NCEP Network of Conservation Educators & Practitioners

Developing capacity to sustain the Earth's diversity

NPS/Mike Quinn

Native Ecosystems Unit

The Colorado River is the lifeblood of the southwestern United States and northwest corner of Mexico. From the high peaks of the Rocky Mountains in Colorado, through the desert canyons of Utah and Arizona, touching the borders of Southern Nevada and California, and finally flowing across the lowlands of Mexico and into the Gulf of California (also called the Sea of Cortez), the Colorado River is the primary water source for thousands of plant and animal species. While many of the species that are dependent on the flows of the Colorado River live within the channel of the river itself, others thrive on the vegetation that grows from the constant source of soil moisture provided by the river to the surrounding riparian area. In the vast desert of the American Southwest, the Colorado River provides nourishment for migratory birds passing through on their annual journey.

This unit describes the transformation of ecosystems as a result of water resource development of the Colorado River. We will focus on a few key regions that provide habitat for species that are now endangered and how choices that we have made over the last 80-years have impacted these regions. We will also discuss what efforts are being done to improve the habitat for these endangered species and what is not being done.

In this unit we will discuss:

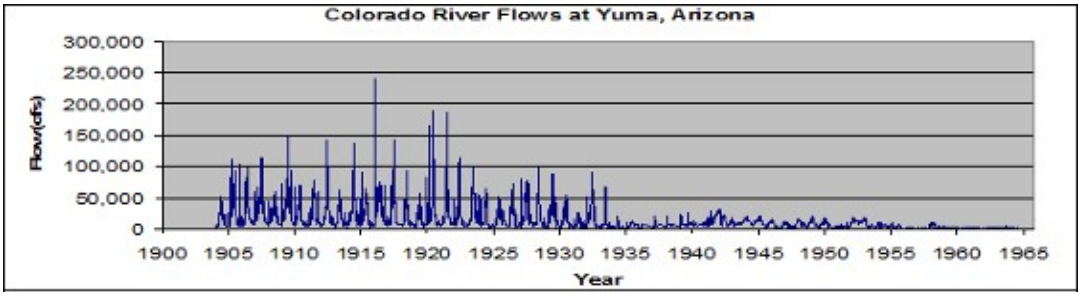
1. Transforming Natural Hydrologic Flows to a Controlled System
    - Changes of Volume and Timing
    - Changes in Water Quality
    - General Impacts on Native Species
2. Current Management Policy for Instream Flows
    - Case Study 1: Upper Colorado Fish Recovery Program
    - Case Study 2: Lower Colorado Multiple Species Conservation Program
    - Case Study 3: Colorado River Delta

A Rapid Transformation

It is difficult for anyone today to comprehend what the Colorado River was like before its waters were dammed and diverted. Few quantitative records exist from before that period, but qualitative stories from explorers such as John Wesley Powell, who first traveled through the Grand Canyon by boat in 1869, paint a picture of immense grandeur with an untamed and unforgiving river running through it. Similarly Aldo Leopold wrote the following of his first experience through the Colorado River Delta: "… but in fact the river was nowhere and everywhere, for we could not decide which of a hundred green lagoons offered the most pleasant and least speedy path to the Gulf" (A Sand County Almanac, 1948).

However we can understand that essentially all of the waters that entered the river stayed in the channel and flowed to the sea in an annual cycle that species have evolved to depend on. In the figure below, we can see the measured flows on the Colorado River near Yuma, Arizona. Notice how high the flows were prior to the construction of the Hoover Dam in 1935. After the construction of the dam, high flows from spring runoff could be captured and released to serve the demands of the rapidly growing agricultural districts and cities. Not only did these great feats of engineering provide water for people to use throughout the arid southwest, but it dramatically reduced the amount of water that was available for the native species that already depended on the river.

In addition to severely reducing the amount of water passing through channels, the construction of the major dams and reservoirs altered the timing of the flows. Since the one of the main purposes of building reservoirs is to retain water during high flow periods and release it during low flow periods, this often contradicts the biological patterns that various native species are adapted to. One significant example of this is the annual inundation of floodplains historically allowed vegetation to grow within them, which provided habitat for various animal species. While eliminating the potential for such large flooding events to occur protects communities and farms from becoming submerged, this comes at the cost of vast amounts of critical habitat.

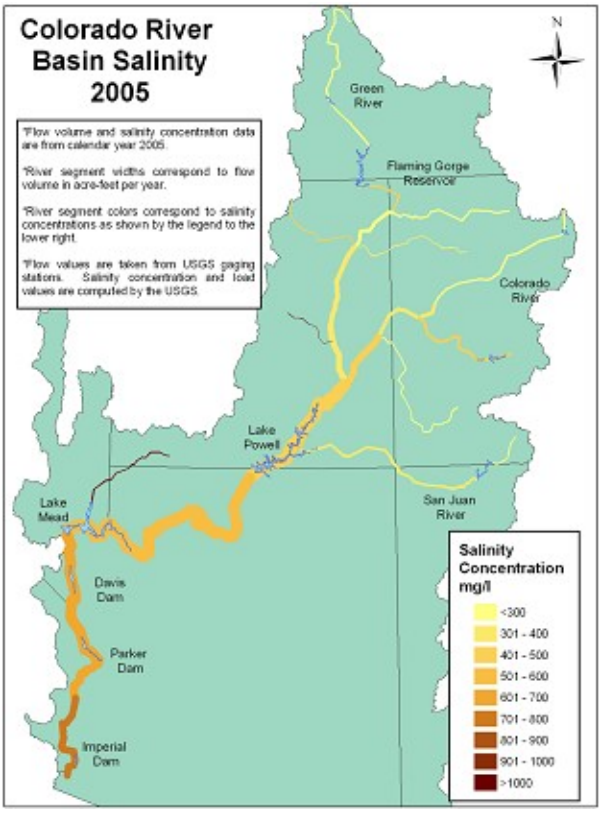


Changes in Water Quality

The water quality of the Colorado River was also significantly altered by the construction of the numerous dams along the river. One characteristic of the river was the high rate of sediment transport that historically existed. Prior to the construction of these dams, the Colorado River transported massive amounts of sediment through milky colored water. This sediment movement provided nutrients for plant growth throughout the river channel and especially to the Delta region as the river entered the Sea of Cortez. Today much of the sediment is captured behind numerous dams along the course of the river's path.

Concurrently an increase in salinity concentrations has occurred. This is due to excess water being used for irrigation purposes across the basin. As water gets diverted from the river and sprayed across the land, natural salts that occur in the soils are dissolved and return back to the river with return flows. This increased salt load, in combination with less water in the river due to diversions, has resulted in extremely high concentrations and expensive measures to remove salt from the river.

Another significant effect on the water quality of the Colorado River was a dramatic change in water temperatures downstream of the various dams. Prior to the construction of the reservoirs, high spring runoff of snowmelt would result in close to freezing water temperatures while the temperature of the flows in the summer would increase significantly due to the shallow depth. After construction of the reservoirs, flows were redistributed more uniformly throughout the year based on downstream demands and hydropower generation. Since temperatures deep in the reservoirs tend to be colder and releases through dam turbines draw water all year from these lower levels within the reservoirs, the flow in a river downstream of a dam tends to be steadier and the average temperature tends to be colder than would occur in a natural stream channel.



Impacts on Species

So what do these changes mean for native species? This is a complex question because some species can adapt while others cannot. Some major impacts that have been documented are:

- Reduced flows causing reduction in critical floodplain habitat
- Changing water levels from fluctuating reservoir releases stranding eggs and fish larvae
- Increase in non-native fish species competing for food with and predation of native species
- Reduction in native riparian vegetation and increases in non-native species vegetation, especially Salt Cedar
- Water temperature reductions disturbing reproduction cycles
- Reduction in flows result in increased salinity concentrations in the estuarine habitat in the Sea of Cortez, which has dramatically reduced the area suitable for breeding and egg laying of now endangered species such as the Totoaba and Vaquita porpoise

We will now explore some of the species that have suffered from changes in flows and water quality due to diversions and the construction of dams, and what we are doing and are not yet doing to reverse this trend.

Case Study #1: Upper Colorado Fish Recovery Program

Overview

The Upper Colorado River Basin, which is composed of the Colorado River and its tributaries upstream of Lake Powell, is home to 14 native fish species, 4 of which are now endangered. These 4 fish include the Colorado pikeminnow, razorback sucker, bonytail, and humpback chub. These species have evolved in the Colorado River basin and exist nowhere else on earth. The fish are now endangered because of human impacts on their habitat over the past 100 years. The two types of habitat alterations that appear to have had the greatest impact have been water development and introductions of non-native fish. Hundreds of dams, diversions, and other barriers have been constructed; river flows have been cut by a third; and more than 40 species of non-native fish have been introduced in the Upper Colorado River Basin.

Location

The Colorado River and its tributaries make up one of the world's most colorful river basins. From the high mountains of Wyoming and Colorado, the river drops more than two miles in elevation on its 1,700-mile journey to the Gulf of California. For long stretches, the river is bounded by red canyon walls. River flows fluctuate widely from season to season and from year to year, historically reaching peaks of nearly 400,000 cubic feet per second. It took tough, adaptable creatures to survive in this river system.

Native Fish Species in the Upper Colorado River Basin

Only 14 species of fish are native to the Upper Colorado: the Colorado pikeminnow, bonytail, humpback chub, razorback sucker, Colorado River cutthroat trout, Rocky Mountain whitefish, roundtail chub, speckled dace, Kendall Warm Springs dace, flannelmouth sucker, mountain sucker, bluehead sucker, mottled sculpin, and the paiute sculpin. Click on the buttons to the right for more in-depth description of the 4 endangered species.

Upper Colorado Fish Recovery Program: Why Some Native Fish in the Upper Colorado River Basin are Endangered

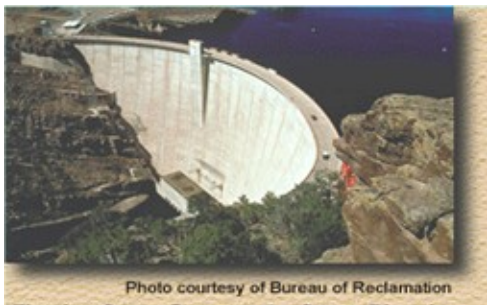


Photo courtesy of Bureau of Reclamation

Flaming Gorge Dam, on the Green River in Utah, provides water to support growth in the West. But dams also block migration paths for fish and alter natural river flows.

Photo courtesy of Bureau of Reclamation

Human population growth has caused a need for water for agriculture and other purposes. Such water depletions have reduced natural river flows required by endangered fish.

Water Development

Human population growth since the turn of the century has created a significant demand for water and hydroelectric power in western states. To meet that demand, hundreds of water projects, including dams, canals, and irrigation projects, have been constructed on the Colorado River and its tributaries. Water projects have restricted the fish to about 25% of their former range and have blocked some of the spawning migration routes of the Colorado pikeminnow and other species. Also, tailwaters 6 to 20 miles downstream from dams can be as much as 15 degrees colder than the rare fishes' preferred habitat. Downstream of Lake Powell, dams have segmented the once free-flowing, silty, and warm waters of the Colorado River into a series of lakes connected by cold, clear waters.

The remaining habitat has been changed considerably. The number and size of life-supporting wetlands has been cut dramatically across the nation. According to a 1990 U.S. Fish and Wildlife Service Congressional report on wetlands, over the last 200 years Colorado has lost an estimated 50% of its wetlands; Utah has lost roughly 30%; and Wyoming about 38%. In the Upper Colorado River Basin, stream-side wetlands have been drained or cut off from the river by dikes, and many of the rivers' backwaters have disappeared. Young native fish have depended on these areas, which enabled them to grow significantly faster and which provided warmer, slower-moving water chock-full of microscopic food.

- Source: U.S. Fish and Wildlife Service

Upper Colorado Fish Recovery Program: Why Some Native Fish in the Upper Colorado River Basin are Endangered

Photos courtesy of (clockwise from top left) William Roston; Colorado Division of Wildlife; Utah Division of Wildlife Resources; New Hampshire Fish and Game.

Red shiner, channel catfish, fathead minnow and northern pike are among more than 40 non-native fish species that been stocked into the upper Colorado River basin.

Non-Native Fish

Introductions of non-native fish into rivers, lakes, and reservoirs also have taken a toll on the native fish. Historically, there were only 14 fish species in the Upper Colorado River Basin. Then in the late 1800s, private citizens and state and federal wildlife agencies began stocking non-native fish into lakes, reservoirs, and streams in the Colorado River drainage.

Now the 4 endangered fish have to compete with more than 40 non-native species.

Trout tend to inhabit colder stretches of river than the 4 endangered fish and generally are not considered a threat. But many of the non-native species, such as northern pike, channel catfish, red shiner and fathead minnow, are efficient predators that prey on the eggs and young of endangered fish.

Non-native fish also compete with native fish for food and space, often with greater success. Several studies have documented these effects. For example:

- In some areas of the Upper Colorado River Basin, the percentage of native fish is quite low. At the confluence of the Colorado and Green Rivers in Utah, biologists have found that 95% of the fish species are non-native; only 5% of the fish that now exist in this part of the river basin are native.
- At least four studies have shown predation by channel catfish, green sunfish, and carp on razorback sucker eggs and larvae.
- In a study of predation on Colorado pikeminnow and various non-native fish, the largemouth bass showed a strong preference for native fish, eating twice as many young pikeminnow as red shiners and as much as 20 times the number of pikeminnow as green sunfish. (Largemouth bass, red shiners, and green sunfish are not native to the Colorado River basin.)
- Young Colorado pikeminnow have been found in the stomachs of channel catfish collected in the Dolores River, even though pikeminnow are very rare in the area. Also, researchers as well as early settlers reported finding pikeminnow that had died trying to swallow channel catfish. Apparently, the barbs of the catfish make it difficult or impossible for pikeminnow to swallow and digest this non-native fish.
- Utah State University researchers found that in the Duchesne River, 1- to 3-year-old Colorado pikeminnow constituted 5% of the diets of northern pike - a disproportionately high percentage, given that pikeminnow constitute a much smaller portion of the available food base in the river. Based on their findings, the researchers concluded that a single northern pike could consume more than 100 one year-old pikeminnow per year.

- Source: U.S. Fish and Wildlife Service

Upper Colorado Fish Recovery Program: Why Some Native Fish in the Upper Colorado River Basin are Endangered

Photo by Connie Young

Signs have been posted along the upper Colorado River basin to alert anglers to the presence of endangered fish.

Photo by Richard A. Valdez

Parasites (as circled above) may have contributed to the decline of some Colorado River fish.

Other Factors

Some portions of the Upper Colorado River Basin have high levels of selenium. Animals need this naturally occurring element in trace amounts but in larger concentrations, selenium can cause severe birth defects in wildlife. Researchers are conducting studies to determine if selenium is affecting the ability of endangered fish to survive and produce healthy offspring. Selenium is believed to increase due to agricultural irrigation runoff.

Some native fish have been killed by anglers who did not release the fish properly. Also, some anglers may prefer to catch northern pike, channel catfish, and other non-native sport fish they consider more desirable. After hooking a native fish, they may have tossed it on the riverbank to die.

n the mid-1960s, efforts were made to reduce native fish populations and make way for stocking non-native sport fish in Flaming Gorge and Navajo reservoirs. This was done with the use of rotenone, a substance extracted from the root of the derris plant. (Rotenone reduces fish populations by temporarily preventing fish from absorbing oxygen through their gills.) Following the use of rotenone, biologists found that although the total number of fish had dropped, the ratios of various species remained about the same. This led them to conclude there had been no lasting effect on the native fish species.

Other factors that may have contributed to the fishes' decline include pollution and parasites. Among the chubs, hybridization may also be a factor.

- Source: U.S. Fish and Wildlife Service

Upper Colorado Fish Recovery Program: Finding Solutions

The Upper Colorado Fish Recovery Program has identified 7 major methods to try to restore the endangered species in the area of interest. Below you can explore each of these methods and consider how all these components are necessary to recover species that we have brought to the edge of extinction. These species will be considered recovered when there are self-sustaining populations of each fish species and when there is natural habitat to support them. -- Source: U.S. Fish and Wildlife Service

Case Study #2: Lower Colorado River Multiple Species Conservation Program

Overview

The Lower Colorado River Multi-Species Conservation Program (LCR MSCP) is a coordinated, comprehensive, long-term multi-agency effort to conserve and work towards the recovery of endangered species, and protect and maintain wildlife habitat on the Lower Colorado River.

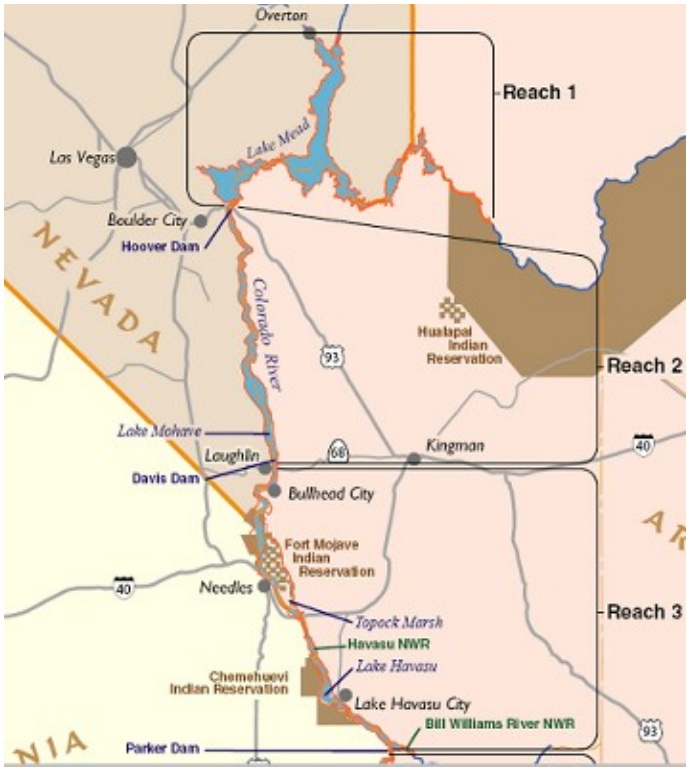
The MSCP's purposes are:

- protect the Lower Colorado River environment while ensuring the certainty of existing river water and power operations;
- address the needs of threatened and endangered wildlife under the Endangered Species Act (ESA); and
- reduce the likelihood of listing additional species along the Lower Colorado River.

The program was developed and is being implemented and funded by a partnership of state, federal, and other public and private stakeholders in Arizona, California, and Nevada with interests in managing the water and related resources of the Lower Colorado River. The impetus for the creation of the LCR MSCP was the recognition by federal and non-federal participants of the potential for their activities to affect species listed as threatened or endangered under the ESA, as well as designated critical habitat along the Lower Colorado River. The participants agreed to form a partnership to develop and implement a long-term endangered species compliance and management program for the historic floodplain of the Lower Colorado River.

Multiple Species Conservation Program: Location

The LCR MSCP covers areas up to and including the full-pool elevations of Lakes Mead, Mohave, and Havasu and the historical floodplain of the Colorado River from Lake Mead to the United States-Mexico Southerly International Boundary, a distance of about 400 river miles. Conservation measures currently focus on the area from Hoover Dam to the border, but may include Grand Canyon in the future.



MSCP Goals

- Conserve habitat and work toward the recovery of threatened and endangered species as well as reduce the likelihood of additional species being listed;
- Accommodate present water diversions and power production and optimize opportunities for future water and power development, to the extent consistent the law
- Provide the basis for incidental take authorizations

The driving force behind the LCR MSCP is multi-faceted. Notice that the goals of the LCR MSCP are not only to recover threatened and endangered species and to avoid additional species from becoming threatened or endangered during the 50 year term of the LCR MSCP; in addition, the goals explicitly focus on allowing present and future water and power uses. Water users and power production companies have a vested interest in finding ways to conduct business while avoiding violations of laws that protect endangered and threatened species. Furthermore, they also want to avoid new species from becoming threatened or endangered because the Endangered Species Act (ESA) could potentially affect their future ability to use and control Colorado River water.

For water and power users, the LCR MSCP is a trade-off. Under the ESA, activities that impact endangered and threatened species can be restricted to protect the viability of the species. Therefore making any modifications to the operation of the Colorado River requires an evaluation of how that modification might impact those species. Furthermore, if a change to the Colorado River results in a negative impact to a threatened or endangered species, then it could be restricted from occurring due to the ESA regulations. However, organizations can pro-actively apply to the U.S Fish and Wildlife Service to make modifications to the ecosystem that may damage habitat for threatened species. If certain criteria are met by the applicants to the U.S Fish and Wildlife Service then these modifications can be allowed to take place.

The purpose of the MSCP then is to analyze the impacts of and mitigate for a wide range of actions that currently affect or may affect many species in the river. With this lumped approach, impact statements for individual modifications could be avoided. Activities covered by the Habitat Conservation Plan (HCP) include all non-federal actions involved in:

- water diversions and returns of up to 7.5 million acre-feet per year from existing facilities;
- diversions and returns for any surplus waters;
- future changes in points of diversion of up to 1.574 million acre-feet per year;
- implementation of the LCR MSCP, including mitigation measures;
- many present and future flow- and non-flow-related non-federal actions or projects; and
- demand for and receipt of hydropower.

The LCR MSCP Habitat Conservation Plan (HCP) states: *This HCP is intended to meet all the regulatory requirements necessary for the USFWS to issue a section 10(a)(1)(B) permit to allow incidental take of threatened and endangered species affected by specified non-Federal agency activities (covered activities) within the LCR MSCP planning area (Multiple Species Conservation Plan – Final Habitat Conservation Plan, 2004).*

Multiple Species Conservation Program: Applicants

The List of Applicants includes a variety of entities with interests in the Colorado River.

California

- Bard Water District
- Coachella Valley Water District
- Colorado River Board of California
- Imperial Irrigation District
- The Metropolitan Water District of Southern California
- Palo Verde Irrigation District
- San Diego County Water Authority
- Southern California Public Power Authority

Arizona

- Arizona Department of Water Resources
- Arizona Game and Fish Department
- Arizona Power Authority
- Central Arizona Water Conservation District
- Mohave County Water Authority
- North Gila Valley Irrigation and Drainage District
- Salt River Project Agricultural Improvement and Power District
- Wellton-Mohawk Irrigation and Drainage District
- Yuma County Water Users Association
- Yuma Mesa Irrigation and Drainage District
- Yuma Irrigation District

Nevada

- Basic Water Company
- Colorado River Commission of Nevada
- Nevada Department of Wildlife
- Southern Nevada Water Authority

In addition, several federal entities are involved seeking ESA coverage for various activities including:

- Bureau of Reclamationy
- Western Area Power Administration
- National Park Service
- Bureau of Indian Affairs

The MSCP is managed and implement by two entities including:

- Program Manger employed by the Bureau of Reclamation
- A Steering Committee whose members are divided into several participating groups: Federal, Arizona, California, Nevada, Native American, Conservation, and Other Interested Parties

Particular projects to create or restore habitat are outlined in the Habitat Conservation Plan and funding is shared between federal and state sources. Numerous stakeholder meetings throughout the Lower Colorado Region were held during the development of the HCP, along with coordination with scientific review panels, to identify the specific projects that are included in the HCP.

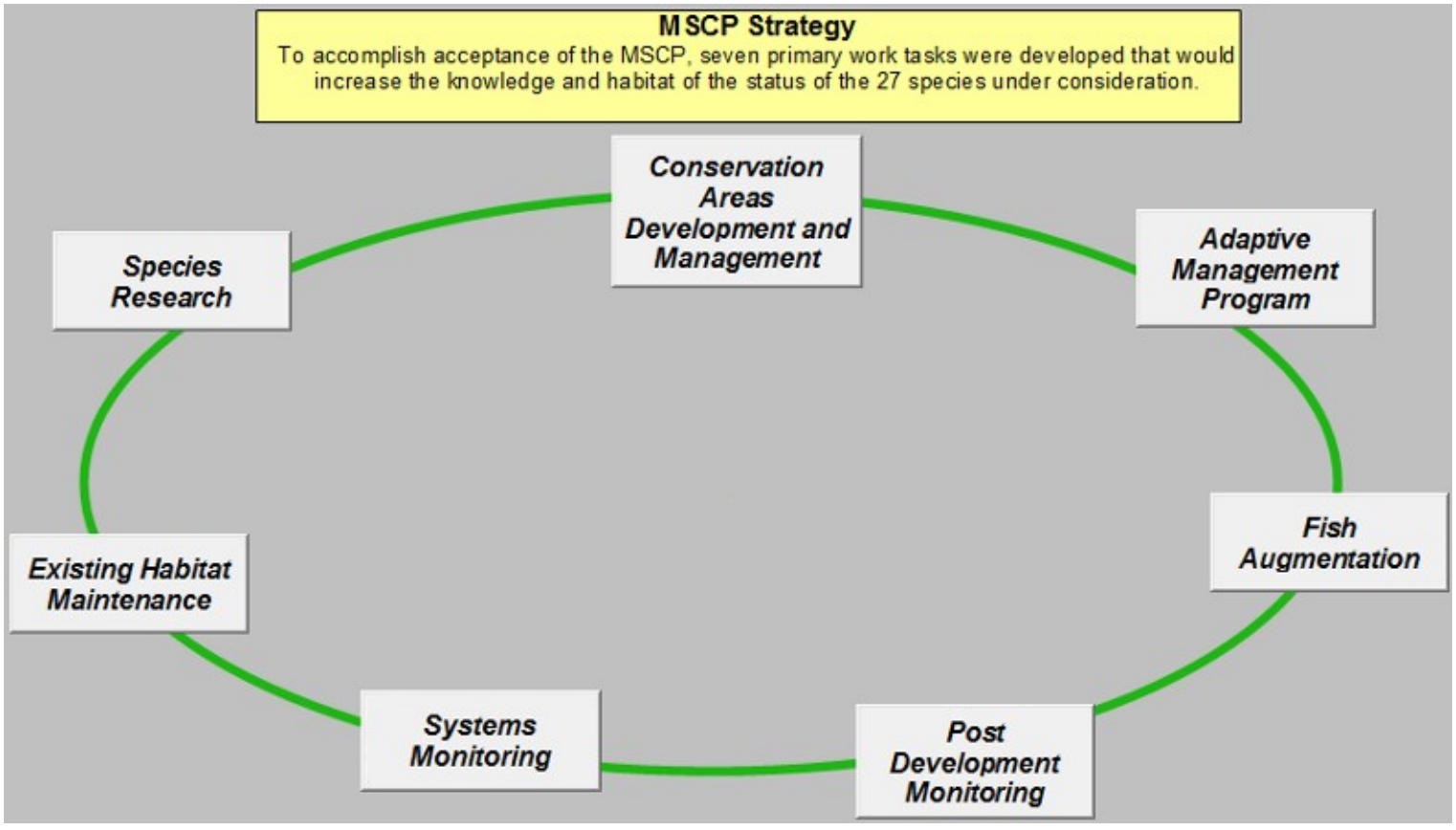
Multiple Species Conservation Program: Species Evaluated

Originally 149 species were evaluated and 27 were chosen for the "Incidental Take" permit as defined by the ESA. Six species of these species are currently considered federally threatened or endangered, while 21 other species are listed as endangered under specific state laws. Four evaluation species were also evaluated that are not currently listed, but may become so during the 50-year term of the LCR MSCP.

Endangered and Threatened Species	
Yuma clapper rail	*Rallus longirostris yumanensis*
Southwestern willow flycatcher	*Empidonax trailii extimus*
Desert tortoise (Mojave population)	*Gopherus agassizii*
Bonytail	*Gila elegans*
Humpback chub	*Gila cypha*
Razorback sucker	*Xyrauchen texanus*

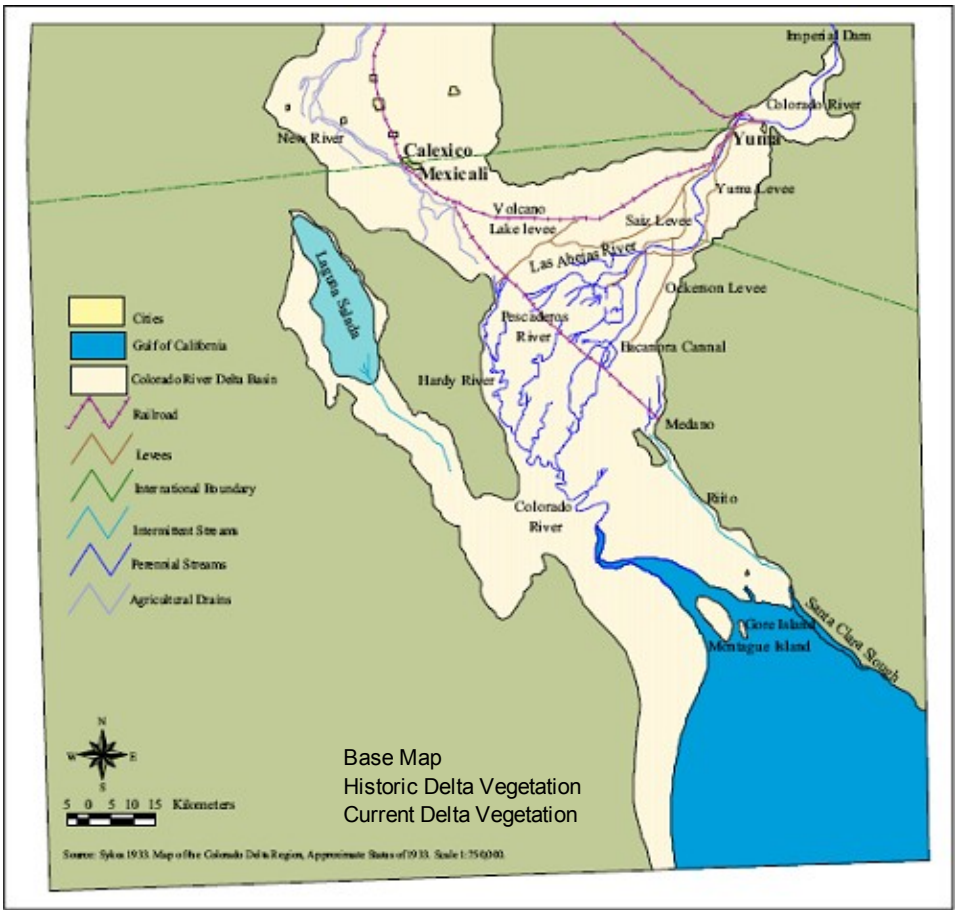
Evaluation Species	
California leaf-nosed bat	*Macrotus californicus*
Pale Townsend's big-eared bat	*Corynorhinus townsendii pallescens*
Colorado River toad	*Bufo alvarius*
Lowland leopard frog	*Rana yavapaiensis*

Other Covered Species	
Western red bat	*Lasiurus blossevillii*
Western yellow bat	*Lasiurus xanthinus*
Desert pocket mouse	*Chaetodipus penicillatus sobrinus*
Colorado River cotton rat	*Sigmodon arizonae plenus*
Yuma hispid cotton rat	*Sigmodon hispidus eremicus*
Western least bittern	*Ixobrychus exilis hesperis*
California black rail	*Laterallus jamaicensis coturniculus*
Yellow-billed cuckoo	*Coccyzus americanus occidentalis*
Elf owl	*Micrathene whitneyi*
Gilded flicker	*Colaptes chrysoides*
Gila woodpecker	*Melanerpes uropygialis*
Vermilion flycatcher	*Pyrocephalus rubinus*
Arizona Bell's vireo	*Vireo bellii arizonae*
Sonoran yellow warbler	*Dendroica petechia sonorana*
Summer tanager	*Piranga rubra*
Threecorner milkvetch	*Astragalus geyeri var. triquetrus*
Flat-tailed horned lizard	*Phrynosoma mcalli*
Relict leopard frog	*Rana onca*
Flannelmouth sucker	*Catostomus latipinnis*
MacNeill's sootywing skipper	*Pholisora gracielae*
Sticky buckwheat	*Eriogonum viscidulum*



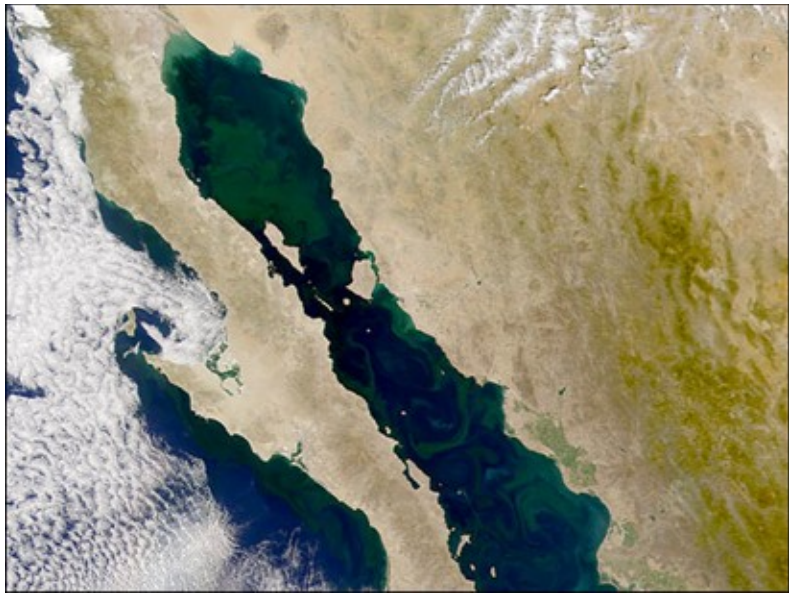
Case Study #3: The Colorado River Delta

Perhaps one of the most dramatically changed ecosystems of the Colorado River is the last reach before it enters the Gulf of California. At its southernmost extent, the River forms the Colorado River Delta. Prior to the construction of the major dams, the Colorado River fed one of the greatest desert estuaries in the world with annual flood flows that nourished a complex mosaic of riparian, freshwater, brackish, and tidal wetlands that covered 1,930,000 acres (780,000 hectare). In the vast Sonoran Desert, the silt and nutrients that poured through the Delta provided a rich habitat for abundant wildlife including nesting and feeding grounds for several bird species and spawning habitat for fish and crustaceans. Following such abundant food sources, mammals also used the Delta to thrive in a harsh environment.



The Colorado River Delta (Continued)

Today conditions in the Delta are different. Two major reservoirs and dozens of smaller reservoirs and diversion dams keep the water from reaching this critical ecosystem. All the waters that are currently released from the reservoirs are intended for consumption. Only when the reservoirs are full and releases must be made for flood control is there any significant opportunity for water to reach the Delta.



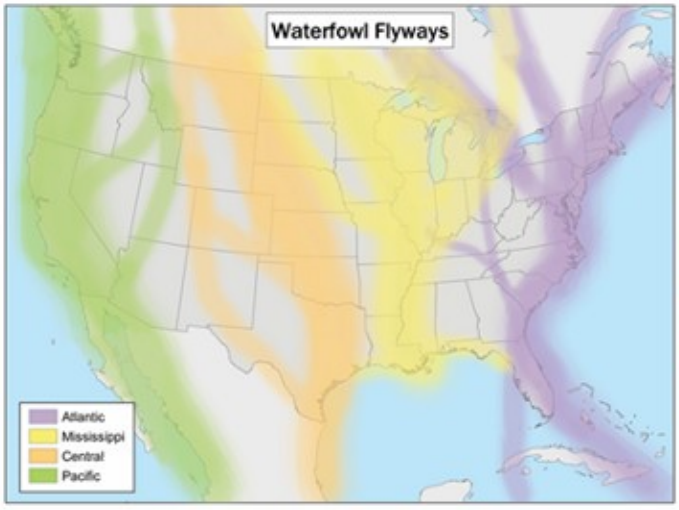
Other Sources?

Some water does reach the Delta, but in very small quantities. Return flows from irrigation of agricultural fields in the Mexicali Valley fields seep back into the Delta region providing a precarious subsistence for the remaining ecosystem. Although this agricultural wastewater can change the ecosystem health by introducing fertilizers, insecticides, and elevated levels of other pollutants such as selenium, these discharges are the only reliable source the delta currently has to survive.

One other source of water currently exists. The Cienega de Santa Clara is the major marsh wetland in the eastern region of the Delta. This region is supplied by agricultural wastewater pumped from the Wellton-Mohawk Irrigation District and discharged through a concrete canal to the Southern International Boundary. However this lifeline to the Delta will potentially be severed if a desalination plant at Yuma Arizona is put into operation.

The Colorado River Delta (Continued)

Although the Colorado River Delta has been dramatically transformed, it still provides a critical resource. Numerous migratory birds use the Delta as stopping point along the Pacific Flyway. In addition, various endangered species use the Colorado River Delta as their habitat for all or part of the year. Bird species include the Yuma Clapper Rail and the Willow Flycatcher. These species thrive in the vegetation and marshes of the Delta.

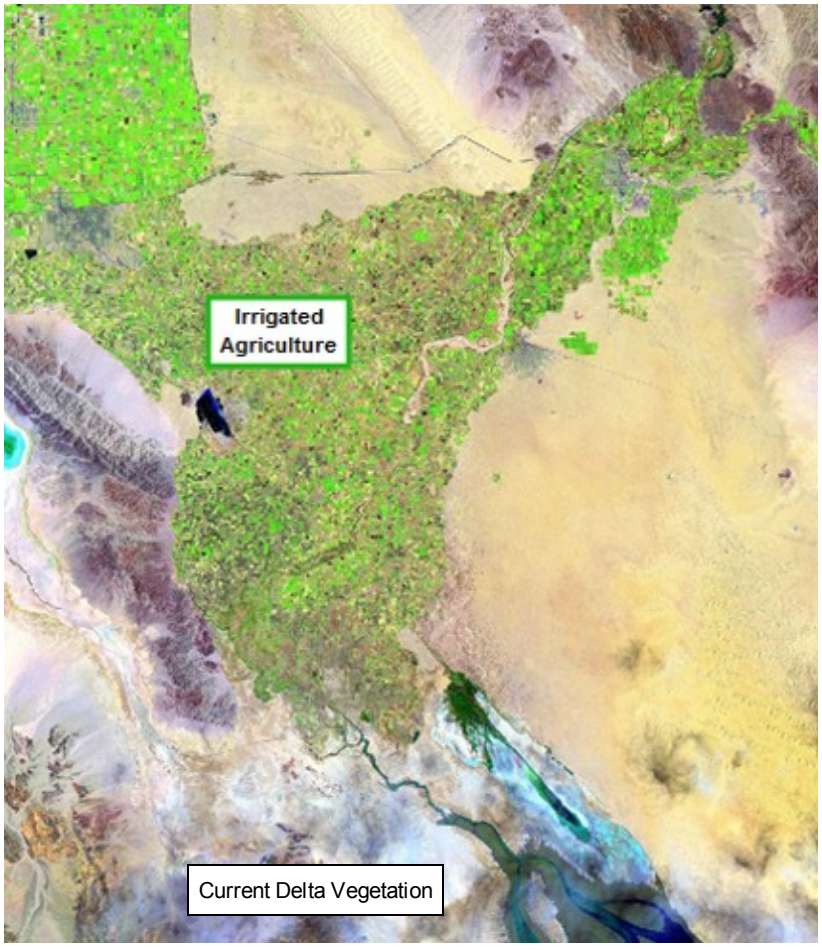


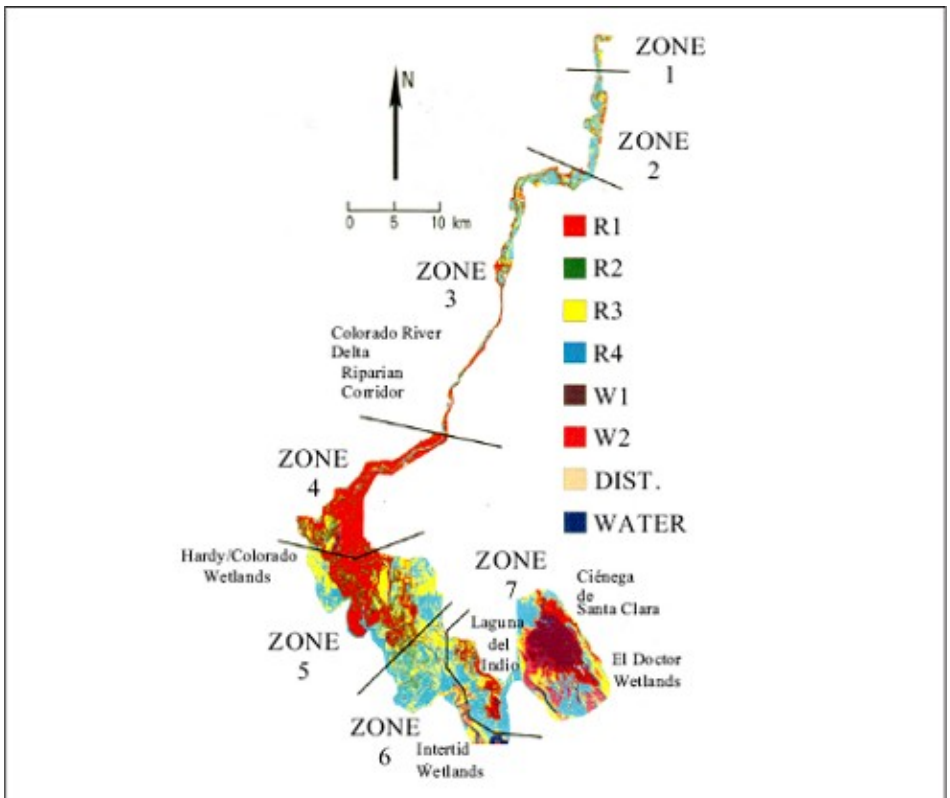
The Colorado River Delta (Continued)

During the 20th century, river flows into the Delta have been reduced nearly 75%, from an annual average of 16.7 million acre-feet (20.7 x 109 m3) between 1896 to 1921, to an annual average of 4.2 million acre-feet (5.2 x 109 m3) between 1984 and 1999. This reduction in water has resulted in major changes to the Delta: less silt, fewer nutrients, higher salinity, and higher concentrations of pollutants.

Erosion, rather than accretion, is now the dominant physical process in the Delta, a highly unusual condition for a river Delta. Like other river deltas at risk, such as the Nile, the Colorado's Delta has actually begun to decrease in size. The loss of freshwater flows to the Delta over the past century has reduced Delta wetlands to about 5% of their original extent, and non-native species have compromised the ecological health of much of what remains. Stress on ecosystems also has allowed invasive plants to choke out native species along Colorado River riparian areas. Native forests of cottonwood and willow have yielded to sand and mudflats dominated by the nonnative tamarisk (also known as salt cedar), arrowweed, and iodinebush, a transformation that has decreased the habitat value of the riparian forest (Briggs el al., 2004; EDF, 1999).

The rich soils of the Delta are now used extensively for agriculture and levees have been constructed to constrain the flood flows of the Colorado. Although the overall landscape has been transformed, the small amount of vegetation that remains between is a critical resource for the current ecosystem.





Classification of vegetation communities, using spectral analysis of a satellite image (July 15, 1997). R1-R4 include riparian vegetation, with R1 having the highest biomass level. W1 and W2 include marsh vegetation, with W1 having the higher biomass level. DIST refers to the areas covered with salt grass (Distichlis palmerii), and WATER refers to open water areas.

The Colorado River Delta (Continued)

Three general regions can be identified within the Delta region:

- The northernmost region (Zones 1-3) is constrained between the levees and provides a rich riparian corridor.
- Two major wetland zones exist in the Delta region. Near the confluence with the Rio Hardy, an extensive wetland area provides cover and nesting for many of the species that thrive in the Delta region (Zones 4, 5). In addition a major wetland habitat exists to the east of the main channel which includes the Cienega de Santa Clara, El Doctor Wetlands and Laguna del Indio (Zone 7).
- The southernmost region is also an intertidal wetland heavily influenced by the saltwater reaching northward into the Delta.

The Colorado River Delta (Continued)

The Delta needs water to sustain its limited ecosystem. A constant baseflow and occasional flood flows are necessary to both maintain the riparian vegetation and inundate the floodplain between the levees. In addition, regular flows would keep the nutrients cycling through the Delta and flush the salt that concentrates on the banks through evaporation.

Since all the water is typically diverted upstream of the Delta, only incidental flood flows currently reach the Delta. However if additional water were allowed to reach the Delta through intentional releases from the upstream reservoirs, significant benefits could result for the ecosystem.

Whose Responsibility is the Delta?

We know that most of the destruction of the Delta is caused by water management decisions in the United States, but the fact that most of the Delta exists in Mexico makes it difficult to resolve. The U.S. federal government claims that its responsibility for species protection generally ends at the border, so even the Endangered Species Act doesn't require any programs such as the Lower Colorado Multiple Species Conservation Program to incorporate the Delta into its planning process. Mexico, on the other hand, has limited water and infrastructure to manage flows and believes much of the responsibility exists with the United States. An unfortunate political line has pushed a critical habitat to the brink of extinction.

Protection Designation

The Gulf of California lies within the jurisdictional boundaries of Mexico and its states of Baja California and Sonora. In 1974, the Mexican government designated portions of the upper Gulf and lower Colorado River Delta as a reserve zone.

The United Nations Educational, Scientific, and Cultural Organization (UNESCO) designated over 3 million acres (12,000 km²) of upper Gulf of California and the Colorado River Delta as a Biosphere Reserve in June 1993. Within this 3 million acres (12,000 km²), over 1 million acres (4,000 km²) nearest the Colorado River Delta are designated as the Reserve core area, with the remaining 2 million acres (8,000 km²) of open water and shoreline designated as a buffer area.

The Colorado River Delta (Continued)

The questions become:

- How much baseflow is needed?
- How much flood flow is needed?
- How frequently is a flood flow needed?
- Where could this water come from?
- How could this water be obtained?

Modeling the Delta Habitat

To understand the effects that flows might have on the Delta, we can construct a model of the vegetation and the response to these increased flows. Let's start out with the major factors that we know:

- The vegetation in the Delta can be simplified to three zones:
  - Riparian Corridor
  - Wetland Area
  - Tidal Wetland/Estuary Area
- We know that increasing flow in the Delta allows increased growth of vegetation.
- We also know that constant flows increase the ratio of native to non-native species.

Delta Simulator

Download the Excel-based interactive and jump to the end of the Unit to explore the Delta Simulator

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- U.S Bureau of Reclamation, Upper Colorado Region. Colorado River Basin Salinity 2005.

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- National Oceanic and Atmospheric Administration. **http://swfsc.noaa.gov/textblock.aspx?Division=PRD&ParentMenuId=229&id=13812**

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- Pikeminnow. **http://wildlife.state.co.us/WildlifeSpecies/Profiles/Fish/PikeMinnow.htm**
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Slide 9