THE U.S. CARIBBEAN REGION

Wetlands and Fish

A Vital Connection

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Wetlands and Fish: A Vital Connection

Wetlands are very common land features found almost everywhere in the world, and the Caribbean is no exception. In addition to coral reefs, wetlands such as mangroves and seagrass beds are the dominant ecosystems along the Caribbean coast. For many years wetlands were highly undervalued and consequently they were often destroyed or degraded. Today the many values of wetlands have been recognized and efforts towards wetland protection and conservation are more the rule than the exception. The connection between wetlands and the health, abundance and diversity of fish and other organisms was one of the first widely recognized justifications for defending wetland preservation. Many species of fish use wetlands as nursery grounds and as a habitat, finding both food and shelter. Wetlands are a vital ecosystem for fish.

This document will explain the important link between wetlands and the various species of fish inhabiting them, with particular attention to the U.S. Caribbean region (Puerto Rico and U.S. Virgin Islands). We have included general information about wetlands, their importance to fish and other organisms, and their connections to their surroundings. More specific information is also given about the use of wetlands by fish, including a description of common species of fish that can be found in different types of wetlands. Also included is a case study describing the interactions among mangrove wetlands, seagrass beds and coral reefs, and their associated fish communities. Finally, we address the current threats wetlands are facing, both human and natural, and what we can do to protect these valuable environments. While this document focuses on the wetlands and fish communities of the U.S. Caribbean, the general information about wetlands as well as some of the information regarding their fish communities might also be applicable to other Caribbean countries. Throughout this document, the term "U.S. Caribbean region" refers to both Puerto Rico and the U.S. Virgin Islands (St. John, St. Croix and St. Thomas).

Photo courtesy of National Oceanic & Atmospheric Adminstration (NOAA).

Mangroves showing root system below the water surface: important fish habitat.

What is a Wetland?

Wetlands can be found on all continents except Antarctica and in all climates. Wetlands vary in size from a small pond to a large expanse such as the Florida Everglades. Because of the wide geographic distribution and environmental conditions in which wetlands occur, the term "wetland" can mean different things to different people. There are, however, three main features that are usually considered to characterize a wetland:

- The presence of standing water or saturated soils for at least part of the year.
- Unique soil conditions that differ from adjacent uplands.
- The presence of unique vegetation and/or organisms adapted to such wet conditions.

Although wet areas without vegetation can also be defined as wetlands, for the purpose of this publication we will only consider vegetated wetlands because of the services they provide to associated fauna such as fish. Even though seagrasses sometimes are not considered wetlands, they are classified as such under the classification of wetlands and deepwater habitats of the United States, provided by the U.S. Fish and Wildlife Service.

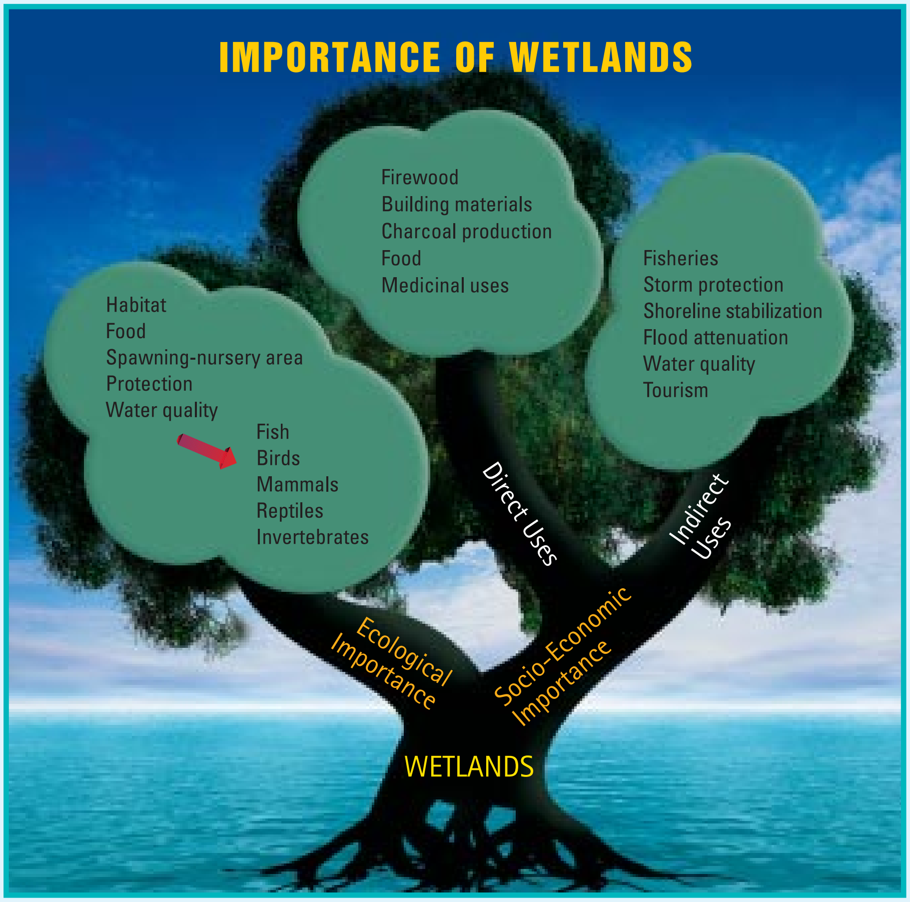
Photos courtesy of Lisamarie Carrubba

Are Wetlands Important?

Wetlands are among the most important environments on earth. They render many services to nature and humans, making them very valuable from both an ecological and socio-economical point of view:

- Ecological importance: Wetlands provide habitat, food, and protection to many different species of animals including fish, birds, mammals, reptiles, and invertebrates, including endangered and commercially important species of fish, shrimp, crabs, and shellfish. Wetlands can also function as "filters" by removing excess sediments, nutrients, and contaminants that come from the associated watershed (area of land that drains to a particular body of water such as a river, lake or wetland). By doing this, wetlands provide cleaner water to their inhabitants and to plants and animals of adjacent environments.

- Socio-economic importance: The socio-economic value of wetlands comes from direct and indirect use of their resources. Forested wetlands, for example, provide firewood, building materials, and wood for charcoal production. Humans have also used wetlands as a source of medicinal plants and food. An indirect, but well-recognized value of wetlands is their role as nurseries for commercially important species of fish. A positive linkage has been established between wetland acreage and fishery production for different regions around the world. Wetlands also are valuable for their role in storm protection, shoreline stabilization, flood attenuation, water quality improvement, and tourism. ■



Wetlands and Their Surroundings

Wetlands are not isolated, but are connected to their surroundings. Because they are often located at the transition between upland and open water, wetlands can be affected by activities and conditions in both terrestrial and aquatic areas. This dual interaction is part of what makes wetlands very productive and dynamic environments.

The transition zone between wetland and upland is important as an interchange zone for species of plants and animals that use both ecosystems. A wetland's proximity to uplands, however, makes it vulnerable to human impacts related to development and agriculture. Even though the sediments and nutrients in freshwater runoff are important for wetland growth and development, excess sedimentation and high input of contaminants and nutrients might cause negative impacts. For example, high sediment accumulation on wetlands as a result of agricultural activities or storms can smother or bury plants, causing their death. More direct effects on wetlands occur when development on adjacent uplands extends into wetlands through the filling or clearing of those wetlands.

Equally important are the interactions between wetlands and adjacent open water areas. In the coastal zone, saltwater input affects a wetland's salinity, tides affect water levels and the movement of materials in and out of the wetland, and waves affect wetland colonization and growth. In inland and riparian wetlands, the interaction with adjacent waters is important in seed dispersion and nutrient exchange. Similar to what occurs at the upland boundary, the transitional zone with the open water allows the interchange of species, especially fishes, between the two systems. A wetland's proximity to open water also makes it vulnerable to natural impacts such as storms, hurricanes, and sea level rise, and human impacts related to water pollution, marine transportation, tourism, and fishing activities. ■

Photo courtesy of Lisamarie Carrubba.

Mangrove and brackish wetlands, Puerto Rico.

WETLANDS IN THE U.S. CARIBBEAN

DISTRIBUTION

The Caribbean Sea covers 1,943,000 km^2. Its coastal zone is shared by more than 25 countries, including islands and continental lands. The Caribbean is bordered by South America in the south, the Central America isthmus in the west, Cuba, Hispaniola and Puerto Rico and U.S. Virgin Islands in the north, and thousands of small islands primarily in the east, but scattered around all coasts. This document focuses on the U.S. Caribbean, which includes Puerto Rico and the U.S. Virgin Islands.

Wetlands within the U.S. Caribbean can be found in river basins, along the shores of estuaries and lagoons, in offshore sandbars and low islands, and bordering lakes and ponds. Along the coast, their distribution is generally discontinuous, limited to areas protected from high wave energy. Mangrove wetlands and seagrass beds are the dominant coastal wetland ecosystems in this part of the Caribbean.

COMMON WETLAND TYPES

SALTWATER WETLANDS

Saltwater wetlands are the most common wetlands in the U.S. Caribbean region, found throughout almost the entire coastal zone. Salty (saline) water and the influence of tides are defining factors of this type of wetland. The salinity of saltwater wetlands is not a fixed value, but rather changes with distance from the ocean, water depth, freshwater input (i.e. precipitation, runoff, ground water) and season. The two main types of saltwater wetlands found in the U.S. Caribbean are seagrass beds and mangroves, both of great importance to fish.

Photo courtesy of Lisamarie Carrubba

Seagrass beds:

Seagrass beds are generally found in the shallow subtidal zone of the coastal environment, although occasionally they may be exposed to the air during very low tides. Seagrasses are a type of rooted submerged vegetation that resembles grass, although they are not part of the grass family. In the Caribbean, seagrass beds are generally associated with mangrove wetlands and coral reefs.

Photo courtesy of Carlos Pacheco, DNER

Mangrove wetlands:

The term mangrove is used to refer to a group of trees and shrubs that inhabit the coastal intertidal zone. Mangrove wetlands may also include other associated vegetation including trees, herbs, and ferns, which are generally found in the upland transitional zone, or the intertidal zone as is the case for the leather fern *Acrostichum*. Mangroves are found only in the tropics and subtropics along protected coastlines, including cays, away from the direct action of waves. Mangrove trees have developed special adaptations to survive the variable flooding and salinity conditions imposed by the coastal environment.

FRESHWATER WETLANDS

Freshwater wetlands are often associated with a body of fresh water such as a river, lake, or pond, but the wetland's freshwater supply also can come from precipitation or ground water. Examples of this type of wetland in the U.S. Caribbean are freshwater marshes, forested wetlands, and freshwater aquatic wetlands. In addition to natural freshwater wetlands, human-made impoundments also serve as important habitats for freshwater fish.

Photo courtesy of Lisamarie Carrubba

Photo courtesy of Lisamarie Carrubba

Freshwater marshes:

Depending on their location with respect to the coast, some freshwater marshes can still experience the influence of tides. Even freshwater marshes that are not influenced by the tide can experience water level changes associated with rainfall or ground water. Freshwater marshes are generally vegetated by a diverse group of plants including grasses, sedges, rushes, broad-leaved aquatic plants, and soft stemmed aquatic plants such as cattails, arrowheads, pickerelweed and reeds. Characteristic examples of freshwater marshes in the U.S. Caribbean region include a giant sedge marsh or a cattail marsh (although the latter is considered an invasive, undesirable species in Puerto Rico and U.S. Virgin Islands).

Forested wetlands:

This type of wetland occurs along rivers and streams and occasionally is flooded by these water bodies. When not flooded, these forests remain dry for varying periods during the year. The vegetation in forested wetlands consists mainly of trees and is very diverse. The types of plants found in a forested wetland generally depend on the amount of flooding that occurs in a particular area. A swamp bloodwood forest (*Pterocarpus officinalis*) is an example of this type of wetland in the U.S. Caribbean.

Freshwater aquatic:

These wetlands are associated with streams, rivers, ponds, lakes, canals or reservoirs. In Puerto Rico, freshwater aquatic wetlands are also associated with groundwater upwelling. Freshwater aquatic wetlands can be semi-permanently or permanently flooded with still or moving water. These wetlands are dominated by free-floating or rooted aquatic herbs such as naiad, fanwort, hornwort and pondweeds. Water hyacinth and water lily are also species found in freshwater aquatic wetlands; these are however, considered invasive and undesirable species in Puerto Rico.

WETLAND LOSS AND CONSEQUENCES

Unfortunately, the Caribbean is no exception when it comes to the historical and continuing degradation of wetlands around the world. Erosion, sedimentation, pollution, water nutrient enrichment, salt water intrusion, and loss of biodiversity have been identified as the most significant factors affecting wetlands in the Caribbean. The causes of these impacts include deforestation, tourism, urban development, industry, agriculture, damming and diversion of rivers, and dredging for navigation. In addition, natural phenomena such as tropical storms and hurricanes, sea level rise, and global warming also threaten the health and function of these valuable ecosystems.

There are many consequences of wetland loss as these important ecosystems are destroyed or degraded. Wetland decline will lead to a reduction of the benefits these habitats provide as spawning, nursery grounds, and food supply, which ultimately will affect not only natural ecosystem functions but commercial and recreational fishing as well. In La Parguera, Puerto Rico for example, a recent survey determined that both commercial and recreational fishing have sharply declined, as reported by García et al. (1998). Although a direct relationship has not been established, a parallel decline in mangrove habitat has been recorded as a result of clearing for house construction. Associated wetlands and coastal systems that are important habitats for fish are also being altered. For example, salt marshes have been filled, and seagrass beds and coral reefs have been damaged by excessive and uncontrolled tourist activities such as boating and diving.

As a consequence of this continuing degradation of wetlands in the Caribbean, it is necessary to develop integrated conservation and management plans that will ensure the preservation of such valuable resources for future generations. ■

Photo courtesy of Lisamarie Carrubba

Las Mareas Harbor, Guayama, Puerto Rico.

Fish Need Wetlands

Three main wetland functions provide fish with resources they need to survive: habitat, food production, and water filtering. The longer or more frequently a wetland is flooded, the more time fish can spend there and profit from these wetland services.

WETLANDS AS HABITAT

Wetlands are very important habitats for fish. Wetlands provide fish with a place to live, a place to protect themselves from predators, and a place to reproduce and nurture their young. Many different species of fish, some of commercial importance (such as white mullet and shrimp), use wetland habitats as nursery and spawning grounds. As a result, the presence of wetlands has been proven to be of great importance to commercial and recreational fishing for many regions around the world, including the Caribbean.

Fish can use wetlands as a permanent or temporary home depending on the fish's needs and its adaptation to the wetland's changing environment. For example, some species of shellfish, such as bivalves, spend all their lives in wetland environments. Some species of shrimp, on the other hand, only use wetlands during their juvenile stages when they migrate to the wetlands to find food and protection from predators.

For both permanent and temporary residents, wetland structures such as roots, leaves, fallen branches, and woody debris provide perfect places to hide from predators. Plant growth can visually confuse predators and camouflage small fish; it also obstructs the entrance of big predators. In mangrove wetlands, for example, many young fish find protection in the dense and intricate roots. Other characteristics of wetlands, such as turbidity and shallowness, provide conditions that favor hiding from predators. Turbidity (reduced water clarity due to sediment or other suspended materials in the water) reduces visibility, and shallowness limits the movement of large predators into habitats.

Wetlands as spawning and nursery grounds for fish is one of the most important roles attributed to these habitats. Wetlands offer calm, shallow waters, abundant food, and protection from predators for eggs, larvae, and juvenile fish. Many fish species use the dense vegetation of wetlands, branches, leaves and dead plant material to hide or attach their eggs, providing them protection. Once the eggs hatch, the same wetland habitat continues to provide food and shelter from predators to the young.

There are many examples of fish and shellfish that use wetlands as spawning and nursery areas. The threadfin shad or sardina de agua dulce, for example, attach its eggs to aquatic vegetation of freshwater wetlands. The Nassau grouper depends on seagrass beds for protection and food as juveniles. After spawning in offshore waters, larvae and juveniles of the great barracuda reside in mangrove wetlands and seagrass beds, where they find food and shelter. While the saucereye porgy adults are frequently found in coral areas, the young prefer seagrass beds where they find protection and food.

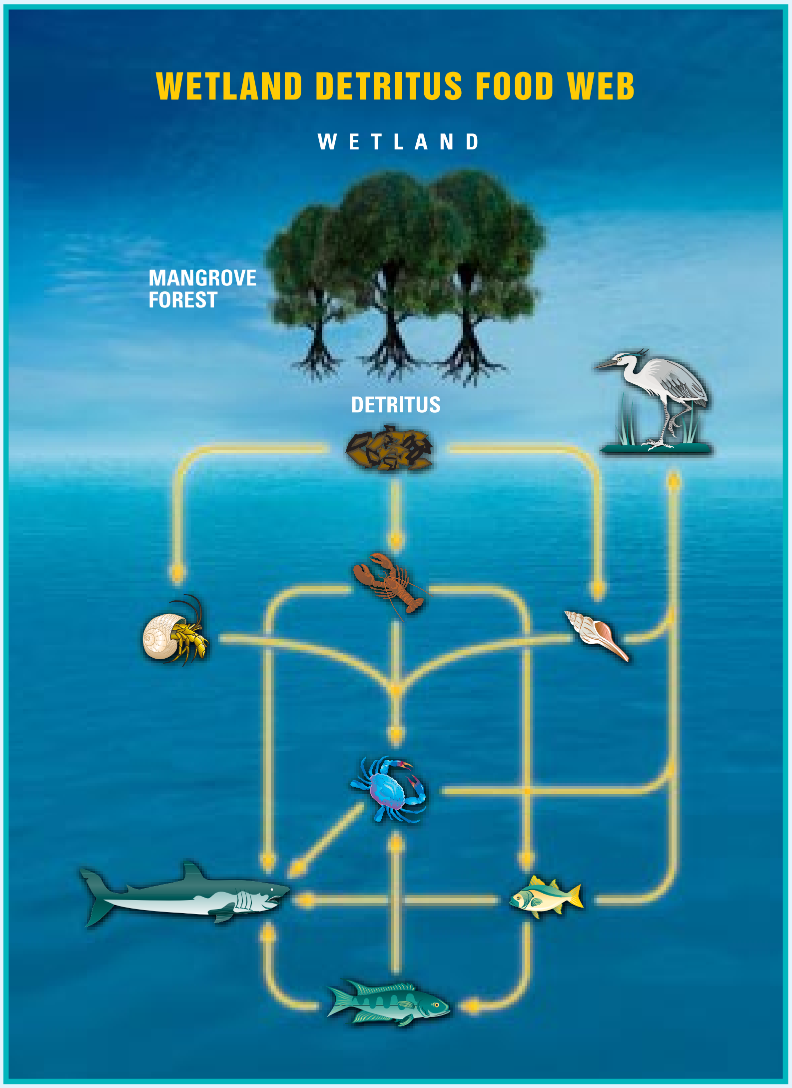
FOOD FROM WETLANDS

Wetlands provide food to a diverse animal community, including fish, through two major pathways. Wetland biomass can be consumed directly through a herbivore-based food web, or can be

consumed indirectly by entering the detrital food web. The detrital food web is based on detritus, which is (wetland) plant material being decomposed through physical, biological, and chemical processes, into an energy-rich organic material. This detritus serves as the main food source for organisms within the first levels of the food web, which are subsequently preyed on by organisms within the higher levels of the food web.

Many fish and other marine organisms are present at different levels of a wetland food web, depending on their eating habits. Some fish, mollusks, shrimps, crabs, and other invertebrates are found at the lower levels of a detrital food web, and are known as detritivores (they eat detritus). Detritivores are then a source of food for organisms present at higher levels of the food web called carnivores. Some fish (and other organisms) can benefit from the large food source supplied by wetlands by feeding on both herbivores and detritivores. In fact, by eating fish that feed on either herbivores or detritivores (or both), humans can also form part of the food web that begins in wetlands.

Because of their interconnectivity, food webs have a delicate balance. For example, wetland degradation will affect not only anchovies that eat and live in swamps, but also herons, egrets, and fish hawks that feed on anchovies. As a result, any wetland alteration that might disrupt the food web will have a cascading effect on fish, wildlife, as well as human populations that benefit from this food web.



WETLANDS AND CLEAN WATER

Clean water is to fish what clean air is to people. Unfortunately, as a result of human activities, aquatic environments are being degraded as they receive excess sediments from deforested areas, contaminated waters from cities and agricultural fields, and other human and animal wastes. Located at the interface between land and water, wetlands intercept water and sediments coming from uplands. In this position, wetlands act as natural filters where excess nutrients can be stored or transformed in the sediments or taken up by plants for growth. Contaminants (e.g. agro-chemicals and heavy metals) can be bound to sediments, dissolved in runoff water, or transformed to less harmful forms by plants or microbes. Wetland vegetation also slows runoff and traps sediments that otherwise would go offshore increasing water turbidity and sedimentation in the oceans.

By improving water quality, wetlands provide an invaluable service to adjacent environments and their flora and fauna. Fish and many other aquatic organisms enjoy a cleaner and healthier environment than they would without wetlands. In addition, establishment and growth of adjacent corals thrive in the clean, clear waters filtered through wetlands.

Wetlands of the U.S. Caribbean and Associated Fish

Over 500 species of fish utilize the different wetland habitats within the U.S. Caribbean region. While some species can be unique to only one type of wetland, many use different wetland types during the same day, during the year, during the seasons or during the different stages of their life cycles. Within this section of the document we provide some detailed information about some common species found in the different wetland types.

Because of their similar geographic position, climatic condition, and coastal habitats, there are many similarities among Puerto Rico and the U.S. Virgin Islands in terms of the vegetation and fish species that can be found in the different wetland habitats. However, because of their smaller size and physical characteristics, wetlands in the U.S. Virgin Islands are more limited in type and extent with mangrove wetlands and seagrass beds being the most common wetland types.

SALTWATER WETLANDS

SEAGRASS BEDS:

Seagrasses are a type of submerged aquatic vegetation that evolved from terrestrial plants and have become specialized to live in the marine environment. Three dominant seagrass species found in the U.S. Caribbean region are: turtle grass (*Thalassia testudinum*), shoal grass (*Halodule wrightii*), and manatee grass (*Syringodium filiforme*), with four other species being also common. These species of grass can be found alone or mixed, forming small or large seagrass beds. The extent of a seagrass bed depends on factors such as substrate, temperature, water clarity and protection from wave energy. Seagrasses prefer protected areas with clear waters that allow good light penetration.

Since seagrass beds are almost always under water (except under exceptionally low tides), fish have access to them all the time. Seagrass beds are areas of high productivity and are important to fish and other organisms as a direct or indirect source of food. The queen conch and fish such as the scrawled filefish, sharpnose puffer, keeled needlefish and ocean surgeon are some examples of species that eat grass blades directly. Other fish find their food in these habitats by feeding on detritus from decomposing leaves, invertebrates, small fish, and/or shellfish that can be found attached to their leaves or living within the plants. Some snappers and parrotfishes, for example, move to seagrass beds at night to feed on small fishes, crustaceans and other organisms.

Seagrasses also provide living space, refuge from predators, and essential nursery areas to commercial and recreational fishery species and to a great number of invertebrates that live within or migrate to these habitats. Juvenile stages of many fish species spend their early days in the relative safety and protection of seagrasses. For example, the young of redband parrotfish and redtail parrotfish are usually found in seagrasses where they find the necessary protection and food.

By forming extensive plant carpets, seagrass beds can diminish the effects of strong currents, providing protection to fish and invertebrates and preventing the erosion of bottom areas. By stabilizing the sediment and increasing deposition of suspended particles, seagrasses also help to provide clear water for adjacent coral reefs.

COMMON FISH FOUND IN SEAGRASS BEDS:

Blackear wrasse or Capitán (*Halichoeres poeyi*)

The blackear wrasse is commonly found in seagrass beds, where it finds food and refuge. It is seen less often on reefs and in shallow muddy bays. This fish feeds upon crustaceans and mollusks. The blackear wrasse can grow up to 20 cm long. Because of its small size it is not of interest to commercial fisheries. It has, however, value as a trade species in aquariums.

Nassau grouper or Cherna (*Epinephelus striatus*)

This grouper is common on offshore rocky bottoms and coral reefs throughout the Caribbean region. Juveniles are found closer to shore in seagrass beds that offer a nursery habitat. It is solitary and mainly diurnal but sometimes forms schools. When threatened by predators, this fish can camouflage itself, blending in with its surroundings. The Nassau grouper has a diet that consists mainly of fish, shrimp, crab, lobster, and octopus. It can grow to a maximum of 1.2 m and weight over 50 pounds. It is one of the largest fish found on the reef, but in the U.S. Caribbean this species is no longer common due to overfishing.

The Nassau grouper is considered an important food fish throughout the Caribbean and in the West Indies. Because of overfishing, harvesting of this species is currently prohibited in the U.S. and U.S. Caribbean and it has been made a candidate for the U.S. Endangered Species List.

Photo courtesy of Andrew Bruckner

Peacock flounder or Tapaculo (*Bothus lunatus*)

This flounder lives in sandy areas among seagrass, mangroves, coral or rubble. It remains immobile on the bottom and changes colors to camouflage itself with its surroundings, which helps it to escape predators or trap its prey. Because of its great ability to change colors it is known as "the chameleon of the sea". It also often buries itself in the sand with just its eyes out, while waiting for its prey. Peacock flounders are carnivorous, feeding mainly upon small fishes, as well as crustaceans and octopi.

Photo courtesy of Andrew Bruckner

This species has minor commercial fishery importance, but is traded as an aquarium fish. Currently, the peacock flounder is managed under a Fisheries Management Plan (FMP) of the Caribbean Fisheries Management Council (CFMC).

Queen conch or Carrucho (*Strombus gigas*)

Queen conchs are mainly found in shallow turtle grass beds, sandy bottoms, and coral reef habitats, where they find food and protection. They can be large, up to 30 cm in length. Adults are most active during the night, feeding on algae adhered to seagrass blades. As larvae they eat plankton. Queen conchs are eaten by crabs, turtles, sharks, rays, and humans.

This species supports an important subsistence and commercial fishery. They are highly valued as a nutritious food source in the West Indies and the Caribbean. In the U.S. Caribbean, queen conchs are highly valued in comparison with many commercial fish species.

Photo courtesy of Andrew Bruckner

As a result of a growing concern on the depletion of queen conch populations in the U.S. Caribbean due to overfishing, this species is currently under management through a CFMC FMP. Management measures include the designation of a minimum harvest size, a maximum of individuals harvested per day, establishment of a close harvest season during the spawning period, and regulation on the use of fishing devices.

Scorpionfish or Rascana (*Scorpaenopsis grandicornis*)

The scorpion fish is commonly seen lying on or near the bottom in seagrass beds, grassy bays, and channels, as well as in coral areas. It is not a very active fish and moves only when disturbed. Because of their coloration and shape they camouflage very well with their surroundings. This poisonous fish has venom glands at the base of the dorsal fin, which are only used in defense. Wounds caused by it are extremely painful, but not fatal. The scorpionfish feeds on crustaceans, cephalopods (such as octopus and squids), and fishes employing a sit-and-wait strategy, remaining stationary and snapping prey that comes near.

This species is managed under a CFMC FMP.

Photo courtesy of Andrew Bruckner

Sergeant major or Sargento (*Abudefduf saxatilis*)

The sergeant major is found in coral reefs and associated habitats such as seagrass beds, where they find food and protection. Often they are seen inshore around rocks and man-made structures. Juveniles are common in tide pools while adults are commonly found over shallow reef tops. This is an omnivorous species and likes to eat a variety of foods of plant or animal origin, including algae, small crustaceans and fish, and invertebrate larvae.

This species can be territorial and aggressive. They will vigorously guard their feeding territories and their eggs during reproduction. During the breeding period, sergeant major males will turn blue when guarding their reddish purple eggs.

Photo courtesy of Andrew Bruckner

The sergeant major is a species of minor importance in commercial fisheries. However, this species is important in aquarium trading, where it has been reared in captivity. The sergeant major is managed under a CFMC FMP.

Spiny lobster or Langosta común (*Panulirus argus*)

The spiny lobster can be found hiding under coral heads, rocks, and any other place that offers protection from predators. Juveniles are observed in seagrass beds and mangrove areas, which serve as nursery habitats. This is a nocturnal species, coming out at night in search of food. They feed on a variety of foods including clams,

mussels, crabs, and worms, and occasionally plants. There is also evidence of cannibalism.

The spiny lobster is an important source of income for many fisherman of the Caribbean. It is exported from various Caribbean countries, but not Puerto Rico or U.S. Virgin Islands, where it is used only for local consumption.

Photo courtesy of Andrew Bruckner

Because of high exploitation, harvesting of this species is managed under a CFMC FMP. Management measures include establishing harvesting periods during the year and limiting the number of individuals that can be caught.

Spotted goatfish or Salmonete colorado (*Pseudupeneus maculatus*)

Adults of this species are seen foraging in small schools among rubble, sandy or muddy areas adjacent to rocky and coral reefs. Juveniles are often found in seagrass beds, which serve as shelter from predators. This fish uses its barbels (slender tactile organs on the lips) to locate and eat benthic invertebrates that are buried in the sand or hiding under small rocks. Their diet consists of crabs, shrimp, other benthic crustaceans, polychaetes (marine worms), and bivalves.

The spotted goatfish is an important commercial species, and it is currently managed under a CFMC FMP.

MANGROVE WETLANDS:

Mangrove forests are limited to the tropics and subtropics because they can not withstand freezing conditions. Along the coastline, mangroves generally grow in the intertidal zone. To survive in this changing environment, mangroves have developed special morphological and physiological adaptations to cope with flooding and salinity changes. Adaptations to withstand flooding include shallow roots to avoid the lack of oxygen in deeper soils and aerial roots, to transport oxygen from the atmosphere to the root system. To cope with varying salinity conditions, different mangrove species have developed different mechanisms to tolerate, exclude or secrete excess salt.

Mangroves are found bordering the coastline, lagoons, and canals or forming large forests within river deltas. In Puerto Rico, mangroves are found surrounding most of the island, but they are especially abundant in areas sheltered from the direct action of waves. In the U.S. Caribbean region mangrove wetlands are dominated by one or a combination of four species: the red mangrove (*Rhizophora mangle*), the black mangrove (*Avicennia germinans*), the white mangrove (*Laguncularia racemosa*), and the button mangrove (*Conocarpus erectus*). Associated vegetation includes other trees, shrubs, ferns and some herbaceous species. The red mangrove dominates in the wetter parts or seaward edge of the coast, while black, white, and button mangrove trees predominate in the landward parts of the wetlands. The red mangrove is generally the dominant species and can be easily distinguished by the formation of a thick root system that rises above the soil and water surfaces. Mangrove cays are commonly dominated by white mangroves.

Due to the influence of tides, most mangroves get flooded at least twice during the day, which facilitates the movement of fish in and out of the wetland. As a result, many different species of fish use mangroves for the same reasons they use seagrass beds. The presence of intricate root systems, fallen branches, wood, and leaves make these wetlands attractive to fishes and

many other organisms that look for food and shelter from predators. Aerial roots of red mangroves are sometimes flooded for long periods of time, allowing crustaceans, sponges, mollusks, and marine vegetation to adhere to the roots and form a rich marine microhabitat. Marine life growing on these flooded aerial roots then provides additional food for fish.

COMMON FISH FOUND IN MANGROVE WETLANDS:

Anchovy or Bocua (*Cetengraulis edentulus*)

Anchovies are small silvery fish with blue-green backs. They usually do not grow larger than 20 cm. Anchovies generally occur inshore, entering brackish waters of lagoons and estuaries. Mangroves growing in these coastal environments generally provide anchovies with food and protection. This species forms large schools. They are filter-feeders feeding on both phytoplankton and zooplankton.

This fish is commonly used as bait and considered of minor commercial importance. However, in some countries such as Perú the anchovy represents an important fisheries resource. Anchovies are highly appreciated for human consumption in countries such as France and Spain. In mangrove ecosystems, this species is important as part of the food web of young groupers.

Gray snapper or Pargo prieto (*Lutjanus griseus*)

The gray snapper is found in coastal as well as offshore waters around coral reefs, rocky areas, estuaries, mangrove habitats, and sometimes in lower reaches of rivers (especially the young). This diversity of location indicates the tolerance of this species to different salinity ranges. A variety of inshore habitats represent important nursery areas for the young gray snapper. Their post-larvae generally settle in mangroves and seagrass beds, where they find food and protection from predators. The gray snapper is a nocturnal feeder, preying on small fishes, shrimps, crabs and other invertebrates.

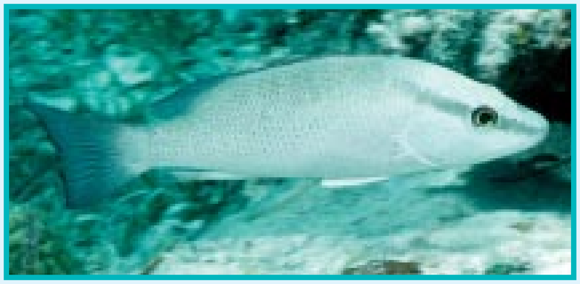


Photo courtesy of Andrew Bruckner

This species of snapper is a very popular game and food fish. Although it is fished commercially, it is sought largely as a seasonal supplement to other fisheries. The gray snapper has been successfully reared for aquaculture, and is also exhibited in commercial aquariums. In the U.S. Caribbean, this species is managed under a CFMC FMP.

Great barracuda or Picúa (*Sphyraena barracuda*)

The great barracuda is often found in nearshore mangroves, seagrasses and coral reefs. After being spawned in offshore waters, the larvae and then one-year old juveniles reside in mangroves and seagrass beds, where they find food and safety. Adults live generally near the surface and occur in a wide variety of habitats from inner harbors to the open sea. Because of its sharp teeth and ability to swim at high speed, the great barracuda is a very efficient predator feeding mainly on fishes, cephalopods and sometimes shrimps. It can reach a size of 2 m and weigh 50 kg and is generally not dangerous to humans.

The great barracuda is a commercial species in the U.S. Caribbean, although in Puerto Rico there is a threat of ciguatera poisoning, especially when consuming larger individuals. In some areas it is commercialized fresh or dried/salted. This is a highly esteemed gamefish. It is also a species commonly shown in aquariums.

Photo courtesy of Andrew Bruckner

Mangrove oyster or Ostión de mangle (*Crassostrea rhizophorae*)

The mangrove oyster is characterized by irregular and rough purple shells, which can reach a maximum length of about 12 cm. It is a sessile organism, generally found in brackish waters forming clusters on the roots of red mangrove trees as well as in rocks or other hard bottoms. Because of their location in the intertidal zone, these communities can become exposed to the air during low tides or submerged during high tides. The mangrove oyster is a filter-feeding organism, which feeds mainly on phytoplankton.

This species is consumed by different organisms including the starfish and some birds. It is also considered a delicacy by humans. It is commercially important in the Boquerón area of Puerto Rico.

Photo courtesy of Lisamarie Carrubba

Mutton snapper or Sama (*Lutjanus analis*)

The mutton snapper occurs in offshore areas as well as the clear waters around islands. Large adults are usually found among rocks and corals. Juveniles occur in mangroves, canals and over sandy, vegetated (usually seagrass) environments, where they find protection. This species forms small aggregations during the day. It is a diurnal and nocturnal feeder. Its diet consists mainly of fishes, shrimps, crabs, and other invertebrates.

Photo courtesy of Andrew Bruckner

This is a highly valued commercial species, and it is also popular in recreational fishing. Currently it is considered to be vulnerable to overfishing, and is managed under a CFMC FMP. The management plan includes a closed season, specific size limits, and gear restrictions.

Irish pompano or Mojarra (*Diapterus auratus*)

The Irish pompano lives in shallow coastal waters with mud or sand bottom, especially in mangrove-lined creeks and lagoons. It is also found on vegetated sand grounds in marine areas. Occasionally, it can be observed in fresh water. Juveniles have a wider distribution than adults. This species feeds mainly on invertebrates.

The Irish pompano is considered a species of minor commercial importance. It is, however, an important bait fish. It can be a fun species to catch on light line.

Common snook or Róbalo (*Centropomus undecimalis*)

The common snook is the most abundant of all snook species. It is often found around mangrove-fringed estuarine habitats, which provide food and shelter. They can also be found in freshwater rivers, nearshore canals, salt marshes, seagrass beds, and reefs. The common snook is a carnivorous species, feeding primarily on other fish. It also eats shrimps, crabs and other crustaceans.

Photo courtesy of NOAA

Because of its popularity as a gamefish and because of its excellent flesh, common snook have declined in certain regions as a result of commercial and recreational over harvesting. Habitat degradation or destruction is another cause of this species' decline.

Tarpon or Sábalo (*Megalops atlanticus*)

Tarpon inhabit a wide variety of habitats, but are mainly found in coastal waters, bays, estuaries and mangrove-lined lagoons. These areas serve as nursery habitats for their larvae, providing food and shelter. This species can also be observed entering fresh waterways or in offshore waters. Because of its ability to inhale air from the surface through a modified air bladder, this species is able to tolerate low oxygen environments. This species is, however, very sensitive to low temperatures. Tarpon feeding habits change with developmental stage. For example, juveniles are planktivorous (feed on plankton) while adults are carnivorous, feeding on fish, shrimp and crabs.

The tarpon is highly prized as a recreational fish due to its great strength and fast swimming speed. A female tarpon can reach over 2.5 m in length and near 161 kg in weight. Even though this species is not valued as a food fish, in some countries such as Panama, the West Indies, and Africa it is considered a delicacy.

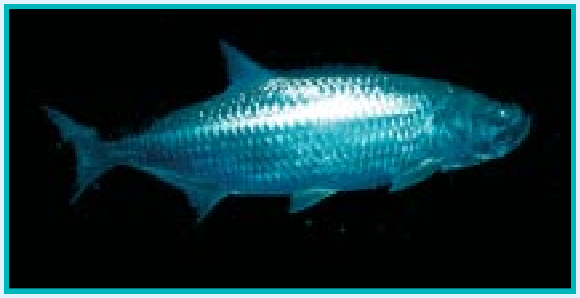


Photo courtesy of Andrew Bruckner

FRESHWATER WETLANDS

FRESHWATER MARSH:

This type of wetland occurs mainly in the lowland coastal areas, and is generally associated with rivers, lakes, lagoons, streams, or ponds, and in areas of groundwater upwelling known as “sumideros” in Puerto Rico. The vegetation found in these environments can be very diverse and generally consists of a mix of species including grasses, sedges, rushes, and broad-leaved aquatic plants. Some dominant species found in this type of wetland are the swamp fern, sawgrass, giant sedge, water grass, hibiscus, arrowhead, and cattail. This latter species is however, considered an invasive nuisance species typically found in disturbed areas. These marshes can be flooded for long periods of time or they might be inundated infrequently. How often and for how long these marshes are flooded is a very important factor determining the abundance and species of fish utilizing them. The deeper the water and the longer the marsh is covered with water, the greater the probability of finding fish in them.

FORESTED WETLAND:

Forested wetlands are normally found in the low-lying and flat coastal areas. As a result of burning, clearing for agriculture, cutting for wood, or damage by hurricanes, this type of wetland can only be found in a few areas within the U.S. Caribbean region. Remnant forested wetlands are commonly found landward of mangrove forests but also inland in swamps and along streams and rivers. Trees of up to 15 m height constitute the main

kind of vegetation forming these wetlands. The dominant tree species growing in these forested wetlands is swamp bloodwood or palo de pollo (*Pterocarpus officinalis*) with associated species such as royal palm, the slender spiny escambrón, pitch apple or cupey, pond apple or corazón cimarrón, leather ferns or palmitas del río, and many others.

FRESHWATER AQUATIC:

These systems are generally found within the flat coastal lowlands, but also occur in human-made impoundments located inland. Freshwater aquatic communities are dominated by free-floating and rooted herbaceous species. Some common examples of plants found in this type of wetlands are water lily, alligator weed, naiad, fanwort, and water hyacinth. This latter considered an invasive species that often out-competes native species. In these wetlands water level changes are often associated with rainfall.

COMMON FISH FOUND IN FRESHWATER WETLANDS:

American eel or Anguila (*Anguilla rostrata*)

The American eel lives most of its life in freshwater, usually in permanent rivers or lakes. This species finds food and protection within the wetland vegetation that grows in these water bodies. It hides from the light during the day in holes or other shelters, often burying itself in the substrate. It is active at night, swimming near the bottom in search of food. Its diet changes according to its level of maturity. Adults feed mainly upon insects, crustaceans, clams, worms, fish, and frogs.

The American eel is a catadromous species, which means that after spending most of its life in fresh water, it returns to salt water to spawn. Because of this, the species undertakes a long migration from freshwater habitats to its spawning site at the Sargasso Sea. After spawning, the adults die and the young are then transported by currents to rivers and streams where they finish their development.

Photo courtesy of L. Miranda, FWS

The American eel is considered of great economic importance. It is sold for human consumption (especially in Japan, Taiwan and Europe) and as bait for other fisheries. It is also used in the aquaculture industry. Even though the American eel is not listed as threatened, the destruction of freshwater habitat through pollution and dam construction, and over harvesting of juveniles is making it difficult for this species to survive.

Bigmouth sleeper or Guavina (*Gobiomorus dormitor*)

The bigmouth sleeper is common in brackish coastal lagoons and freshwater coastal streams. Adults occur typically in flowing fresh water, often well inland. Most of the time it stays on the bottom in the slower moving parts of streams, sometimes on logs, large stones, gravel or debris, or in heavy vegetation, where

Photo courtesy of B. Yoshioka, FWS

it finds protection from predators. This is not a very active species; it is nocturnal and takes advantage of its cryptic coloration to capture its prey, generally fish and crustaceans such as shrimp. Spawning occurs in freshwater or brackish water.

Even though this species is considered of no commercial or recreational importance, it plays an important role within the food web as a source of food for larger fish.

Fat sleeper or Mapiro (*Dormitator maculatus*)

The fat sleeper is generally found in fresh water, but is also observed in brackish environments. It can be found inhabiting marshes, mangroves, muddy ponds, and channels. These habitats provide food and shelter during the different stages of their life cycle. This is a solitary species and feeds mainly on plants, sediments, and invertebrates. During reproduction it changes its coloration and performs a complex mating dance. The adults guard the nest. Since they are quite pretty and are easy to maintain, they are offered in aquarium stores. Fat sleeper is also used as a bait fish.

Mosquitofish or Pez mosquito (Gambusia affinis)

The mosquitofish prefers standing or slow-flowing water environments. It is generally found in vegetated ponds and lakes, backwaters and quiet pools of streams. It is also observed in brackish waters. Juveniles form small schools and use the presence of vegetation for their protection. This is one of the few freshwater fish species that bears live young.

The mosquitofish was introduced to the Caribbean and many other regions around the world as a way to control mosquitoes, hence the common name. They feed on a variety of foods, including mosquito larvae and pupae, plankton, algae, diatoms (one-celled algae), and detritus. They can also tolerate poor water quality environments. Even though they are effective in mosquito control, they compete with indigenous fish and thus represent an immediate threat to the ecological balance of native ecosystems.

Photo courtesy of B. Yoshioka, FWS

Mountain mullet or Dajao (*Agonostomus monticola*)

The mountain mullet is found in rivers and steep mountain streams within the forest. Young are sometimes observed in brackish waters. This is the only mullet that ascends inland to spend its adult life in freshwater. This species is an opportunistic feeder, feeding mainly on aquatic insects and algae, but also on mollusks, small shrimp and detritus. This fish often feeds near the water's surface and depends on its sight to locate its prey.

The mountain mullet is caught and consumed by local populations, thus representing an important species of subsistence fisheries. Its flesh is reported to be of good quality.

River crab or Buruquena (*Epilobocera sinuatifrons*)

The river crab is frequently observed in stream rapids. An active predator, it often feeds on mayfly nymphs as a

Photo courtesy of B. Yoshioka, FWS

juvenile. The species is fished for human consumption. However, the loss or alteration of streams in the U.S. Caribbean due to development and agricultural activities has led to a decline in the species.

River prawn or Langostino (*Macrobrachium spp.*)

Many species of Macrobrachium are found within the U.S. Caribbean region, including *M. acanthurus*, *M. carcinus*, *M. crenulatum*, *M. faustinum* and *M. heterochirus*. These species are observed inhabiting environments such as rivers, bays, ponds, streams and marshes, where they find food and protection. They can be found in holes, under rocks, organic materials, or among submerged vegetation. Most river prawn species are omnivorous, feeding on vegetation, small invertebrates, detritus, algae, and aquatic insects. River prawns can tolerate high salinities, and depend on saline water for larval development. Post larval stages migrate from estuaries to upstream pools.

River prawns are currently of commercial interest because of their potential in aquaculture. Some species are also used in subsistence fisheries. These species are currently vulnerable due to habitat loss and degradation in addition to unregulated harvest of adults.

Photo courtesy of B. Yoshioka, FWS

Swordtail or Pez cola de espada (*Xiphophorus hellerii*)

The swordtail fish is an introduced species. It is mainly found in rapidly flowing streams and rivers, preferring heavily vegetated habitats, which provide important protection from predators and a good source of food. This fish also occurs in warm springs, weedy canals, and ponds. This is a schooling, non-aggressive species. The swordtail is omnivorous, feeding on worms, crustaceans, insects, algae, and plant matter.

Because of its beauty, especially the red variety, the swordtail is a popular species in the aquarium trade. It is also used as bait in some regions and for genetic research.

Tilapia (*Oreochromis mossambicus*)

Tilapia is an introduced species that can live almost anywhere including ponds, reservoirs, drainage ditches, canals, rivers, estuaries, and coastal lakes. Vegetated aquatic environments are important for this species as a source of food and protection, especially for the young. Tilapia can tolerate a broad range of temperature and salinity conditions, low oxygen levels, poor water quality, and pollution. It feeds on almost anything available from algae to insects to crustaceans and small fish, showing some preference for detritus and plant matter.

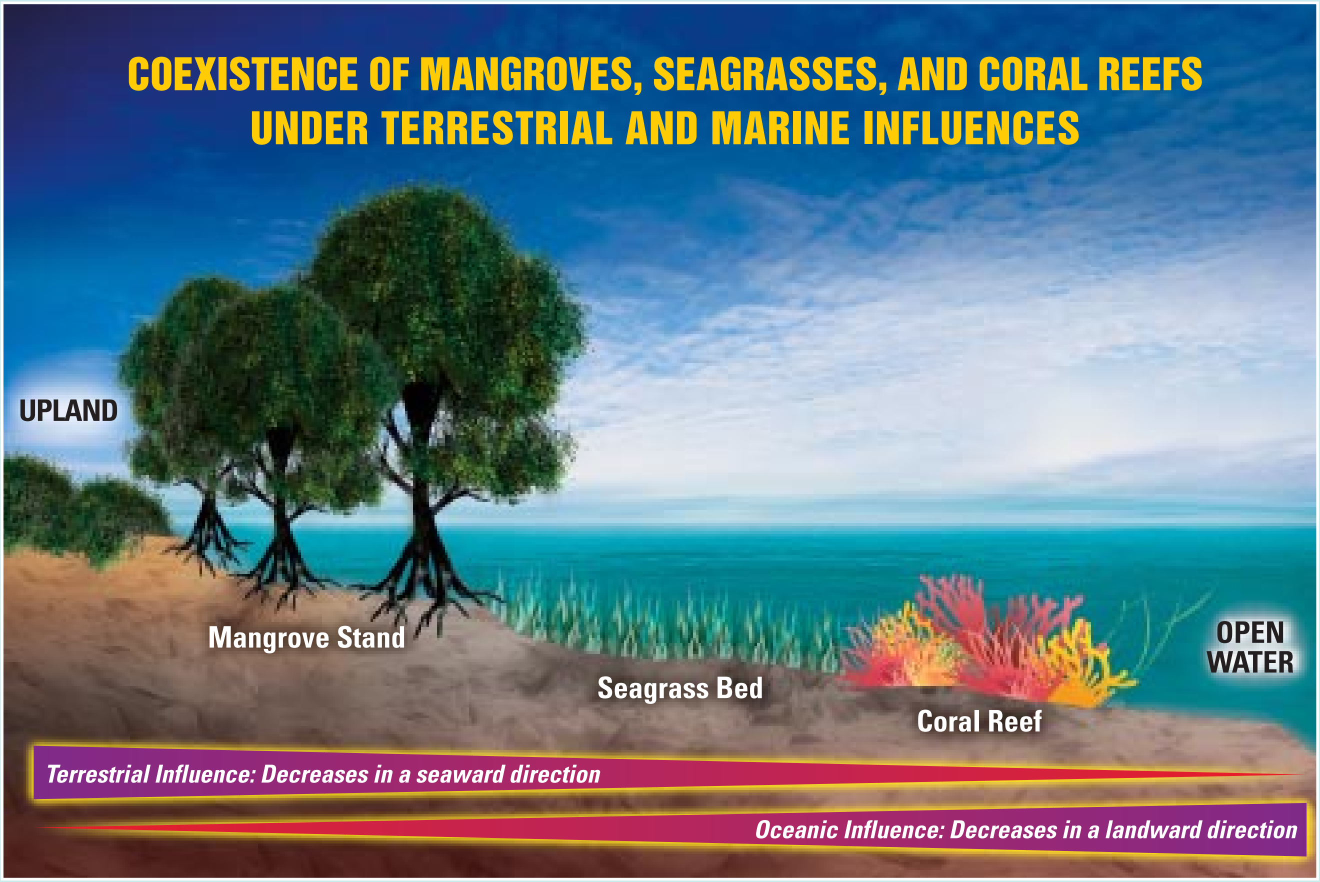
As a result of its flexible habitat preferences, aggressive breeding habits, and simple food requirements this species has colonized a variety of habitats and it is competing with native species. However, Tilapia has also become a species of high commercial importance. It is often used in aquaculture and is also used in recreational fishing and as an aquarium species.

A CASE STUDY:

Mangroves, Seagrasses, and Coral Reefs in the Caribbean, and Their Associated Fish

In the Caribbean region there is often a close association between mangrove stands, seagrass beds, and coral reefs. Stable climate, low wave energy, high water transparency, and low urban coastal development are factors favoring the coexistence of these three ecosystems. Mangroves and corals have somewhat different environmental requirements, so they rarely adjoin one another. Instead, seagrasses are commonly found between mangroves and coral reefs.

Because of their proximity to the uplands, mangroves serve as a barrier to filter sediments and nutrients being transported in runoff. Through this filtering function, mangroves shelter adjacent waters from excessive sedimentation and turbidity. This is important for seagrass establishment but is especially important to coral reefs,



which need clean clear water to grow. Excess sediment in the water column is a leading cause of coral mortality in the Caribbean. In addition to filtering sediments, mangroves also remove contaminants such as heavy metals, which are trapped within sediments or absorbed by plants. Mangroves and seagrasses also contribute organic matter for coral nutrition and serve as important foraging and nursery habitats for coral reef fishes and other organisms. Corals, in return, buffer seagrasses and mangroves from excessive wave action and provide storm energy protection.

Mangroves, seagrasses and coral reefs exist in a delicate balance that can be affected by human activities and/or natural phenomena of terrestrial and marine origin. Seagrasses and corals are sensitive to changes in water quality and are used as indicator species to reflect the overall health of coastal and marine ecosystems.

MANGROVES, SEAGRASSES, CORAL REEFS, AND ASSOCIATED FISH

For fish, mangroves, seagrasses, and coral reefs are great places to live. These habitats provide living space, food, protection, spawning, and nursery areas for as many as 500 different species of fish and shellfish in the U.S. Caribbean region. Fish find spaces to live and hide among the intricate root systems, dense vegetation, and coral structures. Food in these habitats is also plentiful. Herbivores feed on plants, algae or detritus. Carnivores and omnivores have an array of choices including small invertebrates, shells, crustaceans, and other fish. As observed, the fish diversity found in mangroves, seagrasses and corals is very high and reflects the importance of these ecosystems for their subsistence.

Mangroves, seagrasses, and coral reefs are characterized by their own particular fauna, but at the same time, many species of organisms, especially fish, move among these habitats. Fish migrate from one ecosystem to the other in search of food, protection or for reproduction purposes. In other words, some fish species depend not only on one habitat, but on others too. For example, the French grunt needs not only seagrasses, where its larvae settle and spend their first few months, but also reef habitats where they forage as small juveniles.

Different fish use mangroves, seagrass beds, and/or coral habitats in different ways depending on their needs. Species such as the foureye butterflyfish and the butter hamlet depend on coral reefs for protection from predators, as a source of food, or as a place to spawn. Juvenile fishes of many species such as the great barracuda and gray snappers find shelter among red mangrove aerial roots. Some species, such as the bucktooth parrotfish and fringed filefish live their entire lives in seagrass beds whereas other species use these habitats only as nursery areas (french grunts) or for nocturnal feeding (many snappers and grunts). The scrawled filefish is an example of a fish species that depends on soft coral habitats since it feeds mainly on a type of coral known as gorgonians.

Many of the fish species that use seagrass beds, mangroves, and coral reefs as nursery habitats are commercially important, giving these ecosystems high economic value. In Puerto Rico, for example, approximately 75% to 90% of the marine fauna with commercial or recreational importance use mangroves during a given period within their life cycles and/or are associated with coral reefs. An example is the red hind or cabrilla, which is commercially important in terms of numbers caught and total weight of landings in the Caribbean. Other commercially important species in the Caribbean that use mangroves, seagrasses, and/or coral reefs include snappers, jacks, and snooks. ■

Natural and Human Impacts on Caribbean Wetlands and Coral Reefs

Impacts to wetlands and coral reefs can be classified in two main groups: those of natural origin and those associated with human activities. The final effect these impacts have on wetlands and coral reefs depends on both the nature and the severity of the impact. Wetlands within the U.S. Caribbean have been reduced by more than 50%, mostly due to draining for agriculture, flood control projects, and urban and industrial development. In Puerto Rico, for example, approximately 65% of the original mangrove area has been destroyed and only a few areas of forested freshwater wetland (bloodwood forests) remain today. It is important to remember that the degradation of these habitats has direct implications to associated fauna including fish that depend on them.

NATURAL IMPACTS

Storms and hurricanes can be very devastating forces, particularly to coastal ecosystems, which are more exposed to winds and waves. Wind-driven waves may break or uproot seagrasses and damage coral reef structures, while strong winds can devastate a mangrove forest. This kind of habitat loss has subsequent effects on associated fauna such as fish, which use these areas for shelter and feeding. Climate change, which is associated with a gradual increase in sea level rise and changes in water temperature, is also responsible for the loss and degradation of wetlands and coral reefs. Higher water levels increase the flooding of wetlands beyond normal ranges and high water temperatures can cause massive coral bleaching. Grazing and diseases also impact wetlands and corals. For example, excessive foraging of sea urchins and manatees can severely disturb seagrass communities.

Photo courtesy of Lisamarie Carrubba

Impact of Hurricane Georges, 1998 in a mangrove forest in Boquerоñ, Puerto Rico.

Photo courtesy of Lisamarie Carrubba

Human impacts on wetlands, Las Mareas Harbor, Guayama, Puerto Rico.

HUMAN IMPACTS

There are many impacts associated with human activities. Within the U.S. Caribbean deforestation, tourism, urban development, industry, agriculture, damming and diversion of rivers, and navigation are among the human activities affecting wetlands and coral reefs. Deforestation has both a direct and an indirect effect on wetlands and corals. Direct extraction of wood products or clearing for housing, agriculture or industry has devastated most of the freshwater forested wetlands and a great portion of the mangrove forests in Puerto Rico. Deforestation also increases erosion and, as a result, more sediments are transported via runoff to water bodies, increasing turbidity. Higher water turbidity affects seagrasses and especially coral reefs by decreasing the amount of light reaching these submerged habitats. Excessive sediment accumulation in the roots of plants such as mangroves can also lead to mortality by reducing oxygen exchange.

In addition to sediments, runoff can also carry contaminants (chemicals, pesticides, etc.) and nutrients from agricultural fields and urban areas. Excessive nutrients in the water can cause massive blooms of algae, which reduce water clarity. Reduction of water clarity plus depletion of nutrients is followed by the death and decomposition of these algae. This process of decomposition degrades water quality by using up most of the dissolved oxygen in the water column, which can lead to fish kills. Water pollution, especially in coastal areas, can also be the result of oil spills or contamination from boat transportation.

Even tourism can have serious adverse effects on the very ecosystems that attract tourists. Hotel construction sometimes occurs directly in wetlands or immediately adjacent to seagrass beds. An increase in Caribbean tourism has resulted in more frequent anchor damage and boat groundings, causing devastating effects on coral reefs and seagrass beds. As an example of the magnitude of this kind of damage, in October of 1988 a cruise ship dropped an anchor on a coral reef in Virgin Islands National Park, St. John, leaving a scar 128 m long and 3 m wide. Because they grow very slowly, some only 0.5 cm per year, corals require a long time to recover from this kind of damage.

Protecting our Wetlands and Coral Reefs

Wetlands and coral reefs are too valuable to allow them to degrade or disappear. It is up to everyone to make an effort to preserve these beautiful and valuable ecosystems. Considering the increasing threat to coastal wetlands and coral reefs, especially due to human activities, there is an immediate need to protect these habitats. Preservation efforts can range from a small restoration project to the creation of wetland legislation.

WETLAND AND CORAL REEF PROTECTION THROUGH LEGISLATION

The governments of Puerto Rico and U.S. Virgin Islands have developed and expanded through the years a series of environmental laws and regulations in an effort to avoid and prevent further degradation to their coastal resources, including wetlands, coral reefs and associated fish communities. Many of the laws were created for the protection, conservation and management of each country's natural resources. The creation of national parks, protected reserves, and designation of sensitive areas are some of the steps taken to preserve their coastal ecosystems. More specific regulations were developed to limit and control public access to sensitive areas, control the extraction of natural resources, including fisheries, control ship anchorage, and regulate environmental pollution, for example. A series of management and restoration plans have also been developed to better assure the preservation and management of wetlands, coral reefs, and associated resources.

Some laws under the jurisdiction of the Department of Commerce of the United States, such as the Magnuson-Stevens Fishery Conservation and Management Act, identify and help protect important fishery habitat including wetlands. Local governments, too, have an

Photo courtesy of Lisamarie Carrubba

Mangrove restoration project, Cabo Rojo, Puerto Rico.

important role to play in efforts to conserve wetlands and coral reefs, especially when it comes to law enforcement, and to ensure the use of appropriate management plans and monitoring programs within specific regions.

CITIZEN ACTION

Even though national and local legislation plays an important role in protection, conservation, management, and restoration efforts geared toward wetlands, coral reefs, and associated fauna, partnerships and community involvement are essential to continued success. It is very important that citizens, government, businesses, and other interested parties work together to ensure the protection of these valuable resources.

An example of a successful partnership restoration effort in the U.S. Caribbean is the Partners for Fish and Wildlife Program (formed by 27 organizations including small local organized groups, local universities, local governmental institutions as well as world recognized conservation organizations). Even though this Partner Program started working in the Caribbean just recently, they have restored among other ecosystems, more than 100 acres of wetlands and have established about 3 miles of riparian buffers.

Even though much has been accomplished by this Partnership Program, restoration needs within the U.S. Caribbean are great and there is still much to do. By joining existing programs or promoting similar efforts we can make a difference in restoring and preserving our valuable ecosystems and protecting organisms that depend on them.

AWARENESS: YOU CAN MAKE A DIFFERENCE

A first step toward protecting our wetlands and coral reefs is raising personal and community awareness of the importance of these ecosystems and their value to associated fauna and our economy. It is important to become an active steward for the protection and preservation of such valuable habitats.

WHAT CAN WE DO?

Some possibilities include:

- Help in the development of educational programs for our children (primary and secondary levels) to teach them about the importance of wetlands and coral reefs and the importance of protecting and preserving them.
- Join a local conservation organization.
- Participate in local efforts to protect and restore wetlands, including participation in the public comment period for development projects.
- Become involved in local community land-use planning to prevent wetland destruction.
- Become a voice to raise awareness to others in your community about the importance of wetlands for fish and other organisms, including us.
- Volunteer in restoration programs organized by local organizations.
- Help to keep our wetlands clean and healthy.
- Share this publication with friends, family and anyone who care about our wetlands, coral reefs and the fish that depend on them.

GLOSSARY

AMPHIPOD: A small shrimp-like crustacean.

BENTHIC: Organisms that live on the bottom of a water body. They are not free-floating like pelagic organisms.

BIODIVERSITY: The variability among living organisms from all sources, including land-based and aquatic ecosystems, and the ecosystems of which they are part.

BIOMASS: The total mass of material resulting from the growth of an organism or weight of living organisms (plant or animal) per unit area.

COASTLINE: The line that forms the boundary between land and the water.

COPEPOD: A member of a large group of species of very small shrimp like crustaceans; common in marine and, to a lesser extent, freshwater systems.

CRIPTIC: Refers to a behavior or coloration that tends to conceal an animal.

DEBRIS: The remains of something that has been destroyed or broken up.

DEGRADATION: The deterioration in quality, level, or performance of a functional system.

DEMERSAL: Refers to fish and animals that live near water bottoms.

DIATOM: Unicellular algae capable of photosynthesis and characterized by producing a thin outer shell made of silica.

DIURNAL: Belonging to or active during the day.

ECOSYSTEM: A community of plants and animals interacting with one another and with their environment.

ENDANGERED: As defined under the Federal Endangered Species Act, a species is considered endangered if it is in danger of extinction throughout all or a significant portion of its range.

ESTUARY: A semi-enclosed body of water with an open connection to the sea, where saltwater and freshwater mix.

FISHERY/FISHERIES: The act, process, and industry of catching fish, crustaceans, mollusks, or other aquatic organisms for commercial, recreational, subsistence or other purpose.

FOOD WEB: Elaborate, interconnected feeding relationships in an ecosystem.

GLOBAL WARMING: An increase in the average temperature of the Earth's surface, which occurs following an increase in greenhouse gases.

GROUND WATER: Underground water that is generally found in the pore space of rocks or sediments.

HABITAT: The place and conditions in which an organism lives.

HERBIVORE: An animal that eats plants.

HERMAPHRODITE: An animal or plant, which has both male and female reproductive organs.

INSULAR: Related to, characteristic of, or situated on an island.

INTERTIDAL: Refers to the zone between high and low tides, which is alternately exposed to the air and to the sea.

LITTORAL ZONE: Area on or near the shore of a body of water.

NERITIC: Refers to fish and organisms that live in near shore waters.

NURSERY: The part of a fish's or animal's habitat where the young grow up.

OFFSPRING: Immature or young fish.

OMNIVOROUS: Feeding on all kinds of foods, plant or animal material.

PELAGIC: Refers to fish and other organisms that live in the open sea, in the water column, away from the sea bottom.

RIVER BASIN: Drainage area of a river and its tributaries.

RUNOFF: That part of precipitation or irrigation water that flows from the land to streams or other surface waters.

SALINITY: Measure of the salt content of water or other liquids.

SANDBAR: A ridge of sand built up by currents, especially in a river or in coastal waters.

SARGASSUM: A brown algae forming dense floating masses in tropical Atlantic waters such as the Sargasso Sea.

SEA LEVEL RISE: An increase in the mean level of the ocean.

SESSILE: Organisms that are permanently attached or fixed to a surface. Oysters for example are sessile organisms.

SHELLFISH: Any aquatic animal that has a shell, such as crustaceans and mollusks.

SPAWN/SPAWNING: Process of releasing and fertilizing eggs.

SUBSISTENCE FISHERY/FISHERIES: A fishery in which the harvested resource is used directly without sale for profit; not considered a leisure or sporting activity.

SUBTIDAL: Zone below the low-tide mark, which is always submerged in the water.

THREATENED: As defined under the Federal Endangered Species Act, a species is considered threatened if it is likely to become an endangered species.

TIDAL: Pertaining to, affected by, or having tides.

TROPHIC LEVEL: Relating to processes of energy and nutrient transfer from one or more organisms to others in an ecosystem.

TUNICATE: A primitive marine organism characterized by a saclike un-segmented body.

TURBIDITY: A measure of the cloudiness of water, which is a function of the amount of suspended material, both organic and inorganic.

UPLAND: The ground above the floodplain that is not covered by water.

WATERSHED: An area of land that drains to a particular body of water.

ZOOBENTHOS: Animals that live on or near the bottom of a water body.

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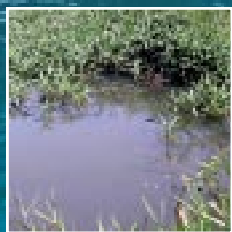
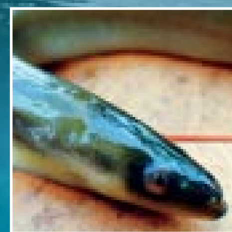

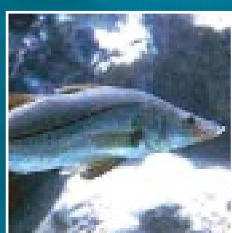
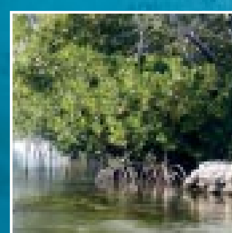

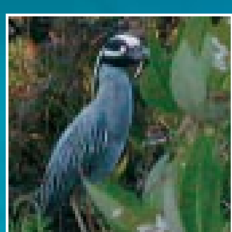

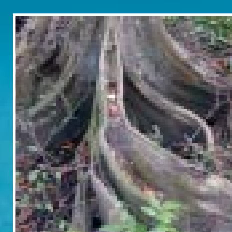

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