

***Mapping Conservation Priorities in the Colorado River Delta, Mexico.***

***A state-of-knowledge workshop***

***October 2002***

***BORRADOR***

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***Mapping Conservation Priorities  
in the Colorado River Delta, Mexico:  
A state-of-knowledge workshop***

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## PREFACE

This report provides a comprehensive description of the results from the “Mapping Conservation Priorities in the Colorado River Delta: a state-of-knowledge workshop,” held in October 2002. The workshop was conceived and designed to produce results that will help guide conservation programs and projects for the next two decades in the Colorado River Delta (delta) and Upper Gulf of California (Upper Gulf). We accomplished this by identifying a network of priority conservation sites. Some 55 participants, collectively representing over 400 years of experience in the delta, identified and analyzed the region’s biological and physical resources, factors that threaten them, and opportunities for conservation, all in an effort to “map the possible” for the ecosystems of the delta and Upper Gulf. We call these areas *Conservation Priorities*.

Our primary goal in preparing this report is to provide comprehensive information in an attractive and practical form for use by a diverse audience for management and conservation efforts in the delta and Upper Gulf. The data contained herein provides numerous opportunities for increased collaboration and improved management by local resource users, water managers, government officials, non-governmental organizations and other decision makers to ensure the long-term persistence of biodiversity in the region. The report concludes with a series of recommendations for developing and implementing a comprehensive conservation plan for the delta and Upper Gulf. While most of the information in this report was identified and synthesized by workshop participants, the concluding recommendations were prepared only by the report’s authors.

The organizations that assembled this document are committed to restoration of the Colorado River Delta and Upper Gulf of California over the long term. We invite other non-governmental and governmental organizations, local users, scientific institutions, and the general public to join our future efforts toward a comprehensive conservation plan for the region.

**BORRADOR**

## ACKNOWLEDGEMENTS

The organizing committee would like to acknowledge all workshop participants for their interest, enthusiasm, and hard work. The results presented in this report would not have been possible without them. We express special thanks to those whose comments and suggestions helped to refine the process and methodology used in the workshop: Saul Alvarez, Mark Briggs, Rick Brusca, Luis Calderon, Michael Cohen, Exequiel Ezcurra, Richard Felger, Karl Flessa, Milton Friend, Manuel Galindo, Alejandro Hinojosa, Osvel Hinojosa, Silvia Ibarra, Rob Marshall, Eric Mellink, and Robert Mesta.

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**EXECUTIVE SUMMARY**

- problem or need for the workshop
- approach-methodology
- results:
  - conservation priorities #, has, conservation an restoration
  - ecological assessment
  - hydrological assessment
  
- Research gaps
- Summary of conclusions and recommendations section
  - Next steps
  - Minute 306 provides a framework
  - Current actions: CRICA, protected area in Mexico
  - Identify areas to deliver water for conservation
  - Integrate all of this into a comprehensive plan.

## **I. Why and How to Define Conservation Priorities**

### **A. Introduction**

The greatest desert river in the Western Hemisphere, the Colorado, once formed a lush delta as it flowed into the Gulf of California. Extensive cottonwood and willow forests, marshes, and other coastal ecosystems supported a great diversity of animals and plants. The delta was of critical important to resident and migratory birds, which by the thousands found food and shelter in the delta. Today, the delta has been reduced to 10% of its original size after 65 years of vigorous water management to satisfy agriculture, industrial and urban needs in the U.S. and Mexico. At the same time, unsustainable fishing practices and lax enforcement in the Upper Gulf of California, widely recognized as one of the richest subtropical inland seas in the world, have severely depleted populations of fish, invertebrates, and marine mammals, and disrupted ecological processes in the coastal marine zone.

Realizing that the delta cannot be restored to its original condition, what can be done to protect and enhance the remaining delta? What are the natural areas that remain worthy of conservation? Why do they merit conservation? What threats can be eliminated or mitigated based on opportunities in each area? The workshop was conceived with these questions in mind and with the expectation that by answering these questions, government, scientific, non-governmental communities, as well as resource users, and the general public would have the information needed to decide where conservation efforts should be directed.

For almost 20 years, during the filling of Lake Powell from 1964 to 1981, the mainstem of the Colorado River provided no water to the delta. Nevertheless, after 1981, large floods in some years, as well as minimum but continuous flows, have provided clear evidence of the delta's capacity to re-establish its ecological functions. Surveys demonstrate that the delta contains significantly more native trees and wetlands than does the lower basin of the Colorado River in the United States and that it serves as a refuge for species that are threatened and endangered elsewhere in the watershed. This holds special promise for the delta, suggesting that relatively modest flows of freshwater and appropriately managed brackish water could significantly stimulate ecological recovery.

## **B. Why hold a workshop?**

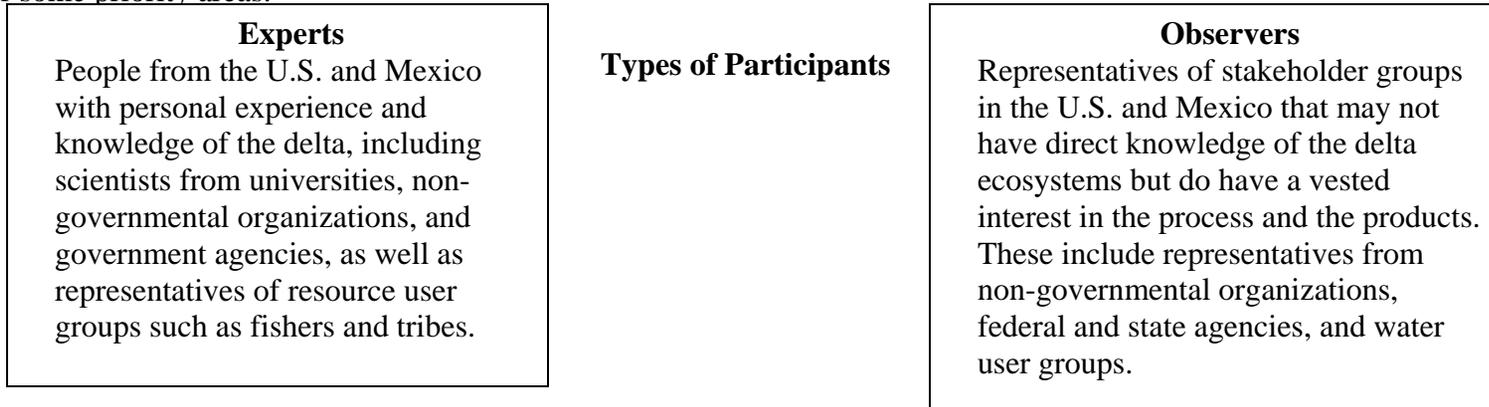
The collective value of the terrestrial, riparian, intertidal and coastal habitats of the delta has been recognized in several ways. Ten years ago, the Mexican government afforded initial protection by designating close to one million hectares as the Biosphere Reserve of the Colorado River Delta and the Upper Gulf of California (Biosphere Reserve). Two ecological priority-setting exercises, one for the Sonoran Desert Ecoregion in 1998 and one for the Gulf of California Ecoregion in 2001,<sup>1</sup> have recognized the delta and the Upper Gulf as sites of special importance for conservation at the regional scale. In addition, improved fishery management policies and alternative fishing practices are taking hold in the Upper Gulf. Nonetheless, the Colorado River continues to be classified as one of North America's ten most endangered rivers.

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<sup>1</sup> Marshall et al (2000) and WWF (2004)

In the past five years, five major symposia or meetings have been held on the Colorado River Delta (San Luis Río Colorado 1998, Mexicali 1999, Riverside 2000, Washington 2000, Mexicali 2001). Though all were important to advancing broader awareness and stimulating strategies for its restoration, none responded to a basic requirement of sound conservation planning. Furthermore, the level of detail resulting from previous priority setting exercises required a more in-depth analysis of ecological functions and threats and opportunities in order to identify priority areas for conservation and to set the foundation for a comprehensive conservation plan.

In bringing together 55 Mexican and American scientists, water managers, and local resource users, this workshop provided, for the first time, ample opportunities to work in an interdisciplinary way to analyze and discuss the most recent and detailed information of the physical and biological resources of the delta. The task for each working and plenary session was to look at the biological importance of these areas, and their threats and opportunities for conservation. With this information, participants were able to identify a network of priority conservation sites that, with proper management, will ensure the long-term persistence of the region's diversity of plants and animals; this includes rare and common species, native vegetation communities, and the ecological processes needed to maintain these elements of biodiversity. When identifying these areas, special emphasis was made to truly reflect a "map of the possible" based on real opportunities for conservation and on the quantity, quality, and timing of water flows required to support them. Also, a state-of-knowledge and gap analysis allowed participants to identify priority research needs and the resources required to provide a thorough analysis for some priority areas.



### **C. Area of Interest**

The workshop focused on the portion of the delta in Mexico as well as the U.S. portion along the international boundary formed by the Colorado River. It included not only terrestrial areas, but also the intertidal and coastal zone, following the limits of the Biosphere Reserve.

The area of interest was divided into seven ecological zones based on their distinct biophysical characteristics (See table I.I and Fig. 1.1).<sup>2</sup> These zones are important in the delta both in a local context as well as in the context of larger regional ecological functions, for example as part of the Pacific Flyway.

Table I.I: Ecological zones used in the workshop

Ecological Zone	Description	Acres	Habitat Types
Riparian Corridor	Colorado River, from Morelos dam to the confluence with the Rio Hardy	65,376	Cottonwood-willow forest intermix with saltcedar and other native bushes
Rio Hardy	Rio Hardy basin, from Cerro Prieto to the confluence of Colorado River, including Pescaderos river	45,235	Perennial stream with cattail marshes and saltcedar along the river banks
Off channel Wetlands	Includes Cienega de Santa Clara, El Doctor, Cerro Prieto, El Indio, and Andrade Mesa Wetlands	187,917	Cattail marshes, mudflats, springs and open water lagoons
Intertidal	From coastline to upstream areas at the confluence of Rio hardy with Colorado River	157,816	Mudflats and salt grass beds
Coastal - Marine	Coastal waters in the upper Gulf	1,391,175	Predominant sand/mud benthos with occasional rocky outcrops
Greater Laguna Salada Basin	Laguna Salada and other areas subject to inundation only during major tides or large river floods	590,906	Shallow flooded basin to a dry evaporation pan
Farmland	Agricultural Irrigation District 014 and other farmland	685,283	Agriscape and vegetated irrigation drains

Figure 1.1. Ecological Zones of the Colorado River Delta

<sup>2</sup> The report authors eliminated the open desert zone, proposed during the workshop, because it is adjacent to but not part of the delta region..

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#### **D. Workshop Process**

In order to map conservation priorities in the Colorado River Delta, the workshop authors designed a process to develop geographical and biological resource maps for the delta region based on published and public domain data, and to engage experts in an analysis of these resources and relationships. Preparation and implementation of the workshop consisted of a three-part process illustrated in Figure 1.2.

Figure 1.2 Mapping Conservation Priorities Process

### Phase 1: Data Collection

Prior to the workshop, authors collected and synthesized existing published and public domain information about the Colorado River Delta. The workshop authors used this to develop preliminary maps of the delta's physical and biological characteristics, including species distributions, ecological zones, etc. In addition, the workshop authors developed a list of key ecological relationships identified in

the delta region, and used them as a starting point for discussion during the workshop. Also during this phase, an advisory committee was formed to help in the design of the workshop methodology.

### Phase 2: Analysis

Expert and observer analysis took place at the workshop in October 2002. The first session of the workshop consisted of identifying conservation targets based on the knowledge of participants and preliminary information prepared by authors.

A conservation target is defined as biological and physical, or a combination of biotic and abiotic features that represent the biodiversity of the delta, the conservation of which increases the chances of conserving other living resources. (Grove, et al. 2002) Conservation targets can be individual species, communities, ecosystems, or physical features like important hydrological features.

To identify conservation targets, participants were divided into five groups according to scientific expertise or taxonomic focus. Experts identified on a map and documented the main characteristics and reasons for supporting them. Additional information was provided for each target, and a geographic representation was captured either on hard copy or digital maps.

Conservation targets were identified for each of the following expert groups:

- Coastal and marine
- Fish and marine mammals
- Terrestrial vertebrates (Birds and other fauna)
- Habitat/vegetation/restoration
- Hydrology

During the remainder of the workshop, experts and observers worked in interdisciplinary groups to perform an analysis of ecological relationships, threats,

and opportunities for conservation for each of the seven ecological zones. By looking only at ecological relationships, experts grouped individual targets into special interest areas, which are areas considered important because of their biophysical characteristics and connection to one or more conservation targets.

Experts analyzed threats and conservation opportunities for each special interest area. Careful consideration of the degree, intensity and reversibility of threats as well as real opportunities for conservation and restoration allowed experts to begin the identification of conservation priority areas that are in urgent need of conservation action. Conservation priorities were divided into two types, those needing protective actions (Protection) and those needing restoration actions (Restoration). The role of observers was critical at this stage, because of their knowledge of water management and land use practices. Threats and opportunities were documented for each conservation priority area. When information was available, experts assessed and estimated the water requirements needed to maintain and enhance the ecological integrity and functions of these areas. Recognizing that in some cases insufficient information was available, experts and observers at the workshop defined future research or information priorities. The ultimate purpose was to provide credible and thorough information on all conservation priorities areas rather than a ranked or prioritized list.

**Conservation  
Priorities**  
Areas that are in urgent  
need of conservation  
action

**Threats**  
Impacts on biological  
features (e.g. vegetation  
clearing, burning,  
exploitation) or physical  
features (e.g. changes in

**Opportunities**  
Biological or physical  
improvements that can be  
implemented to maintain  
and/or enhance ecological  
functions in the delta

### Phase 3: Product Development:

The organizing committee took a twofold approach to organizing, analyzing and finalizing the expected products from this process. Based on the need to share the results of the workshop immediately after the workshop, a preliminary report was prepared in November 2002 to share with participants and other stakeholders. This report described a summary of results as they were presented in the plenary session at the end of the workshop.

Nevertheless, the workshop produced much more information that needed to be documented in a more detailed report. This report includes the comprehensive results produced in the workshop, and also incorporates further analysis and information that was not available during the workshop. Maps have been refined based on the analysis of information recorded by workshop participants. To prepare this final report, the authors also consulted with several experts who attended the workshop.

In addition to the hard-copy report, the authors have prepared a CD-ROM with the workshop GIS database, maps, tabular data, and narrative, as well as a poster-sized map that graphically summarizes the results.

## **II. Conservation Targets**

Conservation targets are the building blocks used in this workshop to determine conservation priorities. Successful protection of conservation targets increases the chances of conserving other living resources.

For this workshop, experts identified conservation targets in five groups:

- Coastal and Marine Resources
- Fish and Marine Mammals
- Terrestrial Vertebrates
- Habitat and Vegetation
- Hydrologic Features

Each group identified and described conservation targets for the seven ecological zones within the Colorado River Delta study area, and when possible, identified or provided documentation of their importance. Some expert groups started with preliminary lists of conservation targets in hand, including lists of target species identified in previous priority setting exercises, while others began identifying targets from scratch, relying solely on the collective knowledge of participants. Although comprehensive information was not available for all fauna and flora species, the small size of the Colorado River Delta study area relative to other exercises of this type (such as those conducted for the Sonoran Desert and Gulf of California) simplified the task of identifying targets. Nevertheless, additional documentation is still needed for some targets. This chapter summarizes the results of the conservation targets exercise, and Appendix 1 contains a complete description and a map of all conservation targets.

#### A. Coastal and Marine Resources [\(maybe insert a picture of a Marine landscape\)](#)

### **1. Participants**

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## **2. Conservation Targets**

The group selected five species, six biological and physical processes, and one habitat type as conservation targets.

Species:

The group selected two endangered species as conservation targets, the vaquita (*Phocoena sinus*) and totoaba (*Totoaba macdonaldi*), both of which are also endemic to the region. Three unprotected species were also selected as targets: a clam (*Mulinia coloradoensis*), the corvina golfina (*Cynoscion xanthalus*), and shrimp species. The clam and corvina are endemic to the study area, whereas shrimp fishing is the most important fishery industry in the Upper Gulf of California. For each of the species identified as conservation targets, the group set the conservation goal as the sustainability of viable populations.

Processes:

Participants identified as conservation targets a number of biological and physical processes. Invertebrate and vertebrate life cycles were selected because of their importance as biological processes affecting many other species. The conservation goal is to sustain these life cycles by protecting habitat as well as maintaining physical processes upon which they depend. The physical processes of mixing of fresh and marine water and presence of tidal currents were selected as they affect life cycles and other biological processes. Finally, the group identified groundwater flow to off-channel wetlands such as at El Doctor, as well as the sediment transport process as it affects the morphology of the delta, as conservation targets.

Habitats:

The group identified remnants of the large estuarine wetlands that existed historically in the delta as conservation targets for their key role in the life cycle of many species, either as spawning or nursery grounds for marine vertebrates and invertebrates, which eventually are important for other species like marine mammals and sea birds.

### **3. Gaps in Knowledge**

During the process of identifying conservation targets, the group identified the following gaps in knowledge:

- Amount of water going into the ocean
- Ground water dynamics
- Impact of geothermal use and exploration
- Residence times of water in the estuary and Upper Gulf
- Effect of shrimp trawlers
- Minimum freshwater flows needed in the marine ecosystem
- Distribution and use of habitats
- Environmental effects of shrimp farm operations
- Environmental effects of tourism development
- Baseline monitoring of physical, chemical and biological processes in the Upper Gulf
- Presence and effects of pollutants in the Upper Gulf

B. Fish and Marine Mammals ([maybe insert a picture of a Marine Mammal, like VAQUITA](#))

### **1. Participants**

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*Miriam Lara, Pronatura Sonora, Note-taker*

## 2. Conservation Targets

The fish and marine mammal expert group identified many species as conservation targets, but did not identify any processes or habitats.

Species:

The group included all extirpated or highly endangered species of native freshwater fish as conservation targets, with special focus on the desert pupfish (*Cyprinodon macularius*), bonytail (*Gila elegans*), razorback sucker (*Xyrauchen texanus*), and woundfin (*Plagopterus argentissimus*). The team did not include any sea turtles, as these are largely restricted to the mid and lower Gulf.

For marine mammals, the group selected the endangered vaquita (*Phocoena sinus*), the blue whale (*Balaenoptera physalus*) as a representative of the large whales, bottlenose dolphin (*Tursiops truncatus*) as an indicator of ecosystem health, and the California sea lion (*Zalophus californianus*).

For elasmobranches (sharks and rays), the group selected manta rays (*Manta birostris*) and the Pacific sharpnose shark (*Rhizoprionodon longurio*) as targets. For bony marine fish, representative species were selected from families that carry special ecological significance in the Upper Gulf. For the Antherinids (sardines) and the Engraulids (anchovies), the group chose as targets the Delta silverside (*Colpichthys hubbsi*), the Pacific anchovy (*Cetengraulis mysticetus*) and anchoa helleri, respectively. For the Sciaenids, the bigeye croaker (*Micropogonias megalops*), the totoaba (*Totoaba mcdonaldi*), and gulf corvina (*Cynoscion othonepterus*) were selected as targets. For Serranids, participants selected as targets the baqueta (*Epinephelus acanthistius*) for deep muddy bottoms, and the gulf grouper (*Mycteroperca jordani*) for rocky bottoms.

In addition to these target species, the group identified others that are of special interest, though they were not mapped. These include three sharks, great white shark (*Carcharodon carcharias*), scalloped hammerhead (*Sphyrna lewini*), and whale shark (*Rhincodon typus*); two Serranids, the leopard grouper (*Mycteroperca rosacea*) and the giant sea bass (*Stereolepis gigas*), one Lutjanid, the green bar snapper (*Hoplostagrus guntheri*). Finally, although no sea turtles were identified as conservation targets, the group identified two

of special interest, the leatherback (*Dermochelys coriacea*) and green sea turtle (*Chelonia mydas*). Finally, it was proposed that marine mammals serve as a ecosystem umbrella guild (group of similar species) for the Upper Gulf.

The group considered adding to the list of conservation targets certain exotic freshwater fish species, such as tilapia and large mouth bass, because of their importance in an expanding sport and subsistence fishery, but concluded that only native species should be included in the list of targets.

### **3. Gaps in Knowledge**

Marine mammals as a group are identified as needing special attention for long term monitoring, and special research needs were noted for the sea lions, bottle-nosed dolphin, manta rays, and all sharks. Another identified priority is a system to register strandings of moribund marine mammals and sea turtles.

## **C. Terrestrial Vertebrates (maybe insert a picture of a Bird---YUMA CLAPPER RAIL)**

### **1. Participants**

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*Enrique Zamora, University of Arizona, Note-taker*

## 2. Conservation Targets

### Species:

In identifying conservation targets, the group aggregated many individual species into guilds. Information on bird species was more advanced than for other vertebrate species. This allowed participants to develop a complete list of bird species, which is presented in more detail in Appendix 2. Based on the results from the workshop, Pronatura led the development of the “Bird Conservation Plan for the Colorado River Delta, Baja California and Sonora, Mexico” (Hinojosa et al, 2004). For a full description of current status and required management actions for bird species management, the reader is referred to this plan.

Eight marsh birds were combined as a conservation target. Four are focal or of special interest: Least bittern, California black rail, Yuma clapper rail, and the American coot. The Yuma clapper rail is endemic to the delta and lower Colorado River, under protection in Mexico and endangered in the U.S., whereas the California black rail is endangered in Mexico and in California. The conservation goal for this group is the protection and expansion of wetlands, which are critical habitat for these species.

The nesting waterbirds conservation target is composed of twelve species. Some of these species are protected under the Migratory Bird Treaty Act and the Endangered Species Act in Mexico. This target is associated with specific sites in the delta, like El Doctor, Cerro Prieto, Montague Island, and the flats of Flor del Desierto. The conservation goal for this target is to maintain suitable nest, roost and foraging sites.

The riparian obligate breeding bird species conservation target includes 15 species. This conservation target is associated with native riparian forest, which currently is limited to approximately 2% of its historic extent in the Colorado River Delta. As a result, U.S. law identifies the Southwest willow flycatcher as an endangered species and the Yellow-billed cuckoo as a candidate species. The conservation goal for this target is to conserve and expand native cottonwood-willow riparian forests and control exotic species in order to establish contiguous and large blocks of native forest.

The group identified two conservation targets for migratory bird species: migratory landbirds and migratory waterbirds. These targets indicate the critical role of the delta as a stopover site along the migration routes. In the case of migratory landbirds, the delta is particularly important during spring and to a lesser degree in fall and winter. For migratory waterbirds, on the other hand, the delta is most important during the winter, particularly for the western population of white pelicans (including those that use the Salton Sea), as well as the many shorebird species that use the area for wintering and stopover in large numbers. In both cases, the conservation goal for these targets is to ensure that the delta continues to provide suitable habitat for these species.

The group identified most aquatic native amphibians and reptiles endemic to the Sonoran Desert as a conservation target. This target includes *Bufo alvarium*, *Rana yavapaiensis*, *Kinosteron sonorense*, *Thamnophis marcianus*. These species indicate the quality of freshwater aquatic habitats. The conservation goal for this target is to increase the populations of these species.

Finally, the group identified two individual species as conservation targets: the beaver and Palmer's salt grass (*Distichlis palmerii*). The beaver is an important indicator of freshwater, and in the case of the delta, beavers come from upstream when water is released into the river and flows past Morelos Dam. The salt grass is an endemic species as well as an indicator of the presence of freshwater in the intertidal zone because it requires freshwater for sexual reproduction.

Habitats:

In addition to the habitats associated with the targets already mentioned, the group identified the marine zone as a conservation target for its significance as a post-breeding dispersal area for pelicans, grebes, terns, and gulls, and as feeding grounds for nesting waterbirds.

### 3. Gaps in Knowledge

In general, there was a reasonable amount of information available for many of the species in the different conservation targets. Important gaps, however, are:

- General and specific information for aquatic amphibians and reptiles
- Long term monitoring data for marsh birds and migratory landbirds
- Vital rates and abundance for riparian obligate breeding species

#### D. Habitat and Vegetation (maybe insert a picture of a cottonwood-willow forest)

### 1. Participants

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Gerald Zimmerman, Colorado River Board of California  
*Meredith de la Garza, Pronatura Sonora, Facilitator*  
*Jose Maria Beltran, GIS team*  
*Yamilett Carrillo, Pronatura Sonora, Note-taker*

## 2. Conservation Targets

### Habitats

The group discussed the utility of identifying individual sites versus “circling the whole area.” For purposes of the workshop and to aid river managers, it was decided that it would be preferable to identify priority areas. By isolating the larger habitats into smaller, truly unique sites, the chance of ignoring their special significance would be avoided. The group agreed, however, that smaller sites might eventually be combined into more ecologically functional areas.

In the end, the group identified fourteen habitat-type conservation targets. These included three in the Colorado riparian zone: the limitrophe, the reach from San Luis Río Colorado south to the railroad bridge, and the reach from the railroad bridge south to the Río Hardy confluence. Additional conservation targets include one tributary stream, the Río Hardy, one swamp (marsh with trees), one intertidal area (*Distichlis palmerii* flats), seven off-channel wetland sites (including the Sonora Mesa, Andrade Mesa, El Indio, El Doctor, Ciénega de Santa Clara, Cerro Prieto, Pozos La Salina and abandoned agriculture lands). The Biosphere Reserve formally protects six of the off-channel wetland sites. The remaining habitat sites are either privately held or managed by Mexico’s National Water Commission (CNA) and receive no special conservation consideration.

The group concluded that habitat condition ranges from pristine or excellent in several off-channel wetlands, to highly modified in the Río Hardy, El Indio wetland, and retired agricultural lands. Receiving special consideration for quantity and quality of vegetation were the limitrophe and San Luis-railroad bridge reaches of the Colorado River mainstem, the Sonora Mesa, and Andrade Mesa wetlands. The only endemic habitat was the *Distichlis palmerii* flats in the intertidal zone. Habitats with superb opportunities for restoration include all reaches on the mainstem of the Colorado River and the retired agricultural lands.

The group also made special mention of areas with unique qualities or properties, including the Ciénega de Santa Clara as the largest freshwater wetland in the delta; Río Hardy as the largest continuous stretch of vegetation (albeit salt cedar); the reach from San Luis to the railroad bridge for its excellent channel morphology and regenerative conditions; the reach from the Railroad Bridge to the Río Hardy confluence for the quantity of agriculture return flows; Cerro Prieto for the largest pupfish population; and the Río Hardy swamp as an important fishery, particularly in periods of flood and high tide when it becomes contiguous with open water in the Laguna Salada.

### **3. Gaps in Knowledge**

The group identified the need for detailed channel morphology and a complete and detailed vegetation map.

#### **E. Hydrological Features** ([maybe insert a picture of a Morelos dam from the air](#))

#### **1. Participants**

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*Cheryl Lord-Hernandez, Sonoran Institute, Note-taker*

Due to the unique nature of conservation targets for hydrologic form and function, this section’s structure differs from the rest.

## 2. Conservation targets

To identify hydrological targets, the group focused its analysis on hydrological features in the study area considered important in terms of river operation and flood control, as well as those important to maintaining healthy riparian systems. Most of this information came from the Missing Water report (Cohen and Henges-Jeck, 2001). While the lack of critical and detailed information precluded precise identification of the targets during the workshop, additional information collected later by the authors of this report has been used to refine the geographic extent of these targets.

Mainstem and backwater areas:

The group identified the hydrological processes that sustain the limitrophe section as conservation targets, as the limitrophe is most likely to have permanent water throughout the year in the main channel. These processes include water that flows relatively steadily past Morelos Dam, flood flows past Morelos Dam, water flowing into the main channel from local irrigation drains, and groundwater that flows into the channel. Similarly, limitrophe backwater areas are fed by groundwater flow or agricultural runoff. The excellent condition of native vegetation and the seasonal occurrence of wetted backwater areas that sustain food production feeding resident and migratory birds in the limitrophe reach of the river are good indicators of the ecological importance of these flows.

Drainage system and receiving areas:

Another important hydrological feature in the delta is the irrigation drainage system, which captures return water and allows it to drain from nearby farmlands. This water is delivered through drains into several locations in the delta. The group identified water sources as conservation targets: the flows from the Main Outlet Drain Extension (MODE) into the Ciénega the Santa Clara, flows into El Indio wetland, flows in the Ayala drain that inundate the area where the drain intersects the levee, and the flows that enter the Colorado River floodplain between Benito Juarez (about 5 km north of the Railroad Bridge) and the Carranza Crossing. It is important to note that these flows originate in irrigated lands of the Mexicali and San Luis valleys, except for flow to the Ciénega de Santa Clara, which originates in the Welton-Mohawk Irrigation and Drainage District in the U.S.

Table 1. Flow Discharges into Colorado River Mainstem below Morelos Dam and Rio Hardy, 1998-2002 (*in thousands of acre feet*)

Source/Year	1998	1999	2000	2001	2002
<b>Colorado River through Morelos Dam</b>	2,405	861	135	110	33

<b>Operational spills in Mexico</b>						
	<b>Wasteway Km. 27</b>	223	100	51	12	5
	<b>Wasteway Canal Barrote</b>	18	7	20	13	5
	<b>San Luis residual waters*</b>	8	9	9.7	9.7	10.5
<b>Agricultural return flows</b>						
	<b>Plan de Ayala Drain</b>	17.8	13.7	17.8	13.7	15.4
	<b>Santa Clara Drain</b>	14.5	12	13	12	11
	<b>Drains into Rio Hardy</b>	13	11.3	11.3	6.5	4
	<b>Welton-Mohawk into Cienega de Santa Clara</b>	113	78.6	107.7	103.7	105
	<b>Total flow to the Delta</b>	<b>2812</b>	<b>1,092</b>	<b>365</b>	<b>280</b>	<b>189</b>

Source: Personal communication with authorities of the Mexican National Water Commission, and information registries at the Engineering and Drainage Department of the 014 Colorado River Irrigation District. \* Source: OOMAPAS

Treated and untreated sewage water is another source of water for the delta. The City of San Luis Río Colorado's sewage system releases approximately 10,500 acre-feet per year into the Colorado River mainstem. Plans to construct a treatment plant in San Luis may jeopardize this flow, as the delivery of treated water to the river is not guaranteed. Similarly, a new treatment plant is planned for a portion of Mexicali's sewage. The plant, named Mexicali II Las Arenitas, will be in operation by 2006 and could deliver approximately 17 cubic feet per second (cfs) during the first years of operation, which is comparable to the volume of agricultural drainwater that flows to the Río Hardy during the low farming season. At full operating capacity, the plant will be delivering up to 28 cfs.

Operational spills and receiving areas:

When Colorado River water enters Mexico at Morelos Dam and is diverted into the Central Canal, but is not used for irrigation (due, for instance, to local rainfall that occurs after the water has been ordered), CNA and the irrigation district prevent overflow damage by releasing water back to the mainstem of the river. These are called "operational deliveries" and take place mainly at two wasteway sites: Km. 27 and Canal Barrote. The group identified these operational deliveries in wasteways as conservation targets.

Intertidal zone:

The intertidal area, 10 miles above and 20 miles below the confluence of the Río Hardy and the Colorado River, was considered a conservation target because of its importance to estuarine productivity, nursery habitat for macro invertebrates, fish of value to fisheries, and food change to support migratory wetland birds.

### **3. Gaps in knowledge:**

The group identified the following gaps in knowledge:

- Flood plain morphology
- A surface and groundwater hydrological model
- Monitoring of flow rates and total volume at major drains that flow into natural habitat and at the mainstem of the Colorado River
- Estimates of water needs for riparian and estuarine habitat
- Influence of freshwater flows on estuarine processes

### **III. Conservation Priority Areas**

The Experts' Workshop defined a total of fifteen conservation priority areas for the Colorado River delta and Upper Gulf of California in Mexico and the United States (Fig. 3.1). Totaling 849,397 acres (343,740 hectares), these areas vary in size and type of habitat (table III-1). As described in chapter I, conservation priority areas were identified based on analysis of ecological relationships, threats, and opportunities for the conservation targets identified in each ecological zone.

We divided conservation priorities into areas suitable for “protection” and “restoration.” Protection areas (264,438 acres or 107,015 hectares) are those currently in good condition that should be protected as they provide critical habitat for species of conservation concern, including endangered or threatened, in the U.S. or Mexico. Restoration areas (584,958 acres or 236,725 hectares) are those needing restoration action to reestablish ecological form and function. This chapter describes each conservation priority area, as well as threats to their viability, opportunities for conservation, and water needs.

The information presented in this chapter consists primarily of experts' contributions during the workshop and a review of the literature before the workshop. Additional details were contributed after the workshop by the authors of this report as they continued their research activities in the delta and Upper Gulf, drawing on work already published work as well as research-in-progress.

Information added after the workshop includes data from recent literature published by workshop participants, specifically research on birds and relationships between freshwater flows and ecological processes in the estuarine and coastal ecosystems. However, this chapter does not necessarily represent an exhaustive literature review of the delta and Upper Gulf. All information presented in this report without a specific citation should be considered an expert opinion.

Figure 3.1. Map showing Conservation Priority Areas defined for the Colorado River Delta

Table III-1. Conservation Priorities Areas by ecological zone

### **A. Colorado River Riparian Corridor**

The Colorado River in Mexico extends approximately 95 miles (153 km) downstream from Morelos Dam to the Gulf of California. The first 60 miles (97 km) are confined between flood-control levees, forming what is known as the riparian corridor. Varying in width from less than a mile (1.6 km) in its northernmost portion, to eleven miles (18 km) in its lower end, the riparian corridor is still subject to over bank flooding during major flood events. During the last two decades, small annual flows combined with larger flood events have re-established significant native riparian plant communities. The entire riparian corridor was defined as a conservation priority area.

1. Riparian corridor.

Workshop participants defined as a conservation priority all natural areas (excluding agricultural lands) in the riparian corridor, from Morelos Dam downstream to the point where the last stands of cottonwood and willow are found (see area 1 in figure 3.2). This conservation priority area, which includes 51,000 acres (20,600 ha), was defined because it has the largest dense stands of cottonwoods and willows in the Lower Colorado River basin, which, along with other vegetation and open water areas in backwaters and oxbows, provide for a variety of critical habitat types for riparian birds and other wildlife species. However, it was also recognized that some sub-areas of the riparian corridor, mainly bare soil and saltcedar stands, are suitable for restoration activities to improve overall conditions in the corridor and to increase the extent of the cottonwood and willow riparian forest.

Figure 3.2. Conservation Priorities Areas in the Riparian Corridor Ecological Zone

Ecological Zone		Conservation Priority Area	Conservation Objective	Size (acres)	Size (ha)	Habitat type
<b>Riparian Corridor</b>						
	<b>1</b>	Riparian Corridor	Protection and Restoration	51,010	20,643	Cottonwood-willow forest; saltcedar; and cattail marshes with open water
<b>Rio Hardy</b>						
	<b>2</b>	Upper Rio Hardy	Protection	3,355	1,358	Perennial river, with saltcedar and isolated patches of mesquite and cattail marshes
	<b>3</b>	Rio Hardy-Cucapa	Restoration	4,337	1,755	Saltcedar with cattail and reed marshes and isolated patches of mesquite; small stream flow
	<b>4</b>	Campo Mosqueda Restoration	Restoration	53	21	Upland area with mesquite and native bushes
	<b>5</b>	Caiman	Protection	692	280	Agricultural drain with common reed, saltcedar, and cattail
	<b>6</b>	Rio El Mayor/Campo Sonora	Restoration	483	195	Upland vegetation, marshes, and open water areas with aquatic vegetation
<b>Off channel Wetlands</b>						
	<b>7a</b>	Cienega de Santa Clara Marsh	Protection	15,189	6,147	Brackish marsh wetland with emergent vegetation dominated by cattail
	<b>7b</b>	Cienega de Santa Clara Mudflats	Protection	24,680	9,988	Mudflat with shallow water areas
	<b>7c</b>	Cienega de Santa Clara Restoration	Restoration	12,396	5,016	Low lying areas with bare land
	<b>8</b>	El Doctor Wetlands	Protection	2,135	864	Springs: open water and cattail marsh and vegetated upland areas with mesquite and saltcedar
	<b>9</b>	Andrade Mesa Wetlands	Protection	9,711	3,930	Marshes with open water and emergent vegetation; playas, partially vegetated; vegetated dunes
	<b>10</b>	Cerro Prieto Ponds	Protection	4,985	2,017	Ponds in the brackish salinity range with sparsely vegetated small islands
	<b>11</b>	Pangas Viejas	Restoration	288	116	Marshes with open water and emergent vegetation; saltcedar
<b>12</b>	El Indio Wetlands	Restoration	1,927	780	Marshes with open water and emergent vegetation; saltcedar	
<b>Coastal, Marine and Intertidal</b>						
	<b>13</b>	El Borrascoso	Protection	14,364	5,813	Rocky shores
	<b>14</b>	Coastal and Estuarine	Restoration	565,476	228,841	Coastal and estuarine
	<b>15</b>	Vaquita Marina-Roca Consag	Protection	138,317	55,975	Coastal-marine

**Ecological Relationships.** . The ecosystem dynamics between water, vegetation, and wildlife in the riparian corridor are complex. Following is a broad discussion that touches on many of the relationships.

The native tree populations are extremely dynamic and depend upon a continuous instream flow and repeated pulse flood events to survive. Willows are about twice as abundant as cottonwoods throughout the corridor (Nagler et al., in preparation). In 1999, the mean age of trees was 9-10 years. The most abundant age class was established during the 1993 flood release, but there were also a significant number of trees established during the 1983-1988 floods, and during the more recent 1997 floods. Native trees accounted for about 10% of the vegetation in 1999, significantly higher than the density of native trees found in the flow-regulated reach from Davis Dam to the Northern International Border (NIB), where they account for only 1-2% of vegetation. Mean cottonwood and willow tree heights were 23-26 feet (7-8 m), much taller than surrounding saltcedar and other shrubs, which were mostly 6-13 feet (2-4 m) in height. Mesquites were rare.

By 2002, the tree populations had changed considerably (Nagler et al., in preparation). The mean age of willows and cottonwoods was 3.2 and 4.5 years, respectively, and mean heights were only 13-15 feet (4-5 m). The most abundant age class was two-year-old trees, established by modest flows in 2000. In 2002 field surveys, native trees accounted for about 10% of total riparian vegetation, similar to results from 1999, but the trees were much younger. Most of the trees surveyed in 2002 were found in the first 165 feet (50 m) on either side of the active channel, although older age classes of trees from previous, larger floods are still present further out on the floodplain. The density of native trees immediately adjacent to the channel on the riverbanks was more than 20% along the entire length of the river from the NIB to the junction with Río Hardy (70 miles [113 km]). Trees from the 1997 and 1993 floods were still present in small numbers but age classes from the 1980's had nearly disappeared. Numerous dead trees were found along relict channels, and the ratio of dead to live trees was 1:2.2. The cumulative data record for tree age and abundance indicates that there is a very rapid turnover of trees in the riparian corridor. As in 1999, mesquites were rare (about 1% of vegetation).

Using the Anderson-Ohmart system (Ohmart et al., 1988), altogether 30% of the Colorado River riparian zone below Morelos Dam was rated as Cottonwood-Willow habitat (containing >10% cottonwoods and willows) in 2002, compared to only 5% for the lower Colorado River riparian corridor between the Glen Canyon Dam and Morelos Dam (Nagler et al., in preparation). In the 2002 field survey, the river channel had developed areas of emergent marsh, dominated by cattails, common reed and bulrush. This vegetation serves as habitat for breeding pairs of Yuma clapper rails and other water birds.

The vegetation patterns in the riparian corridor are directly related to river flow patterns. In general, cottonwood and willow trees did not survive the period from 1964-1981 when river flows did not occur below Morelos Dam because Colorado River water was filling the just-built Lake Powell, the reservoir behind the Glen Canyon Dam. Some pockets of cottonwoods and willows were maintained by agricultural return flows, but they are gone today. Their disappearance is not well understood, and could be due to channel scouring.

Since 1981, instream flows have occurred below Morelos Dam in high water years when upstream reservoirs are so full that they have spilled. During these floods, the levee system has contained the river, and the channel has meandered within the levees. Riparian vegetation has changed due to this flooding. Many of the native trees that exist in the riparian corridor today were established in the 1993 floods, and most were established no earlier than 1983. These trees are maintained by agricultural return flows and smaller volume river flows (base flows). During dry years, these trees are supported by a shallow water table. Base flows have since 2000 promoted the growth of new native trees, mainly willows, along the main river channel.

Upstream of Morelos dam in the United States, the Colorado River channel capacity is so large that floods do not spill onto the floodplain of the river. Consequently little native riparian vegetation has survived, and established species are halophytic. Downstream of Morelos Dam, the channel is much smaller, and the floodplain within the levees has experienced periodic flooding since the early 1980's. This flooding has maintained the dynamic of river meander, and has also sustained the native riparian species that can neither tolerate the absence of flooding when they would be replaced by halophytes) nor constant flows.

Factors considered important for the establishment and maintenance of native riparian vegetation in the lower Colorado River include: the frequency and timing of stream flow, sediment movement (which is both influenced by, and influences, channel morphology), and by water quality (native riparian vegetation has a low salt tolerance [3-4 ppt], and seedlings cannot germinate in saline soils). In general, natural regeneration of native riparian corridor trees requires the presence of surface water that is less than 1.4 ppt and the presence of groundwater that is generally in the range of 1 – 2 ppt (Zamora et al, 2001; Glenn et al., 1998 and 2001). However, artificial plantings can sometimes use more saline water sources. These three factors (frequency of flows, sediment movement, and water quality) define how the riparian zone has changed over time in the delta. In the riparian corridor of the Colorado River below Morelos Dam, cottonwood and willow stands comprise only 10% of the total surface area, while bare soil accounts for 25% (Nagler et al., in preparation). Uplands are generally converted to agriculture, thus mesquite stands are rare. Historical accounts indicate that mesquites were fairly common, with stands mixed in among the cottonwoods and willows.

Wildlife species, mainly birds, have responded positively to vegetation changes in the last two decades. Some bird species have returned to the riparian corridor, and others appear to be increasing in abundance but are not yet as common as they used to be (Hinojosa-Huerta et al. 2004; see appendix II). Beyond vegetation, several additional factors define which bird species are present. Some species may require older willows that are not yet abundant. Certain sensitive species have not yet returned, while some have returned but are not significant in number (Hinojosa-Huerta et al. 2004).

The recent pattern of low but steady flows may account for changes in bird species abundance. Some bird species were more abundant during 2002-2003 surveys than in 1996, and vice versa (Ruiz-Campos and Rodriguez Meraz, 1997; Hinojosa-Huerta et

al., 2004) suggesting that modest instream flows have a positive effect on populations of resident riparian birds. Riparian flooding is also essential to the neotropical migrating birds that depend on the river corridor. The insects that breed in riparian backwaters and the under-story and annual plants that thrive in the riparian corridor all provide important food sources. Understory vegetation is a critical part of the habitat of riparian birds. Saltcedar interspersed in the native species adds to the diversity of foliage, again providing greater habitat opportunities for a diversity of bird species.

The diversity and abundance of birds is positively related to the abundance of native trees and surface water. For some bird species, saltcedar provides important nesting habitat, including the Southwestern willow flycatcher. However, it appears that birds prefer areas dominated by cottonwood-willow, with a complex vertical structure complemented with a diversity of other plants, including seep willow, arrowweed, saltbush, and saltcedar. Apparently saltcedar serves a function as part of the habitat for birds when it is in combination with native plants. The best saltcedar habitats are those with wet soils and/or surface water where trees grow larger and thicker. However, while saltcedar monocultures may support high densities of birds, diversity of bird species is usually low. In areas where saltcedar is mixed with other riparian vegetation, bird diversity increases. In general, migrating birds have more flexibility in choosing habitat than resident species. These observations suggest that where saltcedar dominates because water quality is limited, or flood regimes are non-existent, it may make sense to maintain saltcedar rather than eradicate it, because native vegetation will not be able to colonize in those conditions. Eradication of saltcedar is recommended only where artificial planting of native trees is ensured.

Mesquite is known as a hardy species that attracts insects, and birds might benefit if the riparian corridor is managed to replace saltcedar with mesquite. The upland agricultural fields provide great benefit to the delta's birds, offering a plentiful food source. However, the absence of native mesquite stands may have eliminated species that depend on them. The lower Colorado River community of smaller shrubs such as saltbush, arrowweed, and others is very productive for insects and birds.

The riparian corridor is used by migrating species, and thus its ecological value cannot be considered in isolation. Neotropical migratory songbirds travel through this region on their journey to northern breeding areas in the U.S. and Canada and wintering grounds in southern Mexico and Central America (little is known about other migrating animals such as bats). These species migrate along the Sonoran coast of the Gulf of California, and the Colorado River delta provides their first opportunity to stop in native riparian habitat where food and cover are abundant. The rarity of cottonwood-willow forest in this reach of the migration route – populations of riparian obligates have been significantly reduced on the lower Colorado River – adds significantly to the importance on a landscape basis of the Colorado River riparian corridor below Morelos Dam.

While there is a distinct difference between the quality of Colorado River riparian habitats in Mexico and the United States, it remains important to recognize the connectivity of the water source and the potential for connectivity in habitat. It is clear that

the huge populations of migrating birds that move through California and along the Colorado River in the U.S. pass through the Colorado River delta, but it is not known what percentage of these migrants actually use the riparian corridor in the delta. Recorded density of migratory landbirds in the riparian corridor is not extremely high, likely because birds are dispersed in the wide floodplain. Densities of these birds are higher along the wetlands of the desert escarpment (El Doctor), because birds are funneled and concentrated in that small area. The abundance of water birds in the delta's riparian corridor is lower than it is in the nearby Ciénega de Santa Clara and delta mudflats, but provides unique habitat types (freshwater river banks) for some sensitive species, such as the Spotted sandpiper. The riparian corridor is considered to be most important for resident landbirds, especially riparian songbirds, as these birds depend upon healthy stands of cottonwoods and willows.

**Water Needs:** The riparian corridor functions as an integrated ecological unit based on how water flows through the entire system, both in the channel and, occasionally, in the floodplain. An analysis of the impact of flood events on biomass (total vegetation) in the riparian corridor, from 1992 to 2002, shows that the greenness of the corridor in summer is determined by the number of preceding years of river flow but not the volume of flow (Zamora-Arroyo et al, 2002). The best estimate of the riparian corridor's water needs is a base flow for channel maintenance of 30,000-50,000 acre-feet ( $3.7 - 6.1 \times 10^7 \text{ m}^3$ ) flowing year-round at a rate of at least 70 cubic feet per second (cfs) ( $2 \text{ m}^3/\text{s}$ ), and a periodic pulse flow that inundates the floodplain between the levees of 260,000 acre-feet ( $3.2 \times 10^8 \text{ m}^3$ ), at a rate of 3,500 – 7,060 cfs ( $100\text{-}200 \text{ m}^3/\text{s}$ ) over a period of approximately 39 days (Luecke et al., 1999). Base flow sustains existing vegetation and provides a wetted soil substrate for productivity at lower trophic levels (supporting the bottom of the food chain). Base flows are needed year-round, and are particularly important in March and April for to sustain existing vegetation, and through the summer for wildlife. Pulse flows scour the floodplain, flush salts and other pollutants, discourage saltcedar growth, and establish native cottonwoods and willows that require flooding for seeds to germinate. As was the case previous to construction of dams in the river, floods are needed in spring and early summer. Water for the riparian corridor to sustain and regenerate native cottonwoods and willows should be less saline than 1.4 parts per thousand (ppt) (Zamora et al, 2001). In addition to mainstem flows that pass through Morelos Dam, the southeast reach of the riparian corridor generally receives about 12,000 acre-feet ( $1.5 \times 10^7 \text{ m}^3$ ) of agricultural return water annually from the Ayala drain. This water is important for the maintenance of emergent marsh areas.

**Threats:** Threats to the riparian corridor include concerns about diminishing water supply for the environment as well as management of the riparian corridor itself. This is in part the result of the lack of a guaranteed source of water to maintain natural systems. The main threats are:

- a. Vegetation clearing, dredging and changes in river morphology associated with the International Boundary and Water Commission's plan, to channelize the Limitrophe zone for flood control and border rectification purposes. Although this is a

potential threat, it has a high degree of impact and low reversibility. The threat is based on a proposed project that would dredge a pilot channel in the Colorado River riparian corridor from Morelos Dam to Southerly International Boundary (SIB) that would accommodate 15,000 cubic feet per second (cfs) (425 m<sup>3</sup>/s). The IBWC has proposed the pilot channel both to define the international boundary and as a flood control measure, to help accommodate a 140,000 cfs (4000 m<sup>3</sup>/s) flow from levee to levee. The construction of a pilot channel would decrease the complexity of channel morphology (which is known to benefit riparian species), close secondary streams, and change the dynamic of discharge in the river. By cutting below the existing channel bottom, the pilot channel would not only change existing surface flow in the channel (concentrating it and increasing the rate of downstream flow due to reduced channel friction), but also would lower the groundwater table. Both these effects would reduce water available to riparian vegetation, resulting in the elimination of the native forests and vegetated backwaters that provide habitat value for migrating birds. The proposed pilot channel and riparian corridor maintenance regime appear to be over-designed, anticipating the 10,000-year flood event given current system hydrology and river management. As of this writing, IBWC has announced that a Draft Environmental Impact Statement for their proposed project is on hold.

- b. Vegetation clearing by the Comisión Nacional del Agua (CNA) in riparian corridor in Mexico south of SIB. As part of its flood control plan, in 1996 CNA began the construction of a pilot channel in Mexico, which starts just south of the town of San Luis Río Colorado and extends about 98 miles (61 km) downstream. The pilot channel is designed to accommodate 21,200 cfs (600 m<sup>3</sup>/s). Work to construct the pilot channel included removing sediments and straightening portions of the river channel, as well as clearing vegetation 165 – 330 feet (50-100 m) from the riverbanks. This pilot channel continues to be a threat as CNA maintains it by re-dredging and re-clearing different sections over time. The impacts of this threat are similar to those described above for the limitrophe section, but with lower degree of impact and higher reversibility as the pilot channel is not as wide as nor as deep as in the limithrophe zone.
- c. Diminishing and possible elimination of annual and flood flows resulting from:
  - application of the Interim Surplus Criteria (ISC) (while the ISC will remain in effect until 2016, the extent of their impact is unknown because the volume of water released under these criteria, if any, is dependent on system storage, which varies according to system hydrology and water use);
  - additional development of Colorado River basin flows, including tributary flows, in the United States;
  - operation of a wastewater treatment plant in San Luis Río Colorado (not yet built) that will put an end to the municipal effluent that now flows into the riparian corridor;
  - plans for water efficiency improvements in local irrigation districts that do not address environmental water needs (not only is there no regulatory mechanism to transfer conserved water to the environment, but water conservation will

reduce the quantity of agricultural drainage water that supplies the groundwater table that contributes to continuous flows in the channel);

- transfers of water now used to irrigate agriculture in the Mexicali Valley to urban uses in the city of Mexicali, which will diminish agricultural waste flows now sustaining riparian corridor habitat.

While the certainty and specific details of these threats are unknown, they are all highly probable. Moreover, the severity of impacts will be high considering the close correlation between the presence of water and existence of native habitat in the riparian corridor. The reversibility of these impacts is medium-high as vegetation will respond rapidly to a return of river flows after a dry period.

- d. Frequent wildfires that consume riparian vegetation. While some incidence of fire may be part of the natural cycle, it is assumed that fire occurs more frequently with nearby human populations. In addition, the changing composition of the riparian forest has changed the availability of fuels. Without frequent flooding, fuels produced by cottonwood and willow forests remain in the corridor instead of being washed downstream with regularity. Fires burn with greater intensity, eliminating trees instead of clearing the ground as they once might have, giving saltcedar yet another opportunity to displace native vegetation. Although the location of some past fires is known, new fires can occur anywhere in the corridor, and therefore are not shown on the map. The threat of wildfire has a high probability and low reversibility.
- e. Small scale clear-cutting practices by local residents. While infrequent at present, vegetation removal by locals may become a more significant threat in the future, not only for the high impact of tree removal, in particular older trees, but also because the threat has low reversibility as it will take several years for new trees to grow and form riparian forest.
- f. Cowbird parasitism. The persistence of cowbirds in the riparian corridor threatens breeding bird reproduction rates, as these birds are parasitic upon the nests of songbirds with eggs, destroying the eggs of the host. This threat is highly probable could be reversed only with a high intensity control program of cowbird populations.
- g. Environmental pollutants. The impact of pollutants from sewage discharges is not known. Untreated effluent from the city of San Luis Río Colorado discharges directly into the river corridor. Although the effluent has not been analyzed, it appears that its salinity is low, and it sustains large stands of willows directly downstream. The health effects of this effluent on people who recreate downstream are not known. This threat is too poorly quantified at present to allow for an assessment of degree and reversibility.

**Opportunities:** Opportunities for restoration in the riparian corridor consist primarily of ways to protect or increase instream flows and provide reliable water for the environment.

- a. Dedicated instream flows of biologically sufficient quantities, both perennial and pulse floods, would ensure that established habitats are sustainable, and could provide the opportunity for increasing the habitat available.
- b. With better management, existing flows in the mainstem and irrigation delivery system could help to meet ecosystem goals. At the workshop, it was noted that given the typically short notice of high flows at the border, flows in excess of agricultural needs are diverted into the Central Canal, as the short notice does not allow for the gates at Morelos Dam to be lowered, and part or all of these flows generally return to the mainstem at the 27 km wasteway.
- c. Spill criteria at Parker Dam could be revised to synchronize administrative purposes and Colorado River delta ecosystem needs.
- d. Low-lying areas supplied with water, as well as existing backwaters and oxbows, could be managed for maintenance of trees from older age classes. Old growth cottonwood and willows are needed to sustain faunal biodiversity (e.g., for cavity nesters, habitat management requires young stands and patches or isolated trees of older growth).
- e. Levees could be stabilized with stands of riparian vegetation, as has been proposed by CNA.
- f. Landowners (and tenants) could lease water for ecosystem purposes. A survey of people who own land adjacent to the riparian corridor indicates that many are willing to consider such leases (Carrillo-Guerrero, 2003).
- g. Conservation of water resulting from improved efficiency in irrigation methods could provide water for the environment as long as a mechanism can be implemented to dedicate the conserved water to the environment.
- h. The proposed Colorado River International Conservation Area could help to coordinate management among myriad landowners along the limitrophe reach of the riparian corridor. Similarly, a protected area or reserve for the riparian corridor in Mexico could extend the opportunity for management coordination and link the riparian corridor with the Biosphere Reserve of the Colorado River Delta and Upper Gulf of California.
- i. Farmers adjacent to the riparian corridor could increase vegetation in riparian areas. A survey of farmers indicates that many are willing to do this in order to protect the lands they farm during large floods (Carrillo-Guerrero, 2003).

- j. Native nursery stock could be established to re-vegetate the floodplain with trees and mid- and under-story species, in order to increase biodiversity.
- k. Both IBWC and CNA could accommodate excess flows in secondary meandering channels for the purpose of maximizing ecosystem form and function.
- l. An education program could increase local opposition to vegetation clearing in the riparian corridor.
- m. With advance notice of flood releases, local managers could make progress towards the elimination of saltcedar stands and could increase native seed germination.
- n. With active management and restoration activities, the ecological value of areas that receive water from agricultural drains could be increased.

## **B. Río Hardy Corridor**

The Río Hardy is a former backup arm of the Colorado River that flows approximately 19 miles (30 km) from south of the Cerro Prieto Geothermal Ponds to the junction with the Colorado River near the tourist camp at Campo Flores. The Río Hardy is a perennial stream carrying approximately 6,000-11,000 acre-feet ( $7.4 - 13.6 \times 10^6 \text{ m}^3$ ) of agricultural drainage water per year. Because the agricultural wastewater has high salinity (3 ppt), few native trees grow along the Río Hardy's banks. Nevertheless, it is an important corridor water birds and songbirds. Part of the Río Hardy is located outside the floodplain of the Colorado River (outside the area delimited by the flood-control levees), within the Mexicali Irrigation District, and part is located within the floodplain. The portion of the Río Hardy located within the floodplain inundates with Colorado River floods, and supports wetlands, shallow ponds and thousands of acres of saltbush and saltcedar. The Río Hardy is dominated by a near monoculture of saltcedar, with very little native vegetation. Although mesquite is found in upland areas, a few willows and cottonwoods are only found along river banks. Five conservation priority areas were defined for the Río Hardy.

- 2. Upper Río Hardy: This area covers the perennial reach, from the Río Hardy's origin in the southwest portion of the irrigation district, near Cerro Prieto, downstream to the Campo Mosqueda tourist camp. A flow control gate at Campo Mosqueda is operated to ensure that this reach is flooded with several feet of water throughout the year. The banks along this 34-mile (55

km) reach are dominated by saltcedar, with isolated mesquites and rare small patches of cattail marshes. A few miles north of Campo Mosqueda, houses have been developed along the riverbanks. In sum, the Upper Río Hardy site is considered a conservation priority for protection, as it is currently one of the few places in the delta with a perennial flow and a deep channel (> 1 m) and already provides habitat for some wildlife species.

3. Río Hardy-Cucapá: This site, nearly 4,300 acres (1725 ha), extends from the Río Hardy at Campo Mosqueda downstream to the area known as “El Riñón” (the kidney) passing through the community of Cucapá El Mayor (inhabited by the Cucapá Indians), as well as other tourist and hunting campsites. Here the river is perennial, flows are much smaller than upstream, and the river is too shallow for navigation. Water salinity is also higher, and salts accumulate in the river banks, as these areas are flooded only sporadically. These conditions have promoted the establishment of saltcedar. Dense thickets of saltcedar dominate the riverbanks and upland areas, with some mesquite in upland areas. Isolated cottonwoods and willows, planted by owners of tourist camps, are found along the banks despite the high salinity (3 ppt) of the river water. This site is considered a priority for restoration due the potential to augment the mesquite population, as well as to manipulate agricultural wastewater to create marshes with emergent vegetation. Current restoration projects have increased and maintained the water level of the Río Hardy by three feet (one meter) since summer 2002, and patches of cattail have returned and channel navigability has improved. This site includes the area locally know as El Tapón lagoons, which consists of new inundated areas resulting from increased water levels.
4. Campo Mosqueda: This site has great restoration potential. Of the 53 acres (21 ha) owned by the Mosqueda family, 22 acres (9 ha) are already managed for restoration. To date, projects include the planting of approximately 1,000 mesquite trees on an upland site, and the planting of cottonwoods and willows along the agricultural drain adjacent to the Campo.
5. Caiman: This site, currently known as the Pescaderos drain, was historically an old course of the Colorado River. The site is dominated by common reed and saltcedar with small patches of cattail marsh and isolated mesquites. Caiman is a priority protection site, where it is important to maintain the current agricultural drain flows that sustain existing flora and fauna, and can potentially serve as a water source for restoration activities.
6. Campo Sonora-Río El Mayor: Río El Mayor is a small tributary of the Río Hardy, also supported by agricultural drainage. Campo Sonora is located along Río El Mayor, where the river is deeper, attracting waterbirds, including American white pelicans and waterfowl. This site also includes backwater lagoons where the river reaches the flood-control levee. These lagoons do not drain into the Colorado River floodplain, and typically function as evaporative basins, creating shallow pools and mudflats that attract shorebirds. This site is a conservation priority for restoration

**Ecological Relationships:** Analysis of ecological relationships in the Río Hardy zone focused on the connections between river flows, vegetation patterns, and their ecological value for bird and fish species. The main factors considered important for the establishment and maintenance of vegetation were stream flow and water and soil salinity. Historically, the Río Hardy was flushed with freshwater during Colorado River mainstem floods. Today, Río Hardy flows originate as agricultural returns from the western side of the Mexicali Valley. Annually, the river carries approximately 6,000-11,000 acre-feet ( $7.4 - 13.6 \times 10^6 \text{ m}^3$ ) of water with an average salinity of 3 ppt. Current high salinity conditions in water and soils promote the growth of saltcedar and limit the growth of native willow and cottonwood. Mesquite trees can tolerate these saline conditions, and are found predominantly in locations close to the river channel. Optimal habitat conditions include a greater diversity of vegetation types than is presently found in the Río Hardy zone. Nevertheless, the existing large areas of saltcedar and mesquite, with open water areas on the river, provide important habitat for migratory birds.

Stream flow patterns and salinity also influence fish health, abundance, and diversity. From its upstream origin to Campo Mosqueda, the Río Hardy flows year-round. Many introduced fish species are found, including catfish, mullet, and tilapia. Downstream from Campo Mosqueda, Río Hardy flows are reduced. The southernmost reach of the Río Hardy is subject to tidal influence, connecting the river with the marine environment further downstream. This connection occurs during the largest tides of the year, which transport seawater with crustaceans and other fauna from the ocean into the river, and sends river-dwelling species down into the estuary.

**Water Needs:** The Río Hardy functions as an integrated ecological unit based on how water flows through the priority conservation areas. Unlike the Riparian Corridor, where instream flows are subject to reduction or elimination by any number of changes in the massive upstream watershed, the Río Hardy has a more localized, annual water supply of some 6,000-11,000 acre-feet ( $7.4 - 13.6 \times 10^6 \text{ m}^3$ ) of agricultural drainage water with a salinity of approximately 3 ppt. Flows in the Río Hardy vary through the year with seasonal irrigation patterns. Nevertheless, this water supply is not guaranteed, and the viability of the Río Hardy conservation priority areas depends on it.

Water quality in the Río Hardy is problematic, particularly during periods when local irrigation rates are low and instream flows decrease. Stabilization of the Río Hardy's salinity is therefore essential, both throughout the year and over the long term.

**Threats:**

- a. Water quality is the greatest threat to habitat value in the Río Hardy zone. In the absence of regular Colorado River mainstem floods, the Río Hardy's sole water source is irrigation returns, which are not only high in salts but also may contain pesticide residues, heavy metals, selenium and nitrates from fertilizers. Fortunately, the degree of this threat is low as none of these contaminants are as yet known to impact the health of wildlife or the human population using the corridor. Occasional flushing flows on the Colorado River mainstem help to keep contaminants diluted. Without these flushing flows, the

reversibility of this threat is low considering that many of these contaminants would remain in sediments and could be a potential threat for many years. The high content of salts in the water has a major impact on vegetation, preventing the growth of native riparian species like cottonwoods and willows. An increase in the salinity of flows would diminish existing habitat, and flows with salinity greater than that already in the channel should not be added. The impacts of this threat are reversible as long as there are opportunities to reduce the Río Hardy's salt content to less than 1.4 ppt.

Additional threats identified by the experts include the following:

- b. The potential reduction in the volume of drainage water into the river due to changes in irrigation practices could deteriorate soils and reduce the amount of water available for plants, resulting in increasing dominance of saltcedar over more desirable native vegetation. The degree of this threat will depend on the change in drainage water volume. Reversibility of this threat is low for upland areas, but high for areas along the banks of the river as water based on the restoration of flow volumes.
- c. Sedimentation of the Río Hardy channel due to low velocity flows could impede navigation and degrade fish habitat. This is an existing threat with moderate to severe impacts. Much of this sedimentation occurred during the 1993 Colorado River mainstem flood, and the present degree of its impact is unknown. This threat is reversible, but only with the implementation of dredging to remove built-up sediments.
- d. Potential for pollution from the Mexicali II wastewater treatment plant (expected to be operational in 2006), includes fecal coliform and sediment. This pollution could result from malfunction of the plant or could be an incremental effect of plant operation. Impacts could be severe for animal species as well as humans. In most cases these impacts are reversible if the quality of treated water is improved to meet safe standards.
- e. Potential invasion of giant salvinia (*Salvinia molesta*) could cause severe impacts by blocking flows in the Río Hardy channel and displacing native species, and its reversibility will be low. Fortunately, Giant salvinia has not been found in the Río Hardy, apparently because its salinity is too high to sustain the species.
- f. Pulse floods from the mainstem of the Colorado River carrying large amounts of sediments could exacerbate sedimentation and habitat degradation if they are not followed by perennial flows that flush sediments. This threat is probable, and while it would be reversible, the restoration of pulse floods will require significant changes in Colorado River management.
- g. Illegal hunting is apparently present in the area and results in the loss of an unquantified number of birds. The extent of this threat and the degree of its impact are unknown.

- h. Potential pollution by heavy metals in discharges from Cerro Prieto, if practices change or spills occur, will cause severe impacts to local flora and fauna. The degree of this threat is unknown.
- i. Pollution from shrimp farms is a potential threat to water quality, and consequently to local flora and fauna, but its degree and reversibility are unknown.
- j. Pollution from land uses, other than agricultural, along the Río Hardy is considered to be an existing threat but of very low impact because the low intensity of use.
- k. Fires are potential threats that could cause severe impacts by destroying remnants of mesquite trees and other native vegetation. The reversibility of these impacts is likely to be very low for mesquite and another native vegetation because the prevalent dry conditions do not favor new recruitment.
- l. Native species may be eliminated due to vegetation-clearing and competition from non-natives such as eucalyptus. This threat is present only in very small areas of Río Hardy and its impacts are low.
- m. Management decisions made in the absence of sufficient information on water quality, and without ecosystem conservation objectives continue to threaten the long-term viability of the Río Hardy conservation priorities.

**Opportunities:** Restoration opportunities in the Río Hardy consist primarily of ways to increase instream flows and to improve water quality, as well as efforts to maintain the involvement of local users in restoration and sustainable economic activities. They include:

- a. Secure current instream flows for the Río Hardy through water concessions or acquisitions. Augmentation of Río Hardy flows and improvements in water quality could result in considerable habitat improvements such as increased acreage of marsh and open water, and increased viability of native riparian forest species. Significant restoration could be achieved with an increase both in the quantity of water and in river depth downstream from Campo Mosqueda. This would improve navigation for recreational users, would be beneficial for the existing aquatic populations, and would help with saltcedar management, both limiting its spread and increasing the success rate of eradication activities. In order for any flow augmentation to achieve these results, it will be necessary to increase channel capacity by dredging portions of lower Río Hardy to remove sediments deposited during repeated flood events over the last two decades. At present, a check dam built by local residents has successfully elevated the water level in this reach of the Río Hardy by approximately 3 feet (one meter). Consequently, water now inundates areas previously dry,

forming new cattail marshes. As with any restoration activities, this site should be monitored to identify changes in sedimentation and salinity.

- b. Secure effluent water from the Mexicali II Sewage Treatment Plant, which will begin operation in 2006 and could deliver up to 35 cfs (1 m<sup>3</sup>/s), doubling the current volume of water entering the Río Hardy. This could result in a decrease in salinity (with a target of 1.4 ppt) and yield improvements in habitat value, including an increase in the rate of cottonwood and willow recruitment along the riverbanks.
- c. Maintain the activities of the Ecological Association of Users of Hardy and Colorado River (AEURHYC), which has been working in the area since 1999 with the mission to conserve and restore the two rivers and develop compatible economic opportunities.
- d. Use check dams to help manage water for habitat restoration, such as was done in AEURHYC's project El Tapón, which successfully increased the water level in the Río Hardy and created conditions such that nearly 1000 acres (400 ha) of dry land are inundated and new wetland areas have developed without additional intervention. This kind of restoration work could provide additional opportunities for restoration of upland areas with mesquite trees and riparian areas with cottonwood and willow. Higher water levels, if maintained, would also help control and eradicate saltcedar. Improved habitat areas will provide for new opportunities to develop ecotourism activities, aquaculture, and environmental management for hunting.
- e. Improved irrigation efficiency and the dedication of conserved water to Río Hardy instream flows would enhance local flora and fauna.
- f. The Biosphere Reserve of the Upper Gulf of California and Colorado River Delta could be extended to include the Río Hardy corridor, which would allow Biosphere Reserve managers to expand their management objectives to include an improved connection between freshwater and marine environments.
- g. An environmental outreach program in local communities could increase local community environmental awareness and lead to increased participation in stewardship activities.
- h. The Río Hardy could be selected as an implementation site for restoration by the fourth working group of IBWC/CILA, which provides the mechanism for increased dialogue between Mexico and the United States about environmental issues in the delta. This could lead to increased binational cooperation in restoration of the Colorado River delta as a whole.

- i. Healthy stands of native vegetation in the Río Hardy corridor, although limited, can provide a seed source for restoration projects.

### **C. Off-channel wetlands**

The off-channel wetland zone is a catchall designation for several important wetland groups that are not directly supported by water from the Colorado River. Some are formed by naturally occurring water sources, but most are supported by agricultural drainage water or canal seepage. Most areas in which wetlands have developed due to the presence of managed water sources were historically part of the vast Colorado River delta ecosystem that existed before extensive upstream development. Their current anthropogenic origins do not diminish their importance as wildlife habitats. Almost all the freshwater that reaches the delta today has passed through human hands, but is no less wet for that. Wildlife and vegetation studies conducted over the past ten years have shown that these wetlands are critical stopover and wintering areas for migratory birds, while local residents hunt, fish and provide guiding services in them. Yet they are so little known to the outside world that none had official place names before 1992.

Analysis of the conservation targets defined by all expertise groups at the workshop resulted in the identification of seven special interest areas. In most cases these areas are isolated from each other mainly due to the geomorphology of the delta as well as their water sources. Further analysis of threats and opportunities for these areas led the workshop participants to define eight conservation priority areas.

#### 7. The Ciénega de Santa Clara

The Ciénega is the largest marsh wetland in the entire Sonoran Desert and one of the most important wetlands in the lower Colorado River basin. This dense cattail marsh (154,000 acres or 6000 ha) and mudflats and open water areas (25,000 acres or 10,000 ha) is located at the spot where the main arm of the San Andreas Fault enters the Gulf of California. The Ciénega was created in 1977, when the U.S. began sending brackish groundwater from the Wellton-Mohawk Irrigation and Drainage District in southern Arizona to this spot in the delta via a 60 mile (100 km) long, concrete canal (the Main Outlet Drain Extension, or MODE canal). Twenty-five years of water delivery in the MODE canal have turned the Ciénega into a wetland of remarkable ecological significance. A portion of the Ciénega lies within the boundaries of the core zone of the Upper Gulf of California and Colorado River Delta Biosphere Reserve of,

established in 1993, and the rest is within its buffer zone. The inclusion of the Ciénega in the Biosphere Reserve demonstrates Mexico's recognition of its outstanding wildlife values. The experts divided the Ciénega into three conservation priority areas:

- 7a. The Ciénega de Santa Clara marsh is identified as a priority for protection. This zone consists of 15,000 acres (6000 ha) of brackish wetland with emergent vegetation of cattail, bulrush, and common reed intermixed with open water areas. It is an important refuge and home of the world's largest population of Yuma clapper rail (*Rallus longirostris*) (Hinojosa-Huerta et al., 2001a), as well as an important desert pupfish population (Varela-Romero et al., 2002). The Ciénega marsh also sustains large quantities of carp, mullet, tilapia and large mouth bass. It is also a major stopover for migratory waterfowl and shorebirds along the Pacific Flyway.
- 7b. The Ciénega mudflat consists of 25,000 acres (10,000 ha) of shallow water areas that are supplied with brackish water from the marsh to the north as well tidal inflows from the south. These mudflats are in good condition and were identified as a priority for protection given their importance for shorebirds.
- 7c. The Ciénega restoration area identified on the west side of the existing emergent wetland, is an area presently not vegetated, mostly a dry plain intermixed with wet and ephemeral mudflats. It was defined with the objectives of increasing the marsh habitat and adding diversity by developing upland vegetation. With additional water it could be converted into another 12,000 acres (4900 ha) of emergent wetland and upland mesquite areas.

**Water needs:** The Ciénega de Santa Clara receives 85% of its water (about 110,000 acre-ft/yr or  $1.4 \times 10^8 \text{ m}^3$ , at 2400 ppt) from the Wellton-Mohawk Irrigation and Drainage District (WMIDD) in the United States and the rest from local irrigation return flows through the Riito Drain. Each source enters at the northern end in separate canals. The water from the WMIDD was formerly delivered to Mexico in the mainstem of the Colorado River as part of the country's water right under the 1944 Treaty, but was removed from the mainstem when Mexico began to complain that the high salinity of Colorado River water was damaging their crops. The U.S. and Mexico negotiated Minute 242 to the 1944 Treaty, which guaranteed that water delivered to Mexico would be no more than 145 ppm more saline than water at Imperial Dam in the U.S. The U.S. Bureau of Reclamation built the Yuma Desalting Plant to attempt to salvage WMIDD's saline wastewater, but it only operated briefly, at one-third capacity in 1993. In total the Ciénega is sustained by brackish water (3-4 ppt, which is saltier than water in the MODE due to evaporation that increases salinity by the time these flows reach the Ciénega). The maximum salinity tolerated by the Cienega is thought to be 5 ppt (**important to have a cite for this**). The concentrations of selenium and other trace metals in the Ciénega are not well known, and should be monitored. Additional studies are required to determine the water needs for the Ciénega restoration area; though it is known that water salinity must be less than 3 ppt in order to support mesquite trees.

### **Threats:**

- a. The main threat to the Ciénega is the operation of the Yuma Desalting Plant, which still sits in "ready reserve" in Yuma, Arizona just north of the Mexican border. Although operation of the plant is today only a potential threat, its operation will result in high degree impacts by drastically changing the water volume and quality flowing into the Ciénega. Present inflows would be decreased 60%, to about 30,000 acre-feet ( $3.7 \times 10^8 \text{ m}^3$ ) with a sharp increase in salinity from 2.8 ppt to 9 ppt (BOR, 2003) (note that these salinities reflect water quality at the northern end of the MODE rather than at the Ciénega itself, where salinities increase due to evaporation). The decrease in water quantity compounded with the increase in salinity due to operation of the plant is expected to eliminate all present life forms. The reversibility of the impacts from this threat is moderate to high but would require a replacement water source, which is a significant challenge. If the plant was operated and inflows later replaced, the degree to which wildlife would return to the Ciénega is not known. Desalter operation is currently planned by the U.S., and work has begun to re-tool the plant's technology, so the probability of this threat is high.
- b. Invasive species (plants and animals) have the potential to establish in the Ciénega, reducing its value as habitat for resident and migrating birds. Giant salvinia (*Salvinia molesta*) flourishes in some drain canals of the lower Colorado River and, although it has not yet been established in the MODE. or at the Ciénega, it could as it tolerates water with salinity up to 3-4 ppt (Divakaran et al., 1980). The degree of impact if giant salvinia establishes in the Ciénega is high with low reversibility.
- c. Pollution from agricultural fields, from river water or from rural sewage would impact flora and fauna at the Ciénega. This threat is possible, and reversible. Fortunately, current concentrations of selenium in sediments, plants, and fish are not considered hazardous for wildlife or humans (Garcia-Hernandez et al., 2001b). However, selenium concentrations will increase considerably if the Yuma Desalting Plant is operated.
- d. Flooding on the Gila River could disrupt flows to the Ciénega if the MODE is broken or breached (as occurred in 1983). This threat is possible, though floods on the Gila are rare, and reversible with repairs to the MODE.

### **Opportunities:**

- a. The Biosphere Reserve provides for the protection and management of the Ciénega's benefits, including ecotourism and birdwatching, commercial and sport fishing, regulated hunting, and the economic value of cattail. In addition it is possible that the Ciénega could be managed more intensively to enhance the habitat value for wildlife, which would allow for management activities such as prescribed burning in cattail areas and the restoration of additional wetland areas.
- b. There are also opportunities for the local ejido to improve and expand the ecotourism activities and tours at the Ciénega.
- c. With additional water for the Ciénega, the Ciénega upland area could be restored

## 8. El Doctor

El Doctor is a group of small, hydrologically-related natural springs (pozos) that form 5200 acres (2,100 ha) of wetlands on the eastern margin of the delta in the intertidal zone south of the Ciénega. Most of these wetlands are just below the eastern escarpment of the delta, where it borders El Gran Desierto. The water is slightly salty, and supports a bulls-eye pattern of plant growth. Freshwater vegetation such as bulrush grows nearest the center, whereas more salt tolerant plants ring the outer areas. Scientists have documented 22 species of aquatic plants growing in these marshes. Although they are not vast in area, the El Doctor wetlands create a long green line across barren desert, connecting the southeastern end of the delta with the coastal esteros to the south. They are extraordinarily important in supporting bird migrations, critically important for neotropical migratory landbirds, moving up the Sonoran coast and through the delta on their way north. These wetlands are also important for the California Black Rail (*Laterallus jamaicensis coturniculus*), the desert pupfish, and the sand bread (*Pholisma sonorae*), a plant species of the Gran Desierto.

**Water needs:** El Doctor's water source is rainwater that falls on the western flanks of the Pinacate Mountains and flows under the desert sand to emerge, slightly brackish, on the delta mudflats. Little has been documented about the quantity, quality, or timing of this water. Additionally information is needed to understand groundwater dynamics and its effects on El Doctor, the importance of the Gran Desierto groundwater, and the relationship with the ocean (saltwater intrusion is minimal but could be a problem in the future). Long-term monitoring studies are needed to characterize these pozos.

### **Threats:**

- a. Although the El Doctor wetlands are part of the Biosphere Reserve, heavy cattle grazing pressure has degraded them. This is an existing threat with high degree impacts, but its reversibility is high. If efforts to control grazing are successful, plant communities are expected to regenerate in less than a year.
- b. Another potential threat is related to Mexico's plans to construct a highway linking the towns of El Golfo de Santa Clara and Puerto Peñasco, which would complete the Sonoran coastal highway and link the delta to the rest of Mexico. Inevitably, El Golfo will grow, and there will be a temptation to install a well field along the Gran Desierto escarpment to recover the fresh water under the dunes for human use. This would be the end of the El Doctor wetlands and the reversibility of these impacts would be low.
- c. Invasive species threaten to displace natives, including the Asian freshwater clam (*Curbicula*). The degree of this threat is low.
- d. Clearing of honey mesquite and screwbean mesquite for wood supply is an additional existing threat to native vegetation. Its impacts are low as clearing targets only branches of mesquite trees, and therefore its reversibility is high.
- e. The presence of organic and inorganic pollutants presents a potential threat to wildlife. Fortunately, selenium levels measured in bottom material and biota at El Doctor do not exceed toxicity thresholds. Mercury and organochloride pesticides were found in high concentrations in mosquitofish, but it is not clear whether these concentrations exceed toxicity levels.
- f. Finally, occasional, small fires threaten the persistence of existing vegetation, mainly marsh vegetation. The degree of this threat is low considering that fires are small and occasional, and its reversibility is high.

**Opportunities:** El Doctor species richness should be preserved and restored. This could be accomplished with the implementation of the Biosphere Reserve's management plan, which considers actions to protect and enhance this wetland. There are opportunities for ecotourism and bird watching, especially during the migration of neotropical migratory landbirds. These activities could create incentives for conservation of the site, including the elimination of cattle grazing around the springs. Specific actions to manage these activities are outlined in the Biosphere Reserve's management plan.

## 9. The Andrade Mesa Wetlands

Mexican and American scientists first noticed the Andrade Mesa Wetlands (comprising some 8600 acres or 3500 ha in Mexico) while conducting low-level, aerial vegetation mapping in the delta in 2002 (Hinojosa-Huerta et al., 2002). These wetlands occur along the

southern escarpment of the Andrade Mesa dunes, at the northern edge of the agricultural fields in Mexico. The wetlands were soon mapped and at least partly explored on foot, and they proved to support 67 species of birds, including rare and endangered species (Yuma clapper rails, large-billed savannah sparrow, gull-billed terns, and California black rails). Open areas with brackish and shallow water are also attractive for many species of waterbirds. These wetlands are unique because they support marshes, vegetated dunes, and saltgrass beds (*Distichlis spicata*) surrounded with stands of cattail. The dunes that surround these wetlands are covered with halophytic shrubs and honey mesquite trees rooted into the water beneath. Although just now noticed by the outside world, these wetlands may date back a hundred years, when the first canal was cut across Andrade Mesa.

**Water needs:** . The Mesa Andrade wetlands are fed by seepage from the All-American Canal. Local farmers used to have problems with water seepage from the All American Canal (AAC), which inundated farmland, until a drain was built to collect this water. This presents evidence that the drainage morphology actually runs south from the AAC. However, additional studies are needed to verify this and especially to quantify water volumes.

**Threats:** The main threat to these wetlands is the construction of a new, lined canal parallel to the current All American Canal. Although construction has not begun, this is considered a present threat because the lining of the canal has been approved in the United States. The contract for its construction was awarded in June 2004, and construction is expected to take up to four years. The degree of impacts has not been studied, but is likely to be high because the new lined canal will eliminate most of the water that currently feeds the Andrade Mesa wetlands. Some water will continue to flow to these wetlands if the current, unlined canal, is used as storage reservoir once the new canal is in operation.

**Opportunities:** Very little is known about these wetlands, so research documenting flora, fauna, and water needs would be important to begin consideration of protecting and restoring them.

## 10. The Cerro Prieto Ponds

The Cerro Prieto ponds are artificial ponds created by the Cerro Prieto Geothermal Plant, located to the north of the headwaters of the Río Hardy. They are sparsely vegetated with iodine bush (*Allenrolfea occidentalis*), and their salinity ranges from just brackish (less saline than seawater) to hypersaline, depending on how they are sequenced as evaporation ponds. The ponds that support pupfish are brackish (between 10 and 20 ppt) and also have *Ruppia maritima*, an aquatic plant, growing in them. These man-made ponds receive spent, geothermal water after it has been used (as steam) to generate electricity, resulting in accumulation of silicates and sulfur in addition to other metals in the ponds.

Ponds in the brackish salinity range are colonized by duckweed and periphyton, as well as pupfish by the thousands, which appear to be the only vertebrates present in the ponds. The ponds are important habitat for the pupfish due to their isolation from other wetland areas in the delta and the lack of predators. This isolation maintains the pupfish population in the ponds, apparently as a different subspecies that those found at el Doctor Wetlands (Varela-Romero et al., 2002).

Soil removed to make the ponds was left in mounds around or in the ponds, creating small islands. These mounds provide protected roosting and nesting sites for a number of colonial water birds and other birds, including Gull-billed Tern, Least Tern, and Large-billed Savannah Sparrow (Molina and Garret, 2001). These man-made habitats are completely dependent on the operational decisions made by the managers of the geothermal facility. Fortunately, the managers are now aware of the ecological value of the ponds and mounds and are taking steps to preserve and enhance their wildlife value.

**Water Needs:** The current volume of water is needed to maintain the wildlife value of these ponds. It would be desirable to reduce the concentrations of heavy metals and other minerals that are harmful for wildlife. Consultation with administrators of the geothermal plant is required to better understand the quantity and quality of water as it flows through the ponds.

**Threats:**

- a. Concentrations of sulphur, copper, mercury and other metals have an unstudied effect on wildlife. This is an existing threat, but little is known about its impacts or reversibility.
- b. Vehicle traffic along the levees as part of regular operation of the plant may destroy nests or potential breeding sites. This is an existing threat, but little is known about its impacts or reversibility.

**Opportunities:** Protection of ponds with desert pupfish is possible if managers of the geothermal facility incorporate consideration of wildlife values into operational decisions. This also applies to management of islands during the nesting season, and possibly the creation of additional nesting sites.

## 11. Pangas Viejas

Pangas Viejas is a 660 acre (270 ha) permanent wetland with emergent vegetation, mainly cattail, common reed, and saltcedar. This wetland is maintained by agricultural return water delivered by the Zacatecas drain as it intersects the eastern flood control levee on the Colorado River mainstem. Water is brackish and shallow. This wetland is important for migratory birds and for the Yuma clapper rail, and is used by hunters.

**Water needs:** Little is known about quality and quantity of water that creates the Pangas Viejas wetlands. However, maintenance of these wetlands requires the preservation of current flows, at minimum. In addition, it would be desirable to increase the quantity of these flows to expand these wetlands.

**Threats:** The main threat to this wetland is the potential for reduced inflows. If flows are reduced or eliminated, the expected impacts will be high, resulting in the reduction and possible elimination of this wetland. However this threat is highly reversible if flows are restored.

**Opportunities:** Current water supply represents an opportunity to maintain, and possibly to expand, this wetland. Active restoration actions could enhance the benefits of this water supply, including for example the introduction of mesquite trees.

## 12. The El Indio Wetland

The El Indio wetland is located on the southeastern end of the Mexicali Valley, adjacent to the eastern flood control levee, within the buffer zone of the Biosphere Reserve, and within the boundaries of Ejido Oviedo Mota Indiviso. The wetland currently extends for some 100 acres (40 ha), maintaining a permanent marsh with shallow open water. The wetland is maintained by agricultural drainage from the Dren Perimetral that collects drainage from most of the San Luis Agricultural Valley. The most recent study of El Indio (Briggs et al, 2004) describes the vegetation as dominated by saltcedar (*Tamarix ramosissima*), accompanied by honey mesquite (*Prosopis glandulosa*) screwbean mesquite (*P. pubescens*), saltbush (*Atriplex spp.*), seepweed (*Suaeda spp.*), and pickleweed (*Allenrolfea sp.*). The study also identified pockets of cattail (*Typha domingensis*), bulrush (*Scirpus spp.*), and other hydrophytes that persist in areas where soils remain saturated throughout the year, as well as significant populations of salt grass (*Distichlis spicata*) on the salt-affected fringes of the ponds and in the tidal affected areas south of El Indio wetlands.

The wetland provides habitat for two endangered species, the Yuma clapper rail and the desert pupfish, as well as for waterfowl. For these reasons and the high potential for restoration related to its continuous water flow, El Indio is considered a priority for restoration. Based on restoration opportunities, the boundary of the El Indio Wetland conservation priority area extends beyond the existing 100 acres (40 ha) of wetlands to include surrounding land for a total of 1,900 acres (770 ha) of wetlands that could be created through restoration actions.

**Water needs:** The El Indio wetland receives an average monthly flow that ranges from 14-22 cfs (0.4 – 0.6 m<sup>3</sup>/s) of agricultural return water through the Perimetral drain. Flows are reduced during summer months, but remain sufficient to maintain shallow ponds year-

round. Water at the El Indio wetlands at present has a salinity of 3-4 ppt. Maintenance of existing wetlands requires the preservation of these current flows, at minimum. The expansion of this wetland to 1,900 acres (770 ha) would require an increase in the quantity of flows. Additional studies are required to determine how much more water is needed and to identify potential sources.

**Threats:** These threats have been recognized in the new management plan of the Biosphere Reserve of the Upper Gulf of California and Colorado River Delta

- a. As with most habitat areas in the delta, the water source feeding El Indio wetland is not secure. It is possible that these flows could be reduced or eliminated, and the El Indio wetlands would be diminished. The degree of this threat is unknown and will depend on the amount by which flows are reduced. This threat is highly reversible if flows are restored.
- b. In addition, pollution from agricultural activities, rural and urban sewage, and from the Colorado River may impact both flora and fauna. Selenium levels measured in bottom material exceed toxicity thresholds, but its bioaccumulation in wildlife species has not been measured. Other trace elements and organochlorides also need to be measured in order to determine the degree of impacts of these pollutants.
- c. Illegal hunting activities threaten local fauna. The degree of this threat is unknown, but expected to be highly reversible.

**Opportunities:** The El Indio wetlands could be improved with active management of agricultural drainage water. This wetland along with Pangas Viejas could be managed as a functional unit as they are located between the Ciénega and El Doctor and the Colorado River mainstem riparian corridor. In addition, increased recognition of the economic value of the El Indio wetlands, including ecotourism and birdwatching, and sustainable aquaculture, would likely encourage their conservation and restoration. The new management plan of the Biosphere Reserve recognizes the threats and considers some restoration activities in El Indio. Furthermore, staff of the Reserve is currently exploring mechanisms to secure water for El Indio (Maria de Jesus personal communication).

### Laguna Salada

The Laguna Salada, a former wetland of the Colorado River delta, is now a dry depression that fills with freshwater only during large floods on the Colorado River mainstem (as 1983-87, 1993 and 1998). When filled with water, the Laguna Salada becomes important place for shorebirds, and commercial fisheries (fish and shrimp). Because floods from the Colorado River are rare, the Laguna Salada

is not identified as a conservation priority. However, when freshwater or tidal flooding does occur, the area should be managed for its habitat values.

**Water needs:** Water quality at the Laguna Salada ranges from brackish (5-6 ppt) to hypersaline , and little is known about the quantity or timing of water inputs.

**Threats:** Because the Laguna Salada is not presently a functioning wetland ecosystem, it is not threatened.

**Opportunities:** One potential for restoring habitat at the Laguna Salada is the construction of a channel from the Upper Gulf that would allow seawater to enter the basin. However, additional study is required to better understand the hydrology of the area, including the influence of tides, so that any attempts to bring water to Laguna Salada result in sustainable habitat, and problems such as those found at the Salton Sea are avoided. Attention should be directed to estimate potential impacts that seawater could have on groundwater aquifers.

#### **D. Intertidal, Coastal and Marine Areas**

Tides in the Gulf of California are large, extending nearly as far upriver as the junction of the Colorado and Hardy Rivers, some 25 miles (40 km) to the north. Tides, along with freshwater flows from the Colorado River, used to support a remarkable estuarine ecosystem. With the near-elimination of freshwater flows, the quality and extent of the estuarine environment has been reduced. Although additional studies are required to establish the influence of a range of freshwater flows, magnitude and timing, on the extent

of the intertidal and estuarine zones, they remain breeding and nursery areas for marine species including shrimp, Gulf corvina and the endangered totoaba, a large, high-quality endemic fish that was the basis for an early commercial fishery in the region.

The vegetation in this zone is relatively simple, with the banks of the river dominated by the endemic Palmer's saltgrass (*Distichlis palmerii*), and sparse thickets of iodine bush and saltcedar. The role of upstream saltcedar (the dense thickets along the Río Hardy) in the intertidal ecosystem is not well documented. However, the saltcedar likely feeds detritus into the estuary and marine zone, and the detrital food chain drives much of the productivity of the marine zone.

The marine zone begins at Montague Island. The island and adjacent shore are fringed with Palmer's saltgrass (*Distichlis palmeri*), an endemic found only in the northern Gulf of California. Its large grain was historically a staple food of the indigenous Cucapá, but without freshwater flow in the river grain production is minimal. Nevertheless, the island is an important breeding and feeding ground for water birds. In the past, before 1935 when Hoover Dam was completed, the influence of the Colorado River on the Gulf of California extended on average as far as 40 miles (64 km) south of the river's mouth, and possibly farther away during above average floods (Rodriguez et al., 2001). Today, with much diminished flows, freshwater only occasionally reaches as far downstream as Isla Montague. In order to determine the southernmost extent of the marine zone for this conservation priority-setting exercise, the experts identified a line drawn across the Gulf between San Felipe and Puerto Peñasco, the same line that defines the southernmost extent of the Upper Gulf of California and Colorado River Delta Biosphere Reserve.

The large geography of the ecological zone covering intertidal, coastal, and marine areas, as well as the nature of the spatial ecological relationships between species and habitat, presented a significant challenge to experts charged with identifying specific boundaries of conservation targets. Limited data sets and information added to this challenge. The experts were concerned that by identifying only small areas within the large zone, they might inadvertently contribute to fragmentation in conservation planning, the ignoring of ecological principles, and piecemeal, ineffective restoration of the delta. Moreover, the experts were frustrated by the need to limit conservation priorities to the zone defined for the workshop, and would have preferred to extend their scope further south into the Upper Gulf ecosystem. However, in the context of the connection between the Colorado River and the intertidal, coastal and marine areas, the experts agreed to limit their focus and identify conservation priorities within the defined zone. The group identified three areas that deserve special attention as conservation priorities:

### 13. Coastal and Estuarine areas

This includes 565,000 acres (222,600 ha) of estuarine and coastal areas and is designated as a restoration priority, based on the potential ecological impacts of increased freshwater flows, including the quantity, quality, timing, and nature of mixing with tidal processes in the intertidal and coastal zones.

**Ecological relationships:** The dramatic reduction in freshwater flows has resulted in significant changes to the Upper Gulf and estuary. Today these ecosystems are deemed a ‘reverse estuary’ because minimum freshwater inflows and high evaporative rates result in hypersaline conditions.

It is only during years of excess snowpack in the Upper Colorado River basin and full reservoir storage throughout the basin, or very rare years when the Gila River floods, that flows reach the estuary. Even though freshwater flow has been reduced practically to zero during normal years, the delta, including its estuarine and coastal ecosystems, is very productive. The question remains as to how much more productive and important for Upper Gulf ecosystem health these flows were before the extensive water development of the twentieth century. Though impressively rich now, it may be that the lack of freshwater inputs is a serious ecological bottleneck in the functioning of this complex ecosystem. Reduction in river flows has reduced the quantity and quality of wetlands and estuarine habitat and this, in turn, has greatly reduced nursery areas and the organic matter available to the intertidal, coastal, and marine ecosystems.

The close relationship between freshwater flows and productivity in the Colorado delta is also evident in the resiliency of these ecosystems. Delta ecosystem can survive as long as 10-20 years without freshwater inflow and can be revived if provided with sufficient annual and occasional flood flows.

The relationship between freshwater inputs and species productivity has, in some cases, been documented. Freshwater inflow is needed for sexual reproduction of *Distichlis palmerii*. The Gulf corvina fishery increased in coincidence with the major flood pulses in the 1990’s (Roman, 2004). A study of the annual San Felipe shrimp catch showed a positive influence of the river on the succeeding year’s harvest (Galindo-Bect et al., 1999). Evidence suggests this is due to an increased of postlarval abundance during years of higher freshwater flows reaching the estuary (Cortez and Aragon, 2004). Small floods may not carry sufficient water, silt or nutrients to impact the marine zone directly, but they reduce the salinity in the intertidal portion of the river to the point that predator fish cannot penetrate to the nursery areas of post larval shrimp and fish, including totoaba and Gulf corvina, both of which have returned to the marine zone and estuary. Valdes et al. (1998) report that in January 1998, with river flows of 7,000 cfs (200 m<sup>3</sup>/s), water salinities of 20 ppt were found at 5.5 miles (9 km) upstream from the river mouth (areas further upstream were not surveyed), whereas with flows of 38 cfs (1 m<sup>3</sup>/s) salinity ranged between 35 and 39 ppt

Though the exact relationship between Gulf corvina spawning and freshwater flows is not fully understood, it is likely that the increase in the fishery that occurred in the 1990's is related to the major flood events that occurred during the decade. Similarly, the number of Gulf clams (*Mulinia coloradensis*) was much higher when regular freshwater flows occurred, suggesting that this clam depends on freshwater flows (Rodriguez et al, 2001). Under the present hypersaline regime their population has been reduced by 90 percent (Rodriguez et al., 2001). It may be that predators of the clam are also reduced, or that they switched prey. No documentation of this relationship exists.

Isotope data suggest sciaenids, like Gulf corvina and totoaba, use low salinity habitats in their early juvenile stages (Rowell et al, 2004). Totoaba spawning occurs during spring, coinciding with the snowmelt flood pulse that reached the delta between March and June. Shrimp in their post-larval stage migrate into the estuary, including the mouth of the Colorado River, and emerge as juveniles. Fresh water influx has a beneficial effect on their growth and survival (Galindo-Bect et al., 2000; Calderon-Aguilera et al., 2003).

In extraordinary flood events, freshwater reaches at least as far south as Isla Consag and Borrascoso sites. However the importance of such pulses to the maintenance of refugia for rocky benthos and other marine fauna and flora is unclear. In the case of the vaquita, habitat alteration resulting from the reduction in Colorado River flow is currently a low risk factor, compared to incidental mortality gillnets (Rojas, personal communication June 2004). According to Rojas, it is unknown how important perennial and pulse flows from the Colorado River were as part of its habitat as only one author has described it as a fluvial or estuarine species. Additional studies are needed to determine the influence of freshwater flows and the population of the vaquita and other cetaceans.

Water quality has also been impacted. Agricultural drainwater influences the overall quality of water reaching these habitats, and contributes to nutrient loading. Low-water periods and resulting erosion may enhance release of captured nutrients. Another major difference between the pre-development Upper Gulf and the ecosystems there today is the decrease in sediment inputs. Re-establishing sediment deliveries will be difficult given the extensive system of dams upstream that block delivery of sediments originating as far as 1000 miles to the north. Reduced freshwater flow contributes to erosion of the delta (Alvarez-Borrego, 2002), the filling in of off-channel areas, and ultimately creates navigation obstacles.

Sediment types vary from sandy in the eastern portion of the delta to silt and clay in the western section. Despite the reduction of instream flows, sediments originating upstream on the Colorado River remain the most important source of sediments to the region (Carriquiry et al, 2001). The distribution of sediment type influences distribution of some species of finfish. .

**Water Needs:** While water needs have been calculated for the riparian corridor of the Colorado River delta, little is known about the Upper Gulf's freshwater requirements. A "seat of the pants" estimate of freshwater flows needed to sustain the intertidal, coastal, and marine ecosystems of the Colorado River delta might be approximately 1.5 million acre-feet ( $1.8 \times 10^9 \text{ m}^3$ ), approximately 10% of the

Colorado's average annual flow, per year. The work on *Mulinia coloradensis* (Cintra-Buenrostro, 2004) and shrimp (Aragon-Noroega, 2004), which estimates annual flow of 17% and 11% respectively, supports this estimate. This also is congruent with Texas state government estimates that 12.5 % of the Río Grande's annual flow is required to sustain Gulf of Mexico's shrimp fisheries; this flow requirement is enacted in the legislation (Texas water code 11.47). Although the Gulf of Mexico and Gulf of California are different marine systems, this provides an example of how instream flows needs are being considered and defined in other part rivers in North America. Although this provides the first estimates of freshwater flows needs, there are still unresolved issues regarding the magnitude of the flows as well as their frequency, timing and quality. It is not known if agricultural return flows were to be included in this "sustaining" flow, whether the total flow volume would need to be increased in order to make up for the loss in water quality. Although it has been documented that salinities lower than seawater positively influence life cycles of mollusks and crustaceans, it still uncertain what would the target salinity be.

Research that might make the calculation of the Upper Gulf's freshwater flow needs more robust should continue by focusing on the relationship between freshwater flows and the life cycles of eight species: brown and blue shrimp, salt grass (*Distichlis palmerii*), Colorado Delta clam (*Mulinia coloradoensis*), totoaba (*Totoaba macdonaldi*), Gulf corvina (*Cynoscion othonopterus*), the Chione clam (*Chione cortezi*), and vaquita porpoise (*Phocoena sinus*).

### **Threats:**

- a. Low level of freshwater inflows result in the degradation and loss of physical and aquatic habitat for key species, reduce nutrients inputs, and a change in the circulation of sediment transport that exacerbates coastal erosion. The degree on these impacts is high, but in most cases highly reversible.
- b. Shrimp farming potentially may cause the following, high degree and highly reversible, impacts:
  - Mortality of estuarine organisms at the water intake screens;
  - Potential escape of disease and viral pathogens from the ponds to the open Gulf; and
  - Effluent from the ponds contributing to eutrophication.
- c. High nutrient loading and sewage deposition may pose increasing threats. Among these are potential, local "dead zones" where toxin-producing or pathogenic microorganisms will cause unnatural algal blooms and faunal mortality. Situations like this are known to have occurred in the past at nearby Puerto Peñasco, for example, and possibly on one occasion at El Golfo. The degree of these impacts is considered moderate and highly reversible.

- d. Unmanaged coastal development (tourism) results in noise pollution affecting marine mammals (vaquita), as well as habitat degradation and destruction in Golfo de Santa Clara and San Felipe, which contributes to the mortality of fauna and flora. The degree and reversibility of impacts varies depending on the threat. In the case of habitat destruction resulting from coastal development, the degree of impacts is high with low reversibility. Habitat degradation or disruption results in moderate impacts with medium-high reversibility, depending of the specific threat. These include excessive off-road vehicle use on coastal dunes, tidal flats, and beaches; animal removal by tourists; and excessive boat use.
- e. Benthic trawling is an existing threat that causes high degree impacts with low reversibility, including:
  - Massive disruption of the physical substrate and its benthos; and
  - Incidental catch and mortality of non-target fish and marine mammals.
- f. The use of gill nets causes the following high degree impacts with low reversibility:
  - Incidental catch and mortality of birds and marine mammals; and
  - Overexploitation of target finfish species.
- g. Potential development of tidal power, if implemented, will result in high degree impacts and irreversible loss of the Upper Gulf habitat.
- h. Contaminants may be re-suspended from the sediments in agricultural drains, raising the problem of contaminants reaching the Gulf. Fortunately, assessments of animal tissue have thus far shown low levels of DDT/DDD. Unlike the Salton Sea, where such pollutants and sediments accumulate in the water column and benthos without a natural outlet, the delta is a flow-through system. The degree of impact is high as sediments show high concentrations of some of these contaminants, and its re-suspension is likely to increase the likelihood of bioaccumulation in wildlife species. The reversibility of this threat is moderate to low, depending on the actual degree of impact.

**Opportunities:**

- a. Increase freshwater flows to the river mouth.
- b. Redirect water from the Colorado River to Estero Diablo to enhance reproduction grounds.
- c. Eliminate benthic trawling in the Upper Gulf.

- d. Reduce or eliminate gillnetting in the Upper Gulf.
- e. Research, develop, and promote alternative fishing gear that is vaquita-friendly.
- f. Research, develop, and promote economic alternatives to commercial fishing.
- g. Develop a comprehensive monitoring and research program, with special attention to the impact of freshwater flood inputs.
- h. Document the recovery of benthos after trawling practices are halted.
- i. Apply private conservation tools strategically and comprehensively, such as the promotion of easements.
- j. Promote government management tools such as environmental management plans (UMA), stricter implementation of the Biosphere Reserve management plan, enforcement of existing resource use regulations, and application of land use planning principles (Ordenamiento Ecologico Territorial) to mitigate coastal development impacts, overuse of resources, and pollution.

#### 14. El Borrascoso

This area is important because of the potential bank of information available from its 125,000 year old shell repository. El Borrascoso is situated to the northwest of Puerto Peñasco, and is comprised of rocky outcrops, rare habitat in the Upper Gulf.

**Ecological Relationships:**

**Water needs:**

**Threats:**

**Opportunities:**

#### 15. Vaquita Marina-Isla Consag:

This priority area of 138,000 acres in size covers the preferred habitat of the vaquita and an important reproduction site for shrimp. This area includes Isla Consag to the east of San Felipe, which is comprised of rocky outcrops, rare habitat in the Upper Gulf.

**Ecological Relationships:** The vaquita is endemic to northern portion of the Gulf of California, and its population is estimated to be 567 individuals (Flores-Skydancer and Turk, 2002). This latest estimate from 1997 sightings, as well as other census, indicate that although the vaquita occurs in the entire northern Gulf, its distribution concentrates mainly around Rocas Consag island and close to El Golfo de Santa Clara. It appears that this concentration is related to the abundance of food resulting from upwelling events in these areas. Thus, food availability does not seem to be a limiting factor for vaquita populations. Analysis of stomach contents indicated that its diet is composed by diverse species, which in turn reduces competition for same resource by other species like sea lions and dolphins.

**Water needs:** Little is known about the importance of fresh water flows for vaquita. Although reduced freshwater flows from the Colorado River do have an effect on life cycles of some organisms and on the food web, the available evidence is not sufficient to determine the impact on vaquita's population and distribution (Flores-Skydancer and Turk, 2002). Part of the problem is that there is no data on the distribution and population size of vaquita before the dams, and therefore there is not baseline for comparison. Lack of evidence, however does not indicate that there not exists a relationship between fresh water flows and the vaquita. Further studies to investigate this relationship and to quantify water needs are needed.

#### **Threats:**

- b. Incidental mortality in gill nets is estimated to cause 75% of vaquita mortality (Barrera, 2004). Gill nets are used widely and intensively used in fisheries activities in the northern Gulf. Despite gill nets with mesh size greater than 10 inches were prohibited in 1992, there are reports that vaquita gets entangled in nets with smaller mesh sizes used for shrimp, sharks, among other fisheries (Flores-Skydancer and Turk, 2002). Fishing activities with gill nets is a current threat with high degree impacts and low reversibility.
- c. Incidental mortality in trawling nets has also been reported by fisherman, and affects particularly vaquita calves. The contribution of trawling nets to vaquita mortality is less compared to gill nets. Flores-Skydancer and Turk (2002) indicate that between 1985 and 1990 fisherman from San Felipe and El Golfo de Santa Clara reported eight dead vaquitas, while an average of 32 vaquitas get killed on a single year in gill nets (Flores-Skydancer and Turk, 2002). Sea bottom trawling fishing is a current threat with medium to high degree impacts and low reversibility.

- d. Habitat alteration is considered another for vaquita population. This is a current but indirect threat as it affects the food web cycles of organisms that are part of the vaquita diet. However, the degree of impacts has not been determined. The reversibility of this threat is likely to be low if habitat destruction increases mortality of vaquita.

**Opportunities:**

- k. Fishing regulations have restricted the use of some types of gill nets and reduced the number of shrimp trawlers that are allowed to operate inside the Biosphere Reserve. Enforcement of these regulations will eliminate the major threats of the vaquita. However, because the main distribution area of the vaquita lies outside the reserve, it is necessary to extend the application of these fishing regulations to include this area.
- l. Public involvement of fisherman in the development of alternatives to save the vaquita has increased in the last few years. This could provide the framework to reach out to more fisherman and government officials to jointly develop, implement, and enforce specific actions to save the vaquita while sustainable economic activities, which may include ecotourism.

**Chapter IV**

**RESEARCH NEEDS IDENTIFIED FOR COLORADO RIVER DELTA AND UPPER GULF RESTORATION**

The results of the Experts' Workshop on Conservation Priorities for the Colorado River Delta and Upper Gulf of California are based on an extensive history of research conducted in this region, starting in the middle of the twentieth century. In the last decade, the collective research effort has increased considerably. While the primary purpose of the Experts' Workshop was to identify and synthesize existing information on natural resources, the Workshop also provided an opportunity to query experts and other stakeholders about their priorities for additional research needed. Participants were asked to list all information gaps and priority research in the Colorado River Delta and Upper Gulf of California. Later, they identified the most urgent and important research needed to support conservation and restoration action.

In particular, the top priorities reflect a need for comprehensive research efforts, at a scale likely requiring extensive resource commitments. Existing and historic research efforts have largely been conducted by academic and non-governmental organizations. While these smaller-scale studies have led to today's understanding of ecosystem form and function in the Delta and Upper Gulf, larger-scale, comprehensive studies are needed to form a strategic and valid basis for large scale restoration and conservation.

In addition, three of the top research priorities suggest a need to move beyond resource inventories to an "adaptive management" style of research and experimentation with management regimes, specifically with respect to water use, commercial fishing, and restoration activities.

### **Top 5 priorities:**

1. Conduct a comprehensive inventory of the Colorado River delta ecosystems including an all-species inventory and hydrologic conditions, which can be used to create and identify restoration priorities. Establish a monitoring program to track status of species and hydrologic conditions.
2. Following a participatory approach and using a multidisciplinary team, develop a hydrologic flow model (surface and groundwater) for the delta based on detailed elevation data.
3. Identify water uses and needs in the delta region so that compromises and trade-offs are well understood in water management and allocation decisions.
4. Determine ecological impacts of shrimp trawling as well as shrimping restrictions on the marine ecosystem.
5. Develop a binational master plan for the conservation and development of the entire delta region.

### **Complete list of research priorities:**

#### **WATER BUDGET**

- Using an interdisciplinary approach (and team), develop a flow model for the delta based on elevation data and channel morphology.
- Identify water needs for all uses in the delta region so that trade-offs are understood.
- Quantify groundwater flows (agricultural and non-agricultural) and interactions with surface waters.

- Determine the fate of water in the river channel.
- Determine with precision the flow of surplus water in agricultural canals into the river channel.
- Monitor water quantity and quality, and identify trends at agricultural drains.
- Install stream gauges.
- Get more information on plans for municipal wastewater treatment, especially treated effluent.
- Identify the water source for El Doctor and determine whether pumping in San Luis Rio Colorado impacts water supply for the wetland.
- Determine flow rate at which scour has negative impact on riparian ecosystem.
- Correlate flow data from mainstem and agricultural drains with species research and monitoring.
- Identify the dynamics of water in the estuary and Upper Gulf, including the quantity, quality, and timing of freshwater flows, and residence time, mixing patterns, and physical, chemical, and biological processes in the estuary and Upper Gulf.
- Determine the presence and effects of pollutants in the upper Gulf.
- Assess the impact of geothermal water use and exploration.

## INVENTORY AND MONITORING

- Conduct a full inventory and monitoring of resources, including flora and fauna species, quantitative and qualitative data. Use this along with results from the hydrological model to further refine restoration priorities
- Determine impact of shrimp trawling, as well as shrimping restrictions on the marine ecosystem.
- Determine ecological impacts of shrimp farming.
- Establish long-term monitoring programs for marine mammals as a group, with a special focus on sea lions, bottle-nosed dolphin, manta rays, and all sharks.
- Register strandings of moribund marine mammals and sea turtles.
- Study distribution and seasonality of shorebirds and migratory species.
- Assess vital rates and abundance for riparian obligate breeding species.
- Establish long-term monitoring programs for marsh birds and migratory landbirds.
- Inventory contaminants in sewage, agricultural wastewater, and other water sources entering the river and determine impacts on humans and biota.
- Identify the food sources for shorebirds and migratory species, and identify nursery habitat for fisheries.
- Conduct cross-disciplinary monitoring of resources to identify trends and relationships to management activities (e.g. what is the impact of trawling restrictions?). To be effective, a study of benthic productivity should start immediately.
- Inventory aquatic amphibians and reptiles.

- Where threats have been identified, inventory and monitor resources.
- Assess environmental impacts of tourism development.
- Certain species seem to be responding to river flows that reach the intertidal zone, but sorting out exactly how they respond needs a comprehensive interdisciplinary monitoring program. These include the shrimp, corvina runs and migratory birds. Other than clams, few species, unfortunately, offer opportunities to use stabilized isotopes to reconstruct their connection to freshwater. It may be useful to explore this connection through the assessment of teeth in vaquita or otoliths in the totoaba population.
- Any monitoring program in the upper gulf and intertidal zone of the Biosphere Reserve should take advantage of existing research. It should also be binational in scope and measure the environmental effects (both positive and negative) of tourism and commercial shrimp production in the Upper Gulf of California.
- Assess the impact of noise pollution on coastal species, particularly the vaquita and other marine animals.

#### DATA MANAGEMENT

- Create a detailed map within levees using aerial photography and orthophotos and use as standard basemap among all agencies, researchers, etc.
- Create a multi-institution database.
- Improve the coordination of, and access to, data.

#### DEFINITION OF RESTORATION

- Develop a binational master plan for the entire delta region.
- Quantify water needs for all ecosystem types, including minimum freshwater flows needed for marine ecosystem restoration.
- It is important to identify goals for restoration studies and projects.

#### ADAPTIVE MANAGEMENT

- Conduct pilot restoration studies at various sites.
- Conduct pilot leasing of water for restoration.
- Establish an outreach program for sustainability.
- Inventory and explore wildlife management and biodiversity conservation goals at the agricultural-upland interface.

## **CHAPTER V: CONCLUSIONS AND RECOMMENDATIONS**

In summing existing information on the Colorado River delta and Upper Gulf of California, the experts at the Conservation Priorities Workshop made many conclusions and recommendations intrinsic to the exercise in which they were engaged. In addition they established a prioritized list of research and data needs, presented in Chapter IV. This chapter contains conclusions and recommendations of the organizations that convened the workshop: participants have not endorsed these ideas, although some may agree with them.

### **A. Conclusions**

1. Although more research is needed, sufficient information already exists about the ecosystems of the Colorado River delta and the Upper Gulf of California to determine priorities for conservation and restoration. The priorities determined in this

workshop are based on sound science. A bibliography of published and unpublished data sources is included in the digital version of this report.

2. A principle threat to the delta and Upper Gulf ecosystems is the lack of dedicated freshwater inputs. The Colorado River mainstem flows of recent decades that revived these ecosystems are subject to disappear as consumptive water use increases, and climate change reduces total basin water yield. Nor are the flows guaranteed that sustain off-channel wetlands, including the flows to the Ciénega de Santa Clara. Another immediate threat to the Colorado River delta is the channelization and vegetation-clearing project proposed for the Limitrophe reach and the riparian corridor to the south, extending approximately 61 miles (98 km) south of Morelos Dam.
3. Non-governmental organizations and academic institutions have made significant commitments to conservation and restoration of the ecosystems of the delta and Upper Gulf of California. However, until the U.S. and Mexican federal governments match this commitment, the health of these ecosystems cannot be assured, and large-scale improvements in ecosystem health will remain unattainable.
4. There are a number of different ecosystem types in the Colorado River delta and the Upper Gulf of California. Each has distinct attributes, values, and water needs, and for each there are threats to resource values as well as opportunities for restoration.

## B. Broad Recommendations

1. The United States and Mexico should immediately adopt policies that ensure no further harm is done to the ecosystems of the Colorado River delta and Upper Gulf of California.
2. The United States and Mexico should use Minute 306 as a framework for developing a conservation and restoration plan for the Colorado River delta.
3. The United States and Mexico should commit to an agreement that protects and restores the ecosystems of the Colorado River delta and Upper Gulf of California as defined by the conservation priorities identified in this report, and that includes quantified, dedicated sources of water for the environment through treaty agreement, national policy, or market-based mechanisms.
4. The United States and Mexico should develop and implement a strategy to procure water for instream flows to sustain the ecosystems of the Colorado River delta and Upper Gulf of California. This binational strategy should result in quantified,

dedicated sources of water for the environment via mechanisms such as a new Minute to the U.S.-Mexico water treaty, national policy, and market transactions.

5. The Commission on Environmental Cooperation (CEC) should establish delta conservation and restoration as a priority and identify funding to support research and infrastructure to this end.
6. All plans for ecosystem protection and restoration in the Lower Colorado region, including plans for the delta and for the Salton Sea, should recognize the interrelated nature of aquatic habitats in the region.
7. All entities engaged in activities that may affect the region's ecosystems should engage in consultation with local communities.
8. Government agencies and other funding institutions in both countries should commit resources to support research as outlined in Chapter IV.

#### C. Site-specific Recommendations:

##### Colorado River Riparian Corridor:

1. **Dedicate water:** The United States and Mexico should develop and implement an agreement to maintain the volume, frequency, timing, and quality of instream flows that have created and sustained the native riparian vegetation. This includes an estimated perennial baseflow of 30-50,000 acre-feet ( $3.7-6.2 \times 10^7 \text{ m}^3$ ) at about 70 cubic feet per second ( $2 \text{ m}^3/\text{s}$ ) and an estimated periodic flood flow of 260,000 acre-feet ( $3.2 \times 10^8 \text{ m}^3$ ) at about 7,050 cfs ( $200 \text{ m}^3/\text{s}$ ) in the late spring once every four or five years. These instream flows are needed to regenerate and sustain native riparian species and to flush salts from the floodplain. To serve this function instream flows should be maintained at a salinity no greater than 1.6 parts per thousand (ppt). In order to secure these flows, the United States and Mexico will need to define a new agreement on instream flows below Morelos Dam.
2. **Manage the riparian corridor for maximum ecological benefit:** The International Boundary and Water Commission (IBWC), the Comisión Nacional de Límites y Aguas (CILA), the Comisión Nacional de Aguas (CNA), the Cocopah Indian Tribe, the Bureau of Land Management (BLM), the Bureau of Reclamation (BOR), the Arizona Department of Game and Fish (ADGF), and several private landowners have land within or management authority for the riparian corridor below Morelos Dam (including both US and Mexican territory), and these entities should cooperate to make ecosystem management and habitat restoration a priority. Under no circumstances should any management activities be implemented that degrade ecosystem values in the riparian corridor.
3. **Designate the riparian corridor a protected natural area:** Efforts are underway in both the United States and Mexico to procure protected area designation for the Colorado River from the Northern International Boundary south to the northernmost

extent of the boundary of the Upper Gulf of California and Colorado River Delta Biosphere Reserve. In the United States, this effort is led by the Cocopah Tribe, whose reservation includes riverfront lands. The Cocopah Tribal Council has asked for a feasibility study for designating the river an international protected area. In Mexico, several non-governmental organizations are preparing a proposal to create a protected natural area for the river corridor. The Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT) in Mexico, and the relevant agencies in the United States (including Department of Interior agencies, IBWC, ADFG and the Arizona Department of Water Resources [ADWR]) should assist these efforts and ensure that they result in success.

4. **Improve water management:** IBWC, CILA, and CNA should identify and implement changes in management of existing flows in the riparian corridor in order to maximize ecological benefit. BOR should identify and implement changes in management at Parker Dam (one of the few lower Colorado River impoundments with storage) that could benefit the Colorado River riparian ecosystem below Morelos Dam.
5. **Implement experimental floods below Morelos Dam:** The United States and Mexico should agree on a program of occasional, experimental floods below Morelos Dam for the purpose of restoring native trees and marsh habitat.
6. **Study sediment transport and manage for ecological benefit:** The sediment transport process in the Colorado River channel below Morelos Dam is poorly understood, and should be studied. IBWC should conduct this research as a component of their flood control responsibilities in the limitrophe. Once the sediment transport process is understood, IBWC and CILA should manage sediment to maximize ecological benefit.
7. **Assess regional management practices that affect the riparian corridor and implement practices that minimize harm and maximize benefit:** CNA should identify and mitigate negative impacts to the riparian corridor of irrigation efficiency projects and agricultural-to-urban water transfers.
8. **Build capacity among riparian corridor landowners to improve habitat:** Non-governmental organizations and government agencies should collaborate to conduct outreach workshops to educate riparian corridor landowners about the negative effects of wildfire, and the benefits of augmenting vegetation both for bank stabilization and for habitat.

Rio Hardy Corridor:

1. **Identify and improve Rio Hardy instream flows:** CNA should identify the characteristics of instream flows in the Rio Hardy, and determine flows that would maximize ecological benefit. Flows in the Rio Hardy today are the result of agricultural wastes, and salinity levels are correspondingly high, approximately 3 - 5 ppt. CNA should not allow salinity in the Rio Hardy to increase, and should work to lower salinity levels. The U.S. Environmental Protection Agency should work with CNA, the Comisión Estatal del Agua de Baja California, and the Comisión Estatal de Servicios Públicos de Mexicali (CESPM) to dedicate effluent from the Mexicali II wastewater treatment plant as instream flow for the Rio Hardy, and should explore the potential to create additional wetlands as a means of "pre-treating" water before it enters the Rio Hardy channel. These agencies should work together to set and maintain water quality standards that meet the concerns and expectations of communities along the river. In addition, these agencies should explore opportunities to use the topography and vegetation of the Rio Hardy basin, in conjunction with proper water management, to increase water levels, enhance navigation, and improve opportunities for the development of sustainable economic activities. In addition, these agencies should explore opportunities to create a saltwater marsh that would be of seasonal benefit to shorebirds.

Off-channel wetlands:

1. **Protect the El Doctor and El Indio wetlands:** The Biosphere Reserve of the Colorado River Delta and Upper Gulf of California, in collaboration with Instituto del Medio Ambiente y el Desarrollo Sustentable (IMADES), should assess the quantity and quality of water that sustains these wetlands. CNA, in collaboration with local users, should investigate opportunities to manage local water resources such as agricultural drainwater to maximize the ecological benefit at these wetlands.
2. **Protect desert springs (pozos del desierto):** These unique desert springs depend on a high groundwater table for their water supply. Any increase in local agricultural and municipal groundwater extraction will jeopardize their survival. All plans to increase groundwater withdrawal should be considered by CNA and reviewed by the Instituto Nacional de Ecología (INE) for potential environmental impacts, and negative impacts should be mitigated.
3. **Maintain the quantity and quality of water that sustains the Ciénega de Santa Clara:** The United States and Mexico should commit to an agreement that dedicates a sustaining water supply to the Ciénega. Until this agreement is reached, the United States should refrain from operating the Yuma Desalting Plant.
4. **Assist local communities in developing profitable ecotourism enterprises based on the natural amenities of the Ciénega de Santa Clara and in the Rio Hardy:** Federal agencies such as SEMARNAT and the Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación (SAGARPA) and their state counterparts should provide through rural assistance

programs, and with the assistance of non-governmental organizations, technical and financial assistance to local individuals and organizations that are developing businesses to guide tourists through the Ciénega, guide birdwatchers and boaters, and fishermen and hunters, and should assist these groups to expand their efforts to include the Rio Hardy.

5. **Ponds at Cerro Prieto that sustain desert pupfish should be protected:** The Cerro Prieto ponds, dependent on operational decisions made by managers of the nearby geothermal facility, have become significant refugia for desert pupfish and a critical site for many bird species. Managers of the Cerro Prieto geothermal facility should integrate into their management specific objectives to protect and enhance the wildlife value of these resources.
6. **The Mesa Andrade wetlands should be protected and given a dedicated water source:** SEMARNAT should consider giving these wetlands legal protection through designation as a protected area. Their water source, which has not been well-documented, should be quantified. IBWC and CILA should work with California agencies to explore the possibility of modifying the All American Canal to accommodate flows to sustain the wetlands. If this is not successful, local water managers should explore opportunities to direct drainwater from Mexicali agriculture to the wetlands.
7. **Improve local water management to benefit the Ayala Drain wetlands:** This important agricultural drain and many other smaller drains and mid-field wetlands are potential areas for delta restoration. CNA should work with local irrigation districts and non-governmental organizations to maximize use of Ayala drain water for ecological benefit, and should identify additional local water sources. With improved management, the Ayala Drain wetlands could be connected to Rio Hardy wetlands and eventually to the Ciénega de Santa Clara.

#### Intertidal, Coastal, and Marine Resources:

1. **Study the relationship between freshwater inputs and intertidal, coastal, and marine resources:** While studies have documented the relationship between freshwater flood flows and shrimp productivity in the Upper Gulf, little quantitative is known about the correlation of freshwater floods to other species. Academic and research institutions, led by the INE and the Comisión Nacional de Areas Naturales Protegidas (CONANP), should define and fund a research program that investigates freshwater flows and species including (but not limited to): Gulf croakers (with a focus on reproduction), the gulf clam (mulinia), totoaba, Palmer's saltgrass, and finally the general characteristics of biological productivity and consequent contributions of organic matter to the Upper Gulf. The focus of this research should be to quantify the freshwater flows required to sustain viable populations of various species. The role of freshwater flows in the health of three unique near-shore marine habitats (Isla Consag, Borrascoso, and the Pocitos on the eastern shore of the delta) should be addressed in a concerted and systematic fashion.

2. **Minimize threats to intertidal, coastal, and marine resources from local economic activity:** Shrimp farming, coastal development, sewage deposition, benthic trawling, gillnet fishing, and the development of tidal power generators have all been identified as existing or potential threats to the estuary's health. SEMARNAT and the Instituto Nacional de Pesca (INP), in collaboration with non-governmental organizations, local communities, and the industrial and small-scale fishing sectors, should work to minimize or mitigate the negative impacts of these destructive harvest practices and pollution sources.
3. **Provide local communities with resources to help them develop economic activities not based on marine resource extraction:** Mexican federal and state rural development programs should work in collaboration with non-governmental organizations, entrepreneurs, and coastal communities in the Upper Gulf to define viable economic activities that do not require the extraction of marine resources, and to secure grants or loans to promote these activities.