MITIGATION: CONCEPT TO REALITY

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ABSTRACT

In 1987, the Port of Los Angeles entered into an interagency agreement to restore Batiquitos Lagoon in Carlsbad, California as mitigation for the construction of cargo terminals in the Outer Los Angeles Harbor. After ten years of planning, environmental review, design and permitting, the restoration was completed and the lagoon was opened to the Pacific Ocean. The $57 million project not only provided for the restoration but also provided for maintenance in perpetuity and long term biological monitoring. In return, the Port was able to obtain permits for the construction of 381 acres of Pier 400 for use for storage of liquid bulk and container handling facilities. The project required hydraulic dredging of 3.4 million cubic yards of sand, construction of two jetties, two bridges and five nesting sites for protected bird species. Sand from the lagoon was used to nourish local beaches and fine saline sediments were buried in a pit in the lagoon. Based on the first five years of monitoring, the mitigation has been very successful in replacing the marine fish and marine bird values lost in Los Angeles Harbor. In addition, the restoration has enhanced/expanded coastal salt marsh habitat, improved flood control, nourished local sand starved beaches and replaced a boom-bust ecological system with a more moderate dependable habitat. However, there has been some recent loss of habitat value for birds in the lagoon due at least in part to poor maintenance of the tidal inlet and nesting site and reduced protection provided protected bird species. Carefully planned and executed maintenance activities are one of the most important aspect of successful mitigation.

Keywords: Dredging, coastal wetland, port, restoration, enhancement, biological monitoring.

INTRODUCTION

A nation behaves well if it treats the natural resources as assets which it must turn over to the next generation increased, and not impaired, in value. Theodore Roosevelt

In the mid 1980s, National Marine Fisheries Service NMFS), U.S. Fish and Wildlife Service (USFWS) and the California Department of Fish and Game (CDFG) approached the Port of Los Angeles (Port) to consider restoring a coastal wetland as compensatory mitigation for planned fills in the Outer Harbor of the Port of Los Angeles. This set in motion a complex series of events stretching from the development of a *concept* restoration plan in 1985 until the *reality* of the opening of a restored coastal embayment on December 7, 1996. This lengthy and controversial restoration project, spanned a decade, cost in excess of $57 million, and included two separate law suits.

The success and failure of compensatory mitigation, especially as it relates to wetlands, has become a topic of interest. In some instances, basic academic research (e.g. Zedler and Callaway 1999) suggests that certain wetland mitigation attempts have not been successful. There is also controversy in regulatory affairs as evident in opinions expressed (Sibbing 2003) and countered (Goodin et al. 2003) on the recent U.S. Army Corps of Engineers (COE) and U.S. Environmental Protection Agency (EPA) publication of their regulatory guidance letter on mitigation (COE and EPA 2002). An unfortunate outcome of this controversy is that interested public and environmental groups quite often adopt a negative approach towards mitigation, especially associated with wetlands, regardless of the project details and circumstances.

The purpose of this paper is to discuss the restoration of Batiquitos Lagoon and discuss the success and difficulties of this mitigation project from its conceptual development during planning and environmental review through to its becoming a reality during construction and recent completion of the first five years of monitoring. The project also illustrates the very critical role of beneficial uses of dredge material in coastal planning.

CONCEPT: PLANNING AND ENVIRONMENTAL EVALUATION

Mitigation Planning for Port Development

The Port of Los Angeles is a landlord Port which operates under a state tidelands trust granted to the City of Los Angeles. The grant is for the purpose of navigation, fisheries and maritime commerce. In addition, the California Coastal Act recognizes the Port as one of the five locations where maritime commerce can occur along the California coast. The public mandate has provided the Port special recognition in carrying out its mandate, including the ability to participate in compensatory off-site mitigation.

In 1992, the U.S. Army Corps of Engineers (COE) with the Port as the local sponsor, published a feasibility report and Environmental Impact Statement/Report (EIS/EIR) (COE and LAHD 1990) to allow for new and deeper navigation channels to access existing land and utilization of the dredge material to create approximately 500 acres of new land called Pier 400 (Figure 1). An interagency mitigation team comprising USFWS, NMFS, COE, CDFG and the Port, developed a mitigation plan to mitigate the unavoidable lost of marine habitat as a result of construction of the locally preferred disposal site for the dredge material (COE and LAHD 1992, Appendix B).

Los Angeles Harbor contains a variety of marine habitats, some natural and some man-made. Most of the harbor bottom is composed of soft substrate that supports burrowing (infaunal) organisms. Over 70 fish species commonly use the various habitats in the harbor, including several of recreation and commercial value such as the California halibut, (*Paralichthys californicus*), sand bass (*Paralabrax nebulifer*), anchovy (*Engraulis mordax*), sardine (*Sardinops sagax*) shiner surfperch (*Cymatogaster aggregata*) and topsmelt (*Atherinops affinis*) (MEC 1988, 2001). While the fish fauna of the harbor is not particularly unique along the California coast in terms of species present, the abundance of many of these species as juveniles within the harbor indicates a more significant biomass and nursery function than on areas of open coast. In this regard, the harbor is more similar to coastal embayment/wetland habitats. The Outer Harbor is also lined in many locations with kelp (*Macrocystis pyrifera*) and in the last five years has developed extensive areas of eel grass (*Zoastera marina*). The endangered California least tern (*Sterna antillarum browni*) nests in the harbor on a 15-acre sand substrate site prepared and protected by the Port. In some years as many as 500 least terns have nested in the harbor.

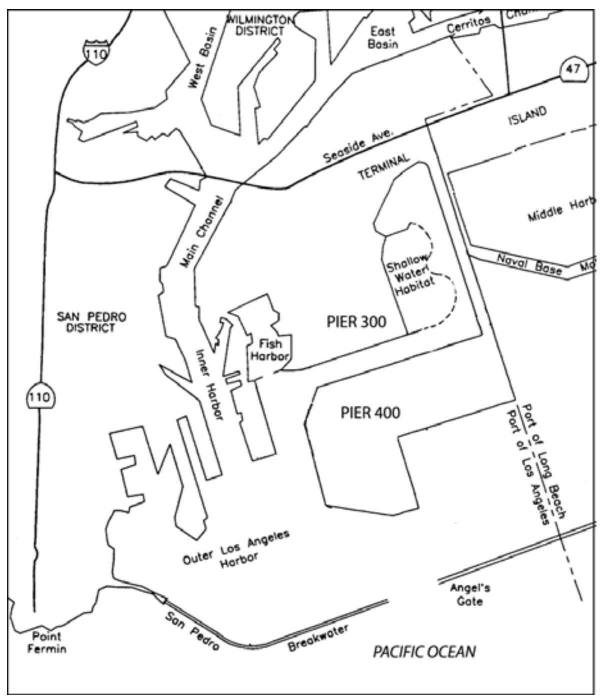

Figure 1. Port of Los Angeles

The mitigation goal for general marine resources developed by the interagency mitigation team *was no net loss of in-kind habitat value where 'in-kind' refers to coastal marine, tidally influenced habitat of value to marine fish and water-associated birds, and between Pt. Conception and the Mexican border*. In addition, any mitigation would be carried out prior to, or concurrent with development project construction, and mitigation must be in perpetuity. Of the large number of on-site and off-site mitigation opportunities that were examined, only the on-site creation of shallow water and the off-site creation of coastal embayment habitat (i.e., creation/restoration of coastal wetlands) were identified as the preferred mitigation options. The primary candidate for off-site mitigation was the restoration of Batiquitos Lagoon in Carlsbad, California. Subsequently, the Port entered into the Batiquitos Lagoon Mitigation Agreement (LAHD et al. 1987). The utilization of interagency agreements has been a reliable administrative vehicle in support of Port development projects. Besides being vehicles for the protection of fish and wildlife resources, these agreements acknowledge the Port's mandate to accommodate maritime commerce, provide for mitigation banking, provide predictability in the obtaining of permits and control of costs and avoid regulatory conflicts.

The Batiquitos Lagoon Mitigation Agreement (LAHD et al. 1987) provided that the Port would fund all restoration activities including: preliminary design, environmental review, final design, construction and maintenance in perpetuity (Table 1). The lagoon would be leased to CDFG by the California State Lands Commission and maintained as an ecological reserve in perpetuity with the use of an $8.4 Million maintenance fund established by the Port. The City of Carlsbad was to be lead for environmental review, obtaining necessary permits and overseeing the construction by the Port. Through a habitat valuation performed by the resource agencies and the Port, the restoration of the lagoon would allow the Port to fill deep water habitat in the Outer Los Angeles Harbor. The agreement also provided that the Port could discontinue the project at key milestones: following preliminary design, following environmental review, upon completion of final design/permitting and after receiving construction bids. While the agreement did establish a mitigation bank, the credits in the bank could not be used by Port, or sold as compensation for impacts to jurisdictional wetlands.

Table 1. Gross costs to restore Batiquitos Lagoon.

Project Component	Cost
Planning/Environmental	$1.9 M
Design/Permitting	$2.8 M
Const. Mgmt., Monitoring, Acquisition	$8.8 M
Construction	$32.3 M
Maintenance	$8.7 M
Biological Monitoring	$1.8 M
Total	57.3 M

Restoration Planning for Batiquitos Lagoon

Conditions at Batiquitos Lagoon Prior to Restoration

Batiquitos Lagoon is a 596-acre coastal wetland located in the North San Diego county within the limits of the City of Carlsbad, California (Figure 2). It is located approximately 90 miles south of the Port of Los Angeles.

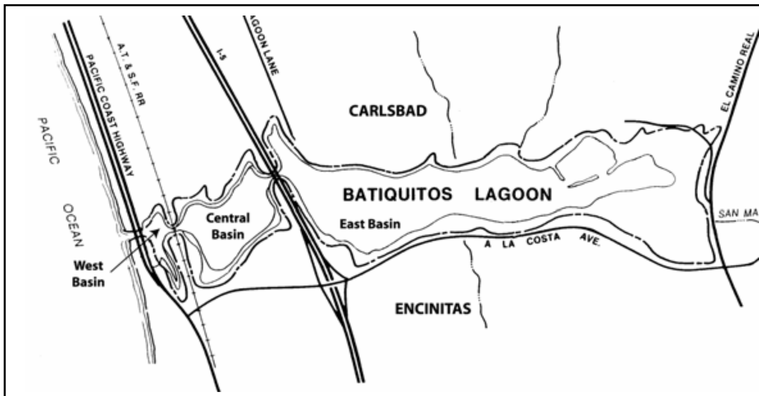

Figure 2. Features of Batiquitos Lagoon.

Less than 150 years ago Batiquitos Lagoon was fully tidal. Archaeological evidence shows the lagoon held marine shellfish, which the local Indians harvested. The lagoon changed significantly with the arrival of European settlers. Roads and railroads were built across the lagoon (Figure 3) restricting water flows; sediment washed down from plowed and graded lands in the watershed, and filled in the lagoon. Portions of the lagoon were filled for developments or used for salt evaporation ponds and duck hunting; water flows from the upper watershed were dammed and diverted to other uses. All these alteration combined to drastically alter the lagoon (Coastal Conservancy 1987). In the mid 1980s, the sand on the beaches up and down the coast of the lagoon have been replaced with cobbles as a result of severe winter storms. Due to the above conditions, the lagoon mouth was permanently closed to tidal influence except when it was mechanically opened as a flood control measure or to make the lagoon available to nesting by the California least tern. The water quality of the lagoon was generally poor; salinity and temperature ranged dramatically between basins, and seasonal variations in the lagoon environment were extreme, ranging from a near fresh water lake in the winter to shallow hypersaline ponds in the summer and fall. In some years the lagoon was dry enough that people drove their vehicles across it. In other years, sewage spills into the lagoon resulted in eutrophic conditions and odor problems. The lagoon had been altered to a degree that its capacity to naturally reestablish tidal influence had been eliminated due the reduction in its tidal volume (Table 2). In addition with no obvious solutions to control the continued deposition of fine upland sediment and deposition of organic matter due to decaying floral mats, the lagoon would gradually evolve into upland. In the 1980s, a developer proposed residential development at the lagoon including a marina. Due to financial difficulties and under pressure from resource and regulator agencies, the developer deeded over most of the lagoon to the State of California in exchange for development rights in the uplands along the north shore of the lagoon.

Table 2. Estimates of historical lagoon size.

Year	Tidal Volume (cubic yards)	% of 1887 Tidal Volume
1887	5,646,000	100
1888	4,849,000	86
1960	4,300,000	76
1965	3,620,000	64
1978	12,300	>1

Despite the declining physical state of the lagoon, in some years it provided significant habitat value for overwintering waterfowl, fall-migrating shore birds and two endangered species, the California least tern (*Sterna antillarum browni*) and the Belding's savannah sparrow (*Passerculus sandwichensis beldingi*). When the lagoon was full of water in winter, waterfowl fed in large numbers over submerged vegetated areas of the East Basin. If the water levels were relatively low in the fall, shorebirds fed on insects in the nontidal flats throughout the lagoon.

As a result of the accelerated physical modification/evolution of the lagoon and resulting fluctuations in physical parameters, the value of the lagoon for wildlife particularly marine fish, and marine invertebrates, was highly variable. Further, resources would continue to decrease as the lagoon filled with sediment. The nesting of both the Belding's savannah sparrow and the least tern was dependent on a mechanical opening of the lagoon in the spring which would release the freshwater which had filled the lagoon.

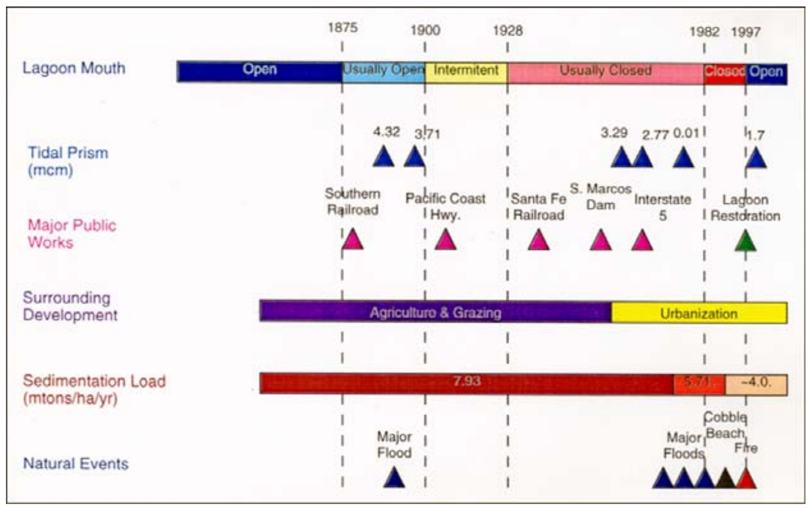

Figure 3. Historical events affecting Bagiquitos Lagoon.

Restoration Plan/Goals

In 1985, an enhancement group formed and the California Coastal Conservancy began the process of preparing an enhancement plan for Batiquitos Lagoon (Figure 4). The enhancement plan was completed in 1987; the primary goals of the program were to *enhance Batiquitos Lagoon for wildlife habitat* and to *open the lagoon to tidal action while retaining migratory bird habitats to the greatest degree feasible* (Coastal Conservancy 1987). It was during this time that the resource agencies approached the Port to restore the lagoon as mitigation for a proposed Port development in the Outer Los Angels Harbor. Through the Conservancy plan, restoration would be achieved by dredging and/or excavation to produce shallow subtidal and intertidal habitats and by maintaining a continuous open ocean inlet with sufficient tidal prism to ensure flushing and good water quality throughout the lagoon. A preliminary design report was prepared by the Port as a means of determining feasibility (CH2M Hill 1988). Major project components included:

- Construction of two low-profile rock jetties at the ocean entrance of the lagoon to maintain a permanent non-navigable tidal opening to the ocean without cutting off the southerly littoral drift.
- Physical reconfiguration of the lagoon through dredging and contouring to create shallow subtidal and intertidal habitats.
- Nourishment of adjacent ocean beaches with clean sands mined from the lagoon as part of the overall dredging and disposal plan.
- Construction of approximately 32 acres of least tern nesting sites.
- Pilot planting of vegetation that requires tidal flushing and that did not occur in the lagoon including cordgrass (*Spartina foliosa)* and eelgrass, (*Zoastera marina).*

Of particular importance was the need to create very gentle slopes in the East Basin of the lagoon to provide foraging habitat for shorebirds. Over time it was anticipated that some beach sand material would be deposited inside the mouth of the lagoon as a flood tide delta. This material would be dredged and placed on local beaches at a predicted interval of three years. A preliminary design report was prepared by the Port as means of determining feasibility (CH2M Hill 1988).

During the environmental review of the project ten project alternatives were examined including varying sizes of tidal alternatives, intermittent tidal and non tidal alternatives. The City of Carlsbad's deliberations resulted in selection of a fully tidal project and made the following findings:

- The project selected would restore marine values to the lagoon, and protect existing habitat values.
- Without full tidal exchange the lagoon would continue to fill with fine sediments and organic matter and the existing habitat values would be lost over the long term.
- Of ten alternatives evaluated, Mitigated Alternative B provided for tidal flushing and provided the best balance of wildlife values for the lagoon.
- Selection of this alternative would result in unavoidable short-term impacts in the areas of biology, water quality and recreation but would be outweighed by the long term benefits of the restoration.
- Over dredging of the Central Basin, with deposition of eastern basin fine sediments into the resulting pit and the placing of the over dredged central basin sands on the beach as nourishment, was the environmentally preferred dredge disposal scheme.

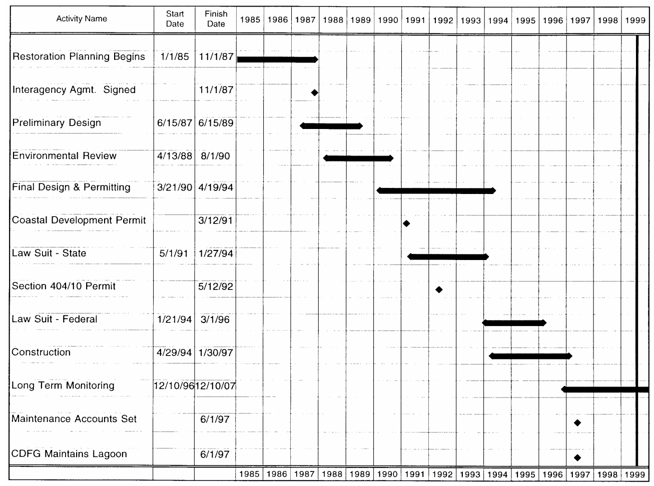

Figure 4 Restoration events at Batiquitos Lagoon.

Project Opposition

The environmental review and permitting for the project was very contentious. Local environmental groups protested that the massive dredging project would ruin the lagoon for birds including the threatened and endangered species that nested there; that it would transform a productive brackish system into a tidal system of value only to fishes; and that "mitigation doesn't work". Other contentious issues included the construction and functioning of a tidal inlet and the effect it would have on sand transport, surfing and whether it would remain open. The project survived two law suits (one in State Court and one in Federal Court) by the Sierra Club and the Audubon Society (Figure 4). The State suit alleged that in issuing the Coastal Development Permit, the California Coastal Commission had not approved the "least damaging" restoration alternative and had not adequately considered other more protective alternatives for restoration. The Federal suit alleged that no consultation in accordance with the Endangered species Act had been carried out for the western snowy plover, which had been listed as threatened after the permitting process and before construction.

REALITY: CONSTRUCTION AND LONG TERM MONITORING

Construction

Construction of the project began in March of 1994 and was concluded in July of 1997 (Figure 5). Major construction items included contouring the lagoon to specific slopes and habitat acreage; construction of five nesting sites for the least tern and snowy plover; reconstruction of two bridges across the lagoon and retrofitting of the railroad and Interstate 5 bridges; construction of a tidal inlet structure and relocation of several utility lines. During the process approximately 3.4 million cubic yards of material was dredge from the lagoon, of which 1.8 million cubic yards of sand was used to nourish sand depleted beaches three miles to the north of the project site. The remainder was used for construction of the nesting sites or for capping the Central Basin disposal area. Electric hydraulic dredges were used to reduce air emissions during project construction. The three-year construction duration (Figure 5) was required to avoid certain construction activities during the nesting season of the least tern and snowy plover and to avoid nourishing the beach with lagoon sand during the summer high-use season. Environmental monitoring of construction activities and public relations were carried out during project construction. The latter included newsletters, tours and a hotline to respond to questions and emergencies. The project included weekly and biweekly meetings of the construction manager, engineers of record, contract managers for the City of Carlsbad and the Port, and the environmental manager to discuss upcoming activities and resolve problems.

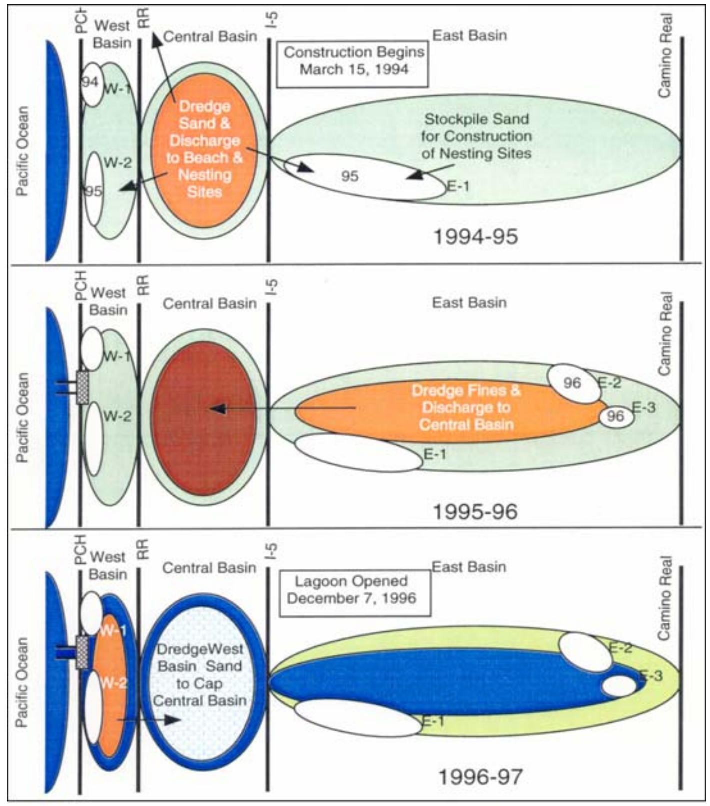

Figure 5 Three-year restoration sequence for Batiquitos

In order to implement the exact design required in the project specifications and to keep the lagoon from drying out, a water elevation control system was put in place. This allowed pumping of water into the lagoon from the ocean as the hydraulic dredge discharged sand to the beaches. This also provided a stable datum for the dredge to work from when contouring the lagoon especially the very flat slopes (> 1:100) in the East Basin.

In order to achieve these flat slopes the contractor was provided a pay incentive. The contractor was paid by quantity to dredge the Central Basin pit and the West Basin. In the East Basin, where very flat slopes were required, the contractor was paid by acres completed at specific elevations. As built surveys were completed and approved for sections of the lagoon as they were completed.

The construction also called for the salvaging and planting of pickleweed (*Salicornia virginica*) that would be lost to dredging. Unfortunately, high inundation levels in the lagoon during dredging activities did not result in successful planting, so salvage pickleweed was potted and held for planting following completion of construction.

The Batiquitos Mitigation Agreement required that following construction, the parties to the agreement must agree that the project was built in substantial conformance with the design prior to releasing the mitigation credits to the Port. This was accomplished through use of as-built surveys and a tidal monitoring survey to determine if the lagoon was functioning as anticipated (Tables 3, 4). The tidal elevation inside the lagoon compared well with the ocean data. However, as anticipated, there was an increase in the MLW and the MLLW lagoon water elevations by approximately 0.4 and 0.7 feet , respectively.

Comparison of the design acreage with expected functioning of a maintained inlet showed that the largest habitat discrepancy would occur in the intertidal area (Table 4). This was due largely to the modification of tidal amplitudes causing a tidal muting, particularly in the East Basin. It was also noted that between the opening of the lagoon and the time of survey completion, high wave energy had transported sand placed up coast (to the north) of the lagoon into the West Basin. Based on this information, the parties to the agreement agreed that the lagoon was constructed in substantial conformance with the design.

Table 3. Comparison of tidal data at La Jolla[1] and Batiquitos Lagoon tide levels at reference datum.

Elevations	La Jolla	West Basin	Central Basin	East Basin
Mean Higher High Water (MHHW)	5.4	5.4	5.3	5.4
Mean High Water (MHW)	4.6	4.7	4.6	4.7
Mean Low Water (MLW)	0.9	1.4	1.3	1.3
Mean Lower Low Water (MLLW)	0.0	0.7	0.7	0.7

1. Scripps Institute of Oceanography tidal data taken at the Scripps Pier.

Table 4. Comparison of planned and actual habitat.

Habitat Zone Type	Habitat Zone MLLW (feet)	Permit Acreage[1]	Design Acreage[2]	As-Built Acreage[3]	Tidal Ref. Acreage[4]	Maintained Acreage[5]
Subtidal	Below –1.6	148	147	139	156	149
Intertidal	-1.6 to +3.9	144	139	140	124	128
Low Marsh	+3.9 to +5.4	98	99	102	101	104
High Marsh[6]	Above +5.4	166	170	173	173	173
Nest Sites	Above +7.0	38	39	40	40	40
Total		594	594	594	594	594

1. Acreage required in the Section 10/404 Permit and the Coastal Development Permit.
2. December 1993 design acreage as approved by the agencies based on 1990 lagoon survey.
3. Actual acreage based on compilation of as-built surveys dated 1990, 1994, 1996 and 1997.
4. Modeled acres based on estimated lagoon tidal reference datum projected to 18.6-year tidal epoch reference datum.
5. Modeled acres that exist in a maintained inlet channel. Accuracy is approximately plus/minus five percent.
6. No project construction in this area. Accuracy is approximately plus/minus five percent.

Source: Moffat and Nichol Engineers (1997)

Long Term Monitoring

Following lagoon construction, the Port implemented a long term biological monitoring program covering years 1, 2, 3, 5 and 10 which equates to years 1997, 1998, 1999, 2001 and 2006. The long term monitoring program is being carried out by Merkel and Associates (1997, 1998, 1999, 2001). The program includes documenting changes in the vegetation community, fish community, benthic community avian community, water quality and sediment, and pilot restoration programs for eelgrass and cordgrass. The goals of the long term biological monitoring program are to:

- Fulfill conditions associates with the various project approvals and mitigation agreements including pilot planting of cord grass and eel grass, and documentation of reestablishment of pickleweed within the lagoon.
- Document changes in the ecology of the lagoon environment over time.
- Provide timely identification of any problems with the physical chemical, or biological development of the lagoon; and
- Assist in providing a technical basis for resource management of the lagoon system by documenting maintenance needs and enhancement opportunities.

Physical Changes in the Lagoon

The CDFG was responsible for the physical monitoring of the lagoon in order to determine maintenance needs. This monitoring was not completed with the exception of information collected by the biological monitor, Merkel and Associates, using aerial photos and data collected during the biological monitoring periods.

Batiquitos Lagoon has undergone some significant changes to the basin configurations and elevations which, combined with the tidal restoration, has resulted in a number of physical and biological effects. Prior to the maintenance dredging event that occurred in the winter of 2002, the lagoon had accreted sediments totaling approximately 123,650 cubic yards, while erosion had resulted in a loss of 15,850 cubic yards, and consolidation of the Central Basin had yielded a gross lagoon volume increase of 213,500 cubic yards. However, it is estimated that between 1997 and 1999, approximately 75,150 cubic yards of beach sand were deposited in the flood-tide delta. Figure 5 illustrates depositional changes that have occurred in the West Basin of the lagoon since 1996. Lack of maintenance of the inlet resulted in accretion of sand in the inlet, initially building a delta in the West Basin and then spreading into the Central Basin. Development of the flood tide delta in the West Basin also redirected wave energy entering the lagoon to the south, which eroded the railroad spur and deposited sand material along the east shore of the West Basin. The failure to remove the exdpanding flood tide delta has had a significant effect on the overall tidal circulation in the lagoon. This has resulted in a loss of over 1.1 feet vertical of tidal range in the lagoon, and a time lag of up to 140 minutes behind oceanic tides in the East Basin. Besides the loss of tidal prism, the muted tidal range has resulted in other biologically consequential effects. These include a longer residence time of lagoon waters, thus a greater influence by freshwater inputs, including increased nutrients and contaminants. In addition, the loss of tidal range has also resulted in a narrowing of the range over which marsh vegetation is distributed and has reduced the extent of intertidal mudflats. However, in 2002, CDFG removed a significant amount of the sand from the flood tide delta and removed more following the 2003 least tern nesting season.

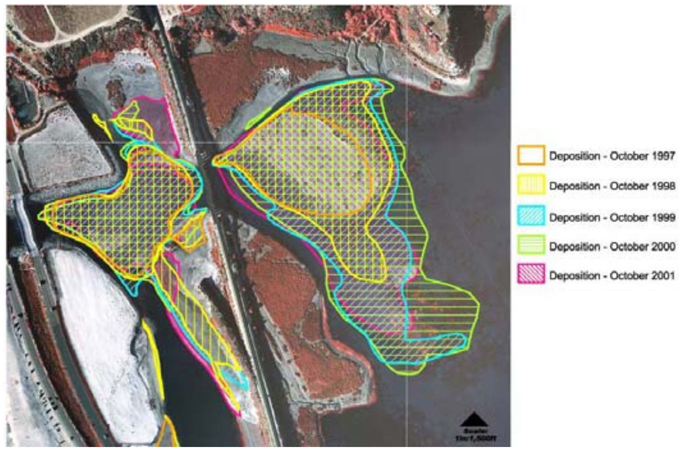

Figure 6. Major areas of depositional change in the West Basin during the 1997-2001 monitoring years.

Opening of the lagoon to tidal waters has stabilized the large swings in water level, temperature and salinity (Table 5). In addition, significant depressions in dissolved oxygen (D.O) caused by the decay of floral mats during the summer and fall have been moderated.

Vegetation Communities

Lagoon-wide changes in vegetation communities and geomorphology were monitored using remote sensing techniques, combined with ground-truthing and field transect monitoring. The total acreage of coastal salt marsh within the lagoon has increased during each monitoring year (Table 5) particularly at the middle marsh elevations. The dominant species is pickleweed (*Salicornia virginica*). As might be expected with the reintroduction of a marine system, the freshwater and brackish vegetation component in the lagoon has been reduced, especially in the east end of the East Basin.

Pilot planting of eelgrass (*Zoastera marina*) and cordgrass (*Spartina foliosa*) in 1997/98 and 1999, respectively, have resulted in the establishment of both species in the lagoon.

Fish Assemblages

Fish were captured in the lagoon using a variety of gear including otter trawls, purse seines and large and small beach seines. With the opening of the lagoon to the ocean, a significant marine fish assemblage has become established and had replaced the few brackish/freshwater species in the lagoon. The total number of species in the lagoon had increased from 8 to 66 species. Dominant species include northern achovy (*Engraulis mordax*), deepbody and slough anchovies (*Anchoa compressa, A. delicatissima*), topsmelt (*Atherinops affinis*), California killifish (*Fundulus parvipinnis*), shiner surfperch (*Cymatogaster aggregatta*), diamond turbot (*Hypsopsetta gutulatta*), and California halibut (*Paralichthys californica*). These species are typical of other fully tidal systems along the coast.

Table 5. Summary of various biological and physical parameters monitored at Batiquitos Lagoon.

Biological Component	Before Restoration	After Restoration 1997	1998	1999	2000	2001
Coastal Salt Marsh (acres)	~85	65.6	85.0	102.7	125.5	137.7
Eel grass (acres)	0	0.25		4.46	53.5	>39
Cordgrass (acres)	0	0	0	0.3		2.0
Fish species (cum.)	8	45	53	59	-	66
Fish mean abund. (gm/m^e)	Low	1.70	2.57	3.02	-	3.01
Epibenthic sp. (cumulative)	-	8	15	18	-	50
Infunal Phyla (ave/station)	~3	5.6	6.2	6.4	-	6.8
Infaunal Desity (ind/m^2)	366-44675	7750	2600	1750	-	2050
Infaunal Biomas (g/m^2)	-	30 (6-70)	34 (3-140)	14 (3-78)	-	15 (3-39)
Bird species/yr	95	127	133	131	-	123
Bird numbers (ave/survey)	~5000	4921	5904	3546	-	3366
Least tern nests	~30	298	211	176	172	222
Snowy plover nests	~15	38	26	7	-	10
Belding,s sparrow pairs	20-47	31	25-36	20-34	-	36
Temperature (^{o}C)	19-31	19.3	19.1	17.5	-	18.3
D.O (mg/l)	1.6-18.65	5.5-7.6	4.3-8.7	5.4-9.7	-	5.0-10.3
Salinity (ppt)	0 - 100	28.1-34.7	17.7-35.3	29.9-34.7	-	23.4-34.8

Benthic and Epibenthic Community

Benthos was sampled with grabs, epibenthic enclosures and fishing gear. The benthic community has transformed from a freshwater/brackish, predominantly insect-based, and species poor system (MEC 1988) prior to the lagoon opening to a marine system composed primarily of crustaceans, polychaetes and molluscs. Major population explosions and crashes of single epifaunal organisms were observed throughout 1997 and into 1998. Since that time, the spikes of infaunal densities and biomass have declined and stabilized (Table 5). There has been a significant increase in the number of epibenthic species in the lagoon; the very large increase in 2001 is attributed to the increase habitat provided by the developing eelgrass beds.

Avian Community

The number of bird species utilizing the lagoon is comparable to the number measured at the lagoon prior to the restoration. However, spatial abundance and density of birds at the lagoon remain highly variable. The mix of species has changed, with an overall decline in waterfowl and an increase in small shorebirds, particularly spring migrants. This has also been associated with a decline in the freshwater/brackish marsh habitat and increased availability of intertidal mud flat. However, in 2001 there was a decline in birds using the lagoon, particularly small shorebirds (Table 5). The peaks and valleys in avian abundance that occurred before the restoration have been moderated.

The numbers of protected avian species has increased with the opening of the lagoon. While the number of tern and plover nests have generally increased, the number of fledglings was very low in 1999 and 2000, and in 2001 for plovers. This was due is due to predation of the chicks during these years and to the poor maintenance of the nesting sites utilized by terns and plovers.

CONCLUSIONS

The planning, design and restoration of Batiquitos Lagoon provides a number of insights that may be applicable to other restoration projects.

- The use of an interagency mitigation agreement has provided an excellent model for administering such long term developments by providing predictability. As a side benefit, it has significantly strengthened the trust and working relationships among the various parties to the agreement.
- Reintroduction of marine tidal waters to an isolated embayment has resulted in the successful mitigation of marine fish and marine bird resources lost at the Port.
- This particular mitigation project has resulted in enhancement/restoration of values above and beyond values lost at the Port including: expansion of coastal salt marsh, introduction of special aquatic sites (eelgrass and cordgrass), flood control, beach nourishment, protection of protected bird species, aesthetics, passive recreation, mosquito abatement and enhanced surfing adjacent to the inlet.
- It is likely that the presence of historic estuarine sediments at the lagoon facilitated expansion of salt marsh vegetation.
- Major construction/restoration projects can occur in sensitive areas without significant or long term damage to existing wildlife resources. The greatest nesting success for terns and plovers actually occurred during project construction.
- The physical construction was innovative in its method of sediment disposal of fines into a pit and beach nourishment, the method of contractor payment, and the use of a hydraulic dredge with special positioning equipment and water level control to create very flat slopes.
- The successful implementation of the restoration has allowed for the accommodation of maritime commerce at the Port of Los Angeles.
- Preconstruction monitoring is important in measuring success but it is difficult to design a monitoring program that applies equally well to the very different physical environment that exists prior to, during and after the restoration.
- It is difficult to predict in detail all the physical changes that may occur following such major restoration projects.
- Implementation of restoration projects may result in a loss/moderation of some existing values (e.g., existing value to dabbling ducks) to avoid long-term degradation of the system (e.g., filling of the lagoon with sediment).
- Effective management of the physical system following restoration is critical to avoid loss of restored resources. A recent decline in small shore birds, may be due to the muting of tides as a result of the formation of the flood tide delta in the West and Central Basin.
- Effective administration and implementation of a well-planned management plan is perhaps the most critical component in maintaining the habitat values created during the restoration process.

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