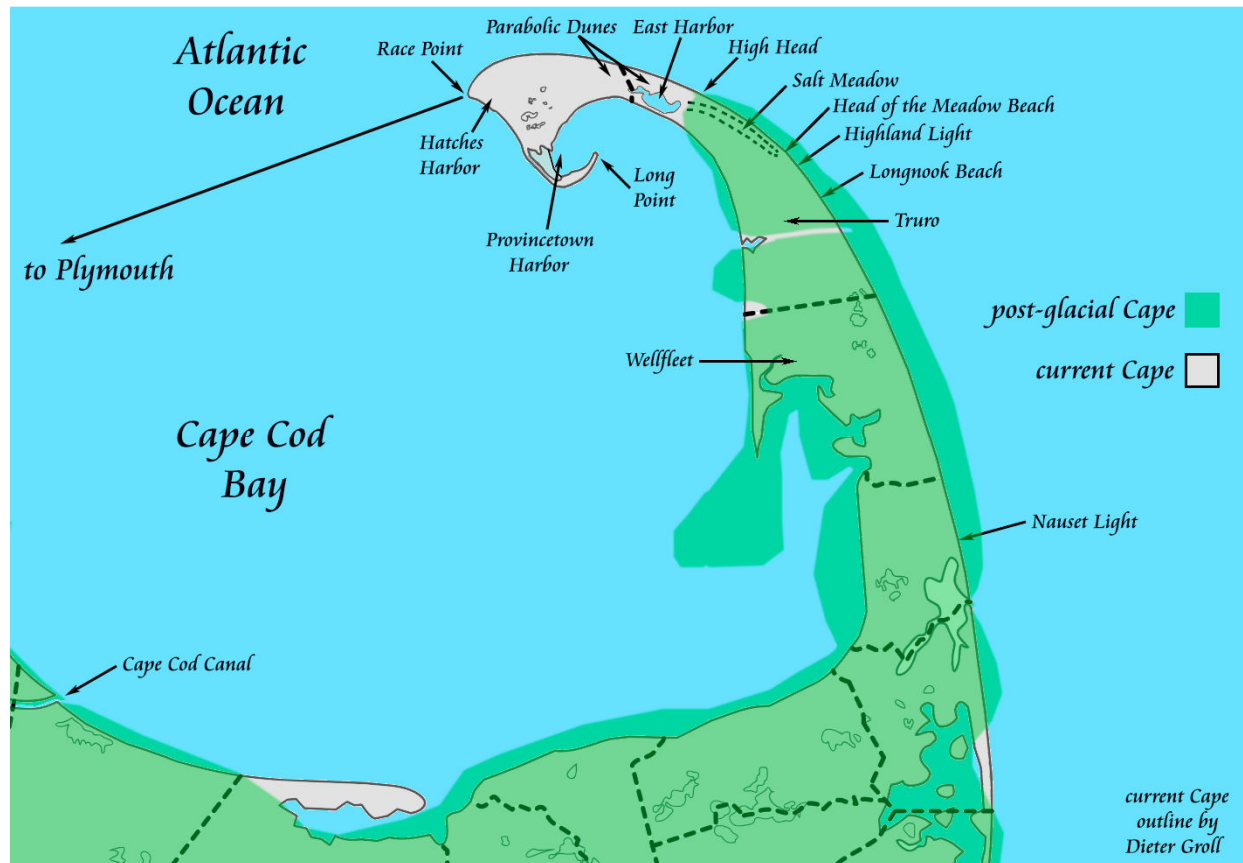
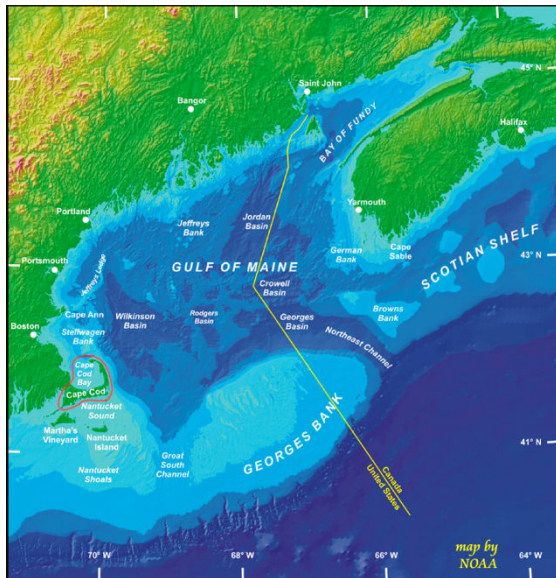


A Desultory Treatise on Outer Cape Cod Biogeography

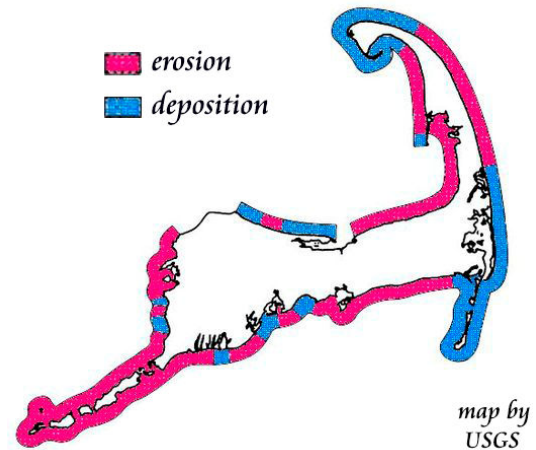
Michael Sargent - 2016



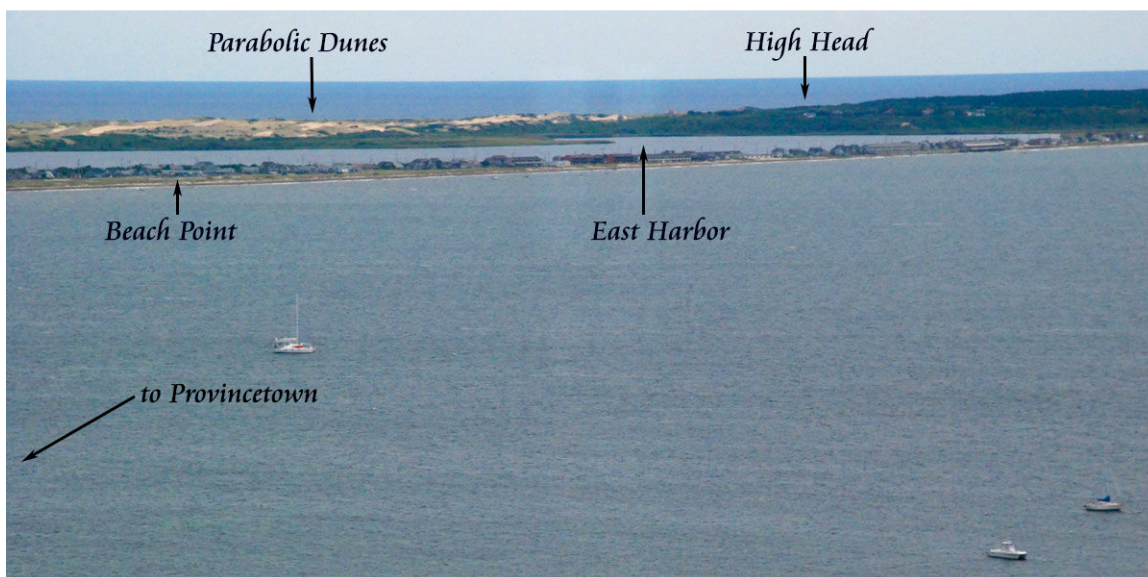
The retreat of the glacier system covering Cape Cod left a land mass depicted by the green area of the above map, ending at what is now known as High Head. Initially, erosion of the eastward-facing cliffs resulted in sediment deposition in a southerly direction, forming the barrier systems of Nauset Spit and Monomoy Island. This process was aided by a complex system of currents, including the Gulf Stream from the south and branches of the Labrador Current from the north, which operate in primarily a counter-clockwise direction. About 6,000 years ago, rising water levels began to cover Georges Bank to the southeast. This reduced a significant barrier shielding the northeastern portion of the outer Cape, and also amplified a clockwise current around the bank. This resulted in an acceleration of erosion, with a new trend of sediment deposition in a northerly direction. This process is what formed the East Harbor region of North Truro and all of what is now Provincetown. Long Point, the absolute tip of the Cape, is still growing out around Provincetown Harbor. Meanwhile in Cape Cod Bay, which is separated from the Atlantic Ocean by a line connecting Race Point with Plymouth, a large area of shoreline and islands was eroded and covered south of Wellfleet, with some sediment moving in both northerly and southerly directions. As global warming causes increasing water levels, the protective effect of Georges Bank will diminish further, and the erosive forces, like many other natural phenomena, will increase in intensity.



This map shows the location of Georges Bank, in relation to the Cape (enclosed in red), the Gulf of Maine and Nova Scotia.



This drawing shows the areas of the Cape where either erosion or deposition is the dominant process.



This view from the Pilgrim Monument in Provincetown shows the end of the post-glacial cliff at High Head, the parabolic dunes formed by prevailing winds, and East Harbor. In 1868, a dike closed off East Harbor, connecting Beach Point with Provincetown for construction of a railway. A formal roadway was established in 1887. East Harbor, renamed Pilgrim Lake in 1910, gradually desalinized and experienced various ecological disasters, including invasive plants, oxygen depletion, midge outbreaks and fish kills. In 2002 the culvert connecting Pilgrim Lake with the bay was opened for bidirectional flow, beginning gradual recovery of its saline and tidal health. In 2008, Pilgrim Lake was un-renamed back to East Harbor. Salt Meadow extends eastward from East Harbor between the High Head cliff and barrier dunes along the ocean beach.



Here is an aerial view of the same region, at low tide. Various migrating sand bars can be seen.



This directly downward view clearly shows the “parabolic” nature of the dunes.



Each cubic meter of seawater slamming into the beach and cliffs has a mass slightly over a metric ton.



Longnook Beach in Truro is located in one of the zones of predominant erosion. The sand of the eroding cliff is colored differently from that of the beach and ocean floor. Deposition from this zone proceeds toward Provincetown and contributes to the sand bars seen on the previous page. The beach itself changes in width from year to year.



Erosion and deposition cause changes even within the space of a season. These photos of Head of the Meadow Beach were taken in April and September 2016, less than 5 months apart. The photo on the right shows plantings of beach grass, which stabilizes sand dunes by minimizing their migration and for the same reason facilitates their growth.



A group of several hundred grey seals favors the sand bars between Head of the Meadow and High Head for low tide haul-outs. A sand bar also attracts a rare beach visit from a great blue heron. Large numbers of shorebirds such as these sanderlings congregate on the bars, including various gulls and sandpipers, and rare and endangered species such as piping plover, least terns and roseate terns.

Seals were almost exterminated from the New England coast, until bounties were discontinued by Maine in 1945 and Massachusetts in 1962. Further protection was afforded by the Marine Mammal Protection Act in 1972. Since the 1980's, the seal

population has been growing steadily, so that now there are probably more than 10,000 on the Cape. This has caused concern among local fishermen, who feel that their livelihood is being threatened. This also has caused concern about the increasing numbers of great white sharks which have been attracted by the seals. Already one person of questionable judgment has been bitten by a shark in Truro, though he managed to survive. Tagging and other means of observation are being used to study the sharks, as oceanside communities,

particularly near the Cape's "elbow" where the majority of seals congregate, try to ensure the safety of beachgoers.



There are two types of dunes on the outer Cape. The previously-noted parabolic dunes are formed by prevailing winds, in this case from the northwest. The windward side of the dunes becomes blown out and its sand is deposited on and over the parabolic-shaped crests. This process results in migration of the dunes, which can eventually cover the vegetation on the leeward sides, even trees. Beach grass planting has slowed the migration of these dunes considerably, although it also collects the sand and allows for dune enlargement. This has significantly reduced the need for the removal of tons of sand from Route 6. The blowout areas can retain water when water tables are high in the spring. These "dune slacks" are important sites for plant and small animal life, including the threatened spadefoot toad, which breeds in temporary pools.



Other low areas between major dunes, which become flooded in the spring, allow for the formation of cranberry bogs like this one in the Province Lands.



Linear dunes, “foredunes” or barrier dunes are formed when onshore winds carry beach sand inland, where it is caught by beach grass and other vegetation. This photo was taken from the High Head cliff. It shows the barrier dunes separating Salt Meadow from the ocean. To the right, the dunes and the cliff converge at Head of the Meadow Beach. To the left, the meadow connects with East Harbor at the end of High Head.



This view looking westward shows the barrier dunes with greater contrast.



Salt Meadow is frequented by raptors such as red-tailed hawks (left) and sharp-shinned hawks (right), which prey on rodents and birds respectively, as well as northern harriers and peregrine falcons.



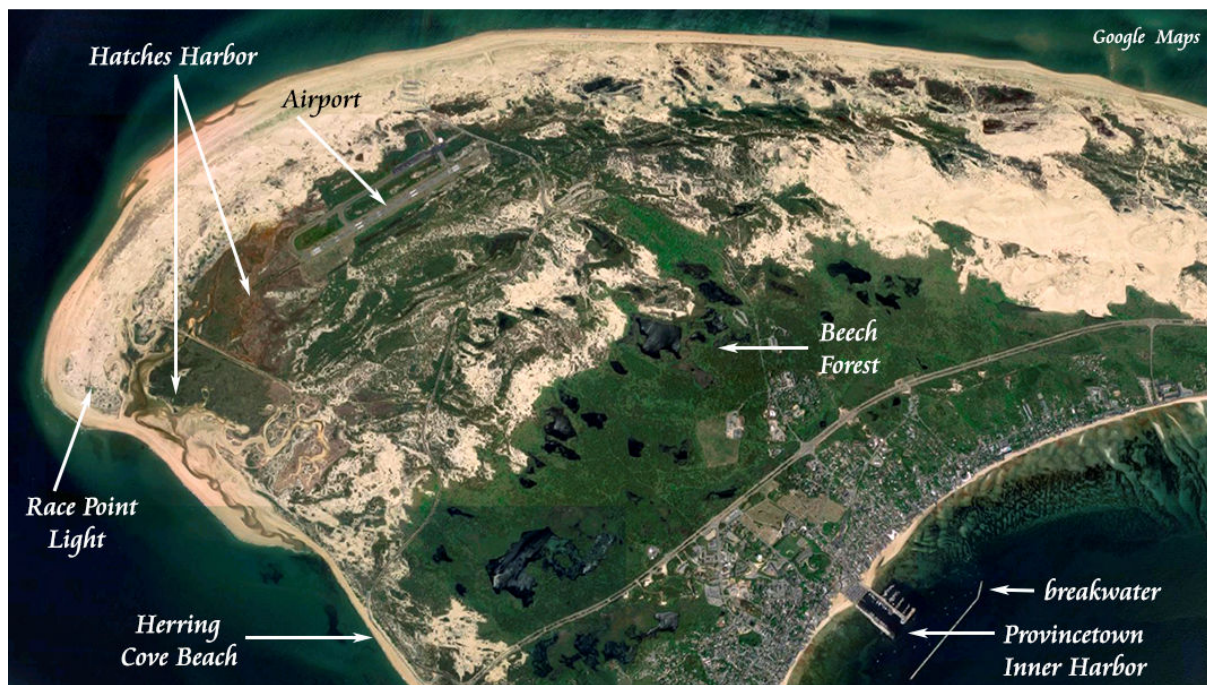
In the early 17th Century, the Cape was covered by oak and beech forests. After the invasion of Europeans, these forests were completely leveled for houses, firewood and boats, and to clear land for agriculture and grazing. Apparently many of the colonists believed that it was God's will that they should "tame" the wilderness, and that they would be rewarded by divine providence with improved weather and living conditions. Unfortunately that didn't happen. Other settlers simply ignored the laws passed by a few far-sighted individuals, so that by the end of the 18th century, essentially no trees were left, and subsequent travelers including Thoreau described the area as a desert. With nothing to anchor the sandy ground, land-based erosion compounded the millennia of sea-based erosion. Because of cliff collapse, both Nauset (left) and Highland (right) Lighthouses have had to be moved further inland.



This scene in the Province Lands shows the process of plant life recovery. Across the middle, lichens are seen growing on the sand, generating the beginnings of organic soil beneath them. In the foreground, grasses and shrubs are advancing. Taller and thicker plants are seen behind the lichens. A small pitch pine at left center sends low branches laterally, which eventually grow roots into the ground. A larger pine is seen at the upper left, with a black oak at the upper center.



The pines in the grove on the left, near Head of the Meadow, are able to send roots deep into the ground to find water. The beech forest on the right, off Race Point Road in the Province Lands, also contains oaks and other hardwoods, and is the climax forest of the outer Cape.



Hatches Harbor is an extensive salt marsh located just east of Race Point, opening into Cape Cod Bay. In the aerial view, a dike can be seen dividing the marsh. This was built in 1930 to protect adjacent land for a planned airport, and also as an attempt to control mosquitoes. As with East Harbor, the water in the marsh became fresh and the marsh was invaded by various reeds, displacing salt grasses. Numerous flora and fauna were eliminated. Ironically, the dike prevented estuarine fish from reaching the high marsh pools to feed on mosquito larvae. In 1987 the National Park Service began a restoration project, which involved some political wrangling with the town and the FAA. A system of culverts in the dike has been used to re-introduce tidal flow to the upper marsh gradually, which is allowing salt water vegetation and the previous diversity of animal species to recover.



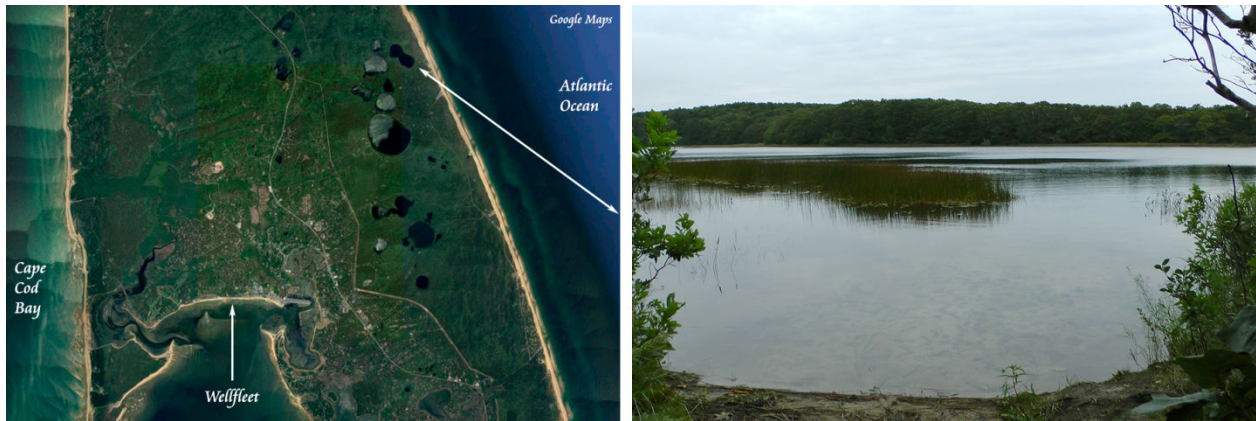
The Hatches Harbor salt marsh supports numerous shorebirds, including black-bellied plovers (left, non-breeding plumage) and yellowlegs (right).

The tidal zone also supports a variety of invertebrates, such as this green crab.



A “coywolf” runs across the edge of Hatches Harbor, with a red fox tagging along in the foreground. These are hybrids of western coyotes and 3 types of wolf (eastern, grey and red), and have migrated from Canada, swimming across the Cape Cod Canal. They are one of the few large animals in the U.S. that are extending their range. While it is legal to kill unlimited numbers of “coyotes” in Massachusetts during the winter season, wolves are protected species, and there is no consensus about the status of coywolves. Rare attacks on humans and pets have angered many, yet such attacks are likely the result of the ill-advised insistence of some humans on feeding the animals.





There are over 350 ponds on Cape Cod, most of which are “kettle ponds”. These were formed after the glacier system retreated, leaving behind many large blocks of ice that were partially buried in the outwash plains. These blocks produced depressions, which held water when the bottoms were below the water table. By definition, a “pond” is shallow enough that light is sufficient to support plant growth on the bottom. Technically, many kettle ponds are “lakes”.

Northern Wellfleet and southern Truro contain a group of relatively large ponds with complex biological attributes. Plant and animal life are affected by pond depth, nutrient availability (natural and human-introduced), climate and biological interactions, which influence water clarity. Human activity has had a significant impact on these delicate ecosystems, including pollution and introduction of various fish species. Some ponds are connected to salt water via creeks and are able to host spawning runs of herring. The ponds are dependent on groundwater (supplied exclusively by precipitation) for turnover, which typically takes 10-15 years.

The ponds may become saline if the sea level rises above the water table. If sediment accumulates faster than it can be broken down, a pond eventually can become a swamp or marsh. Sediment layers provide geological information about previous climate and plant prevalence.

Pilgrim Pond in North Truro was the campsite of Miles Standish and 15 companions on November 16, 1620, their second night in North America. However, the Pilgrims were not the first Europeans to explore the Cape. John Smith had visited Provincetown Harbor in 1614. And in 1805, a stone wall was discovered in Provincetown that initially was believed to have been built by Thorvald Eiriksson around 1007. Subsequent dating suggests that the wall was built at least a hundred years later.





Provincetown has the third largest deep water harbor in the world. There's plenty of room for a pod of 200 Atlantic white-sided dolphins.



Double-crested cormorants use the harbor's breakwater for drying their wings.



Cape Cod Bay adjacent to Wood End, Herring Cove and Race Point is a relatively sheltered area where phytoplankton can flourish. Small crustaceans such as copepods and krill eat the phytoplankton and then serve as food for larger animals, up to and including right whales. These critically endangered animals stop over in the spring before migrating further north.

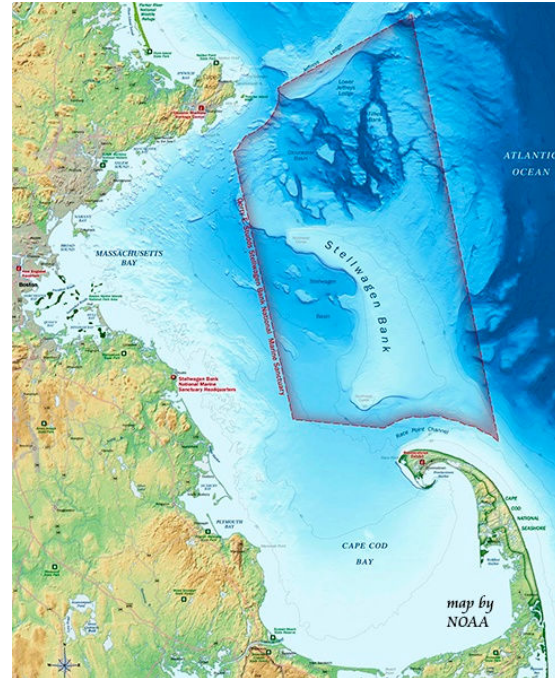


Juvenile humpback and finback whales also can be found in the bay. This finback has continued to feed in the area throughout the summer. It shows typical asymmetric head coloring, with the right side white and the left side grey, as well as a “chevron” pattern on its dorsal surface.

These eider ducks have been diving for food in the bay and have come out onto the beach at Race Point.



Stellwagen Bank is a plateau located 6 miles north of the Provincetown spit. The bank was designated a National Marine Sanctuary in 1992. Its depth averages 100 feet, and the depth of the surrounding sea floor ranges over several hundred feet. The steep sides of the bank cause an upwelling of deep-water currents which brings up nutrients from the bottom to the bank, supporting a diverse ecosystem from plankton to invertebrates to groundfish to pelagic birds to whales. The bank is glacial in origin, similar to the Cape, and at one time, like Georges Bank, it was located above sea level. Fossil evidence of mammoths and mastodons has been discovered. Shipping lanes crossing the bank to and from Boston have been diverted in an attempt to minimize collisions with whales.



The coarse sandy bottom of Stellwagen Bank is an ideal habitat for sand lance, fish which grow to a size of 4 - 6 inches. They serve as a dietary staple for any fish larger than themselves, as well as for a variety of birds, including gulls, terns, northern gannets, and the four species of shearwaters pictured above: great, Cory's, Manx and sooty. Gannets and shearwaters are pelagic, migrating thousands of miles between the hemispheres and living entirely on the open ocean except for breeding.



Sand lance also are a primary component of the diet of humpback, finback and Minke whales. Humpback whales such as these can eat a ton of sand lance daily. The two at the upper left have just taken in mouthfuls of fish-containing water, which they will strain through their baleen to retain the fish and expel the water.

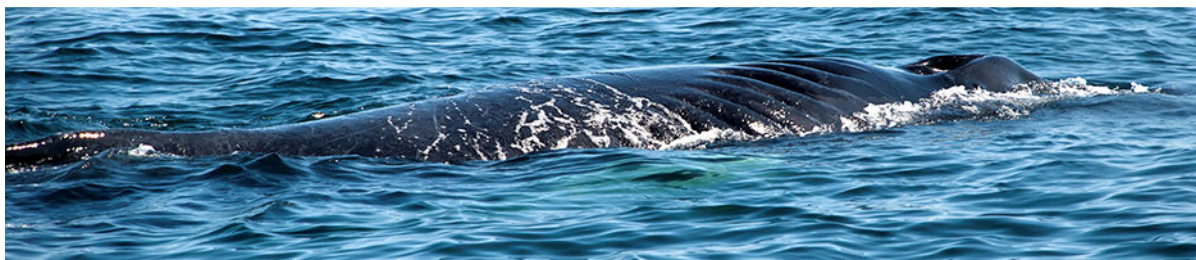




Feeding whales often can be located under flocks of birds such as these laughing gulls, which are taking advantage of the whales' work in rounding up the fish.



Roseate terns and Bonaparte's gulls also get into the act.



The outer Cape affords numerous examples of both the destructive effects of human activity and the ability of humans to ameliorate or even prevent such effects. But such outcomes seem to be achieved more readily on land than at sea. The humpback whale pictured above shows scarring from being struck by a propeller. The relocation of Boston shipping lanes has decreased but not eliminated collisions, which remain a significant cause of whale mortality. Over half of the whales studied in the Gulf of Maine show scars from entanglement with fishing gear, including "ghost gear", which is damaged and abandoned gear that drifts around indefinitely. If an entangled whale is prevented from swimming to the surface, and it cannot free itself or be freed by human rescuers, it cannot breathe and will drown.

Industrialized fishing has become too effective. Overfishing, beyond the obvious matter of local extermination of target species, has even more devastating consequences, including destruction of the topography of the sea floor and re-suspension of sediment and toxins, which threatens the entire food chain from the bottom up. The following information is quoted from the American Museum of Natural History Web site, at:

<http://www.amnh.org/explore/science-bulletins/bio/documentaries/will-the-fish-return/>

Over the past several decades, people have become increasingly aware that the destruction of tropical forests is causing great biodiversity loss. "It is difficult to imagine that another severe human disturbance of even greater extent could occur almost unnoticed by scientists, the media, and political leaders. But there is one: fishing on the seabed with towed gear such as trawls and dredges," write Dr. Les Watling, Professor of Oceanography at the University of Maine, and Elliott A. Norse of the Marine Conservation Biology Institute in a controversial paper published in December 1998.

Of all fishing methods, "trawling is the worst for marine ecology by many orders of magnitude," says Watling. Most trawling occurs along the sea bed, targeting such species as groundfish, shrimp, and scallops, and disturbing or destroying a great number of other species in the process. In heavily trawled areas, the ocean floor becomes a flattened wasteland. Along with destroying habitat, trawling literally empties the sea. Any creature larger than the holes in the net is caught in its vast reach.

"In the minds' eye, people can easily visualize coral reef or sea grass fishes. But when you start talking about animals like cod and flounder, the mental pictures tend to be of the fish on the deck of a boat or on a dinner plate," observes Dr. Peter Auster, science director of the National Undersea Research Center at the University of Connecticut. Because what happens under the surface of the sea is unseen and difficult to study, the impact of trawling on marine ecosystems has been largely overlooked. Yet, write Watling and Norse, "with the possible exception of agriculture, we doubt that any other human activity physically disturbs the biosphere to this degree."

By its nature, trawling is highly nonselective. All species larger than the mesh size can be swept up, regardless of whether they were the targeted species. Although regulations mandate minimum mesh size, once the back wall of the net is lined with catch, little of any size escapes. This unintentionally snared catch is called bycatch or incidental take, and it involves all different kinds of marine life: species with no commercial value, fish that are undersized, fish that are over quota, even large vertebrates. Bycatch also removes large numbers of juvenile fish before they have spawned for the first time. Millions of these undesired organisms are tossed back overboard, maimed or dying, making them easy prey. Often they are already dead when discarded.

In 1989, the worldwide catch peaked. In 1990 and 1991, after a fivefold increase in forty years, the annual take began to decline before more or less stagnating. It has become painfully apparent that the centuries-long increase was owed only to ever-more-efficient fishing methods, which allowed us to expand into new fishing grounds and switch to different species as favored stocks crashed. But many once-abundant fish are now considered commercially extinct - that is, so few in number that it is not profitable to pursue the remaining stock - and many of the world's pre-eminent fishing grounds have been largely exhausted. Meanwhile the human population and the demand for fish continue to grow.

Refer to the above link for the entire discussion. It should be noted that whales are included in the category of "bycatch". While Stellwagen Bank is a sanctuary, it is much harder to enforce protective regulations at major commercial sites like Georges Bank and the Grand Banks.



The Hatches Harbor salt marsh, seen here as the moon rises over Provincetown, shows that humans can exert extensive stress on ecosystems, both intentionally and unwittingly. It also shows that we can recognize and try to repair and prevent the damage. Since eventually the entire Cape is likely to be eroded and/or submerged into a disconnected series of shoals (until the sea level drops with the next ice age in 1500 years), such preservationism can be considered an existential endeavor, but perhaps it should also be considered an ethical obligation.



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