COASTAL HABITAT STUDY, 2003-2005: INFLUENCE OF BEACH NOURISHMENT ON BIOLOGICAL RESOURCES AT BEACHES IN THE CITY OF ENCINITAS, CALIFORNIA

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1.0 INTRODUCTION

The San Diego Association of Governments (SANDAG) implemented the San Diego Regional Beach Sand Project (RBSP) in 2001, which involved placement of approximately 2.1 million cubic yards (cy) of sand at twelve beach receiver sites from Oceanside to Imperial Beach. Prior to the SANDAG Project, many of the beaches within San Diego County were characterized by narrow beach widths and seasonally, shallow sand depths and/or extensive cobble cover or exposed bedrock (SANDAG and U.S. Navy 2000). Reconnaissance surveys documented few biological resources at beach sites with eroded sand conditions (MEC 2000).

SANDAG established a monitoring program of before and after comparisons of beach profiles to evaluate the fate of sand nourishment material, and of sensitive biological habitats to determine whether sand migration from receiver sites resulted in significant impacts. Beach profiles were measured during spring and fall, corresponding to periods after winter erosion and summer accretion (Coastal Frontiers 2004, 2006). The shore zone of California beaches seasonally varies in width and depth due to erosion from larger waves associated with winter storms and accretion during milder sea conditions of summer (Shepard and Inman 1951). SANDAG's biological monitoring included assessment of resources in rocky intertidal habitat, shallow subtidal reef habitat, and kelp forests (AMEC 2005), but did not address sandy beach habitat.

The City of Encinitas funded this coastal habitat study in 2003 through 2005 to examine biological resource use of its beaches after sand nourishment from the SANDAG 2001 RBSP. A total of 455,000 cy of sand was dredged from offshore borrow sites and placed on beaches at four sites in the City of Encinitas between June and August 2001 (AMEC 2002). Because of limited available data prior to the RBSP, this study was designed to include comparisons of beach habitats and biological resources at three sites that did (receiver sites) and three sites that did not (non receiver sites) receive sand placement during the SANDAG Project. Surveys examined physical characteristics of beaches, marine invertebrates living in beach sands, bird use at the beaches, and the potential for beaches to support grunion spawning. Surveys were conducted during late summer-early fall (late September-October) 2003-2005 corresponding to the period when beach profiles were at a seasonal maximum. Surveys also were conducted in May 2004 and 2005, corresponding to the month when pre-project reconnaissance data were available for comparison with post project data, and also as being representative of spring conditions after the winter storm season.

Two questions addressed by the study were whether biological resource use of sandy beach habitat differed among City of Encinitas receiver and non receiver sites two to four years after beach nourishment and at receiver sites before and after the SANDAG 2001 RBSP. The timing of the study did not enable documentation of post construction recovery rates, but provided useful comparison of biological resource use of receiver sites during the first several years of post project performance under normal erosion and accretion cycles. In addition, the inclusion of non receiver sites in the study design permitted some documentation of post project sand influence on beach habitat and biological resources as a result of downcoast sand migration.

Methods used during this study are described in Section 2.0. Results of the 2003-2005 surveys, including comparisons to 1999 pre-project data, are separately evaluated for beach habitat physical characteristics (Section 3.0), marine invertebrate resources (Section 4.0), bird use of beaches (Section 5.0), and potential grunion spawning habitat (Section 6.0). Results of the separate evaluations of habitat and biological resources are discussed and summarized in Section 7.0. Study participants are acknowledged in Section 8.0, and literature citations are provided in Section 9.0. Two appendices provide background survey data.

2.0 METHODS

Six beach sites were surveyed between the northern and southern boundaries in the City of Encinitas (Figure 2-1). Sites at Batiquitos, Moonlight, and Cardiff corresponded to SANDAG receiver sites. Non receiver sites were established at Leucadia, San Elijo, and Seaside. Although SANDAG established a receiver site at Leucadia, the location surveyed in 2003-2005 was further south at Beacon's Beach, which was evaluated but rejected as a potential receiver site in 1999. The designation of the beach sites surveyed during the present study, whether they were surveyed prior to the SANDAG Project in 1999, and their approximate distance from the nearest SANDAG receiver sites are given in Table 2-1.

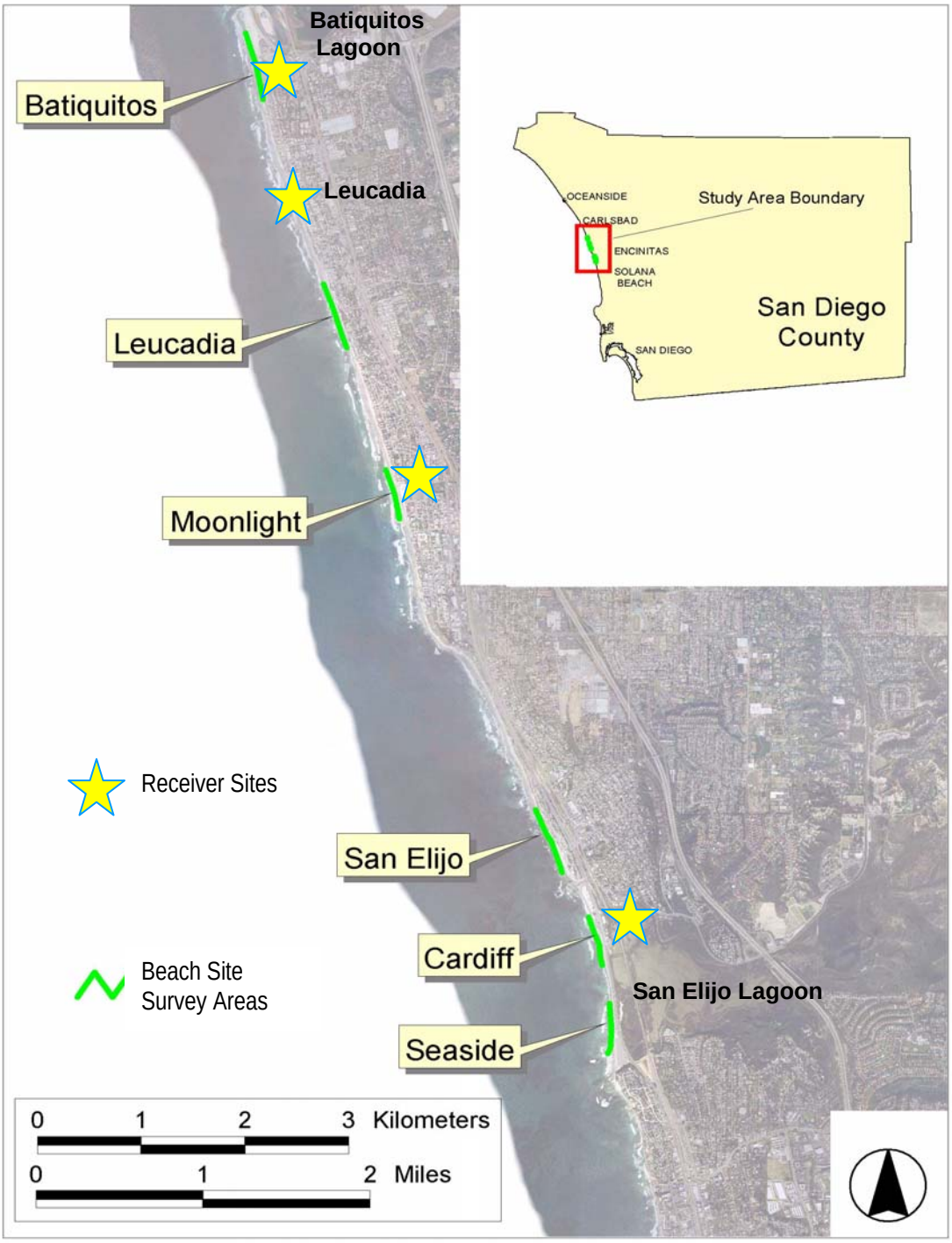
Table 2-1. Beach survey locations relative to SANDAG receiver sites.

Beach Sites Surveyed	Designation	Available Data From 1999	Approximate Distance to Nearest SANDAG Receiver Sites
Batiquitos	SANDAG receiver site	Yes	0
Cardiff	SANDAG receiver site	Yes	0
Moonlight	SANDAG receiver site	Yes	0
Leucadia	Non receiver site	Yes	300 m (1,000 ft) downcoast from Leucadia receiver site and 1,067 m (3,500 ft) upcoast from Moonlight receiver site
San Elijo	Non receiver site	No	457 m (1,500 ft) upcoast from Cardiff receiver site and 2.4 km (1.5 mi) downcoast from Moonlight receiver site
Seaside	Non receiver site	No	300 m (1,000 ft) downcoast from Cardiff receiver site and 1,067 m (3,500 ft) upcoast from Solana Beach receiver site

Surveys were conducted during summer-fall of 2003 (October), 2004 (late September), and 2005 (October) when sand depths on beaches are generally at a seasonal maximum. Surveys also were conducted in May 2004 and 2005, which was the same month as the 1999 reconnaissance survey. Spring represents a time period when sand depths generally are lower on beaches as a result of erosion associated with winter storms. The study originated as a single exploratory survey and was subsequently funded on a per survey basis. The May 2004 survey was abbreviated due to funding limitations, with fewer sampling locations evaluated at a beach for sand depths and marine invertebrates; however, bird use was completely surveyed at all beach sites. All other surveys included the same number of sampling locations per beach. Methods used to document physical habitat characteristics and biological resources are described in the following subsections.

2.1 Beach Habitat Physical Characteristics

The six beach sites were approximately 467 to 610 m (1,500 to 2,000 ft) in length. Sand depths in the upper, middle, and lower intertidal zones were measured by hammering a metal rod into the sand up to a maximum depth of 122 centimeters (cm) (4 feet, ft) or to refusal and recording the depth. Sand depths were measured at three sampling locations per beach; i.e., near the north (upcoast), middle, and south (downcoast) portions of the beach sites. During the abbreviated May 2004 survey, measurements were taken at one sampling location; i.e., north, middle, or south, depending on ease of beach access.



Source: modified from MEC 2003
Notes: Batiquitos, Moonlight, and Cardiff were SANDAG receiver sites
Leucadia, San Elijo, and Seaside were non receiver sites
An additional receiver site at Leucadia, which was not surveyed during this study, was located north of the Leucadia non receiver site

Figure 2-1. Map of City of Encinitas receiver and non receiver site survey locations.

Sand depths were measured during low tide conditions so that a broad width of the beach was uncovered by water. Table 2-2 summarizes the time of sampling, tide, and weather conditions during the 2003-2005 habitat surveys. Low intertidal sand depths were measured near the water's edge when tides ranged between -0.37 and 0.27 meter (m) Mean Lower Low Water (-1.2 and +0.9 ft MLLW). Upper intertidal measurements were taken in the upper beach within a few feet of where sand had been wetted from the previous high tides, which ranged from approximately +1.6 to +1.9 m MLLW (+5.4 to +6.4 ft MLLW) during the surveys. Middle intertidal measurements were taken nearly equal distant between the low and upper intertidal sampling areas. Representative photographs of beach habitat conditions were taken during habitat surveys and during low and high tide bird surveys.

2.2 Marine Invertebrate Resources

Shovel samples were collected within the upper, middle, and lower intertidal zones at each sampling location (north, middle, south) where sand depths were measured. Thus, a total of 18 samples per beach were collected (i.e., 2 samples x 3 intertidal zones x 3 sampling locations). During the abbreviated May 2004 survey, a total of 6 samples were collected per beach (i.e., 2 samples x 3 tide zones x 1 sampling location).

Shovel samples were dug to depths of approximately 30 cm (12 inches, in). A standardized surface area of 0.08 m^2 was sampled. The sides and interior of the shoveled holes were examined for the presence of grunion eggs. Sand samples were sieved through a 1-millimeter (mm) screen in the wave wash zone. Retained organisms were counted according to the following categories: sand crabs (*Emerita analoga*), other mole crabs, amphipods/isopods, bean clams (*Donax gouldii*), olive snails (*Olivella biplicata*), pismo clams (*Tivela stultorum*), worms, and other invertebrates. Invertebrates that were not identifiable to species in the field were returned to the laboratory for identification.

The diameter of collected sand crabs was measured according to four size categories > 1.3 cm, 0.9 to 1.3 cm, > 0.56 to 0.9 cm, and < 0.56 cm (> 0.5 in, > 0.375 to 0.5 in, > 0.22 to 0.375 in, and < 0.22 in), and the occurrence of eggs was noted to provide information on the development of the sand crab population; that is, occurrence of juveniles, adults, and reproductive activity.

The wave wash area within a beach site was searched to identify occurrence of concentrated patches of sand crabs, relative abundance (abundant, moderate, sparse) of bean clams, occurrence of sand dollars, and/or other invertebrates.

Available preserved samples from July 1999 reconnaissance surveys at sites in the vicinity of the study area were analyzed to provide representative data on number of invertebrate species on local beaches to augment May 1999 pre-project information reported by MEC (2000).

Table 2-2. Environmental conditions during habitat surveys at City of Encinitas receiver and non receiver beach sites after beach nourishment, 2003-2005.

Beach Site (North to South)	Date	High Tide m (ft) MLLW Before Survey	Time of Survey	Tide Height m (ft) MLLW During Survey	Weather
October 2003 Survey					
Batiquitos Receiver	10/8/2003	1.65 (5.4)	1325 to 1525	0.2 to 0.5 (0.7 to 1.6)	Overcast to Clear
Leucadia Non Receiver	10/8/2003	1.65 (5.4)	1550 to 1730	0.3 to 0.7 (0.9 to 2.2)	Overcast
Moonlight Receiver	10/10/2003	1.7 (5.6)	1450 to 1650	0.1 to 0.3 (0.4 to 1.0)	Overcast
San Elijo Non Receiver	10/9/2003	1.68 (5.5)	1515to 1630	0.15 to 0.2 (0.5 to 0.7)	Sunny
Cardiff Receiver	10/9/2003	1.68 (5.5)	1330 to 1450	0.2 to 0.6 (0.7 to 1.9)	Overcast
Seaside Non Receiver	10/9/2003	1.68 (5.5)	1650 to 1800	0.3 to 0.6 (0.9 to 1.9)	Clear
May 2004 Survey					
Batiquitos Receiver	5/10/2004	1.65 (5.4)	0655 to 0720	0.15 to 0.3 (0.5 to 1.0)	Overcast
Leucadia Non Receiver	5/10/2004	1.65 (5.4)	0735 to 0755	0.03 to 0.25 (0.1 to 0.5)	Overcast
Moonlight Receiver	5/10/2004	1.65 (5.4)	0820 to 0840	-0.09 to -0.03 (-0.3 to -0.1)	Overcast
San Elijo Non Receiver	5/10/2004	1.65 (5.4)	0915 to 0935	-0.18 to -0.15 (-0.6 to -0.5)	Overcast
Cardiff Receiver	5/10/2004	1.65 (5.4)	0950 to 1010	-0.18 to -0.15 (-0.6 to -0.5)	Overcast
Seaside Non Receiver	5/10/2004	1.65 (5.4)	1025 to 1045	-0.15 to -0.09 (-0.5 to -0.3)	Overcast
September 2004 Survey					
Batiquitos Receiver	9/28/2004	1.68 (5.5)	1340 to 1515	0.18 to 0.54 (0.6 to 1.8)	Clear
Leucadia Non Receiver	9/28/2004	1.68 (5.5)	1540 to 1655	0.15 to 0.27 (0.5 to 0.9)	Clear
Moonlight Receiver	9/29/2004	1.74 (5.7)	1600 to 1730	0.09 to 0.21 (0.3 to 0.7)	Clear
San Elijo Non Receiver	9/29/2004	1.74 (5.7)	1350 to 1540	0.15 to 0.64 (0.5 to 2.1)	Clear
Cardiff Receiver	9/30/2004	1.74 (5.7)	1445 to 1630	0.15 to 0.55 (0.5 to 1.8)	Clear
Seaside Non Receiver	9/30/2004	1.74 (5.7)	1630 to 1750	0.12 to 0.15 (0.4 to 0.5)	Overcast
May 2005 Survey					
Batiquitos Receiver	5/26/2005	1.95 (6.4)	0745 to 0910	-0.21 to 0.15 (-0.7 to 0.5)	Overcast to Clear
Leucadia Non Receiver	5/26/2005	1.95 (6.4)	0545 to 0720	-0.4 to -0.3 (-1.2 to -0.9)	Overcast to Clear
Moonlight Receiver	5/27/2005	1.83 (6.0)	0650 to 0720	-0.3 to -0.33 (-1.0 to -1.1)	Overcast to Clear
San Elijo Non Receiver	5/27/2005	1.83 (6.0)	0750 to 0925	-0.3 to 0.03 (-0.9 to 0.1)	Overcast to Clear
Cardiff Receiver	5/25/2005	1.95 (6.4)	0545 to 0700	-0.4 to -0.18 (-1.4 to -0.6)	Overcast to Clear
Seaside Non Receiver	5/25/2005	1.95 (6.4)	0710 to 0830	-0.18 to 0.3 (-0.6 to 1.0)	Overcast to Clear
October 2005					
Batiquitos Receiver	10/4/2005	1.7 (5.6)	1630 to 1815	0.12 to 0.3 (0.4 to 1.0)	Clear and Sunny
Leucadia Non Receiver	10/4/2005	1.7 (5.6)	1400 to 1610	0.12 to 0.6 (0.4 to 2.0)	Clear and Sunny
Moonlight Receiver	10/5/2005	1.74 (5.7)	1655 to 1815	0.09 to 0.15 (0.3 to 0.5)	Clear and Sunny
San Elijo Non Receiver	10/5/2005	1.74 (5.7)	1443 to 1640	0.12 to 0.4 (0.4 to 1.4)	Clear and Sunny
Cardiff Receiver	10/3/2005	1.65 (5.4)	1345-1545	0.18 to 0.46 (0.6 to 1.5)	Clear and Sunny
Seaside Non Receiver	10/3/2005	1.65 (5.4)	1600 to 1735	0.18 to 0.4 (0.6 to 1.3)	Clear

Note: MLLW = mean lower low water

2.3 Birds

Birds were counted according to species along the entire beach site, from intertidal through adjacent backshore. Bird behavior (foraging, resting) also was recorded. Separate surveys were conducted during low and high tides to determine if beach width affected bird use. Environmental conditions during bird surveys are given in Table 2-3.

Table 2-3. Environmental conditions during bird surveys at City of Encinitas receiver and non receiver beach sites after beach nourishment, 2003-2005.

Beach Site (North to South)	Tide	Time of Survey	Tide Height m (ft) MLLW During Survey	Cloud Cover	Wind (miles/ hour)	Air Temp. (°F)
October 9, 2003 Survey						
Batiquitos Receiver	High	1105 to 1125	1.4 to 1.5 (4.5 to 4.9)	100%	4-9	65
	Low	1415 to 1445	0.2 to 0.3 (0.7 to 1.0)	100%	1-3	71
Leucadia Non Receiver	High	1040 to 1100	1.5 to 1.6 (4.9 to 5.3)	100%	3-7	63
	Low	1500 to 1530	0.15 to 0.18 (0.5 to 0.6)	0%	0	75
Moonlight Receiver	High	0945 to 1030	1.6 to 1.7 (5.3 to 5.5)	100%	3-7	63
	Low	1545 to 1615	0.15 to 0.18 (0.5 to 0.6)	0%	0-2	75
San Elijo Non Receiver	High	0840 to 0905	1.5 to 1.95 (5.1 to 5.4)	100%	2-5	62
	Low	1630 to 1650	0.2 to 0 (0.7 to 0)	20%	2-5	74
Cardiff Receiver	High	0735 to 0756	1.3 to 1.4 (4.2 to 4.7)	100%	1-3	62
	Low	1705 to 1725	0.3 to 0.4 (1.0 to 1.4)	40%	3-8	68
Seaside Non Receiver	High	0800 to 0818	1.4 to 1.46 (4.7 to 4.8)	100%	1-3	62
	Low	1730 to 1800	0.4 to 0.6 (1.4 to 1.9)	20%	4-9	63
May 7 and May 10, 2004 Survey						
Batiquitos Receiver	High	1530 to 1600	1 to 1.1 (3.5 to 3.7)	100%	12-15	67
	Low	0900 to 0945	- 0.15 to 0.18) -0.5 to -0.6	20%	10-15	65
Leucadia Non Receiver	High	1630 to1700	1.2 (3.9)	100%	8-11	70
	Low	0800 to 0830	-0.06 to 0.03 (-0.2 to 0.1)	95%	5-10	63
Moonlight Receiver	High	1715 to 1745	1.2 (3.9)	100%	6-10	67
	Low	0700 to 0745	0.18 to 0.33 (0.6 to 1.1)	95%	5-10	63
San Elijo Non Receiver	High	1308 to 1340	1.1 to 1.1 (3.5 to 3.6)	5%	0-2	70
	Low	0808 to 0845	-0.2 to 0 (-0.7 to 0)	60%	3-7	64
Cardiff Receiver	High	1230 to 1255	0.3 to 0.4 (0.9 to 1.3)	0%	3-5	68
	Low	0710 to 0740	-0.4 to 0.3 (-1.4 to -1.1)	80%	0-1	63
Seaside Non Receiver	High	1200 to 1225	1 to 1.1 (3.5 to 3.6)	10%	3-5	68
	Low	0630 to 0700	-0.5 to -0.4 (-1.5 to -1.4)	90%	1-3	67
September 29 - 30, 2004 Survey						
Batiquitos Receiver	High	1215 to 1245	1.2 to 1.7 (4.0 to 5.5)	100%	1-3	75-76
	Low	1445 to1515	0.18 to 0.3 (0.6 to 1.0)	0%	1-5	76-77
Leucadia Non Receiver	High	1130 to 1200	1.5 to 1.6 (5.0 to 5.4)	100%	0-2	75
	Low	1530 to 1600	0.12 to 0.18 (0.4 to 0.6)	0%	1-3	76-77
Moonlight Receiver	High	1045 to1115	1.7 to 1.7 (5.5 to 5.6)	100%	1-3	74-75
	Low	1615 to 1645	0.09 to 0.12 (0.3 to 0.4)	0%	3-5	76
San Elijo Non Receiver	High	0930 to 1000	1.6 to 1.7 (5.3 to 5.6)	100%	0-2	72-73
	Low	1845 to 1915	0.5 to 0.7 (1.7 to 2.4)	10-20%	1-5	70-74
Cardiff Receiver	High	0900 to 0930	1.5 to 1.6 (5.0 to 5.3)	100%	1-3	71
	Low	1745 to 1815	0.2 to 0.4 (0.8 to 1.3)	0%	3-5	75
Seaside Non Receiver	High	0830 to 0900	1.4 to 1.5 (4.5 to 5.0)	100%	1-3	70-71
	Low	1715 to 1745	0.15 to 0.2 (0.5 to 0.8)	0%	3-5	75-76

Table 2-3 (Continued)

Beach Site (North to South)	Tide	Time of Survey	Tide Height m (ft) MLLW During Survey	Cloud Cover	Wind (miles/ hour)	Air Temp. (°F)
May 26, 2005 Survey						
Batiquitos Receiver	High	1705 to 1730	0.7 (2.2)	0%	4	64
	Low	0905 to 0930	0.3 (0.9)	100%	3	65
Leucadia Non Receiver	High	1830 to 1850	0.9 (3.0)	0%	4	64
	Low	0820 to 0850	-0.15 (-0.5)	100%	3	65
Moonlight Receiver	High	1740 to 1810	0.8 (2.8)	0%	5	65
	Low	0720 to 0800	-0.2 (-0.8)	100%	1	64
San Elijo Non Receiver	High	1700 to 1730	0.8 (2.6)	0%	5	65
	Low	0630 to 0700	-0.3 (-1.1)	100%	4	63
Cardiff Receiver	High	1630 to 1700	0.8 (2.8)	< 50%	4	69
	Low	0530 to 0600	-0.4 (-1.3)	100%	4	63
Seaside Non Receiver	High	1600 to 1630	0.9 (3.0)	< 50%	4	69
	Low	0600 to 0630	-0.4 (-1.4)	100%	3	63
October 03-05, 2005 Survey						
Batiquitos Receiver	High	0815 to 0900	1.2 to 1.6 (4.4 to 5.2)	0%	2-4	60
	Low	1500 to 1525	0.09 to 0.4 (0.3 to 1.4)	0%	5-8	76
Leucadia Non Receiver	High	0915to 1015	1.6 to 1.7 (5.2 to 5.7)	0%	2-4	64
	Low	1555 to 1625	0.09 to 0.18 (0.3 to 0.6)	0%	6-8	70
Moonlight Receiver	High	0935 to 1010	1.6 to 1.7 (5.4 to 5.6)	0%	2-4	67
	Low	1650 to 1710	0.12 to 0.15 (0.4 to 0.5)	0%	2-4	74
San Elijo Non Receiver	High	0845 to 0910	1.6 to 1.65 (5.2 to 5.4)	0%	2-4	64
	Low	1540 to 1600	0.12 to 0.15 (0.4 to 0.5)	0%	1-3	76
Cardiff Receiver	High	0900 to 0920	1.6 to 1.65 (5.3 to 5.4)	0%	2-4	64
	Low	1515 to 1545	0.18 to 0.2 (0.6 to 0.7)	0%	2-4	73
Seaside Non Receiver	High	0810 to 0835	1.5 to 1.55 (4.8 to 5.1)	0%	2-4	64
	Low	1550 to 1615	0.18 to 0.3 (0.6 to 1.0)	0%	3-5	70

Note: MLLW = mean lower low water

2.4 Potential Grunion Habitat

Physical characteristics of beach sites were considered for potential suitability to support spawning by the California grunion (*Leuresthes tenuis*). Beach surface characteristics (e.g., cobble, sand) and measurements of sand depths in the upper intertidal zone were considered. In addition, the interior of holes dug during shovel sampling for marine invertebrates was examined for presence or absence of grunion eggs.

Grunion eggs
Photograph from Dr. K. Martin, Pepperdine University

3.0 RESULTS OF BEACH HABITAT SURVEYS

Results of 2003-2005 beach habitat surveys are presented in Section 3.1. The 2003-2005 survey data are compared with available data prior to the 2001 SANDAG Project in Section 3.2. Beach habitat characteristics are summarized in Section 3.3. Sand depth measurements by sampling location and survey and beach width measurements are given in Appendix A.

3.1 Comparison of Sandy Beach Habitat at City of Encinitas Receiver and Non Receiver Sites After Beach Nourishment, 2003-2005

The receiver and non receiver sites shared some overall similarities and site specific differences in physical appearance. The backshore was relatively narrow at the beach sites, ending either at coastal bluffs and/or urban development (road). The backshore at Batiquitos and Moonlight receiver sites ended at coastal bluffs along most of their length; however, each of these sites also had a localized area of open backshore ending at urban development within their site boundaries. The backshore at San Elijo and Leucadia non receiver sites also ended at coastal bluffs. An open backshore area ending at urban development was located adjacent and downcoast of the San Elijo beach site, but coastal bluff occurred along the entire backshore at Leucadia, and extended without interruption > 1.5 km (> 1 mi) downcoast and upcoast of that site. Cardiff receiver and Seaside non receiver sites both had open backshore that ended at rip rap and/or urban development. The Batiquitos and Cardiff receiver sites and San Elijo and Seaside non receiver sites were located < 1 km (< ½ mi) from Batiquitos or San Elijo Lagoons.

Overall patterns of sand depths differed among receiver sites and non receiver sites. Average sand depths across tide zones generally ranged > 60 cm (2 ft) at the receiver sites; whereas, shallower sand depths were observed on one or more surveys at the non receiver sites (Figure 3-1).

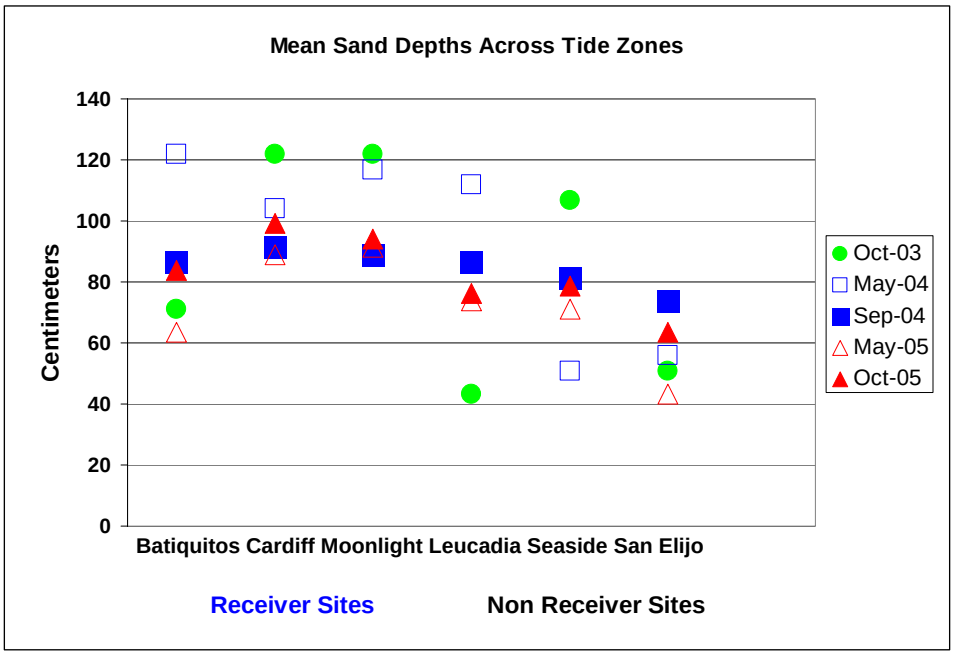


Figure 3-1. Mean sand depths across tide zones at City of Encinitas receiver and non receiver beach sites after beach nourishment, 2003-2005.

Average sand depths varied among surveys in different ways at the receiver and non receiver beach sites, suggesting different influences from the RBSP. Average sand depths at receiver sites were less variable (spanned a narrower range) among surveys at Cardiff and Moonlight than at Batiquitos. There was a sequential decline in mean sand depths between 2003 and 2005 at Cardiff and Moonlight of approximately 33 cm (1 ft). In contrast, mean sand depths at Batiquitos were comparatively shallow in 2003, deeper in spring 2004, and sequentially declined through 2005 to a level slightly lower than in 2003. Additional sand was placed on Batiquitos in late 2003 from maintenance dredging of Batiquitos Lagoon (B. Hoffman, personal communication), and may have contributed to the deeper depths measured in spring 2004. The variability in sand depths at Batiquitos suggests that sand movement was more dynamic at this site than the other receiver sites.

Average sand depths substantially differed across surveys at the non receiver sites. At Leucadia, the mean sand depth was relatively low in summer 2003 and substantially deeper across seasonal surveys in 2004 and 2005. Sand depths of > 100 cm (> 3.3 ft), which were measured at Leucadia in May 2004 were also only observed at receiver sites. The Leucadia non receiver site was located approximately 300 m (1,000 ft) downcoast of the Leucadia receiver site and 2 km (1.3 miles) downcoast of the Batiquitos receiver site. The substantially deeper sand depths in 2004-2005 suggest that sand from upcoast receiver sties(s) migrated downcoast to the Leucadia non receiver site.

Mean sand depths at Seaside were as deep in October 2003 as at receiver sites. Sand depths at Seaside exhibited substantially greater seasonal variation than observed at receiver sites in 2004, and were less seasonally variable in 2005 Seaside was located approximately 300 m (1,000 ft) downcoast from the Cardiff receiver site, which likely served as a feeder beach with sand migration to Seaside before and during the study period.

Mean sand depths varied over a relatively narrow range at the San Elijo non receiver site. The relatively similar sand depths among surveys indicated no substantial influx of sand to this site during the course of the study.

3.2 Comparison of Sandy Beach Habitat Before and After Beach Nourishment

Sand depth measurements and substrate characteristics are compared before and after beach nourishment in Section. 3.2.1, and beach width data are reviewed in Section 3.2.2.

3.2.1 Sand Depths and Substrate Characteristics

A reconnaissance survey between May 17 and 20, 1999 was conducted during low tides at potential receiver sites prior to implementation of the SANDAG 2001 RBSP (MEC 2000). Photographs were taken and sand depths were measured in upper, middle, and lower intertidal zones approximately every 90 m (300 ft) along the beach sites. Batiquitos, Leucadia (Beacon's Beach), Moonlight, and Cardiff were surveyed. Additionally, a site further north in Leucadia, which was subsequently used as the SANDAG receiver site was surveyed. Substrate at most beach sites included more cobble cover in 1999 than in 2003-2005 (Figure 3-2).

Batiquitos Receiver Site

Cardiff Receiver Site

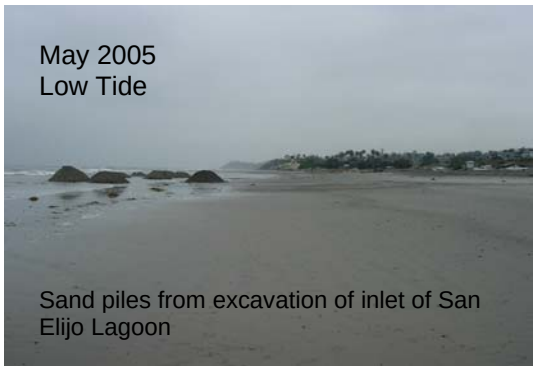
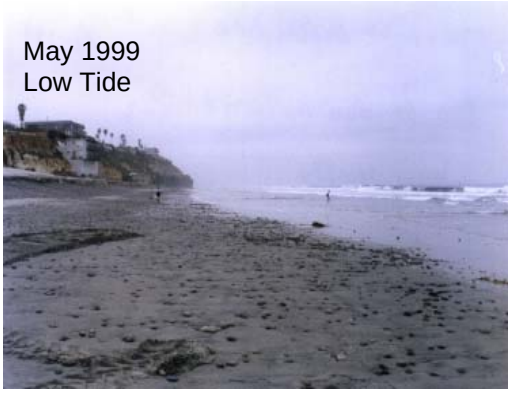


Figure 3-2. Photographs of City of Encinitas receiver and non receiver beach sites before and after beach nourishment.

Moonlight Receiver Site



Leucadia Non Receiver Site

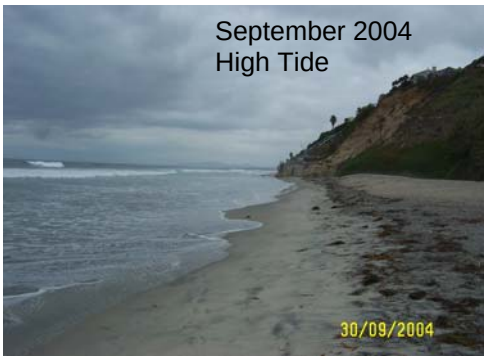


Figure 3-2 (Continued).

Seaside Non Receiver Site

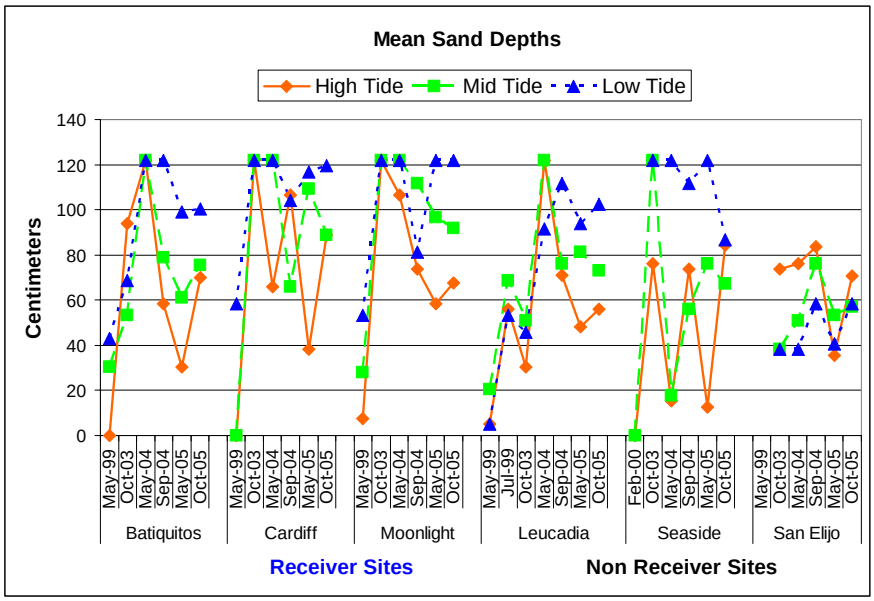
San Elijo Non Receiver Site

Figure 3-2 (Continued).

There was a mix of sand and cobble at Batiquitos, Moonlight, and Leucadia beach sites in 1999. Cobble cover was extensive at Cardiff and Seaside prior to the SANDAG 2001 RBSP. Although not surveyed in 1999, San Elijo during minus tide conditions in spring 2002, a few months after implementation of the SANDAG Project, had sand habitat between bluffs and nearshore reefs.

In 2003-2005, substrate surface was sandy with little to no cobble at Cardiff and Moonlight receiver sites (Figure 3-2). This generally was the case at Batiquitos; however, some cobble and shallower sand depths were measured at the middle and south sampling locations during the October 2005 survey (Appendix A). Substrate surface also was sandy at Leucadia and San Elijo non receiver sites. Sand and some cobbles were placed north of the Cardiff survey boundaries in May 2005 from inlet excavation at San Elijo Lagoon. Sand was placed on the beach and cobbles were placed near the backshore. The May 2005 survey was conducted during the early phase of the inlet maintenance, which did not appear to influence the sand depth measurements during that survey. Substrate surface seasonally varied at Seaside from sandy during summer-fall to a mix of cobble and sand during spring (Figure 3-3). Cobble cover corresponded with shallow sand depth measurements, indicating cobbles became exposed after seasonal erosion of sand at Seaside (Appendix A).

Variations in sand depths between tide zones illustrate dynamic sand movement across surveys at each beach site (Figure 3-3, Table 3-1). Cobble and/or bedrock occurred below shallow sand depths. Prior to the SANDAG 2001 RBSP, mean sand depths across tide zones were < 30 cm (< 1 ft) in May 1999. Data from Leucadia in July 1999 indicated an average 49 cm (1.6 ft) accretion across tide zones between spring and summer prior to the SANDAG Project. Sand depths were deeper across seasons at receiver sites after the SANDAG Project. Sand depths at Leucadia and Seaside non receiver sites also appeared to range deeper after the SANDAG Project, although seasonal patterns in sand depth differed among these non receiver sites. Limited variability in sand depths among surveys at San Elijo indicated only minor seasonal sand migration and no obvious SANDAG influence during the study.



Note: Before period = 1999-2000, After period = 2003-2005

Figure 3-3. Mean sand depths by tide zone at City of Encinitas receiver and non receiver beach sites before and after beach nourishment.

Table 3-1. Mean sand depths (cm) at City of Encinitas receiver and non receiver beach sites before and after beach nourishment.

Beach Site	Survey	Upper Intertidal	Middle Intertidal	Lower Intertidal	Mean
Batiquitos Receiver	May 1999	0 (cobble)	30.5	43.2	24.5
	October 2003	94.0	53.3	68.6	72.0
	May 2004	>122	>122	>122	>122
	September 2004	58.4	78.7	>122	86.4
	May 2005	30.5	61.0	99.1	63.5
	October 2005	69.8	75.40	100.3	81.8
Cardiff Receiver	May 1999	0 (cobble)	0 (cobble)	58.4	19.5
	October 2003	>122	>122	>122	>122
	May 2004	66.0	>122	>122	103.3
	September 2004	106.7	66.00	104.1	92.2
	May 2005	38.1	109.20	116.8	92.3
	October 2005	88.9	88.9	119.4	99.1
Moonlight Receiver	May 1999	7.6	27.90	53.3	29.6
	October 2003	>122	>122	>122	>122
	May 2004	106.7	>122	>122	116.9
	September 2004	73.7	111.8	81.3	88.9
	May 2005	58.4	96.5	>122	92.3
	October 2005	67.6	91.7	>122	93.8
Leucadia Non Receiver	May 1999	5.1	20.3	5.1	10.1
	July 1999	55.9	68.6	53.3	59.3
	October 2003	30.5	50.8	45.7	42.3
	May 2004	>122	>122	91.4	111.8
	September 2004	71.1	76.2	111.76	86.4
	May 2005	48.3	81.3	94.0	74.5
	October 2005	55.9	73. 2	102.4	77.1
Seaside Non Receiver	February 2000	0 (Cobble)	0 (Cobble)	NS	?
	October 2003	76.2	>122	>122	106.7
	May 2004	15.29	17.8	>122	51.7
	September 2004	73.7	55.9	111.8	80.5
	May 2005	12.7	76.2	121.9	70.3
	October 2005	84.3	67.3	86.6	79.4
San Elijo Non Receiver	May 1999	NS	NS	NS	?
	October 2003	73.7	38.1	38.1	50.0
	May 2004	76.2	50.8	38.1	55.0
	September 2004	83.8	76.2	58.4	72.8
	May 2005	35.6	53.3	40.6	43.2
	October 2005	70.6	57.2	58.4	62.0

Notes: NS = not surveyed; 1999 sand depth measurements from MEC (2000)

Mean sand depths at receiver sites after the SANDAG 2001 RBSP were 66 to > 122 cm (2.2 to > 4 ft) across tide zones, except for the May 2005 survey when depths of 30 to 60 cm (1 to 2 ft) were measured in the upper intertidal. Upper intertidal depths exhibited seasonally lower sand depths in spring (May) than summer-fall (September-October) at Cardiff in 2004-2005 and at Batiquitos and Moonlight in 2005. The Batiquitos and Moonlight receiver sites changed from seasonal sandy beaches to persistent sandy beaches after the SANDAG Project. At Cardiff the change was even more dramatic, with a change from a predominantly cobble beach to a persistent sandy beach.

As previously mentioned, average sand depth patterns varied among the non receiver sites. For the Leucadia site, no evidence of SANDAG 2001 RBSP influence was reflected in the mean sand depth measurement of 43 cm (1.4 ft) in October 2003, which was similar to that measured in July 1999. Sand depths of 91 to > 122 cm (> 3 to > 4 ft) during spring 2004 suggest that indirect nourishment occurred over the 2003-2004 winter season. Average sand depths at Leucadia then displayed a more similar pattern to receiver sites in 2004-2005, with more seasonal variability in the upper intertidal (48 to > 122 cm, 1 ½ to > 4 ft) and relatively deeper sand depths in middle (73 to > 122 cm, 2.4 to > 4 ft) and lower (91 to 102 cm, 3 to 3.3 ft) intertidal zones.

Although Seaside was not surveyed in 1999, the 2000 pre-project photograph showed extensive cobble throughout the upper and middle intertidal zones similar to the condition observed at Cardiff (Figure 3-2). The sand depth measurements in 2003-2005 showed that Seaside changed from a predominantly cobble beach to a seasonally sandy beach after the SANDAG 2001 RBSP. Seaside differed from the other sites by exhibiting clear seasonality in sand depths in both 2004 and 2005. Average sand depths in the upper intertidal were relatively shallow in the spring (13 to 15 cm, 0.5 ft) and deeper in summer (73 to 84 cm, 2.4 to 2.7 ft). Average sand depths in the middle intertidal were seasonally shallower in spring 2004 (18 cm, 0.6 ft), but spring 2005 depths were similar to those of summer-fall surveys (56 to > 122 cm, 1.8 to > 4 ft). The low intertidal zone sand depths were consistently deeper across surveys (87 to > 122 cm, 2.8 to > 4 ft). The relatively greater average sand depth in the middle intertidal in spring 2005 suggests a continued influx of sand to this site between 2004 and 2005.

Sand depths were not measured at San Elijo prior to the SANDAG 2001 RBSP; therefore, only 2003-2005 data were available for this site. Average sand depths varied across a relatively narrow range at San Elijo (36 to 85 cm, 1.2 to 2.8 ft), with greater variability in the upper intertidal during spring 2005 than other surveys. The shallower upper intertidal sand depths during spring 2005 at most of the surveyed sites suggests the 2004-2005 winter season mobilized more sand than the 2003-2004 winter season.

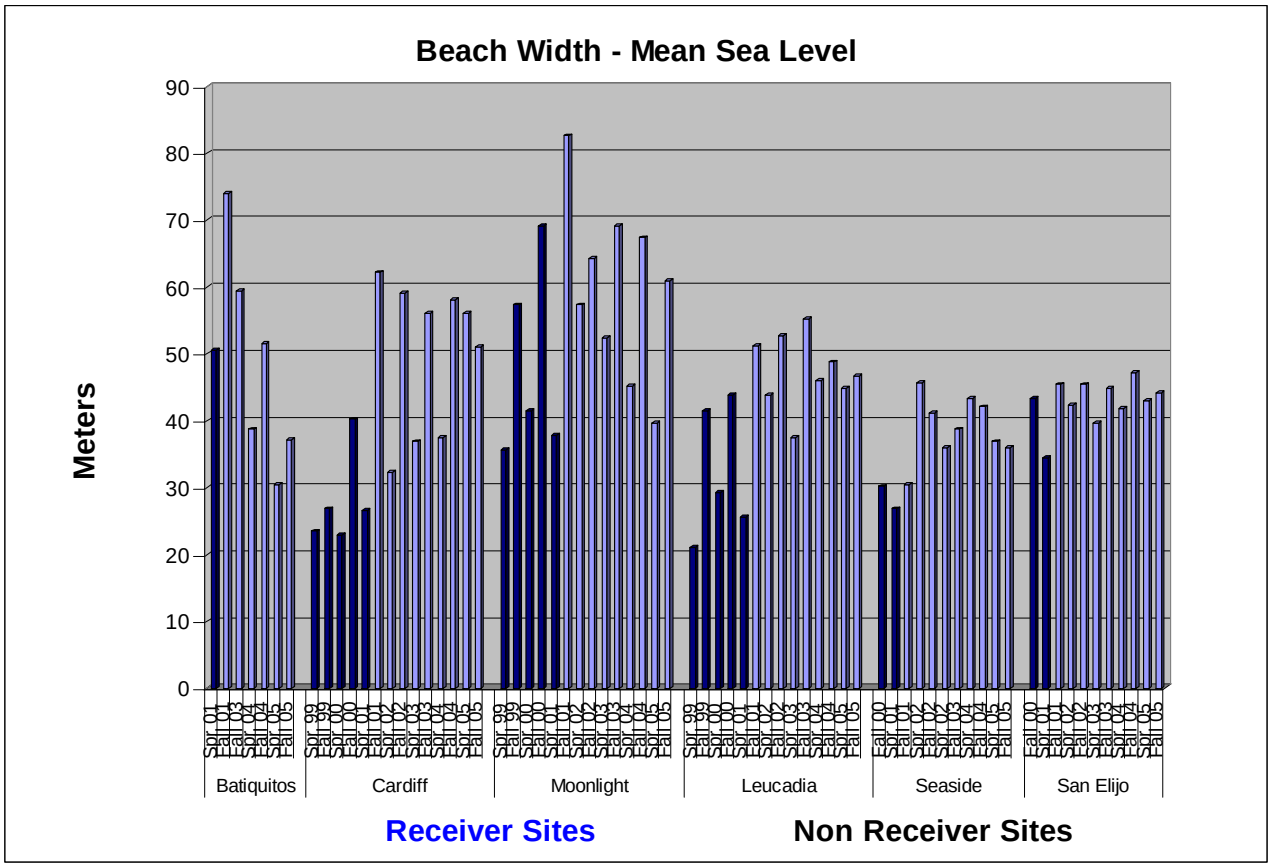
3.2.2 Beach Width

Beach width measurements by Coastal Frontiers (2004, 2006) indicated that City of Encinitas beach sites generally were seasonally wider in fall than spring (Figure 3-4, Appendix A) Beach widths were wider at receiver sites after beach nourishment and to a much lesser degree at non receiver sites.

The beach width data for the Batiquitos receiver site showed decreasing widths between fall 2001 (first profile survey after beach nourishment) and 2005, suggesting sand migration from the site since sand placement.

Beach widths at the Cardiff receiver site were seasonally wider after sand placement. Post project beach widths were highly seasonal between 2001 and 2004, but much less so between 2004 and 2005. Beach widths at Cardiff exhibited a declining trend, indicating sand movement from the site. However, the rate of decline in beach width among post project surveys was less at Cardiff than at other examined receiver sites.

Moonlight receiver site beach widths generally ranged wider after sand placement. Moonlight beach widths displayed regular seasonality with wider beaches in fall than in spring. Beach widths showed a declining trend across seasons between 2001 and 2005, indicating sand movement from the site.



Notes: Darker shading indicates surveys prior to the SANDAG 2001 RBSP
Before period = 1999-spring 2001, After period = fall 2001-2005

Figure 3-4. Beach widths at City of Encinitas receiver and non receiver beach sites before and after beach nourishment.

Trends in beach widths varied among non receiver sites. The Leucadia non receiver site was somewhat wider after the SANDAG 2001 RBSP, but exhibited a change in seasonality with less difference between spring and fall beach widths beginning in spring 2004, which also corresponds to when deeper sand depths were measured during this study (Section 3.2.1).

Beach widths at the Seaside non receiver site showed a substantial increase in spring 2002, representing the first winter season after the SANDAG Project. That result as well as the minor seasonal differences in beach widths between 2002 and 2005 suggests persistence and/or continued influx of sand over the winter seasons at Seaside.

Beach widths at the San Elijo non receiver site were similar during fall both before and after the SANDAG Project, but spring beach widths ranged somewhat higher. The small range between spring and fall beach widths at San Elijo suggests limited on- and offshore movement of sand at this location, perhaps related to the nearshore reefs providing a natural sand retention function.

3.3 Summary of Beach Habitat Characteristics

The SANDAG 2001 RBSP was responsible for substantial increases in sand depths across intertidal beach zones at receiver sites that persisted two to four years after the project, and resulted in indirect nourishment of some nearby beaches from sand migration. Prior to the SANDAG Project, the difference between mean spring and mid summer sand depth measurements at Leucadia was 49 cm (1.6 ft), which was within the historical range of 30 to 100 cm (1 to 3.3 ft) associated with seasonal erosion and accretion cycles at depths of 0 to -1.5 m (0 to -5 ft) MLLW (Moffatt & Nichol 2000, MEC 2000). Mean sand depths of 30 to > 122 cm (1 to > 4 ft) across tide zones ranged deeper than the historical range at receiver sites two to four years after sand placement. Beach nourishment also resulted in wider beach widths at the receiver sites. The beach substrate at receiver sites changed from a seasonal mix of cobble and sand at Batiquitos and Moonlight and persistent cobble at Cardiff to persistent sandy beach habitat.

Relatively wider beach widths at Leucadia and Seaside, in combination with substantially deeper sand depths than the historical range, indicated that these non receiver sites received indirect sand nourishment from migration of sand from receiver sites. Leucadia and Seaside non receiver sites were located approximately 300 m (1,000 ft) downcoast of Leucadia and Cardiff receiver sites, respectively. Apparently, sand migration rates varied along the coast. Although beach widths were wider at Leucadia in 2003, deeper sand depths were not measured until 2004. Sand depths at Seaside exceeded historical averages during the first survey in 2003 indicating indirect nourishment occurred prior to the start of this study. The wider beach widths measured at Seaside the first winter after the SANDAG 2001 RBSP support this interpretation. Sand volume associated with indirect nourishment also differed between Leucadia and Seaside. Sand depths were relatively deep (> 48 to > 122 cm, > 1 ½ to > 4 feet) across seasons at Leucadia in 2004-2005. However, seasonal cycles of erosion and accretion remained a major influence at Seaside during the study, with average sand depths in upper and/or middle intertidal zones less than 18 cm (< 0.6 ft) during spring and approximately 56 to > 122 cm (2 to > 4 ft) in summer-fall. The beach substrate changed from a seasonal mix of cobble and sand at Leucadia to persistent sandy beach habitat, and changed at Seaside from persistent cobble to a seasonally variable cobble/sand mix.

Average sand depths were relatively stable across seasons at San Elijo, perhaps due to the nearshore reefs serving a natural sand retention function. Average sand depths across tide zones at the San Elijo non receiver site in 2003-2005 (38 to 83 cm, > 1 to < 3 feet) were within the historical range for City of Encinitas beaches, without deeper depths or wider beach widths suggestive of SANDAG 2001 RBSP influence.

4.0 MARINE INVERTEBRATE RESOURCES

Results of 2003-2005 invertebrate surveys are presented in Section 4.1. These results are compared in Section 4.2 with available data prior to the SANDAG 2001 RBSP. Marine invertebrate resource use of beach habitats is summarized in Section 4.3. Invertebrate data by sampling location and survey are given in Appendix B.

4.1 Comparison of Marine Invertebrates at City of Encinitas Receiver and Non Receiver Sites After Beach Nourishment, 2003-2005

Marine invertebrates were collected across beach sites in upper, middle, and low intertidal zones at three locations except for the May 2004 survey (Section 2-2). A total of 24 species of invertebrates was collected at City of Encinitas beach sites across surveys (Table 4-1). During each survey, a total of 13 to 19 species were collected across beach sites. The reduced sampling effort during the May 2004 survey probably contributed to the fewer total number of species collected during that survey (13) compared to other surveys (16-19). Sampling effort can be influential when species are patchy in distribution and/or abundance.

Table 4-1. Mean total number of invertebrate species at City of Encinitas receiver and non receiver beach sites after beach nourishment, 2003-2005.

Survey	Receiver Sites			Non Receiver Sites			Total
	Batiquitos	Cardiff	Moonlight	Leucadia	Seaside	San Elijo	
October 2003	7	9	9	9	8	8	16
May 2004*	5	5	4	5	3	6	13
September 2004	9	9	11	9	8	11	19
May 2005	8	9	8	5	6	10	17
October 2005	9	12	10	7	8	10	17
Mean Total	8	9	9	7	7	9	8
Mean Total Spring	6.5	7	6	5	4.5	8	6
Mean Total Summer-fall	8	10	10	8	8	10	9
Grand Total	13	17	16	15	15	17	24

* Note: Abbreviated May 2004 survey included replicate sampling across tide zones at 1 location per beach site (6 samples), other surveys included replicate sampling across tide zones at 3 locations per beach site (18 samples).

The total number of species across surveys was greatest at Cardiff and Moonlight receiver sites and the San Elijo non receiver site (16-17). The fewest total number of species across surveys was collected at the Batiquitos receiver site (13), and an intermediate total number of species (15) was collected at Leucadia and Seaside non receiver sites.

Similarly, the mean total number of species across surveys was highest (9) at Cardiff and Moonlight receiver sites and the San Elijo non receiver site; however, the mean at the Batiquitos receiver site was slightly higher (8) than at the Leucadia and Seaside non receiver sites (7) (Figure 4-1). The trend of a slightly higher mean total number of species at receiver sites and the San Elijo non receiver site compared to Leucadia and Seaside non receiver sites was similar with or without consideration of the reduced sampling effort during the May 2004 survey (Figure 4-1). The mean total number of species reduces the influence of between survey variability in species assemblages and/or patchy species distributions.

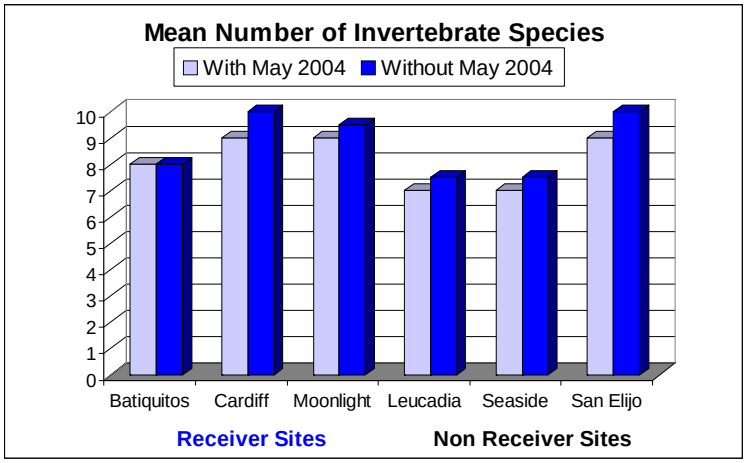


Figure 4-1. Mean total number of invertebrate species at City of Encinitas receiver and non receiver beach sites after beach nourishment, 2003-2005.

The mean total number of invertebrate species per survey ranged from 3 to 12 depending on survey and beach site (Table 4-1). As noted above, the fewer species collected during the May 2004 survey likely related to sampling effort. However, relatively fewer species also were collected during the May 2005 survey compared to summer-fall surveys at some beach sites, suggesting there was some seasonality in invertebrate assemblages at beach sites. During spring, the mean number of species was lower at Leucadia and Seaside non receiver sites (5 species) than other surveyed beach sites (6-8 species) (Table 4-1, Figure 4-2). During summer, the mean number of species at Leucadia and Seaside non receiver sites was similar to that at the Batiquitos receiver site (8 species), but lower than at Cardiff and Moonlight receiver sites and the San Elijo non receiver site (10 species). These results indicate that the invertebrate assemblage developed somewhat earlier in the season at the receiver sites and the San Elijo non receiver site than at Leucadia and Seaside non receiver sites. In addition, the invertebrate assemblages at the Batiquitos receiver site and the Leucadia and Seaside non receiver sites did not develop as fully as those at Cardiff and Moonlight receiver sites and the San Elijo non receiver site.

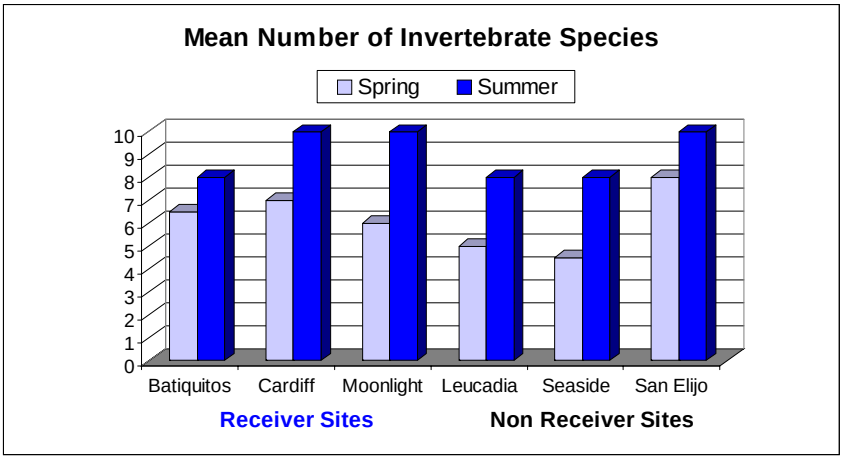


Figure 4-2. Mean total number of invertebrate species during spring and summer at City of Encinitas receiver and non receiver beach sites after beach nourishment, 2003-2005.

Collected invertebrates included 7 species of crustaceans, 3 species of mollusks, 10 species of polychaete worms, and 3 species of nemertean ribbon worms (Table 4-2, Appendix B). Characteristic species collected during most surveys included beach hoppers (talitrid amphipods), sand crabs (*Emerita analoga*), isopods (*Excirolana* sp.), bean clams (*Donax gouldii*), glycerid polychaetes (*Hemipodus borealis*), nephtyid polychaetes (*Nephtys californiensis*), and spionid polychaetes (*Scolelepis bullibranchiata)*.

The collected invertebrates represented a variety of feeding strategies and life styles (Fauchald and Jumars 1979, Morris et al. 1980). Crustaceans included talitrid beach hopper amphipods, other amphipods, isopods, sand crabs, and other mole crabs. Beach hoppers were collected in the upper intertidal, where they construct burrows; these amphipods are herbivores on washed ashore kelp wrack. Sand crabs are suspension-feeders on plankton and migrate up and down the beach with the tides. *Excirolana* isopods are scavengers that mainly feed on sand crabs and their eggs. Porcelain mole crabs (*Lepidopa californica*), which also feed on plankton but burrow to deeper depths than sand crabs, were collected in low abundance at all sites except Moonlight Beach. The spiny mole crab (*Blepharipoda occidentalis*) (> 2 inch diameter), which scavenges mainly on dead sand crabs, was collected at the Moonlight receiver site, and a dead molt was seen in the wave wash area at the Batiquitos receiver site. Two detritus-feeding amphipods (*Eohaustorius* sp., *Erichthonius brasiliensis*) were infrequently collected at Cardiff, Leucadia, and San Elijo beach sites.

Mollusks included the suspension-feeding bean clam (*Donax gouldii*) and pismo clam (*Tivela stultorum*), and the omnivorous olive snail (*Olivella biplicata*). Bean clams were collected during all surveys at all beach sites. Pismo clams were only collected at the Seaside non receiver site in September 2004, and 1 dead Pismo clam was observed in the wave wash area at the Batiquitos receiver site during that same survey. Pismo clam is a managed fishery species by the California Department of Fish and Game. Olive snails, which may feed on algae and/or dead invertebrates, were infrequently collected at Cardiff, Leucadia, and San Elijo beach sites. At Cardiff and Seaside beach sites, egg cases of the moon snail (*Polinices* sp.) were found in the wave wash area. Moon snails prey on clams in low intertidal to subtidal depths.

Collected worms included a mix of polychaete and nemertean worms. Polychaetes represented a variety of feeding strategies, including suspension-deposit-feeding spionids (*Dispio uncinata, Scolelepis bullibranchiata, S. squamata*); subsurface deposit-feeding capitellids (*Notomastus tenuis*), opheliids (*Euzonus mucronata*), and orbiniids (*Scoloplos acmeceps*); and several carnivorous arabellids (*Arabella* sp,), glycerids (*Hemipodus borealis*), lumbrinerids (*Scoletoma* sp.), and nepthyids (*Nephtys californiensis*). Nemertean ribbon worms are carnivores, feeding on crustaceans and/or polychaetes. Collected ribbon worms included *Carinoma mutabilis, Cerebratulus* sp., and *Paranemertes californica.* Polychaete and ribbon worms mainly were collected in the middle and lower intertidal zones. An exception was *Euzonus mucronata*, which occurred in dense aggregations in the upper intertidal at some beach sites.

A notable observation was the occurrence of dead sand dollar tests (*Dendraster excentricus*) in the wave wash area at several beach sites, suggesting offshore populations in the vicinity. Sand dollar tests were seen at all beach sites except Leucadia and San Elijo, which have nearshore subtidal reefs (MEC 2000, http://nearshore.ucsd.edu/).

Table 4-2. List of invertebrate species at City of Encinitas receiver and non receiver beach sites after beach nourishment, 2003-2005.

Common Name	Scientific Name	Taxa-Food Life Style	Receiver Sites			Non receiver Sites		
			Batiquitos	Cardiff	Moonlight	Leucadia	San Elijo	Seaside
Crustaceans								
Beach Hopper	Talitrid	C-H	5/04, 9/04, 5/05, 10/05*	9/04, 10/05	10/03, 5/04, 5/05, 10/05	5/04, 9/04, 5/05, 10/05	5/05, 10/05	10/05
Other Amphipods	*Eohaustorius* sp.	C-D		5/05		10/03		
	Ericthonius brasiliensis	C-D					10/03	
	Unidentified	C-D	10/03, 5/05			5/04		
Isopod	*Excirolana sp.*	C-SC		10/03, 9/04, 10/05	10/03, 9/04	10/03	10/03, 9/04, 5/05, 10/05	9/04
Porcelain Mole Crab	*Lepidopa californica*	C-S	10/03, 5/04, 9/04, 5/05	9/04		10/03	9/04	5/05, 10/05
Sand Crab	*Emerita analoga*	C-S	10/03, 5/05*, 10/05	10/03, 10/05	10/03, 9/04, 5/05, 10/05	10/03, 9/04, 5/05, 10/05*	10/03, 5/04, 9/04, 5/05, 10/05	10/03, 5/05, 10/05
Spiny Mole Crab	*Blepharipoda occidentalis*	C-SC	5/05* (molt)		9/04			
Mollusks								
Bean Clam	*Donax gouldii*	M-S	10/03, 5/04, 9/04, 5/05, 10/05	10/03, 5/04, 9/04, 5/05, 10/05	10/03, 5/04, 9/04, 5/05, 10/05	10/03, 5/04*, 9/04, 5/05, 10/05	10/03, 5/04, 9/04, 5/05, 10/05	10/03, 5/04, 9/04, 5/05, 10/05
Pismo Clam	*Tivela stultorum*	M-S						9/04
Purple Olive	*Olivella biplicata*	M-O		10/05		9/04	5/05	
Polychaete Worms								
Arabellid	*Arabella* sp.	W-C					10/03	
Capitellid	*Notomastus tenuis*	W-BD			10/05		9/04	
Glycerid	*Hemipodus borealis*	W-C	10/03, 5/04, 9/04, 5/05, 10/05	10/03, 9/04, 5/05, 10/05	10/03, 5/04, 9/04, 5/05, 10/05	10/03, 5/04, 9/04, 5/05, 10/05	9/04, 5/05, 10/05	10/03, 5/04, 9/04, 10/05
Lumbrinerid	*Scoletoma* sp.	W-C		10/03, 9/04, 5/05	9/04		9/04	5/05
Lumbrinerid	Lumbrineridae	W-C	10/05	5/05, 10/05	5/05, 10/05		5/05, 10/05	
Nephtyid	*Nephtys californiensis*	W-C	10/03, 5/04, 9/04, 10/05	10/03, 5/04, 9/04, 5/05, 10/05	10/03, 9/04, 10/05	10/03, 9/04, 5/05, 10/05	10/03, 9/04, 5/05, 10/05	10/03, 5/04, 9/04, 10/05
Opheliid	*Euzonus mucronata*	W-BD high tide		10/03, 5/04, 5/05	10/03		10/03, 5/04, 9/04, 5/05, 10/05	10/03
Orbiniid	*Scoloplos acmeceps*	W-BD	10/05	10/03, 10/05	9/04	10/03		
Spionid	*Dispio uncinata*	W-SD	9/04, 5/05	9/04, 10/05	5/05, 10/05	10/05	9/04	5/05
Spionid	*Scolelepis bullibranchiata*	W-SD	10/03, 9/04, 5/05	10/03, 5/04	10/03, 5/04, 9/04	10/03, 5/04, 9/04, 10/05	10/03, 5/04, 9/04, 5/05, 10/05	10/03, 9/04
Spionid	*Scolelepis squamata*	W-SD				9/04	5/04	
Spionid	*Scolelepis* sp.	W-SD			5/05		10/03	
Spionid	Spionidae	W-SD		5/05	10/03	10/05		
Nemertean Worms								
Ribbon Worms	*Carinoma mutabilis*	W-C	9/04, 10/05	9/04, 10/05	9/04			10/03, 9/04, 10/05
	Cerebratulus sp.	W-C		5/05, 10/05	10/05			10/05
	Paranemertes californica	W-C	9/04, 10/05	5/05	9/04	9/04	10/05	10/03, 9/04
	Unidentified	W-C		5/04, 5/05, 10/05	10/03, 5/05, 10/05		5/04	5/05
Total Number of Species			13	17	16	15	17	15
Number of taxa-Food-Life Style Types			7	10	8	9	10	7

*Noted, but not in shovel samples; **C = Crustacean, M = Mollusk, W = Worm,** C = carnivore, BD = subsurface deposit-feeder, D = detritus/deposit-feeder, H = herbivore, O = omnivore, S = suspension feeder, SC = scavenger, SD = suspension-deposit- feeder

The variety of invertebrates according to taxonomic category, feeding type, and life style was examined to further identify differences in functional development of invertebrate assemblages among beach sites. Life style distinctions were made between near surface suspension-feeding sand crabs (*Emerita*) versus other deeper burrowing suspension (*Lepidopa*) or scavenger mole crabs (*Blepharipoda*), surface versus subsurface deposit-feeding worms, and *Euzonus* subsurface deposit-feeding worms that live in the high tide zone versus other subsurface deposit feeding worms living in lower tide zones. The collected species represented a total of 9 taxonomic-food-life style categories (Table 4-2). In this comparison, no distinction was made between polychaete and nemertean worms with carnivorous feeding and life style habits.

Generally, the San Elijo non receiver site had a relatively consistent species assemblage across surveys (except for the abbreviated May 2004 survey), which was characterized by several types of crustaceans (amphipods, isopods, sand crabs), clams, and worms with different feeding strategies (carnivore, suspension-deposit, subsurface deposit, *Euzonus* subsurface deposit) (Figure 4-3). Moonlight and Cardiff receiver sites also had a variety of crustaceans (amphipods, isopods, sand crabs), clams, and worms comprising at least three feeding categories (carnivore, suspension-deposit, subsurface deposit). Other beach sites had assemblages with fewer types of invertebrates and/or greater variability in assemblages among surveys. For example, at the Batiquitos receiver site and Leucadia non receiver site, subsurface deposit-feeding worms and isopods generally were not collected. Seaside had the least variety of invertebrates, often lacking amphipods, isopods, and subsurface deposit feeding worms.

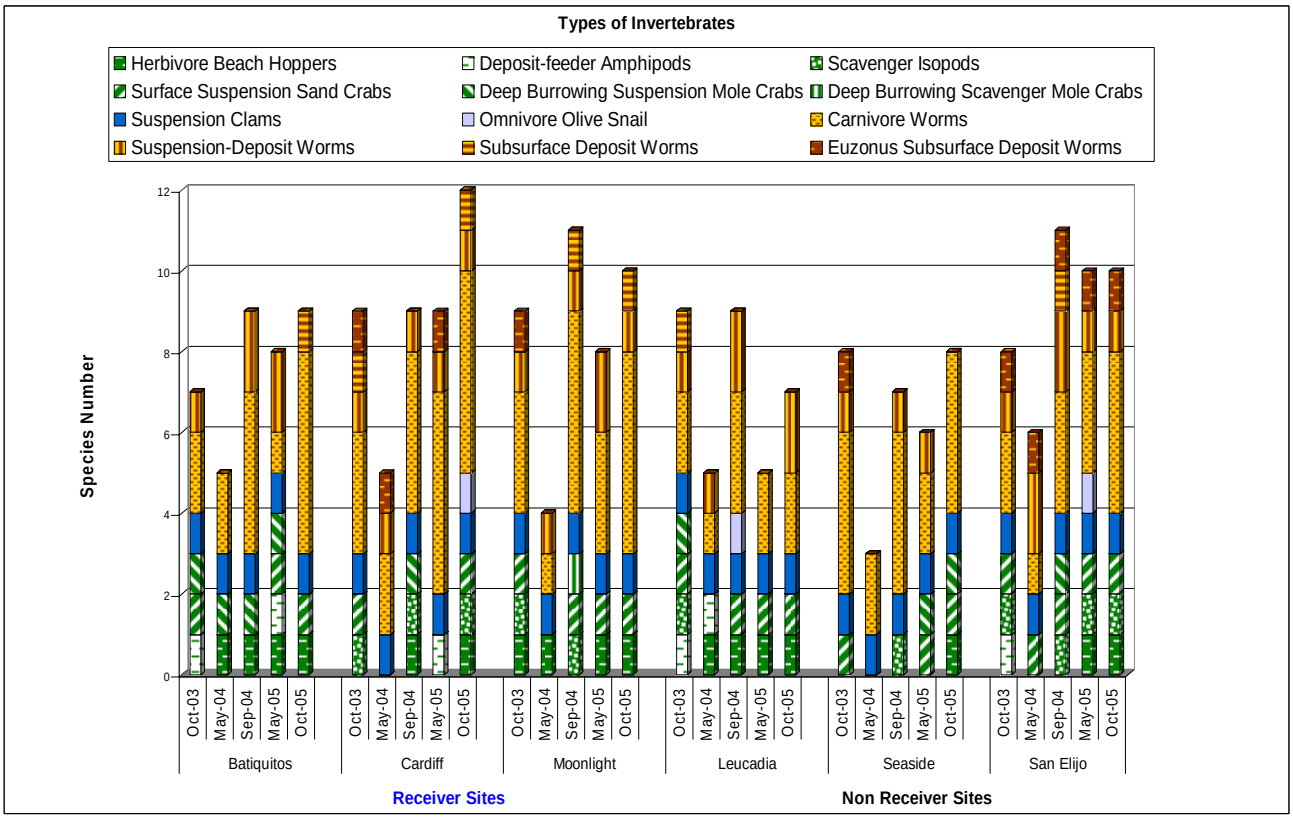


Figure 4-3. Variety of invertebrates collected at City of Encinitas receiver and non receiver beach sites, 2003-2005.

The functional developoment of the invertebrate assemblage, as indicated by the total number of taxa-food-life style categories, generally was higher at the San Elijo non receiver site and receiver sites (Figure 4-4). The San Elijo non receiver site had a similar average number of taxa-food-life style types across spring (average = 7) and summer-fall (average = 7) surveys. Cardiff and Moonlight receiver sites both had an average number of taxa-food-life style types that was lower in spring (average = 5) than summer-fall (average = 7). The functional development of invertebrate assemblages at the Batiquitos receiver site and Leucadia receiver site were somewhat less with an average of 5 to 6 taxa-food-life style types across seasons. The invertebrate assemblage was least developed at Seaside with a number of taxa-food-life style types that averaged from 3 in spring to 5 in summer-fall.

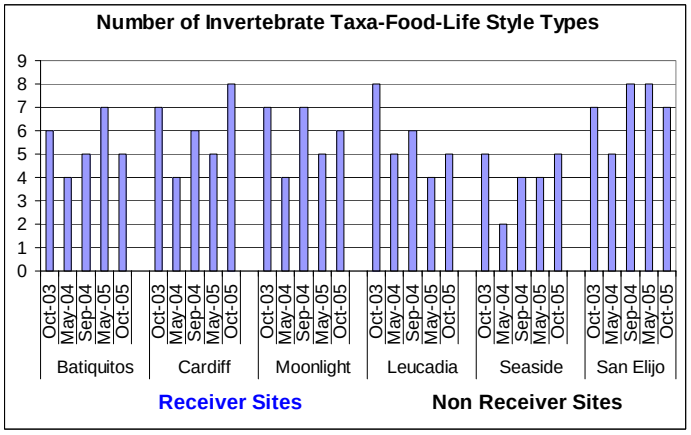


Figure 4-4. Number of invertebrate taxa-food-life style types at City of Encinitas receiver and non receiver beach sites, 2003-2005.

Mean total invertebrate density across tide zones varied among surveys (Figure 4-5). Generally, fewer invertebrates were collected during the abbreviated May 2004 survey except at Cardiff receiver and San Elijo non receiver sites. Differences in invertebrate density were site specific with no obvious distinction between receiver and non receiver sites in 2003-2005.

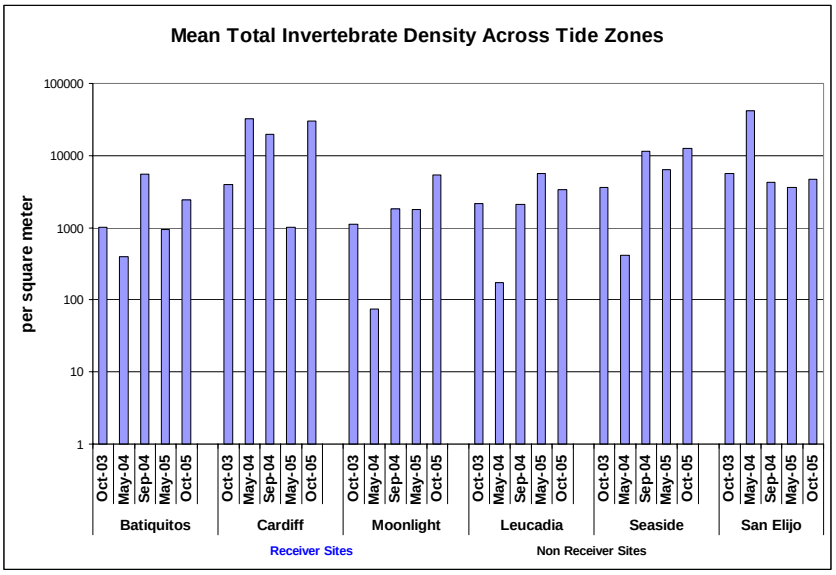


Figure 4-5. Total mean invertebrate density across tide zones by survey at City of Encinitas receiver and non receiver beach sites, 2003-2005.

Mean invertebrate density patterns by tide zone also varied without obvious differences between receiver and non receiver sites in 2003-2005 (Figure 4-6). Density patterns were broadly similar between San Elijo and Cardiff, which had relatively high densities in the upper intertidal zone on some surveys. Other beach sites generally had higher densities in the middle and lower intertidal zones compared to the upper intertidal zone, although between survey variability was greater in the upper intertidal at Batiquitos and in the middle intertidal at Seaside.

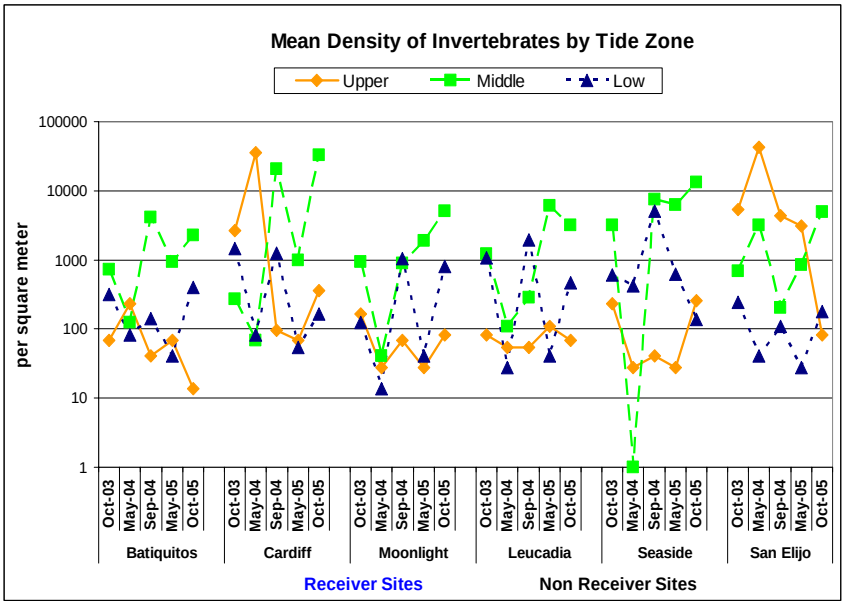


Figure 4-6. Mean invertebrate density by tide zone at City of Encinitas receiver and non receiver beach sites, 2003-2005.

The most abundant invertebrates collected in the upper intertidal included talitrid amphipods (mean densities up to 225 per m^2), *Excirolana* isopods (mean densities up to 275 per m^2), and *Euzonus* worms (mean densities up to 38,450 per m^2) (Appendix B). *Euzonus* worms were patchy in distribution, and shovel samples in dense patches highly influenced upper intertidal density estimates at Cardiff and San Elijo during some surveys. *Euzonus* were not observed in dense patches at other sites, although they did occur in low abundance at Moonlight and Seaside during the October 2003 survey.

Bean clams were common in the middle and lower intertidal zones, reaching highest mean densities in the middle intertidal (up to 29,850 per m^2). Differences in bean clam densities among surveys were site specific. Bean clam densities generally increased across surveys and between spring and summer.

Sand crabs were collected at all beach sites, although not on each survey (Table 4-2). Sand crabs recruit to southern California beaches in spring and may migrate offshore in fall with generally greater survival at beaches where sand is retained through winter (Morris et al. 1980, Dugan and Hubbard 1996). The 2003-2005 surveys were near the beginning and/or end of their seasonal occurrence period and may have contributed to variability in sand crab abundance among surveys. Sand crabs collected in 2003-2005 ranged from juveniles to adults, some with eggs, indicating functional populations developed at both receiver and non receiver sites during the study (Table 4-3). The largest sand crabs, representing overwintered females, were collected at all but the Cardiff receiver site, but were more frequently collected at Batiquitos and Moonlight receiver sites than other surveyed beach sites.

Table 4-3. Population characteristics of sand crabs collected at City of Encinitas beach sites, 2003-2005.

Beach Site	Tide Zone	Adults (> 0.5 inch wide)	Adults (> 0.375 inch wide)	Juvenile to Adults (> 0.22 inch wide)	Juveniles (< 0.2 inch wide)	Total Count
October 2003 Survey						
Batiquitos Receiver	U				18	18
	L		1 w/eggs, 1 damaged	1 no/eggs	0	3
Cardiff Receiver	U			7 no/eggs		7
	L				25	25
Moonlight Receiver	U				11	11
	L			3 no/eggs		3
Leucadia Non Receiver	U	1 w/eggs	8 w/eggs, 3 no/eggs	1 w/eggs, 10 no/eggs		23
	M		1 w/eggs, 1 damaged	1 no eggs		3
	L		1 no/eggs			1
Seaside Non Receiver	U		3 w/eggs, 1 no/eggs	8 no/eggs	6	18
	L			2 no/eggs	0	2
San Elijo Non Receiver	L			2 w/eggs	0	2
May 2004 Survey						
San Elijo Non Receiver	U				27	27
	M				50	50
	L				1	1
September 2004 Survey						
Moonlight Receiver	L	1 w/eggs			0	1
Leucadia Non Receiver	L				5	5
San Elijo Non Receiver	M				2	2
	L				2	2
May 2005						
Batiquitos Receiver	L	4 w/eggs*	15 w/eggs*, 34 no eggs*	37 no eggs*	0	90*
Moonlight Receiver	L		3 w/eggs*, 3 no eggs*	2 w/eggs* 48 no eggs*	1	1, 56*
Leucadia Non Receiver	L		1 no eggs	2 no eggs	0	3
San Elijo Non Receiver	M			14 no eggs	348	362
	L				1	1
Seaside Non Receiver	U			3 no eggs	3	6
	L			2 no eggs	1	3
October 2005						
Batiquitos Receiver	M		2 no eggs			2
Moonlight Receiver	M		1 w/eggs 1 no eggs		90	92
	L			2 no eggs	83	85
Cardiff Receiver	M				1	1
	L				1	1
Leucadia Non Receiver	Wave Wash					Observed in wave wash, but not counted
Seaside Non Receiver	L				1	1
San Elijo Non Receiver	H				2	2
	M				11	11
	L		2 w/eggs		1	3

Note: Counts based on total of 18 shovel samples per beach for all surveys, except May 2004 when 6 shovel samples were collected. * Extra sample collected from sand crab patch in wave wash.

4.2 Comparison of Marine Invertebrates Before and After Beach Nourishment

Before the SANDAG 2001 RBSP, potential receiver sites were surveyed in May 1999. Invertebrates were field counted and identified according to taxonomic categories within upper, middle, and lower intertidal zones from three sampling locations per beach at Batiquitos, Cardiff, Moonlight, and Leucadia beach sites (Appendix B, Table B-2). Additional potential receiver sites were surveyed in July 1999, and the closest sites at Leucadia, south Carlsbad, and Solana Beach, all within 3.5 km (2.2 mi) of the study area, provide representative pre-project data of species assemblages during summer (Table 4-4).

Table 4-4. List of invertebrates species at City of Encinitas and other selected beach sites before beach nourishment, May and July 1999.

Common Name	Scientific Name	Taxa-Food-Life Style	Batiquitos	Cardiff	Moonlight	Leucadia	North Leucadia	Solana Beach	South Carlsbad
			May	May	May	May	July	July	July
Crustaceans									
Beach Hopper	*Megalorchestia benedicti*	C-H					√	√	
Other Amphipods	*Eohaustorius barnardi*	C-D					√	√	√
	Rhepoxynius sp.	C-D					√		
Isopod	*Excirolana* sp.	C-SC					√		
Sand crab	*Emerita analoga*	C-S	√		√	√	√	√	√
Mollusks									
Bean Clam	*Donax gouldii*	M-S					√	√	√
Polychaete Worms									
Capitellid	*Notomastus tenuis*	W- BD					√		√
Lumbrinerid	*Scoletoma* sp.	W-C						√	
Nephtyid	*Nephtys californiensis*	W-C					√	√	
Ophelid	*Euzonus mucronata*	W-BD high tide					√		
Orbiniid	*Scoloplos acmeceps*	W-BD						√	
Spionid	*Dispio uncinata*	W-SD					√	√	√
Spionid	*Scolelepis bullibranchiata*	W-SD					√		
Unidentified high tide zone					√	√			
Unidentified mid-low tide zone			√		√	√			
Nemertean Worms									
Ribbon Worm	*Paranemertes californica*	W-C					√	√	√
Total Number of Species			?	0	?	?	12	9	6
Number of taxa-Food-Life Style Types			2-4	0	3-5	3-5	8	7	6
Grand Total Number of Species			14						

Source: MEC 2000 for May 1999 data; July 1999 data from laboratory analysis of preserved samples.

Notes: North Leucadia was surveyed at Leucadia receiver site, approximately 1,000 feet north of Leucadia non receiver site.
C = Crustacean, M = Mollusk, W = Worm, C = carnivore, BD = subsurface deposit-feeder, D = detritus/deposit-feeder, H = herbivore, O = omnivore, S = suspension feeder, SC = scavenger, SD = suspension-deposit- feeder. Number of taxa-food-life style categories in May 1999 estimated based on potential categories associated with sand crabs (suspension-feeders), potential worms in high tide zone (subsurface deposit high tide), and potential worms in other tide zones (suspension-deposit, subsurface deposit, carnivores).

Invertebrate assemblages were far less developed in spring than summer prior to the SANDAG 2001 RBSP (Table 4-4). Although total numbers of species at beach sites in May 1999 are unknown since invertebrates were field counted without aid of a microscope, sand crabs and worms were the only types of invertebrates collected at most surveyed sites (MEC 2000). In contrast, a mix of beach hoppers, other amphipods, sand crabs, bean clams, polychaete worms, and ribbon worms were collected in July 1999 similar to what was seen during the 2003-2005 study. The most notable reconnaissance result was the absence of marine invertebrates at Cardiff which was extensively covered with cobbles in 1999. Although not surveyed, it is expected that a similar condition occurred at Seaside due to cobble cover (Section 3-2).

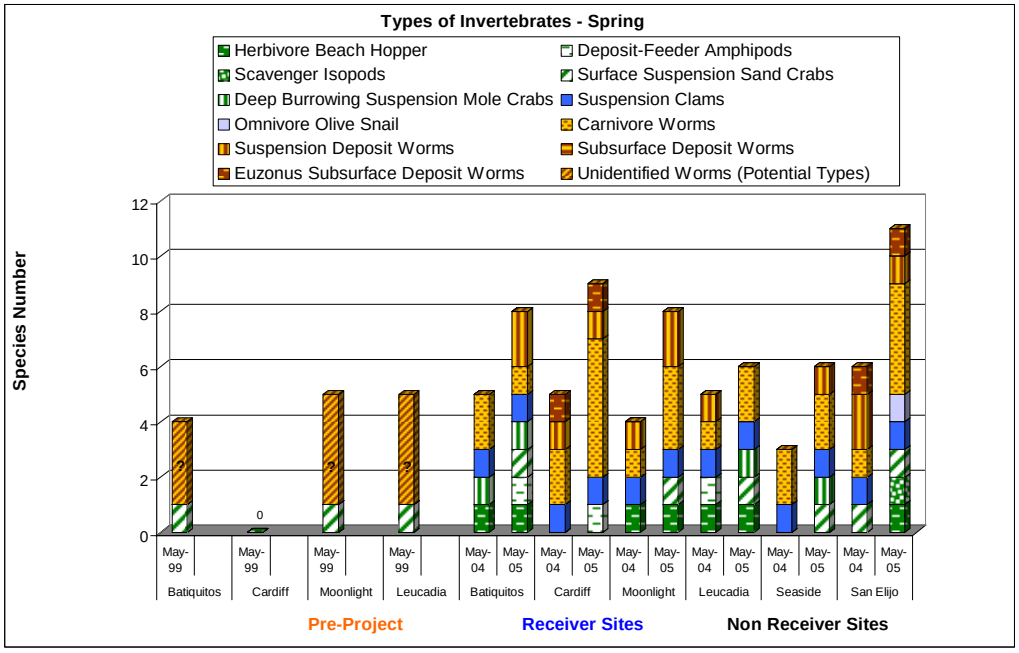
Similarly, the number of taxa-food-life style types potentially represented by invertebrates was less in May (2-5) than July 1999 (6-8). The number of taxa-food-life style types was estimated for May 1999 based on the feeding type of sand crabs (suspension) and potential feeding-life style types of worms (carnivore, suspension-deposit, subsurface deposit, *Euzonus* subsurface deposit high tide zone). The seasonal difference in invertebrate assemblages in 1999 likely related the erosive condition in spring and greater sand development in summer. Average sand depths of < 30 cm (< 1 ft) were measured in one or more tide zones in May; whereas, average depths were > 45 to < 90 cm (> 1 ½ to < 3 ft) in July 1999 (Section 3.2, Table 3-1).

Spring species assemblages were more developed at receiver sites after beach nourishment, suggesting invertebrate assemblages were able to develop earlier in the season with more persistent sand habitat (Figure 4-7). May 2004 and 2005 collections at Cardiff included bean clams, a variety of worms, and/or amphipods in contrast to no animals in May 1999 samples. Batiquitos and Moonlight spring 2004 and 2005 samples included amphipods, bean clams, sand crabs, and worms. Average sand depths at receiver sites during May 2004 and 2005 ranged deeper, from > 30 to > 122 cm (> 1 to > 4 ft) across tidal zones, compared to the shallower sand depths in May 1999.

Spring species assemblages also were more developed at the Leucadia and Seaside non receiver sites compared to pre-project conditions, presumably due to indirect sand nourishment (Figure 4-7). Two types of invertebrates (sand crabs, worms) were collected at Leucadia in May 1999 when average sand depths were < 30 cm (< 1 ft) across tidal zones. Beach hoppers, other amphipods, sand crabs, other mole crabs, bean clams, and/or worms were collected at Leucadia in May 2004 and 2005 when average depths were > 45 to > 122 cm (> 1 ½ to > 4 ft). Although the invertebrate assemblage at Seaside was relatively poorly developed compared to other sites in May 2004 and 2005, the occurrence of sand crabs, other mole crabs, bean clams, and worms was a substantial improvement over expected pre-project conditions when cobble would have limited invertebrate occurrence similar to that at Cardiff.

Invertebrate species assemblages during summer-fall were relatively similar before and after beach nourishment, except at Cardiff and Seaside, which changed from cobble to sand and invertebrate development was possible (Figure 4-8). In summer 1999, a total of 6 to 12 species was collected at beach sites in the vicinity of the study area. Average summer sand depths in 1999 at sites in the vicinity of the study area ranged from 45 to 90 cm (1 ½ to 3 ft). In summer-fall 2003-2005, a total of 6 to 12 species was collected at receiver and non receiver sites, and average sand depths ranged from approximately 30 to > 122 cm (1 to > 4 ft).

The invertebrate assemblage at San Elijo was not surveyed prior to the SANDAG 2001 RBSP, but had a relatively well developed assemblage across seasons in 2003-2005 with a combination of beach hoppers, other amphipods, sand crabs, isopods, bean clams, and a variety of worms.



Notes: Worms were not identified in May 1999 (before nourishment period); a maximum potential of 3-4 feeding types (carnivore, suspension deposit, subsurface deposit, subsurface deposit high tide zone) were graphed with a "?"added to the worm bar to emphasize that the number of species was not analyzed.

Figure 4-7. Comparison of invertebrates during spring at City of Encinitas receiver and non receiver beach sites before and after beach nourishment.

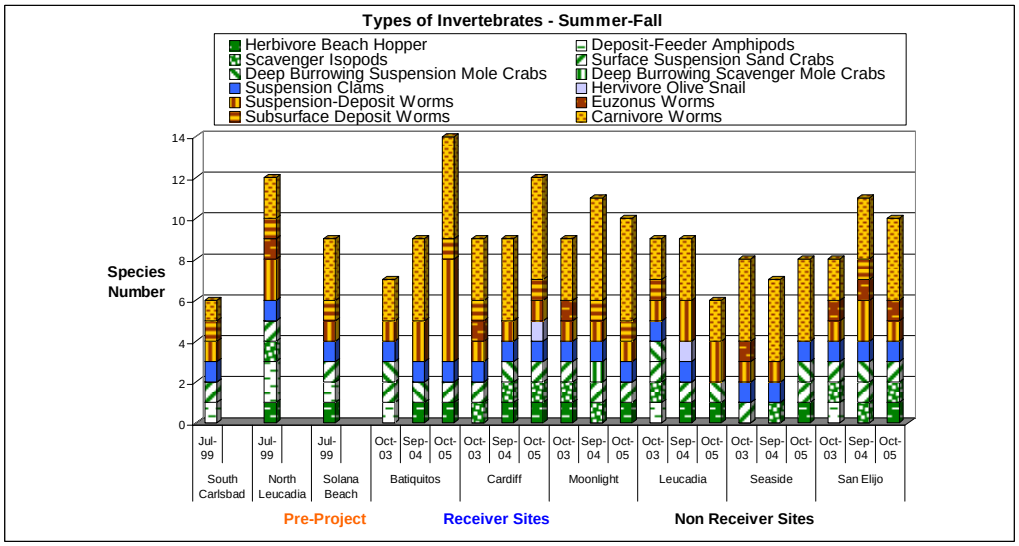


Figure 4-8. Comparison of invertebrates during summer-fall at City of Encinitas receiver and non receiver beach sites before and after beach nourishment.

4.3 Summary of Marine Invertebrate Resource Use of Sandy Beach Habitat

SANDAG Project influence on invertebrate assemblages was substantial at beach sites where sand nourishment resulted in a change in physical habitat characteristics from cobble to sand.

No invertebrates were collected in spring 1999 at Cardiff; whereas, 5 to 10 species representing two to three types of invertebrates (bean clams, worms, amphipods) were collected in spring 2004 and 2005, and 9 to 12 species representing several types of invertebrates (amphipods, bean clams, isopods, sand crabs, other mole crabs, worms) were collected in summer-fall 2003 through 2005. Although Seaside was not surveyed prior to the SANDAG 2001 RBSP, no invertebrates would have been expected due to extensive cobble cover similar to conditions surveyed at Cardiff. During 2003-2005, assemblages at Seaside seasonally ranged from 3 to 6 species representing four types of invertebrates (bean clams, worms, sand crabs, other mole crabs) in spring 2004 and 2005 to 8 species representing several types of invertebrates (bean clams and/or Pismo clams, isopods, sand crabs, and worms) in summer-fall 2003-2005. Average sand depths in 2003-2005 ranged from > 60 to > 122 cm (>2 to > 4 ft) across tide zones and seasons at Cardiff, but ranged from < 30 to > 122 cm (< 1 to > 4 ft) across tide zones with substantial seasonal variability at Seaside.

The SANDAG 2001 RBSP appeared to have a positive influence on invertebrate assemblages at Batiquitos and Moonlight receiver sites and the Leucadia non receiver site where indirect sand nourishment was detected. Post-project habitat changes at these sites involved a deepening of sand depths across seasons. A greater variety of invertebrates was collected earlier in the season after beach nourishment. For example, two types of invertebrates (sand crabs and worms) were collected at Batiquitos, Moonlight, and Leucadia in spring 1999. In contrast, four types of invertebrates (amphipods, bean clams, sand crabs, other mole crabs, and worms) representing 5 to 8 species were collected at Batiquitos in spring 2004 and 2005, and four types of invertebrates (amphipods, bean clams, sand crabs, and worms) representing 4 to 8 species at Moonlight and 5 to 6 species at Leucadia were collected in spring 2004.

Post-project summer-fall assemblages were characterized by several types of invertebrates (e.g., amphipods, bean clams, sand crabs and/or other mole crabs, and worms) representing 7-9 species at Batiquitos, 9-12 species at Moonlight, and 9-10 species at Leucadia. These post-project summer-fall species numbers were within the range of 6-12 species surveyed in summer 1999 at other sites in the vicinity of the study area.

Invertebrate assemblages at the San Elijo non receiver site were relatively well developed with three to 6 types of invertebrates (bean clams, sand crabs, amphipods, isopods, olive snails, worms) represented by 6 to 10 species in spring 2004 and 2005 and several types of invertebrates (amphipods, bean clams, isopods, sand crabs and/or other mole crabs, and worms) represented by 8-11 species in summer-fall 2003-2005. San Elijo was not surveyed prior to the SANDAG Project; however, average sand depths in 2003-2005 did not indicate any obvious influence from the SANDAG 2001 RBSP. The relatively well developed invertebrate assemblage across seasons in 2003-2005 at San Elijo may have resulted from relatively stable sand depths, which ranged from > 30 to < 90 cm (> 1 to < 3 ft) across tide zones and seasons.

Study results demonstrated that physical habitat characteristics influenced the development of invertebrate assemblages. Beach nourishment at sites that resulted in a change of habitat from cobble to sand (Cardiff, Seaside) provided habitat for invertebrates to develop. Beach nourishment resulting in deeper sand depths across seasons appeared to promote development of invertebrate assemblages earlier in the season. Invertebrate assemblages also developed earlier in the season where sand depths were relatively stable across seasons. Generally, more species of invertebrates occurred at sites where variability in sand depths and presumably disturbance was less. Several results associated with different beach sites and surveys indicated few species of invertebrates occurred when average sand depths in one or more tide zones were < 30 cm (< 1 ft).

5.0 BIRD USE OF SANDY BEACH HABITAT

The 2003-2005 bird survey results are presented in Section 5.1. These results are compared with available data prior to the SANDAG 2001 RBSP in Section 5.2. Bird use of beach habitat is summarized in Section 5.3.

5.1 Comparison of Bird Use of Sandy Beach Habitat at City of Encinitas Receiver and Non Receiver Sites After Beach Nourishment, 2003-2005

Birds were observed during both high and low tides during mild environmental conditions (Section 2.3). Cloud cover ranged from 0 to 100 percent, and winds generally were less than 10 miles per hour. Temperatures ranged from 17 to 25 degrees Centigrade (63 to 77 degrees Fahrenheit). Tide elevations during surveys ranged from +1.1 to +1.7 m (+3.5 to +5.7 ft) MLLW (high tides) and -0.46 to +0.6 m (-1.5 to +1.9 ft) MLLW (low tides), except for a higher low of 0.5 to +0.7 m (+1.7 to +2.4) at San Elijo during the September 2004 survey.

Over 3,800 birds were counted during October 2003 through October 2005 surveys (Table 5-1). Slightly more birds were observed during high (2,035, 53%) than low (1,792, 47%) tides. Birds were three times more abundant (mean abundance = 87) during late summer-fall than spring (mean abundance = 28) surveys.

More birds were counted across tide condition at sites that received sand nourishment than non receiver sites (Figure 5-1). Total bird counts across all surveys ranged from 820 to 1,169 at receiver sites and from 166 to 371 at non receiver sites (Table 5-1). However, patterns of bird use varied among surveys depending on beach site. Generally, birds were more abundant across seasons and tide conditions at receiver sites; whereas, birds were more abundant during summer surveys on low tides at non receiver sites (Figure 5-2, Table 5-1)

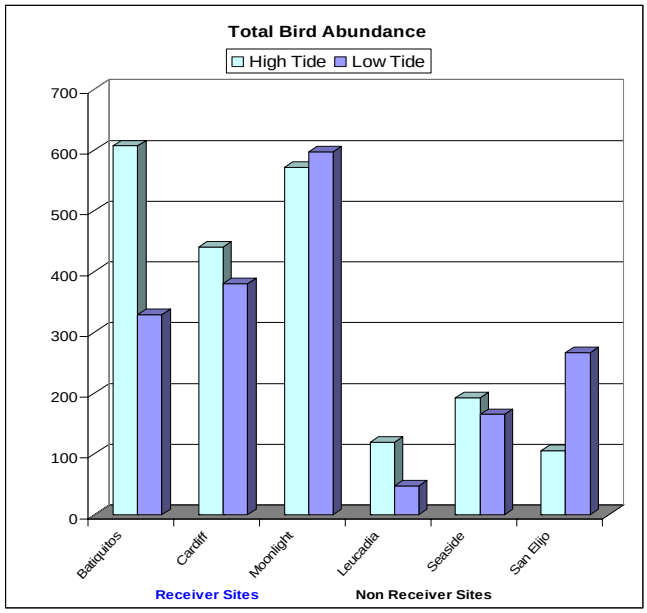
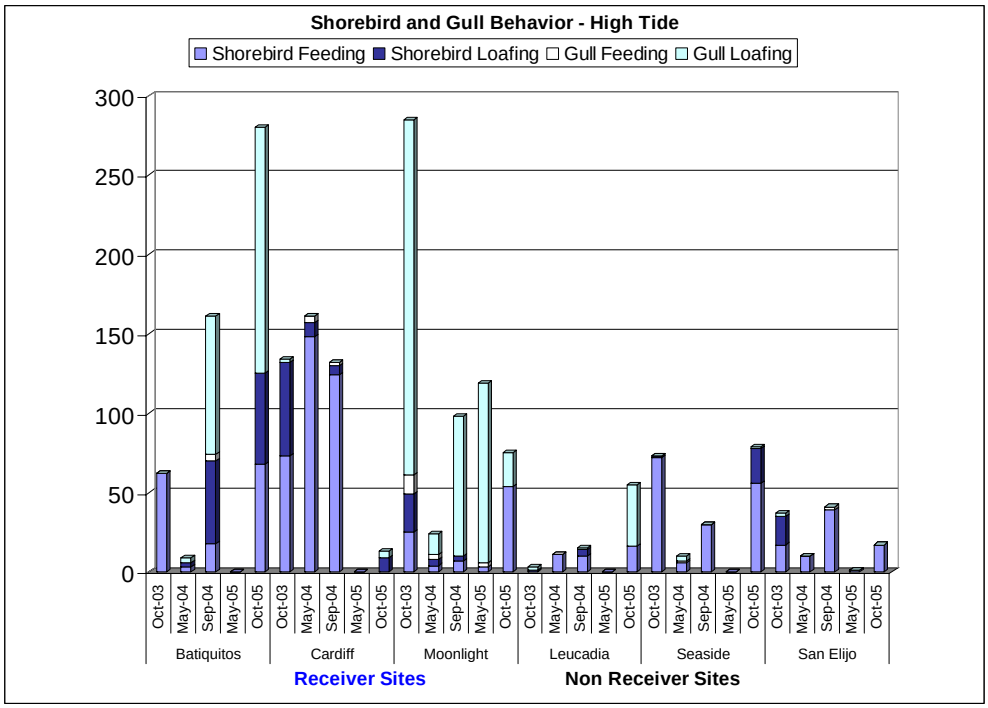


Figure 5-1. Total number of birds by tide condition at City of Encinitas receiver and non receiver beach sites, 2003-2005.

Shorebirds and gulls were the most abundant types of birds observed (Table 5-1). Terns were mainly observed at Batiqutios and Cardiff beach sites, which were near Batiquitos and San Elijo Lagoons and were observed once at the Leucadia non receiver site located downcoast of Batiquitos Lagoon. Other (mainly terrestrial) birds sometimes were observed in relatively low abundance at Cardiff, Moonlight, and San Elijo beach sites.



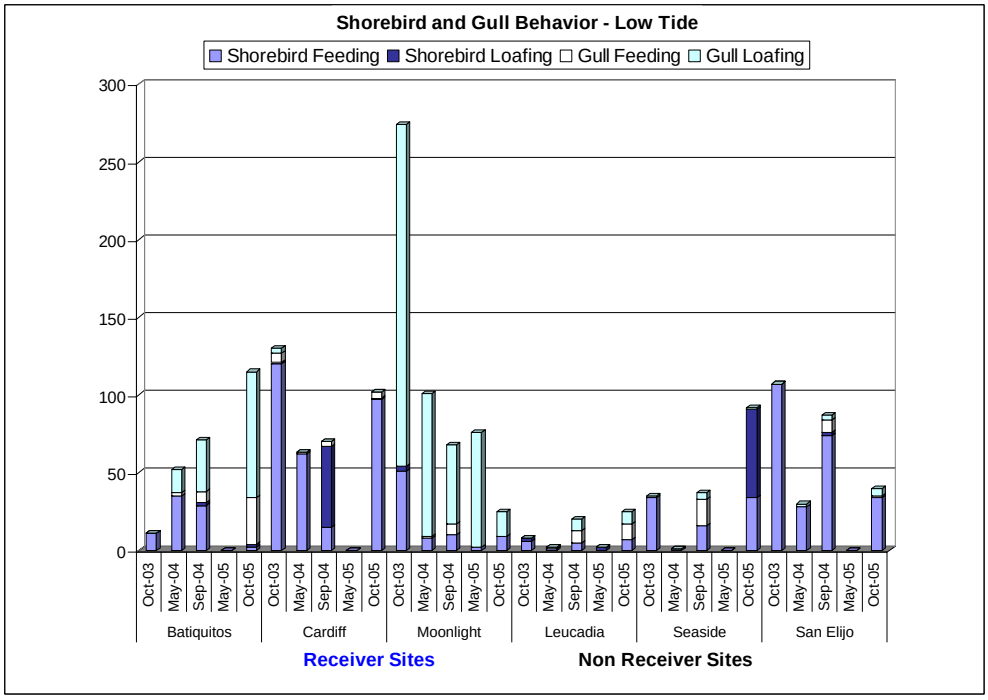


Figure 5-2. Abundance of different types of birds by survey and tide condition at City of Encinitas receiver and non receiver beach sites, 2003-2005.

Table 5-1. Summary of bird abundance at City of Encinitas receiver and non receiver beach sites, 2000-2005.

Bird Type	Tide	SANDAG Receiver Sites			Non receiver Sites			Grand Total
		Batiquitos	Cardiff	Moonlight	Leucadia	San Elijo	Seaside	
October 2003								
Shorebirds	High	62	132	49	1	35	73	352
	Low	11	121	54	8	107	34	335
Gulls	High	0	2	236	2	2	0	242
	Low	0	9	220	0	0	1	230
Other Birds	High	0	0	0	0	0	0	0
	Low	0	0	1	0	0	0	1
Total	High	62	134	285	3	37	73	594
	Low	11	130	275	8	107	35	566
May 2004								
Shorebirds	High	3	157	8	11	10	6	195
	Low	35	62	8	1	28	1	135
Gulls	High	3	4	16	0	0	4	27
	Low	17	1	93	1	2	0	114
Other Birds	High	0	0	0	0	0	0	0
	Low	0	2	9	0	1	0	12
Total	High	6	161	24	11	10	10	222
	Low	52	65	110	2	31	1	261
September 2004								
Shorebirds	High	70	130	10	14	39	30	293
	Low	31	67	10	5	76	16	205
Gulls	High	91	2	88	1	2	0	184
	Low	40	3	58	15	11	21	148
Terns	High	44	0	0	0	0	0	44
	Low	78	12	0	0	0	0	90
Other Birds	High	0	0	0	0	0	0	0
	Low	0	1	0	0	0	0	1
Total	High	205	132	98	15	41	30	521
	Low	149	83	68	20	87	37	444
May 2005								
Shorebirds	High	0	0	2	2	0	0	4
	Low	0	0	3	0	1	0	4
Gulls	High	0	0	74	0	0	0	74
	Low	0	0	116	0	0	0	116
Total	High	0	0	76	2	0	0	78
	Low	0	0	119	0	1	0	120
October 2005								
Shorebirds	High	125	9	54	16	17	78	299
	Low	4	97	9	7	34	91	242
Gulls	High	155	4	21	39	0	1	220
	Low	111	5	16	18	6	1	157
Terns	High	37	0	0	33	0	0	70
	Low	0	0	0	0	0	0	0
Other Birds	High	17	0	14	0	0	0	31
	Low	2	0	0	0	0	0	2
Total	High	334	13	89	88	17	79	620
	Low	117	102	25	25	40	92	401

Table 5-1 (Continued)

Summaries	Tide	SANDAG Receiver Sites			Non receiver Sites			Grand Total
		Batiquitos	Cardiff	Moonlight	Leucadia	San Elijo	Seaside	
Total Summer-Fall 03	High	62	134	285	3	37	73	594
	Low	11	130	275	8	107	35	566
Total Summer-Fall 04	High	205	132	98	15	41	30	521
	Low	149	83	68	20	87	37	444
Total Summer-Fall 05	High	334	13	89	88	17	79	620
	Low	117	102	25	25	40	92	401
Total Spring 04	High	6	161	24	11	10	10	222
	Low	52	65	110	2	31	1	261
Total Spring 05	High	0	0	76	2	0	0	78
	Low	0	0	119	0	1	0	120
Mean Total Spring	High	3	81	50	7	5	5	28
	Low	26	33	115	1	16	1	
Mean Total Summer-Fall	High	200	93	157	35	32	61	87
	Low	92	105	123	18	78	55	
Grand Total	High	607	440	572	119	105	192	2035
	Low	329	380	597	55	266	165	1792
Overall Total		936	820	1169	166	371	357	3819

Beach use by people and dogs appeared to have only limited influence on 2003-2005 bird survey results (Table 5-2). Generally, beach use by people and dogs was low. Moderate use (10-30 people) was observed on a few occasions, but there was no clear pattern of bird abundance associated with higher human use within the range observed during beach surveys. One possible exception was the October 2005 low tide survey at Moonlight Beach when 25 birds were observed, but 89 birds were observed during high tide when human beach use was less on that date. Surveys were conducted during Monday through Friday and not on weekends, likely contributing to the relatively low human influence during most surveys.

Moonlight, October 2005 low tide

People walking past foraging marbled godwits at San Elijo Lagoon, October 2005 low tide

Table 5-2 . Comparison between bird use and physical beach characteristics and beach use during 2003-2005 surveys.

Beach Site	Survey	High Tide		Low Tide	
		Total Birds	Beach Use	Total Birds	Beach Use
Batiquitos Receiver	Oct 2003	62	few w	11	few w
	May 2004	6		52	few w
	Sep 2004	205	few w, s	149	1 d, few w
	May 2005	0	few f, w	0	classroom*
	Oct 2005	334	1f, 2r, 1w	117	10w, 10sb *
Cardiff Receiver	Oct 2003	134	none	130	few w
	May 2004	161		65	few w
	Sep 2004	132	few	83	3 d, few w
	May 2005	0	few w	0	few w, equipment use
	Oct 2005	13	1d, 3w	102	3d, 5w
Moonlight Receiver	Oct 2003	285	few w	275	few w
	May 2004	24		110	few w
	Sep 2004	98	1 f, few w	68	d, >10 w*
	May 2005	76	few s, w	119	few w
	Oct 2005	89	10s, 10w*	25	25 w/sb*
Leucadia Non Receiver	Oct 2003	3	nd	8	few w
	May 2004	11		2	few w
	Sep 2004	15	few w	20	few w
	May 2005	2	few w	0	few w
	Oct 2005	88	2r, 10s	25	30 w/s*
San Elijo Non Receiver	Oct 2003	37	few w	107	few w
	May 2004	10		31	few w
	Sep 2004	41	few w, s	87	few w
	May 2005	0	few w, sb	1	few w
	Oct 2005	17	1d, 4w, 5s	40	20w*
Seaside Non Receiver	Oct 2003	73	none	35	d, few w
	May 2004	10		1	few w
	Sep 2004	30	none	37	few w
	May 2005	0	few w	0	few w
	Oct 2005	79	2d, 2w	92	2d, 5w

*moderate use (10-30 people observed); d = dog, f = fisherman, r = runner, s = surfer, sb = sunbather, w = walker

A total of 28 species of birds were identified across beach sites during 2003-2005 surveys (Table 5-3). A total of 18 to 20 bird species were identified at receiver sites. Fewer species of birds were seen at the Leucadia (11), Seaside (12), and San Elijo (15) non receiver sites. Shorebirds accounted for most bird species (16), followed by gulls (6), other birds (5), and terns (3) (Figure 5-3).

Table 5-3. Summary of number of bird species by tide condition at City of Encinitas receiver and non receiver beach sites, 2003-2005.

Bird Type	Tide	SANDAG Receiver Sites			Non receiver Sites			Grand Total
		Batiquitos	Cardiff	Moonlight	Leucadia	Seaside	San Elijo	
October 2003								
Shorebirds	High	3	7	7	1	5	6	13
	Low	1	4	4	3	2	3	6
Gulls	High	0	1	4	1	0	1	4
	Low	0	3	4	0	1	0	4
Terns	High	0	0	0	0	0	0	0
	Low	0	0	0	0	0	0	0
Other Birds	High	0	0	1	0	0	0	1
	Low	0	0	1	0	0	0	1
Total	High	3	8	12	2	5	7	18
	Low	1	7	9	3	3	3	11
May 2004								
Shorebirds	High	2	2	1	2	1	2	5
	Low	5	4	2	1	1	3	7
Gulls	High	3	2	2	0	3	0	3
	Low	6	1	5	1	0	1	6
Terns	High	0	0	0	0	0	0	0
	Low	0	0	0	0	0	0	0
Other Birds	High	0	0	0	0	0	0	0
	Low	0	2	3	0	0	1	3
Total	High	5	4	3	2	4	2	8
	Low	11	7	10	2	1	5	16
September 2004								
Shorebirds	High	6	7	4	6	2	8	11
	Low	4	5	3	3	3	5	8
Gulls	High	3	2	5	1	0	1	5
	Low	3	1	4	1	2	4	4
Terns	High	2	0	0	0	0	0	2
	Low	3	1	0	0	0	0	3
Other Birds	High	0	0	0	0	0	0	0
	Low	0	1	0	0	0	0	1
Total	High	11	9	9	7	2	9	18
	Low	10	8	7	4	5	9	16
May 2005								
Shorebirds	High	0	0	1	1	0	0	2
	Low	0	0	1	0	0	1	0
Gulls	High	0	0	3	0	0	0	3
	Low	0	0	4	0	0	0	4
Total	High	0	0	4	1	0	0	5
	Low	0	0	5	0	0	1	4

Table 5-3 (Continued)

Bird Type	Tide	SANDAG Receiver Sites			Non receiver Sites			Grand Total
		Batiquitos	Cardiff	Moonlight	Leucadia	Seaside	San Elijo	
October 2005								
Shorebirds	High	5	2	7	5	2	6	10
	Low	1	4	3	2	1	6	6
Gulls	High	3	1	2	2	1	0	3
	Low	2	2	2	2	1	2	3
Terns	High	1	0	0	1	0	0	1
	Low	0	0	0	0	0	0	0
Other Birds	High	2	1	1	0	0	0	3
	Low	1	0	0	0	0	0	1
Total	High	11	4	10	8	3	6	17
	Low	4	6	5	4	1	8	10
Grand Total	High	15	13	17	12	9	14	26
	Low	15	13	15	6	7	12	23
Overall Total		20	18	19	11	12	15	28

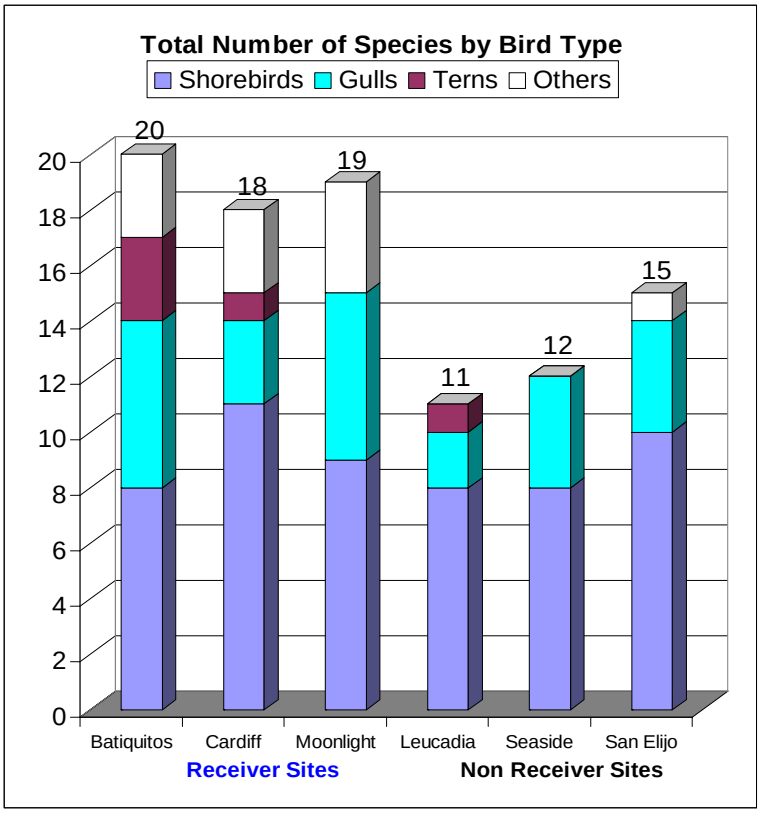


Figure 5-3. Total number of bird species observed at City of Encinitas receiver and non receiver beach sites, 2003-2005.

Shorebirds occurring at all or most beach sites during spring and summer-fall surveys included marbled godwit (*Limosa fedoa*), sanderling (*Calidris alba*), willet (*Catoptrophorus semipalmatus*), and whimbrel (*Numenius phaeopus*) (Table 5-4). Marbled godwit and sanderling were most abundant. Other shorebird species were observed at fewer beach sites and in relatively lower numbers. Slightly more shorebirds were observed during high than low tides, except at San Elijo where more were observed during low tides. The total number of shorebirds across surveys was similar among two of the receiver (Batiquitos, Moonlight) and non receiver sites (San Elijo, and Seaside). Shorebird use was higher across high and low tides at the Cardiff receiver site and substantially lower at the Leucadia non receiver site than other beach sites.

Marbled godwit and bean clams at Leucadia

The occurrence of the threatened western snowy plover at Batiquitos, Cardiff, and Seaside beach sites was notable; this species is known to nest at Batquitos and San Elijo Lagoons. The Batiquitos beach site is adjacent to Batiquitos Lagoon, and the Cardiff and Seaside beach sites are adjacent to San Elijo Lagoon. Snowy plovers were observed foraging and loafing at those beach sites adjacent to the lagoons.

Western snowy plover at Batiquitos

The variety of shorebirds included species with different feeding strategies. Most shorebirds were observed foraging regardless of tide condition, although relatively more shorebirds loafed on high tides than low tides (Figure 5-4). Birds that feed at the surface or probe to shallow depths included a variety of sandpipers, sanderlings, plovers, and turnstones. Birds with long bills included marbled godwit, short-billed dowitcher, willet, and whimbrel. Both long and short-billed shorebirds were observed at all beach sites, indicating that a variety of forage prey developed at these sites. However, more long billed birds were counted at receiver sites and San Elijo non receiver site than at Leucadia and Seaside.

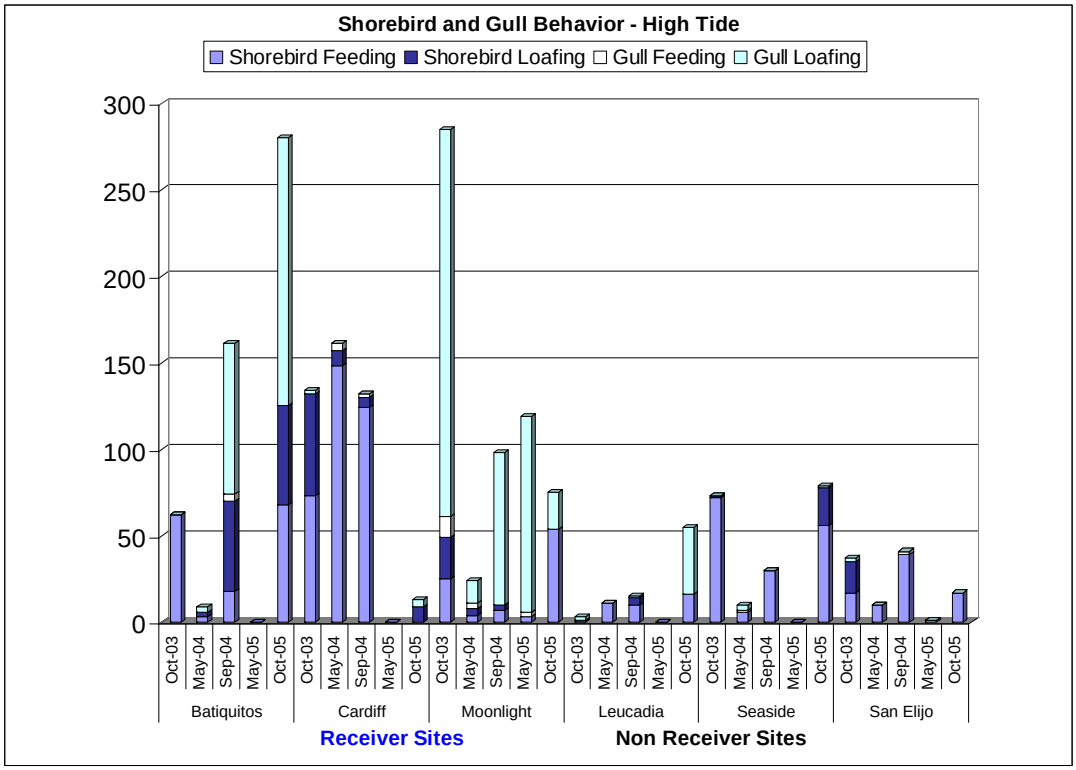
Least sandpipers foraging at Seaside

Willet at Cardiff

Table 5-4. Shorebird species and abundance at City of Encinitas receiver and non receiver beach sites, 2003-2005.

Common Name	Scientific Name	Survey	SANDAG Receiver Sites			Non receiver Sites		
			Batiquitos	Cardiff	Moonlight	Leucadia	San Elijo	Seaside
Black turnstone	*Arenaria melanocephala*	10/03 9/04 10/05	0 0 0	0 0 0	0 0 0	0 0 0	6H 7H 4H	0 0 0
Ruddy turnstone	*Arenaria interpres*	10/03 9/04 5/05	0 0 0	0 2H 0	0 0 0	0 0 2H	1H 1L 0	0 0 0
Black-bellied plover	*Pluvialis squatarola*	10/03 5/04 9/04 5/05 10/05	0 0 0 0 0	1L 2L 1L 0 2L	1H, 1L 1L 1H, 4L 2H 7H, 5L	0 0 3H, 2L 0 1H	0 0 7L 0 1H, 4L	0 0 0 0 0
Semi-palmated plover	*Charadrius semipalmatus*	10/05	0	0	1H	5H	1H, 1L	0
Snowy plover	*Charadrius alexandrinus*	10/03 5/04 9/04 10/05	0 2L 30H, 7L 38H	3H 0 6H 5H	0 0 0 0	0 0 0 0	0 0 0 0	3H 0 0 0
Kildeer	*Charadrius vociferus*	10/05	1H	0	0	0	0	0
Dunlin	*Calidris alpina*	10/03	0	0	0	0	0	1H
Least sandpiper	*Calidris minutilla*	10/03 9/04 10/05	0 0 21H	32H 0 4H	0 0 2H	0 0	13H 1H 3L	5H 0 8H
Red Knot	*Calidris canutus*	10/03	0	1H	0	0	0	0
Sanderling	*Calidris alba*	10/03 5/04 9/04 10/05	57H 2H, 29L 35H, 20L 54H	80H, 115L 156H, 39L 116H, 57L 28L	19H, 37L 8H 5H 26H	0 0 4H 4H	62L 9H 15H, 6L 8H, 10L	56H, 33L 0 29H, 14L 70H, 91L
Spotted sandpiper	*Actitis macularia*	10/03 9/04	0 0	0 0	2H 0	0 1H	0 0	0 0
Western sandpiper	*Calidris mauri*	10/03 5/04 9/04 10/05	0 0 1H 0	12H 20L 0 0	2H 0 0 0	0 10H 0 5H	12H 0 2H 0	8H 0 0 0
Marbled godwit	*Limosa fedoa*	10/03 5/04 9/04 10/05	4H 1H, 2L 1H, 3L 11H, 2L	3H,3L 0 3H, 4L 12L	14H, 7L 7L 2H, 4L 11H, 2L	1L 1L 1H 2L	2H, 37L 22L 11H, 56L 1H, 12L	0 0 1L 0
Short-billed dowitcher	*Limnodromus griseus*	9/04	0	1H	0	0	1H	0
Willet	*Catoptrophorus semipalmatus*	10/03 5/04 9/04 5/05 10/05	1H, 11L 1L 2H, 1L 0 2L	0 1L 1H, 4L 0 55L	6H,9L 0 2H, 2L 3L 5H, 2L	1H, 6L 1H 2H, 2L 0 1H, 5 L	8L 1H, 5L 1H, 6L 1L 4L	1L 6H, 1L 1H 0 0
Whimbrel	*Numenius phaeopus*	10/03 5/04 9/04 10/05	0 1L 1H 0	1H, 2L 1H 1H, 1L 0	5H 0 0 2H	1L 0 3H, 1L 0	1H 1L 1H 2H	0 0 1L 0
Total Abundance		High Tide	260	428	123	44	101	187
		Low Tide	81	347	84	21	246	142
		Grand Total	341	775	207	65	347	329

Note: H = high tide, L = low tide



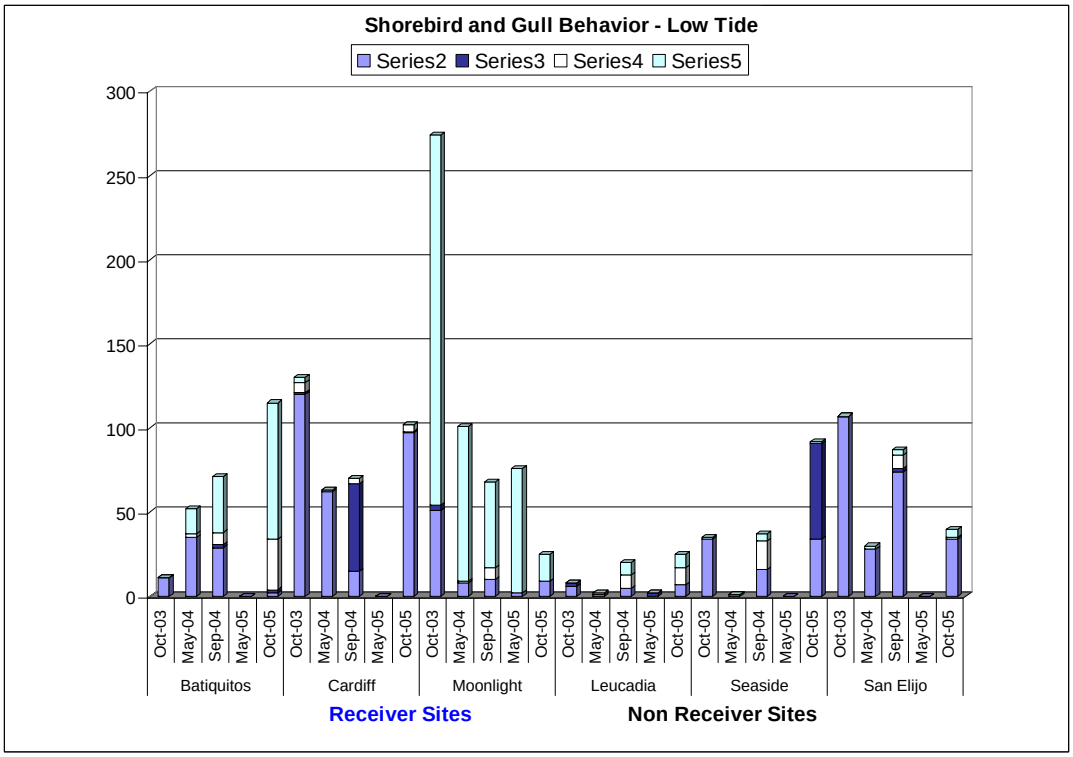


Figure 5-4. Bird behavior across tide conditions at City of Encinitas receiver and non receiver beach sites, 2003-2005.

Six species of gulls were observed during 2003-2005 surveys. The most abundant species was western gull (*Larus occidentalis*), followed in decreasing order of abundance by Heerman's (*Larus heermanni*), ring-billed (*Larus delawarensis*), and California (*Larus californicus*) gulls (Table 5-5). Herring (*Larus argentatus*) and mew (*Larus canus*) gulls had infrequent occurrence. Gulls were most abundant at Batiquitos and Moonlight receiver sites, and occurred in relatively lower abundance at other beach sites. Gulls usually were observed close to the entrance jetty to Batuquitos Lagoon; however, they sometimes were within or outside the boundaries of the survey area, which contributed to between survey variability in gull abundance at this site. Most gulls were seen loafing on the beach (Figure 5-4), although several were observed foraging at low tide and/or picking through kelp wrack. Many of the gulls at Moonlight Beach were seen congregating in and/or near the outlet of Cottonwood Creek.

Gulls and terns loafing near Batiquitos

Gulls in and near Cottonwood Creek outflow

Table 5-5. Species and abundance of gulls observed at City of Encinitas receiver and non receiver beach sites, 2003-2005.

Common Name	Scientific Name	Survey	SANDAG Receiver Sites			Non receiver Sites		
			Batiquitos	Cardiff	Moonlight	Leucadia	San Elijo	Seaside
California gull	*Larus californicus*	10/03	0	2H, 2L	21H, 45L	0	0	0
		5/04	1H, 6L	1H	41L	0	0	0
		9/04	13H, 2L	0	7H	0	0	2H
		5/05	0	0	12H, 12L	0	1L	0
		10/05	28H	4L	2H, 2 L	8H,1L	2L	0
Heerman's gull	*Larus heermanni*	10/03	0	0	50H, 35L	0	0	0
		5/04	1H, 1L	0	3H, 1L	0	0	0
		9/04	50H, 19L	0	17H, 29L	0	0	1H
		5/05	0	0	16H, 17L	0	1H	14L
		10/05	21H, 6L	0	0	0	0	0
Herring gull	*Larus argentatus*	5/04	1L	0	0	0	0	0
		5/05	0	0	1L	0	0	0
Mew gull	*Larus canus*	5/04	1L	0	6L	0	0	0
		9/04	0	0	1H, 3L	0	0	0
Ring-billed gull	*Larus delawarensis*	10/03	0	4L	63H, 80L	0	2H	1L
		5/04	1L	0	4L	0	0	0
		9/04	0	1H	7H, 4L	0	1H, 3L	0
Western gull	*Larus occidentalis*	10/03	0	3L	102H, 60L	2H	0	0
		5/04	1H, 7L	3H, 1L	13H, 41L	1L	2L	1H
		9/04	28H, 19L	1H, 3L	56H, 22L	1H, 15L	2H, 5L	7L
		5/05	0	0	46H, 86L	0	0	0
		10/05	106H, 105L	4H, 1L	19H, 14L	31H, 16L	4L	1H, 1L

Note: H = high tide, L = low tide

Three species of terns were observed during the study. Elegant (*Sterna elegans*), Forster's (*Sterna forsteri*), and Royal (*Sterna maxima*) terns were observed loafing at the Batiquitos receiver site during the September 2004 survey, and Royal terns also were seen in October 2005 (Table 5-6). Similar to gulls, terns were sometimes observed close to the entrance jetty to Batuquitos Lagoon, sometimes within or outside the boundaries of the survey area, which contributed to between survey variability in tern abundance at this site. Royal terns also were seen loafing on the beach at the Cardiff receiver site in September 2004 and at Leucadia in October 2005.

Table 5-6. Species and abundance of terns observed at City of Encinitas receiver and non receiver beach sites, 2003-2005.

Common Name	Scientific Name	Survey	SANDAG Receiver Sites			Non receiver Sites		
			Batiquitos	Cardiff	Moonlight	Leucadia	San Elijo	Seaside
Elegant tern	*Sterna elegans*	9/04	28H, 48L	0	0	0	0	0
Forster's tern	*Sterna forsteri*	9/04	2L	0	0	0	0	0
Royal tern	*Sterna maxima*	9/04 10/05	16H, 28L 37H	12L 0	0 0	0 33H	0 0	0 0

Other birds were seen in relatively low abundance at a few beach sites (Table 5-7). A mallard duck (*Anas platyrhynchos*) was seen during the October 2003 survey feeding at Moonlight Beach. In addition, a few land birds were observed feeding along the backshore at Batiquitos, Cardiff, Moonlight, and San Elijo beach sites during some surveys.

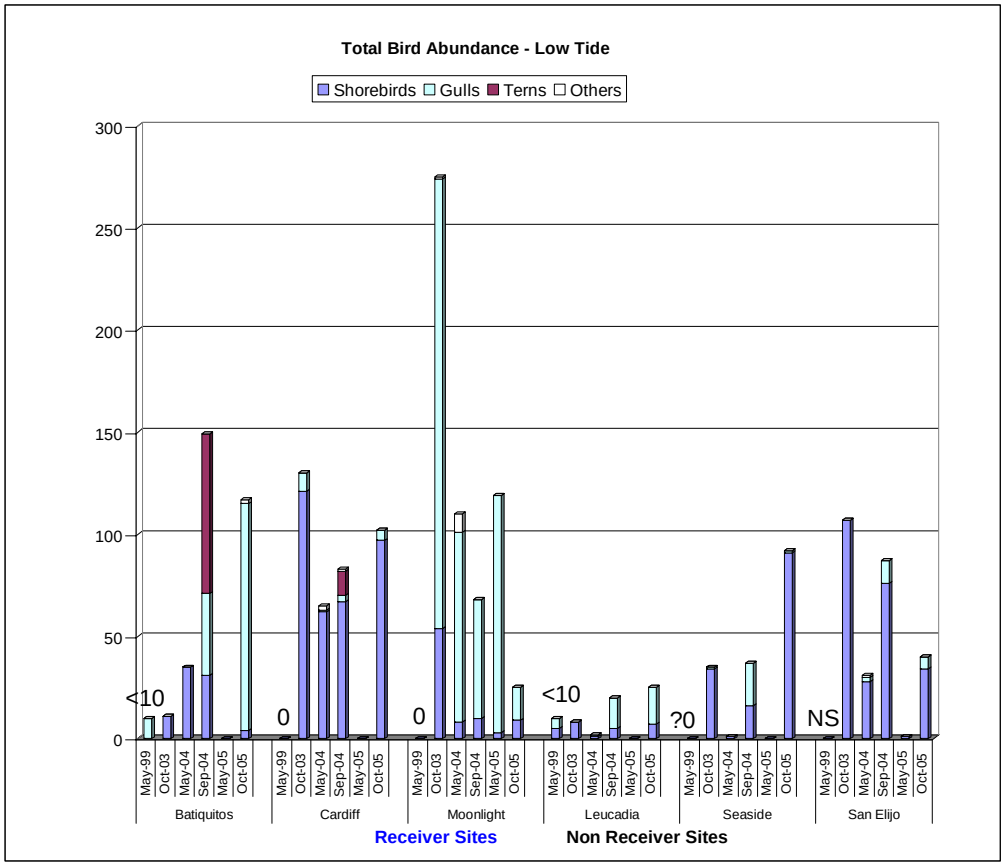
Table 5-7. Species and abundance of other birds observed at City of Encinitas receiver and non receiver beach sites, 2003-2005.

Common Name	Scientific Name	Survey	SANDAG Receiver Sites			Non receiver Sites		
			Batiquitos	Cardiff	Moonlight	Leucadia	San Elijo	Seaside
American crow	*Corvus brachyrhynchos*	5/04 10/05	0 16H	0 0	2L 0	0 0	1L 0	0 0
Barn swallow	*Hirundo rustica*	9/04	0	1L		0	0	0
Black phoebe	Sayornis nigricans	5/04 10/05	0 1H	1L 0	1L 1H	0 0	0 0	0 0
Mallard	*Anas platyrhynchos*	10/03	0	0	1H, 1L	0	0	0
Rock pigeon	*Columba livia*	5/04 10/05	0 2L	1L 0	5L 14H	0 0	0 0	0 0

5.2 Comparison of Bird Use of Beach Habitat Before and After Beach Nourishment

Limited data of bird use on City of Encinitas beaches are available prior to the 2001 SANDAG Project. Only a few shorebirds and gulls were observed at City of Encinitas beach sites during May 1999 reconnaissance surveys of potential receiver sites (MEC 2000). Birds were identified according to categories (shorebirds and gulls), relative abundance was recorded (e.g., 1-10, 11-20, 21-40), and behavior was noted (i.e., foraging, loafing). No birds were seen at Cardiff and Moonlight beach sites. A few gulls (1-10) were seen loafing at the Batiquitos beach site. A few (1-10) shorebirds were observed foraging in the wave wash zone and a few (1-10) gulls were observed loafing at the Leucadia beach site. Beach sites at Seaside and San Elijo were not surveyed in 1999.

Because of the limited available data prior to this study, only broad comparisons can be made of bird use before and after the beach nourishment. Also the timing of surveys must be considered since bird occurrence and abundance on southern California beaches varies seasonally (Hubbard and Dugan 2002). Bird abundances at receiver sites were lower in May 1999 than in May 2004, but were similar or lower than observed in May 2005 (Figure 5-5). No information on bird use of beaches during summer 1999 was available for comparison with summer 2003-2005 data.



Note: NS = not surveyed; ?0 = expected 0 based on cobble substrate

Figure 5-5. Bird abundance during low tides at City of Encinitas receiver and non receiver beach sites before and after beach nourishment.

Differences in bird abundance during spring surveys may vary relative to timing of spring bird migration. Therefore, pre- and post-project comparisons also considered habitat suitability for birds based on beach width, sand depth, and number of types of forage prey (Table 5-8). The comparison of habitat suitability was based on May low tide surveys when both pre and post project data were available. Sandy beach habitat conditions generally improve between spring and summer with additional sand accretion unless cobble cover remains extensive.

Table 5-8. Comparison of beach habitat characteristics and bird use of City of Encinitas receiver and non receiver beach sites during low tides before and after sand nourishment.

Beach Site	Survey	MSL Beach Width (meter)	Average Sand Depth (cm)*	Substrate Surface	Invert Taxa-Food-Life Style Types	Shorebirds	Gulls
Batiquitos Receiver	May 1999	50.6 (Spring 2001)	15	sand/ cobble	2-4	0	<10
	May 2004	38.7	>122	sand	4	35	17
	May 2005	30.5	46	sand/ cobble	7	0	0
Cardiff Receiver	May 1999	23.5	(cobble)	cobble	0	0	0
	May 2004	37.4	94	sand	4	62	1
	May 2005	55.7	86	sand	5	0	0
Moonlight Receiver	May 1999	35.7	18	sand/ cobble	3-5	0	0
	May 2004	45.1	114	sand	4	8	93
	May 2005	39.6	78	sand	5	3	116
Leucadia Non Receiver	May 1999	21	12.6	sand/ cobble	3-5	<10	<10
	May 2004	46.0	>122	sand	5	1	1
	May 2005	44.8	64	sand	4	2	0
San Elijo Non Receiver	May 1999	34.4 (Spring 2001)	NS	sand	NS	NS	NS
	May 2004	41.8	63	sand	5	0	2
	May 2005	43.0	44	sand	8	0	0
Seaside Non Receiver	May 1999	26.8 (2001)	?	cobble	?0	?0	?0
	May 2004	43.3	17	sand/ cobble	2	0	0
	May 2005	36.9	45	sand/ cobble	4	0	0

Beach width data from Coastal Frontiers 2006
NS = Not surveyed; ?0 = expected 0 based on cobble substrate
* Average of upper and middle intertidal zones, ** fall 1999 profile measurement
Number of invertebrate taxa-food-life style types from Figure 4-4 and Table 4-4

The greatest change in bird habitat occurred at Cardiff receiver and Seaside non receiver sites, where substrate changed from cobble to sand. Data collected at Cardiff in 1999 indicated no invertebrates (i.e., no forage base) associated with the cobble substrate. Deep sandy substrate was observed at Cardiff in May 2004 and May 2005, supporting 4 to 7 types of invertebrates (representing 5 to 8 species). Thus, spring beach habitat changed from hard substrate without bird prey to soft substrate with food. A substantial number of birds (> 60) were observed at

Cardiff in May 2004, indicating habitat was suitable for bird use. Habitat characteristics were similar to better in May 2005, indicating habitat was functionally ready for migratory birds during spring 2005, although no birds were observed during the May 2005 survey.

Although not surveyed in 1999, a photograph of Seaside in 2000 indicated extensive cobble throughout upper and mid tide zones similar to conditions surveyed at Cardiff. Spring-time habitat suitability in 2004 and 2005 was relatively poor compared to other surveyed beach sites, consisting of a mix of cobble and sand and 2 to 4 types of invertebrates (representing 3 to 6 species).

Spring-time bird habitat suitability at Batiquitos and Moonlight receiver sites improved after beach nourishment. In May 1999, sand depths were ≤ 18 cm (≤ 0.6 ft) with exposed cobble and potentially supported 2 to 5 types of invertebrates. In May 2004 and 2005, sand depths exceeded 46 cm (> 1.5 ft) and supported 4 to 7 types of invertebrates (representing 5 to 8 species) at Batiquitos, and sand depths were ≥ 78 cm (> 2.5 ft) and supported 4 to 5 types of invertebrates (representing 4 to 8 species) at Moonlight.

Spring-time habitat suitability improved at the Leucadia non receiver site after indirect sand nourishment in 2004. Site conditions changed from very shallow sand depths (< 13 cm, < 0.4 ft) with cobble and potentially supporting 3 to 5 types of invertebrates in May 1999 to deeper sand depths (≥ 64 cm, ≥ 2 ft) supporting 4 to 5 types of invertebrates (representing 5 species) in May 2004 and May 2005.

Pre-project data are lacking for the San Elijo non receiver site. However, conditions in 1999 likely would have been expected to be similar to that seen in spring 2004 and 2005 given that this site received no apparent influence from the SANDAG 2001 RBSP. Spring-time habitat was relatively good with sand depths ≥ 44 cm (≥ 1.4 ft) and 5 to 8 types of invertebrates (representing 6 to 10 species). Beach widths were slightly wider in spring 2004-2005 than in 1999.

5.3 Summary of Bird Use of Beach Habitat

Bird use of beach sites seasonally varied with higher abundance during late summer-fall than spring surveys unrelated to the SANDAG 2001 RBSP. A total of 28 species of birds was identified across beach sites during 2003-2005 surveys. Shorebirds and gulls were most abundant types of birds. Terns and the threatened western snowy plover were noted at beach sites located near Batiquitos and San Elijo Lagoons, where terns and plovers are known to seasonally nest. Terns were observed resting and western snowy plover were observed foraging and resting.

The SANDAG 2001 RBSP appeared to have a positive influence on bird habitat at Batiquitos, Cardiff, and Moonlight receiver sites. Prior the SANDAG Project, beach habitat during spring was narrow and characterized by extensive cobble cover and/or shallow sand depths in upper and middle intertidal zones and supported few types of invertebrate prey. Few to no birds were observed during limited, spring 1999 reconnaissance surveys at City of Encinitas beach sites. In contrast, receiver sites had persistent and deeper sand and a greater variety of invertebrate prey across seasons during the 2003-2005 study. Beach widths varied from being greater after nourishment at Cardiff and Moonlight) to less at Batiquitos, where widths rapidly declined after nourishment. Total numbers of bird species and bird abundance in 2003-2005 were relatively higher across tide conditions at receiver sites than non receiver sites, particularly during

summer-fall when birds were most abundant. This result may have been related to beach widths, which were generally wider at receiver sites than non receiver sites.

Results at non receiver sites were mixed. Although average sand depths indicated Leucadia and Seaside received indirect sand nourishment, bird use substantially varied among these sites. Bird use was similarly low at Leucadia before and after the SANDAG 2001 RBSP, indicating other factors besides sand nourishment influenced bird use at this site.

Birds were not surveyed at Seaside prior to the SANDAG Project, but use likely was limited due to extensive cobble cover similar to what was observed at Cardiff. Bird use at Seaside in 2003-2005 was low to moderate with substantially fewer birds during spring. Shallow sand depths with exposed cobbles may have contributed to seasonal variability at this site. Although bird habitat varied seasonally at Seaside after indirect nourishment, conditions likely represented an improvement over pre-project conditions when more extensive cobble cover may have substantially limited habitat suitability.

Bird use at San Elijo was not surveyed prior to the SANDAG 2001 RBSP. During 2003-2005, bird abundance was relatively high, perhaps due to stable sand depths unrelated to the SANDAG Project. Bird use at this site substantially varied with tide condition with generally higher abundance during low than high tide conditions, perhaps related to beach width.

6.0 POTENTIAL GRUNION HABITAT

Sandy beaches provide spawning habitat for the California grunion (*Leuresthes tenuis*), which is a CDFG managed fishery species. California grunion spawn in the higher high tide zone of sandy beaches mainly between March and August, and sometimes February and September. Female grunion burrow several centimeters into upper intertidal sands to deposit eggs, which incubate for 10-14 days until the next higher high tide cycle when inundation triggers eggs to hatch and larvae to swim back to sea. Initially, eggs are laid about 5 cm (2 in) into fluid sand and covered with additional sand by tides to a depth of 15 to 20 cm (0.5 to 0.7 ft) over the next several days (Moffatt and Thomson 1978 cited in Smyder and Martin 2002). Potential suitability of beaches for grunion spawning relates to substrate type and beach width. Sandy substrate is required for grunion burrowing and egg incubation, and beach width must be sufficient for egg incubation to occur without inundation except under highest tides. Given that eggs are suspended in the sand matrix, sand depths of at least 30 cm (1 ft) were assumed to represent the minimum associated with potential habitat suitability.

Substrate characteristics and the occurrence of grunion eggs in shovel samples at beach sites were considered indicators of potential habitat suitability for grunion spawning (Section 2.4). Results of 2003-2004 surveys are presented in Section 6.1, and are compared to pre-project data in Section 6.2. Potential suitability of City of Encinitas beach sites for grunion spawning is summarized in Section 6.3.

6.1 Comparison of Potential Suitability of Sandy Beach Habitat for Grunion Spawning at City of Encinitas Receiver and Non Receiver Sites After Beach Nourishment, 2003-2005

Grunion eggs were observed in shovel samples at the Moonlight receiver site during the May 2004 survey and at Leucadia in May 2005 (Table 6-1). No eggs were observed in shovel

samples during late September-October 2003 through 2005, which were outside the peak spawning season.

Table 6.1. Occurrence of grunion eggs in shovel samples from City of Encinitas receiver and non receiver beach sites, 2003-2005.

Survey	SANDAG Receiver Sites			Non Receiver Sites		
	Batiquitos	Cardiff	Moonlight	Leucadia	San Elijo	Seaside
October 2003	No	No	No	No	No	No
May 2004	No	No	Yes	No	No	No
September 2004	No	No	No	No	No	No
May 2005	No	No	No	Yes	No	No
October 2005	No	No	No	No	No	No

While presence of eggs confirms habitat suitability for grunion spawning at the Moonlight receiver and Leucadia non receiver sites, absence of eggs in shovel samples from other beach sites does not necessarily indicate habitat unsuitability. Average sand depth measurements from the upper intertidal zone indicate that all receiver sites had sufficient depths to support grunion burrowing and egg incubation throughout their spawning season (Table 6-2). The San Elijo non receiver site also had sufficient sand depths to support this function.

Average upper intertidal sand depths indicated that habitat suitability for grunion spawning was seasonal at the Seaside non receiver site; upper intertidal sand depths were < 16 cm (< 0.5 ft) during spring (Table 6-2). Sand depths had borderline suitability at Leucadia in October 2003, and shallower depths would have been expected in spring prior to seasonal sand accretion. This suggests that potential habitat suitability did not span the entire grunion spawning season in 2003 at Leucadia. With indirect sand nourishment, sand depths were deeper across spring and summer suggesting habitat suitability extended across the grunion spawning season in 2004-2005 at Leucadia. Upper intertidal sand depths had borderline suitability as potential grunion spawning habitat at Batiquitos in spring 2005.

Table 6-2. Average sand depths (cm) in the upper intertidal zone at City of Encinitas receiver and non receiver beach sites, 2003-2005.

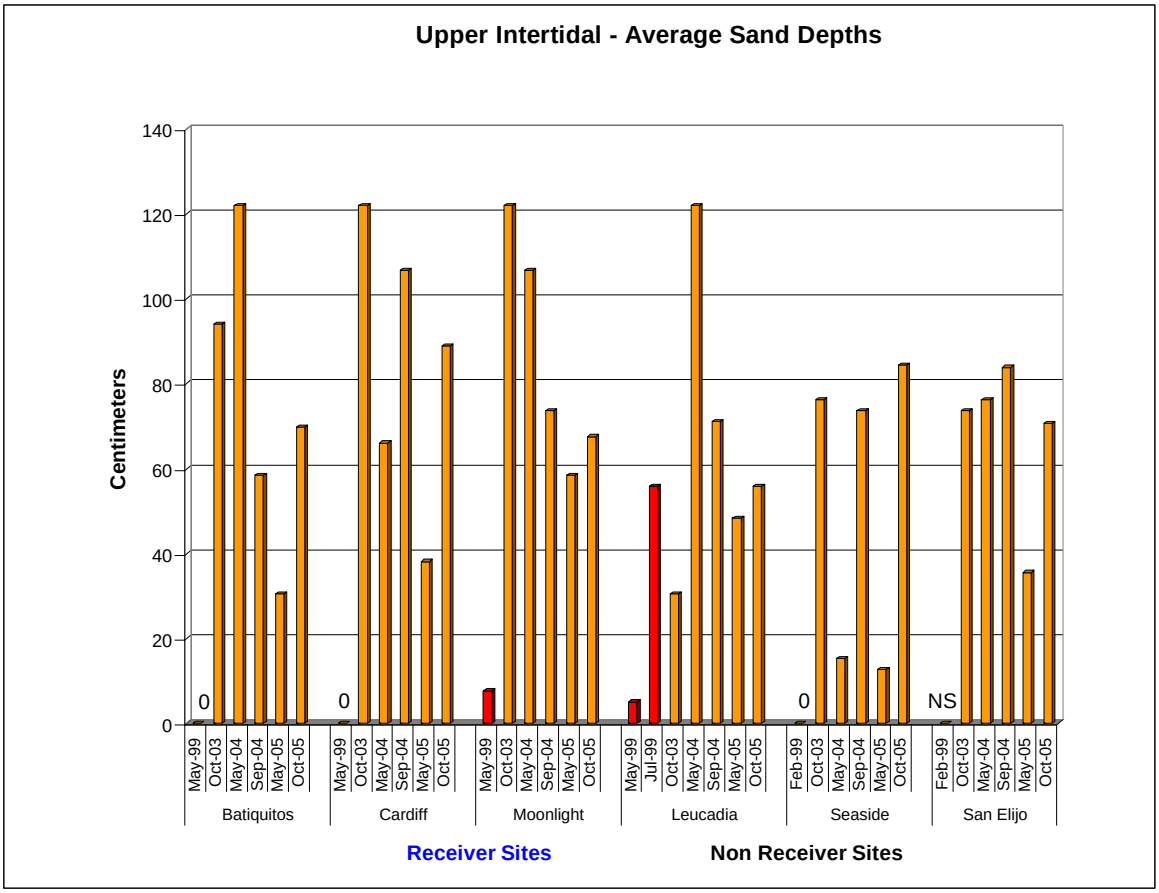
Survey	SANDAG Receiver Sites			Non Receiver Sites		
	Batiquitos	Cardiff	Moonlight	Leucadia	San Elijo	Seaside
October 2003	94.0	> 122	> 122	30.5	73.7	76.2
May 2004	> 122	66.0	106.7	>122	76.2	15.2
September 2004	58.4	106.7	73.7	71.1	88.8	73.7
May 2005	30.5	38.1	58.4	48.3	35.6	23.7
October 2005	69.9	88.9	67.6	55.9	70.6	84.3

6.2 Comparison of Potential Grunion Habitat Before and After Beach Nourishment

Upper intertidal sand depths indicated limited suitability of most City of Encinitas beach sites for grunion spawning prior to beach nourishment (Figure 6-1). Cobble instead of sand occurred in the upper intertidal of Batiquitos and Cardiff beach sites in spring 1999 and in winter-spring

2000 at Seaside. Upper intertidal sand depths were very shallow < 15 cm (< 0.5 ft) and unsuitable for grunion spawning in spring 1999 at Moonlight and Leucadia. Measured sand depths at Leucadia during summer 1999, however, were sufficient for grunion spawning. This indicates that pre-project potential suitability of beach sites for grunion spawning was seasonal at beach sites with a mix of sand and cobble substrate and was non existent at beach sites with extensive cobble cover.

After sand nourishment, Cardiff and Moonlight receiver sites were potentially suitable throughout the entire grunion spawning season in 2003-2005 based on sand depths. At Batiquitos, habitat suitability extended across seasons in 2004, but may have declined to seasonal in 2005 associated with the decreasing sand depths at this site over the 2004 winter season. Results for non receiver sites were mixed. Sand depth measurements suggest grunion habitat suitability was seasonal in 2003 similar to what was seen in 1999, but extended throughout the spawning season in 2004 and 2005 at Leucadia. Sand depths at Seaside indicated grunion habitat suitability changed from non-existent (from cobble) prior to the project to seasonal after indirect nourishment. No pre-project data are available for comparison with 2003-2005 data from the San Elijo non receiver site. Grunion habitat suitability extended across the spawning season in 2003-2005 at this site.



Notes: NS = not surveyed; red color = before nourishment (1999), orange color = after nourishment (2003-2005)
Sources: MEC 2000, present study

Figure 6-1. Comparison of upper intertidal sand depths at receiver and non receiver sites before and after beach nourishment.

6.3 Summary of Potentia/ Habitat Suitability for Grunion Spawning

City of Encinitas beach sites either had unsuitable substrate or were potentially only seasonally suitable for grunion spawning prior to the SANDAG 2001 RBSP. After beach nourishment, potential grunion spawning habitat was created at the Cardiff receiver site and habitat suitability extended throughout the grunion spawning season at Moonlight in 2003-2005 and at Batiquitos in 2003-2004; suitability for grunion declined to potentially seasonal at Batiquitos in 2005.

Indirect sand nourishment at Leucadia and Seaside non receiver sites also improved grunion spawning habitat. Potential grunion habitat suitability at Leucadia changed from seasonal in 2003 to extending throughout the spawning season in 2004-2005. Potential grunion spawning habitat was created at Seaside, however, potential habitat suitability did not extend throughout spawning season due to seasonal variability of sand depths.

Sand depth measurements indicated that potential habitat suitability for grunion spawning extended across seasons at the San Elijo non receiver site in 2003-2005. No obvious project influence was detected at the San Elijo non receiver site.

7.0 SUMMARY AND DISCUSSION

An overview summary of results of the 2003-2004 study is given in Section 7.1. Results specific to each beach site are summarized in Section 7.2. Conclusions are given in Section 7.3.

7.1 Overview Summary

Surveys were conducted in 2003 and 2005 to examine potential SANDAG Project influence on beach habitat and biological resources two to four years after beach nourishment in the City of Encinitas. Surveys examined physical characteristics of beach habitats, marine invertebrates living in beach sands, bird use at the beaches, and the potential for beaches to support grunion spawning. Five surveys were conducted, three in late summer-fall 2003 through 2005 and two in spring 2004 and 2005. Surveys were designed to include comparisons of beach habitats and biological resources at sites that did (receiver sites) and did not (non receiver sites) receive beach nourishment. The study also compared results with available data collected in 1999 prior to the SANDAG 2001 RBSP.

Results indicated physical improvement of beach habitat quality for biological resources at Batiquitos, Cardiff, and Moonlight receiver sites due to sand placement. Prior to the SANDAG 2001 RBSP, beach habitat was dominated by cobbles at Cardiff, and beach habitat seasonally eroded to a mix of cobbles and sand at Batiquitos and Moonlight beach sites. Average sand depths across tide zones eroded to < 30 cm (< 1 ft) in spring at receiver sites prior to beach nourishment. During 2003-2005, receiver beaches were predominantly sandy with depths that averaged > 60 cm (> 2 ft) across tide zones and seasons. Thus, Cardiff changed from a cobble to sand beach and sand depths at other receiver sites ranged deeper and did not display as substantial a seasonal change in substrate condition as was observed during pre-project conditions. Average sand depths exhibited greater variability at Batiquitos than the other receiver sites during this study, suggesting that dynamic sand movement from this site was greater than at other receiver sites. There was some indication of additional sand influx in 2004 that likely was associated with sand placement from maintenance dredging of Batiquitos Lagoon.

Sand depths of > 122 cm (> 4 ft) over one or more tide zones at all receiver sites was observed on one or more surveys, which exceeded the historical average sand depth range of 30 to 100 cm (1 to 3.3 ft) at depths from 0 to -1.5 m (0 to -5 ft) MLLW for City of Encinitas beaches (Moffatt & Nichol 2000, MEC 2000). Thus, sand depths > 122 cm (> 4ft) provided an easily identifiable indicator of beach nourishment influence in this area of coastline. Above-normal sand depth measurements on one or more surveys provided evidence of indirect nourishment at Leucadia and Seaside non receiver sites. Both these non receiver sites were located approximately 300 m (1,000 ft) downcoast of receiver sites. Beach profiles measured by Coastal Frontiers (2006) indicated dispersal of sand from receiver sites after the SANDAG 2001 RBSP.

Results of the present study suggest timing and volume of indirect nourishment varied among Leucadia and Seaside. Sand depth measurements indicated sand nourishment occurred between 2003 and 2004 at Leucadia and prior to 2003 at Seaside. Coastal Frontiers (2004, 2006) beach width data indicated a substantial increase in beach width at Seaside in spring 2002 after the first post sand placement winter storm season. At Leucadia, less change between spring and fall beach widths occurred after 2003. At Seaside, beach habitat was cobble dominated prior to the SANDAG 2001 RBSP, but varied in 2003-2005 from a seasonal mix of cobble and sand in spring (with decreasing cobble influence between 2003 and 2005) to deeper sands across tide zones of 79 to 80 cm (> 2.6 ft) in summer-fall. Thus, Seaside changed from a cobble beach to a seasonal sandy beach after indirect nourishment. Leucadia changed from a seasonal sandy beach habitat to a persistent sand habitat after indirect nourishment.

No obvious SANDAG Project influence was detected at the San Elijo non receiver site. Average sand depths across tide zones of > 40 to 73 cm (> 1 to < 3 ft) were within the historical range and were relatively stable across seasons perhaps due to the influence of nearshore reefs.

Biological resource use and potential use of City of Encinitas beach sites improved relative to pre-project conditions for sites that received direct and indirect sand nourishment. Biological use was somewhat higher at receiver than non receiver sites depending on site specific conditions. These improvements in biological resource use were reflected in earlier seasonal development of invertebrate forage base and seasonal suitability of habitat for birds and grunion spawning.

A total of 24 species of invertebrates was collected at City of Encinitas beach sites in 2003-2005. Total numbers of invertebrate species were similar among receiver and non receiver sites. However, functional development of invertebrate assemblages, as represented by types of species and their feeding strategies, was earlier in the season at receiver sites and at the San Elijo non receiver site than other non receiver sites. Generally, more species of invertebrates developed earlier in the season where sand depths averaged > 30 cm (> 1ft) across in all tide zones.

A total of 28 species of birds was observed at City of Encinitas beach sites in 2003-2005. Total numbers of bird species and bird abundance were relatively higher across low and high tide conditions at receiver sites, presumably due to the relatively greater beach widths at these sites. Results at non receiver sites were mixed. Bird use at Seaside represented a substantial improvement over pre-project conditions when cobble cover limited habitat suitability for birds. Bird use was similarly low at Leucadia during 2003-2005 as observed in 1999. Bird use at San Elijo was not surveyed prior to the SANDAG 2001 RBSP. During 2003-2005, bird abundance was relatively high, perhaps due to stable sand depths unrelated to the SANDAG Project,

suggesting that other factors unrelated to SANDAG Project influence contributed to site specific differences in bird use among City of Encinitas beach sites.

Habitat suitability for grunion spawning was evaluated based on physical characteristics of beach sites. The grunion spawning season ranges from February to September and sandy substrate is necessary to support spawning behavior and incubation of eggs. Initially, eggs are laid about 5 cm (2 in) into fluid sand and covered with additional sand by tides to a depth of 15 to 20 cm (0.5 to 0.7 ft) over the next several days (Moffatt and Thomson 1978 cited in Smyder and Martin 2002). Given that eggs are suspended in the sand matrix, sand depths of at least 30 cm (1 ft) were assumed to represent the minimum associated with potential habitat suitability. Grunion spawning habitat suitability was absent due to cobble cover either during spring and/or throughout the year at several of the beach sites prior to the 2001 SANDAG Project. Persistent and relatively deep sands across seasons indicated habitat was suitable throughout the grunion spawning season at receiver sites after beach nourishment, although suitability had declined to being questionable at Batiquitos in May 2005. Habitat suitability for grunion spawning also improved at sites that received indirect nourishment. Habitat suitability changed from seasonal to persistent across seasons at Leucadia after indirect nourishment. Habitat changed from unsuitable cobble to seasonally suitable at Seaside. Habitat was potentially suitable for spawning across seasons at the San Elijo non receiver site, apparently unrelated to project influence.

SANDAG Project influence on biological resources was substantial at beach sites where sand nourishment resulted in a change in physical habitat characteristics from cobble to sand. No invertebrates or birds, and no potential habitat for grunion spawning were observed during spring 1999 surveys at the Cardiff receiver site, which was covered with cobbles prior to sand placement. Invertebrate and bird resources were observed at this site and sand depths were sufficient to support potential grunion spawning during 2003-2005. Although the Seaside non receiver site was not surveyed prior to the SANDAG 2001 RBSP, cobble cover was extensive and biological resource use would have been expected to be limited. Indirect sand nourishment at Seaside supported invertebrate and bird resources and sand depths were sufficient to support seasonal use for potential grunion spawning in 2003-2005. Biological resource use was greater at Cardiff where there was less seasonal variability in sand depths than at Seaside where seasonal erosion of sand depths in upper and/or middle intertidal zones occurred. More species of invertebrates, higher bird abundance, and a longer seasonal duration of habitat suitability for potential grunion spawning was observed at Cardiff than at Seaside during the 2003-2004 study.

Biological resource use of Batiquitos and Moonlight receiver sites appeared to be greater two to four years after than before the SANDAG 2001 RBSP. A greater variety of invertebrates and early seasonal suitability of habitat for potential grunion spawning was observed in spring 2004 and 2005, while these functions were limited in spring 1999. Few birds were observed at Batiquitos and no birds were observed at Moonlight during the spring 1999 survey. Recognizing the limitation associated with single survey comparisons, more birds were observed during one or both of the spring 2004 and 2005 surveys than in 1999 at both these beach sites. Potential habitat suitability for birds was unarguably better in 2003-2005 than observed in spring 1999. The habitat conditions available to birds at Batiquitos and Moonlight in spring 1999 were characterized by narrow beaches with a mix of sand and cobbles and few types of invertebrates (worms, sand crabs). In contrast, birds in spring 2004 and 2005 encountered wide sandy beaches with a relatively well developed forage base of worms, crustaceans (amphipods, sand crabs, and/or other mole crabs), and clams.

Biological resource use at the Leucadia non receiver site showed some improvements in 2004-2005 related to indirect sand nourishment, but results did not extend across all resource groups. A greater variety of invertebrates was collected in spring 2004 and 2005 than spring 1999, indicating earlier seasonal development of the invertebrate forage base after indirect nourishment In addition, potential grunion habitat was present earlier in the season after indirect nourishment. However, bird use remained relatively low at Leucadia similar to pre-project conditions, indicating that other unmeasured factors affected bird use at this site.

Biological resource use at the San Elijo non receiver site was not surveyed prior to the SANDAG 2001 RBSP. Survey results in 2003-2005 indicated relatively high resource use of the site. A varied invertebrate forage base (crustaceans, clams, worms) was present throughout the season, the number of bird species and abundance were relatively high, and sand depths and substrate in the upper intertidal were sufficient to potentially support grunion throughout their spawning season. Relatively high use at San Elijo was more similar to results at receiver sites than at other non receiver sites; however, no obvious SANDAG Project influence was detected at San Elijo. Sand habitat depths were relatively stable across seasons, perhaps due to natural sand retention by nearshore reefs. Presumably this stability was associated with relatively low habitat disturbance and contributed to habitat quality at this site.

One notable difference between receiver sites and the San Elijo non receiver site was the greater bird use across low and high tide condition at receiver sites; whereas, birds were twice as abundant during low than high tides at San Elijo. This result was most apparent during summer-fall surveys when bird abundance was highest. Beach widths were relatively wider at receiver sites than non receiver sites during summer-fall, suggesting the 2001 SANDAG Project contributed to the greater bird use across tide conditions at receiver sites.

Some observed differences among beach sites related to seasonal differences unrelated to the SANDAG 2001 RBSP. Beach width and sand depths exhibited seasonal variability associated with natural cycles of erosion (winter) and deposition (summer) at most beach sites, although seasonality in sand depths was less apparent at sites that received sand nourishment. Marine invertebrates exhibited greater species variety in summer-fall than spring. Bird use of beach sites also was higher in summer-fall than spring due to the migratory nature of most of the observed species. California grunion use beaches as spawning habitat in spring and summer. Thus, 2003-2005 surveys were near the beginning or end of seasonal use periods of biological resources, which may have contributed to some of the observed variability among beach sites and surveys.

The timing of these surveys allowed identification of differences in resource use that probably would have been less missed if surveys were conducted during summer peak use periods. Several differences among beach sites were associated with relatively greater use across seasons than with differences during summer when beaches are naturally in an accreted sand condition. Conducting surveys during both spring and summer-fall seasons showed that marine invertebrates developed earlier in the season and potential habitat suitability for grunion spawning extended across seasons at beach sites with deeper sands and/or greater stability in sand depths across seasons than at sites that seasonally eroded over winter. Similarly, conducting surveys over both high and low tide conditions for birds revealed beach width was sufficient to support similar bird use across tide condition at wider receiver sites, but bird use was limited during high tides at narrower non receiver sites.

7.2 Summary by Beach Site

7.2.1 Cardiff Receiver Site

Of the City of Encinitas surveyed beaches, the most dramatic change in beach habitat quality occurred at Cardiff after the SANDAG 2001 RBSP.

The beach site changed from cobble to sandy beach, which was wider across seasons after beach nourishment. Before the SANDAG Project, only cobble was present in upper and middle intertidal zones, and moderate sand habitat was limited to the lower intertidal. In contrast, sand depths ranged from > 60 to > 122 cm (> 2 to > 4 ft) across tide zones during 2003-2005 surveys.

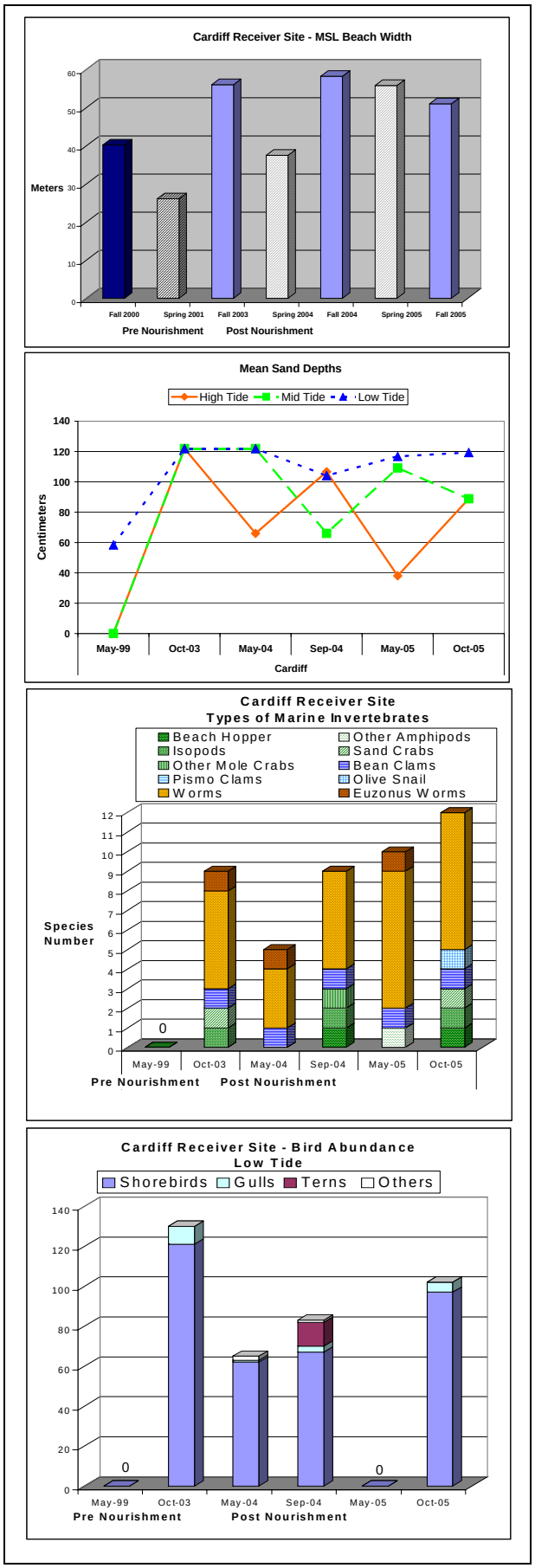
No marine invertebrates or birds were observed during surveys in May 1999, and the site was considered unsuitable for grunion spawning (MEC 2000).

A total of 17 species of invertebrates was collected was collected across tidal zones and seasons in 2003-2005. Invertebrates included amphipod, isopod, sand crabs, other mole crabs, clams, and worms.

A total of 18 bird species were observed in 2003-2005. Relatively high numbers of birds foraged and rested on the beach during high and low tides in spring and summer-fall, indicating functional habitat across environmental conditions.

Average upper intertidal sand depths of 38 to 107 cm (1.2 to 3.5 ft) indicated beach habitat was potentially suitable for grunion throughout their spawning season in 2003-2005.

At the end of the study, potential habitat suitability for invertebrates, birds, and grunion extended across seasons.



7.2.2 Batiquitos Receiver Site

The Batiquitos receiver site changed from seasonal cobble/sand to a more persistent sandy beach habitat after the 2001 SANDAG Project. However, beach width steadily declined in 2003-2005, indicating substantial sand movement from the site.

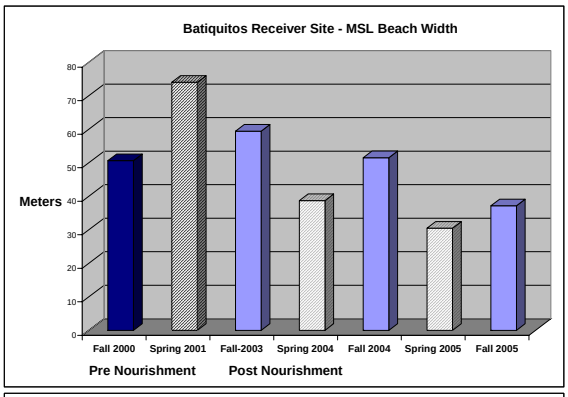
In May 1999, Batiquitos had cobble cover in the high tide zone, and average sand depths in middle and low tide zones were 30 to 45 cm (1 to 1.4 ft). In 2003-2005, average sand depths ranged from 30 to > 122 cm (1 to > 4 ft) across tide zones. Deeper sands in May 2004 may have resulted from dredging Batiquitos Lagoon.

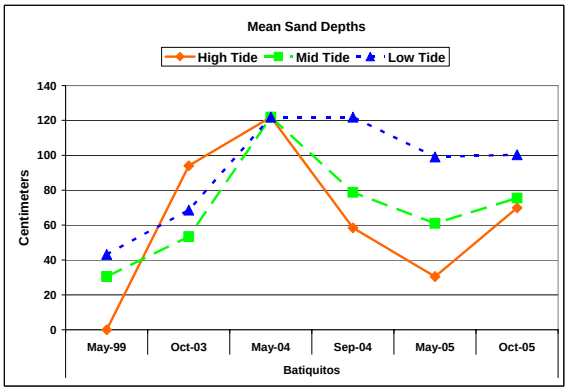
Sand crabs and worms were the only invertebrates collected in May 1999. In contrast, invertebrates in May 2004 and/or 2005 included amphipods, bean clams, sand crabs, other mole crabs, and worms. A total of 13 species was collected across tidal zones and seasons in 2003-2005.

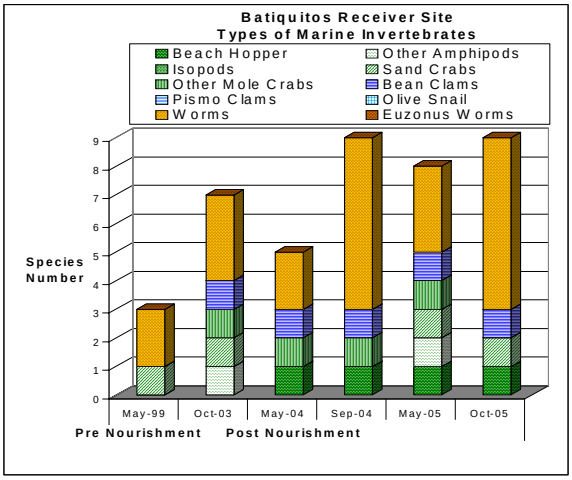
In May 1999, a few gulls were seen loafing at the site. Bird abundance during spring 2004 and 2005 surveys was variable, ranging from 0 to > 50 birds, including gulls and shorebirds. A total of 15 species of birds was observed in 2003-2005. Relatively high numbers of birds foraged and rested on the beach during high and low tides in spring and summer-fall, indicating functional habitat across environmental conditions in 2003-2005.

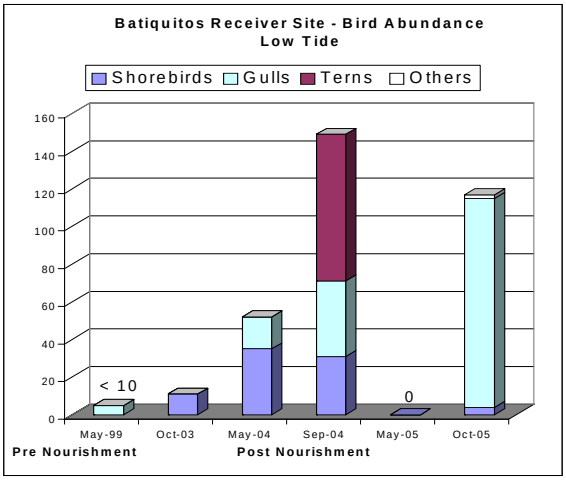
Prior to the SANDAG Project, potential spawning habitat for grunion was considered to vary seasonally (MEC 2000). Average upper intertidal sand depths of > 58 cm (> 2 ft) indicated potential suitability across the grunion season in 2003-2004, but shallower depths (30 cm, 1 ft) in May 2005 were of questionable suitability.

At the end of the study, potential habitat suitability extended across seasons for invertebrates and birds, but may have been seasonal for grunion.









7.2.3 Moonlight Receiver Site

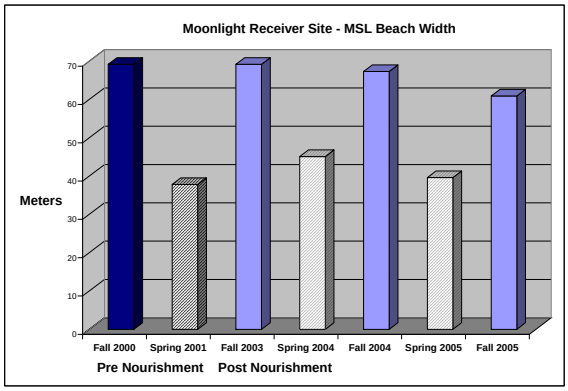
The Moonlight receiver site changed from seasonal cobble/sand to persistent sandy beach habitat after the 2001 SANDAG Project. Beach widths in 2003-2005 were not substantially different from widths during some years prior to the project, although spring and fall widths in 2003-2005 were wider than in 1999 when biological reconnaissance surveys were conducted. In May 1999, average sand depths across tide zones ranged from < 15 to 60 cm (<0.5 to 2 ft). Average sand depths of 58 to > 122 cm (1.9 to > 4 ft) were substantially deeper across tide zones in 2003-2005.

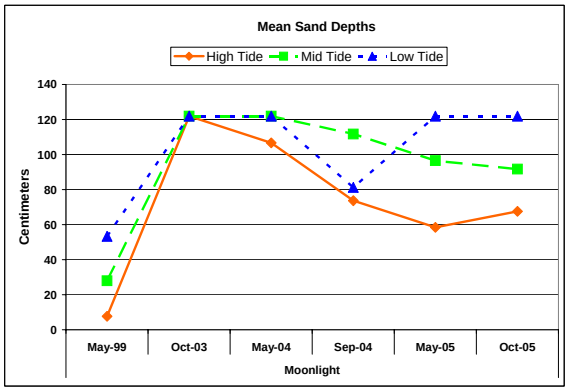
In May 1999, sand crabs and worms were the only species collected. In contrast, invertebrates in May 2004 and/or 2005 included beach hopper amphipods, sand crabs, bean clams, and worms. Summer season assemblages in 2003-2005 also included *Euzonus* worms, spiny mole crabs, and isopod crustaceans. A total of 16 species was collected was collected across tidal zones and seasons in 2003-2005.

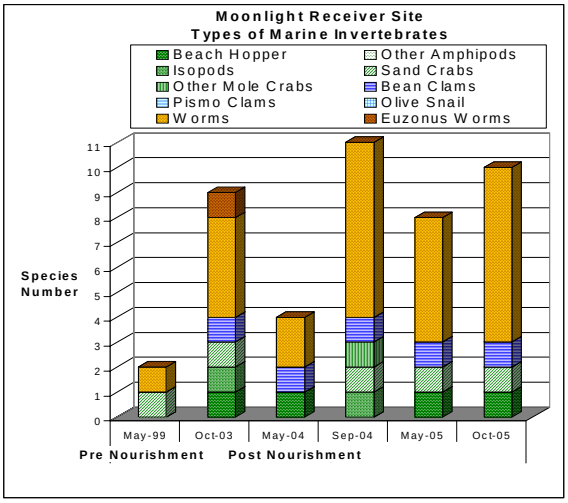
No birds were observed on the beach in May 1999 (MEC 2000). A total of 19 bird species was observed in 2003-2005; 5 to 10 species were seen during May 2004 and 2005 surveys. Gulls were attracted to the outlet of Cottonwood Creek. Overall bird use was relatively high across seasons and tide conditions, indicating suitable habitat across environmental conditions.

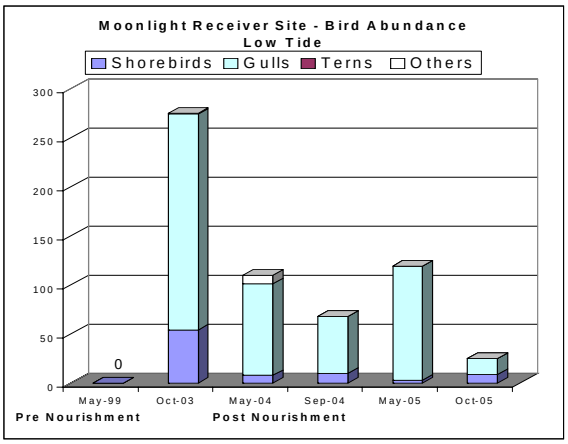
Prior to the SANDAG Project, potential spawning habitat for grunion was considered to vary seasonally (MEC 2000). Average upper intertidal sand depths of > 58 cm (1.9 ft) indicated potential suitability for grunion throughout their spawning season in 2003-2005. Grunion eggs were noted at the site in May 2004.

At the end of the study, potential habitat suitability for invertebrates, birds, and grunion extended across seasons.









7.2.4 Leucadia Non Receiver Site

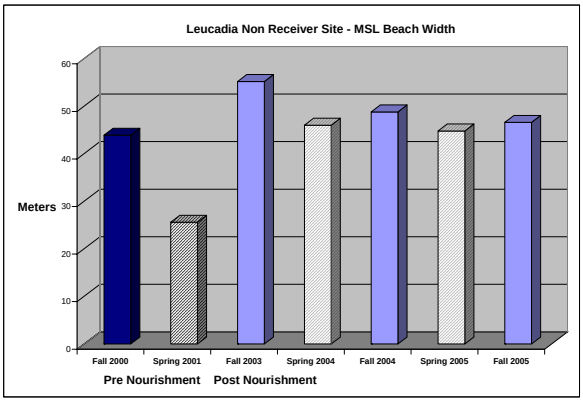
The Leucadia non receiver changed from seasonal cobble/sand to persistent sandy beach habitat during the course of the study. Beach widths and sand depths in 2003 were similar to those measured in 1999. Increased beach widths and substantially deeper sand depths of 48 to > 122 cm (1.6 to > 4 ft) among tide zones and seasons indicated the site received indirect sand nourishment in 2004.

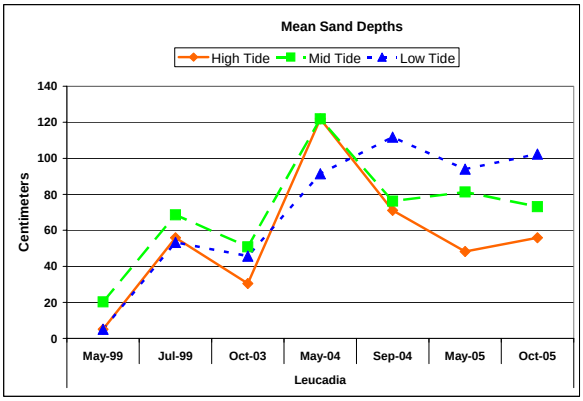
Sand crabs and worms were the only invertebrates collected in May 1999. In contrast, invertebrate assemblages in May 2004 and/or 2005 included beach hoppers and other amphipods, sand crabs, other mole crabs, bean clams, and worms. Summer-fall assemblages in 2003-2005 sometimes included isopods and olive snails. A total of 15 species was collected across 2003-2005 surveys.

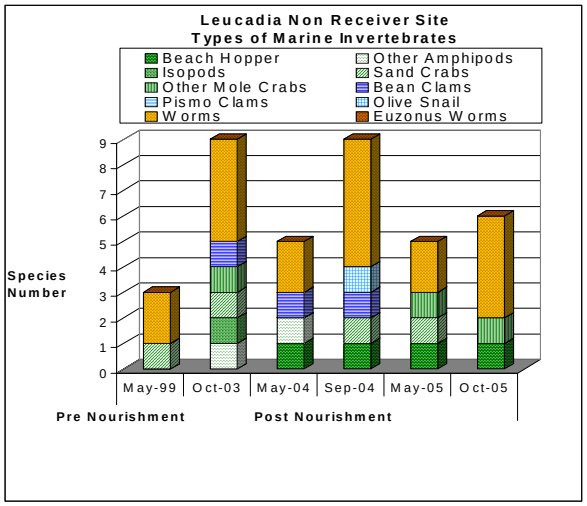
Few birds were observed during the May 1999 survey. Bird use was seasonal and relatively low in 2003-2005, although the site appeared to have suitable sand substrate and forage base. A relatively low number (11) of bird species was observed in 2003-2005. Other factors besides sand apparently influenced bird use at this site.

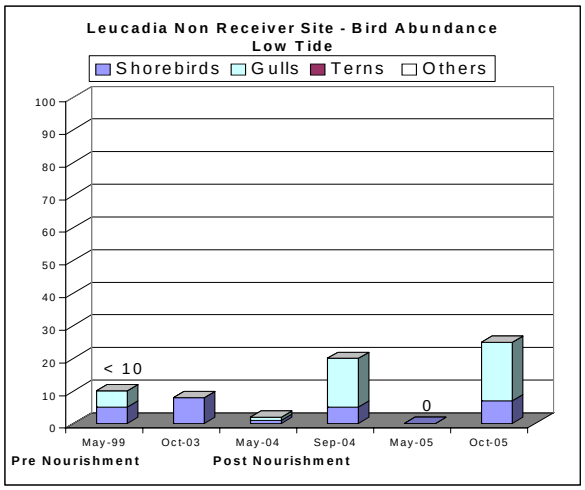
The site was considered to have limited suitability to grunion in 1999 (MEC 2000). This also may have been the case in 2003, when the average upper intertidal sand depth was 30 cm (1 ft) in October and shallower sand depths would have been expected earlier in the season. Average upper intertidal sand depths of > 48 cm (>1.6 ft) indicated the site was potentially suitable for grunion throughout their spawning season in 2004 and 2005. Grunion eggs were noted at the site in May 2005.

At the end of the study, potential habitat suitability for invertebrates and grunion extended across seasons; bird use remained relatively low at the site.









7.2.5 Seaside Non Receiver Site

Seaside was not surveyed prior to the SANDAG 2001 RBSP, but photographs indicate the site was extensively covered with cobble in 2000. Habitat varied seasonally from cobble/sand to sandy beach in 2003-2005. The beach was wider in 2003-2005 compared to before the SANDAG Project. These changes in habitat characteristics suggest indirect sand nourishment occurred at this site.

Average sand depths in 2003-2005 exhibited seasonal variability, ranging from 13 to >122 cm (0.4 to > 4 ft) across tide zones in spring, and from 56 to > 122 cm (1.8 to > 4 ft) across tide zones in summer-fall. Sand depths ranged deeper in the middle intertidal zone in 2005, suggesting greater habitat persistence.

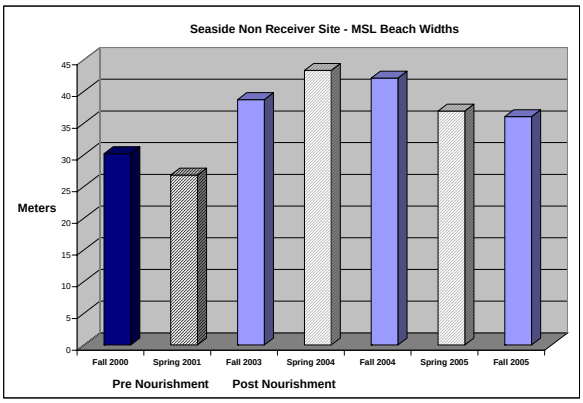
Although not surveyed in 1999, limited invertebrate development would have been expected due to the cobble habitat, similar to that found at Cardiff.

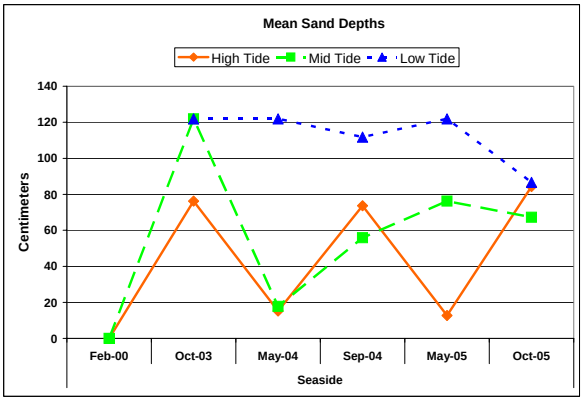
A total of 15 species of invertebrates was collected in 2003-2005 including sand crabs, isopods, worms, *Euzonus* worms, bean clams, and pismo clams. Development of invertebrate assemblages was less in spring 2004 than 2005.

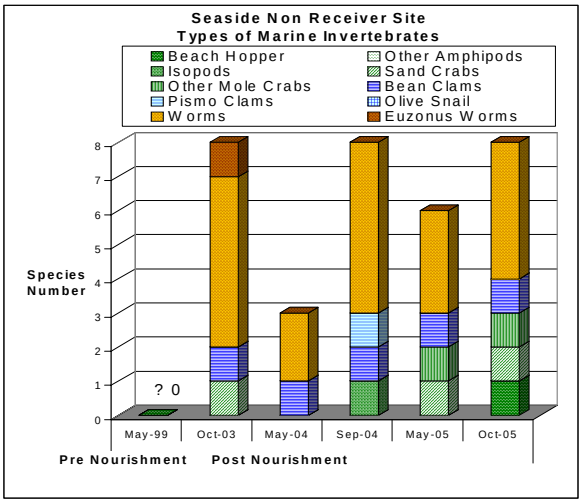
A total of 12 bird species was observed during 2003-2005 surveys. Bird use was seasonal with moderate-high abundance in summer-fall and few birds in spring. .

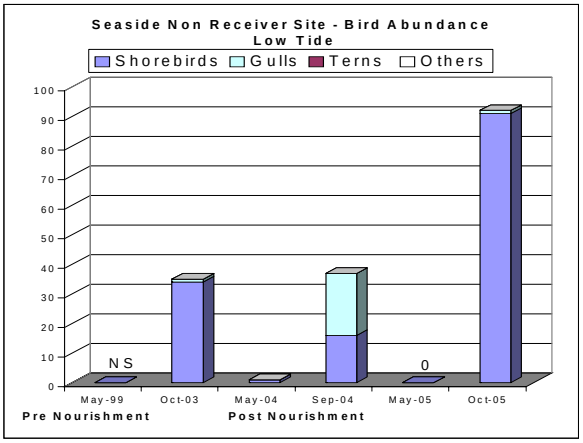
Upper intertidal sand depths indicated potentially seasonal suitability for grunion spawning in 2003-2005. Average depths of 13 to 15 cm (0.4 to 0.5 ft) in spring were unsuitable, but suitable depths of > 73 cm (> 2.4 ft) occurred in summer-fall.

At the end of the study, habitat suitability varied seasonally for invertebrates, birds, and grunion.









NS = not surveyed;
?0 = expected 0 based on cobble substrate

7.2.6 San Elijo Non Receiver Site

No biological resource surveys were conducted at San Elijo prior to the SANDAG 2001 RBSP. No obvious influence from the SANDAG Project was detected during 2003-2005 surveys.

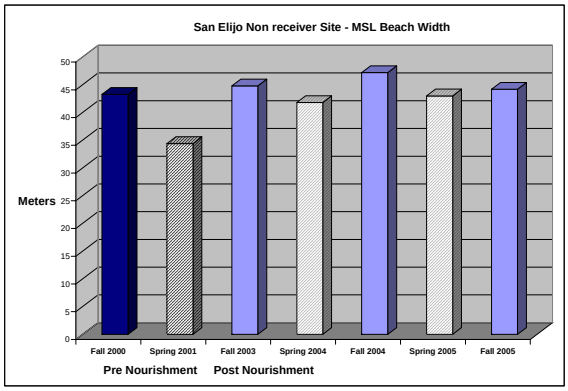
Beach widths showed a greater difference between spring and fall in 2000-2001 than in 2003-2005, suggesting mild winter conditions during the study. Maximum beach widths during fall were similar before and after the 2001 SANDAG Project. Average sand depths ranged from 38 to 84 cm (1.2 to 2.7 ft) across tide zones in 2003-2005, with generally more variability among surveys in sand depths in the upper intertidal than other tide zones.

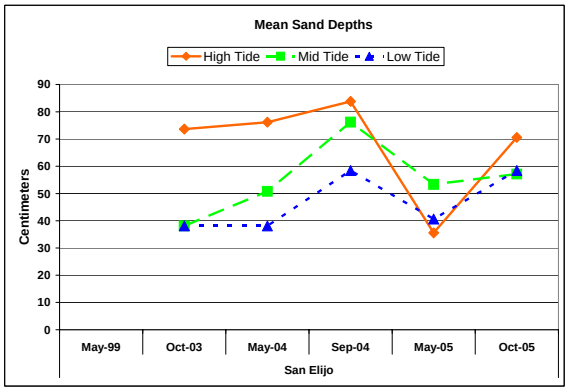
A total of 17 species of marine invertebrates was collected in 2003-2005. Invertebrate assemblages included amphipod, isopod, sand crab and other mole crab crustaceans, bean clams, olive snail, and a variety of worms. Invertebrate assemblages in spring were nearly as developed as those in summer-fall.

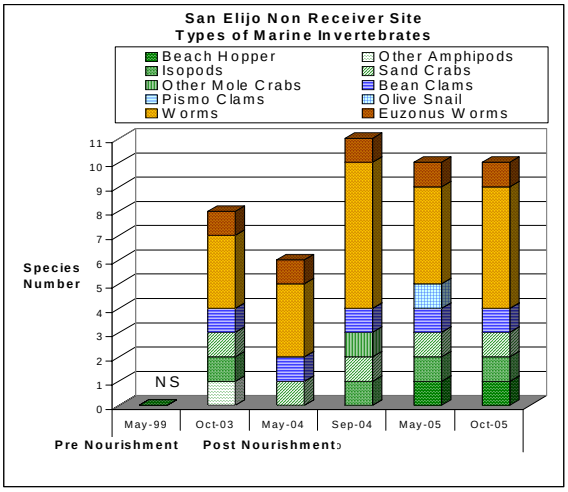
A total of 15 bird species was observed in 2003-2005. Most were shorebirds, which seasonally varied with relatively higher abundance in summer-fall and lower abundance in spring. Substantially more birds were observed during low than high tides, indicating habitat suitability varied according to tide condition.

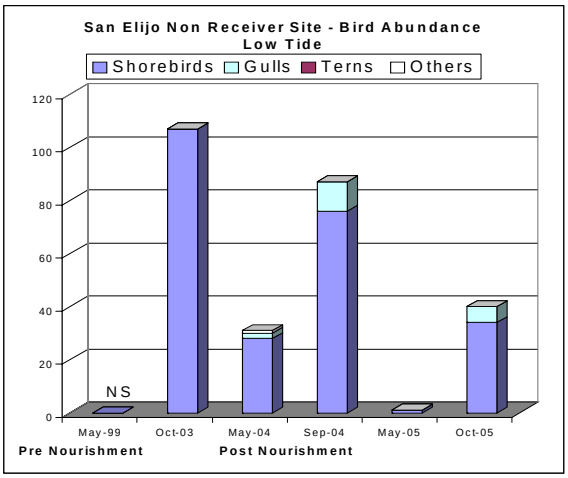
Average upper intertidal sand depths ranged from > 35 cm to 84 cm (> 1.1 to 2.8 ft), indicating the site was potentially suitable for grunion throughout their spawning season in 2003-2005.

At the end of the study, potential habitat suitability for invertebrates, birds, and grunion extended across seasons.









NS = not surveyed

7.3 Conclusions

Results of this study indicated environmental benefits to City of Encinitas beaches two to four years after receiving sand from the SANDAG 2001 RBSP. The receiver sites provided habitat for a diverse variety of marine invertebrates (crustaceans, clams, and worms), which served as prey for hundreds of foraging birds. In addition, beaches provided resting habitat for shorebirds and gulls, and provided potential spawning habitat for California grunion. Prior to the SANDAG Project, many of these habitat functions were absent or seasonally limited at the receiver beach sites. Thus, there was an improvement in habitat quality and biological resource use of beach habitat at receiver sites after the SANDAG Project.

SANDAG's strategy to improve recreational benefits to beaches within the San Diego region involved placement of sands at selected beach receiver sites and reliance on natural coastal processes to disperse and transport sands. Sand transport rates apparently varied along the coast since indirect sand nourishment at non receiver sites apparently occurred in different years or not within four years of project implementation. There were differences in biological resource use and/or potential use at indirectly nourished beaches related to differences in sand depths. This suggests that benefits to sandy beach habitat and resources from the 2001 SANDAG Project on beaches within the region were variable along the coast, occurring at different time scales and at different potential benefit levels.

Although the geographic extent of benefit to biological resources using beach habitats was not addressed by this study, positive influences were seen at two non receiver sites, each located approximately 300 m (1,000 ft) downcoast of receiver sites. However, improved habitat conditions for biological resources were more variable at these non receiver sites across seasons and/or years compared to those at receiver sites, presumably due to differences in extent of indirect nourishment. No obvious influence from the 2001 SANDAG Project was detected at a non receiver site located 2,438 m (8,000 ft) downcoast and 457 m (1,500 ft) upcoast of receiver sites two to four years after sand placement. That site had persistent sand habitat across seasons that may have related to nearshore reefs providing a natural sand retention function. Habitat quality and biological resource use were relatively high at this site although bird use was less than at the wider, receiver sites during high tide conditions.

Results demonstrated that habitat quality and potential biological resource use of sandy beach habitat varied across seasons and tide conditions. Beaches may be quite similar in habitat quality and/or resource development during summer when more sand naturally occurs on beaches. However, resource development may be substantially affected during winter-spring when sand naturally erodes from beaches if sand supply is limited. Sand supply also affects beach width, which typically is wider during fall (after summer accretion) than spring (after winter erosion) and more beach is exposed during low than high tides. Several of the detected differences in biological resource use among beach sites in this study were associated with whether sand depths persisted across seasons and/or beach width was sufficient for birds across high tides as well low tides. The invertebrate community developed earlier in the season, habitat suitability for grunion spanned their entire spawning season, and birds foraged and rested across tide conditions on sand nourished beaches. Some of these functions were limited across seasons and/or high tide conditions at non receiver sites. Habitat functions were seasonally persistent at one of the non receiver beach sites that did not appear to be influenced by the SANDAG project; that site had nearshore reefs that perhaps contributed to sand retention.

The study would have been enhanced by a more complete set of pre-project data. The study design, which included both receiver and non receiver sites helped overcome some of the short comings of limited pre-project data. Seasonal surveys also provided insight regarding the role of sand persistence and supply on biological resource use of sandy beach habitat that otherwise would not have been possible if only single season surveys had been conducted.

Other studies of biological resources after beach nourishment generally have focused on invertebrates, mainly recovery, with lesser attention given to birds and fish. Several studies have reported invertebrate recovery rates of approximately 1 year or less after the impact of sand placement from beach nourishment (Parr 1978, Navqi and Pullen 1982, NRC 1995, Burlas 2001). Some studies have documented improved bird nesting habitat and/or beneficial changes in bird behavior (more time resting less time flying) after beach nourishment (Melvin et al. 1991, CZR 2003). In contrast, a few studies have reported delayed recoveries and/or altered invertebrate communities, which were mainly attributed to dissimilarity in substrate characteristics between placed sediments and native beaches (Reilly and Bellis 1983, Petersen et al. 2001). Dissimilar substrates (e.g., high shell content) also have linked with reduced bird foraging after beach nourishment (Petersen et al. 2001).

The present study was initiated two years after sand placement; therefore, short term impacts and recovery of beach habitat functions and biological resources were not addressed. Placed sediments, which were dredged from offshore borrow sites, were of a similar grain size diameter (overall mean of 0.27 to 0.44 mm) as on native beaches (0.16 to 0.46 mm) and had a silt/clay content of less than < 10 percent (MEC 2000, SANDAG and U.S. Navy 2000). Results demonstrated that these materials were suitable for biological resource development and habitat functions for invertebrates and birds, and resulted in potentially suitable habitat for California grunion two to four years after sand placement. Therefore, no long-term adverse impacts to beach habitat and associated biological functions were indicated from implementation of the 2001 SANDAG Project in the City of Encinitas. Results also indicated that positive benefits to sandy beach habitat functions and biological resources were largely still in effect at the end of the study, four years after sand placement.

8.0 LIST OF PREPARERS

The sampling design was developed by Karen Green, Project Manager (SAIC), in consultation with Kathy Weldon, Program Manager (City of Encinitas). The marine invertebrate surveys were conducted by personnel from SAIC (Karen Green, Victoria Frank, Daniel Heilprin, Andrew Lissner, Charles Phillips, Tom Norris,), City of Encinitas (Nick Christoph, Paul Hartman, Brian Leslie, and Roshan Sirimanne), and MEC-Weston (Karen Green, Bill Isham, Tracy Schuh, Jack Word). The bird surveys were conducted by William Haas (Varanus Biological Services, Inc.) and Andrew Lissner. Invertebrates were identified by Karen Green, John Ljubenkov (Consultant), Lawrence Lovell (Scripps Institution of Oceanography), and Douglas Diener (MEC-Weston). Bruce Ferguson (MEC-Weston) prepared the figure of the study site. Ms. Green prepared all other report figures and the report. Photographs were taken by K. Green, A. Lissner, and W. Haas.

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APPENDIX A

SAND DEPTH AND BEACH WIDTH MEASUREMENTS

A-1. Sand depths measured at City of Encinitas beach sites, 2003-2005.

Beach Site	Sampling Location	Sand Depth (inches)		
		Upper Tide Zone	Middle Tide Zone	Low Tide Zone
October 8-10, 2003 Survey				
Batiquitos Receiver	North	>48	6	28
	Middle	>48	12	29.25
	South	14.5	44.5	23.5
	Average	37	21	27
Cardiff Receiver	North	>48	>48	>48
	Middle	>48	>48	>48
	South	>48	>48	>48
	Average	>48	>48	>48
Moonlight Receiver	North	>48	>48	>48
	Middle	>48	>48	>48
	South	>48	>48	>48
	Average	>48	>48	>48
Leucadia Non Receiver	North	14	8.5	19
	Middle	6	3.5	23
	South	17	>48	13
	Average	12	20	18
San Elijo Non Receiver	North	23	10	13
	Middle	15	12	4
	South	>48	24	27
	Average	29	15	15
Seaside Non Receiver	North	23.5	>48	>48
	Middle	27.5	>48	>48
	South	38	>48	>48
	Average	30	>48	>48
May 10, 2004 Survey				
Batiquitos Receiver	North	> 48	> 48	> 48
Cardiff Receiver	North	26	> 48	> 48
Moonlight Receiver	Middle	42	> 48	> 48
Leucadia Non Receiver	North*	> 48	> 48	36
San Elijo Non Receiver	South	30	20	15
Seaside Non Receiver	South	6	7	> 48
September 28-30, 2004 Survey				
Batiquitos Receiver	North	24	>48	>48
	Middle	18.5	27	>48
	South	26.5	18	>48
	Average	23	31	>48
Cardiff Receiver	North	43	26	48
	Middle	44	34	>48
	South	39.5	18	29.5
	Average	42	26	41
Moonlight Receiver	North	29	>48	23
	Middle***	28	43	25
	South	31	41	>48
	Average	29	44	32

Table A-1. (Continued)

Beach Site	Sampling Location	Sand Depth (inches)		
		Upper Tide Zone	Middle Tide Zone	Low Tide Zone
Leucadia Non Receiver	North**	28	13	>48
	Middle	21	>48	35
	South	34	28	>48
	Average	28	30	44
San Elijo Non Receiver	North	26.75	23.5	18
	Middle	36.5	28	19
	South***	36.5	39	31
	Average	33	30	23
Seaside Non Receiver	North	31	26	36
	Middle	28	18	>48
	South	28	22	>48
	Average	29	22	44
May 25-27, 2005 Survey				
Batiquitos Receiver	North	16	21	>48
	Middle	3	21	32
	South	16	30	37
	Average	12	24	39
Cardiff Receiver	North	23	34	> 48
	Middle	20	> 48	43
	South	3	> 48	> 48
	Average	15	> 43	> 46
Moonlight Receiver	North	36	> 48	> 48
	Middle***	17	39	> 48
	South	15	28	> 48
	Average	23	> 38	> 48
Leucadia Non Receiver	North**	18	30	21
	Middle	21	28	>48
	South	18	37.5	43
	Average	19	32	> 37
San Elijo Non Receiver	North	17	17	8
	Middle	8	19.5	14
	South***	18	25.5	27
	Average	14	21	16
Seaside Non Receiver	North	1	10	> 48
	Middle	7	> 48	> 48
	South	6	31	> 48
	Average	5	> 30	> 48

Table A-1. (Continued)

Beach Site	Sampling Location	Sand Depth (inches)		
		Upper Tide Zone	Middle Tide Zone	Low Tide Zone
October 03-06, 2005 Survey				
Batiquitos Receiver	North	>47	40.5	>47
	Middle	15	27.5	43.5
	South	20.5	21	28
	Average	27.5	29.7	39.5
Cardiff Receiver	North	34.5	22	>47
	Middle	37	>47	>47
	South	33.5	37	>47
	Average	35	35	>47
Moonlight Receiver	North	34.5	33.5	> 47
	Middle***	22.5	> 47	> 47
	South	23	28	> 47
	Average	26.6	36.1	>47
Leucadia Non Receiver	North**	19	15	>47
	Middle	21	32	>47
	South	26	39.5	27
	Average	22	28.8	40.3
San Elijo Non Receiver	North	20.5	18.5	14.5
	Middle	35.5	19	15
	South***	27.5	31.3	40.5
	Average	27.8	22.5	23
Seaside Non Receiver	North	40.5	38.5	>47
	Middle	41	39	>47
	South	18	2	6.5
	Average	33.2	26.5	34.1

Notes: *coarser sand at depths < 12 inches, **coarser sand at depths > 12 inches,
*** sulfide smell at depths > 12 inches

Table A-2. Mean sea level beach widths at City of Encinitas beach sites before and after beach nourishment.

Transect	Years Surveyed for Biological Resources	Mean Sea Level (MSL) Beach Widths (meters)													
		Spring 1999	Fall 1999	Spring 2000	Fall 2000	Spring 2001	Fall 2001	Spring 2002	Fall 2002	Spring 2003	Fall 2003	Spring 2004	Fall 2004	Spring 2005	Fall 2005
SD-710 * Batiquitos	1999, 2003-2005	---	---	---		50.6	74				59.4	38.7	51.5	30.5	37.2
SD-680 Beacons Beach - Leucadia	1999, 2003-2005	21.0	41.4	29.3	43.9	25.6	51.2	43.9	52.7	37.5	55.2	46	48.8	44.8	46.6
SD-670 *Moonlight Beach	1999, 2003-2005	35.7	57.3	41.4	69.2	37.8	82.6	57.3	64.3	52.4	69.2	45.1	67.3	39.6	60.9
SD-650 (ENC-03) San Elijo State Beach	2003-2005	---	---	---	43.3	34.4	45.4	42.4	45.4	39.6	44.8	41.8	47.2	43	44.2
SD-630 * Cardiff State Beach	1999, 2003-2005	23.5	26.8	22.9	40.2	26.1	62.2	32.3	59.1	36.9	56.0	37.5	58.2	55.8	50.9
SD-620 (ENC-05) Seaside	2003-2005	---	---	---	30. 2	26.8	30.5	45.7	41.1	36	38.7	43.3	42.1	36.9	36

Source: Coastal Frontiers 2006.

*SANDAG sand receiver sites; sand was placed between spring and fall 2001.

APPENDIX B
INVERTEBRATE DATA

Table B-1. Range (and mean) abundance of invertebrates collected in shovel samples and relative abundance of invertebrates observed in the wave wash area at City of Encinitas beach sites, 2003-2005.

Beach Site	Tide Zone	Amphipods	Isopod	Sand Crab	Other Mole Crabs	Bean Clam	Other Mollusk	*Euzonus* Worm	Other Polychaetes	Ribbon Worms	Wave Wash
October 2003											
Batiquitos Receiver	U	0-1 (0.3)	0	0-8 (4)	0	0	0	0	0	0	sparse-moderate bean clams
	M	0	0	0	0	0-130 (41)	0	0	0-24 (12)	0	
	L	0	0	0-1 (0.5)	0-1 (0.5)	6-42 (20)	0	0	0-4 (1)	0	
Cardiff Receiver	U	0	0-43 (14)	0-5 (1)	0	0-20 (5)	0	0-995 (171)	0-6 (3)	0	abundant bean clams, dead sand dollar, moon snail egg case
	M	0	0	0	0	6-27 (14)	0	0-21 (3)	1-5 (3)	0	
	L	0	0	0-25 (4)	0	50-236 (101)	0	0	0-2 (0.3)	0	
Moonlight Receiver	U	0-19 (4)	0-1 (0.2)	0-8 (2)	0	0-1 (0.2)	0	0-16 (3)	0-3 (0.5)	0	sparse-moderate bean clams
	M	0	0	0	0	9-127 (67)	0	0	0-7 (2)	0	
	L	0	0	0-1 (0.5)	0	4-12 (7)	0	0	0-2 (0.5)	0	
Leucadia Non Receiver	U	0	0-1 (0.2)	0-8 (4)	0	0	0	0	0-3 (1)	0	sparse-moderate bean clams
	M	0-1 (0.2)	0	0-1 (0.5)	0	13-158 (80)	0	0	2-11 (6)	0	
	L	0	0	0-1 (0.3)	0-1 (0.2)	28-126 (76)	0	0	0-3 (1)	0	
San Elijo Non Receiver	U	0	4-9 (6)	0	0	0	0	206-719 (372)	(10)	0	sparse–moderate bean clams
	M	0	0	0	0	12-84 (49)	0	0	0-2 (1)	0	
	L	0	0	0-1 (0.3)	0	12-28 (16)	0	0	0-3 (1)	0	
Seaside Non Receiver	U	0	0	0-5 (3)	0	0	0	(1)	7-24 (13)	0	sparse-abundant bean clams
	M	0	0	0	0	54-483 (227)	0	0	0-8 (4)	0	
	L	0	0	0-1 (0.3)	0	18-76 (43)	0	0	0	0	
May 2004											
Batiquitos Receiver	U	15-30 (17)	0	0	0	0	0	0	0	0	sparse bean clams
	M	2-15 (9)	0	0	0	0	0	0	0	0	
	L	0-4 (2)	0	0	0-1 (0).5	0-1 (1)	0	0	0-3 (2)	0	
Cardiff Receiver	U	0	0	0	0	0	0	(2,598)	0	0	sparse bean clams
	M	0	0	0	0	1-6 (3)	0	0	0-4 (2)	0	
	L	0	0	0	0	3-8 (5)	0	0	0	1-4 (1)	
Moonlight Receiver	U	0-1 (0.5)	0	0	0	0	0	0	0-1 (0.5)	0	sparse-abundant bean clams
	M	0	0	0	0	0	0	0	2-5 (3)	0	
	L	0	0	0	0	0-1 (0.5)	0	0	0	0	
Leucadia Non Receiver	U	0-8 (4)	0	0	0	0	0	0	0	0	sparse bean clams
	M	1-2 (1.5)	0	0	0	0	0	0	5-9 (7)	0	
	L	0-1 (0.5)	0	0	0	0	0	0	1-2 (1.5)	0	
San Elijo Non Receiver	U	0	0	12-15 (13)	0	0	0	(3,076)	0-1 (0.5)	0	sparse bean clams
	M	0	0	25-26 (25)	0	0	0	(208)	1-1 (1)	0	
	L	0	0	0-1 (0.5)	0	0-2 (1)	0	0	0	0-1 (0.5)	

Table B-1 (Continued)

Beach Site	Tide Zone	Amphipods	Isopod	Sand Crab	Other Mole Crabs	Bean Clam	Other Mollusk	*Euzonus* Worm	Other Polychaetes	Ribbon Worms	Wave Wash
May 2004 (Continued)											
Seaside Non Receiver	U	0	0	0	0	0	0	0	1-2 (1.5)	0	moderate bean clams
	M	0	0	0	0	0	0	0	0	0	
	L	0	0	0	0	24-35 (29)	0	0	0-4 (2)	0	
September 2004											
Batiquitos Receiver	U	0-10 (2)	0	0	0	0	0	0	0-3 (1)	0	moderate bean clams, dead sand dollar, dead pismo clam
	M	0	0	0	0-2 (0.5)	0-1,175 (295)	0	0	0-3 (0.5)	0	
	L	0	0	0	0	31-446 (141)	0	0	0-2 (1)	0-1 (0.3)	
Cardiff Receiver	U	(2)	(3)	0	0	0-1 (0.2)	0	0	0-1 (0.2)	0	abundant bean clams, dead sand dollar, moon snail egg case
	M	0	0	0	0-1 (0.2)	1,227-2,156 (1,489)	0	0	0-5 (1)	0	
	L	0	0	0	0	20-236 (89)	0	0	0-3 (1)	0-3 (1)	
Moonlight Receiver	U	0	0-6 (2)	0	0	0-1 (0.2)	0	0	0-5 (1)	0-1 (0.2)	abundant bean clams, dead sand dollar
	M	0	0	0	0	21-161 (63)	0	0	0-4 (1)	0-1 (0.2)	
	L	0	0	0-1 (0.2)	0-1 (0.2)	23-199 (73)	0	0	0-4 (0.5)	0-1 (0.2)	
Leucadia Non Receiver	U	0-11 (2)	0	0	0	0-1 (0.2)	0	0	0-5 (1)	0	sparse bean clams
	M	0	0	0	0	0-59 (20)	0	0	0-3 (0.5)	0	
	L	0	0	0-3 (1)	0	10-340 (138)	0-1 (0.2)	0	0-5 (1)	0-1 (0.2)	
San Elijo Non Receiver	U	0	6-30 (22)	0	0	0	0	4-500 (292)	(2)	0	sparse bean clams
	M	0	0-2 (0.5)	0-1 (0.3)	0	1-17 (11)	0	0-2 (0.3)	0-2 (1)	0	
	L	0	0	0-1 (0.3)	0-2 (0.3)	0-10 (5)	0	0	0-5 (1)	0	
Seaside Non Receiver	U	0	0-5 (1)	0	0	0-1 (0.2)	0	0	0-4 (1)	0	abundant bean clams, dead sand dollar, moon snail egg case
	M	0	0	0	0	152-900 (541)	0	0	0-1 (0.2)	0-1 (0.2)	
	L	0	0	0	0	47-553 (370)	0-1 (0.2)	0	0-1 (0.2)	0-1 (0.2)	
May 2005											
Batiquitos Receiver	U	0-11 (2.6)	0	0	0	0-2 (0.3)	0	0	0-2 (0.7)	0	sparse-dense bean clams, 5 patches of sand crabs, 1 spiny mole crab molt
	M	0	0	0	0-1 (0.2)	6-135 (66)	0	0	0-3 (1.3)	0	
	L	0	0	*	0-2 (0.3)	0-2 (0.5)	0	0	0-2 (0.6)	0	
Cardiff Receiver	U	0-2 (0.5)	0	0	0	0-6 (1.7)	0	0-3 (0.7)	1-2 (1.5)	0-1 (0.2)	sparse-moderate bean clams, 3 dead sand dollars, 1 dead wavy turban snail
	M	0	0	0	0	5-186 (72)	0	0	0-1 (0.5)	0	
	L	0	0	0	0	0-7 (2.3)	0	0	0-2 (0.3)	0-4 (0.7)	
Moonlight Receiver	U	0-5 (2.3)	0	0	0	0	0	0	0	0	sparse-moderate bean clams, sand crab patches, 1 dead sand dollar
	M	0	0	0	0	25-265 (136)	0	0	0-1 (0.2)	0	
	L	0	0	0-1 (0.2)*	0	0-3 (1)	0	0	0-3 (0.5)	0	

Table B-1 (Continued)

Beach Site	Tide Zone	Amphipods	Isopod	Sand Crab	Other Mole Crabs	Bean Clam	Other Mollusk	*Euzonus* Worm	Other Polychaetes	Ribbon Worms	Wave Wash
Leucadia Non Receiver	U	0-6 (3.3)	0	0	0	0	0	0	0-13 (4.8)	0	sparse-dense bean clams, sand crab patches, 1 dead sand dollar, 1 live wavy turban and shore crab
	M	0	0	0	0	47-901 (446)	0	0	0	0	
	L	0	0	0-3 (0.5)	0	0-6 (1)	0	0	0-1 (0.2)	0	
San Elijo Non Receiver	U	0	0-6 (1.3)	0	0	0	0	0-427 (224)	1-6 (3)	0	no invertebrates observed on sand; snails, crabs, sea hare, octopus observed on reef
	M	0	0	0-288 (60.3)	0	0	0	0-1 (0.2)	0-2 (0.5)	0	
	L	0	0	0-1 (0.2)	0	0-2 (0.5)	0)	0	0	0	
Seaside Non Receiver	U	0	0	0-4 (1)	0	0-1 (0.5)	0	0	0	0	moderate bean clams
	M	0	0	0	0-1 (0.2)	324-606 (457)	0	0	0-1 (0.2)	0	
	L	0	0	0-2 (0.5)	0	10-101 (42)	0	0	0-1 (0.2)	0-1 (0.3)	
October 2005											
Batiquitos Receiver	U	*	0	0	0	0	0	0	0-1 (0.2)	0	sparse bean clams, 3 dead sand dollars, dead croakers
	M	0	0	0-1 (0.3)	0	6-508 (163)	0	0	1-8 (2)	0	
	L	0	0	0	0	6-68 (27)	0	0	0-1 (0.5)	0-1 (0.5)	
Cardiff Receiver	U	1-37 (18.3)	0-18 (4.2)	0	0	0-17 (4.2)	0	0	0	0	sparse bean clams, 1 dead sand dollar, 1 dead lobster tail
	M	0	0-1 (0.2)	0-1 (0.2)	0	1571-3700 (2388)	0	0	0-6 (2.5)	0-1 (0.2)	
	L	0	0	0-1 (0.2)	0	0-18 (8.6)	0-3 (0.5)	0	0-2 (0.8)	0-1 (1)	
Moonlight Receiver	U	0-15 (5.8)	0	0	0	0	0	0	0	0	sparse bean clams, sparse sand crab patches lower intertidal
	M	0	0	0-80 (15.3)	0	3-1151 (353)	0	0	0-6 (3)	0	
	L	0	0	0-83 (14.1)	0	0-106 (41)	0	0	0-3 (2)	0-3 (0.6)	
Leucadia Non Receiver	U	0-15 (4.5)	0	0	0	0	0	0	0	0	sparse bean clams, sand crab patches, dead croaker
	M	0	0	0	0	23-448 (229)	0	0	2-3 (2.3)	0	
	L	0	0	**	0	6-78 (33)	0	0	0-3 (1.2)	0	
San Elijo Non Receiver	U	0-6 (2.5)	0-6 (2)	0-2 (0.3)	0	0	0	0-6 (1.5)	0	0-1 (0.2)	sparse bean clams
	M	0	0-1 (0.2)	0-10 (2)	0	176-556 (353)	0	0	4-8 (4)	0	
	L	0	0	0-1 (0.5)	0	0-38 (11)	0	0	0-1 (0.3)	0	
Seaside Non Receiver	U	3-38 (18)	0	0	0	0-3 (0.5)	0	0	0	0	sparse bean clams, 3 dead sand dollars
	M	0	0	0	0-1 (0.2)	592-1006 (968)	0	0	0-2 (0.5)	0-1 (0.2)	
	L	0	0	0-1 (0.2)	0	0-24 (7)	0	0	0-2 (0.5)	0-1 (0.3)	

Note[1]: October 2003 and September 2004 data based on 6 samples per tide zone per beach, May 2004 data based on 2 samples per tide zone per beach. Note[2]: Range not available for some taxa that were counted as combined category in field; mean determined from lab samples. U = upper intertidal, M = middle intertidal, L = lower intertidal. * Sand crabs observed in wave wash, extra sample collected, see sand crab Table 4-3. ** Sand crabs observed in wave wash, not collected.

Table B-2. Summary of relative abundance of invertebrates collected in shovel samples and observed in the wave wash area at study area and other selected beach sites, May and July 1999.

Beach Site	Tide Zone	Average Sand Depth	Amphipods	Isopod	Sand Crab	Other Mole Crabs	Bean Clam	Other Mollusks	*Euzonus* Worm	Other Worms	Ribbon Worms	Wave Wash
1999												
Batiquitos (May)	U	0	0	0	0	0	0	0	0	0	0	sand crabs
	M	12	0	0	0->10	0	0	0	NA	0->10	NA	
	L	17	0	0	0-<5	0	0	0	NA	0-<5	NA	
Cardiff (May)	U	0	0	0	0	0	0	0	0	0	0	none
	M	0	0	0	0	0	0	0	0	0	0	
	L	23	0	0	0	0	0	0	0	0	0	
Moonlight (May)	U	3	0	0	0	0	0	0	NA	0->10	NA	sand crabs
	M	11	0	0	<5->10	0	0	0	NA	<5->10	NA	
	L	21	0	0	0-<5	0	0	0	NA	0-<5	NA	
Leucadia (May)	U	2	0	0	0-<5	0	0	0	NA	0-<5	NA	sand crabs
	M	8	0	0	0->20	0	0	0	NA	<5->10	NA	
	L	2	0	0	<5	0	0	0	NA	0-<5	NA	
N. Leucadia (July)**	U	22	0	0-1	0	0	0-1	0	0-19	0	0	sand crabs, bean clams
	M	27	0-3	0	0	0	0	0	0	0-1	0	
	L	21	0-14	0	0-22	0	0-22	0	0	1-3	0-1	
Solana Beach** (July)	U	21	0	0	0	0	0	0	0	0	0	sand crabs
	M	25	0-5	0	0	0	0-8	0	0	0-1	0	
	L	37	1-9	0	0-26	0	4-44	0	0	0-3	0-1	
S. Carlsbad (July)**	U	30	0	0	0	0	0	0	0	0	0	sand crabs, bean clams
	M	28	0	0	0	0	0	0	0	0	0	
	L	34	1-11	0	0-1	0	0-13	0	0	0-1	0-1	

Source: MEC 2000, except as noted below.
Note: July 1999** results for S. Carlsbad, N. Leucadia, and Solana Beach based on recent laboratory analysis of preserved samples.
NA = Not analyzed; worms counted but not identified during May field surveys, counts of *Euzonus* and ribbon worms added from lab analysis of July samples.
Note: North Leucadia was surveyed at Leucadia receiver site, approximately 1,000 feet north of Leucadia non receiver site.