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THE ECOLOGY AND ENVIRONMENTAL IMPACTS OF MARSHLAND AND ESTUARIES[1]

by

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ABSTRACT

Along the seacoast or sea rim, the immediate action of the tides produces an area devoid of vegetation build-up or peat formation. Here, wave action piles up layers of sand and shale (marine sediments) on top of the river sediments. The sea rim is characterized by pioneer species of plant life and an abundance of shore birds and other animals.

INTRODUCTION

Behind the protective sea rims are vast areas of salt marsh. Salt marsh may also extend directly into adjacent open seawater areas protected from wave action. This occurs particularly in the numerous bays and terminal ends of the major stream channels. Frequent inundation by

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[1] The findings in this report are not to be construed as an official Department of the Army position unless so designated by other authorized documents.

saltwater as a result of natural storm tides is necessary to maintain usual salinities. Protection against the abrasive action of waves is afforded by the sea rims and bays and the natural levees along the transecting waterways. The high production levels characteristic of smooth cordgrass (Spartina alterniflora) provide for extensive accretion if it were not for the abrasive action of the tides. The vegetation produced in these areas is mechanically broken down, flushed by the tides, and enters the detrital food chains. It is estimated that as much as 50% of the Spartina organic matter is flushed from the estuary and that 80% of that amount finally gets offshore. This is in part accounts for the enormous value of this marsh type in shellfish and fish fry production.

Further inland where the pressures of the freshwater flow compensate for tidal pressures, a mixing zone occurs. These brackish marshes are the site of one of the most productive areas in the world. Vegetative land accretion in terms of peat accumulation can be very dramatic in the brackish marshes. The high nutrient levels provided by the freshwater flow, coupled with the preserving qualities of the saltwater, allow the accumulation of many yards of peat in the more productive areas. The most productive areas of coastal marsh are intermediate zones where salinity is not too high to restrict growth, and yet available nutrients are in high enough concentrations to allow good growth. These moderately saline marshes are in the greatest danger of being destroyed by saltwater intrusion and industrial activities.

In the areas normally protected from saltwater, a different marsh type develops. While plant species differ, a good nutrient supply makes productivity nearly equal to that of the brackish marshes. Peat formation is, however, somewhat less in these areas due to the lack of protection against decay that the higher salt content of the brackish and saline marshes provide. Temporarily increased salinity from storm tide action, if not sustained, will usually be flushed from the system before serious changes occur. With prolonged salinity increases, existing salt-intolerant species will die out, followed by the growth of more salt-tolerant species until a new salinity equilibrium is established. The lag time in reestablishment of an equilibrium depends on the source of the initial

salinity change and its duration. Aside from the initial impacts of such losses of vegetation, large expanses of mudflats may result if salinities do not become reestablished.

Coupled with the varying potential of the marshes in organic detrital production, substantially different substrate stabilities occur. The stability of a particular site will greatly influence the impact of construction on that area. A continuum of substrate makeup exists from the pure silt soils to the pure organic soils. Both of the endpoints of this continuum represent highly unstable soils. The uniformity of both the silt and muck soil provides for little consolidation and thus little stability. However, in areas where vegetation products and silt have mixed, soils may have greater stability. Peat areas and others, where root and tubor production are extensive, are characteristically very stable.

The terrestrial environment for the purposes of this report includes all lands and lands supporting terrestrial and emergent vegetation. Although the boundaries between lands and the estuarine system are not always clear and the importance of the terrestrial energy system to the estuarine is immense, the separation permits categorization of ecological conditions. On a subject basis, consideration is given to plants, animals, birds, insects, and rare and endangered species (1, 2, 3, 4, 5, 6, 7).

COASTAL LANDSCAPES

The coastal landscapes owe their varying character to continual changes in sea level. No matter how the changes are accomplished -- by slow fluctuations in the quantity of ocean water, by the languid drifting of the earth's tectonic plates or by sudden shifts of massive slabs of crustal material -- they have a marked impact on the shoreline, which generally advances or retreats as they occur. Where not much time, geologically speaking, has passed since the most recent major

change in the location of the shoreline, the land usually rises precipitously from the water's edge, and any beaches present are narrow, short, and rocky, with a scant veneer of sand. Along the Northwest coast of the United States, for instance, beaches are pocketed between rocky headlands and backed by sheer cliffs. But where the shore's location has been stable for an extended period, its rock has been ground into sand by the waves and tides, and its rugged contours have been smoothed with sand swept along the coast by longshore currents.

Where there is some protection from the wind and waves, other kinds of coastal terrain arise. Gentle tides in the sheltered waters of estuaries, which typically are river valleys drowned by a slowly rising sea, may wash mud and silt onto intertidal flats. Marine and salt-marsh plants begin to grow in the mud, and they trap more sediment until the flats, no longer vulnerable to tidal destruction, have become stable wetlands. These coastal wetlands are among the most fecund of earth's habitats, as fertile as the best farmlands; but at the same time their fragile and unusual ecology is highly sensitive to the effects of human activity.

In its natural state, a barrier island is a miracle of serene loveliness. The smooth, straight ocean edge is characterized by wide, sandy beaches sloping gently upward to wind-blown dunes bedecked with high grasses. Behind the dunes, in the island's interior, may be found shrubs, woods, perhaps even a maritime forest, which may abound in deer, snakes, raccoons and other wildlife. (Among America's barrier islands, Assateague Island, which lies off Virginia and Maryland, is particularly treasured because it is the home of a herd of rare wild ponies.) The shoreward side of such an island is punctuated by bays, quiet tidal lagoons, salt marshes, and -- in the tropics -- mangrove swamps. These wetlands provide a natural habitat for oysters and other estuarine species, and for a splendid array of marsh birds.

For many reasons, barrier islands are the most fascinating of the interfaces between the landforms and the oceans of the world. Not the least of the reasons is the seeming inequality

between their frail structure and the power that the sea brings to bear against them. Nowhere is this drama played out more vividly, or on a grander scale, than on North America's East coast.

It is virtually impossible for a tropical storm or a hurricane to more ashore there without first crossing the longest stretch of barrier islands in the world, sprawling for 1,500 miles from Long Island southward to the tip of Florida. (The string of islands then resumes for another 1,300 miles along the Gulf Coast states to Mexico.) Other, more frequent assaults are made by the winter storms known as northeasters. About 30 to 40 times a year, these storms occur with enough force to scour beaches or chew into frontal dunes; of this total, perhaps three storms will be strong enough to do serious environmental damage (1, 2, 3, 4, 5, 6, 7).

PLANT COMMUNITIES[1]

Sea Rims

The so-called sea rims develop as a result of wave and tidal action along the shoreline in areas where there is limited natural subsidence and an availability of sand and/or fragmented shells. High salinities, numerous shore birds, and limited pioneer vegetation characterize this habitat. Similar "beach" areas developing in a bay not contiguous with marsh or land are called "shell shoals".

Salt Marsh

The saline vegetative type makes up about 22% of the coastal marshes. The saline marshes are represented by nearly pure stands of the smooth cordgrass (S. alterniflora). Salt grass (Distichlis spicata) and black rush (Juncus roemerianus) are present though much less abundant.

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1 Abstracted from C.G. Ash. 1978.

The profile of this community is very short, 2 to 4 ft. The deeper lagoons are usually free of standing vegetation, but are characteristically surrounded by pure stands of S. alterniflora. The upper few feet of marsh are well consolidated by the roots and rhizomes of the vegetation. Below this, the substrate is almost totally unconsolidated. These subsoils are almost pure silts or silt and clay and contain very little organic matter.

Brackish Marsh

The flora and fauna of the brackish or intermediate salinity indirectly reflect this salinity. While most of these organisms are adapted to a fairly wide range of salinities, extended periods of inundation with freshwater or seawater would change and eliminate some of them. Organic content may be extremely high. Deep layers of peat are not usual.

The brackish marsh contains a number of species of vascular plants, with marsh hay cordgrass (Spartina patens), the dominant species (as much as 55%). The brackish vegetation type makes up about 30% of the marsh area. The brackish marshes are most often characterized by an association of S. patens, salt grass (D. spicata), and black rush (J. roemerianus). This vegetation is taller than the salt marshes, reaching heights of 4 to 6 ft. While this marsh type can and often does stand uniform for many miles, significant variations can occur with slight changes in elevation or salt content. One of the major variations is the cane zone (Phragmites communis-Spartina cynosuriodes). Quill cane and roseau cane are major components of this taller plant association. Heights of 6 to 8 ft. are not uncommon. The water table in these cane zones is usually below the surface. Another major variation in the brackish marsh is the three-cornered grass (Scirpus olneyi) marsh. While this species is often present in many brackish marshes, it frequently forms a dense uniform stand of large area. This is a subclimax stage of the Spartina-Distichlis-Juncus association and will be naturally displaced if undisturbed. This three-cornered grass or Scirpus marsh is a favored habitat for the muskrats and waterfowl, and as such is the site of extensive resource management.

Intermediate Marsh

The intermediate marsh vegetation type comprises only about 16% of the marsh area. S. patens, comprising as much as 34% of the vegetation, remains dominant in these marsh areas. Roseau cane (P. communis) and bulltongue (Sagittaria falcata) are also major species in these areas.

Fresh Marsh

A diversity of associations and a larger number of species are found in the fresh marsh. The fresh marsh area in southern regions are almost completely dominated by alligatorgrass (Alternanthera philoxeroides) and waterhyacinth (Eichornia crasspies). These two exotics are so well adapted as to have displaced the natural vegetation in this area. Other widespread plant associations of the fresh marshes are edaphically controlled by water level and water quality for the most part. Some of these include large expanses of maiden cane (Panicum hemitomon). Spikerush (Eleocharis sp.) and bulltongue are also major components. Other species present are cattail (Typhasp), bulrush (Scirpus californicus), saw grass (Cladium jamicense), and wapato (Sagittaria platyphylla), with alligatorgrass and waterhyacinth. These marshes may be attached or floating. Floating marshes are characteristic of some areas of fresh and brackish marshes. They may occur anywhere the clay pan has subsided, allowing the root consolidated vegetation mat to float on a sea of water and organic muck.

Island Beaches

The dynamic nature of the coastline is shown by the development of stranded beaches within the marshlands. Earlier deltaic formations pounded by storm tides formed beach lines that have now become stranded inland. These terrestrial "islands" are usually parallel to the ocean. These islands differ from the sea rim because of its terrestrial sediment composition rather than the marine origin of sea rim sediment. Many of these islands have sunk below mean water level and

now provide an area of sandy bottom and an important substrate for oysters and other shell creatures; however, others remain above water level, providing high ground, possibly 2 to 3 ft. above normal high tide. This condition provides for the occurrence of a different habitat. Similar species are seen to invade the natural levees of streams and rivers and the spoil piles along canals -- areas in which the sand content of the soils may be elevated over the surrounding marshes. While absolute species composition (sand and silt content) and water level, certain plants are characteristic of the island and levee areas. The lower areas are occupied by various grass and sedge species, depending on the salinity and water level.

Swamps

In certain areas adjacent to higher ground in the marshes and in protected inland areas, successional patterns have led to various tree associations. Two basic types are defined consisting of saltwater and freshwater swamps.

Mangrove swamps occur only in southern waters. They are composed almost entirely of the shrubby honey or black mangrove (Avicennia nitida) occupying high saline environments. The crest of a "ridge" in the salt marshes may provide a habitat for this species. As little as 2 in. above the adjacent salt marsh, this zone is usually above high water level. Very high soil salinities are characteristic. Reaching a height of approximately 25 ft., the honey mangrove is an evergreen shrub. Aerial roots or "knees" are characteristic physical features of the plants. With these structures, the mangrove has the potential to evade more deeply into the marsh, but is usually restrained from doing so by frequent marsh fires. The mangrove is also intolerant of cold and is killed back by any frost or freeze, further reducing its potential for spreading.

The cypress-gum swamps of the freshwater and nearly freshwaters are characteristic of extensive areas and scattered areas within the open freshwater marsh where water conditions are static and where some protection from storms and fires is afforded. Bald cypress (taxodium

distichum) and tupelo gum (Nyssa aquatica) are codominants in southern areas. Other tree species include water ash (Fraxinum profunda) and swamp maple (Acer rubrum) which tend to dominate as one moves in a northerly direction. Where the swamp is open, numerous herbaceous species prevail. Along the swamp borders area a great number of black willows (Salix nigra) and buttonbush (Cephalanthus occidentalis). Other species associated in areas where innundation is only periodic include sweetgum (Liquidambar styraciflua), water oak (Quercus nigra), hackberry (Celtis laevigata) cottonwood (Populus deltoides), sycamore (Platanus occidentalis), and box elder (Acer negundo) (1, 2, 3, 4, 5, 6, 7).

ANIMAL COMMUNITIES

Stratification within a community often plays an important role in the number of kinds of animal organisms that community is able to support. The hardwood forest communities of the swamps and islands do provide multiple strata for support of types of organisms found nowhere else in the marsh, e.g., in the water, in emergent herbaceous vegetation, or in shrubs. While the typical marsh plants and animals are found associated on the ground level within these communities, even here new species will occur when shading or water level changes bring about conditions that are different from the adjacent swamp. In effect there may be three or more different levels supporting corresponding plant and animal associations within one community type. The mangrove swamps (Avicennia) promote a similar effect. Here, however, fewer strata occur, and the single species dominance of the mangrove reduces the available number of ecological niches. Still, there is one association of plants and animals associated with the root zone and other associated with the canopy of the mangrove swamps.

Furbearers

Species hunted for their fur pelts include muskrat, mink, otter, bear, nutria, and raccoon. Other furbearers include opossum, skunk, lynx, fox, and beaver. The large numbers represented are a result of intensive management of large portions of our wetlands, particularly in the brackish marshes. For example, three-cornered grass marshes produce most of the muskrats and many of the nutria. to ensure good three-cornered grass production, extensive late fall burning of the marshes is practiced annually

Other Mammals

The white-tailed deer and black bear are the only large mammals in the wetlands. The deer presently have a strong healthy population. They are abundance in all parts of the marsh except the saline where only a limited population exists.

While the bear is not officially listed by the USDI as an endangered species, its continuing presence in the southeastern U.S. will depend on a concentrated effort by man to protect the remaining habitat and in fact to enhance them. Other important mammals include the fox, cottontail and marsh rabbits, and squirrels. All seem to have healthy populations and are surviving the effects of man on the wetlands because of their adaptability in habitat preference.

Insects

The mosquito is the major insect of importance to man in the wetlands, or perhaps, it is better to say the control of the mosquito is of importance to man. Large-scale chemical control is now limited mainly to the urban areas. Drainage of freshwater marshes is another important control method used in the suburban and urban areas. State authorities are now encouraging flooding as an effective and of less harm as a method of mosquito control. Flooding of an area by means of dams, levees, and weirs prevents the female from laying eggs and thus produces a

significant population reduction. This procedure has also proven very beneficial to fish and waterfowl production as well.

Major carnivorous insects in the marsh include the praying mantis and dragon fly. Herbivores include, among many others, grasshopper species that graze on the grasses of the marsh. The importance of the grazing herbivores in the marshlands is less important as compared to their usual within temperate ecosystems because of the particular energy dynamics of the marshes. The marsh system results in most of the grass biomass being broken down mainly by physical processes to small fragments where it is acted upon by bacteria and detritus feeders. The larger carnivores feed from this aquatic chain rather than from the terrestrial chain as would be the case further inland or on higher dry ground.

Reptiles

Snakes present in the wetlands include several species of water snakes, blue runners, ribbon snakes, black snakes, and bull snakes, as well as water moccassins, rattlesnakes, copperheads, and coral snakes.

Several species of freshwater and saltwater turtles are found in the wetlands. Sufficient quantities are found to make commercial harvest profitable in some areas.

Amphibians

Frogs are extremely abundant throughout the marshlands. A number of salamander species are also found in the marsh.

Avifauna and Its Habitat

There are hundreds of species of birds frequenting the wetlands. Under the various habitat groups, the following avian statuses, where salient of applicable, are considered: permanent, summer, and winter residents and migrants.

Permanent Residents

Grebes form a minor part of the avifauna and are fish feeders. They are, for the most part, dependent on small fish, although invertebrates are also eaten. The few hawks and owls that frequent the marshes on a permanent basis are mostly adaptable species and are primary, secondary, or tertiary consumers. One species that may be encountered there that should receive special consideration is the swallow-tailed kite. Kites in general seem to be seriously declining in parts of the southern U.S., and a couple have a tenuous hold on their environment or, in the case of the swallow-tailed kite, have an undetermined status. Some kites seemingly respond markedly to only minor habitat disruptions. Pigeons, kingfishers, woodpeckers, or perching birds that may occur in this habitat are generally numerically healthy and widespread.

Four groups of major importance, in part because of economic reasons, are the herons, pelican-like birds, ducks and geese, and rails and their relatives. Ducks and geese are of major importance as wintering or migrant birds and will be considered under that heading. Rails and coots are prime inhabitants of this environment and of economic importance as a sport and food bird. One would a priori suggest that coots are versatile enough to be little affected by habitat changes, but rails demand special attention as they seemingly have a much more narrow range of tolerance and more specific habitat requirements. Both are rather general in food habitats although rails are primarily invertebrates, a fact which dictates within limits the habitat that can be used. Habitat considerations are principally concerned with water depth or density of vegetation.

The brown pelican has virtually disappeared from some states. The reason for this decline is apparently variable, but probably not related to habitat destruction. The question of habitat of proper quality and quantity becomes germane. Successful reproduction seemingly depends on a certain amount of seclusion for nesting and a proper spectrum of water depth from which to secure food.

Herons, egrets, and relatives are generally colonial breeders. The colonies are local in nature. That the habitat is not used with generally uniform frequency suggests the spotty distribution of limiting factors and perhaps semirigid requirements. However, many of the requirements may be a function of social convention, and the physical destruction of habitat holding colonies may be simply temporary. With regard to specific pipeline routes, this group of birds requires attention, as they form a conspicuous part of the environment both in feeding and nesting habitat requirements. They cannot use water over a certain depth as dictated by the length of bill or leg of the species involved. They may conflict with man's interests in the commercially important invertebrates should the habitat become limited to the extent of that utilization of remaining habitat becomes intensive and severe. Turkeys have commercial importance as game and sport birds and may use this habitat peripherally where the proper cover occurs on elevated areas.

Winter Residents

Ducks and geese are of major importance because of the drastic build-up of members in fall and winter. The major species are mallards, black ducks, gadwall, greenwinged teal, pintail, scaup, and Canadian blue, and snow geese. Ducks utilize most heavily the shallow coastal waters and marshes and adjacent agricultural lands.

Blue geese winter in few localized regions in the U.S. (California, Texas, and Louisiana in the main). Louisiana coastal marshes constitute one of the prime wintering areas where, together

with the snow geese, about 300,000 to 400,000 individuals winter. Loss of large amounts of natural habitat of any of the waterfowl will have considerable impact on adjacent rice and agricultural lands in which they will utilize as resting and foraging areas. Canada geese have resting areas in more northern states. The largest numbers are found in the vicinity of the Chesapeake Bay.

Two other species are the bald eagle and osprey. Both of these are secondary and tertiary consumers, and because of their often long or complex food webs, they have been affected over broad areas of North America. Some populations of bald eagles have declined almost to the point of no return. Ospreys also show locally severe reductions.

Migrants

This area provides major resting area for migrants of a variety of kinds, depending on the nature of the cover type. This category is so broad and general that only the most drastic changes in habitat or cover type would have impact, and then the impact would be of questionable nature.

Aquatic Ecology

The value of estuaries and marshlands to the U.S. fisheries is realized when it is considered that almost two thirds (in value) of the commercial catch and most of the sports fish are composed of species who spend at least a part of their life in estuaries. Indeed, freshwater, saltwater, and estuarine fishes taken in amounts of million pounds each year.

The thousands of acres of marshes and brackish water areas in the highly productive coast serve as the area of mixing of freshwater runoff with the waters of the Gulf and Oceans. Small tide extremes and intricate water courses combine to produce gradual salinity and water volume transitions, with resultant large zones of relatively stable conditions. These zones may range from

quite salty near the ocean to nearly fresh on the inner edges. The wide range of environmental characteristics provides the necessary habitats for many aquatic forms of life.

The most important factor involved in the distribution of estuarine species is salinity. Although organisms typically found in estuaries must have capacities to tolerate changing conditions, many are adapted to function more effectively in given ranges. An excellent illustration of the importance in salinity ranges is that of two enemies of the oyster grown optimally in brackish water areas. Both the oyster drill, Thias haemastoma, and a marine fungus, Dermacystidium marinum, invade waters of higher salinity during drouth and saltwater intrusions.

FISHERIES POPULATIONS

General groupings of species comprising the fisheries can be made based on distribution and life histories (with some variation). Four such groupings are convenient and include resident, semicatadromous, seasonal migrant, and anadromous species.

Resident Species

Species dependent on the estuarine environment most of the time and completing their life cycles in this zone are termed resident species. These are represented by oysters, blue crabs, and spotted seatrout, although the latter two species do venture into the shallow waters of the Gulf or oceans. Of the three members of this group, oysters and clams are by far the most valuable of these commercial species which are supported by the estuaries.

One species of fish which does not effectively fall into the resident species or semicatabromous grouping is the bay anchovy (anchoa mitchelli). It is nevertheless an important species to the estuary habitat if for no other reason than its exceedingly large numbers and

biomass. Researchers report that this species probably has the greatest biomass of any fish in estuarine waters of the south atlantic and Gulf of Mexico. This species made up almost 85% of the noncommercial vertebrate catch in Louisiana coastal area. Anchovies are fished commercially off the coast of California. The bay anchovy constitutes a very important food chain organism and must, therefore, be considered when alterations of its environment are contemplated. Its value has been recognized as furnishing food for many predatory species whose habitat distributions suggests its importance in both weedy shallows and surface and bottom waters of open lakes.

Semicatadromous Species

The second and perhaps the largest group of organisms are those termed semicatagromous. Species within this group exhibit a generally similar life history which includes

1. Spawning in ocean waters
2. Migration of the young to estuarine areas
3. Growth to subadults in this area
4. Return to ocean waters to complete the cycle

A relatively large number of commercially important species of coastal fisheries are included in this group, and because some return for short periods to the estuaries as adults, they are significant in the inland sports fishery in addition to their commercial value from the ocean.

Important species falling into this group include white shrimp, brown shrimp, menhaden, red drum, flounder, black drum, Atlantic croaker, spot, and sand seatrout, etc.

By far the most abundant species in the commercial fishery in the Gulf area is the menhaden. It is second in value to the two species of shrimp taken. The U.S. is the foremost producer of shrimp in the world, with the shrimp fishery occupying a relatively prominent position in the economy. The shrimp fishery of the Gulf coastal zone consists of two species, the white

shrimp, Penaeus setiferous, and the brown shrimp, Panaeus aztecus. Spawning of both species generally occurs offshore, but at different depths, brown shrimp utilizing waters 240 to 250 ft. in depth and white shrimp spawning in shallower waters of 35 to 50 ft. During the months of February, March, and April, postlarva brown shrimp begin their migration from offshore waters into the estuaries. White shrimp postlarva are found migrating into the estuaries in greatest numbers during the months of July and August. While in the estuarine nursery area, shrimp detritus in areas where the substrata is muddy or peaty. Brown shrimp tend to be distributed rather uniformly in waters 2 to 3 ft. deep having attached vegetation. White shrimp have a tendency to "school" in waters less than 2 ft. deep in areas with large amounts of detritus.

Migration out of the estuary occurs about early spring to midsummer for brown shrimp and around November and December for white shrimp. During their stay in the estuary, growth is quite rapid. White shrimp average about 1 1/2 in. of growth per month, while brown shrimp grow at an average rate of 1 1/2 to 1 3/4 in./month. Distribution of these species in the estuaries is also governed by salinity ranges, brown shrimp, 9.80% to 60% and white shrimp, 0.45% to 45%. Alteration of coastal areas influencing salinity regims can be expected to cause shifts in populations of these important species.

In addition to being important in the commercial fishery, most of the semicatagromous species mentioned (with the exception of menhaden) are also valued by recreational fisherman and are taken in large numbers annually. Indeed, it has been reported that the value of the sprouts fisherman to the U.S. economy system probably exceeds that of the commercial fishery and will in the future. Also, some species of this group constitute the largest industrial fishery in the U.S. for production of oil, pet foods, and fish meal. Although menhaden are the principal component of this fishery, others included in the semicatagromous grouping are sand seatrout, atlantic croaker, spot, and several other species. It is interesting to note that the menhaden fishery does not conflict

with estuarine sports of other commercial fisheries, since the gear used does not select for other species of fish nor does it destroy the estuarine habitat as alleged.

Seasonal Migrant Species

The third grouping of fishes is the seasonal migrant species which appear in the estuarine zones briefly during warmer parts of the year chiefly to forage. Because of this characteristic, they are more valuable recreationally than commercially. Major fishes of this group are tarpon, jacks, kink mackerel, Spanish mackerel, ladyfish, bluefish, and cobia.

Anadromous Species

The last major group are termed anadromous. These species spawn and the young spend their early life history in freshwater. When juveniles, they migrate to the ocean where they grow to maturity and return as adults to freshwater to complete their life cycle. Some species, such as Pacific salmon, die after spawning, while others return to freshwater several times during their life.

The major species comprising the anadromous group are the Pacific and Atlantic salmon, steelhead trout, searun cutthroat trout, shad, and several other species of the herring family.

Since these fish spawn in freshwater and spend the greater portion of their adult lives in the sea, the estuary is used mainly as a migratory route between the two environments. However, the time of migration through the estuary varies with the species involved, the temperature of the water, and water flows as well as the geographical area involved. Most species require considerable time in the low-salinity estuarine area to become acclimated to the change in salinity and, in some situations, waiting for appropriate water quality conditions, such as temperature (1, 2, 3, 4, 5, 6, 7).

SUMMARY AND CONCLUSIONS

The marsh and swamp lands are quite rich in dominant and successional plant species. This richness contributes to the dramatic resiliency of the systems to disturbance from natural forces and man-made activity. Because of the dynamic nature of the systems, no effects were identified for rare and endangered plant species.

Additionally, the lowering of water tables via ditch and canal drainage of lands slightly higher than sea level may allow better aeration in the soils as well as spoil banks, resulting in reduced forms of sulfur being oxidized. The resultant sulfides and acids, in some marshes, overwhelm the buffer potential of the salts and may cause extensive vegetation damage. The extent of the damage to vegetation is related to the extent of the washoff from spoil banks and the distance that the water level has been lowered.

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