light Station, Cape Hatteras National Seashore Cultural Landscape Report*. National Park Service, Southeast Regional Office, Cultural Resources Division.
- 2003b 2002 Colonial Waterbird Breeding Summary. Cape Hatteras National Seashore.
- 2003c Director's Order #77-2: Floodplain Management. September 8, 2003.
- 2003d 2002 Piping Plover Activities. Cape Hatteras National Seashore.
- 2003e 2002 Sea Turtle Summary, Breeding and Stranding Activities, Cape Hatteras National Seashore.
- 2004a *Off-Road Vehicle Beach Access Ramp History 1978 to 2004*. Draft. Cape Hatteras National Seashore.
- 2004b *Synopsis: Off-Road Vehicle Planning, Cape Hatteras National Seashore*. Prepared by Steve Harrison, Chief. Resource Management. April 2004.
- 2004c *Superintendent's Order #07: ORV Management*. May 2004.
- 2004d 2003 Sea Turtle Summary Breeding and Stranding Activities Cape Hatteras National Seashore.
- 2004e 2003 Piping Plover Activities. Cape Hatteras National Seashore.
- 2004f 2003 American Oystercatcher Breeding Activity. Cape Hatteras National Seashore.
- 2004g 2003 Colonial Waterbird Breeding Summary. Cape Hatteras National Seashore.
- 2005a 2004 Piping Plover Activities. Cape Hatteras National Seashore.
- 2005b *Cape Hatteras National Seashore Strategic Plan: October 1, 2005 – September 30, 2008*.
- 2005c 2004 Sea Turtle Summary, Breeding and Stranding Activities, Cape Hatteras National Seashore.
- 2005d 2004 Colonial Waterbird Breeding Summary, Cape Hatteras National Seashore
- 2005e 2004 American Oystercatcher Breeding Activity. Cape Hatteras National Seashore.

References

- 2006a *Cape Hatteras National Seashore Interim Protected Species Management Strategy/Environmental Assessment*. January 18, 2006.
- 2006b *Biological Assessment of the Interim Protected Species Management Strategy: Cape Hatteras National Seashore*. National Park Service. January 2006.
- 2006c *NPS Management Policies 2006*. U.S. Department of the Interior, National Park Service, Washington, D.C.
- 2006d Piping Plover (*Charadrius melodus*) Monitoring at Cape Hatteras National Seashore. Draft 2005 Summary Report.
- 2006e Turtle Nest and False Crawl Data for Calendar Year 2005. Cape Hatteras National Seashore
- 2006f *Cape Lookout National Seashore Interim Protected Species Management Plan / Environmental Assessment*. March 2006.
- 2006g 2005 Colonial Waterbird Breeding Summary, Cape Hatteras National Seashore.
- 2007a *Finding of No Significant Impact Interim Protected Species Management Strategy/Environmental Assessment, Cape Hatteras National Seashore, North Carolina*. July 13, 2007.
- 2007b *Strategic Plan for Cape Hatteras National Seashore October 1, 2006 – September 30, 2011*.
- 2007c Piping Plover (*Charadrius melodus*) Monitoring at Cape Hatteras National Seashore. 2006 Annual Report.
- 2007d Cape Hatteras National Seashore Long-Range Interpretive Plan. September 2007.
- 2007e 2006 Sea Turtle Summary, Breeding and Stranding Activities, Cape Hatteras National Seashore.
- 2007f The Creation and Establishment of Cape Hatteras National Seashore. Cape Hatteras National Seashore Administrative History. Prepared by Cameron Binkley, Southeast Regional Office, Cultural Resource Division. August 2007.
- 2007g 2006 Colonial Waterbird Breeding Summary, Cape Hatteras National Seashore.
- 2007h Cape Hatteras National Seashore 2006 Annual Piping Plover (*Charadrius melodus*) Report.
- 2007i Cape Hatteras National Seashore Seabeach Amaranth Surveys – 2006 Annual Report.
- 2007j NPS: Nature and Science – Air Resources Division: Natural Lightscapes. Updated January 15, 2007. <http://www.nature.nps.gov/air/lightscapes>
- 2008a Cape Hatteras National Seashore 2007 Sea Turtle Annual Report.
- 2008b *Procedural Manual #77-1: Wetland Protection*. Reissued February 2008.

- 2008c Cape Hatteras National Seashore 2007 Annual Piping Plover (*Charadrius melodus*) Report.
- 2008d 2007 Colonial Waterbird Breeding Summary.
<http://www.nps.gov/caha/naturescience/protected-species-2007-annual-reports.htm>
- 2008e National Park Service Public Uses Statistics Office. Accessed July 2008:
<http://www.nature.nps.gov/stats/>
- 2008f Night Sky Team Site Visit to Cape Hatteras National Seashore, National Park Service Night Sky Program.
- 2008g “Cape Hatteras National Seashore ORV Access Information.” Accessed July 2008:
<http://www.nps.gov/caha/planyourvisit/orv-access-information.htm>
- 2008h *Cape Hatteras National Seashore Press Release: A Sixth Deliberate Violation of Resource Protection Area*. July 31, 2008. <http://www.nps.gov/caha/parknews/a-sixth-deliberate-violation-of-resource-protection-area.htm>
- 2008i Cape Hatteras National Seashore 2007 Annual Piping Plover (*Charadrius melodus*) Report.
- 2008j Cape Hatteras National Seashore Seabeach Amaranth Surveys – 2007 Annual Report.
- 2008k Current Status of Archeological Sites Listed in ASMIS as of FY 2007. Archeological Sites Management Information System (ASMIS). Midwest Archeological Center.
- 2008l NPS Archeological Sites Management Information System FY 2007.
- 2008m Cape Hatteras National Seashore Resource Management Weekly Field Summary; June 5 to 11, 2008 (Bodie Island, Hatteras, and Ocracoke Districts), p. 4; June 26 to July 2, 2008, p. 4; July 3 to 9, 2008, p. 4; July 17 to 23, 2008; p. 4.
- 2009a Cape Hatteras National Seashore Seabeach Amaranth Surveys 2008 Annual Report.
- 2009b Cape Hatteras National Seashore Piping Plover (*Charadrius melodus*) Monitoring. 2008 Annual Report.
- 2009c Cape Hatteras National Seashore 2008 Sea Turtle Annual Report.
- 2009d National Park Service Beach Access Report for September 10, 2009.
- 2009e Cape Hatteras National Seashore Seabeach Amaranth Surveys. 2008 Annual Report.
- 2009f *Superintendent’s Compendium for Cape Hatteras National Seashore*.
- 2009g Nature and Science, Natural Sounds. Accessed September 10, 2009:
<http://www.nature.nps.gov/naturalsounds/>
- 2009h Nature and Science, Natural Sounds, Understanding Sound. Last updated August 25, 2009. Accessed September 8, 2009: <http://www.nature.nps.gov/naturalsounds/understanding/>

References

- 2009i Nature and Science, Natural Sounds, Sources of Human-Caused Sounds in National Parks. Last updated August 25, 2009. Accessed September 8, 2009: <http://www.nature.nps.gov/naturalsounds/sources/>
- 2009j Nature and Science, Natural Sounds, Effects of Noise. Last updated September 2, 2009. Accessed September 8, 2009: <http://www.nature.nps.gov/naturalsounds/impacts/>
- 2009k 2008 Colonial Waterbird Breeding Summary. <http://www.nps.gov/caha/naturescience/protected-species-2008-annual-reports.htm>
- 2009l National Park Service Public Uses Statistics Office. Accessed February 2009: <http://www.nature.nps.gov/stats/>
- 2009m [Negotiated Rule Making Advisory Committee for Off-Road Vehicle Management at Cape Hatteras National Seashore: Final Report of the Proceedings. Submitted to the National Park Service on behalf of the Committee by Patrick Field, Robert Fisher, and Ona Ferguson, Committee Facilitators, March 20, 2009. Accessible at: http://parkplanning.nps.gov/document.cfm?parkID=358&projectID=10641&documentID=26286](http://parkplanning.nps.gov/document.cfm?parkID=358&projectID=10641&documentID=26286)
- 2009n [American Oystercatcher Report for 2008–2009. Cape Hatteras National Seashore.](#)
- 2010a [Cape Hatteras National Seashore 2009 Sea Turtle Annual Report.](#)
- 2010b [National Park Service News Release. *NPS Seeks Information about Sea Turtle Fatality on Ocracoke June 25, 2010.*](#)
- 2010c [NPS Stats. http://www.nature.nps.gov/stats/park.cfm?parkid=171. Accessed August 2010.](http://www.nature.nps.gov/stats/park.cfm?parkid=171)
- 2010d [Cape Hatteras National Seashore 2009 Piping Plover Annual Report.](#)
- 2010e [Cape Hatteras National Seashore 2009 Seabeach Amaranth Annual Report.](#)
- 2010f [Cape Hatteras National Seashore 2009 American Oystercatcher Summary.](#)
- 2010g [Cape Hatteras National Seashore 2009 Colonial Waterbird Summary.](#)
- 2010h [Interim Guidance for Impairment Determinations in NPS NEPA Documents. 4 pages.](#)
- Neville, A., W.D. Webster, J.F. Gouveia, E.L. Hendricks, I. Hendricks, G. Marvin, and W.H. Marvin. 1988 "The Effects of Nest Temperature on Hatchling Emergence in the Loggerhead Sea Turtle (*Caretta caretta*)." in *Proceedings of the Eight Annual Workshop on Sea Turtle Conservation and Biology*. National Oceanic and Atmospheric Administration Technical Memorandum NMFS-SEFC-214.
- New Jersey Department of Environmental Protection (NJDEP)
- 2005 "Endangered Plants of New Jersey Fact Sheet: Sea-Beach Amaranth (*Amaranthus pumilus*)." New Jersey Department of Environmental Protection, Division of Parks and Forestry, Office of Natural Lands Management. Accessed October 7, 2005: http://www.fws.gov/northeast/nyfo/es/amaranthweb/fact_sheets/NJ.pdf

Nicholls, J.L., and G.A. Baldassarre

- 1990 "Habitat Selection and Interspecific Associations of Piping Plovers Along the Atlantic and Gulf Coasts of the United States." *Wilson Bull.* 102:581–590.

Niles, L.J., H.P. Sitters, A.D. Dey, P.W. Atkinson, A.J. Barker, K.A. Bennett, K.E. Clark, N.A. Clark, C. Espoz, P.M. Gonzalez, B.A. Harrington, D.E. Hernandez, K.S. Kalasz, R. Matus, C.D.T. Minton, R.I.G. Morrison, M.K. Peck, and I.L. Serrano

- 2007 *Status of the Red Knot (Calidris canutus rufa) in the Western Hemisphere*. Report to USFWS, Ecological Services, Region 5, Pleasantville, NJ. 287 pp.

Nisbet, I.C.T.

- 2002 "Common Tern (*Sterna hirundo*)." In *The Birds of North America*, ed. A. Poole and F. Gill. Washington, D.C.: The Academy of Natural Sciences, and Philadelphia, PA: American Ornithologists' Union.

Nol, E.

- 1989 "Food Supply and Reproduction Performance of the American Oystercatcher in Virginia." *Condor* 91:429–435.

Nol, E., and R.C. Humphrey

- 1994 "American Oystercatcher (*Haematopus palliatus*)." In *The Birds of North America Online*, ed. A. Poole. Ithaca, NY: Cornell Lab of Ornithology.
<http://bna.birds.cornell.edu/bna/species/082>

Nol, E., B. Truitt, D. Allen, B. Winn, and T. Murphy

- 2000 "A Survey of Wintering American Oystercatchers from Georgia to Virginia, U.S.A., 1999." *International Wader Study Group Bulletin*. 93: 46-50.

North Carolina Audubon

- 2008 "Protect Beach-Nesting Birds." Accessed July 15, 2008:
<http://nc.audubon.org/ProtectBeachNestingBirds.htm>

North Carolina Department of Commerce

- 2009 "Economic Impact of Travel in North Carolina Based on Visitor Spending." Accessed September 2, 2009:
<http://www.nccommerce.com/en/TourismServices/PromoteTravelAndTourismIndustry/TourismResearch/visitorspending.htm>

North Carolina Department of Conservation and Development, Forestry Division, State Parks Unit (NCD CD)

- 1937 *Master Plan Report to Accompany Master Plan for Cape Hatteras State Park*. Prepared by T.W. Morse, Assistant in Charge of State Parks. February 1937.

North Carolina Department of Crime Control and Public Safety (NCDCCPS)

- 2008 *North Carolina Floodplain Management: 2008 Quick Guide*.

References

North Carolina Department of Environment and Natural Resources (NCDENR)

- 2008a “Coastal Wetlands: Get to Know Them.” Accessed June 18, 2008:
<http://dcm2.enr.state.nc.us/wetlands/know.htm>
- 2008b “Wetlands: Their Functions and Values in Coastal North Carolina.” Accessed June 18, 2008: <http://dcm2.enr.state.nc.us/wetlands/brochure.htm>

North Carolina Department of Transportation (NCDOT)

- 2008 NCDOT: Bonner Bridge. Accessed December 2008:
<http://www.ncdot.org/projects/bonnerbridgerepairs/>

North Carolina Division of Marine Fisheries (NCDMF)

- 2009 State Fishing Regulations. <http://www.ncfisheries.net/index.html>

North Carolina Natural Heritage Program (NCNHP)

- 2006 Natural Heritage Program List of Rare Species of North Carolina.
<http://www.ncnhp.org/Pages/publications.html>

North Carolina Office of State Archaeology (OSA)

- 2008 Cape Hatteras National Seashore Beach Shipwrecks. UAB catalog list. Accessed January 5, 2008.

North Carolina Wildlife Resources Commission (NCWRC)

- 2005 *North Carolina Wildlife Action Plan*. Raleigh, NC.
- 2006 *Handbook for Sea Turtle Volunteers in North Carolina*. North Carolina Wildlife Resources Commission, Raleigh, NC. 44 pp.
- 2007 [2007 Survey of Nesting Colonial Waterbirds in the North Carolina Coastal Zone along with an Updating of the Colonial Waterbird Database. Final Report to the U. S. Army Corps of Engineers, Wilmington District](#)
- 2008a *North Carolina Piping Plover Breeding Summary, 2008*.
- 2008b *Protected Wildlife Species of North Carolina*. North Carolina Wildlife Resources Commission, Raleigh, NC. 8 pp.
- 2009 “Coastal Recreational Fishing License Sales Update.” North Carolina Marine Fisheries. Release date: May 31, 2009.
http://www.ncfisheries.net/CRFL/downloads/CRFLSalesReportMay_31_2009.pdf

Nudds, R.L. and D.M. Bryant

- 2000 “The Energetic Cost of Short Flight in Birds.” *Journal of Experimental Biology* 203:1561-1572.

Office of State Budget and Management, North Carolina

- 2009 “Projected Annual County Population Totals.” Accessed September 1, 2009:
http://www.osbm.state.nc.us/ncosbm/facts_and_figures/socioeconomic_data/population_estimates.shtm

Outer Banks Chamber of Commerce

- 2008 “Tour Briefs.” Accessed December 11, 2008:
<http://www.outerbankschamber.com/relocation/history/tourbriefs.cfm>

Outer Banks Task Force (OBTF)

- 2007 “New Bonner Bridge Public Hearings Schedules with Focus on Two New Alternatives.”
Bonner Bridge Update Newsletter.
http://www.obtf.org/SpecialConcerns/BonnerBridge/pdf/February2007_NL.pdf
- 2009 “NC 12 Hot Spots.” Accessed June 2009: <http://www.obtf.org/nc12hotspots/hotspot.html>

Outer Banks Visitors Bureau

- 2010a Dare County Gross Occupancy by District.
http://www.outerbanks.org/about_us/visitors_bureau/
- 2010b Dare County Gross Meals by District.
http://www.outerbanks.org/about_us/visitors_bureau/

Owens, C., District Planner, NCDENR

- 2010 Pers. comm. via email with D. Wetmore, [The Louis Berger Group](#) ~~LBG~~, regarding Dare County Land Use Plan. February 1, 2010.

Page, G.W., L.E. Stenzel, G.W. Page, J.S. Warriner, J.C. Warriner, and P.W. Paton

- 2009 Snowy Plover (*Charadrius alexandrinus*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: <http://bna.birds.cornell.edu/bna/species/154doi:10.2173/bna.154>

Parnell, J.F., and Committee

- 1977 “Birds.” In *Endangered and Threatened Plants and Animals of North Carolina*, ed. J. Cooper, S. Robinson, and J. Funderburg, 330–384. North Carolina State Museum of Natural History, Raleigh, NC.

Parnell, J.F., R.M. Erwin, and K.C. Molina

- 1995 “Gull-Billed Tern (*Sterna nilotica*).” In *The Birds of North America Online*, ed. A. Poole. Ithaca, NY: Cornell Lab of Ornithology. <http://bna.birds.cornell.edu/bna/species/140>

Patterson, M.E., J.D. Fraser, and J.W. Roggenbuck

- 1991 “Factors Affecting Piping Plover Productivity on Assateague Island.” *J. of Wildl. Mgmt.* 55:525–531.

Paulson, D.

- 1993 *Shorebirds of the Pacific Northwest*. Seattle, WA: University of Washington Press.

References

Pendleton, E., R. Theiler, and J. Williams

- 2005 *Coastal Vulnerability Assessment of Cape Hatteras National Seashore (CAHA) to Sea-Level Rise*. Open-File Report 2004-1064.

Peters, K.A., and D.L Otis

- 2006 "Wading Bird Response to Recreational Boat Traffic: Does Flushing Translate into Avoidance?" *Wildlife Society Bulletin* 34(5):1383-1391.

Pipkin, K., North Carolina Wildlife Resources Commission

- 2009 Pers. comm. via email with D. Wetmore, LBGThe Louis Berger Group, providing the date when the American oystercatcher was listed by the state of North Carolina as a species of special concern. January 2, 2009.

Population Division, U.S. Census Bureau

- 2009a "Annual Estimates of Resident Population Change for Counties of North Carolina and County Rankings: April 1, 2000, to July 1, 2008 (CO-EST2008-POPCHG2000_2008-37)." Release Date: March 19, 2009. <http://www.census.gov/popest/estimates.php>
- 2009b "HU-EST2008: State Housing Unit Estimates: April 1, 2000, to July 1, 2008." Release Date: August 6, 2009. <http://www.census.gov/popest/housing/files/HU-EST2008.CSV>
- 2009c "HU-EST2008-37: Housing Unit Estimates for Counties of North Carolina April 1, 2000, to July 1, 2008." Release Date: August 6, 2009. <http://www.census.gov/popest/housing/files/HU-EST2008-37.CSV>

Rabin, L.A., R.G. Coss, and D.H. Owings

- 2006 "The Effects of Wind Turbines on Antipredator Behavior in California Ground Squirrels (*Spermophilus beecheyi*)." *Biological Conservation* 131:410-420.

Rabon, D.R., S. Johnson, R. Boettcher, M. Dodd, M. Lyons, S. Murphy, S. Ramsey, S. Roff, and K. Stewart

- 2003 "Confirmed Leatherback Turtle (*Dermochelys coriacea*) Nests from North Carolina, with a Summary of Leatherback Nesting Activities North of Florida." *Marine Turtle Newsletter* 101, July 2003.

Raffaele, H., J. Wiley, O. Garrido, A. Keith, and J. Raffaele

- 1998 *A Guide to the Birds of the West Indies*. Princeton, NJ: Princeton University Press.

RealtyTrac

- 2008 "Properties with Foreclosure Filings in October, 2008: North Carolina." Accessed December 10, 2008: <http://www.realtytrac.com/>

Reijnen R., R. Foppen, C ter Braak and J. Thissen-

- 1995 "The Effects of Car Traffic on Breeding Bird Populations in Woodland Ill. Reduction of Density in Relation to Proximity of Main Roads." *J. Applied Ecology*. 32:187-202.

Rheindt, F.E.

- 2003 “The Impact of Roads on Birds: Does Song Frequency Play a Role in Determining Susceptibility to Noise Pollution?” *Journal Fur Ornithologie* 144, 295-306.

Riggs, S.R., and D.V. Ames

- 2003 *Drowning the North Carolina Coast: Sea-Level Rise and Estuarine Dynamics*. North Carolina Sea Grant College Program Pub. No. UNC-SG-03-04. 152 pp.

Riggs, S.R., D.V. Ames, S.J. Culver, D.J. Mallinson, D.R. Corbett, and J.P. Walsh

- 2009 “Eye of a Human Hurricane: Pea Island, Oregon Inlet, and Bodie Island, Northern Outer Banks, North Carolina.” In *America’s Most Vulnerable Coastal Communities: Geological Society of America Special Paper 460*, ed. F.T. Kelley, O.H. Pilkey, and J.A.G. Cooper, 43–72. DOI: 10.1130 /2009.2460(04).

Riggs, S.R., S.J. Culver, D.V. Ames, D.J. Mallinson, D.R. Corbett, and J.P. Walsh

- 2008 *North Carolina’s Coasts in Crisis: A Vision for the Future*. East Carolina University. 26 pp.

Rodgers, J.A., Jr., and S.T. Schwikert

- 2002 “Buffer-Zone Distances to Protect Foraging and Loafing Waterbirds from Disturbance by Personal Watercraft and Outboard-Powered Boats.” *Conserv. Biol.* 16:216–224.

Rodgers, J.A., Jr., and H.T. Smith

- 1995 “Set-Back Distances to Protect Nesting Bird Colonies from Human Disturbance in Florida.” *Conserv. Biol.* 9:89–99.
- 1997 “Buffer Zone Distances to Protect Foraging and Loafing Waterbirds from Human Disturbance in Florida.” *Wildl. Soc. Bull.* 25(1): 139–145.

Research Triangle Institute, International (RTI)

- 2009a Pers. comm. via e-mail with-between N. VanDyke of the Louis Berger Group and R. Loomis of RTI regarding visitation data and data sources. April 7, 2009.

- 2009b Pers. comm. via email between N. VanDyke of the Louis Berger Group and with-R. Loomis of RTI regarding estimate of ORV use in summer months. April 20, 2009.

- 2009c Pers. comm. via email between N. VanDyke of the Louis Berger Group and with-C. Mansfield of RTI regarding ORV passenger estimates. April 21, 2009.

- 2010a Visitor Intercept Survey: Off-Road Vehicle Management, Cape Hatteras National Seashore Final Report. Prepared for the National Park Service by Carol Mansfield, Ross Loomis, Brian Evans and Breda Munoz. Research Triangle Park, NC.

- 2010b Ramp Counts: Off-Road Vehicle Management, Cape Hatteras National Seashore Final Report. Prepared for the National Park Service by Carol Mansfield, Ross Loomis, Brian Evans and Breda Munoz. Research Triangle Park, NC. September 2010.

References

- 2010 c Business Survey: Off-road Vehicle Management, Cape Hatteras National Seashore. August 2010.
- Ruppert, E.E., and R.S. Fox
1988 *Seashore Animals of the Southeast*. University of South Carolina Press. 429 pp.
- Sabine, J.B., III
2005 Effects of human activity and predation on breeding American oystercatchers. Thesis, University of Georgia, Athens, GA.
- Sabine, J.B., J.M. Meyers, C.T. Moore, and S.H. Schweitzer
2008 “Effects of Human Activity on Behavior of Breeding American Oystercatchers, Cumberland Island National Seashore, Georgia, USA.” *Waterbirds* 31(1):70–82.
- Sabine, J.B., S.H. Schweitzer, and J.M. Meyers
2006 “Nest Fate and Productivity of American Oystercatchers, Cumberland Island National Seashore, Georgia.” *Waterbirds* 29:308–314.
- Safina, C., and J. Burger
1983 “Effects of Human Disturbance on Reproductive Success in the Black Skimmer.” *Condor* 85:164–171.
- Sayles, K., National Park Service (Cape Hatteras National Seashore)
2005 Pers. comm. via email with S. Smith, [LBGThe Louis Berger Group](#), providing unpublished annual sea turtle data for the year 2005 at Cape Hatteras National Seashore. November 19, 2005.
- Schroeder, B.A., A.M. Foley, and D.A. Bagley
2003 “Nesting Patterns, Reproductive Migrations, and Adult Foraging Areas of Loggerhead Turtles.” In *Loggerhead Sea Turtles*, ed. A.B. Bolten and B.E. Witherington, 114–124. Washington, D.C.: Smithsonian Books.
- Schulte, S., S. Brown, D. Reynolds, and the American Oystercatcher Working Group
2007 *A Conservation Action Plan for the American Oystercatcher (Haematopus palliatus) for the Atlantic and Gulf Coasts of the United States*. Version 2.0. June 2007. Accessed December 20, 2009:
[http://www.fws.gov/migratorybirds/CurrentBirdIssues/Management/FocalSpecies/Plans/A MOY.pdf](http://www.fws.gov/migratorybirds/CurrentBirdIssues/Management/FocalSpecies/Plans/A%20MOY.pdf)
- Schweitzer, S. (North Carolina Wildlife Resources Commission)
2010 Pers. comm. via email to Sandy Hamilton, NPS Environmental Quality Division, regarding the initial number of piping plover breeding pairs in the state of North Carolina in 2010.
- Seaturtle.org
2010 Sea Turtle Nest Monitoring System, North Carolina WRC Sea Turtle Project. Accessed August 30, 2010: <http://www.seaturtle.org/nestdb/index.shtml?view=1>.

Shields, M.A., and J.F. Parnell

- 1990 “March Nesting by American Oystercatchers in North Carolina.” *J. Field Ornith.* 61:431–433.

Simons, T.R., and S. Schulte

- 2007 *American Oystercatcher (Haematopus palliatus) Research and Monitoring in North Carolina: 2007 Annual Report.* USGS North Carolina Cooperative Fish and Wildlife Research Unit.
- 2008 *American Oystercatcher (Haematopus palliatus) Research and Monitoring in North Carolina: 2008 Annual Report.* USGS North Carolina Cooperative Fish and Wildlife Research Unit.

Slabbekoorn, H., and A. den Boer-Visser

- 2006 “Cities Change the Songs of Birds.” *Curr. Biol.* 16(23):2326–2331. December 5, 2006.

Smith, B.S.

- 2007 2006-2007 Nonbreeding Shorebird Survey, Franklin and Wakulla Counties, Florida. Final Report to the U.S. Fish and Wildlife Service in fulfillment of Grant # 40181-7-J008. Apalachicola Riverkeeper, Apalachicola, Florida. 32 pp.

South Carolina Department of Natural Resources (SCDNR)

- 2009 Species Descriptions: Coquina Clam. Accessed April 2009:
<http://www.dnr.sc.gov/cwcs/species.html>
- 2010 Sea Turtle Nest Monitoring System South Carolina DNR Sea Turtle Conservation Program. Accessed at: <http://www.seaturtle.org/nestdb/?view=2>. Accessed on August 23, 2010.

Spaans, A.L.

- 1978 “Status and Numerical Fluctuations of Some North American Waders Along the Surinam Coast.” *Wilson Bull.* 90:60–83.

Staine, K.J., and J. Burger

- 1994 “Nocturnal Foraging Behavior of Breeding Piping Plovers (*Charadrius melodus*) in New Jersey.” *Auk* 111(3):579–587.

Stanley, R., NPS Soundscapes Program

- 2009 Pers. comm. October 28, 2009.

Statistics of U.S. Businesses, U.S. Census Bureau (SUSB)

- 2002—Number of firms, number of establishments, employment, annual payroll, and receipts by receipt size of the enterprise for the United States, all industries: 2002.
http://www2.census.gov/econ/susb/data/2002/us_6digitnaics_receipt_2002.xls

References

Steiner, A.J., and S.P. Leatherman

- 1981 "Recreational Impacts on the Distribution of Ghost Crabs *Ocypode quadrata* Fab." *Biol. Conserv.* 20:111–122.

Stephenson, G.

- 1999 "Vehicle Impacts on the Biota of Sandy Beaches and Coastal Dunes: A Review from a New Zealand Perspective." *Sci. for Conserv.* 121. Department of Conservation, Wellington, New Zealand.

Stevens, P.

- 2005 Pers. comm. with D. Otto, [LBG The Louis Berger Group](#), via fax. Subject: safety closures. December 21, 2005.

Stevenson, H.M., and B.H. Anderson

- 1994 *The Birdlife of Florida*. Gainesville, FL: University Press of Florida.

[Stillman, R., and J.D. Goss-Custard](#)

- [2002 "Seasonal Changes in the Response of Oystercatchers *Haematopus ostralegus* to Human Disturbance." *Journal of Avian Biology*. Vol. 33, No. 4, pp. 358-365](#)

Stover, D., Cape Hatteras National Seashore Cultural Resource Specialist, NPS

- 2008 Pers. comm. via telephone with L. Bambrey, [LBG The Louis Berger Group](#), regarding status of cultural resource studies at Cape Hatteras National Seashore. June 17, 2008.
- 2009 Pers. comm. via email with J. McNiel, NPS, regarding archeology text. November 25, 2009.

Strauch, J.G., Jr., and L.G. Abele

- 1979 "Feeding Ecology of Three Species of Plovers Wintering on the Bay of Panama, Central America." *Studies in Avian Biol.* 2:217–230.

[Suiter, D. \(U.S. Fish and Wildlife Service\)](#)

- [2005 Pers. comm. via email with C. Green, NPS Southeast Region, regarding seabeach amaranth survey data for North Carolina. November 23, 2005.](#)

Sutter, L.

- 1999 *DCM Wetland Mapping in Coastal North Carolina: A Report of the Strategic Plan for Improving Coastal Management in North Carolina*. May 1999.

[Swaddle J.P. and L.C. Page](#)

- [2007 "High Levels of Environmental Noise Erode Pair Preferences in Zebra Finches: Implications for Noise Pollution." *Animal Behaviour* 74, 363-368.](#)

- Tarr, N.M.
 2008 Fall migration and vehicle disturbance of shorebirds at South Core Banks, North Carolina. Thesis, North Carolina State University, Department of Forestry and Environmental Resources.
- Thibault, M., and R. McNeil
 1994 "Daylight Variation in Habitat Use by Wilson's Plovers in Northeastern Venezuela." *Wilson Bull.* 106:299–310.
- Thomas, K., R.G. Kvitek, and C. Bretz
2002 "Effects of Human Activity on the Foraging Behavior of Sanderlings (*Calidris alba*)."
Biological Conservation 109:67-71.
- Thompson, B.C., J.A. Jackson, J. Burger, L.A. Hill, E.M. Kirsch, and J.L. Atwood
 1997 "Least Tern (*Sterna antillarum*)." In *The Birds of North America*, ed. A. Poole and F. Gill. Washington, D.C.: The Academy of Natural Sciences, and Philadelphia, PA: American Ornithologists' Union.
- Thompson, S., National Park Service (Cape Hatteras National Seashore)
 2008 Pers. comm. with D. Wetmore, LBGThe Louis Berger Group, regarding fishing tournaments authorized at the Seashore. December 22, 2008.
- Toland, B.
 1999 "Nest Site Characteristics, Breeding Phenology, and Nesting Success of American Oystercatchers in Indian River County, Florida." *Fla. Field Nat.* 27:112–116.
- Tomkins, I.R.
 1944 "Wilson's Plover in Its Summer Home." *Auk* 61:259–269.
- Traut, A., J. McCann, and D. Brinker
 2006 "Breeding Status and Distribution of American Oystercatchers in Maryland." *Waterbirds* 29:302–307.
- Tsipoura, N., and J. Burger
 1999 "Shorebird Diet during Spring Migration Stopover on Delaware Bay." *Condor* 101:635–644.
- Trevino, Mike (Cape Hatteras National Seashore)
2010 Pers. comm. via email with L. Fox, The Louis Berger Group, regarding ORV counts for Memorial Day and Labor Day in 2008.
- U.S. Army Corps of Engineers (USACE)
 2002 *Manteo (Shallowbag Bay) Project Maintenance of Oregon Inlet Bar Channel, Channel Widener Dare County, North Carolina*. Environmental Assessment. February 2002.

References

U.S. Census Bureau (Census)

- 2000a “Census 2000 Summary File 3 (SF3) – Sample Data” Generated by RTI International using American FactFinder. Accessed December 5, 2008: <http://factfinder.census.gov>
- 2002a “Economic Census—Sector 00: All sectors: Geographic Area Series: Economy-Wide Key Statistics: 2002.” Accessed August 31, 2009: <http://factfinder.census.gov>
- 2002b [Statistics of U.S. Businesses. Number of Firms, Number of Establishments, Employment, Annual Payroll, and Receipts by Receipt Size of the Enterprise for the United States, All Industries: 2002.](http://www2.census.gov/econ/susb/data/2002/us_6digitnaics_receipt_2002.xls)
http://www2.census.gov/econ/susb/data/2002/us_6digitnaics_receipt_2002.xls
- 2004 “Forestry, Fishing and Hunting, and Agricultural Support Services (NAICS 113-115), Hyde County, NC.” Economic Planning and Coordination Division, Nonemployer Statistics. Accessed September 14, 2009:
http://www.census.gov/epcd/nonemployer/2004/nc/NC095_11.HTM
- 2008a Census 2008 Gateway. Accessed November 3, 2008:
<http://www.census.gov/main/www/cen2000.html>
- 2008b [“2006 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation.”](http://www.census.gov/prod/www/abs/fishing.html)
<http://www.census.gov/prod/www/abs/fishing.html>
- 2010 [Generated by RTI International; using American FactFinder; “Sector 00: NS0800A2: 2008 Nonemployer Statistics: Geographic Area Series: Nonemployer Statistics for the US.” Accessed September 1st, 2010: http://factfinder.census.gov](http://factfinder.census.gov)

~~U.S. Department of the Interior, Fish and Wildlife Service, and U.S. Department of Commerce, U.S. Census Bureau~~

~~2008—“2006 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation.”
<http://www.census.gov/prod/www/abs/fishing.html>~~

U.S. Fish and Wildlife Service, U.S. Department of the Interior (USFWS)

- n.d. “Loggerhead Sea Turtles in North Carolina.” Accessed October 19, 2009:
<http://www.fws.gov/nc-es/reptile/logger.html>
- 1988 *Great Lakes and Northern Great Plains Piping Plover Recovery Plan.*
- 1993 Endangered and Threatened Wildlife and Plants; Determination of Seabeach Amaranth (*Amaranthus pumilus*) to a Threatened Species. Federal Register 58(65)18035-18042.
- 1995 [Migratory Nongame Birds of Management Concern in the United States.](http://www.fws.gov/migratorybirds/NewReportsPublications/SpecialTopics/specon/NGBirdMgmtConcern.html)
<http://www.fws.gov/migratorybirds/NewReportsPublications/SpecialTopics/specon/NGBirdMgmtConcern.html>
- 1996a *Piping Plover (Charadrius melodus) Atlantic Coast Population, Revised Recovery Plan.* USFWS Regional Office, Hadley, MA.

- 1996b *Recovery Plan for Seabeach Amaranth (Amaranthus pumilus)*. U.S. Fish and Wildlife Service, Southeast Region, Atlanta, GA.
- 2001 *Statement of the Department of the Interior Concerning the Corps of Engineers Manteo (Shallowbag) Bay Project, Dare County, North Carolina*. Prepared for the Council on Environmental Quality. http://georgewbush-whitehouse.archives.gov/ceq/ceq_supp_state901.pdf
- 2002 *2000–2001 Status Update: U.S. Atlantic Coast Piping Plover Population*. Sudbury, MA. 9 pp.
- 2003 *Recovery Plan for the Great Lakes Piping Plover (Charadrius melodus)*. Ft. Snelling, MN.
- 2004a *2002–2003 Status Update: U.S. Atlantic Coast Piping Plover Population*. Sudbury, MA.
- 2004b *Preliminary 2004 Atlantic Coast Piping Plover Abundance and Productivity Estimates*. <http://www.fws.gov/northeast/pipingplover/status/preliminary.04.pdf>
- 2004c *High Priority Shorebirds. pp 1-5. Unpublished Report. U.S. Fish and Wildlife Service, Arlington, Virginia.*
- 2005a *Preliminary 2005 Atlantic Coast Piping Plover Abundance and Productivity Estimates*. <http://www.fws.gov/northeast/pipingplover/status/preliminary.05.pdf>
- 2005b “Seabeach Amaranth.” Accessed October 7, 2005: <http://www.fws.gov/northeast/nyfo/es/amaranthweb/overview.html>
- 2006a *Biological Opinion on Interim Protected Species Management Strategy*. U.S. Fish and Wildlife Service, Raleigh, NC. August 2006. 112 pp.
- 2006b *Comprehensive Conservation Plan for Pea Island National Wildlife Refuge*. U.S. Fish and Wildlife Service, Southeast Region. September 2006.
- 2006c *2006 Atlantic Coast Piping Plover Abundance and Productivity Estimates*. <http://www.fws.gov/northeast/pipingplover/pdf/final06.pdf>
- 2007a *Amendment to the Biological Opinion for Cape Hatteras National Seashore’s Interim Protected Species Management Strategy*. Raleigh Field Office. April 24, 2007.
- 2007b “The Atlantic Coast Piping Plover.” Online fact sheet. <http://www.fws.gov/northeast/pipingplover/index.html>
- 2007c *2007 Atlantic Coast Piping Plover Abundance and Productivity Estimates*. <http://www.fws.gov/northeast/pipingplover/pdf/final07.pdf>
- 2007d “Seabeach Amaranth (*Amaranthus pumilus*) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Southeast Region, Ecological Services.” Raleigh, North Carolina.
- 2008a *Second Amendment to the Biological Opinion for Cape Hatteras National Seashore’s Interim Protected Species Management Strategy*. Raleigh Field Office. March 28, 2008.

References

2008b “Birds of Conservation Concern 2008.” United States Department of Interior, Fish and Wildlife Service, Division of Migratory Bird Management, Arlington, Virginia. 85 pp. <http://www.fws.gov/migratorybirds/>

2008c *Preliminary 2008 Atlantic Coast Piping Plover Abundance and Productivity Estimates.* <http://www.fws.gov/northeast/pipingplover/status/preliminary.08.pdf>

2009a *Piping Plover (*Charadrius melodus*) 5-year review: Summary and evaluation. Hadley, Massachusetts. 206 pp.*

2009b *Preliminary 2009 Atlantic Coast Piping Plover Abundance and Productivity Estimates.* <http://www.fws.gov/northeast/pipingplover/pdf/preliminary.pdf>

U.S. Shorebird Conservation Plan

~~2004—High Priority Shorebirds—2004, pp. 1–5. Unpublished Report, U.S. Fish and Wildlife Service, Arlington, VA.~~

U.S. Small Business Administration (U.S. SBA)

2008 Table of Small Business Size Standards Matched to North American Industry Classification System Codes. Effective March 11, 2008. <http://www.sba.gov/services/contractingopportunities/sizestandardstopics/size/index.html>

University of Idaho

2003 *Outer Banks Group Parks Visitor Study, Cape Hatteras National Seashore Visitors, Report 136a, University of Idaho, Park Studies Unit.* National Park Service, U.S. Department of the Interior, Visitor Services Project.

2008 *Cape Hatteras NS 2008 Visitor Survey Card Data Report.* Report #CAHA 708.

Verhulst, S., K. Oosterbeek, and B. J. Ens

2001 *Experimental Evidence for Effects of Human Disturbance on Foraging and Parental Care in Oyster-catchers.* *Biological Conservation* 101:375–380.

Vooren, C.M., and A. Chiaradia

1990 “Seasonal Abundance and Behaviour of Coastal Birds on Cassino Beach, Brazil.” *Ornitologia Neotropical* 1:9–24.

Watts, B.D., and D.S. Bradshaw

1995 “Ghost Crabs Prey on Piping Plover Eggs.” *Wilson Bull.* 107:767–768.

Welsh, R. and A.D. Tucker

2009 *Shifting patterns of nocturnal emergence events of nesting loggerhead turtles (*Caretta caretta*).* *Marine Turtle Newsletter* 125:10-12.

Wilke, A., B. Watts, B. Truitt, and R. Boettcher

2005 “Breeding Season Status of the American Oystercatcher in Virginia, USA.” *Waterbirds* 28:3308–315.

- Wilke, A.L., D.F. Brinker, B.D. Watts, A.H. Traut, R. Boettcher, J.M. McCann, B.R. Truitt, and P.P. Denmon
- 2007 “American Oystercatchers in Maryland and Virginia, USA: Status and Distribution.” *Waterbirds* 30 (Special Publication 1): 152–162.
- Wilkinson, P.M., and M. Spinks
- 1994 “Winter Distribution and Habitat Utilization of Piping Plovers in South Carolina.” *Chat* 58:33–37.
- Wisconsin Department of Natural Resources (Wisconsin DNR)
- 2007 “*Phragmites australis* (Common Reed Grass).” Fact sheet produced by the Bureau of Watershed Management. May 2007.
- Witherington, B.E., K.A. Bjorndal, and C.M. McCabe
- 1990 “Temporal Pattern of Nocturnal Emergence of Loggerhead Turtle Hatchlings from Natural Nests.” *Copeia* 4:1165–1168.
- Witherington, B.E., and R.E. Martin
- 1996 *Understanding, Assessing, and Resolving Light-Pollution Problems on Sea Turtle Nesting Beaches*. Florida Marine Research Institute Technical Report TR-2. 73 pp.
- Wolcott, D.L., and T.G. Wolcott
- 1984 “Impact of Off-Road Vehicles on Macroinvertebrates of a Mid-Atlantic Beach.” *Biol. Conserv.* 29: 217–240.
- 1999 “High Mortality of Piping Plovers on Beaches with Abundant Ghost Crabs: Correlation Not Causation.” *Wilson Bull.* 111:321–329.
- Zonick, C.A.
- 2000 The winter ecology of piping plovers (*Charadrius melodus*) along the Texas Gulf Coast. Ph.D. diss., University of Missouri – Columbia.

Intentionally Left Blank



LITERATURE REVIEW: IMPACTS AND MANAGEMENT OF OFF-ROAD VEHICLES

December 2009

Prepared in support of the
Cape Hatteras National Seashore
Off-Road Vehicle Management Plan / Environmental Impact Statement

Table of Contents

INTRODUCTION	A-1
Wildlife and Wildlife Habitat	A-2
Water Quality	A-7
Soils/Dune Ecosystems	A-7
Vegetation and Invasive Species	A-8
Aesthetics/Sound	A-9
Archeological Resources	A-10
Socioeconomics	A-10
Management Issues	A-11
REFERENCES	A-13

Intentionally Left Blank

INTRODUCTION

Officially authorized in 1937 along the Outer Banks of North Carolina, Cape Hatteras National Seashore (the Seashore) is the nation's first national seashore. Consisting of more than 30,000 acres distributed along approximately ~~68~~67 miles of shoreline, the Seashore is part of a dynamic barrier island system.

The Seashore serves as a popular recreation destination with more than 2.1 million visitors in 2008 (NPS 2008e), showing an 8-fold increase in visitation since 1955 (NPS 2007f). Seashore visitors participate in a variety of recreational activities, including beach recreation (sunbathing, swimming, shell collecting, etc.), fishing (surf and boat), hiking, hunting, motorized boating, non-motorized boating (sailing, kayaking, canoeing), nature study, photography, off-road vehicle use (beach driving), shellfishing, sightseeing, watersports (surfing, windsurfing, kiteboarding, etc.), and wildlife viewing. Seashore visitors use ORVs for traveling to and from swimming, fishing, and surfing areas, and for pleasure driving.

Current management practices at the Seashore allow ORV users to drive on the beach seaward of the primary dune line, with a 10 meter backshore areas seaward of the primary dune line protected seasonally. Drivers must use designated ramps to cross between the beach and NC-12 which runs behind the primary dune line. In addition to a multitude of visitor opportunities, the Seashore provides a variety of important habitats created by its dynamic environmental processes, including habitats for the federally-listed piping plover; sea turtles, and one listed plant species, the seabeach amaranth. The Seashore contains ecologically important habitats such as marshes, tidal flats, and riparian areas, and hosts various species of concern such as colonial waterbirds (least terns, common terns, and black skimmers), American oystercatcher, and Wilson's plover, all of which are listed by the North Carolina Wildlife Resources Commission (NCRWRC) as species of special concern. In addition, the gull-billed tern, also found at the Seashore, is listed by the NCRWRC as threatened.

Historically, beach driving at the Seashore was for the purpose of transportation, and not recreation. The paving of NC-12, the completion of the Bonner Bridge connecting Bodie and Hatteras islands in 1963, and the introduction of the State of North Carolina ferry system to Ocracoke Island facilitated visitor access to the sound and ocean beaches. Improved access, increased population, and the popularity of the SUV have resulted in a dramatic increase in vehicle use on Seashore beaches. Motivated in part by a decline in most beach nesting bird populations on the Seashore since the 1990s, in July 2007 the NPS finalized an Interim Protected Species Management Strategy (Interim Strategy) that was to provide resource protection guidance until the long-term ORV management plan and regulation could be completed. ~~There has also been a decline in most beach nesting bird populations on the Seashore since the 1990's.~~

ORV use has increased substantially on public lands nationwide over the last half-century (The Wilderness Society 2006), including at the Seashore. In response to the widespread and rapidly increasing use of ORVs on public lands “often for legitimate purposes but also in frequent conflict with wise land and resource management practices, environmental values, and other types of recreational activity,” Executive Order 11644, *Use of Off-Road Vehicles on the Public Lands*, was issued in 1972 and amended by Executive Order 11989, *Use of Off-Road Vehicles on The Public Lands* in 1977. These executive orders require federal agencies allowing ORVs to designate specific areas and trails on public lands where the use of ORVs is or is not permitted.

In units of the national park system, including the Seashore, the NPS is required to manage according to the NPS *Organic Act*, through which Congress requires the NPS to preserve park resources “unimpaired for the enjoyment of future generations” (16 USC 1). While the Secretary of the Interior has the authority to allow certain activities in park units, those activities must comply with the *General Authorities Act*, which specifies that activities that lead to the “derogation of the values and purposes” of a park unit

should not be allowed (16 USC 1a – 2(h))—language that is mirrored in the *Redwoods Act of 1978* (16 USC 1a-1). This congressional emphasis on uses compliant with park values and purposes is further described in NPS management policies and is vital to policy-based decision-making about land use in national park units.

NPS *Management Policies 2006* includes several guidelines that pertain to monitoring certain uses in park units. Consistent with the Congressional acts, the management policies state that the NPS “must ensure that park uses that are allowed would not cause impairment of, or unacceptable impacts to, park resources and values” (NPS 2006: 1.5). Unacceptable impacts are those that, among other things, “unreasonably interfere with park programs or activities, or an appropriate use, or the atmosphere of peace and tranquility, or the natural soundscape maintained in wilderness and natural, historic, or commemorative locations within the park” (NPS 2006: 1.4.7.1). If unacceptable impacts result from any activity, superintendents are required to “engage in a thoughtful, deliberate process to further manage or constrain the use, or discontinue it” (NPS 2006: 1.5).

While access to public lands improves the experience of ORV users, motorized access to sensitive environments, such as coastal ecosystems, can pose a threat to sensitive species that rely on the beach habitat. Other impacts from motorized access to public lands include adverse effects on water quality, adverse effects on vegetation, impacts to cultural resources, detracting from other visitors’ enjoyment of public lands, and creation of law enforcement issues. ORVs can churn up and damage delicate soils (Proescholdt 2007; Ouren et al. 2007; Webb 1982). Air quality can be negatively affected by exhaust fumes, oil, and dust resulting from ORV use (Taylor n.d.; Proescholdt 2007; Ouren et al. 2007). Loud engines in quiet environments can disturb wildlife and affect visitor enjoyment for those who use parks as places of peace and solace (Proescholdt 2007). Park rangers surveyed during a 1999 study reported incidents where ORV use has destroyed or disturbed cultural resources that parks are bound by law to protect (Bluewater Network 1999). While it is unknown how many coastal park units were included in the study, it can be assumed that such issues also occur in coastal units where ORV traffic is allowed.

This literature review has been prepared to support the development of an ORV management plan at the Seashore. The following sections summarize available information related to the potential effects of ORV use on natural resources, such as wildlife habitat, aesthetics/sound, and vegetation, found in national park units with coastal sand dune ecosystems. Relevant water quality findings are also reported here. In addition, information on the effects of ORV use on socioeconomics and management issues are examined. Because the majority of the area administered as Cape Hatteras National Seashore is best described as a coastal beach environment, with the major issues for resource protection being the protection of threatened and endangered species and the maintenance of coastal wildlife habitat, this literature review focuses on impacts from ORV use in similar coastal environments.

Wildlife and Wildlife Habitat

Numerous studies have detailed the impacts to wildlife of ORV use on public lands. Impacts generally described in these studies include direct mortality, harassment, noise effects, and habitat destruction. Specific risks to wildlife include injury during escape responses and, in severe cases, habitat avoidance and abandonment of young. Radle (2007) found that wildlife generally experience an increase in heart rate, as well as altered metabolism and hormone balance, when introduced to human-made noise. Noise from ORVs can affect the senses of animals that depend on hearing and vibration detection to survive (resulting in inability of wildlife to hear sounds important for mating, avoiding predators, and finding prey) (Berry 1980; Bury 1980; Bluewater Network 1999). ORVs also impact wildlife by destroying or fragmenting habitat. Much of the existing research has dealt specifically with the effects of vegetation damage by visitors and the associated impacts to wildlife habitat values (Monz et al. 2003). This has led some to conclude that the most effective strategies for avoiding habitat disturbance are outright road

removal and the avoidance of new road construction in roadless or sparsely roaded areas (Trombulak and Frissell 2001; Walder n.d.).

Park managers generally agree that intensive ORV use harms wildlife, including endangered species. From July to November of 1999, Bluewater Network conducted a survey of 108 national park units regarding the use of all-terrain vehicles and other ORVs. While the number of surveys conducted at seashore units is not reported, among the issues cited by respondents was the use of ORVs resulting in collisions with and crushing of animals, destruction of habitat, and animals being frightened away from shelter or important habitat (Bluewater Network 1999).

Various studies have examined the effects of ORVs on intertidal invertebrates. Work done on high-energy beaches has suggested that life in the intertidal and supratidal areas may be far more abundant and varied than previously thought (Zaremba et al. 1973), and this life could be affected by ORV use. One study conducted at the Seashore (Landry 2004) documented recovery rates of ghost crab (*Ocypode quadrata*) populations following ORV impacts and high-energy weather events. Beach closures were initiated to study short-term effects and recovery rates. Sediment analysis and beach soil compaction differences in the ghost crab habitat were measured in both untraveled and travelled zones. The study found differences in crab burrow densities between closed and open beaches. Alternative time spans for beach closings varied in their effectiveness for promoting recovery at various beach areas.

Findings from a 1984 study conducted at nearby Cape Lookout (Wolcott and Wolcott 1984) examined impacts of ORV use on mole crabs (*Emerita talpoida*), coquina clams (*Donax variabilis*) and ghost crabs. Results indicated that ghost crabs were completely protected if borrows were at least 5 centimeters (2 inches) deep. The ghost crab creates burrows for shelter from heat and desiccation stress during summer daytime periods. Juveniles produce shallow J-shaped burrows with a mean depth of 160 millimeters (6.3 inches), while adults dig Y-shaped and spiral burrows with mean depths of 361 millimeters (14.2 inches) (Chan et al. 2006). The Wolcott study also found no damage to mole crabs or coquinas; however, crushing of ghost crabs by ORVs occurred during their nighttime feeding on the foreshore¹. The study recommended establishing a ban on ORV traffic on the foreshore between dusk and dawn to protect this species (Wolcott and Wolcott 1984).

Moss and McPhee (2006) compared ghost crab burrow counts on exposed sandy beaches off the coast of southeast Queensland in areas designated as “open” and “closed” to recreational ORV use and found that beaches where recreational ORV activity was present had significantly lower ghost crab abundance than beaches where ORV use was absent. Similarly, a study on North Stradbroke Island in Australia found crab densities to be significantly lower in areas subject to heavy beach traffic. While crab mortality declined with depth of burrows, burrowing only partially protected crabs. Crabs in shallow burrows of 5 centimeters (1.9 inches) were killed by 10 vehicle passes. While deep-living crabs (which burrowed to depths of least 30 centimeters [11.8 inches]) were not killed by ORVs, this subpopulation represented only half of the total population surveyed (Schlacher et al. 2007).

Schlacher and others (2008) used surf clams (*Donax deltooides*) to investigate damages caused by vehicles to sandy shore invertebrates, and found that in situations where cars traversed soft sand and turned across the beach face, clams had some tolerance against vehicles at low traffic volumes (5 vehicle passes), but more than half of them were killed at higher traffic volumes (75 passes). Van Der Merwe (1991) studied

¹ Also known as the intertidal zone, the foreshore is defined as that part of the beach between the spring low water mark and the spring high water mark. The upper limits of the intertidal zone are defined by the uppermost wrack line. A wrack line is a line of stranded debris along a beach face marking the point of maximum run-up during a previous high tide, and there may be several on a beach.

the effects of ORVs on four intertidal invertebrate species in South Africa: the gastropod *Bullia rhodostoma*, the bivalves *Donax serra* and *Donax sordidus*, the benthic mysid *Gastrosaccus psammodytes*, and the supralittoral isopod, *Tylos capensis*. All the above-named species except for the benthic mysid showed a high tolerance for vehicular disturbances. The supralittoral isopod demonstrated increasing damage as with more vehicle passes in the less compact sand above the drift line.

In a study of four beaches at Cape Cod and Fire Island National Seashores, Kluft and Ginsberg (2004), used analysis of variance as a statistical metric and found that invertebrates such as the talitrid amphipod (*Talorchestia longicornis*) and the lycosid spider (*Arcotosa littoralis*) were significantly more abundant in the wrackline in vehicle-free areas than in high-traffic zones. On sandy beaches, invertebrates such as gastropods and bivalves could be safe if buried beneath compact sand (which is common when the tide is out). Stephenson (1999), while not specifying particular invertebrate species, cited research that indicated a reduction in both the abundance and number of species of surface and subsurface invertebrates as a result of vehicles on coastal dunes. Crushing by vehicle wheels, destruction of the surface litter layer (where present), and the changes in soil properties and microclimate that accompany track creation, or the overall reduction in plant cover, all contribute to the negative response of these elements of the fauna. Invertebrates associated with the above-ground portions of plants also exhibited reductions in abundance and number of species as a consequence of vehicle impacts to the vegetation and microclimate of dunes (Stephenson 1999).

Bird species are also affected by ORV use on shoreline ecosystems. Historically, many beach-nesting waterbirds have shown population declines along the beaches of the Seashore in response to increased human disturbance, retreating to small soundside islands created from dredge material excavated from navigational channels. By the late 1970s, erosional forces and changes to dredging techniques had whittled away much of these refuges, leaving no choice for the birds but to return to ocean beaches. One such species of special concern is the piping plover (*Charadrius melodus*), which lays speckled eggs that are perfectly camouflaged in the beach sand. A two-year study of piping plovers along the New Jersey shore (Burger 1994) found that plovers forage along the tidal oceanfront, in the dunes, and in backbays, and their relative use of these habitats partially depends upon human presence. While on beaches with few people, plovers can spend 90 percent of time foraging, whereas on beaches with many people they may spend less than 50 percent of their foraging time in direct feeding behaviors (Burger 1994). Results of a logistic regression analysis of the spatial distribution and productivity of piping plover nests in relation to proxy indicators of human disturbance on the barrier islands of Long Island, New York, indicated that for each additional kilometer of road within a 500-meter (1640-foot) radius, the likelihood of the presence of a plover nest decreased by up to 53%. Higher productivity appeared to be only slightly correlated with increasing distance from parking lots, roads, and residential areas. Moreover, no difference in mean productivity was observed among the levels of ORV access (Thomsen 2006).

Among bird species, adverse reactions to human recreational activities have included nest desertion, temporary nest abandonment, and changes in foraging habits (Douglass et al. 1999). Comparing two beach plots open and closed to human traffic along North Carolina's Outer Banks, Collazo and others (1995) found that resting time of shorebirds was reduced by nearly 50 % in areas open to human activity. Although some research indicates predators are the main cause of nest failure of shore-nesting birds, Stephenson (1999) identifies vehicle use as a major cause for reductions in reproductive potential of birds on both coastal dunes and shorelines. Similarly, Melvin and others (1994) described 14 incidents of direct piping plover mortality caused by ORVs in Massachusetts and New York from 1989 through 1993. They estimated the number of one-way vehicle passes per day during the period when mortality occurred, demonstrating that ORV use, even at levels of less than 10 vehicle passes per day, is a threat to unfledged piping plover chicks and adults during brood-rearing periods.

An in-depth study of colonial waterbird reproductive success and population trends along the Atlantic coast, which involved field research at Cape Lookout National Seashore, revealed that American oystercatchers are also at risk in rapidly changing coastal ecosystems. The nest survival rate was calculated to be 0.928 per nest day (213 nests lost during 2,961 nest-days of incubation), with the probability of a clutch surviving to hatching of 0.133 (Davis et al. 2001). A comparison of reproductive success of the American oystercatcher on three river islands in the lower Cape Fear of North Carolina with that of birds nesting on barrier island beach habitat of Cape Lookout National Seashore (McGowan et al. n.d.) revealed that there were 17.6 times more oystercatcher breeding pairs per kilometer on the river island habitat than on the barrier beach habitat. ORV use was directly investigated in this study. The primary cause of nest failure on river islands was flooding, while the primary cause on barrier islands was mammalian predation. In their study of reproductive success of American oystercatchers along the Atlantic coast from Cape Fear to Cape Hatteras National Seashore, Simons and McGowan (2003) also identified predation as the major factor accounting for population decline. Patterson and others (1991) studied piping plovers on Assateague Island, Maryland, in 1986–87 to estimate population size and to identify factors affecting productivity. The study found that predators accounted for most of the known causes of nest losses (91%), with only one nest lost due to direct human destruction and no evidence that suggested recreational disturbance was a factor affecting productivity.

Detailed results of an analysis of eight seasons of reproductive success data at the Seashore found that mammalian predation accounted for 29 % of nest failures (McGowan 2004). The study also found that human disturbance, 24 % of which attributable to ORVs, increased the frequency of trips from the nest during incubation and could contribute to reduced oystercatcher hatching success (McGowan 2004). A recent study by Sabine (2005) involved video monitoring of 32 American oystercatcher nests to document causes of nest failure at Cumberland Island National Seashore, Georgia. Predation was determined to be the primary cause of nest failure. Vehicle disturbances were also simulated by driving immediately below the high water line at approximately 50 meters (164 feet) seaward of nests in order to observe oystercatcher behavioral responses. Although the study found that vehicular activity reduced foraging behavior during brood rearing, results from the disturbance experiment indicated that oystercatchers were more sensitive to pedestrian disturbance than vehicle disturbance during incubation. McGowan and Simons (2006) also suggest that changes in incubation behavior might be one mechanism by which human recreation affects the reproductive success of American oystercatchers. While ATV traffic was positively associated with the rate of trips to and away from the nest, and negatively correlated with percent of time spent incubating, truck and pedestrian traffic had little measured effect on incubation. Stolen (2003) studied the effects of passing vehicles on the foraging behavior of wading birds at the Merritt Island National Wildlife Refuge near Titusville, Florida, and found that foraging wading birds were more likely to be disturbed when vehicles slowed or stopped adjacent to them than when vehicles continued driving by. Experimental disturbance by a vehicle caused a significant depression in the foraging rates of the snowy egret (*Egretta thula*) and the great egret (*Ardea alba*) and non-significant reductions in foraging rates in the tricolored heron (*E. tricolor*). Nineteen percent of the birds flushed after being disturbed. Species reacted differently to disturbance as vehicles approached closer to nests. Tri-colored heron were the most sensitive to flushing; the great egret was intermediately sensitive; and the snowy egret was the least sensitive.

In a study of shorebirds at South Core Banks, South Carolina, Tarr (2008) determined that vehicle disturbance influences shorebird use of ocean beach habitat for roosting during the nonbreeding season. This conclusion was based on the finding that shorebirds were abundant in areas where vehicle abundance was also relatively high, but their distribution among microhabitats was opposite that of vehicles. Vehicles were primarily located on dry sand, while shorebirds were typically found in the swash zone and wet sand microhabitats. When disturbance was introduced, microhabitat use shifted towards the swash zone. This study concluded that vehicle disturbance influences shorebird use of ocean beach habitat for roosting during the nonbreeding season. A study of the results of a ban on beach driving in 2001 on the

South African coastline (Williams et al. 2004) found that in the first breeding season after the ban, there was an increase in breeding pairs for all five species in the study (two waders, two terns and a cormorant). Available data indicated that a 50-meter buffer distance around nests is adequate to prevent harassment of the majority of incubating piping plovers, as stated in the Piping Plover Revised Recovery Plan (USFWS 1996). However, fencing around nests should be expanded in cases where the standard 50-meter (164-foot) radius is inadequate to protect incubating adults or unfledged chicks from harm or disturbance.

Impacts may result from species' inability to adapt to the pace of human development. Loggerhead sea turtles, for instance, face many anthropogenic nesting threats, including beach armoring, beach nourishment, artificial lighting, commercial fishing, beach vehicular driving, and pollution (Nester 2006). Vehicles on the beach could negatively impact sea turtles by running over nests or nesting females, hatchlings, or stranded turtles that have washed ashore. In addition, ruts left by vehicles in the sand may prevent or impede hatchlings from reaching the ocean after they emerge from the nest. Hatchlings impeded by vehicle ruts are at greater risk of death from predation, fatigue, desiccation, and being crushed by vehicles. Sand compaction due to vehicles on the beach may hinder nest construction and hatchling emergence from nests. Driving directly over incubating egg clutches can cause sand compaction, which may decrease hatching success and directly kill pre-emergent hatchlings. Additionally, vehicle traffic on nesting beaches may contribute to erosion, especially during high tides or on narrow beaches where driving is concentrated on the high beach and foredune (USFWS 2008).

Witherington (2003) cites challenges to loggerhead sea turtle (*Caretta caretta*) conservation: uncertainty over the historical abundance of loggerheads so that assessment of status can be made, and the incremental deterioration of suitable loggerhead nesting beaches through development (including coastal armoring and sources of beach lighting) and sea level rise. A 1996 report by the Florida Department of Environmental Protection explains that artificial lighting from a variety of sources on beaches tends to deter sea turtles from emerging from the sea to nest (Witherington and Martin 1996). If sea turtles do nest on lighted beaches, hatchlings can be jeopardized as artificial lighting disrupts a critical nocturnal behavior of hatchlings, which will move toward artificial light sources instead of crawling from their nest to the sea. Artificial lighting has also been found to deter sea turtles from emerging from the water to nest. The increase of false crawls on ORV beaches may cause nesting turtles to expend additional energy. This energy could be put into egg production or growth. To evaluate the effect of driving ORVs on nesting activity, Nester (2006) compared driven and non-driven beaches, data on beach slope, sand compaction, beach width, sand color, sand grain size, moisture content, incubation temperature, and pedestrian activity collected during the 2005 nesting season at Cape Lookout National Seashore, Cape Hatteras National Seashore, and Pea Island Wildlife Refuge, North Carolina. The study found that light intensities presented a significant factor in determining nesting or false crawls. False crawls were more likely on ORV beaches where light intensities from vehicles were found to be greater than those on non-ORV beaches. A resulting decline of 20% in production of female loggerhead turtles was estimated at these locations. Recommendations for mitigating the impacts of artificial lighting on sea turtles included installing timers and monitoring devices to minimize unnecessary lighting (Witherington and Martin 1996).

ORV tracks interfere with the ability of hatchling loggerhead turtles to reach the ocean. By observing newly-hatched loggerhead turtles which were released to the intertidal beaches at Fort Fisher Beach in southeastern North Carolina and Cape Lookout Beach in coastal North Carolina, Hosier and others (1981) determined the effect of ORV tracks on the behavior and rate of sea-approach of these turtles. The extended period of travel required to negotiate suitable paths to the surf, together with the tendency to invert, may increase the susceptibility of loggerhead turtles to stress and predation during transit to the ocean when hatching on ORV-impacted beaches. Tracks in the sand may change the micro-topography as much as 10–15 centimeters (3.9–5.9 inches), which may serve as a significant impediment to the movement of hatchling turtles to the sea. Moreover, vehicle tracks generally run parallel to the beach, and can result in distances of 10–20 meters (33–66 feet) where hatchlings cannot successfully negotiate such

barriers, especially in coarse sands. At Cape San Blas, Florida, near Eglin Air Force Base, Cox and others (1994) examined hatchling tracks and observed four instances of sea turtle hatchlings being disorientated. Vehicle tracks were thought to be a contributing factor at two sites, causing some hatchlings to make a perpendicular diversion of more than 91 meters (300 feet) en route to the sea. Some hatchling tracks ended within vehicle tracks, which suggests that vehicle tracks may lengthen the time of critical exposure to beach predators, particularly ghost crabs.

Water Quality

Many studies have addressed the effects of ORV use on water quality. Most studies have focused primarily on non-coastal desert or forest environments including soil erosion and sedimentation. In these environments, ORVs which travel along, across, or through creeks, rivers, streams and other waterways create turbidity, harm vegetation, destroy habitat for aquatic species and species that use water resources, and cause increased sedimentation and soil erosion that result in impairments to water quality (Bluewater Network 1999). The Texas Chapter of the American Fisheries Society (2002) cites that ORV use could result in erosion, siltation, bank destabilization, and an increased potential for other water quality impacts. The damage to stream bottoms and increased siltation can change stream temperatures, resulting in increased extremes and temperature variability that can be detrimental to fish populations (TCAFS 2002). No studies were found relating to water quality impacts of ORV use on beaches.

Soils/Dune Ecosystems

Several studies of ORV impacts to coastal soils have focused on comparisons of soil characteristics between high-traffic areas versus non-traffic areas. One such study (Hosier and Eaton 1980) compared two barrier beaches in southeastern North Carolina. Less vegetation cover and fewer species were present on both dunes and grassland areas with vehicular traffic. To illustrate this, when quadrants containing vehicle tracks were removed from the analysis, the average vegetative cover of the dunes on the impacted beaches increased to that of the non-impacted beaches. The soil was also more compact where vehicular traffic had been most intense and where, it was suggested, this compaction may have been contributing to increasing salt flats in the area. Similarly, results of experimental testing of ORV impacts to coastal ecosystems of Cape Cod National Seashore between 1974 and 1977 (Leatherman and Godfrey 1979) showed that the ecosystem most resistant to long-term vehicle impact was the intertidal ocean beach, while the most easily damaged were areas protected from the direct ocean waves by barrier dunes or other upland features (such as salt marshes and sand flats). ORV effects are longest lasting farthest from the source of new sand; the areas farthest away from new sand promote optimal growth of grasses. More specifically, the effects of vehicles on dunes depended on the portion of the dune that was impacted. At dune edges, fewer than 100 vehicle passes stopped seaward growth of grass. In the foredune region, a relatively low number of passes (50–200) reduced plant biomass to very low levels. Recovery of the grasses on the dunes varied with the exact location of the vehicle tracks. On the foredunes, where grass growth is lush and rapid due to fresh sand input, the impacted sites were almost completely recovered after three growing seasons. Findings demonstrated that environments that undergo the greatest physical changes, such as the intertidal ocean beach, appear to have the greatest tolerance to vehicle traffic.

Studies on barrier islands have shown that although infrequent travel over dune vegetation had noticeable immediate impacts, permanent damage was ultimately caused by repeated travel over the same tracks (Judd et al. 1989). Impacts of historic ORV use at Gulf Islands National Seashore included denudation of coastal dunes and resulting blowouts and interior flooding, which have flattened the interior island topography; and the creation of trails that contribute to erosion, further narrowing the island (Shabica 1979). In a similar study at Fire Island National Seashore in New York, Anders and Leatherman (1987) found that vehicular passage over the open beach displaces sand seaward and that ORV use levels could

be contributing to the overall erosion rate by delivering large quantities of sand to the swash zone and affecting dune topography. Vehicle traffic resulted in a maximum of 0.75 meters (2.5 feet) of deposition in the zone of actual impact and a slight reduction in the elevation of the foredune. The results of 89 field experiments to examine the effects of ORVs on the beach showed that slope, sand compaction, and the number of vehicle passes in the same track were the principal factors controlling the measured net seaward displacement of sand.

Investigations made between 1973 and 1974 found beach and foredune areas of North Padre Island along the mid-Texas coast to be greatly modified by vehicular traffic (McAtee and Drawe 1981). The primary effects were reduced ground cover and reduced species diversity of vegetation in the foredune areas. As the intensity of human activity increased, dune elevation decreased. Increasing human activity also correlated to higher observed evaporation, soil pH, soil temperature, average wind velocity, atmospheric and soil salinity, and wind-carried sand particles near the ground surface.

Liddle and Grieg-Smith (1975) demonstrated that below 18-centimeter (7-inch) depths, soils became less compacted as a result of vehicle use. But a study of vehicle impacts to sandy beaches on the east coast of Australia (Schlacher and Thompson 2006) found that ORVs corrugated sand as deep as 28 centimeters (11 inches), with the deepest rutting occurring between the foredunes and the drift line. Off-road vehicles in this study were capable of disrupting from 5.8% to 9.4% of the available faunal habitat matrix (the top 30 centimeters [11.8 inches] of the sand which contain the necessary conditions to support the study fauna) in a single day and routinely disturbed the drift line and the base of the foredunes. Belnap (1995) cited several causes of desertification from off-road vehicle use, including soil compaction resulting in decreased water availability to vascular plants through decreased water infiltration. Soil loss can be further accelerated by wind and water erosion and decreased diversity and abundance of soil biota.

Vegetation and Invasive Species

Numerous studies describe the impacts of ORVs on vegetative communities, including both direct and indirect damage to vegetation by vehicle use. Research conducted in the late 1970s at Cape Cod National Seashore on the ecologic and geomorphic effects of ORVs on coastal ecosystems concluded that there is no “carrying capacity” for vehicular impact on coastal ecosystems, and even low-level impacts can result in severe environmental degradation. The most naturally unstable areas, such as the intertidal ocean beach, tend to be the least susceptible to damage due to the rapid pace of natural environmental change and recovery in these areas. Dunes can be quickly devegetated by vehicular passage, resulting in blowouts and sand migration. Of all the ecosystems evaluated, salt marshes and intertidal sand flats are the least tolerant of ORV impacts and should be closed to all vehicle traffic (Leatherman and Godfrey 1979). Similarly results were demonstrated in an experimental testing of ORV traffic on coastal ecosystems of Cape Cod National Seashore between 1974 and 1977 (Godfrey et al. 1978). As detailed in the Soils/Dune Ecosystems section, this study found that even a relatively low number of vehicle passes can reduce plant biomass to very low levels in the foredune area.

At Cape Hatteras National Seashore, potential habitat for the seabeach amaranth includes coastal overwash flats at the accreting ends of the islands and lower foredunes and on ocean beaches above mean high tide (occasionally on sound-side beaches). In its known range, it often grows in the same areas selected for nesting by shorebirds such as plovers, terns, and skimmers. Intensive recreational use, both vehicular and pedestrian, is one factor that threatens the plant’s survival. Its stems are easily broken or crushed by foot traffic and tires, thus, even minor traffic can be detrimental during the growing season (USSWS 1996).

Hosier (1980) cites several cases at the Seashore where vehicle impacts to vegetation have occurred, such as at Oregon and Ocracoke inlets where vehicle traffic has compacted sediments along the unvegetated

portions of the beach and near Ocracoke Inlet. In these areas, sand flat vegetation has been altered by ORV tracks and chronic operation of ORVs has kept natural stabilizing vegetation from invading the flats.

A study of vehicle impacts to coastal dunes at Fire Island National Seashore, in which vegetation was monitored in both an experimental field test and a control before and after experimental vehicle impacts, revealed that low-level ORV use (one pass per week) is severely damaging to natural dune vegetation, and that a steepening of the dune profile occurred in the impacted zones due to higher rates of ORV-related erosion (Anders and Leatherman 1987). Another study of the response of grassy vegetation and soils of coastal sand dunes to varying degrees of vehicle use in Australia found that some species of grassy vegetation demonstrated decline, while others increased under moderate use (Liddle and Grieg-Smith 1975). The researchers also noted that while damage to plant shoots by vehicles was detrimental to plants, soil compaction alone could be beneficial in the sand dune habitat due to roots gaining greater access to higher moisture retaining soils beneath trampled areas. Similarly, results of a study at Cape Cod National Seashore, in which unstabilized and moderately stabilized dune sites were driven at varying levels of intensity, suggested that a single summer season of driving (300–700 passes) on a confined track through grass vegetation can completely destroy the above-ground portions but leave adequate underground roots and rhizomes for a small amount of vegetative regrowth after driving season ends in the late summer and fall (Brodhead and Godfrey 1977).

Three studies reviewed involved direct examination of vehicles to determine if they were potential distributors of exotic plant seeds. Osborn and others (2002) discuss a study that investigated the potential for seed transport into Kakadu National Park in Australia by means of tourist vehicles. The study concluded that vehicles were partially responsible for weed seed dispersal, but the low density of seeds found on the vehicles did not warrant the park taking preventative action. Another study (Rooney 2005) compared soil samples taken from the undercarriage of ORVs to field surveys for seven invasive species in forested areas of Wisconsin. No evidence of actual invasive plant dispersal was noted; however, because invasive plants have seed traits that predispose them to dispersal, the study found that ORVs may occasionally contribute to long-distance dispersal events. This is further supported by a study conducted by the Montana Weed Control Association (Trunkle and Fay 1991), which involved driving a vehicle 40 feet into a vegetated plot and then to various distances from the plot. Afterwards, plant material (including spotted knapweed (*Centaurea stoebe*) seeds) was collected from the undercarriage. At Cape Lookout National Seashore, Hosier (1980) found that deep ORV tracks trapped seeds of sea oats as they were blown across the beach. The captured seeds were then buried and began germination, but the vehicles subsequently churned up the sand and exposed the roots, thus destroying the plants.

Lathrop (1983) found that in arid regions direct vehicle impacts constituted the primary means of vegetative destruction. The study showed that areas beyond the vehicle track width were also affected, although the degree of impact varied with conditions and intensity of vehicle use. The study demonstrated that concentrated current or recent use in localized areas (such as heavy weekend use) created the greatest reduction in vegetative cover. Also in a study of desert environments, Wilshire (1983) found that even a single pass of an ORV could destroy many types of annual and some perennial plants, although hundreds of passes may be required to destroy tough, deep-rooted shrubs.

Aesthetics/Sound

ORV use influences the character of the wild landscape and can result in conflicts between ORV users and other recreational users. With regard to ORV noise-related impacts to park resources, attempts have been made to qualify how visitor experiences in national parks are affected by the addition of mechanical versus natural sound that may come from ORV or other motorized vehicle use such as personal watercraft (PWC). A limited amount of study has been undertaken regarding ORV use and its impacts to

soundscapes in NPS units. Studies related to air tours and PWC are available but not directly relevant to ORV use at Cape Hatteras National Seashore.

Gramann (1999) used many approaches to garner information from visitors about sound in NPS units to formulate a more precise picture of human reactions to sound. Overall, results showed that park users identify natural sounds as more enjoyable than mechanical sounds, but mechanical sounds do not always interfere with the user's experience. Visitor experience and sensitivity to mechanical sound are dependent on visitor expectations, group size, front or backcountry experience, and activity type. For example, a visitor in a group of three or more visiting a park for the first time in the front country and taking pictures may not be as sensitive to mechanical sounds as a lone hiker in the backcountry. People are generally tolerant of certain noise disturbances if they perceive them as necessary (e.g., helicopters conducting fire suppression activities). In this sense, the Gramann study indicated that it is important for sounds to be consistent with the visual setting within which they are heard. Variable noise disturbances may be more readily tolerated depending on the observer's perception of the setting. As a result, from a management perspective, some scenic overlooks and short front country trails may not require as much protection as backcountry locales where preserving the experience of natural sound is paramount to overall visitor experience (Gramann 1999).

Archeological Resources

Whether it is intentional or inadvertent, ORV use has the potential to affect archeological resources on public lands (BLM 2000; Lyneis et al. 1980; Schiffman 2005; Sowl and Poetter 2004; SUWA 2002). Direct impacts result from the damage or destruction that occurs when ORVs drive over and/or near archeological sites. Site integrity, a necessary element for listing a cultural resource on the National Register of Historic Places, is also affected by the visible changes caused by vehicle tracks and erosion (Sowl and Poetter 2004). Studies conducted in the California desert note that ORVs provide access to previously inaccessible, remote areas as ORV users explore new terrain (Lyneis et al. 1980). According to the BLM, this leads to increased visitation to lands previously used only by small numbers of hikers, and increases the intentional and inadvertent damage of archeological resources through surface disturbances (BLM 2000). ORVs have also enabled collectors and pothunters to reach these remote areas, which facilitates greater archeological resource damage from intentional collection and vandalism (BLM 2000; Schiffman 2005; Lyneis et al. 1980; SUWA 2002).

Socioeconomics

ORV-related economic impacts vary by state and region. The large proportion of revenue generated by ORV-related activities was documented in a 2005 report that provides economic impact estimates for a ban on nighttime vehicular access to Fort Fisher State Recreation Area in North Carolina during the spring/summer season. The study, which incorporated electronic vehicle counts and visitor surveys, found that while the baseline number of annual beach vehicle trips (28,884) supported an estimated \$21.6 million in annual regional sales (as well as 382 regional jobs, and 3.7 million in tax revenues), the proposed policy would result in an estimated loss of \$859,590 per year in regional sales, 15 regional jobs (mostly from restaurants, automotive services, lodging and related visitor services), and \$149,334 per year in tax revenues (NCDENR 2005).

A recent report on the economic benefits of hunting, fishing, and wildlife watching in North Carolina found that in 2006, 3.4 million residents and non-residents participated in some form of fish and wildlife-related recreation in North Carolina and spent \$2.62 billion in retail sales, created \$1.26 billion in salaries and wages, and supported 45,224 jobs. The total economic benefit from fish and wildlife-related recreation was estimated at \$4.3 billion (Southwick 2008). For fishing-related activities alone, a national

survey in 2006 found that in North Carolina, there were nearly 1.3 million fishing participants who spent almost 1.2 billion dollars on the sport (USFWS 2006).

Management Issues

Nationwide, 15 NPS units allow ORV use by the general public. Within these areas, various user groups and ORV manufacturers contend that NPS limits on ORV use unfairly restrict access, establish a precedent for other federal land managers to impose or extend restrictions, and may be economically harmful to gateway communities and industries serving users (Calvert et al. 2007). Conversely, opponents of motorized recreation in NPS units cite damage to the environment and cultural artifacts from ORV use. Conflicts also arise on U.S. Forest Service lands, where uses such as timber harvesting and ORV recreation may affect birdwatching and sightseeing, and can degrade water quality in certain settings (Calvert et al. 2007).

In 1997 the NPS and the National Parks and Conservation Association (NPCA) identified damage from recreational uses as a major concern in coastal units of the NPS (Recksiek 1997). To deal with these issues, Godfrey (1978) explains that while not all shorelines have the same geology or patterns of erosion, some general management recommendations related to ORV use can be applied. These include preventing indiscriminant traffic on dunes and routing traffic around sites of significant dune formation; restricting traffic to intertidal ocean beaches where surveys have shown relatively few marine animal populations are present; not reopening areas that have been closed or have been inaccessible previously; closing off bird and marine turtle nesting sites and important feeding areas; and closing beaches to vehicles during periods of exceptionally high tides (because during high tides vehicles must be driven up the face of dunes, often through nest sites and incipient dune areas).

Operating vehicles on beaches presents special management constraints where loggerhead sea turtles are present. Beach cleaning vehicles, for instance, are common on beaches in southern Florida, and management measures have been established for the use of such vehicles. In order to obtain beach cleaning permits, certain requirements must be met pursuant to Rule 62B-33.005 (11) of the Florida Administrative Code that restricts the timing and nature of beach cleaning. The following permit conditions are included:

- limiting beach cleaning activities to daylight hours only
- limiting cleaning activities to the average high tide mark or debris line and seaward in some areas
- ensuring a daily sea turtle nesting survey has been completed before cleaning activities are conducted
- marking nests for avoidance
- using vehicles with a maximum tire pressure of 10 pounds per square inch and a rake or cleaning apparatus that limits penetration into the surface of the beach to a maximum of 2 inches
- removing accumulated debris from the beach immediately after cleaning has been performed
- avoiding all native, salt tolerant dune vegetation by a minimum of 10 feet (USFWS 2008)

Similarly, the Volusia County, Florida Habitat Conservation Plan (HCP) limits the potential for sea turtle-vehicle interactions through four basic mechanisms: (1) public access is limited to daylight hours and public safety vehicles that operate at night must follow specific guidelines; (2) public driving is limited primarily to those areas where nest densities are lowest; (3) in those areas where public driving is permitted, all driving and parking must occur outside a marked Conservation Zone near the dune, where

the majority of nests are typically deposited; and (4) all nests are conspicuously marked so they can be avoided (USFWS 2008).

Appropriate travel management planning has increased among public agencies and various stakeholder groups in response to continuing ORV use on public lands, particularly BLM lands. Other federal regulatory requirements concerning the protection of resources also provide guidance for travel management plans that may be relevant to management options at the Seashore. However, challenges to crafting and implementing park travel management plans often arise that carry significant implications to the functional management of park resources.

Meyer (2002) prescribes regular maintenance and monitoring of ORV routes, including periodic inspections and condition assessments at 5-year intervals. In addition, Meyer offers several management approaches that can be implemented to curtail trail degradation, some of which may be relevant to seashore environments, including trail rerouting in cases where numerous segments have been degraded by recreational use; seasonal or type-of-use restrictions in instances when specific seasonal uses may be contributing to greater impacts; and outright trail closure as a last resort to protect threatened resources. Traffic volume restrictions or “controlled use” are also suggested as a means to prevent significant resource degradation, although enforcement is needed to implement this management strategy (Meyer 2002).

Christensen and Watson (2006) described challenges resulting from the implementation of the 2006 Bitterroot National Forest ORV management plan, which included maintaining an up-to-date inventory of routes; working with ORV users to reduce impacts and conflicts; and working with all stakeholders to identify appropriate and acceptable ORV opportunities. They also cite lessons learned from the U.S. Forest Service policy and experiences of planners nationwide, which suggest that a collaborative process with a “system-wide, forest-level perspective” is likely to be the most appropriate and successful strategy for developing a widely-supported ORV travel management plan. Moreover, they stress on-going involvement of the public in ORV planning as being crucial for public acceptance of the resulting plans. In an assessment of the efficacy of such a cooperative effort in four counties in North Central Michigan, Nelson and Lynch (2001) conducted stakeholder interviews, surveys of ORV drivers, and investigations of route signage survival. They found that after plan implementation compliance with ORV rules increased as most riders supported the program. By contrast, a study in Utah aimed at creating an inventory of ORV use occurring in 12 high-use or “hotspot” regions of U.S. Forest Service land found that ORV users had taken excessive measures to access closed routes by moving large boulders, removing posts, chain-sawing trees or logs, or purposefully negotiating terrain to create a new trail around management-placed and natural barriers to ORV traffic (Divine and Foti 2004).

Some monitoring efforts have benefitted from the simultaneous observation and data collection of traffic and wildlife made possible by pneumatic road counters and GPS units (USGS 2005). However, Calvert and others (2007) note that monitoring and enforcement may be impeded in some locations (and especially on BLM lands) due to their remoteness, insufficient signs, and inadequate staff and resources, challenges which would also be relevant to the NPS. Adaptive management strategies targeted toward the specific needs of individual parks could provide the most efficacy in resource management. James (2000) argues that a focus on both the component systems of beach environments and interactions among those systems is necessary for improvements in the management, conservation, and overall environmental quality of beaches.

REFERENCES

Anders, F. J. and S. P. Leatherman

- 1987 Effects of Off-road Vehicles on Coastal Foreduces at Fire Island, New York, USA. *Environmental Management*. 11(1): 45–52.

Belnap, J.

- 1995 Surface Disturbances: Their role in Accelerating Desertification. *Environmental Monitoring and Assessment*. 37: 39–57.

Berry, K. H.

- 1980 The Effects of Four-wheel Vehicles on Biological Resources. In R.N.L. Andrews and P. F. Nowak (Eds.), *Off-Road Vehicle Use: A Management Challenge* (231–233). Conf. Proc. March 16–18, 1980. Ann Arbor, MI.

Bluewater Network

- 1999 Off the Track: America's National Parks Under Siege. Bluewater Network. 1999. Accessed April 4, 2009, at <http://www.bluewaternetwork.org/reports/rep_pl_offroad_offtrack.pdf>.

Brodhead, J. M. and P. J. Godfrey

- 1977 Off-road Vehicle Impact in Cape Cod National Seashore: Disruption and Recovery of Dune Vegetation. *International Journal of Biometeorology*. 21: 299–306.

Burger, J.

- 1994 The Effect of Human Distribution on Foraging Behavior and Habit Use in Piping Plover. *Estuaries*. 17(3): 695–701.

Bury, R. B.

- 1980 What We Know and Do Not Know about Off-road Vehicle Impacts on Wildlife. In R. N. L. Andrews and P. Nowak (Eds.), *Off-Road Vehicle Use: A Management Challenge* (110–122). Conf. Proc. March 16–18, 1980. Ann Arbor, MI.

Calvert, K., S. Johnson, C. H. Vincent, R. W. Gorte, N. T. Carter, and N. Lane.

- 2007 Recreation on Federal Lands. CRS Report for Congress. Washington, D.C.: Congressional Research Service, The Library of Congress. November 6, 2007.

Chan, B., K. Chan, and P. Leung

- 2006 Burrow Architecture of the Ghost Crab (*Ocypode ceratophthalma*) on a Sandy Shore in Hong Kong. *Hydrobiologia*. 560(1): 43–49(7).

Christensen, N. and A. Watson

- 2006 Off-Road Vehicle Management on the Bitterroot National Forest under the New Forest Service Travel Management Rule: An Assessment of Conditions and Management Approaches. Missoula, MT: U.S. Department of Agriculture Forest Service. June 1, 2006.

Appendix A

Collazo, J. A., J. R. Walters, and J. F. Parnell

- 1995 Factors Affecting Reproduction and Migration of Waterbirds on the North Carolina Barrier Islands. Final Report to the National Park Service Cape Hatteras and Cape Lookout Seashores.

Cox, J. H., H. F. Percival, S. V. Colwell

- 1994 Impact of Vehicular Traffic on Beach Habitat and Wildlife at Cape San Blas, Florida. Technical Report 50, Florida Coop Fish and Wildlife Research Unit.

Davis, M., T. Simons, M. Groom, J. Weaver, and J. Cordes

- 2001 The Breeding Status of the American Oystercatcher on the East Coast of North America and Breeding Success in North Carolina. *Waterbirds*. 24(2): 195–202.

Divine, A. K. and P. E. Foti

- 2004 Learning to live with Off-highway Vehicles: Lessons learned from Dixie National Forest. *Proceedings of the Fourth Social Aspects and Recreation Symposium*. February 4 –6, 2004. San Francisco, CA. 106–111.

Douglass, K. S., J. Hamann, and G. Joslin

- 1999 Chapter 9, Vegetation, Soils and Water, Effects of Recreation on Rocky Mountain Wildlife. Montana Chapter of the Wildlife Society.

Godfrey, P.

- 1978 Management Guidelines for Parks on Barrier Beaches. *International Journal of National Parks, Historic Sites, and other Protected Areas*. 2(4): 6 –10.

Godfrey, P., S. Leatherman, and P. Buckley

- 1978 Impact of Off-Road Vehicles on Coastal Ecosystems. *Proceedings of the Symposium on Technical, Environmental, Socioeconomic and Regulatory Aspects of Coastal Zone Planning and Management*. San Francisco, California, March 14–16, 1978.

Gramann, J.

- 1999 The Effect of Mechanical Noise and Natural Sound on Visitor Experiences in Units of the National Park System. *Social Science Research Review*. 1(1): 1–15.

Hosier, P.

- 1980 Recreational ORV Impacts in Coastal Carolina. *Carolina Planning*. 6(2): 34 –40.

Hosier, P. E., and T. E. Eaton

- 1980 The Impact of Vehicles on Dune and Grassland Vegetation on a South-eastern North Carolina Barrier Beach. *The Journal of Applied Ecology*. 17(1): 173–182.

Hosier, P. E., M. Kochhar, and V. Thayer

- 1981 Off-Road Vehicle and Pedestrian Track Effects on the Sea-approach of Hatchling Loggerhead Turtles. *Environmental Conservation*. 8: 158–161.

James, R.

- 2000 From Beaches to Beach Environments: Linking the Ecology, Human-use, and Management of Beaches in Australia. *Ocean and Coastal Management*. 43: 495–514.

Judd, F. W., R. I. Lonard, J. H. Everitt, and R. Villarreal

- 1989 Effects of Vehicular Traffic in the Secondary Dunes and Vegetated Flats of South Padre Island, Texas. *Proceedings of Sixth Symposium on Coastal and Ocean Management*. 1989: 4634–4645.

Kluft, J. M. and H. S. Ginsberg

- 2004 The Effect of Off-road Vehicles on Barrier Beach Invertebrates at Cape Cod and Fire Island National Seashores. University of Rhode Island. Department of Plants Sciences/Entomology.

Landry, C.

- 2004 Assessing the Anthropogenic and Natural Impacts on Ghost Crab (*Ocypode quadrata*) Populations at Cape Hatteras National Seashore, North Carolina. Thesis Draft. Department of Coastal and Ocean Policy. Virginia Institute of Marine Science. College of William and Mary. August 5, 2004.

Lathrop, E.W.

- 1983 The Effect of Vehicle Use on Desert Vegetation. In R. H. Webb and H. G. Wilshire (Eds), *Environmental Effects of Off-Road Vehicles, Impacts and Management in Arid Regions*. 153–166. New York: Spinger-Verlag.

Leatherman, S. and P. Godfrey

- 1979 The Impact of Off-Road Vehicles on Coastal Ecosystems in Cape Cod National Seashore: An Overview. National Park Service Cooperative Research Unit. UM-NPSCRU Report No. 34.

Liddle, M. J. and P. Grieg-Smith

- 1975 A Survey of Tracks and Paths in a Sand Dune Ecosystem. *Journal of Applied Ecology*. Vol. 12, No. 3 (December 1975), pp. 893–908.

Lyneis, M. M., D. L. Weide, E. Warren vonTill

- 1980 Impacts: Damage to Cultural Resources in the California Desert. Riverside, CA: Bureau of Land Management.

Marion, J.

- no date Management, Monitoring, and Protection Protocols for Seabeach Amaranth at Cape Hatteras National Seashore, North Carolina. U.S. Geological Survey, Patuxent Wildlife Research Center. 18 pp.

McAtee, J. W. and D. L. Drawe

- 1981 Human Impact on Beach and Foredune Microclimate on North Padre Island, Texas. *Environmental Management*. Vol. 5. No. 2. pp. 121–134.

Appendix A

McGowan, C., T. Simons, W. Golder, and J. Cordes

- no date A Comparison of American Oystercatcher Reproductive Success on Barrier Beach and River Island Habitats in Coastal North Carolina. U.S. Geological Survey, North Carolina Cooperative Fish and Wildlife Research Unit. Department of Zoology. North Carolina State University.

McGowan, C.

- 2004 Factors Affecting Nesting Success of American Oystercatchers in North Carolina. Thesis. North Carolina State University. Department of Zoology.

McGowan, C. P. and T. R. Simons

- 2006 Effects of Human Recreation on the Incubation Behavior of American Oystercatchers. *Wilson Journal of Ornithology*. 118: 485–493.

Melvin, S., A. Hecht, and C. Griffin

- 1994 Piping Plover Mortalities Caused by Off-Road Vehicles on Atlantic Coast Beaches. *Wildlife Society Bulletin*. 22: 409–414.

Meyer, K. G.

- 2002 Managing Degraded Off-Highway Vehicle Trails in Wet, Unstable, and Sensitive Environments. 2E22A68-NPS OHV Management. Missoula, MT: U.S. Department of Agriculture Forest Service Technology and Development Program. October 2002.

Monz, C., Y-F. Leung, H. Bauman, and C. Ingle

- 2003 Phase 1 Project Report, National Park Service Coastal Visitor Impact Monitoring. March 2003.

Moss, D. and D. P. McPhee

- 2006 Impacts of Recreational 4-wheel Driving on the Abundance of the Ghost Crab (*Ocypode cordimanus*) on a Subtropical Sandy Beach in SE Queensland. *Coastal Management*. Vol. 34, No. 1, pp. 133–140.

National Park Service (NPS)

- 2006 NPS Management Policies 2006.
2008 Cape Hatteras National Seashore ORV Access Information. Accessed July 2008 at <<http://www.nps.gov/caha/planyourvisit/orv-access-information.htm>>.

Nelson, C. and J. A. Lynch

- 2001 AuSable Pilot Off-Road Vehicle Project Evaluation. Department of Park, Recreation and Tourism Resources. East Lansing, MI: Michigan State University. October 3, 2001.

Nester, L. R.

- 2006 Effects of Off-road Vehicles on the Nesting Activity of Loggerhead Sea Turtles in North Carolina. MSc. Thesis, University of Florida. 81 pp.

North Carolina Department of Environment and Natural Resources (NCDENR)

- 2005 Ocean Beach Vehicular Access Study at Fort Fisher State Recreation Area. Final Report: Economic Impact Analysis. Addendum – Impacts of Current Policy. March, 2005.

Osborn, S., V. Wright, B. Walker, A. Cilimburg, and A. Perkins

- 2002 Linking Wilderness Research and Management. Understanding and Managing Invasive Plants in Wilderness and other Natural Areas: an Annotated Reading List. General Technical Report RMRS-GTR-79- Vol. 4. Fort Collins, CO: U.S. Department of Agriculture Forest Service, Rocky Mountain Research Station.

Ouren, D. S., C. Haas, C. P. Melcher, S. C. Stewart, P. D. Ponds, N. R. Sexton, L. Burris, T. Fancher, and Z. H. Bowen

- 2007 Environmental Effects of Off-Highway Vehicles on Bureau of Land Management Lands: A Literature Synthesis, Annotated Bibliographies, Extensive Bibliographies, and Internet Resources. Open-File Report 2007: 1353. U.S. Geological Survey.

Patterson, M. E., J. D. Fraser, and J. W. Roggenbuck.

- 1991 Factors Affecting Piping Plover Productivity on Assateague Island. *Journal of Wildlife Management*. 55: 525–531.

Proescholdt, K.

- 2007 Off-Road Vehicle Impacts on Hunting and Fishing. St. Paul, MN: Izaak Walton League of America.

Radle, A. L.

- 2007 The Effect of Noise on Wildlife: A Literature Review. Accessed at <<http://interact.uoregon.edu/MediaLit/FC/WFAEResearch/radle.html>>.

Recksiek, H.

- 1997 Improving Coastal Management in the National Park System: A Review of Current Management Issues and Resource Threats, with Recommendations for the National Parks and Conservation Association. Terry Sanford Institute of Public Policy. Duke University. June 1, 1997.

Rooney, T. P.

- 2005 Distribution of Ecologically-Invasive Plants along Off-road Vehicle Trails in the Chequamegon National Forest, Wisconsin. *The Michigan Botanist*. 44: 178–182.

Sabine, John B.

- 2005 Effects of Human Activity and Predation on Breeding American Oystercatchers. Thesis. University of Georgia.

Schiffman, L.

- 2005 Archaeology, Off-road Vehicles, and the BLM. Archaeology Institute of America. April 20, 2005. Accessed November 26, 2008, at <<http://archaeology.org/online/features/southwest/>>.

Appendix A

Schlacher, T. A. and L. M. C. Thompson

- 2006 Physical Impacts Caused by Off-road Vehicles to Sandy Beaches: Spatial Quantification of Car Tracks on an Australian Barrier Island. *Journal of Coastal Research*. Vol. 24, No. 2, pp. 234–242.

Schlacher, T. A., L. M. C. Thompson, and S. Price

- 2007 Vehicles Versus Conservation of Invertebrates on Sandy Beaches: Mortalities Inflicted by Off-road Vehicles on Ghost Crabs. *Marine Ecology*. Vol. 28, No. 3, pp. 354–367.

Schlacher, T. A., L. M. C. Thompson, and S. J. Walker

- 2008 Mortalities Caused by Off-road Vehicles (ORVs) to a Key Member of Sandy Beach Assemblages, the Surf Clam (*Donax deltoids*). *Hydrobiologia*. 610: 345–350.

Shabica, S. V

- 1979 Off-Road Recreational Vehicle Use of Perdido Key Florida: A Discussion. Gulf Islands National Seashore. Coastal Field Research Laboratory reports to the Superintendent. No. 1.

Simons, T. and C. McGowan.

- 2003 American Oystercatcher (*Haematopus palliatus*) Research and Monitoring in North Carolina. 2003 Annual Report. North Carolina Cooperative Fish and Wildlife Research Unit. Department of Zoology, North Carolina State University. December 2003.

Southern Utah Wilderness Alliance (SUWA)

- 2002 Preserving History. Salt Lake City, Utah.

Southwick

- 2008 The 2006 Economic Benefits of Hunting, Fishing, and Wildlife Watching in North Carolina.

Sowl, K. and R. Poetter

- 2004 Impact Analysis of Off-Road Vehicle Use for Subsistence Purposes on Refuge Lands and Resources Adjacent to the King Cove Access Project. Izembek National Wildlife Refuge, Alaska.

Stephenson, G.

- 1999 Vehicle Impacts on the Biota of Sandy Beaches and Coastal Dunes: a Review from a New Zealand Perspective. Science for Conservation 121. *New Zealand Department of Conservation*. Wellington, NZ.

Stolen, E. D.

- 2003 The Effects of Vehicle Passage on Foraging Behavior of Wading Birds. *Waterbirds*. 26: 429–436.

Tarr, N. M.

- 2008 Fall Migration and Vehicle Disturbance of Shorebirds at South Core Banks, North Carolina. Thesis. North Carolina State University. Department of Forestry and Environmental Resources.

Taylor, R. B.

no date The Effects of Off-road Vehicles on Ecosystems. Texas Parks and Wildlife Department.

Texas Chapter of the American Fisheries Society (TCAFS)

2002 Off-Road Vehicles and their Impact on Stream Environments. January 2002.

The Wilderness Society

2006 Addressing the Ecological Effects of Off-Road Vehicles (ORVs). *Science and Policy Brief*. August 2006. No. 3.

Thomsen, S. K.

2006 A GIS-based Analysis of Human Disturbance on Piping Plover Abundance, Distribution and Productivity on the Barrier Islands of Long Island, New York. May 2006.

Trombulak, S. and C. Frissell

2001 Review of Ecological Effects of Roads on Terrestrial and Aquatic Communities. *Conservation Biology*. 14(1): 18–30.

Trunkle, P. and P. Fay

1991 Transportation of Spotted Knapweed Seeds by Vehicles. *Proceedings Montana Weed Control Association*. Butte, MT. January 14–16, 33.

U.S. Bureau of Land Management (BLM)

2000 Strategic Paper on Cultural Resources at Risk. Prepared by the Washington Office, Cultural Heritage, Wilderness, Special Areas and Paleontology Group (WO-240). June 2000.

U.S. Fish and Wildlife Service (USFWS)

1996 Atlantic Coast revised Piping Plover Recovery Plan. Appendix G: Guidelines for Managing Recreational Activities in Piping Plover Breeding Habitat on the U.S. Atlantic Coast to Avoid Take under Section 9 of the ESA. Accessed March 23, 2009, at <<http://www.fws.gov/northeast/pipingplover/recplan/index.html>>.

2006 National Survey of Fishing, Hunting and Wildlife-Associated Recreation: State Overview. July 2007. Preliminary Findings.

2008 Recovery Plan for the Northwest Atlantic Population of the Loggerhead Sea Turtle. Second Revision. Accessed April 1, 2009, at <http://www.nmfs.noaa.gov/pr/pdfs/recovery/turtle_loggerhead_atlantic.pdf>.

U.S. Geological Survey (USGS)

2005 Roads and Traffic: Effects on Ecology and Wildlife Habitat Use Applications for Cooperative Management. Fact Sheet 2005-3102. September 2005.

Van Der Merwe, D.

1991 Effects of Off-road Vehicles on the Macrofauna of a Sandy Beach. *South African Journal of Science*. 87: 210–213.

Appendix A

Walder, B.

no date Roads Impact Elk Habitat, Decrease Wildlife Security.

Watson, J., G. Kerley, and A. McLachlan

1996 Human Activity and Potential Impacts on Dune Breeding Birds in the Alexandria Coastal Dunefield. *Landscape and Urban Planning*. 34: 315–322.

Webb, R. H.

1982 Off Road Motorcycle Effects on Desert Soils. *Environmental Conservation*. 9(3): 197–208.

Williams, A. J., V. L. Ward, and L. G. Underhill

2004 Waders Respond Quickly and Positively to the Banning of Off-road Vehicles from Beaches in South Africa. *Wader Study Group Bulletin*. 104: 79–81.

Wilshire, H. G.

1983 The Impact of Vehicles on Desert Soil Stabilizers. In R. H. Webb and H. G. Wilshire (Eds), *Environmental Effects of Off-Road Vehicles, Impacts and Management in Arid Regions*. 31–50. New York: Springer-Verlag.

Witherington, B. and E. Martin

1996 Understanding, Assessing, and Resolving Light-pollution Problems on Sea Turtle Nesting Beaches. Florida Department of Environmental Protection. FMRI Technical Report TR-2.

Witherington, B.

2003 Biological Conservation of Loggerheads: Challenges and Opportunities. In: A. B. Bolten and B. E. Witherington, (Eds). *Loggerhead Sea Turtles*. HarperCollins: November, 2003.

Wolcott, T. G. and D. L. Wolcott

1984 Impact of Off-road Vehicles on Macroinvertebrates of a Mid-Atlantic Beach. *Biological Conservation*. 29: 217–240.

Yankoviak, B. M.

2005 Off-Road Vehicle Policy on USDA National Forests: Evaluating User Conflicts and Travel Management. Master's Thesis. University of Montana, Missoula, MT.

Zaremba, R. E., P. J. Godfrey, and S. P. Leatherman

1973 The Ecological effects of Off-Road Vehicles on the Beach/Backshore (Drift Line) Zone in Cape Cod National Seashore, Massachusetts. National Park Service Cooperative Research Unit. Document No. QX79-14.

~~Draft~~ Statement of Findings for Floodplains

for the Proposed

Off-Road Vehicle Management Plan

**Cape Hatteras National Seashore
North Carolina**

Recommended:	_____	_____
	Superintendent, Cape Hatteras National Seashore	Date
Concurred:	_____	_____
	Chief, Water Resources Division	Date
Approved:	_____	_____
	Southeast Regional Director	Date

INTRODUCTION

Executive Order 11988 (Floodplain Management) requires the National Park Service (NPS) and other federal agencies to evaluate the likely impacts of their actions in floodplains. The objectives of the Executive Order are to avoid, as much as possible, the short- and long-term adverse impacts associated with occupancy, modification, or destruction of floodplains and to avoid indirect support of development and new construction in such areas where there is a practicable alternative. NPS Director’s Order #77-2: *Floodplain Management* provides NPS procedures for complying with Executive Order 11988. This Statement of Findings (SOF) for the Cape Hatteras National Seashore ~~draft~~ Off-Road Vehicle Management Plan/EIS (~~draft~~ Plan/EIS) has been prepared in accordance with the guidelines in NPS Director’s Order #77-2. The ~~draft~~ Plan/EIS states that the purpose of taking action is to develop regulations and procedures that carefully manage ORV use/access in the Seashore to protect and preserve natural and cultural resources and natural processes, to provide a variety of visitor use experiences while minimizing conflicts among various users, and to promote the safety of all visitors.

DESCRIPTION OF THE PROPOSED ACTION

Alternative F ~~—Management Based on Advisory Committee Input~~ is identified as the NPS preferred alternative in the ~~draft~~ Plan/EIS and has been revised based on public and agency comments on the draft plan/EIS. Alternative F would provide a variety of opportunities for ORV and pedestrian non-ORV access, but often with controls or restrictions in place to limit impacts on sensitive resources. Interdunal road and ramp access for ORVs would be improved, and more pedestrian access would be provided through substantial additions to parking capacity at various key locations that lend themselves to walking on the beach. Implementation of alternative F would involve the construction of 4 new ORV access ramps, the relocation of 2 existing ORV ramps, installation of 2 new interdunal roads (i.e., ORV routes), establishment of pedestrian trails on Bodie and Ocracoke islands, and the installation of 10 new parking areas (surfaced with pervious materials such as a clay/shell base) and the reuse or resurfacing for public parking of two existing paved areas¹ that were not previously used for public parking, which in combination would create or improve a total of approximately 135 new public parking spaces along the Seashore~~the construction of 1 relocated and 8 new ORV access ramps; construction of 9 new and 3 expanded parking areas; establishment of 1 extended, 1 relocated and 2 new interdunal roads; and establishment of two pedestrian trails~~. These actions are listed in Table 1 below and are considered in this SOF.

¹The reuse/resurfacing of two existing paved areas was not considered to be “new construction” in this Statement of Findings, as the existing paved areas would be replaced with pervious materials and used as public parking areas.

Table 1. Alternative F Proposed New or Relocated Ramps; New, Reused or Resurfaced Expanded Parking Areas; New, Extended Expanded or Relocated Interdunal Roads; and New Pedestrian Trails

BODIE ISLAND
<u>Reuse or resurface for public parking the existing asphalt-paved area -at the old Bodie Island Coast Guard Station site after site is used as a potential staging area for proposed widening and repaving of NC12 (if resurface existing paved area, would use pervious material)</u>
<u>Relocate rRamp 2 relocated approximately 0.5 mile south of Coquina Beach, and install new parking area at 2.5</u>
<u>New parking area and trailhead near ramp 4, with pedestrian trail to the “flats” on the northeast side of the Bait Pond. Pedestrian trail to inlet from new parking near campground established.</u>
HATTERAS ISLAND
<u>New parking 1.0 mile south of ramp 23. Parking at ramp 23 expanded.</u>
<u>New ramps with parking established at 24 and 26-25.5</u>

New parking near soundside ramp 48.
New ramp with parking established at 32.5.
New parking near soundside ramp 52. Parking at ramp 38 expanded.
New ramp 39 across from Haulover and new soundside parking <u>area on west side of highway at or near</u> Kite Point established.
<u>New parking area on west side of highway at or near soundside ramp 60</u>
<u>Reuse or resurface/reconfigure for public parking the existing asphalt-paved area at the old Buxton Coast Guard Station site after U.S. Coast Guard has completed clean-up of the site (if resurface/reconfigure existing paved area, would use pervious material).</u> NPS or Dare County to establish new parking at old Coast Guard Station site.
<u>New parking area at Loran Road</u>
Interdunal ORV route extended from ramp 45 to ramp 49 with new ramp 47.5. road extended and new ramp 47 established.
West of the overwash fan, Pole Road re-routed toward the sound to provide natural barrier to bird nesting area south of road.
New interdunal ORV route road from eastern portion of Spur Road west toward inlet extending southwest and northeast of the south end of Pole Road established to provide access to False Point and inlet.
OCRACOKE ISLAND
<u>Relocate ramp 59 to 59.5</u>
New interdunal road established parallel to the beach extending from ramp 59 for 0.3 mile northeast toward the inlet, with parking at the terminus. New parking area on west/north side of the highway at or near the entrance to Barrow Pit Road
New ramps 62 and 64 established. Parking established at ramp 64.63
Parking at Pony Pen expanded.
A new pedestrian trail to Pamlico Sound from the end of an ORV route perpendicular to the beach 0.6 mile south of ramp 72. New ORV route from .65 miles south of ramp 72 ending in a small, unpaved parking area with a pedestrian trail leading to the sound.

Source: ~~Table 7-1 and Table 8 in the Routes and Areas Table and Summary of Alternative Elements of the draft Plan/EIS. Table does not include two on-sand parking areas for 4-wheel drive access (described below).~~

The interdunal roads, essentially “over sand” ORV routes that are not located along the beach, would be constructed at grade. They would not alter topography, require a finished or impervious surface, or involve any above-grade structures. The pedestrian trails would be primitive sand trails and would not be paved or surfaced. The new or relocated ORV ramps would be surfaced with semi-permeable clay/shell base or some other porous material. The average ORV ramp is 40 feet wide and 500 feet long, occupying 20,000 square feet.

The alternative F on-sand parking areas accessible by 4-wheel drive vehicles at the terminus of the new interdunal ORV routes for Hatteras Inlet and near South Point at North Ocracoke the beginning of a new pedestrian trail to Pamlico Sound would not need a hardened surface because vehicles would travel over sand to reach them. Also, overnight camping would not be allowed in these two on-sand parking areas. Therefore, the on-sand parking areas are not considered further in this SOF. The other new, reused or resurfaced or expanded parking areas would be directly accessible by 2-wheel drive vehicles from NC Highway 12 (NC 12). These would be designed and constructed with a semi-permeable clay/shell base, turf block or some other porous material, using environmentally sensitive standards to minimize stormwater runoff. The only area where a paved surface would be considered is a short section from handicapped spaces to an adjacent boardwalk. With two exceptions involving the reuse, resurfacing and/or reconfiguration for public parking of existing paved areas (a 10-car parking area at the former Bodie Island Coast Guard Station site and a 50-car parking area at the former U.S. Coast Guard Station in Buxton, both in previously disturbed areas), N~~new~~

~~and expanded~~ parking would comprise an estimated ~~25 – 1050~~ spaces per parking area. A ~~1025-~~space, ~~200~~ 100 foot by 80 foot parking area, would occupy about ~~846,000~~ square feet.

Before constructing the proposed new parking areas, the Seashore would conduct a separate ~~process of~~ environmental analysis process to evaluate the potential surface materials that could provide an environmentally sustainable, porous treatment and could avoid the need for stormwater control structures (curbs, drains, culverts, holding ponds, etc.). This on-site analysis would also evaluate specific locations to avoid sensitive species in the Seashore’s Significant Natural Heritage Areas that have been identified by the North Carolina Natural Heritage Program. Exact location and number of added spaces for each area would be determined during the site-specific planning and environmental analysis subsequent to approval of the Plan/EIS.

~~Signs informing visitors of flooding and suggested actions in the event of flooding would be located at the parking areas.~~

SITE DESCRIPTION

The project site is on three North Carolina barrier islands, which are part of the Outer Banks. These islands have historically been and continue to be affected by coastal forces and flooding events. The barrier islands comprising the Seashore are flat and narrow and lie between the Atlantic Ocean and the shallow and wide Pamlico Sound. The widest part of the Seashore islands is near Cape Point, between Buxton and Frisco. According to FEMA Flood Insurance Rate Maps, nearly the entire Seashore is within the 100-year floodplain. Generally, lands along the ocean beaches and adjacent to the sound (at wide points) are in flood zone “VE,” which is the flood insurance rate zone that corresponds to the 100-year coastal floodplains that have additional hazards associated with storm waves. Zone “VE” is also referred to as the “Coastal High Hazard Area.” The rest of the Seashore not directly adjacent to the ocean or sound lies in the “AE” zone, which is in the 100-year floodplain and subject to waves less than 3 feet high (NCDCCPS 2008).

Because the Seashore is almost entirely in the 100-year floodplain and is subject to high-water-table conditions, many areas are conducive to drainage and flooding that often result from storm events. Areas near Buxton Woods and Cape Point Campground have been documented as historically flood-prone and are examples of popular Seashore destinations that experience flooding during times of above-average precipitation events (NPS 2003).

Elevations in the vicinity of the proposed ramps, interdunal roads, pedestrian trails and parking areas range from sea level to about 25 feet above sea level. Due to the low topography, the entire project area is located within the 100-year flood zone and is subject to inundation during extreme storm events. Some parking areas would be within the “VE” flood zone, and others would be located in the “AE” flood zone. Those in the “VE” or coastal high hazard area are classified as a Class III Action, according to Director’s Order #77-2.

GENERAL CHARACTERIZATION OF FLOODPLAIN VALUES AND OF THE NATURE OF FLOODING AND ASSOCIATED FLOODPLAIN PROCESSES IN THE AREA

The Seashore’s barrier island floodplains help reduce the impact of hurricanes and other storms on the shorelines that they shelter. These floodplains provide storm water holding capacity, reducing runoff that could otherwise flood NC12 and other developed areas. They also provide habitat for species adapted to the coastal barrier island environment.

Storm events such as hurricanes and nor’easters (winter storms along the mid-Atlantic coast) and associated wave action and high precipitation are the prime sources of flooding in the Seashore. Additionally some areas are known to be susceptible to minor flooding without wave involvement when large amounts of rainfall occur.

JUSTIFICATION FOR LOCATION OF THE ACTION IN THE FLOODPLAIN

The purpose of constructing or relocating ORV ramps, establishing interdunal roads, creating pedestrian trails, and ~~installing constructing or expanding~~ parking areas is to improve visitor access to the shoreline, both in areas where ORV routes would be designated and in areas where ORV routes would not be designated. To provide access the ORV ramps, interdunal roads, pedestrian trails and parking areas must be located in the vicinity of the shoreline. Avoidance of impacts to floodplains is not possible because the all areas between access points along NC-12 or interdunal roads and the shoreline is within the 100-year floodplain.

INVESTIGATION OF ALTERNATE SITES

Alternatives A and B (the no-action alternatives) do not provide for any new ORV ramps, interdunal roads, pedestrian trails, or new ~~or expanded~~ parking areas. Alternative F and the other action alternatives provide for differing numbers of ramps, interdunal roads, and new ~~or expanded~~ parking areas, as displayed in Table 2 below. As explained above, because all areas between access points along NC-12 (or interdunal roads) and the shoreline is in the floodplain and access to the beach is needed, no sites outside the floodplain were considered.

Table 2. Number of New or Relocated Ramps; New/~~Reused/Resurfaced or Expanded~~ Parking Areas; New, Relocated or Extended Interdunal Roads; and New Pedestrian Trails Proposed in the ~~draft~~ Plan/EIS Alternatives

	Alternative A/B	Alternative C	Alternative D	Alternative E	Alternative F
Number of new or relocated ramps	0	6	4	7	9 6
Number of new, reused or resurfaced expanded parking areas	0	7	0	14	12
Number of new, extended or relocated interdunal ORV routes roads	0	1	0	1	4 2*
Number of new pedestrian trails	0	0	0	1	2

Source: Routes and Areas Tables and Summary of Alternative Elements of the ~~draft~~ Plan/EIS

* In addition to the interdunal ORV route extension between ramp 45 to ramp 49, this number includes the addition of small interdunal ORV route near Hatteras Inlet as described above in Table 1 and as depicted on the maps for alternative F in the FEIS.

The impact analysis in the ~~draft~~ Plan/EIS indicates that ~~A~~ alternatives A and B would have no impacts on floodplains, and the preferred alternative and the other 3 action alternatives would have minor impacts on floodplains. A minor floodplain impact is defined in the ~~draft~~ Plan/EIS as an impact that “would result in a detectable change to floodplain functions and values, but the change would be expected to be small, of little consequence, and localized. There would be no appreciable increased risk to life or property. Mitigation measures, if needed to offset adverse effects, would be simple and successful.”

IMPACTS TO FLOODPLAIN FUNCTIONS AND VALUES

The use of vehicles for NPS administrative use and by visitors for beach access would result in no or negligible impacts to floodplain functions or values ~~because the amounts of oil and grease deposited on the sand by these vehicles would not have any measurable or perceptible consequence on floodplain functions or values~~. Under alternative F, the establishment of interdunal roads would not result in floodplain impacts because impervious surfaces or above-grade structures would not be constructed. The interdunal roads would be constructed at grade and would not alter topography or require a finished surface. Therefore floodplain functions would not be altered.

The pedestrian trails would also not result in floodplain impacts because the trails would be primitive sand trails and would not be paved or surfaced. Minor impacts would result from the construction or relocation of ramps, which would be surfaced with semi-permeable clay/shell base, reducing storm water runoff and limiting the potential for impacts to the floodplain's water storage function. Similarly, minor impacts would result from the construction ~~or expansion~~ of parking areas because they also would be surfaced with semi-permeable or porous materials, with the possible exception of a short access path from handicapped spaces to an adjacent handicapped accessible boardwalk. Because there are no more than minor impacts to the floodplain, there would not be significant impacts to floodplain function and values from establishment or relocation of interdunal roads and ramps, establishment of pedestrian trails, or construction of new ~~or expanded~~ parking areas.

MINIMIZATION OF HARM OR RISKS TO LIFE AND PROPERTY

Mitigation would be provided by incorporating methods for protecting human safety and protection of investment. Minimization of harm or risk to life and property would be accomplished by siting new parking areas ~~and adding new spaces to existing parking areas~~ in locations known to be less susceptible to flooding from rainfall alone. Parking areas directly accessible from NC 12 are landward of the primary dune line. Overnight camping would not be allowed in the new ~~or expanded~~ parking areas, ~~n~~ or on the beach. Hurricanes and large nor'easters that may result in storm surge are predicted far enough in advance to allow ample time for evacuation.

In addition to Cape Hatteras National Seashore, the Fort Raleigh National Historic Site and the Wright Brothers National Memorial are collectively managed by NPS as the Outer Banks Group. The NPS – Outer Banks Group annually updates its *Hurricane Plan* (NPS 2009), which describes the Incident Command System (ICS) priorities, procedures, and timelines for the protection of human safety, property, and park resources and values in the event of a hurricane or other emergency. The *2009 Hurricane Plan* details actions to be taken at the beginning of hurricane season (June 1), at critical intervals from 96 hours before storm force winds through landfall of a hurricane, recovery, and re-entry. As early as 96 hours before storm force winds, the Superintendent activates the ICS and the following occurs on the Seashore:

- Visitors are informed of weather conditions, park status, and recommended actions.
- Hurricane watch notices are posted at all visitor centers, campground kiosks, and on the Park's website.
- Visitors are advised to leave the island or be prepared for short notice evacuation. Ocracoke must be evacuated before termination of ferry services or before onset of gale-force winds, and preparatory actions for Ocracoke Island occur a day in advance of the other Seashore islands.
- Normal park operations and visitor facilities (e.g., visitor centers, campgrounds, swim beaches) close.

- Concessionaires and local businesses are notified of the park status.
- All non-assigned personnel are released by noon to permit daylight evacuation.
- All non-essential vehicles and equipment are secured.

Since the ramps, interdunal roads, pedestrian trails, and parking areas cannot be assured of protection from all future damage related to flood/storm events, the NPS would tolerate risk to these investments and would repair or reconstruct them when damage occurs.

CONCLUSION

Alternative F (the preferred alternative) includes the construction of 4 ORV access ramps and the relocation of 2 ramps, and the construction of 2 new interdunal roads, pedestrian trails on Bodie and Ocracoke islands, and 10 new parking areas, and the reuse for public parking of two existing paved areas, to be surfaced with pervious materials such as a clay/shell base, resulting in the creation of approximately 135 new parking spaces along the Seashore~~construction or relocation of 9 ORV ramps; establishment, relocation or extension of 4 interdunal roads; establishment of 2 pedestrian trails; and construction or expansion of 12 public parking areas.~~ The NPS concludes that there is no practicable alternative for locating these outside the floodplain because their purpose is to provide access for visitors on foot and by ORV to the shoreline. To accomplish this purpose the ramps, interdunal roads, pedestrian trail, and parking areas must be located close to the shoreline.

The establishment of ramps and interdunal roads would not result in floodplain impacts because impervious surfaces or above-grade structures would not be constructed. The pedestrian trails would also not result in floodplain impacts because the trails would be sand trails that would not be paved or surfaced. On the ocean side of NC 12, the parking areas ~~construction or expansion~~ would be located behind the primary dunes. Because hurricanes and big nor'easters are predicted far enough in advance to allow ample time for visitors to evacuate the area, overnight camping would not allowed in the parking areas, and the park has prepared and regularly implements and updates a *Hurricane Plan* for the protection of human safety, property, and park resources and values in the event of a hurricane or other emergency, there would be no effect on human safety from the alternative F actions. Construction ~~or expansion~~ of the parking areas would result in long-term, minor adverse effects to floodplain functions and values because, although the change to floodplain functions and values would be detectable, it is expected to be small, of little consequence, and localized in the immediate area of the parking areas, ramps, and interdunal roads. Mitigation measures, such as ~~signage and avoiding~~ the use of pervious impermeable surface materials, would be simple and successful and ~~these measures~~ have been incorporated into alternative F.

Establishment of the ramps, interdunal roads, pedestrian trails, and parking areas would not affect flood storage capacity of the Seashore as a whole. The existing floodplain would continue to function as a floodplain after the construction or expansion of these areas.

The NPS finds the proposal to be consistent with Executive Order 11988. The NPS finds that this proposed action is consistent with the policies and procedures of NPS Special Directive 93-4 (Floodplain Management Guidelines).

REFERENCES

National Park Service, U.S. Department of Interior

- 1993 Special Directive 93-4: Floodplain Management Guideline. Washington, D.C.
- 2003 October 23, 2003 Letter from Larry Martin (Hydrogeologist, Water Resources Division, NPS) to the Superintendent of Cape Hatteras ~~N~~National Seashore Regarding the Hydrology of the Buxton Woods and Cape Hatteras Areas.
- 2009 2009 Hurricane Plan, National Park Service, Outer Banks Group. Manteo, NC.

North Carolina Department of Crime Control and Public Safety (NCDCCPS)

- 2008. North Carolina Floodplain Management: 2008 Quick Guide.

Intentionally Left Blank