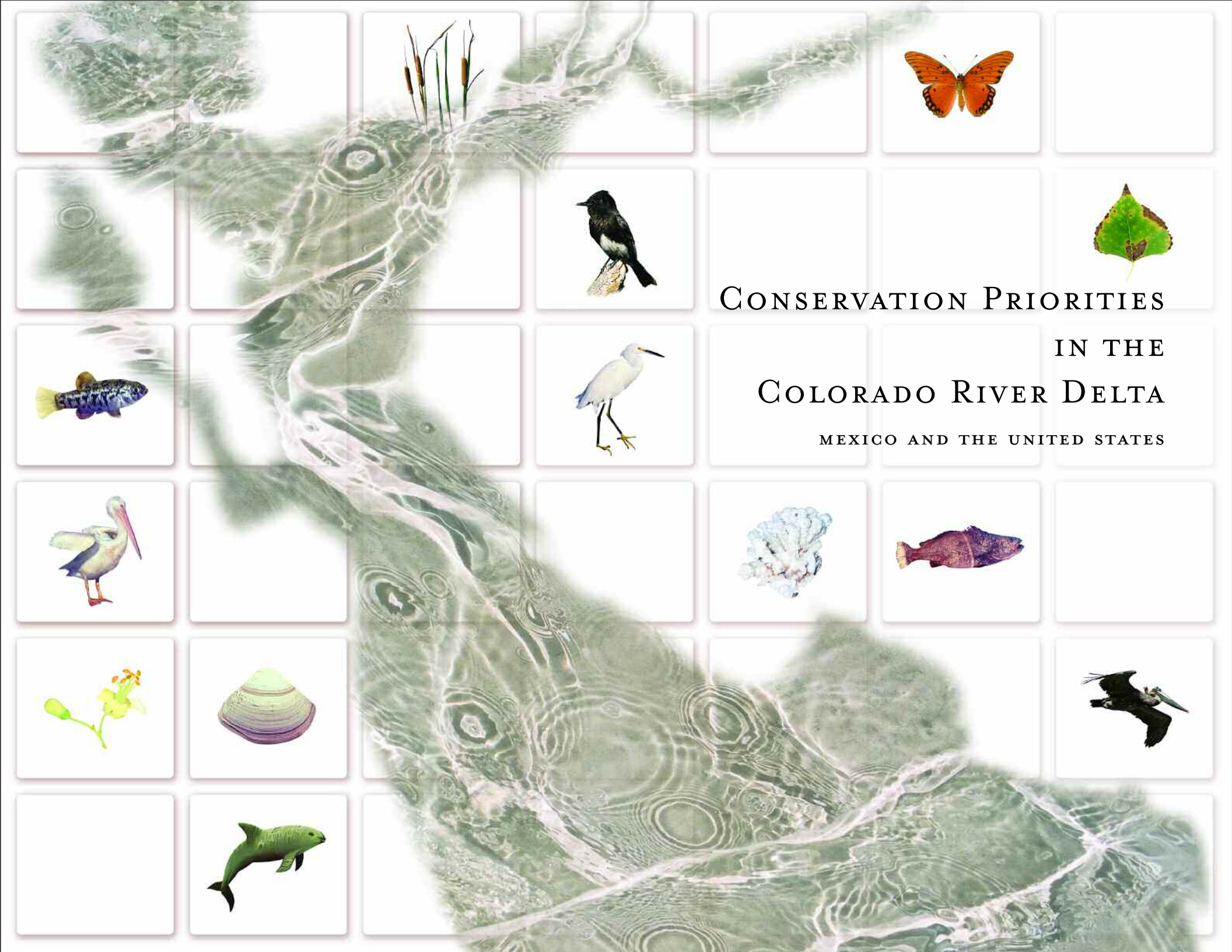

Conservation Priorities in the Colorado River Delta

Mexico and the United States

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Mexico and the United States

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Mexico and the United States

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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 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 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.

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.

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.

Contents

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-Huerta, Silvia Ibarra, Rob Marshall, Eric Mellink, and Robert Mesta. We gratefully acknowledge the help of Karl Flessa, Richard Cudney, Juan Carlos Barrera, Peggy Turk-Boyer, and Lorenzo Rojas in revising the document and the editorial assistance of James Pease, Cheryl Lord-Hernandez, Pat Evans, and Nina Chambers.

We also acknowledge José Beltran, María López, Marcia Moreno, Pam Nagler, Iván Parra, and Miriam Reza who operated the GIS stations; Yamilett Carrillo, Miriam Lara, Cheryl Lord-Hernández, Martin Salgado, and Enrique Zamora who documented the discussion on each session; Rocío Brambila, who coordinated the logistics support before and during the workshop; and to Norma Ramos, Juan Rivera, and Gerardo Sanchez who provided logistics support during the workshop. This group of talented and enthusiastic people made this very complicated exercise run smoothly.

For their financial support of this effort to identify conservation priorities for the Colorado River Delta, we are grateful to:

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foreword

I remember, in my early days as a researcher in the Gran Desierto, reading Sykes' book *The Colorado River Delta* with sadness and a heavy heart. The book describes the beautiful lushness of the Delta in the early 1900s, before the river was dammed, and it evoked in me a feeling of melancholic sorrow. How could two nations have signed a treaty condemning some thirty thousand acres of prime wetlands and beautiful estuaries to tragic extinction? How could two societies have been so blind?

At that time, we all thought the Delta was gone, vanished forever. We thought there was no Delta anymore. But then, the El Niño year of 1982/1983 came, and the Colorado River flowed back into the estuary. Some said it was like in the old days; like only but a few remembered seeing ever: a powerful stream of freshwater reaching the Upper Gulf. It was so wonderful.

And then, as the months passed, the stories started trickling slowly, almost as a whisper among nature lovers and conservationists: The old channels had filled up, cottonwoods had germinated in the old banks and in the levees, and aquatic plants were sprouting all over the flood-lands and the channels. The Delta was back—perhaps a ghost image of its original glorious self, but nonetheless it was back!

And good news kept flowing, like the born-again mighty river had flowed for a few months: Ed Glenn, Dick Felger, and Alberto Búrquez surprised the conservation community with their description of the Ciénega de Santa Clara, revealing that not only the river-flow itself but even agricultural drainage could sustain wetlands.

The rest is history: Conservation groups started to organize to defend this newly found treasure, to map, to research, to explore; to identify conservation priorities for the Delta, and to propose means to protect it. This is what this report is about; it is about preserving a heritage we all thought was gone forever, it is about commitment for the preservation of an essential life-supporting ecosystem. Ultimately, it is about love for nature—biophilia—one of the most fundamental human values. And it is about fostering hope for a more viable, sustainable future.

I thank the authors for their initiative and their effort. This report, I hope, will become a roadmap for many years, a fundamental guide for conservation efforts. Ultimately, it means renewed hope for the Delta.

For those of us that have known this region and worked in it for more than 30 years, it seems almost like a miracle.

Exequiel Ezcurra
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Executive Summary

The Colorado River Delta, including the Upper Gulf of California, has long been recognized as one of North America's most unique and valuable ecosystems. The area serves as habitat for more than 350 bird species, and harbors a number of endangered species including the Yuma clapper rail, the southwest willow flycatcher, and the world's smallest and rarest marine mammal, the vaquita porpoise.

Years of massive upstream water diversions from the Colorado River have taken their toll on the Delta and the Upper Gulf, greatly reducing the historical freshwater inflows that originally sustained nearly two million acres (800,000 hectares) of wetlands and incredibly productive fisheries. The Delta is surprisingly resilient. In fact, several recent decades of wetter than normal years have helped to revive key portions of the Delta ecosystem, including high quality wetlands and a riparian habitat corridor along the lower Colorado River.

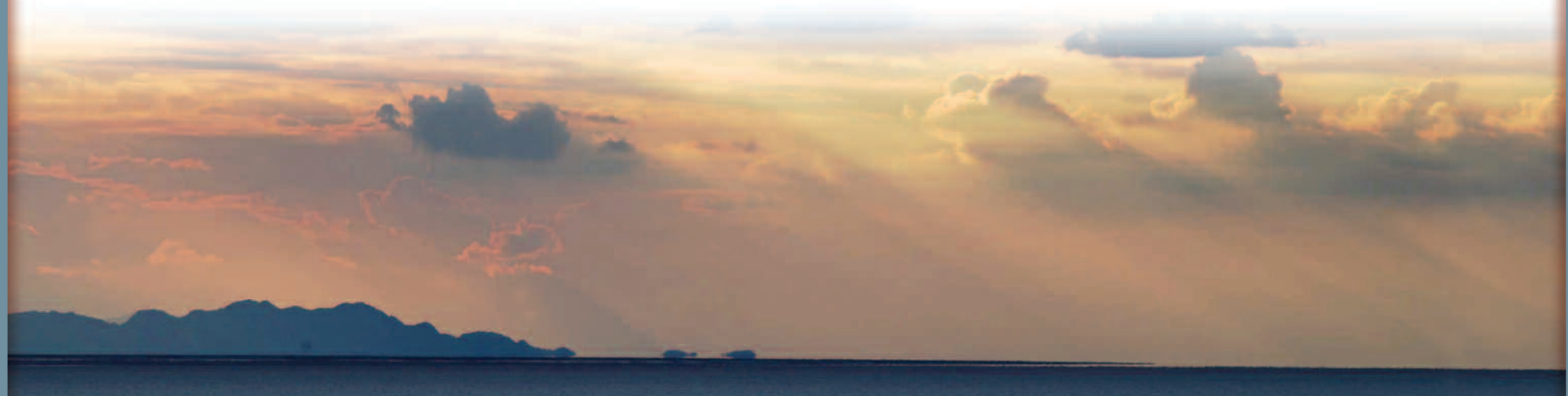
This report presents and describes a list of conservation priorities for the Colorado River Delta and Upper Gulf of California. These conservation priorities consist of the Delta and Upper Gulf's most important ecological sites, be they in excellent shape or in need of restoration. The analysis of information and selection of these areas took place on October 10–11, 2002, when some 55 scientific experts and resource managers gathered in Tijuana, Mexico to review and discuss the "state-of-knowledge" for the Colorado River Delta and Upper Gulf of California. In two intense days, these individuals worked together to complete an ecological exercise that identified conservation targets (species, habitats, and biophysical processes) as well as the specific sites—conservation priorities—where the targets are located.

In identifying these conservation priority areas, special emphasis was put on 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. That is, the experts made the strategic and tactical decision to identify only those areas in which restoration or protection was practical and cost-effective. These conservation priority areas represent a small fraction of the total area affected by human alteration and water diversion.

The workshop participants identified 15 conservation priorities, all of which are mapped and described in detail in Chapter 3. In addition, they identified threats to the conservation priorities, opportunities to restore them, and their water needs. Finally, they established a prioritized list of research and data needs, presented in Chapter 4. With this information, the authors of this report (the workshop conveners) developed the following recommendations for the conservation and restoration of the ecosystems of the Colorado River Delta and Upper Gulf of California.

Conclusions

- 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 electronic version of this report, available at the Sonoran Institute web site at www.sonoran.org.

- The principal 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 curtailment as consumptive water use increases, out-of-basin water transfers increase, and climate change reduces the total basin water yield. The agricultural return flows and groundwater seepage from canals that sustain wetlands and riparian areas, such as Ciénega de Santa Clara, Andrade Mesa wetlands, and Río Hardy, are not guaranteed and also likely to be reduced by greater efficiencies in water use in the area.
- 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. Until the United States and Mexican federal governments make restoration of the Delta and Upper Gulf a priority, however, the health of these ecosystems cannot be assured, and large-scale improvements in ecosystem health will remain unattainable.
- Each of the ecosystem types in the Colorado River Delta and the Upper Gulf of California have distinct attributes, values, and water needs. Each is threatened with loss of resource value and each has opportunities for restoration. All of the ecosystem types are linked through their dependence on the hydrologic regime of the Colorado River.

Recommendations

- 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.
- The United States and Mexico should use Minute 306 of the *U.S.-Mexico Treaty for the Utilization of Waters of the Colorado and Tijuana Rivers and of the Río Grande* as a framework for developing a conservation and restoration plan for the Colorado River Delta.
- 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 includes quantified, dedicated sources of water for the environment through a binational agreement, national policy, or market-based mechanisms.
- 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, or market transactions.
- 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.

- All entities engaged in activities that may affect the region's ecosystems should engage in consultation with local communities in the Delta.
- Government agencies and other funding institutions in both countries should commit resources to support research as outlined in Chapter 4.

Next Steps

The Colorado River Delta and Upper Gulf of California have demonstrated resiliency, and the remaining ecosystems have tremendous local, regional, and continental value despite a dramatic reduction of freshwater flows. What little freshwater that still flows to this area is destined to disappear, however, without successful efforts to secure it for the environment. We don't know when the wet years experienced in the 1980s and 1990s will return, and until then the Delta and Upper Gulf will need a deliberate allocation of water to survive. Given that these needs are small (the estimated water requirement for the Delta's riparian ecosystem is about 1% of the total annual average flow of the Colorado River), this allocation should be possible.

The United States and Mexico already have formed a venue for the study and consideration of conservation of the Colorado River Delta, which is the binational working group established to implement Minute 306 to the *U.S.-Mexico Treaty for the Utilization of Waters of the Colorado and Tijuana Rivers and of the Río Grande*. Minute 306 is the "Conceptual Framework for U.S.-Mexico Studies for Future Recommendations Concerning the Riparian and Estuarine Ecology of the Limitrophe Section of the Colorado River and its Associated Delta." This binational working group should be the seat of formal cooperation between the two countries on the Delta, and as such should consider all of the conclusions and recommendations in this report, as well as the full body of information presented herein.

Two current planning processes may offer an opportunity to realize some of the recommendations in this report, specifically those for the riparian corridor of the Colorado River. In the United States, the Cocopah Indian Tribe has initiated a feasibility study for the designation of the limitrophe reach of the Colorado River as an international protected area. In Mexico, several non-governmental organizations (NGOs) are working with agencies at SEMARNAT and state government to assess the feasibility of protecting the entire Colorado River riparian corridor in Mexico.

Many organizations in the U.S. and Mexico are already working to find ways to secure reliable instream flows for the conservation priorities in the Colorado River Delta and Upper Gulf of California. This report adds detail to the water needs of the Delta and Upper Gulf, and should help to advance these efforts. The authors of this report, as well as many of the workshop participants, are committed to the conservation and restoration of the Colorado River Delta and Upper Gulf of California. We hope that the information presented in this report inspires other organizations and government agencies to join in this important pursuit.

1

Identifying Conservation Priorities

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 abundance and diversity of animals and plants. The Delta was of critical importance to resident and migratory birds, which by the hundreds of thousands found food and shelter there. Today, the Delta has been reduced to 10% of its original size after 65 years of vigorous water management to satisfy agricultural, 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, and non-governmental organizations, 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 minimal but continuous flows, have provided clear evidence of the Delta's capacity to re-establish many of its ecological functions. Surveys demonstrate that the Colorado River below Morelos Dam (the northernmost extent of the Delta) contains significantly more native trees and wetlands than does the lower Colorado River in the United States, which extends from Lake Mead south to Morelos Dam, 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.

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 2.3 million acres (930,777 hectares) as the Biosphere Reserve of the Upper Gulf of California and Colorado River Delta. Two ecological priority-setting exercises, one for the Sonoran Desert Ecoregion (Marshall et al. 2000) and one for the Gulf of California Ecoregion (World Wildlife Fund 2004), 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. Despite these positive developments, the Colorado River Delta continues to be classified as one of North America's ten most endangered rivers (American Rivers 1998). Demands for Colorado River water are likely to increase as the area's population grows and climate warms, and fishing activities and coastal development increase in the northern Gulf of California. The pressures on those Delta habitats that retain their natural values are sure to increase.

PURPOSE

In the past six 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 of scientific, economic, and environmental issues, and strategies for its restoration, none responded to a basic requirement of sound conservation planning. Furthermore, these meetings lacked the detailed analysis to identify priority areas for conservation and to set the foundation for a comprehensive conservation plan. The workshop in Mexicali in 2001, and its report, are the most recent activities within the framework established by Minute 306. This Minute was signed by the United States and Mexico as a framework for developing a conservation and restoration plan for the Colorado River Delta. A binational committee has only recently been formed to further the analysis of the Delta conservation issues.

In bringing together 55 Mexican and U.S. scientists, water managers, and local resource users, this workshop provided, for the first time, opportunities to work in an interdisciplinary way to analyze the most recent information on the Delta. The task set for each session was to look at the biological importance of Delta areas, 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 sites, special emphasis was put on 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. That is, the experts made the strategic and tactical decision to identify only those areas in which restoration or protection was practical and cost-effective. These conservation priority areas represent a small fraction of the total area affected by human alteration and water diversion. Also, a state-of-knowledge and gap analysis allowed participants to identify priority research needs.

Experts

People from the U.S. and Mexico with personal experience and knowledge of the Delta. This group included scientists from universities, non-governmental organizations, and government agencies, as well as representatives of resource user groups, such as fishermen and tribes.

Observers

Representatives of stakeholder groups in the U.S. and Mexico that may not have direct knowledge of the Delta ecosystems, but do have a vested interest in the process and the products. This group included representatives from non-governmental organizations, federal and state agencies, and water user groups.

AREA OF INTEREST

The workshop focused on the Delta in Mexico as well as the U.S. portion along the international boundary formed by the Colorado River. The total area (3 million acres) included not only terrestrial areas (1.5 million acres), but also the intertidal and coastal zone (1.5 million acres), following the limits of the Biosphere Reserve.

The area of interest was divided into seven ecological zones based on distinct biophysical characteristics (see Table 1.1 and Figure 1.1). These zones are important in the Delta both in a local context as well as in the context of regional ecological functions: for example, as part of the Pacific Flyway.

TABLE 1.1 DESCRIPTION OF ECOLOGICAL ZONES USED IN THE WORKSHOP

Ecological Zone	Description	Acres	Hectares	Habitat Types
Riparian Corridor	Colorado River, from Morelos Dam to the confluence with the Río Hardy	65,376	26,468	Cottonwood-willow forest intermixed with salt cedar and other native bushes
Río Hardy	Río Hardy basin, from Cerro Prieto to the confluence of Colorado River, including Pescaderos River	45,235	18,314	Perennial stream with cattail marshes and salt cedar along the river banks
Intertidal	From coastline to upstream areas at the confluence of Río Hardy with Colorado River	157,816	63,893	Mudflats and saltgrass beds
Coastal/Marine	Coastal waters in the Upper Gulf	1,391,175	563,229	Predominant sand and mud benthos with occasional rocky outcrops
Off-channel Wetlands	Includes Ciénega de Santa Clara, El Doctor, Cerro Prieto, El Indio, and Andrade Mesa Wetlands	187,917	76,080	Cattail marshes, mudflats, springs, and open water lagoons
Greater Laguna Salada Basin	Laguna Salada and other areas subject to inundation only during major tides or large river floods	590,906	239,233	Shallow flooded basin to a dry evaporation pan
Farmland	Agricultural Irrigation District 014 and other farmland	685,283	277,443	Agriscape and vegetated irrigation drains
	Total Area	3,123,709	1,264,659	

The authors eliminated the open desert zone, proposed during the workshop, because it is adjacent to but not part of the Delta region.

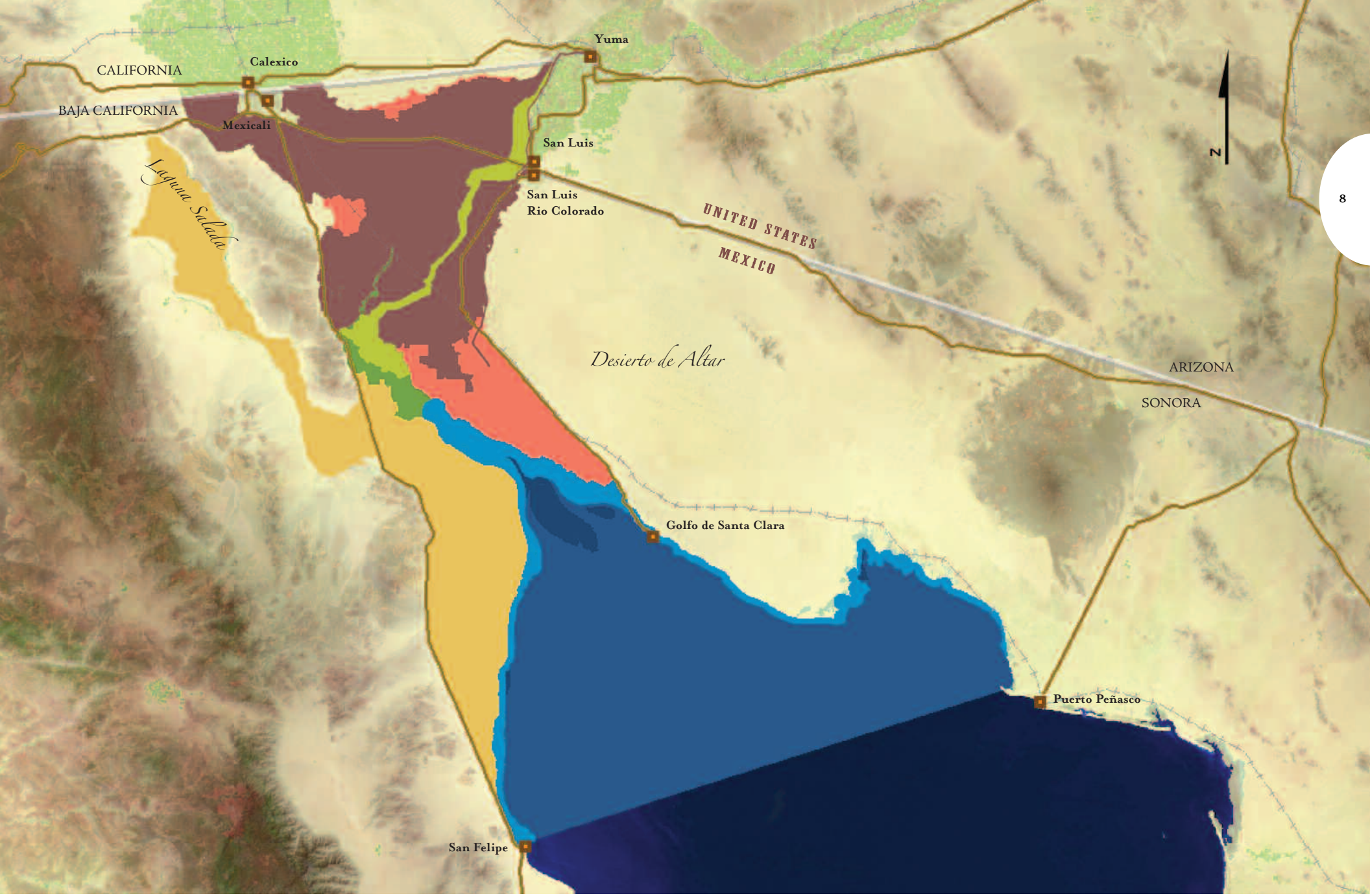


FIGURE 1.1 MAP OF THE ECOLOGICAL ZONES USED IN THE WORKSHOP

WORKSHOP PROCESS

In order to map conservation priorities in the Colorado River Delta, the workshop organizers 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. The workshop consisted of a three-part process illustrated in Figure 1.2. Details of the workshop methodology are outlined in Appendix 1.

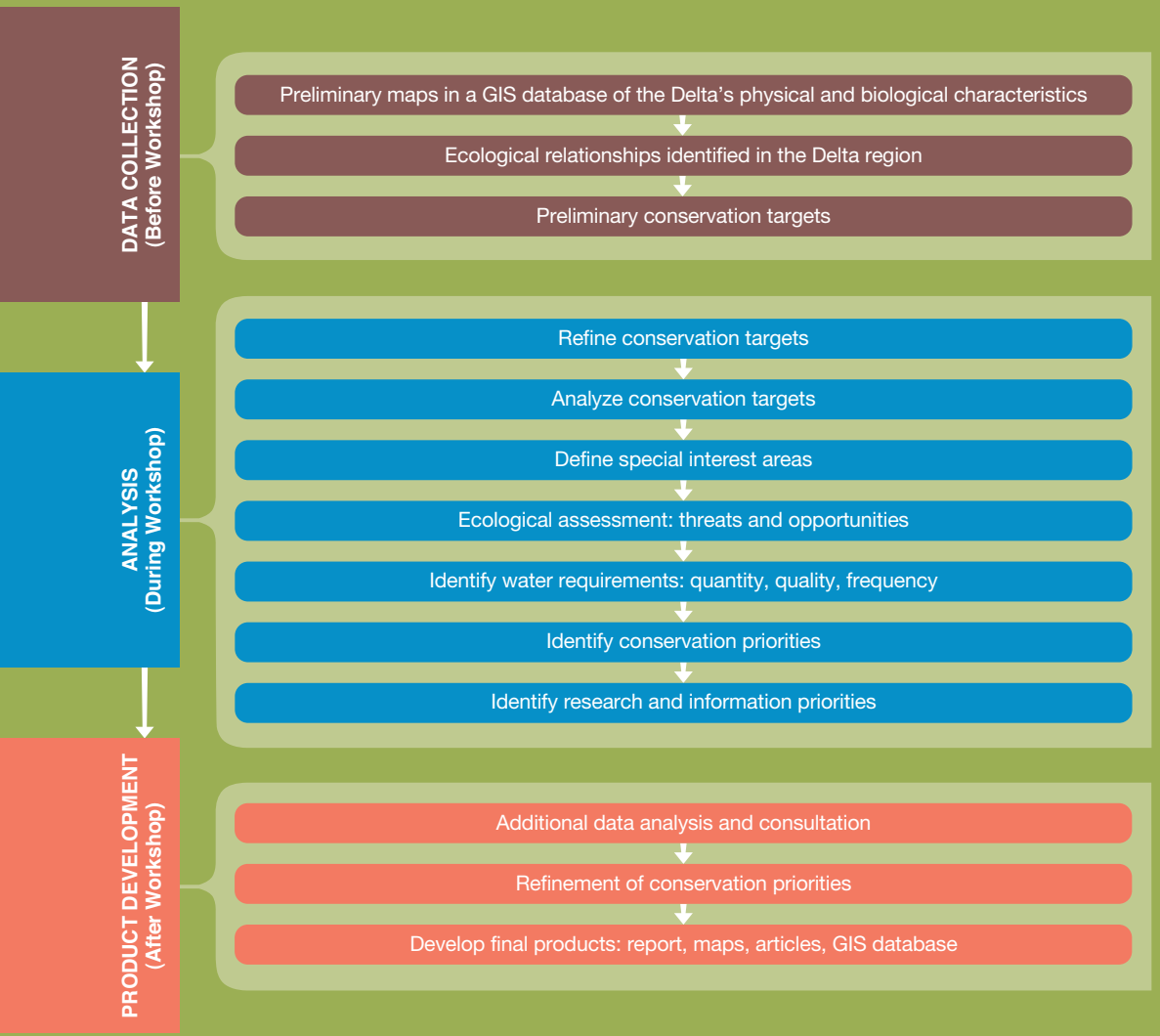


FIGURE 1.2 THREE-PART PROCESS USED IN THE WORKSHOP

DEFINITIONS

Conservation Priorities

Areas that are in urgent need of conservation action

Threats

Impacts on biological features (vegetation clearing, burning, exploitation) or physical features (changes in river morphology)

Opportunities

Biological or physical improvements that can be implemented to maintain or enhance ecological functions in the Delta

TARGETS

Summary of targets as presented in Chapter 2.

Major Species Targets

- Riparian obligate breeding birds (e.g., southwest willow flycatcher and yellow-billed cuckoo)
- Marsh birds (e.g., least bittern, California black rail, Yuma clapper rail, and the American coot)
- Migratory land and water birds
- Nesting water birds
- Most aquatic native amphibians and reptiles
- Beavers
- Desert pupfish
- Palmer's saltgrass
- Vaquita and totoaba
- Gulf clam
- Gulf corvina
- Shrimp species
- Bonytail fish
- Razorback suckerfish
- Woundfin fish
- Bluewhale
- Bottlenose dolphin
- California sea lion

Major Habitat Targets

- Cottonwood and willow riparian forest
- Perennial river stretches with cattail and bottomland vegetation
- Brackish ponds habitat for desert pupfish
- Marsh wetlands
- Remnants estuarine wetlands
- Palmer's saltgrass flats
- The entire marine zone

Major Processes Targets

- Invertebrate and vertebrate species' life cycles
- Natural sediment transport and delivery
- Hydrology-base and flood surface flows and groundwater flows in the river and other wetlands
- Mixing of fresh and marine water and presence of tidal currents

2

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. 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 (Groves et al. 2002). Conservation targets can be individual species, communities, ecosystems, or physical features like important hydrological features. For this workshop, experts identified conservation targets in five thematic groups:

Each expert 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 by thematic group. The major conservation targets are grouped by type: species, habitat, and processes. The detailed description of each target is presented in Appendix 2.

Coastal and Marine Resources

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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 endemic to the region. Three unprotected species were also selected as targets: Colorado Delta clam (*Mulinia coloradoensis*), the Gulf corvina (*Cynoscion othonepterus*), and shrimp species (blue shrimp: *Litopenaeus stylirostris* and brown shrimp: *Farfantepenaeus californiensis*). The Colorado Delta clam and Gulf 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 the 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.

GAPS IN KNOWLEDGE

- The amount of water going into the ocean, and minimum freshwater flows needed in the marine ecosystem
- The effect of shrimp trawlers in the marine ecosystem
- The effect of tourism development
- A baseline for physical, chemical, and biological processes in the Upper Gulf

Fish and Marine Mammals

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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 Heller's anchovy (*Anchoa helleri*), respectively. For the Sciaenids (corvinas), the bigeye croaker (*Micropogonias megalops*), the totoaba (*Totoaba mcdonaldi*), and Gulf corvina (*Cynoscion othonepterus*) were selected as targets. For Serranids (groupers), participants selected as targets the Gulf coney (*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, the 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*); and one Lutjanid (snappers), the green bar snapper (*Hoplopagrus guntheri*). 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*). It was proposed that marine mammals serve as an 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 (*Oreochromis* spp.) and large mouth bass (*Micropterus salmoides*), 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.

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:

- Sea lions
- Bottle-nosed dolphin
- Manta rays
- All sharks
- Marine mammals and sea turtles (particularly monitor strandings of moribund individuals)

Terrestrial Vertebrates

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CONSERVATION TARGETS

The terrestrial vertebrates expert group focused its attention on identifying specific species and habitats associated with these conservation targets, but did not identify any processes.

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 3. 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-Huerta et al. 2004a). For a full description of current status and required management actions for bird species management, the reader is referred to this plan (available in the companion CD-ROM to this report). Eight marsh birds were combined as a conservation target. Four are focal or of special interest: least bittern (*Ixobrychus exilis*), California black rail (*Laterallus jamaicensis coturniculus*), Yuma clapper rail (*Rallus longirostris yumanensis*), and the Virginia Rail (*Rallus limicola*). The Yuma clapper rail is endemic to the Delta and lower Colorado River, protected as a threatened species in Mexico and endangered in the U.S., whereas the California black rail is endangered in Mexico and in California as well as a priority species for conservation in the U.S. 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 nesting, roosting, 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 (*Empidonax traillii extimus*) as an endangered species and the yellow-billed cuckoo (*Coccyzus americanus occidentalis*) 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 the Colorado River toad (*Bufo alvarium*), the lowland leopard frog (*Rana yavapaiensis*), the Sonora mud-turtle (*Kinosteron sonorensis*), and the checkered garter snake (*Thamnophis marcianus*). These species indicate the quality of freshwater aquatic habitats. Populations of these species have decreased considerably, with lowland leopard frogs probably extirpated from the Delta, whereas the Sonoran mud-turtle has never been collected in the Mexican portion of the Delta. 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 (*Castor canadensis*) and Palmer's saltgrass (*Distichlis palmerii*). The beaver is important as an indicator of freshwater and for creating wetlands by dam building. In the case of the Delta, beavers come from upstream when water is released into the river and flows past Morelos Dam. The saltgrass 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 (*Pelecanus* spp.), grebes (*Podiceps* spp.), terns (*Sterna* spp.), and gulls (*Larus* spp.), and as feeding grounds for nesting waterbirds.

Gaps in Knowledge

In general, there was a reasonable amount of information available for many of the species in the different conservation targets. The following important gaps, however, were identified:

- 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

Habitat and Vegetation

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CONSERVATION TARGETS

The habitat and vegetation expert group used a large-scale approach to identify conservation targets for habitats and specific vegetation species associated with them, but did not identify any processes.

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 larger 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 Palmer's saltgrass (*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 four of the off-channel wetland sites. The remaining habitat sites are either privately held or managed by Mexico's National Water Commission 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 Palmer's saltgrass (*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.

GAPS IN KNOWLEDGE

The group identified the need for:

- Detailed channel morphology
- Complete and detailed vegetation map

Hydrological Features

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CONSERVATION TARGETS

To identify targets for hydrological processes, the group focused its analysis on hydrologic 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. Due to the unique nature of conservation targets for hydrologic form and function, this section's structure differs from the rest.

Mainstem and Backwater Areas

The group identified the hydrological processes that sustain the limitrophe section as conservation targets, because the limitrophe is most likely to have permanent water throughout the year in the main channel (see Table 2.1). 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 hydrologic 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 irrigation drain water sources as conservation targets, including: the flows from the Main Outlet Drain Extension (MODE) into the Ciénega de 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 Wellton-Mohawk Irrigation and Drainage District in the U.S. (see Table 2.1).

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 results in the cancellation of a water order), the National Water Commission (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, which extends from 10 miles above the confluence of the Río Hardy and the Colorado River to 30 miles downstream to the river mouth, was considered a conservation target because of its importance to estuarine productivity, nursery habitat for macro invertebrates, fish of value to fisheries, and food chain to support migratory wetland birds.

TABLE 2.1 FLOW DISCHARGES INTO COLORADO RIVER MAINSTEM BELOW MORELOS DAM AND RÍO HARDY, 1998–2002 (IN THOUSANDS OF ACRE FEET)

Source/Year	1998	1999	2000	2001	2002
Colorado River through Morelos Dam	2,405	861.0	135.0	110.0	33.0
Operational spills in Mexico					
Wasteway Km. 27	223.0	100.0	51.0	12.0	5.0
Wasteway Canal Barrote	18.0	7.0	20.0	13.0	5.0
San Luis residual waters*	8.0	9.0	9.7	9.7	10.5
Agricultural return flows					
Plan de Ayala Drain	17.8	13.7	17.8	13.7	15.4
Santa Clara Drain	14.5	12.0	13.0	12.0	11.0
Drains into Río Hardy	13.0	11.3	11.3	6.5	4.0
Wellton-Mohawk into Ciénega de Santa Clara	113.0	78.6	107.7	103.7	105.0
Total flow to the Delta	2,812	1,092	365	280	189

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: Organismo Operador Municipal de Agua Potable, Alcantarillado y Saneamiento (2003).

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
- Estimates of water needs for riparian and estuarine habitat
- Influence of freshwater flows on estuarine processes

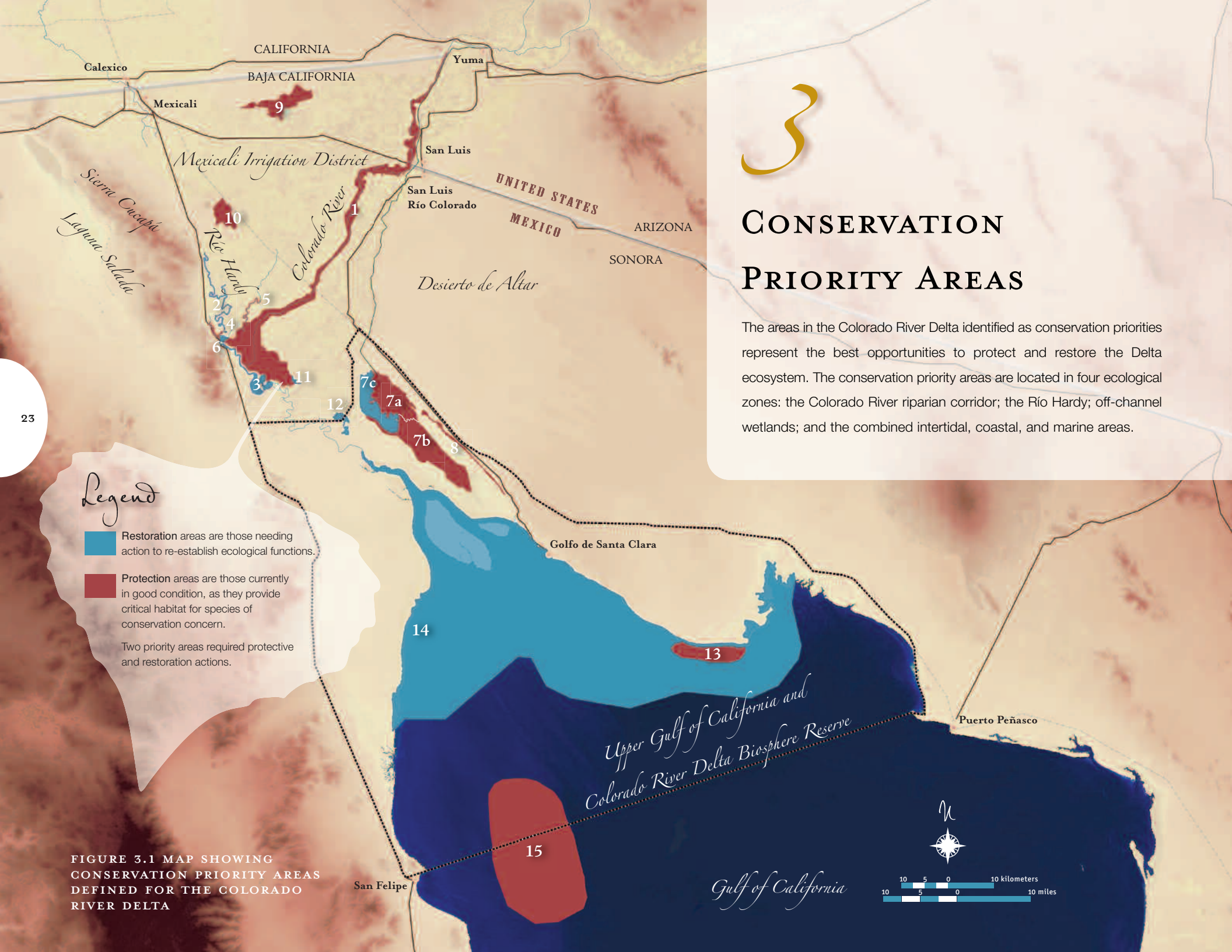


FIGURE 3.1 MAP SHOWING CONSERVATION PRIORITY AREAS DEFINED FOR THE COLORADO RIVER DELTA

3

Conservation Priority Areas

The areas in the Colorado River Delta identified as conservation priorities represent the best opportunities to protect and restore the Delta ecosystem. The conservation priority areas are located in four ecological zones: the Colorado River riparian corridor; the Río Hardy; off-channel wetlands; and the combined intertidal, coastal, and marine areas.

The experts' workshop defined a total of 15 conservation priority areas for the Colorado River Delta and Upper Gulf of California in Mexico and the United States (Figure 3.1). Totaling 849,397 acres (343,740 hectares), these areas constitute 27% of the total area of interest shown in Figure 1.1. Conservation priority areas, varying in size and type of habitat (Table 3.1), 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" or for "restoration." Protection areas total 264,438 acres (107,015 hectares) and are those areas currently in good condition that should be protected to provide critical habitat for species of conservation concern, including those endangered or threatened, in the U.S. or Mexico. Restoration areas total 584,958 acres (236,725 hectares) and are those areas needing restoration action to re-establish ecological functions. This chapter describes each conservation priority area, including threats to their viability, opportunities for conservation, and water needs. To identify the relative impact of various threats, we describe the threat status (existing or potential), the severity of its impact (low, medium, high), and whether its impacts may be overcome and the resource returned to its original condition once the threat disappears (reversibility).

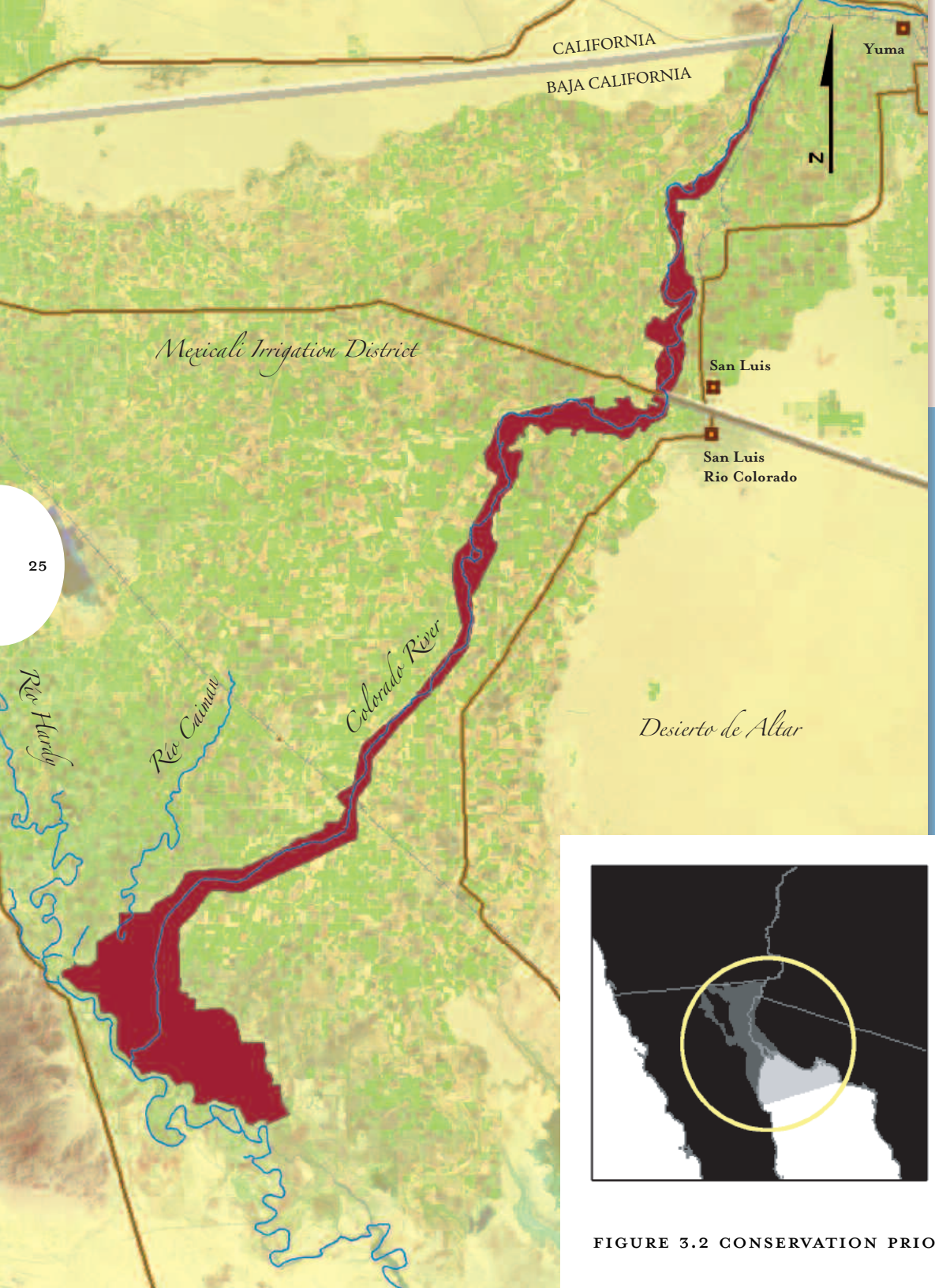
The information presented in this chapter consists primarily of experts' contributions during the workshop and a review of the literature before the workshop. Additional details were contributed after the workshop by the authors of this report as they continued their research activities in the Delta and Upper Gulf, drawing on work already published, 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. This chapter does not, however, 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.

Ecological Zone		Conservation Priority Areas	Size (acres)	Habitat Type
Riparian Corridor	1	Riparian Corridor	51,010	Cottonwood-willow forest; salt cedar; and cattail marshes with open water
Río Hardy	2	Upper Río Hardy	3,355	Perennial river, with salt cedar and isolated patches of mesquite and cattail marshes
	3	Río Hardy Cucapá	4,337	Salt cedar with cattail and reed marshes and isolated patches of mesquite; small stream flow
	4	Campo Mosqueda Restoration	53	Upland area with mesquite and native bushes
	5	Caiman	692	Agricultural drain with common reed, salt cedar, and cattail
	6	Campo Sonora - Río El Mayor	483	Upland vegetation, marshes, and open water areas with aquatic vegetation
Off-channel Wetlands	7a	Ciénega de Santa Clara Marsh	15,189	Brackish marsh wetland with emergent vegetation dominated by cattail
	7b	Ciénega de Santa Clara Mudflats	24,680	Mudflat with shallow water areas
	7c	Ciénega de Santa Clara Restoration	12,396	Low lying areas with bare land
	8	El Doctor Wetlands	2,135	Springs: open water and cattail marsh and vegetated upland areas with mesquite and salt cedar
	9	Andrade Mesa Wetlands	9,711	Marshes with open water and emergent vegetation; playas, partially vegetated; vegetated dunes
	10	Cerro Prieto Ponds	4,985	Ponds in the brackish salinity range with sparsely vegetated small islands
	11	Pangas Viejas Wetlands	288	Marshes with open water and emergent vegetation; salt cedar
	12	El Indio Wetlands	1,927	Marshes with open water and emergent vegetation; salt cedar
Intertidal, Coastal, and Marine	13	El Borrascoso	14,364	Rocky shores
	14	Coastal and Estaurine	565,476	Coastal and estaurine
	15	Vaquita Marina-Roca Consag	138,317	Coastal-marine

TABLE 3.1 CONSERVATION PRIORITY AREAS BY ECOLOGICAL ZONES

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) downstream from the dam 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 11 miles (18 km) in its lower end, the riparian corridor is subject to over-bank flooding during major flood events. During the last two decades, low annual flows combined with large flood events have re-established significant native riparian plant communities.



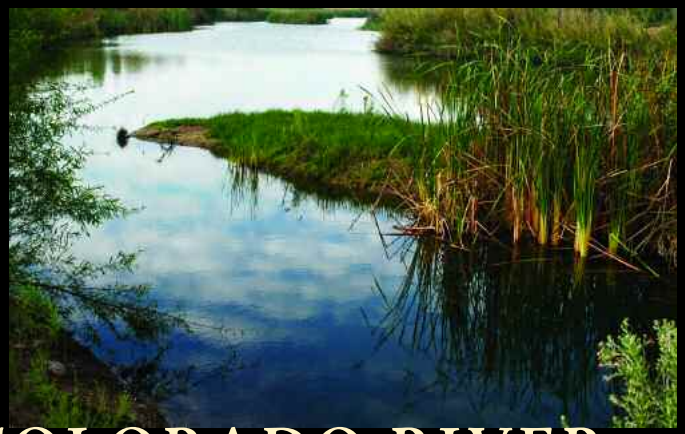
LEGEND

- City
- Highway
- Railroad
- River
- International Boundary

CONSERVATION PRIORITIES

- Protection
- Restoration

FIGURE 3.2 CONSERVATION PRIORITY: COLORADO RIVER RIPARIAN CORRIDOR



conservation priority:

THE RIPARIAN CORRIDOR OF THE COLORADO RIVER

This area includes all natural areas within the levees, excluding agricultural lands, and extends from Morelos Dam downstream to the point where the last stands of cottonwood and willow are found (Figure 3.2). This priority area is 51,000 acres (20,643 hectares) in size, and includes the largest dense stands of cottonwoods and willows in the lower Colorado River basin. This habitat, along with other vegetation and open water areas in backwaters and oxbows, is critical for a variety of riparian birds and other wildlife species. Some sub-areas of the riparian corridor, mainly bare soil and salt cedar 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. Because of these characteristics, this area is designated a priority for protection as well as for restoration.

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 these.

Factors 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 water quality (native riparian vegetation has a low salt tolerance [3–4 parts per thousand (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-Arroyo et al. 2001, Glenn et al. 1998 and 2001); however, artificial plantings can sometimes survive in 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.

The vegetation patterns in the riparian corridor of the Colorado River Delta are directly related to river flow patterns and salinity of surface and groundwater. Particularly, native tree populations are extremely dynamic and depend upon a continuous instream flow and repeated pulse flood events to survive. 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 captured upstream to fill the recently 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 controlled releases of water are necessary. 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. Upstream of Morelos Dam in the United States, the Colorado River channel capacity is so large that floods very rarely spill onto the floodplain of the river. Consequently, little native riparian vegetation has survived, and salt-tolerant plant species (halophytes) have become established. Downstream of Morelos Dam, the channel is much smaller, and the floodplain within the levees has experienced periodic flooding since the early 1980s. This flooding has maintained the dynamic of river meander, and has also sustained the native riparian species that can tolerate neither the absence of flooding (when they would be replaced by halophytes), nor constant flows.

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 meters), much taller than surrounding salt cedar and other shrubs, which were mostly 6–13 feet (2–4 meters) in height. Mesquites were rare.

By 2002, the tree populations had changed considerably (Nagler et al. in press). 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. Based on 2002 field surveys, Nagler and others (in press) indicate that 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 1980s 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).

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 since 2000 have promoted the growth of new native trees, mainly willows, along the main river channel. Sampling of local wells near the riparian corridor indicate that depth to groundwater is shallow (3 feet [one meter]), even when the river channel is nearly dry, suggesting that the direction of groundwater flow during non-flood periods is from the groundwater into the channel (Nagler et al. in press, Zamora-Arroyo et al. 2001).

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 press). In the 2002 field survey, the river channel had developed areas of emergent marsh, dominated by cattails, common reed, and bulrush.

The recent pattern of low but steady flows may account for changes in bird species abundance as birds have responded positively to resulting changes in vegetation in the last two decades. Some bird species, like the yellow-billed cuckoo and yellow-breasted chat, have returned to the riparian corridor, and others like the vermillon flycatcher and ash-trouted flycatcher, appear to be increasing in abundance but are not yet as common as they used to be (Hinojosa-Huerta et al. 2004a, see Appendix 3). Some bird species were more abundant during 2002–2003 surveys than in 1996, while others were more abundant in 1996 (Ruiz-Campos and Rodriguez-Meraz 1997, Hinojosa-Huerta et al. 2004a), suggesting that modest instream flows have a positive effect on populations of resident riparian birds and a negative effect on others as their relative abundance decreases. Certain sensitive species, however, such as the willow flycatcher and yellow warbler, have not yet returned, while some have returned but are not significant in number (Hinojosa-Huerta et al. 2004b). This seems to be related to other vegetation characteristics, such as age and canopy structure, that define which bird species are present. Some species may require older willows that are

not yet abundant. Riparian flooding is also essential to the neotropical migratory birds that depend on the river corridor. The insects that breed in riparian backwaters, and the understory 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. Salt cedar interspersed in the native species adds to the diversity of foliage, providing habitat for a diversity of bird species.

Preliminary results from research in progress indicate that the diversity and abundance of birds is positively correlated with the abundance of native trees and surface water (O. Hinojosa-Huerta, personal communication November 22, 2004). For some bird species, salt cedar provides important nesting habitat, including the Southwest willow flycatcher. It appears, however, that all birds prefer areas dominated by cottonwood-willow, with a complex vertical structure complemented with a diversity of other plants, including seep willow, arrow-weed, saltbush, and salt cedar. Apparently salt cedar serves as habitat for birds when found in combination with native plants (O. Hinojosa-Huerta, personal communication November 22, 2004). The best salt cedar habitats are those with wet soils or surface water, or both, where trees grow larger and thicker; however, where salt cedar monocultures support high densities of birds, diversity of bird species is usually low (O. Hinojosa-Huerta, personal communication November 22, 2004). In areas where salt cedar is mixed with other riparian vegetation, bird diversity increases. In general, migratory birds have more flexibility in choosing habitat than resident species. These observations suggest that where salt cedar dominates because water quality is limited, or flood regimes are non-existent, it may make sense to maintain salt cedar rather than eradicate it, because native vegetation will not be able to colonize in those conditions. Eradication of salt cedar is recommended only where manual planting and maintenance of native trees is ensured.

Mesquite is a hardy species that attracts insects, and birds might benefit if the riparian corridor is managed to replace salt cedar 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, arroweed, and others is a very productive habitat for insects and the birds that feed on them (O. Hinojosa-Huerta, personal communication November 22, 2004).

The riparian corridor is used by migratory 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 to their wintering grounds in southern Mexico and Central America (little is known about other migratory 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 of the remaining Colorado River riparian corridor below Morelos Dam.

Morelos Dam

While there is a distinct difference between the quality of Colorado River riparian habitats below and above Morelos Dam, it remains important to recognize the connectivity of the water source and the potential for connectivity of habitat. It is clear that the hundreds of thousands of migratory 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 land birds in the riparian corridor is not high, likely because birds are dispersed in the wide floodplain (Hinojosa-Huerta 2004a). Densities of these birds are higher in 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 mudflats, but the riparian corridor 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 land birds, 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 and depends on 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, and not necessarily the volume of flow (Zamora-Arroyo 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 (37–61 million m^3) flowing year-round at a rate of at least 70 cubic feet per second (cfs [2 m^3/s]), and a periodic pulse flow that inundates a portion of the floodplain between the levees of 260,000 acre-feet (320 million m^3), at a rate of 3,500–7,060 cfs (100–200 m^3/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 to sustain existing vegetation, and through the summer for wildlife. Pulse flows scour the floodplain, flush salts and other pollutants, discourage salt cedar growth, and establish native cottonwoods and willows that require flooding for seeds to germinate. These 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 ppt (Zamora-Arroyo et al. 2001). In addition to mainstem flows that pass through Morelos Dam, the southeast reach of the riparian corridor generally receives about 15,000 acre-feet (18.5 million 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 the diminishing water supply for the environment as well as management of the riparian corridor that does not support habitat values. This is in part the result of the lack of a guaranteed source of water to maintain natural systems.

Specific threats are:

1 Vegetation clearing, dredging, and changes in river morphology associated with the International Boundary and Water Commission's (IBWC) plan to channelize the limitrophe zone (the Colorado River riparian corridor from Morelos Dam downstream to the Southerly International Boundary, or SIB) for flood control and border rectification purposes. Although this is only a potential threat, it is likely to result in severe impacts with low reversibility. The threat is based on a proposed project that would dredge a pilot channel in the limitrophe to accommodate 15,000 cubic feet per second (cfs) (425 m^3/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 (4,000 m^3/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 back-waters that provide habitat for migratory 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.

2 Vegetation clearing by the Comisión Nacional del Agua (CNA) in the riparian corridor in Mexico south of SIB. In 1996, as part of its flood control plan, 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 38 miles (61 km) downstream. The pilot channel is designed to accommodate 21,200 cfs (600 m^3/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 impact and higher reversibility as the pilot channel is not as wide nor as deep as that proposed for the limitrophe zone.

3 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 its 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 or storage 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; although this is water of poor quality, it maintains healthy riparian vegetation that otherwise would not exist;
- water efficiency improvements in local irrigation districts that do not address environmental water needs. There is no regulatory mechanism to transfer conserved water to the environment. Water conservation will reduce the quantity of agricultural drainage water that supplies the groundwater table and 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. Such transfers will diminish agricultural waste flows now sustaining riparian corridor habitat.

Wildfires in the riparian corridor

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 to high as vegetation will respond rapidly (within a few years) to a return of river flows after a dry period.

4 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 in areas near 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 salt cedar yet another opportunity to displace native vegetation. Although the location of some past fires is known, new fires can occur anywhere in the corridor. The severity of impacts of wildfires is high, with low reversibility as wildfires reduce the number of older tress in the corridor.

5 Small-scale clear-cutting practices by local residents. While infrequent at present, vegetation removal by residents may become a more significant threat in the future. Recent studies show evidence of some removal of larger trees from the riparian corridor, presumably by local residents for fuel (Nagler et al. in press). Tree removal, in particular removal of older trees, has a high impact on the quality of habitat, and this threat has low reversibility because it takes several years for new trees to grow and form riparian forest.

6 Cowbird parasitism. The persistence of cowbirds in the riparian corridor threatens breeding bird reproduction rates; cowbirds are parasitic on songbird nests, destroying their eggs. This threat is highly probable and could be reversed only with a high intensity control program of cowbird populations.

7 Environmental pollutants. Untreated effluent from the city of San Luis Río Colorado discharges directly into the river corridor. At the discharge point, conditions are anoxic (0.4 mg/L); however, salinity is low (1 ppt) and pH is normal (7.7) (J. García-Hernández, personal communication October 29, 2004). Concentrations of heavy metals in sediments at the discharge are high (Pb 43.8 ppm), and pathogens are probably present in high concentrations as well. Although the low salinity of the effluent sustains large stands of willows directly downstream, untreated effluent represents a potential threat to the health of people who use the downstream reach for recreation. In addition to this effluent, there are at least three other discharges into the corridor from agricultural runoff. These sites have not been surveyed, but is possible that they add salts and pesticides to the river corridor. It is important to characterize these discharges in order to determine effects downstream and on the corridor wildlife. This threat is too poorly quantified at present to allow for an assessment of the severity and reversibility if its impacts.

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.

1 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 available habitat. There are numerous options for securing these flows, which are described elsewhere (Pitt et al. 2000, Culp et al. 2005); for example, a program for voluntary, market-based purchase

2 With better management, existing flows in the mainstem and irrigation delivery system could help to meet ecosystem goals. Given the typically short notice given when high flows occur at Morelos Dam, 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 returns to the mainstem at the 27 km wasteway. With more notice of these floods, management of Morelos Dam could spill 3 some of these high flows into the limitrophe.

Spill criteria at Parker Dam could be revised to synchronize the management and operational needs of the reservoir system with the needs of the Colorado River 4 Delta ecosystem.

Low-lying areas supplied with water, as well as existing backwaters and oxbows, could be managed for maintaining trees of older age classes. Old growth cottonwoods and willows are needed to sustain faunal biodiversity (e.g., for cav- 5 ity nesters, habitat management requires young stands and patches or isolated trees of older growth). Levees could be stabilized with stands of riparian 6 vegetation, as has been proposed by CNA.

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 7 such leases (Carrillo-Guerrero 2002).

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 8 dedicate the conserved water to the environment.

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 9 Colorado River Delta and Upper Gulf of California.

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 from the damaging effects of large 10 floods (Carrillo-Guerrero 2002).

Native nursery stock could be established to re-vegetate the floodplain with trees and mid- and under- 11 story species, in order to increase biodiversity.

Both IBWC and CNA could accommodate excess flows in secondary meandering channels for the purpose of maxi- 12 mizing ecosystem form and function.

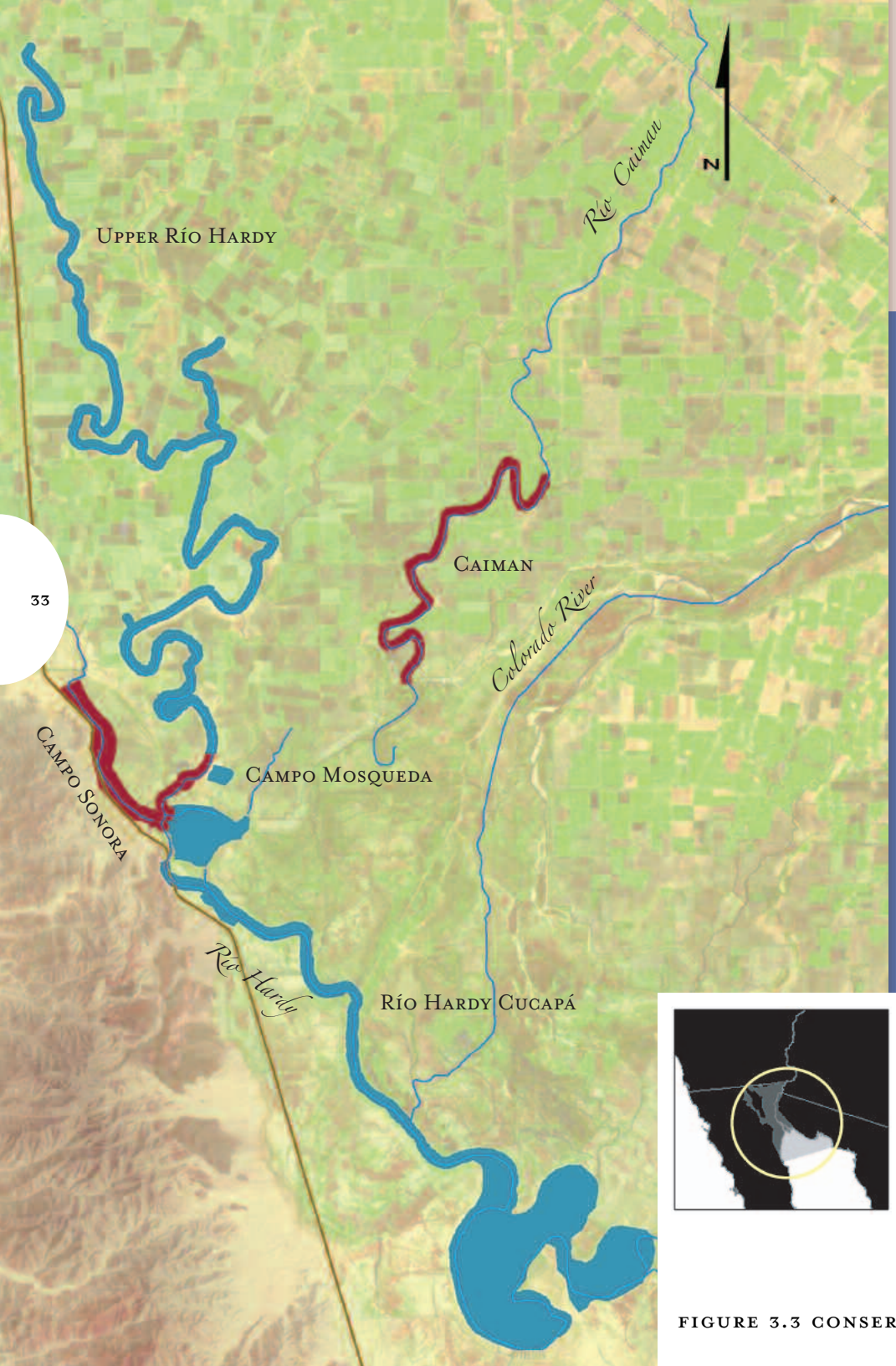
An education program could increase local opposition to the clearing of vegetation in the ripar- 13 ian corridor.

With advance notice of flood releases, local managers could implement specific actions to increase native seed germination and reduce the establishment of salt cedar, and make progress toward its elimination by inundating areas for long 14 periods of time.

With active management and restoration activities, the ecological value of areas that receive water from

Río Hardy Corridor

The Río Hardy is a tributary of the Colorado River that flows approximately 25 miles (40 km) from south of the Cerro Prieto geothermal facilities to the junction with the Colorado River near the tourist camp at Campo Flores. Local residents and others working in the region also include an 11-mile portion downstream from the junction of the Colorado River. The Río Hardy is a perennial stream carrying approximately 6,000–11,000 acre-feet (7.4–13.6 million 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 for 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 salt cedar. The Río Hardy is dominated by a near monoculture of salt cedar, with very little native vegetation. Although mesquite is found in upland areas, a few willows and cottonwoods are found only along riverbanks. Five conservation priority areas were defined for the Río Hardy (see Figure 3.3).



LEGEND

- City
- Highway
- Railroad
- River

CONSERVATION PRIORITIES

- Protection
- Restoration

FIGURE 3.3 CONSERVATION PRIORITIES IN THE RÍO HARDY

conservation priority:

THE UPPER RÍO HARDY

This area (3,355 acres [1,358 hectares]) covers the perennial reach, from the Río Hardy's origin in the southwest portion of the irrigation district, near the Cerro Prieto geothermal facilities, 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 reach of 20 river miles (32 km) are dominated by salt cedar, 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 one of the few places in the Delta with a perennial flow and a deep channel (greater than 3 feet [one meter]), and already provides habitat for some wildlife species.

conservation priority:

RÍO HARDY-CUCAPÁ

This site contains nearly 4,337 acres (1,755 hectares), and extends from the Río Hardy at Campo Mosqueda 16-miles 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 riverbanks, as they are flooded only sporadically. These conditions have promoted the establishment of salt cedar. Dense thickets of salt cedar 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 to the potential to augment the mesquite population, as well as to manipulate agricultural wastewater to create marshes with emergent vegetation. Current restoration projects have maintained and increased the water level of the Río Hardy by 3 feet (one meter) since summer 2002. Consequently, 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 upstream from El Tapón check dam. El Tapón, however, is only a temporary solution implemented by local residents. El Tapón will no longer be needed if a perennial flow of water is

secured for this stretch of the Río Hardy. To accomplish this, local residents need support to develop the required hydrological studies that will help define water needs for this conservation priority, and to establish the mechanisms to meet these needs. In the meantime, the benefits and impacts of the check dam need to be monitored.

conservation priority:

CAMPO MOSQUEDA

This area has great restoration potential. Of the 53 acres (21 hectares) owned by the Mosqueda family, 22 acres (9 hectares) are already managed for restoration. Restoration has begun with the planting of approximately 1,000 mesquite trees on an upland site, and cottonwoods and willows along the agricultural drain adjacent to the campo.

conservation priority:

CAIMAN

Currently known as the Pescaderos drain, this area includes 692 acres (280 hectares) and was historically an old course of the Colorado River. The site is dominated by common reed and salt cedar, with small patches of cattail marsh and isolated mesquites. Caiman is a priority protection site because it sustains existing flora and fauna. It contains open water and marsh habitat with stable conditions, and can potentially serve as a water source for restoration activities.

conservation priority:

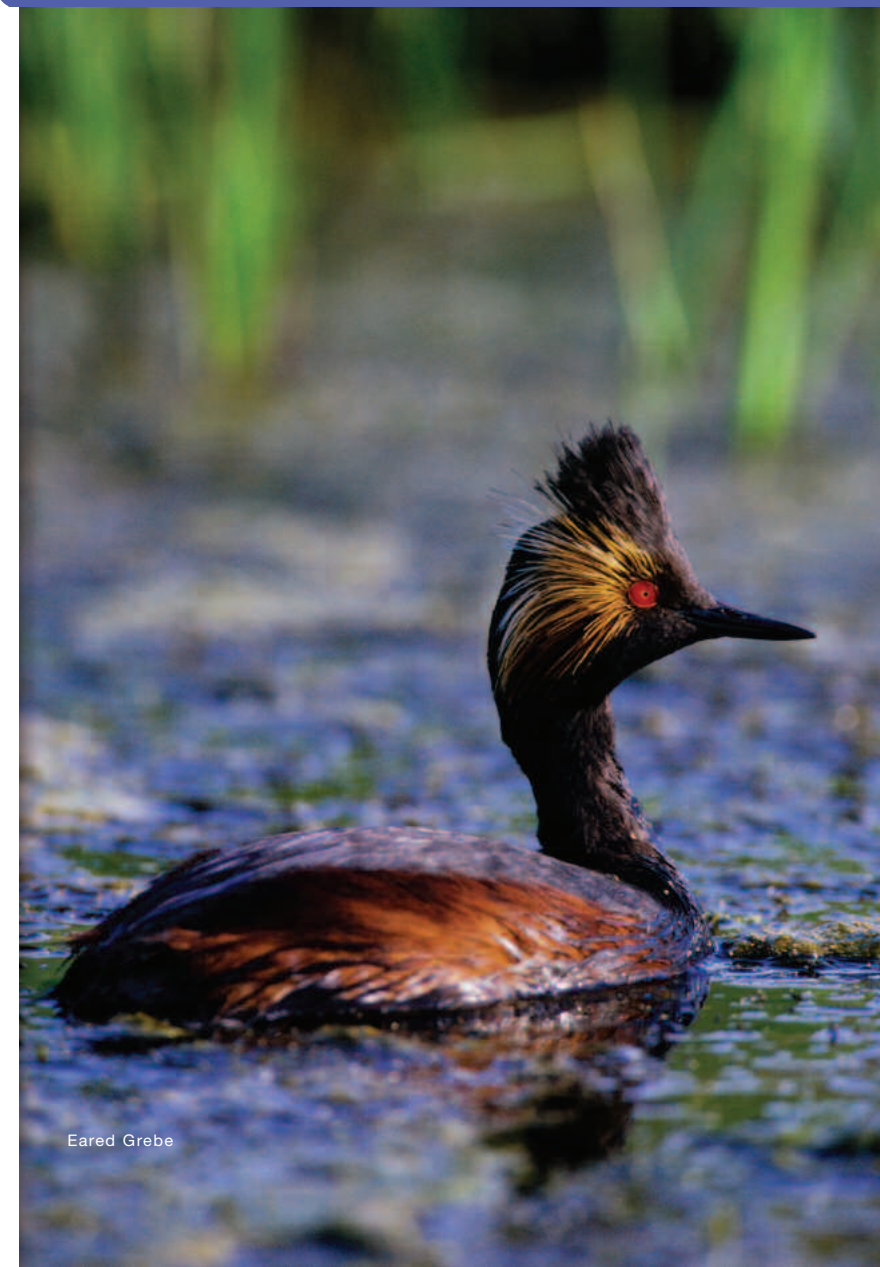
CAMPO SONORA-RÍO EL MAYOR

This site of 483 acres (195 hectares) in size is located on 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 and attracts water birds 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 following description applies to all conservation priority areas in the Río Hardy unless specified otherwise. 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. Current high salinity conditions in water and soils promote the growth of salt cedar 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 salt cedar 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 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.



Eared Grebe

Tapón-created wetland

Water needs

The Río Hardy is an integrated ecological unit whose functions are 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 million m^3) of agricultural drainage water with a salinity of approximately 3 ppt. This water supply is not guaranteed, however, and the viability of the Río Hardy conservation priority areas depends on it.

Current flows in the Río Hardy vary through the year with seasonal irrigation patterns. Only the upper portion of the river has a year-round constant depth of 3–9 feet (1–3 meters). Although a hydrologic model is needed to determine water needs below Campo Mosqueda, local residents suggest that dredging could improve water depth conditions.

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. To this end, additional freshwater flows of lower salinity are needed to dilute agricultural return flows to reach a target salinity of 1.4 ppt or lower to benefit the germination of native vegetation. Increased flows will flush sediments and contaminants, reduce the salinity caused by seawater intrusion from tides, and create a permanent passage for fish from the river to the estuary throughout the year.

Threats

Threats to the Río Hardy include the diminishing quality and quantity of its water supply, which relate to impacts from surrounding activities including tourism, agriculture, and fishing along the river. Specific threats are:

1 Decreased 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

Young mesquite tree

fertilizers. Fortunately, the severity of this threat is low as none of these contaminants are known at present to affect 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 severe impact on vegetation, preventing the growth of native riparian species such as 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. The El Tapón check dam is likely to increase the salinity of the lower stretch of the river as inundated areas result in increased evaporation. This is a potentially significant threat that needs to be closely monitored.

2 The reduction in the volume of drainage water into the river due to increased efficiency in agricultural use could degrade soils and reduce the amount of water available for

Giant Salvinia (*Salvinia molesta*)

plants, resulting in increasing dominance of salt cedar over more desirable native vegetation. The severity of this threat will depend on the change in drainage water volume. As flows return, the reversibility of this threat is likely to be low for upland areas, but high for areas along the banks of the river.

3 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 its severe impacts can still be seen. El Tapón check dam is also likely to increase sedimentation and therefore needs to be closely monitored. This threat is reversible, but only with the implementation of dredging to remove built-up sediments. Sporadic 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. A hydrological analysis is required to better understand the river dynamics and to determine the magnitude and timing of perennial and pulse floods needed to flush sediments, and to enhance habitat and navigability; dredging could and should be avoided if at all possible.

4 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. The cumulative effects of this wastewater with other treated and untreated discharges into the Río Hardy need to be considered. Impacts could be severe for animal species and humans. In most cases, these impacts are reversible if the quality of treated water is improved to meet safe standards; thus, this threat is also considered as an opportunity as described below.

5 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.

6 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 severity of its impact are unknown.

7 Potential pollution by heavy metals in discharges from Cerro Prieto, if practices change or spills occur, will adversely affect local flora and fauna. The severity and reversibility of impacts will depend on the magnitude of discharges, but have not been evaluated.

8 Pollution from shrimp farms is a potential threat to water quality, and consequently to the local flora and fauna, but its severity and reversibility are unknown.

9 Pollution from land uses, other than agricultural, along the Río Hardy is considered to be an existing threat but of very low impact because of the low intensity of use.

10 Fires 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 other native vegetation because the prevalent dry conditions do not favor new recruitment.

11 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.

12 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 efforts.

El Tapón

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:

1 Secure current instream flows for the Río Hardy through water concessions or acquisitions. Stabilization and 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 the management of salt cedar, 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 the lower Río Hardy to remove sediments deposited during repeated flood events over the last two decades.

2 Secure effluent water from the Mexicali II wastewater treatment plant could deliver up to 35 cfs (1 m^3/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 cottonwood and willow recruitment along the riverbanks.

3 Maintain the activities of the Ecological Association of Users of the Hardy and Colorado Rivers (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. Formed by local river users, AEURHYC is increasing local community environmental awareness and increasing participation in stewardship activities. These activities will be strengthened by establishing an environmental outreach program.

4 Use check dams to help manage water for habitat restoration, such as AEURHYC's project at El Tapón located at the southern end of El Riñón area. El Tapón is a temporary check dam built by local residents that has successfully elevated the water level in this reach of the Río Hardy by approximately 3 feet (one meter) and created conditions such that nearly 1,000 acres (405 hectares) 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 salt cedar. Improved habitat areas will provide new opportunities to develop ecotourism activities, aquaculture, and other recreational activities. As with any restoration activities, this site should be monitored to identify changes in sedimentation, salinity, and impacts to the movement of fish and other invertebrate species from the Upper Gulf into the river and vice versa.

5 Improved irrigation efficiency and the dedication of conserved water to Río Hardy instream flows would enhance local flora and fauna. Irrigation efficiency is no longer a threat as described above when conserved water is dedicated to instream flows.

6 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 activities to include an improved connection between freshwater and marine environments.

7 The Río Hardy could be selected as an implementation site for restoration by the fourth working group of IBWC, 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.

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

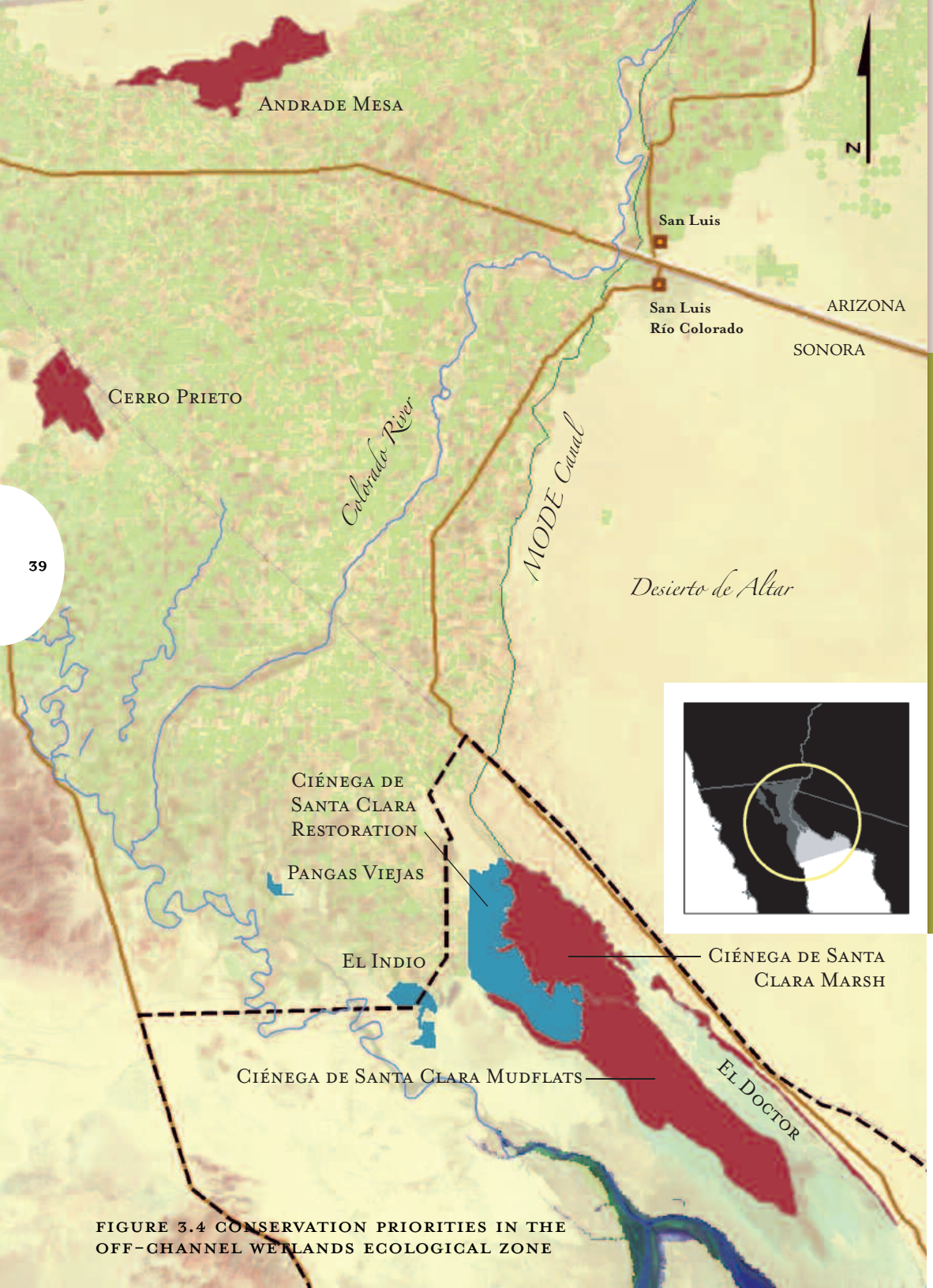


FIGURE 3.4 CONSERVATION PRIORITIES IN THE OFF-CHANNEL WETLANDS ECOLOGICAL ZONE

Off-channel Wetlands

The off-channel wetland zone is a catchall designation for several important wetland groups (see Figure 3.4) that are supported by water that does not flow directly 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.

LEGEND

- City
- Highway
- Railroad
- River
- International Boundary
- Biosphere Reserve

CONSERVATION PRIORITIES

- Protection
- Restoration

THE CIÉNEGA DE SANTA CLARA

The Ciénega de Santa Clara is the largest marsh wetland in the entire Sonoran Desert and one of the most important wetlands in the lower Colorado River basin. This complex of dense cattail marsh with open water and mudflats is located 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 Biosphere Reserve of the Upper Gulf of California and Colorado River Delta, 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: the Ciénega de Santa Clara marsh, the Ciénega de Santa Clara mudflats, and the Ciénega de Santa Clara restoration.

Yuma Clapper Rail

conservation priority:

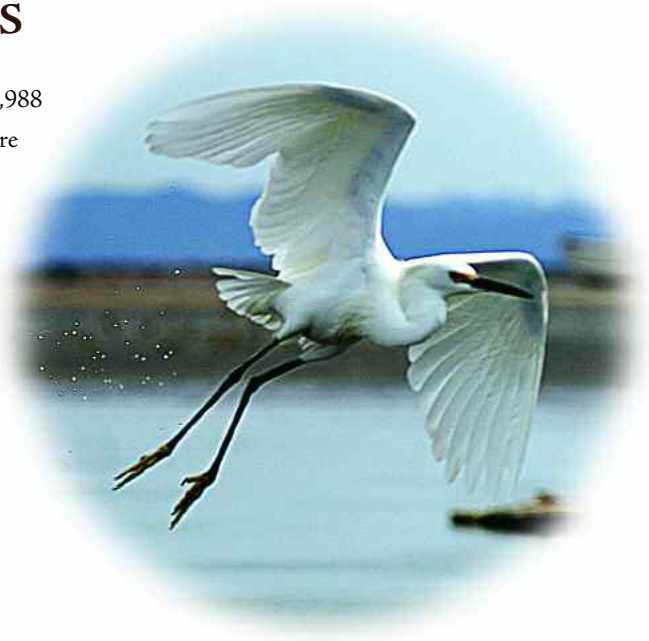
THE CIÉNEGA DE SANTA CLARA MARSH

This marsh is identified as a priority for protection. The marsh consists of 15,189 acres (6,147 hectares) of brackish wetland with emergent vegetation of cattail, bulrush, and common reed intermixed with open water areas. It is an important refuge and home to the world's largest population of Yuma clapper rail (*Rallus longirostris yumanensis*) (Hinojosa-Huerta et al. 2001a), as well as an important desert pupfish population (Varela-Romero et al. 2002). The ciénega marsh sustains large quantities of carp, mullet, tilapia, and large-mouth bass, and it is also a major stopover for migratory waterfowl and shorebirds along the Pacific Flyway.

conservation priority:

THE CIÉNEGA DE SANTA CLARA MUDFLATS

This area consists of 24,680 acres (9,988 hectares) of shallow water areas that are supplied with brackish water from the marsh to the north as well as tidal inflows from the south. These mudflats are in good condition and were identified as a priority for protection given their importance for shorebirds.



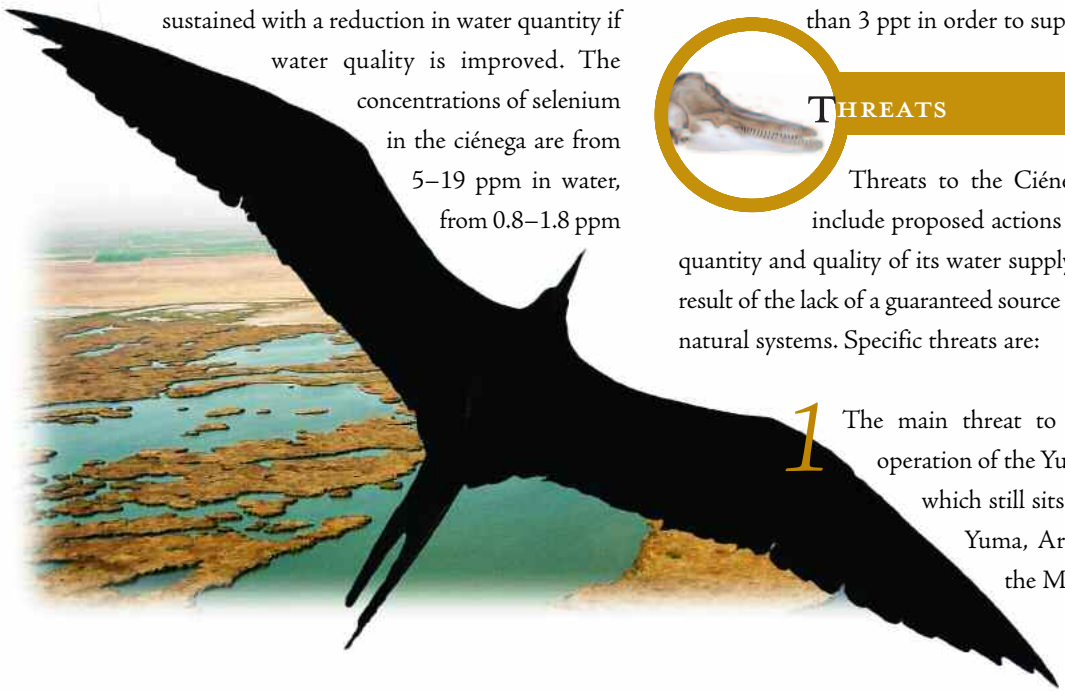
conservation priority:

THE CIÉNEGA DE SANTA CLARA RESTORATION

This area is on the west side of the existing emergent wetland, is presently not vegetated, and is mostly a dry plain intermixed with wet and ephemeral mudflats. It was identified as a priority for restoration with the objectives of increasing the marsh habitat and adding diversity by developing upland vegetation. With additional water, it could be converted into another 12,396 acres (5,016 hectares) 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 [135 million m^3], at 2.4–3.0 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 rights under the 1944 Treaty, but was removed from the mainstem when Mexico complained that the high salinity of Colorado River water damaged 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 (Pitt et al. 2002). 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 ciénega is thought to be 5 ppt (Glenn et al. 1995). It is possible that the ciénega's ecological values could be sustained with a reduction in water quantity if water quality is improved. The concentrations of selenium in the ciénega are from 5–19 ppm in water, from 0.8–1.8 ppm in sediment, from 2.5–5.1 ppm in fish, and from 3.3–8.4 ppm in bird eggs (García-Hernández et al. 2000). Selenium enters the ciénega dissolved in water and bioaccumulates in the food chain. Although concentrations of this element in wildlife have not been found to cause major die-offs or reproductive problems in the ciénega, it is important to continue monitoring wildlife populations in order to detect selenium's possible effects. 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

Threats to the Ciénega de Santa Clara include proposed actions that will reduce the quantity and quality of its water supply. This is in part the result of the lack of a guaranteed source of water to maintain natural systems. Specific threats are:

1 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.

Riito Drain

Ecotourism boating in the Ciénega de Santa Clara

Although operation of the plant is today only a potential threat, its operation will result in severe 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 (37 million m^3), with a sharp increase in salinity from 2.8 ppt to 9 ppt (Bureau of Reclamation 2003) (note that these salinities reflect water quality at the northern end of the MODE rather than at the ciénega itself where salinity increases due to evaporation). The decrease in water quantity compounded with the increase in salinity due to operation of the plant is expected to eliminate most present life. The reversibility of the impacts from this threat is moderate to high but would require finding a replacement water source, which is a significant challenge. If the plant was operated and inflows then 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.

2 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 become established as it tolerates water with salinity up to 3–4 ppt. The degree of impact if giant salvinia establishes in the ciénega is high with low reversibility.

3 Pollution from agricultural fields, river water, or rural sewage would adversely affect the 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 (García-Hernández et al. 2001b). Selenium concentrations will increase considerably if the Yuma Desalting Plant is operated.

4 Flooding on the Gila River could disrupt flows to the ciénega if the MODE is broken or breached (as occurred in 1993). This threat is possible, though floods on the Gila are rare and reversible with repairs to the MODE.

Opportunities

The fact that the ciénega is a natural protected area represents the best opportunity for protecting and enhancing its natural habitats. For example:

1 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.

2 There are also opportunities for the local *ejido* to improve and expand the ecotourism activities and tours at the ciénega.

3 With additional water, the ciénega upland area could be restored.

conservation priority:

EL DOCTOR WETLANDS

Identified as a conservation priority for protection, this group of small, hydrologically related natural springs (*pozos*) form 2,135 acres (864 hectares) of wetlands southeast of the Ciénega de Santa Clara. Most of these wetlands are just below the eastern escarpment of the Delta, where it borders El Gran Desierto and at the foot of the Mesa de Sonora. The water is slightly salty, and supports a bull's-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 (Glenn et al. 1995). 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 estuaries to the south. They are extraordinarily important in supporting bird migrations, but critically important for neotropical migratory land birds 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 (*Cyprinodon macularius*), 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 its 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 natural springs.

California Black Rail

Desert Pupfish

Threats

Threats to El Doctor are mainly associated with land uses surrounding these wetlands. Specific threats are:

1 Although the El Doctor wetlands are part of the Biosphere Reserve, heavy cattle grazing has degraded them. This is an existing threat with very severe impacts, but its reversibility is high; if efforts to control grazing are successful, plant communities are expected to regenerate in less than two years.

2 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 Sonora. Tourist developments and the growth of El Golfo de Santa Clara will likely lead to the installation of wells along the Gran Desierto escarpment to recover fresh water for human use. This would be the end of the El Doctor wetlands and the reversibility of these impacts would be low.

3 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.

4 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 in 2000 did not exceed toxicity thresholds. Concentrations of organochlorine pesticides (DDE) were low in fish tissue, indicating the common use of DDT in the agricultural valley in the past (García-Hernández et al. 2001a).

5 Finally, occasional small fires threaten the persistence of existing vegetation, mainly marshes. The likely damage would be 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 calls for action to protect and enhance this wetland. There are opportunities for ecotourism and bird watching, especially during the migration of neotropical migratory land birds. These activities could create incentives for conservation of the site, leading to the elimination of cattle grazing around the springs. Specific actions to manage these activities are outlined in the Biosphere Reserve's management plan (CONANP 2004).

conservation priority:

THE ANDRADE MESA WETLANDS

Comprising some 9,711 acres (3,930 hectares), these wetlands were identified as a priority for protection. They were first noticed by Mexican and U.S. scientists conducting low-level, aerial vegetation mapping in the Delta in 2002 (Hinojosa-Huerta et al. 2002a). 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. A more recent survey (Hinojosa-Huerta et al. 2004b) indicates that these wetlands support 100 species of birds, including rare and endangered species such as the Yuma clapper rail (*Rallus longirostris yumanensis*), large-billed savannah sparrow (*Passerculus sandwichensis rostratus*), gull-billed terns (*Sterna nilotica vanrossemi*), and California black rail (*Laterallus jamaicensis coturniculus*). Open areas with brackish and shallow water are also attractive for many species of water birds.

In a more detail land cover analysis, Zamora-Arroyo and others (2005) indicated that the Andrade Mesa wetlands consist of two major wetland systems, one near Ejido Irapuato and one near Ejido Nezahualcoyotl, with a total of 4,650 acres (1,882 hectares) of wetland habitat and 1,921 acres (778 hectares) of terrestrial habitat. This wetland habitat consists of 503 acres of marshes (open water, cattail, and saltgrass), 165 acres of arroweed and salt cedar, and 3,980 acres of riparian areas with at least 10% mesquite cover.

These wetlands are unique because they support marshes, vegetated dunes, and saltgrass beds (*Distichlis spicata*) surrounded by 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 Andrade Mesa wetlands are fed by seepage from the All-American Canal (AAC). Local farmers used to have problems with water seepage from the All-American Canal, which inundated farmland, until a drain was built to collect this water. There is evidence that the drainage actually runs south-southwest from the AAC (Cortez-Lara and García-Acevedo 2000, Cortez-Lara et al. 2002, U.S. Bureau of Reclamation 1994); however, additional studies are needed to verify this and 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 severity 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 a 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.

conservation priority:

THE CERRO PRIETO PONDS

These artificial ponds of 4,985 acres (2,017) in size, were created by the Cerro Prieto Geothermal Plant, located to the north of the headwaters of the Río Hardy. These ponds are identified as a priority for protection. 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 support beaked tasselweed (*Ruppia maritime*), an aquatic plant. These man-made ponds receive 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 (*Cyprinodon macularius*) 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 than 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

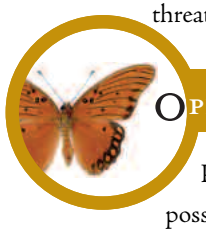
The current volume of water is needed to maintain the wildlife value of these ponds, though it would be desirable to reduce the concentrations of heavy metals and other minerals that are harmful to wildlife. Consultation with administrators of the geothermal plant is required to better understand the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

Threats

Threats to Cerro Prieto ponds are mainly associated with the operation of the geothermal facilities. Specific threats are:

1 Concentrations of silicates, sulphur, copper, mercury, and other metals are likely to affect wildlife if concentrations reach critical thresholds. This is an existing threat, but little is known about its impacts or reversibility. Concentrations of selenium are low in sediment (1.6 ppm) and in pupfish (1.8 ppm) from the geothermal plant ponds (García-Hernández et al. 2001a) because water originates from condensed vapor derived from groundwater rather than from the Colorado River. Lead concentrations are also low (19 part per billion [ppb]) in the ponds (J. García-Hernández, personal communication November 22, 2004) compared with the 43 ppb found in sediments from San Luis sewage discharge. Other metals that may be present at these ponds have not yet been quantified by the Mexican Federal Power Commission (Comisión Federal de Electricidad).

2 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 inhabited by 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.

conservation priority:

PANGAS VIEJAS WETLANDS

This area is a 660-acre (270 hectares) permanent wetland with emergent vegetation, mainly cattail, common reed, and salt cedar, and was identified as a priority for restoration. It is maintained by agricultural return water delivered by the Zacatecas drain as it intersects the eastern flood control levee on the Colorado River mainstem. This shallow, brackish wetland is important for migratory birds and for the Yuma clapper rail, and is used by hunters.

Water needs

Little is known about the quality and quantity of water that creates the Pangas Viejas wetlands; however, their maintenance 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, though this threat is thought to be 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 the introduction of mesquite trees, for example.

conservation priority:

EL INDIO WETLANDS

This 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 hectares), maintaining a permanent marsh with shallow open water. The wetland is maintained by the Perimetral Drain that collects agricultural drainage water 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 salt cedar (*Tamarix ramosissima*), accompanied by honey mesquite (*Prosopis glandulosa*), screwbean mesquite (*P. pubescens*), saltbush (*Atriplex* spp.), seepweed (*Suaeda* spp.), and pickleweed (*Allenrolfea* spp.). 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 saltgrass (*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 hectares) of wetlands to include surrounding land for a total of 1,927 acres (780 hectares) 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^3/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 hectares) 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 are recognized in the new management plan of the Biosphere Reserve of the Upper Gulf of California and Colorado River Delta (CONANP 2004):

1 As with most habitat areas in the Delta, the water source feeding El Indio wetland is not secured. 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.

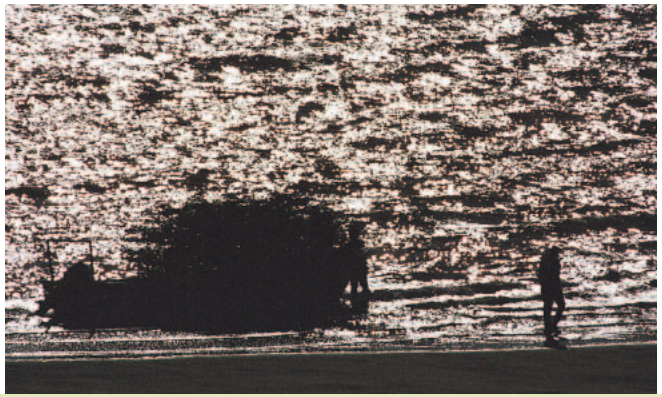
2 In addition, pollution from agricultural activities, rural and urban sewage, and from the Colorado River may impact both flora and fauna. Selenium levels measured in bottom material exceed toxicity thresholds, with concentrations ranging from 2.8 to 3.2 ppm of selenium in sediment (García-Hernández et al. 2001a), 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 impact of these pollutants.

3 Illegal hunting activities threaten local fauna. The severity of this threat is unknown, but is likely 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 de Santa Clara 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, birdwatching, sustainable aquaculture, and controlled waterfowl hunting 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 Biosphere Reserve is currently exploring mechanisms to secure water for El Indio (M. Martínez Contreras, personal communication November 23, 2004).

LAGUNA SALADA



This 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 in 1983–87, 1993 and 1998). When filled with water, the Laguna Salada becomes an 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

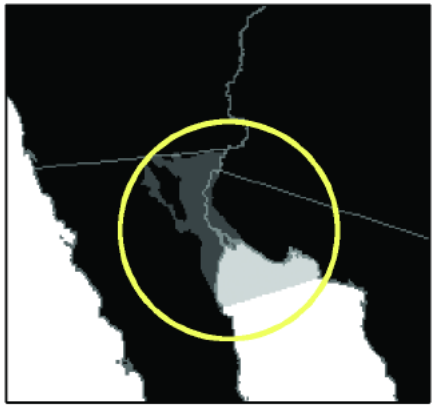
Little is known about the quantity of water that has reached Laguna Salada in the past. When filled with water, its salinity ranges from brackish (5–6 ppt) to hypersaline.

Threats

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

Opportunities

Restoring habitat at the Laguna Salada to its former, freshwater-based ecology will require large freshwater flows, which today only occur during large floods on the Colorado River. Because the likelihood of these large flows in the near future is low, an alternative is the construction of a channel from the Upper Gulf that would allow seawater to enter the basin to create a saltwater ecosystem. Additional studies are 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. The studies should also be directed to estimate potential impacts that seawater could have on groundwater aquifers.



LEGEND

- City
- Highway
- Railroad
- River
- Biosphere Reserve

CONSERVATION PRIORITIES

- Protection
- Restoration

Colorado River

Golfo de Santa Clara

Bahia Adair

Coastal and Estuarine

El Borrascoso

Puerto Peñasco

Gulf of California

Vaquita Marina-Rocas Consag

San Felipe

FIGURE 3.5 CONSERVATION PRIORITIES IN THE INTERTIDAL, COASTAL, AND MARINE ZONES

Intertidal, Coastal, and Marine Zones

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 have been reduced. Although additional studies are required to understand the influence of a range of freshwater flows (magnitude and timing) on the the intertidal and estuarine zones, it is clear that these zones are presently functioning as 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 (see Figure 3.5).

The vegetation in this zone is relatively simple, with the banks of the river dominated by Palmer's saltgrass (*Distichlis palmerii*), an endemic found only in the northern Gulf of California, and sparse thickets of iodine bush and salt cedar. The role of upstream salt cedar (the dense thickets along the Río Hardy) in the intertidal ecosystem is not well documented; however, the salt cedar likely supplies detritus to 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. 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 Montague Island. 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. 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.

conservation priority:

EL BORRASCOSO

This area, also known as "Punta Borrascosa" and located about 35 miles southeast of El Golfo de Santa Clara, Sonora, is important because it represents some of the northernmost rocky intertidal substrates in the Upper Gulf of California. Although we can still find other subtidal and intertidal patch reefs north of El Borrascoso, these are very small and are not rich in flora and fauna. Geologic outcrops on land expose 125,000-year-old deposits of fossiliferous deltaic sediments that provide a historical record of the development of the Delta's marine fauna, and the intertidal and shallow marine outcrops provide hard substrates, a rare habitat in the Upper Gulf. El Borrascoso consists of a unique platform reef constructed primarily of beachrock-coquina limestone that stretches out a considerable distance offshore (approximately 1.2 miles). Cochina reef formations in the Gulf are restricted to the northern region and occur at only three sites other than El Borrascoso: Puerto Peñasco, San Felipe, and El Coloradito. Aside from being rare, these reefs harbor disproportionately high species diversity compared to the rest of the Upper Gulf of California, especially for invertebrates (Brusca 2002). The numerous crevices and, ultimately, niches created in coquina habitat provide for this high species diversity. El Borrascoso includes 14,364 acres (5,813 hectares) and is considered a priority for protection.

Ecological Relationships

El Borrascoso represents an important reproductive, feeding, and nursery ground for numerous commercial species. Both commercial and sport fishermen from Puerto Peñasco and El Golfo de Santa Clara regularly target this area for groupers (particularly Gulf grouper or "baya," *Mycteroperca jordani*) and snappers (particularly barred pargo, *Hoplopagrus guntheri*). Reports include catches of snapper up to one metric ton on one gillnet set (Richard Cudney-Bueno, personal observation), suggesting that El Borrascoso likely forms the northernmost site for the formation of large breeding aggregations of this species. It also provides significant breeding habitat for the black murex snail (*Hexaplex nigritus*), a carnivorous species of snail endemic to the Gulf of California with high demand in the national and Asian market and an important ecological role as a top predator of the subtidal benthic community. Historically, El Borrascoso has served as a major stopover and feeding ground for various migratory and schooling species. These include the Pacific sharp-nose shark (*Rhizoprionodon longurio*), corvinas (*Cynoscion* spp.), totoaba (*Totoaba macdonaldi*), Gulf croaker (*Micropogonias megalops*), sierra (*Scomberomorus sierra*), and sea turtles (*Lepidochelys olivacea*, *Chelonia mydas agassizi*).

Water needs

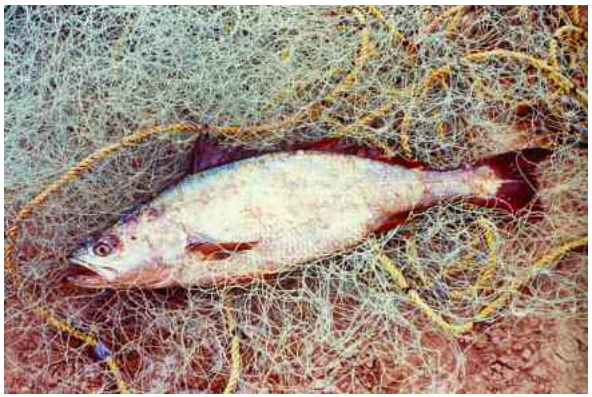
The role that increased freshwater input from the Colorado River could have on this reef is unknown. Currently, there are no means of comparing El Borrascoso's species composition today with conditions before regular freshwater flows were eliminated; however, given its distance to the mouth of the river, it is unlikely that the health of El Borrascoso's ecosystem was ever highly dependent on the river.

Threats

Threats to El Borrascoso are mainly related to coastal development and unsustainable fishing practices. Specific threats are:

1 Housing and development plans for the region: new developments could destroy offshore habitats through dredging, and destroy geologic outcrops with construction activity.

2 Coastal lagoons adjacent to newly developed areas could be modified for shrimp mariculture resulting in damage from construction and pollution from effluents.

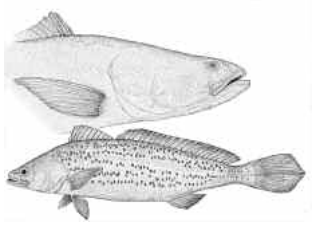


3 Over-fishing with gillnets, hook and line, and commercial diving threatens many marine species.

4 Intertidal collecting and trampling threatens intertidal species and habitats.

Opportunities

El Borrascoso is inside the Biosphere Reserve, and its management framework represents the best opportunity for its conservation. Furthermore, scientific studies of rocky habitats are taking place to assess their importance as breeding area and habitats for offshore species. The Intercultural Center for the Study of Deserts and Oceans recently compiled much of this information. In addition, new studies could focus on fossils from outcrops to trace the development of the Delta's fauna through time, in particular to investigate the influence of freshwater from the Colorado River.



conservation priority:

COASTAL AND ESTUARINE AREAS

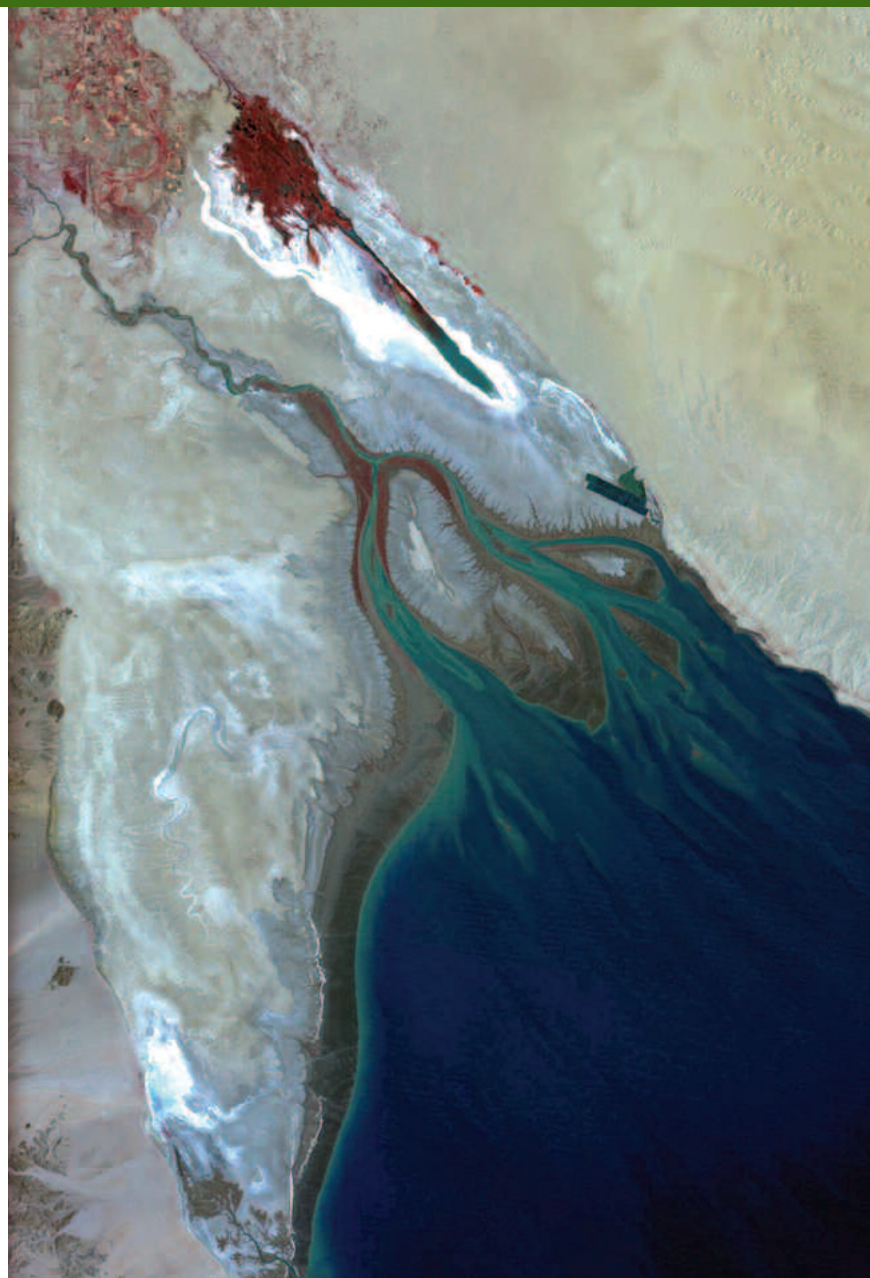
These areas include 565,476 acres (228,841 hectares) that are subject to the influence of fresh water flow from the Colorado River and mixing with ocean water. They provide important spawning and nursery grounds for many species of invertebrates and vertebrates, including shrimp, Gulf corvina, totoaba, as well as other species such as the endangered vaquita, Palmer's saltgrass (*Distichlis palmerii*), and the Colorado Delta clam (*Mulinia coloradoensis*). These areas are designated as a restoration priority based on the potential ecological benefits of increased freshwater flows, including its mixing with seawater in the intertidal and coastal zones.

Ecological Relationships

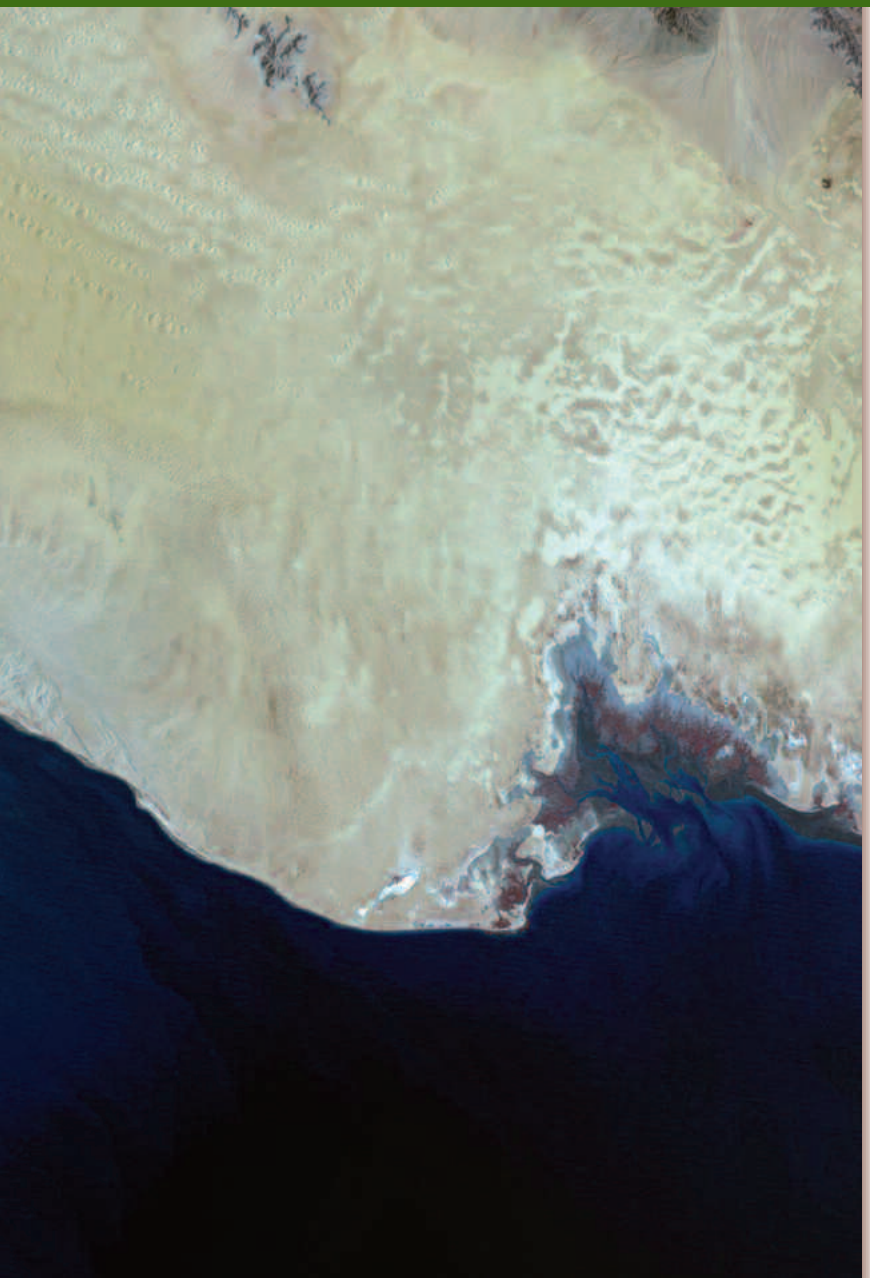
Both the dramatic reduction in freshwater flows and extensive fishing activity have resulted in significant changes to the Upper Gulf and estuary. The reduction in the river's flow has transformed the circulation of the estuary from one in which salinity increases toward the open Gulf to one in which evaporation causes hypersaline conditions at the river's mouth. Trawling and artisanal fishing have affected the benthic fauna of the Upper Gulf and depleted stocks of commercially important shrimp, shellfish, finfish, and marine mammals.

It is only during years of excess snowpack in the Upper Colorado River basin, combined with full reservoir storage throughout the basin, or during the very rare years when the Gila River floods, that river 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 reductions in freshwater inputs over the course of the twentieth century. Though impressively rich now, it may be that the lack of freshwater inputs is a serious limitation 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. Many components of the Delta's estuarine and coastal ecosystems can



Satellite image showing the mouth of the Colorado River in the upper Gulf of California



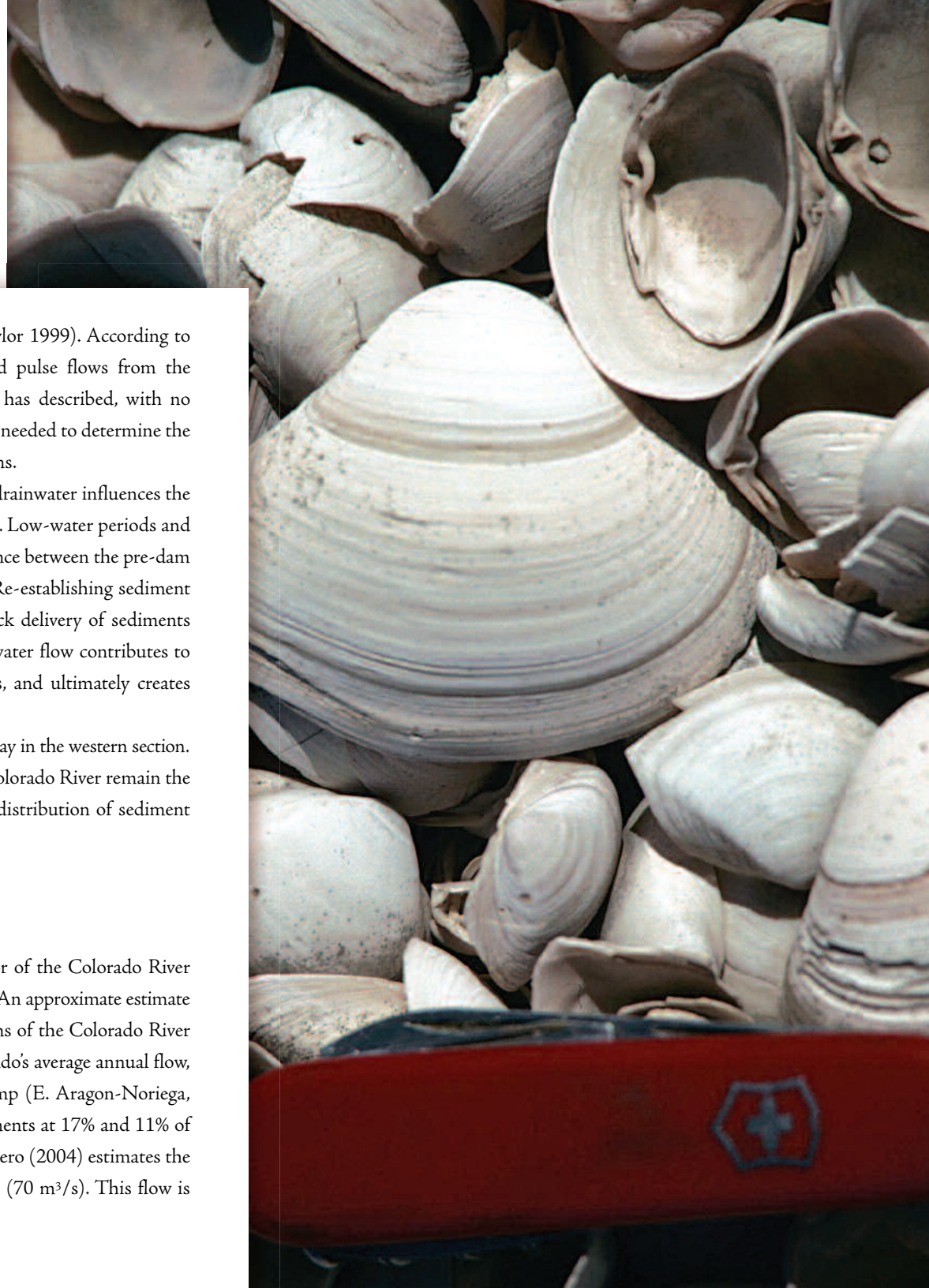
survive as long as 10–20 years without freshwater inflow and can be revived if provided with sufficient annual and occasional flood flows.

The relationship between freshwater inputs and species productivity has, in some cases, been documented. Freshwater inflow is needed for sexual reproduction of Palmer's saltgrass. The Gulf corvina fishery increased following the major flood pulses in the 1990s (Roman-Rodriguez et al. 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. 2000). Evidence suggests this is due to an increase of postlarval abundance during years of higher freshwater flows reaching the estuary (Cortez-Lucero and Aragon-Noriega 2003). Small floods may not carry sufficient water, silt, or nutrients to affect the marine zone directly, but they may 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.

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 1990s 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, as is also indicated by the geochemistry of the clam's shell (Rodriguez et al. 2001). Under the present hypersaline regime, their population has been reduced by 90% (Rodriguez et al. 2001). Species that depend on this clam for food may have also been affected, but this effect is difficult to document.

Isotope data suggest that Gulf corvina and totoaba, like other fish in the sciaenid family, 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 also migrate into the estuary, including the mouth of the Colorado River, and emerge as juveniles. Freshwater 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 the Rocas Consag and Borrascoso sites (Lavin and Sanchez 1999); 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, the evidence so far indicates that habitat alteration resulting from the reduction in Colorado River flow is a low risk factor,



compared to incidental mortality from capture in gillnets (Rojas-Bracho and Taylor 1999). According to Rojas-Bracho and Taylor (1999) it is unknown how important perennial and pulse flows from the Colorado River were as part of its habitat as only one author (Gaskin 1982) has described, with no supporting data, the vaquita 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 in the estuary and Upper Gulf has also declined. 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-dam 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 1,000 miles (1,600 kilometers) to the north. Reduced freshwater flow contributes to erosion of the Delta (Alvarez-Borrego 2003), 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. An approximate estimate of freshwater flows needed to sustain the intertidal, coastal, and marine ecosystems of the Colorado River Delta is 1.5 million acre-feet (1,851 million m^3), approximately 10% of the Colorado's average annual flow, per year. Research on Colorado Delta clam (Cintra-Buenrostro 2004) and shrimp (E. Aragon-Noriega, personal communication November 2004), which estimates annual flow requirements at 17% and 11% of the Colorado's annual average flow respectively, supports this estimate. Cortez-Lucero (2004) estimates the freshwater input threshold for shrimp populations to be approximately 2,473 cfs (70 m^3/s). This flow is

particularly needed during shrimp post-larvae stages (May–June); however, this is a preliminary estimate and additional research is needed to confirm this flow rate and determine if it is only needed during these months or throughout the year. While these studies provide preliminary estimates of freshwater needs, there are still unresolved issues regarding sustainable freshwater flows, including their magnitude, frequency, timing, and quality. It is not known, for instance, if agricultural return flows could provide this "sustaining" flow, or 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, a target salinity remains uncertain. For example, Valdés-Casillas et al. (1998) report that in January 1998, with river flows of 7,000 cfs (200 m^3/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^3/s), salinity ranged between 35 and 39 ppt. The lack of concurrent monitoring of water quality and ecological processes precludes the estimation of salinity requirements.

Research on the Upper Gulf's freshwater flow needs should continue by focusing on the relationship between freshwater flows and the life cycles of eight species: brown and blue shrimp (*Farfantepenaeus californiensis* and *Litopenaeus stylirostris*), Palmer's saltgrass (*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

The main threats to coastal and estuarine areas are related to unsustainable fisheries activities and increased development of coastal areas. Specific threats are:

1 Low levels of freshwater inflow result in the degradation and loss of physical and aquatic habitat for key species, reduce nutrient inputs, and change the circulation of sediment transport so that coastal erosion occurs. The severity of these impacts is high, but in most cases they are highly reversible.

2 Shrimp farming may cause mortality of estuarine organisms at water intake screens, escape of disease and viral pathogens from the ponds to the open Gulf, and increase eutrophication from pond effluent discharge into coastal areas. These are high severity and highly reversible threats.

3 High nutrient loading and sewage deposition may pose increasing threats. Among these are potential, local "dead zones" where toxin-producing or pathogenic microorganisms or unnatural algal blooms cause benthic faunal mortality. Such dead zones have occurred in the past at nearby Puerto Peñasco, for example, and possibly on one occasion at El Golfo de Santa Clara. The degree of these impacts is considered moderate and highly reversible.

4 Unmanaged coastal development (tourism) in Golfo de Santa Clara, San Felipe, and elsewhere results in noise pollution affecting marine mammals (including vaquita), as well as habitat degradation and destruction. These effects contribute to the mortality of fauna and flora. The severity and reversibility of impacts varies depending on the threat. In the case of habitat destruction resulting from coastal development, the severity 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; excessive boat use; and excess

mortality of rare and endangered species from sport fishing. The combined noise output of several vessels in such a shallow area could negatively affect cetaceans, including vaquita. Collisions of whales, particularly fin whales, with vessels have also been reported in the Upper Gulf.

5 Benthic trawling is an existing threat that causes high impacts with low reversibility, including massive disruption of the physical substrate and its benthos, incidental catch and mortality of non-target fish and marine mammals, exposed species susceptible to predation, and changes in benthic communities composition.

6 The use of gill nets causes high impacts with low reversibility, such as incidental catch and mortality of birds and marine mammals, and overexploitation of target finfish species.

7 Potential development of tidal power, if implemented, will result in severe impacts and irreversible loss of the Upper Gulf habitat.

8 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-though system. The severity of the 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

Opportunities to protect and restore coastal and estuarine areas are mainly related to ways to increase freshwater flows and implement and enforce fishing regulations and management actions in the Biosphere Reserve. Specific opportunities include:

1 Increase freshwater flows to the river mouth. Securing a perennial base flow and occasional flood flows for the riparian corridor will benefit the estuarine and marine ecosystems. Although a small base flow may not be sufficient to decrease salinity of the entire estuary, it could help fish and shrimp species by creating localized areas with lower salinity and by creating a passage into these areas. Flood flows could be secured and released during critical periods to benefit shrimp and fish during their larval or juvenile stages.

2 Redirect water from the Colorado River to Estero Diablo to enlarge and enhance nursery grounds for shrimp and fish.

3 Eliminate benthic trawling in the Upper Gulf.

4 Reduce or eliminate gillnetting in the Upper Gulf.

5 Research, develop, and promote alternative fishing gear that is vaquita friendly.

6 Research, develop, and promote economic alternatives to commercial fishing.

7 Develop a comprehensive monitoring and research program, with special attention to the impact of freshwater flood inputs.

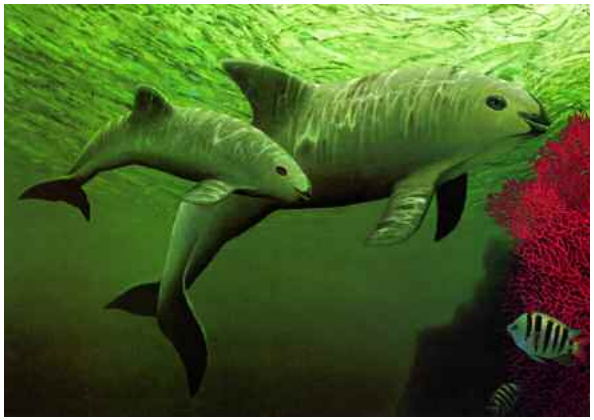
8 Document the recovery of benthos after trawling practices are halted.

9 Apply private-sector conservation tools, strategically and comprehensively, such as the promotion of easements.

10 Promote government management tools such as wildlife management units (*unidad de manejo ambiental*), 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.

conservation priority:

VAQUITA MARINA-ROCAS CONSAG



This priority area of 138,317 acres (55,975 hectares) is identified as a priority for protection, with the vaquita porpoise being the main conservation target. Although the priority conservation area does not cover all sightings of vaquita, as shown in Figure 3.6, it represents the area of greatest concentration of vaquita individuals (Rojas-Bracho et al. 2004). The area also includes the island Rocas Consag to the east of San Felipe, which is comprised of rocky outcrops, a rare habitat in the Upper Gulf. Approximately half of the priority conservation area extends beyond the southernmost limits of the Upper Gulf and Colorado River Delta Biosphere Reserve. Although currently no sightings or acoustic encounters of vaquita have been reported for the east coast of the Upper Gulf, this does not mean that the vaquita are not distributed in that area as well.

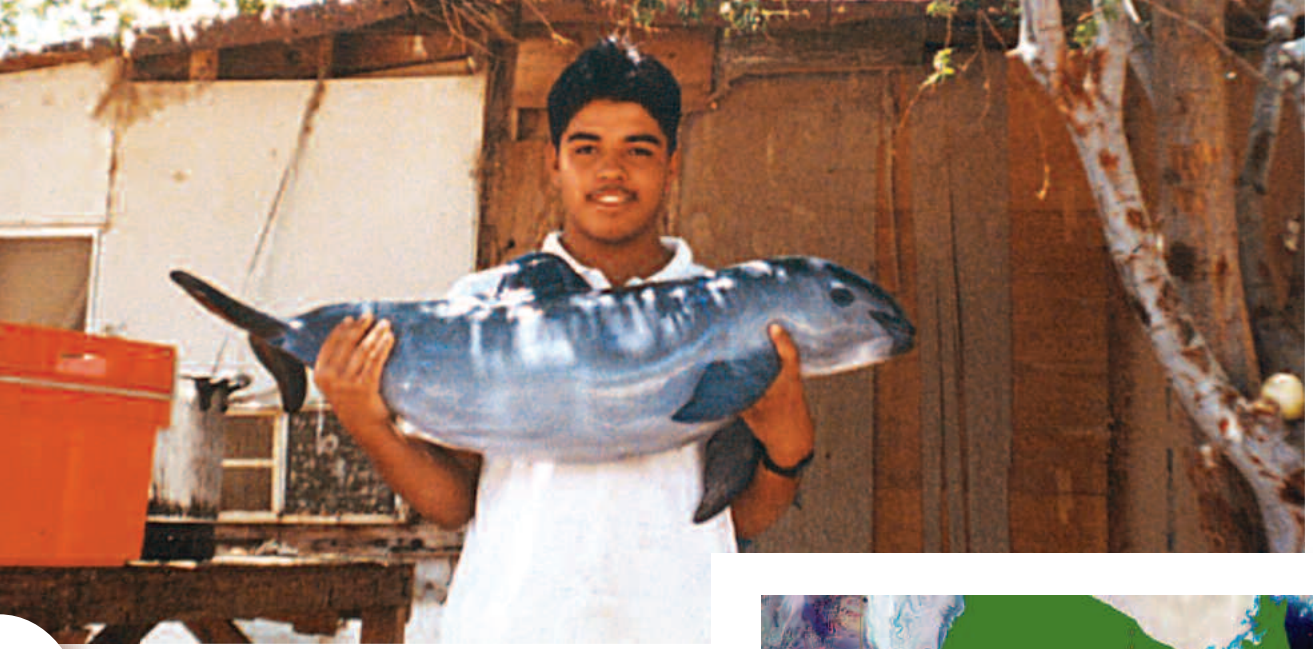
Unfortunately, this conservation priority area is also important for shrimp and other species of fisheries (Cudney and Turk-Boyer 1998). As discussed below, incidental mortality in fishing gillnets is the major risk factor for the survival of the vaquita. The International Committee for the Recovery of the Vaquita (CIRVA) is targeting a conservation goal of zero vaquita mortality because, if the species is to survive, the incidental mortality limits estimated for vaquita must be less than one per year (D'Agrosa et al. 2000, Rojas-Bracho et al. 2002). To accomplish this, and based on most recent visual and acoustic locations of vaquita, CIRVA has proposed a minimum protection area for vaquita shown in the Figure 3.6. This highlights the importance of establishing and enforcing fishing regulations within the priority conservation area, and within the larger area proposed by CIRVA.

Ecological Relationships

The vaquita is endemic to the northern portion of the Gulf of California, and its population is estimated to be 567 individuals (Rojas-Bracho et al. 1999). Concern has been expressed that a sink effect is occurring, and vaquitas are mainly concentrated in this priority conservation area. Food availability does not seem to be a limiting factor for vaquita populations. All adult vaquitas recovered to date have shown basically full stomachs. Analysis of stomach contents indicates that its diet consists of many species (approximately 21), which are expected for a porpoise diet (Rojas-Bracho and Taylor 1999).

Water needs

Little is known about the importance of freshwater flows for vaquita. Although reduced freshwater flows from the Colorado River do have an effect on life cycles of some marine organisms and on the estuarine food web, the available evidence so far does not indicate an impact on vaquita population and distribution (Rojas-Bracho and Taylor 1999, Flores-Skydancer and Turk-Boyer 2002).



There are no data on the distribution and population size of vaquita before the freshwater flows were reduced, therefore no baseline for comparison. Further studies to investigate this relationship, and to quantify water needs, if any, are needed.

Threats

Threats to the vaquita marina priority area are:

1 Incidental mortality in gillnets is the major risk factor for the survival of the vaquita. Available data indicate that 39 vaquitas have died in gillnets every year in the El Golfo de Santa Clara alone (D'Agrosa et al. 2000). Gillnets are widely and intensively used in fishing activities in the northern Gulf. Despite the prohibition of gillnets with mesh size greater than 10 inches (25 cm) in 1992, D'Agrosa reports that vaquita get entangled in the smaller mesh used for shrimp, sharks, and other species. D'Agrosa (1995) and D'Agrosa and others (2000) in a study of vaquita mortality in pangas fishing from El Golfo de Santa Clara between January 1993 and April 1994, found that vaquitas were trapped in a variety of gillnet fisheries including shrimp, chano, shark, and sierra (7–15 cm). Several authors considered that the annual vaquita mortality in gillnets was around 30 animals. This was confirmed in a formal mortality estimate by D'Agrosa and others (2000). Fishing with gillnets is an existing threat with severe impacts and low reversibility.

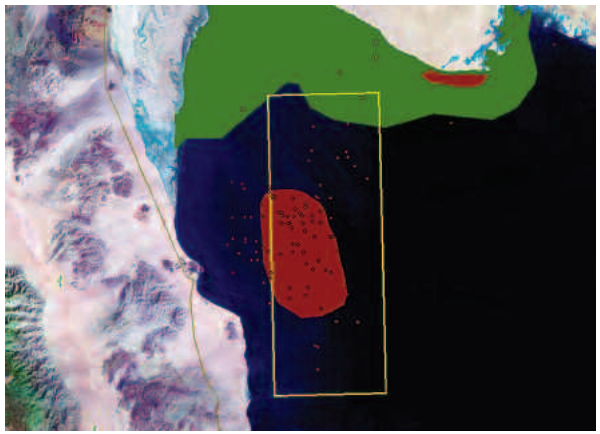


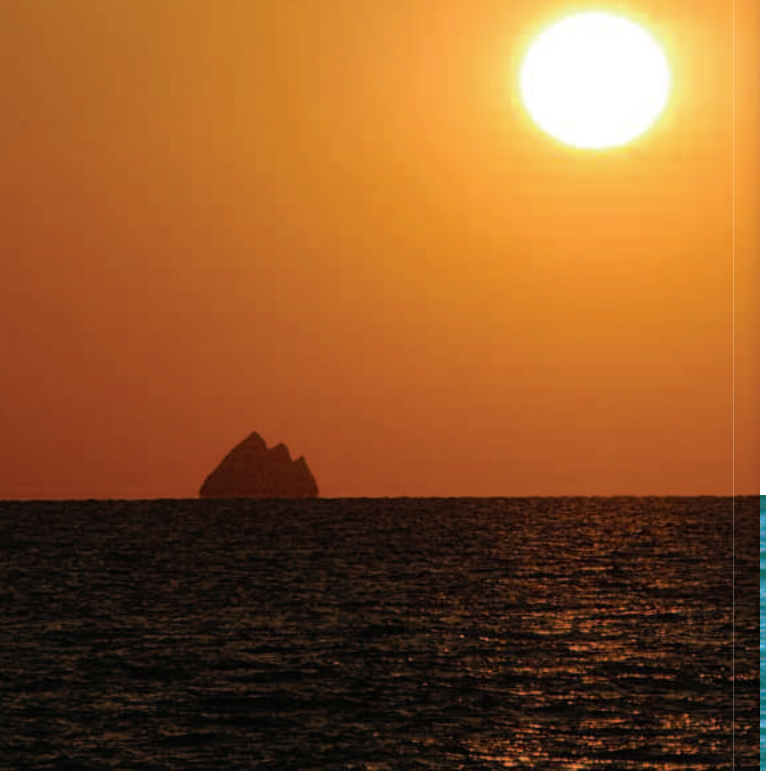
FIGURE 3.6 VAQUITA CONSERVATION PRIORITY (IN RED) AND CIRVA PROPOSED MINIMUM PROTECTION AREA (IN YELLOW)

2 Incidental mortality in trawling nets has been reported by fisherman, and particularly affects vaquita calves; however, the contribution to vaquita mortality is much less compared to that resulting from gillnets. Vidal and others (1999) documented that between the 1960s and 1990s, fisherman from San Felipe and El Golfo de Santa Clara reported eleven dead vaquitas in trawling nets. Known vaquita mortality in shrimp trawl fisheries was generally considered to be sufficiently small and should not warrant a ban on this gear type, but the ecological damage resulting from trawl fisheries is not compatible with the long-term health of the ecosystem in the Upper Gulf of California (J. C. Barrera, personal communication September 2004). Bottom trawling is a current threat with medium to severe impacts and medium to high reversibility depending upon how severe the area has been affected. Nava-Romo (1994) indicates that the impacts of bottom trawler impacts in the Upper Gulf include: (i) deterioration of the bentic-demersal community, with a tendency for decease in its diversity; (ii) changes in the dominant species in the community; and

(iii) reduction of fishing biomass and decrease in the average weight of caught fish.

3 Habitat alteration may be another threat for vaquita populations; however, it is not known how changes in the habitat may affect the vaquita, and therefore this degree of impact has not been determined.

4 Noise pollution may affect the vaquita, especially considering the combined output from several vessels. Rojas-Bracho and others (2002) have proposed that the aggregation behavior and local movements of vaquita are potentially adversely influenced by trawl fishing vessels noise.



Opportunities

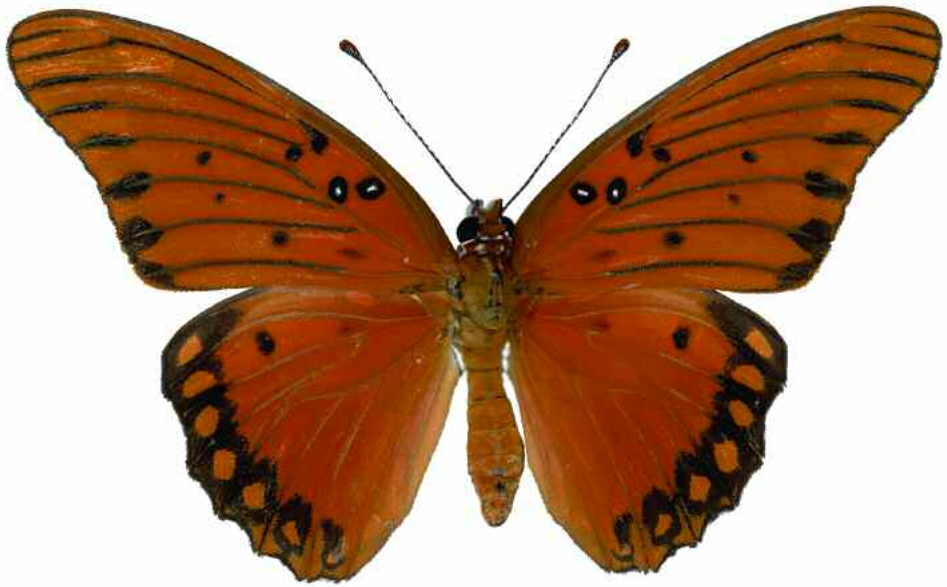
A combination of regulation and enforcement with public participation represents the best alternative to accomplish the conservation goals for the vaquita marina priority area. Specific opportunities are:

1 Fishing regulations have restricted the use of some types of gillnets 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 to the vaquita. Because a portion the main population distribution area (40% of the vaquita sightings) lies outside the biosphere reserve, expanding the application of these fishing regulations to include the entire vaquita habitat is critical. CIRVA recommends reducing incidental mortality to zero as soon as possible by eliminating gillnets from the Upper Gulf in a stepwise manner and looking for alternative fishing gear as well as socioeconomic alternatives (Rojas-Bracho et al. 2004).

2 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 providing sustainable economic activities, such as ecotourism.

4

Research needs



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, with only modest government and foundation support. While these smaller-scale studies have led to today's much-improved understanding of ecosystem form and function in the Delta and Upper Gulf, larger-scale, comprehensive studies are needed to form a sound scientific basis for a binational strategy 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 five priorities

1. Conduct a comprehensive inventory of the Colorado River Delta ecosystems, including an inventory of species 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. Develop a hydrologic model for the Delta based on detailed elevation data, channel morphology, surface and groundwater flow, and estuarine circulation.
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 based on results of sound research and an adaptive management approach.

Expanded list of research needs

During the first session in the workshop, each expertise group identified research gaps, which have been presented in Chapter 2. Later in the workshop, and based on the work of interdisciplinary groups, all participants integrated research needs into the following:

Water budget and water quality

- Develop a detailed surface and groundwater flow model for the Delta that quantifies groundwater flows and interactions with surface waters. The model should include agricultural return flows and natural flows to determine the fate of water in the river channel, which will help to better understand the relations between instream flows and agricultural drain water with keystone fauna and flora species. In addition, the model will help to determine the flow rate at which scour has a negative impact on riparian ecosystem.
- 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.
- Monitor water quantity and quality, and identify trends at agricultural drains by installing flow gauges and quality sampling. This should also include monitoring wastewater effluents.
- Quantify and refine water needs for all ecosystem types, including minimum freshwater flows needed for marine ecosystem restoration.
- Identify the water source for El Doctor and determine whether pumping in San Luis Río Colorado impacts water supply for the wetland.
- Determine the presence and effects of pollutants in the Upper Gulf.
- Assess the impact of geothermal water use and exploration.

Inventory and monitoring

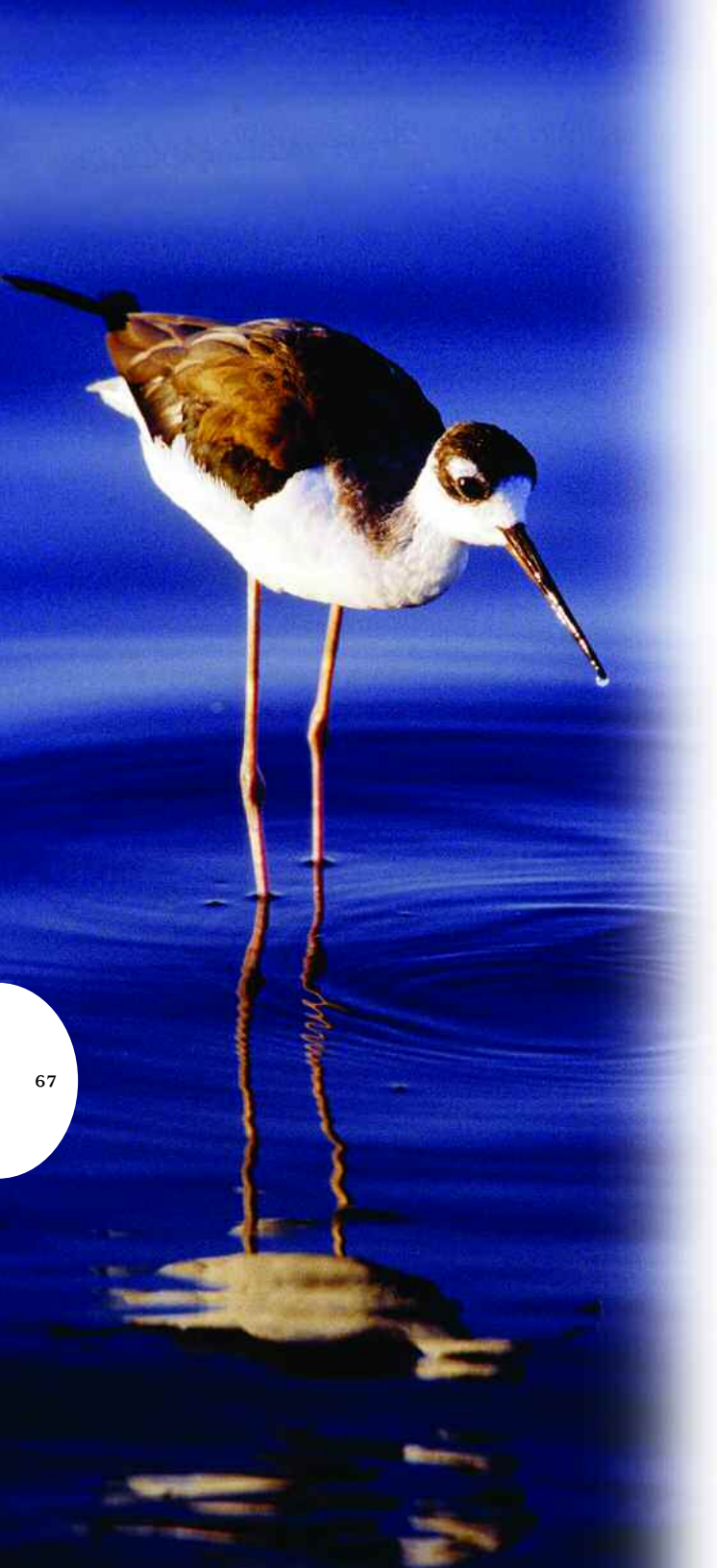
- Conduct a full inventory of conservation targets and establish a program to monitor resources and threats, with the objective of further refining their status, impacts, and reversibility as needed. Use this along with results from the hydrological model to further refine conservation and restoration priorities.
- Inventory contaminants in sewage, agricultural wastewater, and other water sources entering the river and determine impacts on humans and biota.
- Determine the impact of shrimp trawling, as well as shrimping restrictions on the marine ecosystem.
- Determine the 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. This should include registering strandings of moribund marine mammals and sea turtles.
- Study the 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 land birds.
- Identify the food sources for shorebirds and migratory species, and identify nursery habitat for fisheries.
- Study benthic productivity.
- Inventory aquatic amphibians and reptiles.
- Assess environmental impacts of tourism development.
- Develop a comprehensive interdisciplinary monitoring program to determine how certain species, including the shrimp and corvina runs and migratory birds, seem to be responding to river flows that reach the intertidal zone.
- Inventory and explore wildlife management and biodiversity conservation goals at the agricultural-upland interface.
- Assess the impact of noise pollution on coastal species, particularly the vaquita and other marine animals.
- Evaluate the economic costs and benefits of restoration, including existing and potential ecotourism activities.

Other Opportunities

- A few species offer opportunities to use stabilized isotopes to reconstruct their connection to freshwater, such as 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 to measure the environmental effects (both positive and negative) of tourism and commercial shrimp production in the Upper Gulf of California. Many existing research collaborations are binational in scope, and should be strengthened.

Data management

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



5

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. 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.

Conclusions

- 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 and to begin action on those priorities. 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.
- The principal 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 curtailment as consumptive water use increases, out-of-basin water transfers increase, and climate change reduces the total basin water yield. The agricultural return flows and groundwater seepage from canals that sustain wetlands and riparian areas, such as Ciénega de Santa Clara, Andrade Mesa wetlands, and Río Hardy, are not guaranteed and are likely to be reduced by greater efficiencies in water use in the area.
- Non-governmental organizations and academic institutions have made significant commitments to scientific research on the Colorado River Delta and Upper Gulf of California and on the conser-

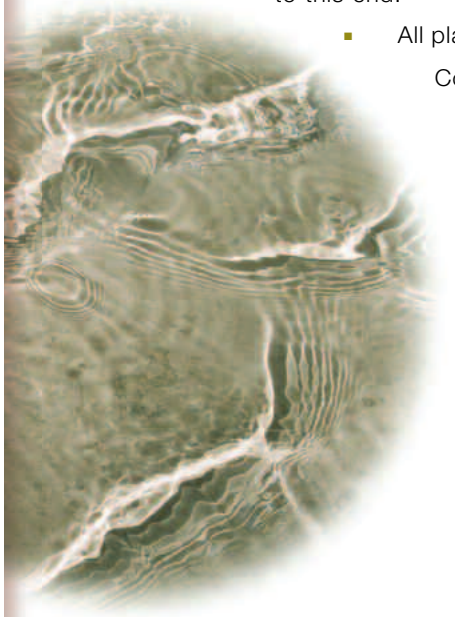
vation and restoration of its ecosystems. Until the U.S. and Mexican federal governments greatly increase their commitment, the health of these ecosystems cannot be assured, however, and large-scale improvements in ecosystem health will remain unattainable.

- Each of the ecosystem types in the Colorado River Delta and the Upper Gulf of California has distinct attributes, values, and water needs. Each is threatened with loss of resource value and each has opportunities for restoration. All of the ecosystem types are linked through their dependence on the hydrologic regime of the Colorado River.

Broad Recommendations

- 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.
- The United States and Mexico should use Minute 306 as a framework for developing a conservation and restoration plan for the Colorado River Delta.
- The United States and Mexico should commit to an agreement that protects and restores the most significant areas of the ecosystems of the Colorado River Delta and Upper Gulf of California as identified by the conservation priorities in this report. That agreement should include quantified, dedicated sources of water for the environment through treaty agreement, national policy, or market-based mechanisms.
- The Commission on Environmental Cooperation should establish Delta conservation and restoration as a priority and identify funding to support research and infrastructure to this end.
- All plans for ecosystem protection and restoration in the lower Colorado River region, including plans for the Delta and for the Salton Sea, should recognize the interrelated nature of aquatic habitats in the region.
- All entities engaged in activities that may affect the region's ecosystems should engage in consultation with local communities.

  Government agencies and other funding institutions in both countries should commit resources to support research as outlined in Chapter 4.



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 (37–62 million m^3) at about 70 cubic feet per second (2 m^3/s) and an estimated periodic flood flow of 260,000 acre-feet (320 million m^3) at about 7,050 cfs (200 m^3/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 1.4 parts per thousand (ppt). There is no storage facility for Colorado River water in or controlled by Mexico, so 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 Limites 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 Game and Fish Department (AGFD), and several private landowners have land within or management authority for the riparian corridor below Morelos Dam (including both U.S. and Mexican territory). 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. Specifically, the IBWC should reconsider its border rectification and flood control project for the limitrophe, and CNA should reconsider its flood control and pilot channel project for the riparian corridor that starts at the Southerly International Boundary and extends to the south. Together, these projects have the potential to affect negatively approximately 61 miles (98 km) of the Delta's riparian corridor through contemplated activities such as dredging and clearing of vegetation, both of which pose significant threats to the Colorado River Delta 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 as 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, AGFD, 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 all of their facilities on the Colorado River, including 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 and BOR should identify and mitigate negative impacts to the riparian corridor of local groundwater pumping, irrigation efficiency projects, and agricultural-to-urban water transfers.

8 **Eradicate salt cedar:** This should be done only when native trees will be planted and maintained in their place. Bird diversity in salt cedar monocultures is low, and native forests tend to harbor higher populations of birds as well; however, salt cedar stands are better than a complete absence of vegetation.

9 **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.

RÍO HARDY CORRIDOR

1 **Identify and improve Río Hardy instream flows:** CNA should identify the characteristics of instream flows in the Río Hardy, and determine flows that would maximize ecological benefit. Flows in the Río 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 Río 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 Río Hardy, and should explore the potential to create additional wetlands as a means of "pre-treating" water before it enters the Río 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 Río 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 del Estado de Sonora (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 to these wetlands.

2 **Protect desert springs:** 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 Río Hardy:** Federal agencies such as SEMARNAT, 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, including birdwatchers, boaters, fishermen, and hunters, and should assist these groups to expand their efforts to include the Río 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.

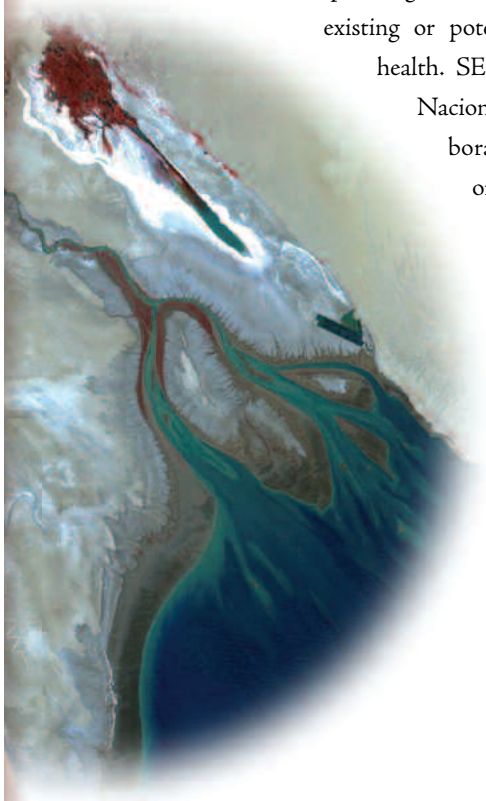
6 **The Andrade Mesa wetlands should be protected and given a dedicated water source:** SEMARNAT should consider giving these wetlands legal protection through designation as a protected area. Their water source, which has not been well-documented, should be identified and quantified. IBWC and CILA should 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 wetlands:** Major agricultural drains, such as the Ayala Drain, as well as 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 Río Hardy wetlands and eventually to the Ciénega de Santa Clara.

INTERTIDAL, COASTAL, AND MARINE ZONES

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 is known about the importance of freshwater flows 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 (totoaba and corvina, with a focus on reproduction), the Colorado Delta clam, 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 unique near-shore marine habitats, such as Consag Island and El Borrascoso, 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 the extraction of marine resource:** Federal and state rural development programs in Mexico 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.

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Appendix 1: Workshop Methodology

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, and other information. In addition, the workshop authors developed a list of key ecological relationships identified for the Delta region and used them as a starting point for discussion during the workshop. 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 (Groves 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 conservation targets 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. Experts identified conservation targets for each of the following groups:

- Coastal and marine systems
- Fish and marine mammals
- Terrestrial vertebrates (birds and other fauna)
- Habitat, vegetation, and restoration
- Hydrology

During the remainder of the workshop, experts and observers worked in interdisciplinary groups to analyze 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. Threats are defined as impacts on biological features (e.g., vegetation clearing, burning, and exploitation) or physical features (e.g., changes in river morphology). Opportunities are biological or physical improvements that can be implemented to maintain or enhance ecological functions in the Delta. Careful consideration of the degree, intensity and reversibility of threats as well as real opportunities for conservation and restoration allowed experts to begin to identify 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 priority areas rather than a ranked or prioritized list.

PHASE 3: PRODUCT DEVELOPMENT

The organizing committee took a two-fold 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.

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 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.

Appendix 2: Conservation Targets Description

Target name	Target goal	Current state of information	Legal status of the target	Condition of the target	Is the target endemic?	Additional information about the target
MARINE SPECIES						
Colorado Delta clam (*Mulinia coloradoensis*)	sustainable population	some information	unprotected	critical	yes	distribution of the Colorado River Delta clam extends from the Upper Gulf to south of the San Felipe point
Shrimp (*Litopenaeus stylirostris* and *Farfantepenaeus californiensis*)	sustainable population	good	unprotected	critical	no	the most important fishery in the Upper Gulf of California
Pacific sharpnose shark (*Rhizoprinodon longurio*)		good		declining steadily	no	top predator; used to be very abundant and important commercially
Scalloped hammerhead shark (*Sphyrna lewinii*)		good		heavy decline	no	used to be abundant; important commercially; top predator
White shark (*Carcharodon carcharias*)						top predator; reproduces in Upper Gulf
Delta silverside (*Colpichthys hubbsi*)	maintain stable population; conserve reproductive grounds	some information		locally abundant	yes	species endemic to the upper reaches of the northern Gulf; requires more research regarding life history; very restricted geographic range
Pacific red snapper (*Epinephelus acanthistius*)	increase population size; conserve deep water rocky and muddy habitat	some information		declining	no	species declining due to heavy fishing
Gulf grouper (*Mycteroperca jordani*)	maintain or increase current population size	good		apparently in decline	no	top predator of Upper Gulf's rocky reefs; indicator of condition of rocky reefs; important commercial species
Barred pargo (*Hoplopagrus guntheri*)	increase and maintain population; protect rocky reefs	good		unknown	no	reproductive aggregations in El Borrascoso; important commercial species; umbrella species

Target name	Target goal	Current state of information	Legal status of the target	Condition of the target	Is the target endemic?	Additional information about the target
MARINE SPECIES (continued)						
Totoaba (*Totoaba macdonaldi*)	recover and sustain population	some information	endangered	endemic species in critical condition; in general, the population is stable with low numbers; recovery conditions are not well known; there are important advances in reproducing the species in captivity	yes	trawling fishing continues to impact the species mainly by affecting juveniles less than 30 cm in length; sport fishing affects older individuals of the population; the adult stages of the life cycle of this species are not well known; tidal mudflats in the southwest Delta could be reclaimed through construction of artificial channels in order to provide nursing grounds
Gulf corvina (*Cynoscion othonepterus*)	conserve healthy population	low	unprotected	despite intensive fishing, populations of this species continue to arrive in large numbers, but with a decrease in numbers of large-size individuals	yes, but it is necessary to better document the distribution and endemism of the species with available information	top predator and its presence indicate that conditions in the Delta still maintain important habitat for reproduction; harvested commercially; poorly regulated
Vaquita (*Phocoena sinus*)	recover and sustain a viable population; zero incidental mortality	some information; new information being collected through acoustic surveys	IUCN critically endangered, Cites I, NOR 059 endangered	critical; population declining (current population size less than 600)	yes	high by-catch in gillnets; current research includes distribution and habitat description and use of acoustic methods; efforts at present to recover this species
Fin whale (*Balaenoptera physalus*)	maintain this endemic population	good	NOM 059 Pr	isolated landlocked population; population numbers likely stable	apparently yes	this is a unique population; acoustic and genetic studies indicate that this is an endemic stock

Target name	Target goal	Current state of information	Legal status of the target	Condition of the target	Is the target endemic?	Additional information about the target
MARINE SPECIES (continued)						
Bigeye croaker (*Micropigonias megalops*)	conserve healthy populations	low	unprotected	critical; evidence of loss of genetic variability in the Upper Gulf	apparently yes	consensus needed about endemism; in Mexico, species is not legally protected and is heavily exploited in the Upper Gulf
Bottlenose dolphin (*Tursiops truncates*)	identify potential endemic stock	some information	NOM 059 Pr	the Delta dolphins seem different from dolphins to the South	potentially endemic stock	current genetic studies are underway to determine if this is endemic stock or a subspecies; research to use this species as indicator of the health of the Upper Gulf
California sea lion (*Zalophus californianus*)	identify potential stock	good	NOM 050 Pr	current genetic and other biological information point to an endemic stock on subspecies	apparently yes	data indicate that sea lions from northern Gulf are more closely related to those in the Galápagos than those in the Southern Gulf
FRESHWATER SPECIES						
Desert pupfish (*Cyprinodon macularius*)	conserve existing population and restore habit	very good	endangered in Mexico, LE, G1	stable at specific sites; declining at least in one site	yes	occurs in very unstable habitats and with several abundant introduced species
Bonytail (*Gila elegans*)	recover population and restore habitat	low	officially extirpated from Mexico and endangered in U.S.		yes	subject to recovery program in the lower Colorado in U.S.; collected in the Colorado River mainstem in Mexico at the turn of the last century
Woundfin (*Plagopterus argentissimus*)	recover population and restore habitat	low	officially extirpated from Mexico and endangered in U.S.		yes	subject to recovery program in the lower Colorado in U.S.; collected in the Colorado River mainstem in Mexico at the turn of the last century
Razorback sucker (*Xyrauchen texanus*)	recover population (restoration target)	low	officially extirpated from Mexico and endangered in U.S.		yes	subject to recovery program in the Lower Colorado in U.S.; collected in the Colorado River mainstem in Mexico at the turn of the last century

Target name	Target goal	Current state of information	Legal status of the target	Condition of the target	Is the target endemic?	Additional information about the target
TERRESTRIAL SPECIES						
Marsh birds	protect existing marshlands; create new wetlands by restoring degraded areas in Río Hardy; control expansion of salt cedar; protect from cattle grazing	good, but needs long-term monitoring	Yuma clapper rail is protected as a threatened species in Mexico and an endangered species in the U.S.; California black rail is endangered in Mexico and California, and listed as a candidate species in the U.S.	Yuma clapper rails are found in high densities but declining, probably due to a decline of cattail health; California black rails are found in low numbers; Ciénega de Santa Clara seems to be getting senescent, need to restore potential habitat areas such as the Río Hardy	yes; Yuma clapper rail is endemic to the Delta and lower Colorado River	for other species, see Appendix 3 for additional information
Aggregations of nesting waterbirds	maintain suitable nesting, roosting, and foraging sites	current status known, ongoing monitoring	some species are protected under the Migratory Bird Treaty Act and Endangered Species Act in Mexico; California least tern and reddish egret designated threatened in Mexico	restricted to Cerro Prieto, Montague Island, and flats of El Doctor and Flor del Desierto	no	colonies are highly localized; require sites free from ground predators and human disturbance
Riparian-obligate breeding species	conserve cottonwood-willow riparian habitat; conserve existing areas, particularly foliage and species heterogeneity; maintain both continuity and larger blocks of habitat; control exotic species; expand habitat with more water; evaluate impact of cowbirds	very little, need vital rates and abundance	southwest willow flycatcher and yellow-billed cuckoo are endangered species	native riparian forest is limited to 2% of historic extent; late 20th century flood flows increased extent of this habitat, but exotic species invasions continue to degrade its quality	no	species include southwest willow flycatcher, yellow-billed cuckoo, and vermilion flycatcher; see Appendix 3 for additional information and a list of all species

Target name	Target goal	Current state of information	Legal status of the target	Condition of the target	Is the target endemic?	Additional information about the target
TERRESTRIAL SPECIES (continued)						
Migratory landbirds	create and maintain a continuous mosaic of riparian shrubs, woodland, mesquite, and desert microphyll woodland used by NW-trending spring migrant landbirds	some data on migrants including numbers, species composition, seasonality; no long-term data; some point counts, mist-netting, and censuses	no protection, except those species found in the Biosphere Reserve (El Doctor); some listed species (e.g., southwest willow flycatcher) likely pass through as migrants	greatly reduced from original extent; degraded by exotic species (e.g., salt cedar); damage from livestock and pumping of groundwater	no	large-scale landbird migration mainly a spring phenomenon (March through early June), also important to a lesser degree in fall and winter; salt cedar and other exotics may be used by migrants, but its relative importance is unknown; preservation and restoration of riparian woodland will greatly aid landbird migrants—there is a broad overlap between these targets; numerous species of hummingbirds, warblers, tanagers, sparrows, buntings, grosbeaks, orioles, and raptors
Migratory waterbirds	ensure the Delta will provide suitable habitat for wintering migratory waterbirds (including shorebirds)	historical data and current surveys of populations	many species are listed in U.S. or Mexico and in Migratory Bird Treaty Act	hemispherically, their habitat is threatened and declining and giving the cumulative effect of habitat loss and degradation; the target is declining and depends in part on the Delta	no, it is part of the Pacific Flyway	white pelican (Western population) is an umbrella species and depends heavily on the Delta bioregion (including Salton Sea); shorebirds use the area for wintering and stopover in large numbers; the Delta is a Western Shorebird Reserve Network site
Marine Zone	maintain the food web	reasonable	protected through the Biosphere Reserve	impacted by commercial activity; perhaps declining influx of fresh water limit nutrients	no	post-breeding dispersal area for pelicans, grebes, terns, and gulls; feeding grounds for nesting waterbirds

Target name	Target goal	Current state of information	Legal status of the target	Condition of the target	Is the target endemic?	Additional information about the target
MARINE PROCESSES (BIOLOGICAL and PHYSICAL)						
Invertebrate and vertebrate life cycles	protect habitat to protect life cycles	some information	some habitat protected through the Biosphere Reserve	poor	N.A.	large estuarine wetlands need restoration, as they are key nursery areas for numerous species; these wetlands are affected by processes in both the U.S. and Mexico
Mixing of fresh and marine water	restore large areas of brackish water	some information	protected through the Biosphere Reserve	poor	N.A.	these areas provide for and protect nursery grounds for both commercial and endangered species; they include salinity fronts that work as barriers for predators; freshwater flow depends on U.S. and Mexican water policies in the Colorado River
Tidal currents	preserve their natural function	very good	protected through the Biosphere Reserve	good	N.A.	threatened by proposals to build infrastructure to generate electricity; tidal currents are a key mechanism for transport of early life stages of many species
Estuarine wetlands	restore large estuarine wetlands	some information	partially protected through the Biosphere Reserve	poor	N.A.	large estuarine wetlands in the Delta's southwest existed historically before dams, mainly during spring floods with anomalous high river flow; these wetlands have been formed in the past and could be restored for habitat enhancement
Groundwater levels and flows	restore and sustain	low	regulated	unknown	N.A.	groundwater levels and flows are affected by U.S. and Mexican water use and policies; there is no information on the impact of groundwater flows on off-channel wetlands and on riparian habitat
Sediment transport	predict future geomorphology of the Delta	some information; dynamics of sediment input from freshwater flows unknown	protected through the Biosphere Reserve	unknown	N.A.	amounts of sediment equivalent to the natural flows before dams are being transported from the Delta to the northern Gulf; these sediments come from erosion of earlier deposits; effect of this erosion on the estuarine coast is unknown

Target name	Target goal	Current state of information	Legal status of the target	Condition of the target	Is the target endemic?	Additional information about the target
FRESHWATER HABITATS						
Vegetation and backwater in railroad area from Benito Juarez to about Carranza highway crossing	maintain water flowing in main channel and backwaters; maintain existing levels of the water table	information available on vegetation coverage and birds; some on groundwater	unprotected; federal zone managed by CNA	excellent conditions, with vegetation and open water areas	N.A.	presence of good stands of cottonwoods and willows, and small lagoons formed in backwaters; main threat is vegetation clearing and fires
El Indio Wetlands: Inundated area behind east dike, from Ayala Drain	maintain and enhance the extension and condition of this emergent wetland	need information on how gates and pumps are operated; where they are opened or operational, and who decides	unprotected; part is federal zone managed by CNA, part is concessioned to private owners	good with high potential for restoration	N.A.	there exists a current restoration effort to improve and increase habitat in El Indio Wetlands
North to South International Boundary (entire limitrophe section), both Mexico and U.S. sides of the river and riparian corridor	conserve and restore riparian habitat; assess the feasibility of designating lands in limitrophe as international wildlife refuge as proposed by the Cocopah tribe	information available on vegetation coverage and birds; need to understand administrative spills through Morelos Dam; need to know what is the conveyance capacity of the channel	unprotected; main threats include vegetation loss to clearing or water table lowering	excellent conditions, with vegetation and open water areas	N.A.	a wildlife refuge would assist in providing wetland habitat for migratory wetland birds and riparian habitat for neotropical migratory songbirds—all part of the Pacific Flyway
Ciénega de Santa Clara	preserve vegetation and habitat for wildlife (specifically wetland habitat); establish permanent flows into the wetland	interaction with groundwater; assessment of impacts under a change in water inflow and quality	protected as part of the core zone of the Biosphere Reserve	excellent conditions of cattail and open shallow water areas	N.A.	
Upper intertidal area, 10 miles above and 20 miles below confluence of Río Hardy and Colorado River	manage flows to maximize estuarine productivity, nursery habitat for macro-invertebrates, fish of value to fisheries, and food chain to support migratory wetland birds	need to develop hydraulic model to assess overbanking; needs for up-river riparian and salinity gradient, maintenance and detrital transport in an intertidal area; need to study the impacts of freshwater on nursery habitat	a portion is protected as part of the Biosphere Reserve	insufficient steady flows to maintain productive salinity regimes and periodic flood events to transport organic detrital materials for estuarine food chain incorporation	no, although some species of fish and invertebrates are endemic to the Upper Gulf	

Target name	Target goal	Current state of information	Legal status of the target	Condition of the target	Is the target endemic?	Additional information about the target
VEGETATION and TERRESTRIAL HABITATS						
Limitrophe	protect and enhance cottonwood-willow stands	information available on vegetation coverage and birds	none, international boundary	high density of willows important for connectivity	no, but all critical native species	high priority site given the presence of threats
San Luis-railroad bridge	protect and enhance cottonwood-willow riparian areas	need information on vegetation, water quality, and channel morphology	unprotected; CNA-managed with private farmland	highly modified; southern portion shows strong regeneration of native riparian trees; significant quantities of mid-age riparian trees and areas with emergent vegetation		excellent channel morphology conditions for regeneration of native trees; water quality is better in this reach than downstream; numerous opportunities for riparian restoration in its southern portion
Railroad-Río Hardy	protect and restore cottonwood-willow forest, marsh wetlands, and mesquite	need information on vegetation, water quality, and channel morphology	unprotected; CNA managed land	highly modified, but it has value because it still has "natural flows" from agricultural drains; shallow groundwater table	no, but native species present	some marsh wetlands with open water and small river flow exist in the area between railroad bridge and Carranza highway; flood plain and channel morphology offer significant potential for regeneration; threats include flood management, channel alignment, lack of flows, deterioration of water quality, wood cutting before trees get maturity, and fires
Río Hardy	restore marshland and mesquite forest; maintain river flow and improve water quality; increase cottonwood-willow forest	some information on birds; need information on vegetation, birds, river surface and groundwater hydrology, fish, and water quality	unprotected	difficult to support cottonwoods and willows because water and soils are too salty; but very good area for shorebirds; southern portion dominated by salt cedar of unknown human and wildlife value	no, but native species present	huge amount of vegetation, mainly salt cedar; semi-permanent wetlands; many opportunities for restoration of mesquite, cottonwoods, and willows if additional freshwater is secured for the river
Ciénega de Santa Clara	maintain at least at current conditions	need monitoring as vegetation is dynamic and changes have not been studied	protected as part of the core zone of the Biosphere Reserve	good; cattail too old and overgrown	yes, Palmer's saltgrass and desert pupfish	the ciénega is linked with El Doctor wetlands and together they offer the largest fresh water wetlands in the Sonoran Desert

Target name	Target goal	Current state of information	Legal status of the target	Condition of the target	Is the target endemic?	Additional information about the target
VEGETATION and TERRESTRIAL HABITATS (continued)						
El Indio Wetlands	reestablish native wetland plants (mesquite, cattail, bulrush, and saltgrass)	need a detailed vegetation map; determine hydrology including sources of water and water quality; evaluate wildlife value	protected by the Biosphere Reserve	highly modified with a lot of salt cedar and cattails	no, but native species present	all water flow is ephemeral (from agricultural drainage)
Cerro Prieto ponds	maintain ponds in existing conditions	some for birds and heavy metals	privately owned, protected from outside	excellent but unstable as they are manmade and managed ponds	yes, desert pupfish	the largest population of pupfish inhabit the ponds
El Doctor Wetlands	conserve wetlands and surrounding upland areas with native vegetation	good for birds using these wetlands; some for heavy metals; and only limited hydrological information is available	protected as part of the core zone of the Biosphere Reserve	excellent	yes for desert pupfish; wide spread plants, mostly native species	combination of open water with wetland plant species makes it very important; pools and springs all along the fault; springs are important for pupfish refugia and neotropical birds; last remaining samples of Delta flora of almost entirely native species; major threat is cattle grazing

Target name	Target goal	Current state of information	Legal status of the target	Condition of the target	Is the target endemic?	Additional information about the target
VEGETATION and TERRESTRIAL HABITATS (continued)						
Palmers' saltgrass (*Distichlis palmerii*)	protect the area's saltgrass at the mouth of the Colorado River; reestablish freshwater flows to support germination	poor; need baseline knowledge and coverage changes of saltgrass areas in the Upper Gulf; work by Zamora-Arroyo and others (2002) provides some data	protected as part of the core zone of the Biosphere Reserve	stable community, but needs river flows for germination	yes, to the Upper Gulf	Palmer's saltgrass is one of the most significant bioresources of Mexico, it is essential for stabilization of banks; Cucapá people used to harvest it for food
Andrade Mesa wetlands	conserve marsh and riparian wetlands	good for habitat types and birds; some for groundwater hydrology	unknown, apparently is private land	excellent, combination of marsh (open water, saltgrass, and cattail) with riparian habitat (mesquite)	unique oasis habitat in the Delta	depends on underflow of the All American Canal seepage
Sonora Mesa	conserve existing habitat		protected as part of the Biosphere Reserve	excellent, with rich ephemeral vegetation in pristine condition; species richness is very high		very significant as it is largely in its original condition; minimum number of invasive species; threats include dune buggies
Abandoned agricultural lands	restore riparian and upland habitat	poor; need land ownership, and groundwater data; area seems to be full of salt bush (*Attriples lentiformes*)	not protected; retired agricultural land		N.A.	very high restoration potential for mesquite (*Prosopis gladulosa* and *Prosopis pubescens*), salt bush (*Atiplex lentiform*), and fresh water wetlands

Appendix 3: Bird Conservation Targets

Extracted from the Bird Conservation Plan for the Colorado River Delta Pronatura Noroeste

Bird conservation targets were selected in order to define the management recommendations for the conservation of birds and their habitats in the Colorado River Delta. These targets set the guidelines for the definition of conservation priorities, as they were defined as bird groups with similar habitat requirements, thus sharing similar pressures and needs. A complete list of species and focal species within each group are defined in order to further refine the habitat management implications and facilitate monitoring and evaluation efforts.

The final list of conservation targets included seven bird groups:

- Marshbirds
- Colonial waterbirds
- Riparian birds
- Migratory landbirds
- Migratory waterbirds
- Saltgrass bird community
- Marine zone bird community

MARSHBIRDS

These birds strongly depend upon the emergent vegetation of freshwater and brackish marshes. The focal species for this conservation target are: Yuma Clapper Rail, California Black Rail, Least Bittern, and Virginia Rail. The overall goal for this target is to maintain a dynamic system of marsh areas in the Colorado River Delta that secures the preservation of these birds. Specific goals include conserving existing marshlands (Ciénega de Santa Clara and El Doctor), restoring or enhancing degraded areas (Río Hardy and Colorado River), limiting the expansion of salt cedar, and protecting the marshes from cattle. The Yuma Clapper Rail is endemic to the Lower Colorado River and the Delta, and is listed as Endangered in the U.S. and Threatened in Mexico (Eddleman and Conway 1998, DOF 2002). The California Black Rail is listed as Endangered in Mexico and in California, and is a candidate species to be listed in the U.S. (California Department of Fish and Game 1999, DOF 2002).

Annotated Checklist of Marshbirds

ARDEIDAE – HERONS AND BITTERNS

Least Bittern (*Ixobrychus exilis*) – Garzita de Tular. Common breeding resident at the Ciénega de Santa Clara; uncommon at Río Hardy, Colorado River, and Andrade Mesa wetlands (Hinojosa-Huerta et al. 2002b).

RALLIDAE – RAILS

California Black Rail (*Laterallus jamaicensis coturniculus*) – Polluela Negra, Ralito Negro. Rare breeding resident at Ciénega de Santa Clara and El Doctor, with less than 50 pairs (Hinojosa-Huerta et al. 2001b). Subspecies listed as Endangered in Mexico (DOF 2002) and as a priority taxon for conservation in the U.S. (California Department of Fish and Game 1999). Single birds detected at Laguna del Indio (May 25, 2001), Río Hardy (May 30, 2001), Colorado River (June 9, 2002), and a canal at Ejido Luis Encinas Johnson (June 13, 2002).

Yuma Clapper Rail (*Rallus longirostris yumanensis*) – Rascón Picudo de Arizona, Palmoteador de Yuma. Common breeding resident at Ciénega de Santa Clara, with an estimated population of over 4,850 individuals (Hinojosa-Huerta et al. 2001a). Uncommon at other wetland sites, including Río Hardy, Río El Mayor, El Doctor, Colorado River mainstem, All-American Canal marshes, and throughout agricultural drains in the Mexicali Valley. Subspecies endemic to lower Colorado River and Delta, listed as Threatened in Mexico (DOF 2002) and Endangered in the U.S. (Eddleman and Conway 1998).

Virginia Rail (*Rallus limicola*) – Rascón Limícola. Common breeding resident at Ciénega de Santa Clara and El Doctor, with numbers augmented by winter visitors. Rare breeder at the Río Hardy and Colorado River. Species under special protection in Mexico (DOF 2002).

NESTING WATERBIRDS

This conservation target includes the waterbird species that breed in aggregations (colonies or semi-colonies) in the Colorado River Delta. This includes 14 species from three families: Ardeidae, Charadriidae, and Laridae. Major breeding sites for these birds are Montague Island, Cerro Prieto, and the saltflats of El Doctor and Ciénega de Santa Clara (Mellink et al. 1996, Molina and Garrett 2001, Peresbarbosa and Mellink 2001). There are also important heronries at some drains in the Mexicali Valley (Mellink et al. 2002). The focal species for this target are: Gull-billed Tern, Laughing Gull, Snowy Plover, Black Skimmer, and Snowy Egret.

The goal for the conservation target is to maintain suitable nesting, roosting, and foraging sites for these species in the Colorado River Delta. One of the major conservation objectives is to protect the highly localized aggregation sites, and protect the colonies from predators and human disturbance.

Annotated Checklist of Nesting Waterbirds

ARDEIDAE – HERONS AND BITTERNS

Snowy Egret (*Egretta thula*) – Garza Nivea. Common breeding resident at Isla Montague, Cerro Prieto (Molina and Garrett 2001, Palacios and Mellink 1992), and heronries in cottonwood and salt cedar trees in the Mexicali Valley (Mellink et al. 2002). Common visitor throughout the Colorado River Delta and coastal wetlands.

CHARADRIIDAE – PLOVERS

Snowy Plover (*Charadrius alexandrinus nivosus*) – Chorlito Niveo. Uncommon breeding resident at El Doctor saltflats, Ciénega de Santa Clara, and Cerro Prieto ponds. Western populations have declined since the 1920s (Powell 1998), and is listed as Threatened in Mexico (DOF 2002) and Endangered in the U.S. (Powell 1998).

LARIDAE – JAEGERS, GULLS, TERNS, AND SKIMMERS

Laughing Gull (*Larus atricilla*) – Gaviota Reidora. Fairly common breeder at Isla Montague (Palacios and Mellink 1992) and Cerro Prieto (Molina and Garrett 2001). Fairly common summer and rare winter visitor throughout the region.

Gull-billed Tern (*Sterna nilotica vanrossemi*) – Gallito piquigrueso. Status of western subspecies *vanrossemi* uncertain, but probably in declining numbers and is under consideration to be listed as Endangered in the U.S. (Parnell et al. 1995). Common breeder at Isla Montague and Cerro Prieto ponds. Common visitors to the Colorado mainstem, Río Hardy, canals, and drains as foragers. These colonies, along with the Salton Sea population, are the stronghold in their northern range (Molina and Garrett 2001).

Least Tern (*Sterna antillarum*) – Golondrina-Marina Mínima. Uncommon breeder, with colonies at Isla Montague, El Doctor, and coastal wetlands north of San Felipe and Puerto Peñasco (Palacios and Mellink 1996). Uncommon spring and summer visitor at other wetland and coastal areas; casual fall transient and winter visitor along the coast (Russell annd Monson 1998). Species under special protection in Mexico (DOF 2002).

Black Skimmer (*Rhynchops niger*) – Rayador Americano. Common breeder at Isla Montague (Peresbarbosa and Mellink 1994) and Cerro Prieto (Molina and Garrett 2001). Fairly

common transient and winter visitor along the coast, especially at El Golfo de Santa Clara and Puerto Peñasco.

RIPARIAN BIRDS

This conservation target includes birds that breed in riparian areas, with a special emphasis on those species that are riparian-obligate nesters. The selected species encompass a wide variety of habitat types, from mature cottonwood-willow forests, to mesquite woodlands, and young stands of colonizing willow, seep willow, and arroweed. The purpose of this selection was to provide the basis to restore and maintain a diverse and ecologically functional riparian system in the Delta.

The goal for this target is to protect the habitat of these birds: in particular the cottonwood and willow forests, but also the mesquite woodlands that occupy the terraces in the floodplain. It is important to maintain foliage (vegetation structure) and species heterogeneity in the floodplain of the Colorado River, as well as maintain both connectivity and large blocks of habitat. The target area includes the floodplain of the river delimited by the levee system that traverses the Mexicali Valley, starting in the north at Morelos Dam, and extending down to the confluence of the Río Hardy and Colorado River.

Focal species for this target include 18 birds from 13 families. This list includes species that were common breeding residents in the Colorado River in Mexico, but that are now extirpated, such as the Southwest Willow Flycatcher, the Fulvous Whistling Duck, and the Summer Tanager. It also includes some species that are now rare or occasional breeders in this region, such as Yellow-billed Cuckoos and Bell's Vireos. In the list are also species that have returned or have increased their numbers in response to revegetation of the floodplain, and some species that have remained common, but that their population fluctuations indicate the health of the system. The status of many of these species is just being determined, and for some is still unclear.

Annotated Checklist of Riparian Birds

ANATIDAE – DUCKS, GEESE, AND SWANS

Fulvous Whistling-Duck (*Dendrocygna bicolor*) – Pijiji Canelo. Former breeding resident in Río Colorado (Bancroft 1922, van Rossem 1945), but no recent records. Post-breeding visitors from breeding grounds at Imperial Valley might occur in the Colorado River and Mexicali Valley (Patten et al. 2001).

ACCIPITRIDAE – HAWKS, KITES, AND EAGLES

Osprey (*Pandion haliaeetus*) – Águila Pescadora. Uncommon breeding resident along the Colorado River. Fairly common non-breeding resident throughout the delta and coastal areas.

CUCULIDAE – CUCKOOS AND ROADRUNNERS

Yellow-billed Cuckoo (*Coccyzus americanus occidentalis*) – Cuco Piquiamarillo. Western populations have declined drastically (Hughes 1999), and the subspecies has been almost extirpated from the Colorado River Delta. Recent records during breeding season (1 pair in July 1995, Patten et al. 2001; 1 bird in June 2000, 2 pairs in July 2001, 2 singing males in June 2002, and 6 singing males in 2003) suggest that cuckoos might nest in the restored riparian patches of the Colorado River. The western subspecies is under consideration to be listed as Endangered in the U.S. (U.S. Fish and Wildlife Service 2001).

STRIGIDAE – OWLS

Western Screech Owl (*Otus kennicottii*) – Tecolote Occidental. Formerly an abundant breeder along the Colorado River (Russell and Monson 1998), now an uncommon breeding resident.

PICIDAE – WOODPECKERS

Gilded Flicker (*Colaptes chrysoides*) – Carpintero Collarejo Desértico. Formerly an uncommon resident of the Río Hardy and Colorado River (Grinnell 1928), but no recent records.

TYRANNIDAE – FLYCATCHERS

Willow Flycatcher (*Empidonax traillii*) – Mosquero Saucero, Papamoscas Saucero. The endangered subspecies *E. t. extimus* formerly bred along the Colorado River and Río Hardy (Unitt 1984). No breeding activity has been detected since 1928, despite extensive surveys being conducted from 1998-2003 (García-Hernández et al. 2001b, Hinojosa-Huerta et al. 2002a).

Vermilion Flycatcher (*Pyrocephalus rubinus flammeus*) – Brasita, Mosquero Cardenal, Pájaro Bule, Chapaturrín. Fairly common breeding resident along riparian areas of the Colorado River, Río Hardy, and Laguna del Indio. Apparently was almost extirpated as a breeder in the Colorado River Delta (Patten et al. 2001), but the local population has increased, most likely associated with revegetation of riparian areas in response to instream flows.

Ash-throated Flycatcher (*Myiarchus cinerascens*) – Copetón Gorjicenizo. Uncommon breeder along the Colorado River. Common transient and rare winter visitor.

VIREONIDAE – VIREOS

Bell's Vireo (*Vireo bellii*) – Vireo de Bell. Formerly was a common breeder along the Colorado River (Rosenberg et al. 1991), now a rare breeder in the remnant riparian patches of the Colorado River. Uncommon spring transient through El Doctor and the Colorado River.

MIMIDAE – MOCKINGBIRDS AND THRASHERS

Crissal Thrasher (*Toxostoma crissale*) – Cuitlacoche Crisal. Fairly common breeding resident of the Colorado River.

PARULIDAE – WOOD WARBLERS

Lucy's Warbler (*Vermivora luciae*) – Chipe de Lucy. Formerly a common breeder throughout the delta (Russell and Monson 1998), but no recent records. Rare transient through the Colorado River and El Doctor.

Yellow Warbler (*Dendroica petechia*) – Chipe Amarillo. Formerly a common breeding resident in the Colorado River Delta (Grinnell 1928, van Rossem 1945), is now a rare summer visitor with unconfirmed breeding. Common transient through El Doctor and the Colorado River. Rare winter visitor, with only one record at Mexicali (Patten et al. 2001).

Yellow-breasted Chat (*Icteria virens*) – Gritón Pechiamarillo. Uncommon breeder along the Río Hardy and Colorado River. Uncommon spring and fall transient through coastal desert scrub, El Doctor, and the Colorado River.

THRAUPIDAE – TANAGERS

Summer Tanager (*Piranga rubra*) – Tángara Roja. Formerly a common breeder along the Río Hardy and Colorado River (Grinnell 1928, Miller et al. 1957), but no recent breeding activity has been documented. Only two recent records, a female at the Río Hardy on April 1984 (Patten et al. 2001) and a male at the Colorado River in September 1999 (van Riper III et al. 1999).

EMBERIZIDAE – TOWHEES, SPARROWS, AND LONGSPURS

Song Sparrow (*Melospiza melodia*) – Gorrión Cantor. Common breeding resident throughout the Colorado River Delta.

CARDINALIDAE – CARDINALS

Blue Grosbeak (*Guiraca caerulea*) – Picogrueso Azul. Common breeder along riparian areas of the Colorado River.

ICTERIDAE – BLACKBIRDS

Bullock's Oriole (*Icterus bullockii*) – Bolsero de Bullock. Common breeder along the Colorado River. Common transient through Puerto Peñasco, Río Sonoyta, and El Doctor.

MIGRATORY LANDBIRDS

This conservation target includes species of landbirds that breed in the United States and Canada, winter in southern Mexico and Central America, and for which the Colorado River Delta is an important stopover site during their northbound migration. The goal for this target is to maintain a continuous mosaic of riparian corridors, desert shrubs, and microphyll woodlands that are used by these birds during their spring migration across the Gran Desierto, Alto Golfo Region, and Colorado River Delta. This goal also benefits fall migrants and those species that over-winter in the Colorado River Delta. Many of these species of migratory landbirds are also benefited by the goals and management recommendations for the riparian birds.

The focal species of this target include 10 birds from 7 families. Similar to riparian birds, this selection includes a variety of birds that encompass different habitat requirements. Emphasis is placed on the most common migrants, however, in order to have a sufficient sample size during monitoring efforts to yield significant results on trends and survivorship.

Annotated Checklist of Migratory Landbirds

TROCHILIDAE – HUMMINGBIRDS

Rufous Hummingbird (*Selasphorus rufus*) – Zumbador Rufo. Uncommon spring and rare fall transient through the coast, Pinacate, and Colorado River Delta.

TYRANNIDAE – FLYCATCHERS

Willow Flycatcher (*Empidonax traillii*) – Mosquero Saucero, Papamoscas Saucero. Western Willow Flycatchers (*E. t. adastus*, *E. t. brewsteri*, and *E. t. extimus*) are common migrants during spring (May to mid-June) and fall (August to early October), conspicuous at El Doctor and willow stands of the Colorado River.

Pacific Slope Flycatcher (*Empidonax difficilis*) – Mosquero Occidental. The most abundant migrant flycatcher through the Colorado River Delta, especially in spring. Abundant at El Doctor from mid-March to mid-May.

VIREONIDAE – VIREOS

Warbling Vireo (*Vireo gilvus*) – Vireo Gorgojeador. Very abundant in the fall, and a spring transient at El Doctor, Colorado River, and Río Sonoyta.

REGULIDAE – KINGLETS

Ruby-crowned Kinglet (*Regulus calendula*) – Reyezuelo Sencillo. Common winter visitor through the region.

TURDIDAE – THRUSHES

Swainson's Thrush (*Catharus ustulatus*) – Zorzalito de Swainson. Common spring and uncommon fall transient through El Doctor, Colorado River, and coastal desert scrub.

PARULIDAE – WOODWARBLERS

Yellow Warbler (*Dendroica petechia*) – Chipe Amarillo. Common transient through El Doctor, Colorado River, and Río Sonoyta. Rare winter visitor, with only two records at Puerto Peñasco (Russell and Monson 1998) and one at Mexicali (Patten et al. 2001).

Yellow-rumped Warbler (*Dendroica coronata*) – Chipe Rabadilla Amarilla. Common transient and winter resident in the Colorado Delta, Río Sonoyta, Pinacate, and coastal desert scrub.

Wilson's Warbler (*Wilsonia pusilla*) – Chipe de Wilson. The most abundant of the migrant warblers. Common spring and fall transient through coastal desertscrub, El Doctor, Río Sonoyta, and the Colorado River.

THRAUPIDAE – TANAGERS

Western Tanager (*Piranga ludoviciana*) – Tángara Occidental. Common in the spring, and fall transient through coastal desert scrub, El Doctor, Río Sonoyta, and Colorado River.

SALTGRASS AVIAN COMMUNITY

This conservation target includes birds that depend upon or that commonly use the saltgrass areas of the Colorado River Delta, in particular the endemic Palmer's saltgrass (*Distichlis palmerii*). This grass covers the banks of the river near its confluence with the Upper Gulf and also covers an important area of Isla Montague (Glenn et al. 2001). The goal is to maintain the remnant areas of the endemic saltgrass in the Delta.

A wide variety of birds use this area, as it provides food and nesting material where no other vegetation grows. Birds in this area include geese, ducks, shorebirds, herons and egrets, gulls and terns, and the Large-billed Savannah Sparrow, an endemic to this region, an obligate resident of the saltgrass areas of the Delta, and a bird under Special Protection in Mexico (DOF 2002). As such, this bird was selected as the only focal species for this conservation target, as its conservation secures the preservation of the saltgrass areas for the benefit of other wildlife.

The Palmer's saltgrass can live with saltwater, but it requires freshwater to reproduce sexually and germinate (Felger 2000). Thus, its distribution has been greatly diminished. Populations of the Large-billed Savannah Sparrow have been reduced as well, as witnessed in coastal California, where it winters (Unitt 1984), and in its breeding grounds (Mellink and Ferreira-Bartrina 2000), though its current abundance and trends are not known. Although the whole area covered by the endemic saltgrass is protected in the core zone of the Biosphere Reserve, its major threat originates further upstream.

Annotated Checklist of the Saltgrass Avian Community

Savannah Sparrow (*Passerculus sandwichensis*) – Gorrión Sabanero. Common winter visitor throughout the region. The Large-billed Savannah Sparrow (*P. s. rostratus*) is a common breeder at Isla Montague, Cerro Prieto, Ciénega de Santa Clara, El Doctor, and coastal salt marshes, although is threatened and declining (Mellink and Ferreira-Bartrina 2000). The subspecies is under special protection in Mexico (DOF 2002).

MARINE ZONE AVIAN COMMUNITY

This conservation target includes species of birds that depend upon the open marine areas of the Upper Gulf of California, in particular as feeding, post-breeding dispersal, and wintering sites. The goal of this target is to maintain the productive food web in these marine areas that sustains a diversity of birds and other wildlife.

The focal species for this group include six species from four families: Common Loon, Brown Pelican, Eared Grebe, Heermann's Gull, Ring-billed Gull, and Forster's Tern. All of these species are common non-breeding visitors to this region (Patten et al. 2001, Hinojosa-Huerta et al. in press), and their population fluctuations could be used as an indicator of the health of these marine areas. Some of the nesting waterbirds use the marine zone for feeding, and would benefit from conservation efforts as well.

Although marine zones are included either as part of the core or buffer zones of the Biosphere Reserve, there are several threats to birdlife in these areas, but the information on their scale and impact is limited. In particular, the extent of commercial fisheries could be causing an impact on the populations of marine birds, as well the reduction of freshwater flows.

Annotated Checklist of the Marine Zone Avian Community

GAVIIDAE – LOONS

Common Loon (*Gavia immer*) – Colimbo Común. Common winter visitor and migrant (spring and fall) in the Gulf. Casual summer visitor off Puerto Peñasco, Ciénega de Santa Clara, and Cerro Prieto.

PODICIPEDIDAE – GREBES

Eared Grebe (*Podiceps nigricollis*) – Zambullidor Orejudo. Common winter visitor throughout the region. Uncommon summer resident at Ciénega de Santa Clara and Cerro Prieto, but breeding activity has not been documented.

PELECANIDAE – PELICANS

Brown Pelican (*Pelecanus occidentales*) Pelícano Café. Common perennial visitor throughout the coastal and marine areas as a non-breeder. Inland it is a regular but uncommon summer visitor to Cerro Prieto and Río Hardy, rare during winter.

LARIDAE – JAEGERS, GULLS, TERNS, AND SKIMMERS

Heermann's Gull (*Larus heermanni*) – Gaviota de Heermann. Common perennial non-breeding visitor to the northern Gulf. Species under special protection in Mexico (DOF 2002).

Ring-billed Gull (*Larus delawarensis*) – Gaviota Piquianillada. Common transient and winter visitor throughout the region, less numerous as a non-breeding summer visitor, especially in the Colorado River Delta.

Forster's Tern (*Sterna forsteri*) – Golondrina-Marina de Forster. Uncommon breeder at Cerro Prieto (Molina and Garrett 2001). Common perennial visitor throughout the region.

MIGRATORY WATERBIRDS

This group includes species of waterbirds that spend the winter or stop during their migration in the Colorado River Delta. The emphasis is on those species of waterfowl and shorebirds that occur in the Delta in the hundreds of thousands of individuals every year. The goal of this target is to ensure that the Delta wetlands will continue to provide habitat for these species.

The focal species for this target include 13 birds from 4 families: Pelecanidae, Anatidae, Charadriidae, and Scolopacidae. The focal species were selected to cover the major aquatic habitat types in the Delta, as well as to include the most representative species of the group. At the continental level, populations of migratory waterbirds have declined due to wetland loss, and their habitats are threatened and still declining (Kushlan et al. 2002).

Wetland loss in the Delta has drastically impacted the abundance of wintering waterfowl in the region. Hundreds of thousands of ducks and geese from at least 26 species used to visit the region in winter (Kramer and Migoya 1989), but habitat for wintering waterfowl has been reduced to a minimum of a few thousand hectares during the dry years in the Delta (Glenn et al. 1996). Recent counts from aerial winter surveys estimate about 50,000 individuals during wet years (1993-1994) and just over 4,000 individuals during dry years (1995-1996) (U.S. Fish and Wildlife Service 2001). Wetlands at critical sites have been restored and maintained, especially at the Ciénega de Santa Clara and Río Hardy, providing over 8,000 hectares of habitat for waterfowl, which now support tens of thousands of wintering individuals every winter (Hinojosa-Huerta et al. in press).

Given the cumulative impacts on these species, the Colorado River Delta represents a major opportunity for the conservation and recuperation of these species. This is particularly important for shorebirds, especially at the mouth of the Colorado River and the Ciénega de Santa Clara. Over 150,000 shorebirds from 32 species visit the Delta every year (Mellink et al. 1997, Morrison et al. 1992). For this reason, the Delta is part of the Western Hemisphere Shorebird Reserves Network (1993) and also a Wetland of International Importance in the Ramsar Convention (1998). The western populations of American White Pelicans also depend strongly on the Colorado River Delta during winter and migration (Patten et al. 2001). Overall, the Colorado River Delta is a critical piece of the Pacific Flyway, necessary for the conservation of waterbird populations across Western North America (Anderson et al. 2003).

PELECANIDAE – PELICANS

American White Pelican (*Pelecanus erythrorhynchos*) Pelícano Blanco Americano. Fairly common winter and spring visitor in the Colorado River Delta region. Uncommon summer visitor as non-breeder.

ANATIDAE – DUCKS, GEESE, AND SWANS

Snow Goose (*Chen caerulescens*) – Ganso Blanco. Fairly common winter visitor at Ciénega de Santa Clara and adjacent agricultural fields, although formerly much more abundant (Leopold 1989, Murphy 1917, Saunders and Saunders 1981).

American Wigeon (*Anas americana*) – Pato Chalcuán. Fairly common winter visitor and casual summer visitor in the Colorado River Delta; common transient through the coast.

Cinnamon Teal (*Anas cyanoptera*) – Cerceta Castaña. Uncommon breeder at Río Hardy, Colorado River, and the Andrade Mesa wetlands (Hinojosa-Huerta et al. 2002b). Fairly common winter visitor at Ciénega de Santa Clara and common transient through the region.

Northern Shoveler (*Anas clypeata*) – Pato Cucharón Norteño. Common winter visitor at Ciénega de Santa Clara and Río Hardy. Rare non-breeding summer visitor.

CHARADRIIDAE – PLOVERS

Black-bellied Plover (*Pluvialis squatarola*) – Chorlo Gris. Common transient and winter visitor at Ciénega de Santa Clara, El Doctor, and along the coast. Uncommon summer visitor in the same areas.

SCOLOPACIDAE – SANDPIPERS AND PHALAROPES

Greater Yellowlegs (*Tringa melanoleuca*) – Patamarilla Mayor. Fairly common transient and winter visitor in the Colorado River Delta and along the coast.

Whimbrel (*Numenius phaeopus*) – Zarapito Trinador. Common winter visitor and transient in the Mexicali Valley, Colorado River Delta, and coastal areas. Few individuals regularly summer in alfalfa fields of the Mexicali Valley.

Ruddy Turnstone (*Arenaria interpres*) – Vuelvepiedras Rojizo. Fairly common transient and winter visitor at the coastal areas of the northern Gulf. Casual at Cerro Prieto (Patten et al. 2001).

Surfbird (*Aprisa virgata*) – Playero de Marejada. Common spring transient and uncommon winter visitor along the shore of the northern Gulf.

Western Sandpiper (*Calidris mauri*) – Playerito Occidental. Common transient and winter visitor through the Colorado River Delta and coastal areas.

Short-billed Dowitcher (*Limnodromus griseus*) – Costurero Piquicorto. Common winter visitor and spring transient, fairly common fall transient. Most numerous at Ciénega de Santa Clara.

Wilson's Phalarope (*Phalaropus tricolor*) – Falarapo de Wilson. Common transient along the coast and Colorado River Delta, and can be numerous at Cerro Prieto. Casual winter visitor in the northern Gulf.

Contributors

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ARIZONA GAME AND FISH DEPARTMENT, GEORGE ANDREJKO
28 Southwest Willow Flycatcher

CHARLES BERGMAN
cover, 5, 69 Black Phoebe; cover, 47 desert pupfish; cover, ii, 12, 17 Snowy Egret; 16 dolphins; 18 Yuma Clapper Rail; 35 Eared Grebe; 63 Burrowing Owl; 65 Colorado River's end (middle); 67 Black Neck Stilt

STEPHEN BUCHMANN
cover, 9, 64 painted lady butterfly (also on opportunities icon); cover, i, 10, 68 cottonwood leaf; cover, 42 palo verde flowers; 20 Mexican poppies

JESUS CAMACHO
61 vaquita porpoise

JOSÉ CAMPOY
cover, 38 White Pelican; cover, 57 totoaba; 54 Gulf corvina

KARL FLESSA
cover 10, 12, 13, 57 Colorado Delta clam

HÉCTOR GARCÍA
6 Ciénega de Santa Clara

TOR HANSEN
54 totoaba drawing

OSVEL HINOJOSA-HUERTA
iv sand footprint; v hand footprint; 20 (2nd from top, right), 40 (top left) Ciénega de Santa Clara

ED NORTHAM
37 giant salvinia

CHUCK MINCKLEY
44 desert pupfish

TERRY MOODY
cover water; cover, 53 coral; ii, 45 cattail; 9 vaquita porpoise skull (also on threats icon); 12, 19 cottonwood leaf; 13 ghost agave (also on water icon)

MARCIA MORENO-BAÉZ
3 Andrade Mesa (left); 46 Andrade Mesa (top), Andrade Mesa cattails (bottom)

JOAQUIN MURRIETA
31 wildfires in riparian corridor (top left); 47 Cerro Prieto ponds

ED PEMBLETON
iii, 26 Colorado River riparian corridor in Mexico; 2 sunset; 4 Río Hardy; 12, 21 Morelos Dam; 41 silhouette of bird; 58 Golfo de Santa Clara

JENNIFER PITT
6 workshop session

JIM RORABAUGH
27 Yellow-breasted Cuckoo

BARBARA TELLMAN
49 salt cedar

UNIVERSITY OF ARIZONA COOPERATIVE UNIT
43 California Black Rail

U.S. FISH AND WILDLIFE SERVICE
40, 50 Yuma Clapper Rail

CARLOS VALDÉS CASILLAS
4 flood plain near the Colorado River's end (middle); Río Hardy; 20 Río Hardy (top right); 22 Morelos Dam; 27 cottonwood-willow forest; 34 upper Río Hardy, canoe; 64 Colorado River during 1998 flood (left); 14, 66 Colorado River's end (top right); 71 Río Hardy; 74 upper Gulf of California

GENE WENDT
28 mesquite bug (also on ecological relationships icon)

WORLD WILDLIFE FUND
55, 56, 73 upper Gulf of California

WORLD WILDLIFE FUND, GUSTAVO YBARRA
cover, 14 pelican; cover, 9, 12, 15, 60, 74 vaquita porpoise; 62 vaquita porpoise (2nd, 3rd, 4th from right); 14, 62 Rocas Consag; 16 fin whale; 40 Snowy Egret; 50 fisherman; 52 dolphins; 53 small-scale fishing boats; 59 fishing nets, fin whale; 65 shrimp fleet (right); 66 Brown Booby (top left), fin whale (middle)

FRANCISCO ZAMORA-ARROYO
1, 2 (right) ecotourism boating in the Ciénega de Santa Clara; 3, 42 Riito Drain near the Ciénega de Santa Clara (middle); Ciénega de Santa Clara marsh; 4 (left), 30 (left) pilot channel in the Riparian Corridor in Mexico, 20 Andrade Mesa marsh (top left); Río Hardy (bottom right), Colorado River (bottom left), Ciénega de Santa Clara (2nd from top, left); 29 Morelos Dam; 30 Colorado River at Carranza crossing; 31 sunset at backwater area in the riparian corridor; 32 Colorado River downstream from railroad bride (left), Western Tanager (right); 36 El Tapón-created wetland (left), young mesquite at Campo Guajardo—Río Hardy; 38 El Tapón; 41 Ciénega de Santa Clara; 43 El Doctor wetlands (top); 44 Yellow-breasted Chat; 45 Black-crowned Night Heron; 46, 72 Andrade Mesa (middle)