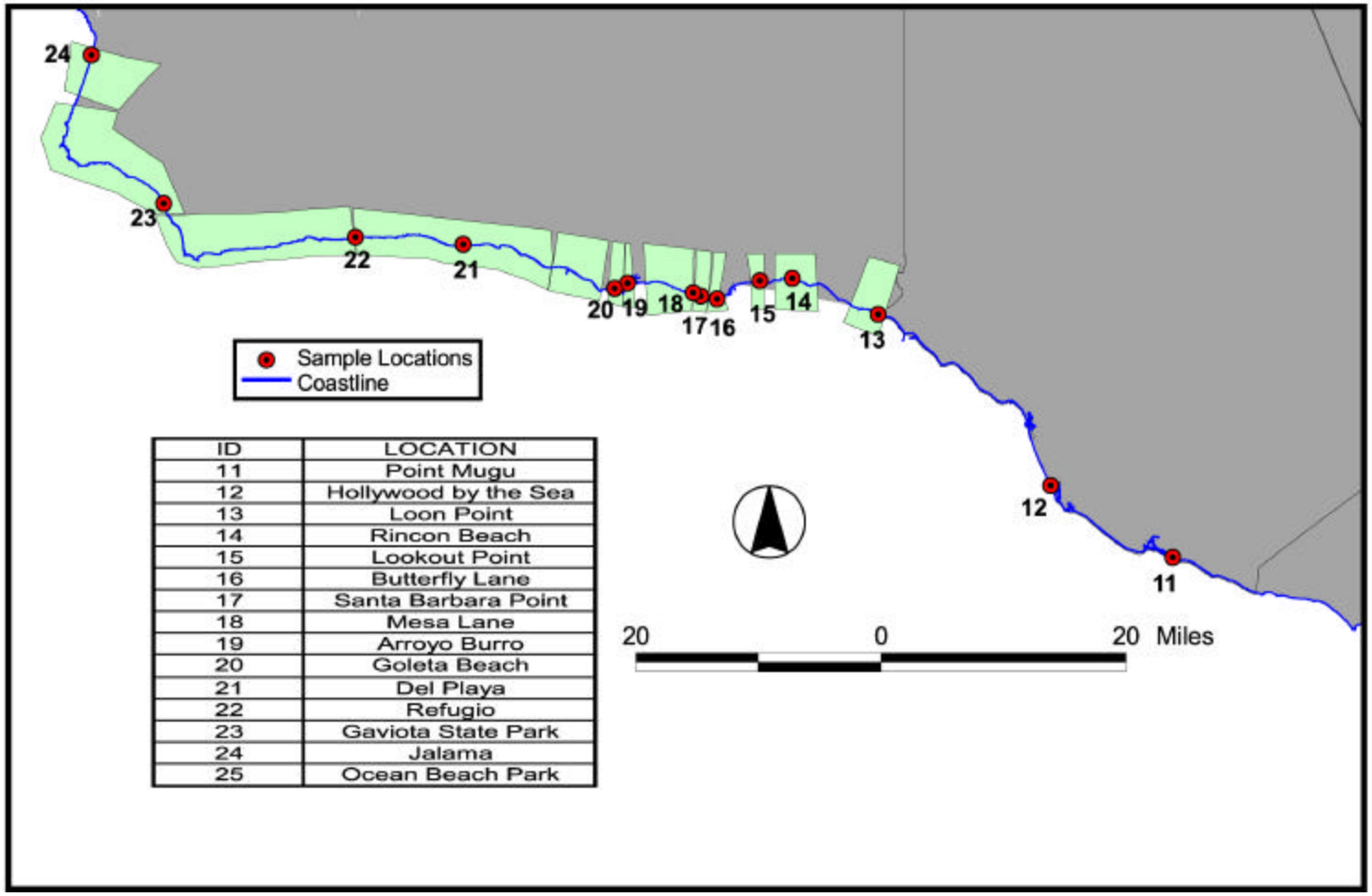
APPENDIX D. BLUFF CONTRIBUTION DATA

Table D.1 Field Data From the Santa Barbara Littoral Cell.

SAMPLE#	GPS WAYPT	LOCATION	TIME	DATE	LAT	LONG	B-C-T	CLIFF HEIGHT	SITE LENGTH	TERRACE THICKNESS	SCHMITT HAMMER
1	4	Pt. Mugu	17:00	4/26/2001	34 05.195	119 03.739	Beach				
2	5	Hollywood by the Sea	17:25	4/26/2001	34 10.387	119 14.131	Beach				
3	6	Rincon Point- Loon Point	18:00	4/26/2001	34 22.606	119 28.831	Cliff	30	5540	0.5	10
4	7	(sample Rincon Beach)			34 22.602	119 28.844	Beach				
5							Terrace				
6	8	Loon Point to Fernald Point	9:00	4/27/2001	34' 25.183	119' 36.158	Beach	21	2934	1-1.5	
7		(sample Lookout Pt)					Cliff				18
7a							Cliff				16
8							Terrace				
9	9	Fernald Point to SB Cemetary	10:00	4/27/2001	34' 25.039	119' 38.930	Beach	29	1350		
10		(sample end of Butterfly Lane)					Cliff/terrace				10
11	10	SB Point to Lighthouse	11:00	4/27/2001	34' 28.785	119' 42.365	Beach	14	2080	3	22
12							Cliff				
13							Terrace				
14	11	Lighthouse to Arroyo Burro	12:00	4/27/2001	34' 23.758	119' 42.622	Beach	14.3	1995	4	42
15		(sample Mesa Lane Stairs)					Cliff				
16	13	Arroyo Burro to Hope Ranch	13:00	4/27/2001	34' 24.191	119' 44.687	Beach	13.7	4200	0.5	14
17							Cliff				
no access:		Hope Ranch- Goleta Pier					No access:				
18	14	Goleta Beach to Goleta Point	13:40	4/27/2001	34' 24.890	119' 50.271	Beach	6.5	1600	3 to 4	28
19		(sample Goleta Beach)					Cliff				
20							Terrace				
21	15	Goleta Point to Coal Oil Point	14:45	4/27/2001	34' 24.521	119' 51.361	Beach	10.2	1960	4	21
22		(sample Del Playa)					Cliff				
23							Terrace				
no access:		Coal Oil Point to Naples	*(use data from next site)				No access:		7280		
24	16	Naples to Port Orford (Gaviota St. Beach)	15:55	4/27/2001	34' 27.651	120' 04.401	Beach	10.2	23640	1	10-20 and 45-55
25		(sample Refugio)					Cliff				
26							Terrace				
27	17	Port Orford to Jalama	16:35	4/27/2001	34' 28.733	120' 13.733	Beach	6.5	28331	0	40
28		(sample Gaviota State Park)					Cliff				
29	18	Jalama to Spring Canyon	18:15	4/27/2001	34' 30.468	120' 30.052	Beach	7.6	31596	2	31
30							Cliff				
31							Terrace				
32	19	Mouth of Santa Ynez River	19:15	4/27/2001	34' 40.977	120; 36.389	DUNE				
		Ocean Beach Park									

Table D.2 Field Data From the Oceanside Littoral Cell.

SAMPLE#	GPS WAYPT	LOCATION	LAT	LONG	B-C-T	CLIFF HEIGHT (M)	SITE LENGTH (M)	TERRACE THICKNESS (M)	SCHMITT HAMMER
100	21	La Jolla Shores	32 51.288	117 15.561	Beach				
101	22	Scripps Pier	32 52.049	117 15.235	Beach	28	6832	3.4	26.4
102					Cliff				
103					Terrace				
104					Cliff2				
105	23	Torrey Pines	32 51.279	117 15.539	Beach	7.7	2556	3.4	12
106					Cliff				
107					Terrace				
108		Power House Park			Beach	8	2858	3.9	20
109					Cliff				
110					Terrace				
111	24	Fletcher	32 57.628	117 16.032	Cliff	4.6	1346	6.2	24
112	25	Encinitas	33 02.078	117 17.561	Beach	14.1	1179	2.8	18
113					Cliff				
114	26	Cardfif	33 01.619	117 17.265	Cliff	9.9	3858	3.7	18
115					Beach				
117	27	Beacon	33 03.983	117 18.353	Beach	3.1	8047	4.3	16
118					Cliff				
119					Terrace				
120	28	San Onofre	33 22.448	117 33.965	Cliff	7.3	19680	0.5	10
121					Beach				
122	29	San Clemente	33 25.819	117 37.847	Beach	13.2	5767	2.3	12
123					Cliff				



ID	LOCATION
11	Point Mugu
12	Hollywood by the Sea
13	Loon Point
14	Rincon Beach
15	Lookout Point
16	Butterfly Lane
17	Santa Barbara Point
18	Mesa Lane
19	Arroyo Burro
20	Goleta Beach
21	Del Playa
22	Refugio
23	Gaviota State Park
24	Jalama
25	Ocean Beach Park

Figure D.1 Sample Locations for the Santa Barbara Littoral Cell

Table D.3 Grain Size Analysis to Determine Littoral Cell Cutoff Diameter in San Diego

LOCATION	PHI	RAW WEIGHT	CUM. WEIGHT	INDIVIDUAL %	CUM. %
La Jolla Shores	1	0.77	0.77	0.44%	0.44%
#100	1.5	1.12	1.89	0.64%	1.09%
Beach	2	13.28	15.17	7.63%	8.71%
	2.5	83.55	98.72	47.98%	56.69%
	3	59.75	158.47	34.31%	91.00%
	3.5	14.79	173.26	8.49%	99.49%
	>3.5	0.88	174.14	0.51%	100.00%
N. Scripps Pier	1	0.92	0.92	0.64%	0.64%
#102	1.5	0.84	1.76	0.58%	1.22%
Beach	2	7.03	8.79	4.88%	6.10%
	2.5	65.88	74.67	45.75%	51.85%
	3	54.44	129.11	37.80%	89.65%
	3.5	14.25	143.36	9.90%	99.55%
	>3.5	0.65	144.01	0.45%	100.00%
Torrey Pines	1	2.69	2.69	1.05%	1.05%
#105	1.5	10.22	12.91	3.97%	5.02%
Beach	2	96.27	109.18	37.42%	42.44%
	2.5	104.63	213.81	40.67%	83.12%
	3	37.08	250.89	14.41%	97.53%
	3.5	5.96	256.85	2.32%	99.85%
	>3.5	0.39	257.24	0.15%	100.00%
Power House Park	1	4.48	4.48	1.98%	1.98%
#108	1.5	12.28	16.76	5.42%	7.40%
Beach	2	85.52	102.28	37.76%	45.16%
	2.5	90.19	192.47	39.83%	84.99%
	3	28.46	220.93	12.57%	97.56%
	3.5	5.14	226.07	2.27%	99.83%
	>3.5	0.39	226.46	0.17%	100.00%
Encinitas Swami	1	0.94	0.94	0.97%	0.97%
#112	1.5	0.91	1.85	0.93%	1.90%
Beach	2	7.19	9.04	7.39%	9.29%
	2.5	44.64	53.68	45.86%	55.14%
	3	43.41	97.09	44.59%	99.73%
	3.5	0.26	97.35	0.27%	100.00%
	>3.5	0	97.35	0.00%	100.00%

Cardiff	1	1.3	1.3	0.90%	0.90%
#115	1.5	3.5	4.8	2.42%	3.31%
Beach	2	23.21	28.01	16.03%	19.34%
	2.5	69.63	97.64	48.08%	67.42%
	3	39.19	136.83	27.06%	94.48%
	3.5	7.69	144.52	5.31%	99.79%
	>3.5	0.31	144.83	0.21%	100.00%
Beacon	1	1.57	1.57	0.55%	0.55%
#117	1.5	5.36	6.93	1.88%	2.43%
Beach	2	148.57	155.5	52.17%	54.60%
	2.5	97.17	252.67	34.12%	88.72%
	3	28.24	280.91	9.92%	98.64%
	3.5	3.84	284.75	1.35%	99.99%
	>3.5	0.04	284.79	0.01%	100.00%
San Onofre Beach	1	178.7	178.7	50.15%	50.15%
#121	1.5	89.3	268	25.06%	75.21%
Beach	2	74.22	342.22	20.83%	96.04%
	2.5	12.22	354.44	3.43%	99.47%
	3	1.6	356.04	0.45%	99.92%
	3.5	0.2	356.24	0.06%	99.97%
	>3.5	0.1	356.34	0.03%	100.00%
San Clemente	1	201.1	201.1	60.31%	60.31%
#122	1.5	75.52	276.62	22.65%	82.95%
Beach	2	42.42	319.04	12.72%	95.67%
	2.5	10.8	329.84	3.24%	98.91%
	3	2.62	332.46	0.79%	99.70%
	3.5	0.92	333.38	0.28%	99.97%
	>3.5	0.09	333.47	0.03%	100.00%

Table D.4 Grain Size Analysis to Determine Littoral Cell Cutoff Diameter in Santa Barbara

LOCATION	PHI	RAW WEIGHT	CUM. WEIGHT	INDIVIDUAL %	CUM. %
Pt. Mugu (#1)	1	51.2	51.2	37.90%	37.90%
	1.5	46.3	97.5	34.28%	72.18%
	2	31.7	129.2	23.47%	95.65%
	2.5	5.1	134.3	3.78%	99.42%
	3	0.7	135	0.52%	99.94%

	3.5	0.07	135.07	0.05%	99.99%
	>3.5	0.01	135.08	0.01%	100.00%
Santa Barb	1	9.94	9.94	4.92%	4.92%
Point (#11)	1.5	22.44	32.38	11.11%	16.04%
	2	86.58	118.96	42.88%	58.91%
	2.5	67.78	186.74	33.57%	92.48%
	3	14.15	200.89	7.01%	99.48%
	3.5	0.99	201.88	0.49%	99.98%
	>3.5	0.05	201.93	0.02%	100.00%
Del Playa	1	3.61	3.61	1.44%	1.44%
#21	1.5	20.01	23.62	7.97%	9.41%
	2	138.56	162.18	55.22%	64.63%
	2.5	68.51	230.69	27.30%	91.93%
	3	19.06	249.75	7.60%	99.53%
	3.5	1.14	250.89	0.45%	99.98%
	>3.5	0.05	250.94	0.02%	100.00%
Refugio	1	9.06	9.06	4.09%	4.09%
#24	1.5	20.98	30.04	9.48%	13.57%
	2	110.22	140.26	49.79%	63.36%
	2.5	59.39	199.65	26.83%	90.19%
	3	18.64	218.29	8.42%	98.61%
	3.5	3.06	221.35	1.38%	99.99%
	>3.5	0.015	221.365	0.01%	100.00%
Jalama	1	5.55	5.55	6.72%	6.72%
#29	1.5	12.89	18.44	15.60%	22.32%
	2	34.41	52.85	41.65%	63.98%
	2.5	26.79	79.64	32.43%	96.40%
	3	2.87	82.51	3.47%	99.88%
	3.5	0.07	82.58	0.08%	99.96%
	>3.5	0.03	82.61	0.04%	100.00%
Ocean Beach Park	1	4.4	4.4	1.62%	1.62%
	1.5	48.15	52.55	17.68%	19.29%
	2	176.02	228.57	64.62%	83.91%

	2.5	39.93	268.5	14.66%	98.57%
	3	3.73	272.23	1.37%	99.94%
	3.5	0.11	272.34	0.04%	99.98%
	>3.5	0.06	272.4	0.02%	100.00%

Table D.5 Grain Size Analysis of Sea Cliff Samples from Santa Barbara

SANTA BARBARA		ORIGINAL WEIGHT (G)		POST TUMBLE (4 PHI SCREEN)			FINER THAN 3.0 PHI (G)	CLIFF/TERRACE THAT WILL END UP ON THE BEACH (G)	% OF SAND SIZE MATERIAL EMANATING FROM CLIFF
	BEACH/CLIFF	BEACH	CLIFF/TERRACE	TOTAL (G)	CLIFF ONLY REMAINING (G)	PEBBLES (G)			
SANTA BARBARA POINT	Cliff	100	100	121	21	0.05	4.7	16.25	16.26%
DEL PLAYA	Cliff	100	78.4	100.1	0.1	1.4	0.9	-2.2	-2.86%
DEL PLAYA	Terrace	100	100	140.9	40.9	9.42	29.54	1.94	2.14%
MESA LANE	Cliff	100	99.8	128.5	28.5	30.6	4.63	-6.73	-9.73%
ARROYO BURRO	Cliff	100	100	128.6	28.6	21.1	2	5.5	5.50%
REFUGIO	Cliff	100	100	181.7	81.7	84.2	3.7	-6.2	-6.20%
JALAMA	Cliff	50	50	90.8	40.8	41.7	1.3	-2.2	-4.40%
RINCON POINT	Cliff	100	100	109.2	9.2	8.4	2.7	-1.9	-1.90%
GOLETA BEACH	Cliff	100	100	119.2	19.2	19.4	3	-3.2	-3.20%
GAVIOTA BEACH	Cliff	50	50	88	38	42.4	3.1	-7.5	-15.00%
SAMPLES THAT DID NOT GET TUMBLED									
REFUGIO	Terrace	0	100	99.8	99.8	6.1	12.6	81.1	81.10%
JALAMA	Terrace	0	50	49.5	49.5	6.9	10.2	32.4	64.80%
GOLETA BEACH	Terrace	0	100	99.5	99.5	8.7	46.2	44.6	44.60%
BUTTERFLY LANE	Terrace	0	100	100.1	100.1	2.6	26.5	71	71.00%
RINCON POINT	Terrace	0	100	99.8	99.8	14.8	15.3	69.7	69.70%

Table D.6 Grain Size Analysis of Sea Cliff Samples from San Diego

San Diego		Original Weight (g)		Post Tumble (4 phi screen)			Finer than 3.0 phi (g)	Cliff/terrace that will end up on the beach (g)	% of sand size material emanating from cliff beach
	Beach/cliff	beach	cliff/terrace	Total (g)	Cliff only remaining (g)	Pebbles (g)			
San Onofre	Cliff	100	100	160.1	60.1	1.84	3.8	54.46	55.48%
Torrey Pines	Cliff	100	100	156.1	56.1	2.36	5.5	48.24	49.41%
Torrey Pines	Terrace	100	100	160.3	60.3	5.45	4	50.85	53.78%
Cardiff	Cliff	50	50	76.1	26.1	0.44	3.5	22.16	44.71%
Cardiff	Terrace	50	50	84.1	34.1	0	0.7	33.4	66.80%
N. Scripps Pier	Terrace	50	50	64.5	14.5	5.1	7.1	2.3	4.60%
Encinitas (Swamis)	Cliff	100	100	181.2	81.2	4.4	5.5	71.3	71.30%
San Clemente	Cliff	100	100	111.1	11.1	5.9	6.8	-1.6	-1.60%
Powerhouse Park	Cliff	100	100	167.7	67.7	4.4	17.3	46	46.00%
Powerhouse Park	Terrace	100	100	186.9	86.9	0	1.7	85.2	85.20%
Beacon	Terrace	100	100	192.3	92.3	0	0.3	92	92.00%
Beacon	Cliff	100	100	180.3	80.3	8.9	6.4	65	65.00%
N. Scripps Pier	Terrace	50	50	99.8	49.8	13.6	10.4	25.8	51.60%

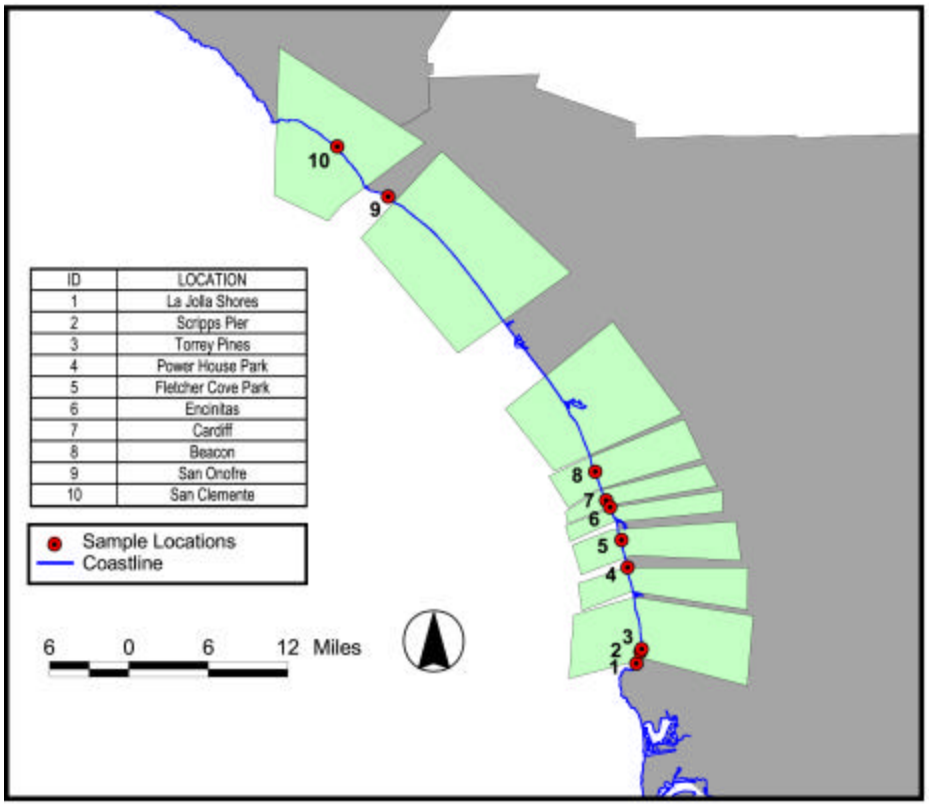


Figure D.2 Sample sites in the Oceanside Littoral Cell

Table D.7 California Coastal Armor Summary: 1971 to 2001

CALIFORNIA COASTAL ARMOR SUMMARY: 1971 TO 2001								
All data shown in kilometers								
Location	Total Shoreline[1]	1971 Armor[2]	1977 Armor[3]	1989 Armor[4]	1998 Armor[5]	2001 Armor[6]	Breakwaters[4]	Total
	(km)	(km)	(km)	(km)	(km)	(km)	(km)	(km)
Del Norte County	73.06	1.93	1.00	7.24		0.92	2.09	3.01
City of Crescent City	4.02			2.01		no data		
Humboldt County	195.70	0	0.00	0.06		0.98		0.98
Mendocino County	196.66	0	0.31	0.48		no data	0.48	0.48
City of Fort Bragg	5.63			0.00		no data		
Sonoma County	100.58	[0.32]	0.00	0.06	0.02	1.69	0.00	1.69
Marin County	112.98	2.74	1.29	1.61	2.25	no data		2.25
San Fransisco City / County	13.52	1.93	2.03	3.22	2.25	-		2.25
San Mateo County	89.96	0	2.72	0.31		5.50	2.41	7.91
City of Daly City	4.18			0.21		0.61		
City of Pacifica	9.66			4.02		no data		
City of Half Moon Bay	9.98		0.00	-		0.21		
Santa Cruz County	67.27	4.67 (+prvt SWs)	6.18	16.09	12.87		0.00	12.87
City of Sant Cruz	9.66			0.80				
City of Capitola	2.25			1.29		0.61		
Monterey County	179.12	0	3.03	1.61	1.45	5.92	1.00	6.92
City of Marina	5.31			0.00		no data		
City of Sand City	2.41			0.48		no data		
City of Monterey	5.63			1.61		no data		
San Luis Obispo County	148.54	0.48 & [2.25]	4.43	4.02	0.97	4.20	2.55	6.75
Pismo Beach	11.27			1.61		3.22		
Santa Barbara County	176.71	5.63 & [0.80]	14.08	16.09	22.53	no data	0.80	23.33
City of Santa Barbara	9.66			2.41		0.55		
City of Carpinteria	4.02			0.00		no data		

Ventura County	66.31	18.02 & [1.77]	26.23	43.45	30.09	no data	1.10	31.19
City of Buenaventura	10.46			2.41		no data		
City of Oxnard	10.46			0.08		no data		
City of Port Hueneme	2.41			1.21		0.48		
Los Angeles County	118.77	3.21 & [2.90]	8.05	4.02		1.67	16.74	18.41
City of Los Angeles	25.75			7.24 (bw - not in total)		no data		
City of Santa Monica	4.83			0.00		0.00		
City of Manhattan Beach	3.62			0.14		0.14		
City of Redondo Beach	4.02			1.61		no data		
City of Palos Verdes Estates	8.85			0.14		0.16		
City of Rancho Palos Verdes	12.07			0.24		0.24		
City of Long Beach	8.05			7.56		no data		
Orange County	67.43	0.32 & [2.74]	20.62	3.22	19.63	no data	1.93	21.56
City of Seal Beach	4.02			3.22		no data		
City of Huntington Beach	13.68			1.61		no data		
City of Newport Beach	8.45			1.61		no data		
City of Laguna Beach	10.46			3.22		no data		
City of San Clemente	7.32			7.32		no data		
San Diego County	122.47	5.79 & [3.54]	10.06		38.30	0.00	1.11	39.41
City of Oceanside	5.63			4.02		no data		
City of Carlsbad	10.46			3.22		no data		
City of Encinitas	10.14			1.21		no data		
City of Solana Beach	2.41			0.40		0.47		
City of Del Mar	3.54			0.97		no data		
City of San Diego	32.99			10.62		no data		
City of Coronado	45.06			17.70		1.16 / 3.06		

City of Imperial Beach	5.31			2.41		no data		
Totals	1729.08	7.24 & [14.3]	100.00	188.37	130.37	11.75	30.06	
Key								
1. From Boating and Waterways 1977 Report: Assessment and Atlas of Shoreline Erosion along the California Coast								
2. From 1971 National Shoreline Study California Regional Inventory, US Army Corp of Engineers								
3. From Boating and Waterways 1977 Report: Assessment and Atlas of Shoreline Erosion along the California Coast								
4. From the 1989 Series of County and City Interviews completed at U.C. Santa Cruz								
5. From 1998 Aerial Oblique Digital Photography Transferred to GIS								
6. The 2001 Series of County and City Interviews completed at U.C. Santa Cruz								
7. From Both 1971 Nat. Shoreline Study, and Boating and Waterways 1977 Report								
BW = Breakwater								

SUMMARY OF ERROR ANALYSIS

Santa Barbara Littoral Cell

- ***Erosion Rates*:** Data taken from Griggs, G.B. and Savoy, L.E., 1985. *Living with the California Coast*, Duke University Press, Durham, N.C., 393 p.
- ***Littoral Cut off Diameter*:** (3 Phi/ 0.125mm), 6 beach samples ranging from 98.61%-99.98% > 0.125 mm.
- ***Bedrock/Terrace Heights:*** Twenty-four field measurements were taken over 144 miles of coast using an inclinometer.
- ***Armor Length***: +/- 10%
- ***Percent sand in terrace***: 6 samples; range: 44.6% - 81.1%, average 60%
- ***Percent sand in cliff***: 9 samples: range: -15%- 5.5%; average = 0.1%

SAN DIEGO/OCEANSIDE LITTORAL CELL:

- ***Erosion Rates*:** Data taken from Benumof, B.T. and Griggs, G.B., 1999. The Relationship Between Seacliff Erosion Rates, Cliff Material Properties, and Physical Processes, San Diego, California. *Shore and Beach 67:4: 29-41*.
- ***Littoral Cut off Diameter*:** (3.5 Phi/0.0875 mm): 10 beach samples ranging from 99.39-100% > 0.0875 mm.

- ***Bedrock/Terrace Heights***: Nine field measurements were taken over 48 miles of coast using an inclinometer.
- ***Armor Length:*** +/- 10%
- ***Percent sand in terrace***: 6 samples: range 4.6%-92% average: 59%
- ***Percent sand in cliff*****:** 7 samples: range 44.71%-71.3% average: 55.3%

Quantifying the error involved in determining the total volume of sand contributed from the sea cliffs of the Santa Barbara and San Diego littoral cells to the beach and thus the amount of sand prevented from ending up on the beach because of cliff armoring is a challenging problem. The variables and potential sources of error can be significant in a project of this scope, simply because of the length of coast involved in each cell and therefore the amount of shoreline that has to be considered or sampled. The ability to deal with problems of scale was limited by the time available and the budget for the project. The following section discusses the potential sources of error or variance in each component of the sand budget components that were calculated and therefore the confidence in the values determined.

The **height of the bedrock and thickness of the terrace deposits** were determined in the field with an inclinometer. Because nearly all of the bluffs were uplifted coastal marine terraces, the height of the cliffs is quite uniform alongshore and within each study segment. The margin of error in these field measurements was sufficient for the scope of this project and believed to be quite low. Seventy-seven miles of bluffs are involved in the Santa Barbara Cell, and field measurements of bluff height varied from 21 ft to 98 ft. In the Oceanside Cell, 48 miles of shoreline were analyzed and coastal bluffs (comprising 35 miles of this cell) varied in height from 10 ft to 92 ft. Terrace thickness varied from 0.3 to 13.1 ft in the Santa Barbara Cell and from 2 to 20 ft in the Oceanside Cell.

The methods involved in determining the **sand content** for the bluff and terrace deposits have been discussed in this report. In coastal segments ranging from less than a mile to 20 miles long it is difficult to know how representative the sample locations may be in both the Oceanside and Santa Barbara littoral cells. The more samples collected and analyzed, the higher the confidence in the average value obtained. The sand content for the bluffs and terraces were averaged along the entire length of the littoral cells to reduce error, thus a single average value was used for each cell.

A few anomalous samples were encountered during the analysis of the sand content of the bluffs and terraces. In Santa Barbara, one bedrock sample did contain 16% littoral-size material. It was collected from Pt. Santa Barbara, near the Santa Barbara Harbor. This

point consists of the Santa Barbara formation, which does contain sand but has only a very limited coastal outcrop area. Also in Santa Barbara, a terrace deposit sample taken from Isla Vista was found to contain only 2.14% sand-size material. This may have resulted from human error when sampling; it is possible that a bedrock sample was interpreted to be a terrace sample. In the Oceanside littoral cell, one bedrock sample contained no sand-size material. This sample was not consistent with the results from the rest of the cell, and was disregarded as anomalous.

The **littoral cutoff diameter** for each cell was determined by means of a sieve analysis. In the Santa Barbara Littoral Cell, six mid-swash zone beach samples were analyzed; 98.6%-99.98% of the sand was coarser than 0.125 mm, thus 0.125 mm (or 3 phi) was taken as the littoral cutoff diameter.

In the Oceanside Littoral Cell, ten beach sand samples were analyzed; 99.4% -100% of the sand in these samples was coarser than 0.088mm (3.5 phi), which was therefore selected as the littoral cutoff diameter. Overall, there was a narrow range of grain sizes in the beach sands in both littoral cells, so the cutoff value used seems to be representative and is not believed to be a significant source of error.

The extent of **armor** throughout the Santa Barbara and Oceanside cells was determined by transferring visually-identified armor from a digital video of the coast to a GIS format using digital 7.5-minute quadrangles as a base map. As previously discussed, armor was often difficult to identify from the video, in part due to the increasing efforts to make new seawalls visually match the existing cliff materials. There also are some low structures that may have been covered with beach sand when the video was shot, thereby making them difficult to recognize. While it is unlikely that a section of unprotected bluff will be mistaken for an armored section, it clear that not all armor could be identified in the video. Thus, we believe that the values obtained for percent of the cells armored represent an underestimate rather than an overestimate. Another challenge in documenting the extent of shoreline armoring was matching the video to the 7.5-minute quadrangles in the GIS. After repeated attempts to digitize the same segment of armor, we determined that there is an inherent digitizing error in this process of ± 50 ft. The digitizing error combined with the visual interpretation error is estimated to be approximately 10% of the total armor.

The greatest potential for error in calculating the sand contribution from sea cliffs is the bluff **erosion rates**. No new erosion rates were calculated in this study. The values used were taken from Griggs and Savoy (1985) for the Santa Barbara Cell, and from Benumof and Griggs (1999) for the Oceanside Cell. Benumof and Griggs (1999) used the most accurate method available for

calculating erosion rates to date: soft-copy photogrammetry. The aerial photographs used for the Oceanside Cell span a period of 40-60 years. The average long-term erosion rate was used for this study. *Living with the California Coast* (Griggs and Savoy, 1985) included input on a regional basis from a group of coastal geologists in California, and maps included in that source incorporate the site-specific cliff erosion rates known at that time. These erosion rates were calculated using comparative measurements of historic and recent aerial photographs and maps, although the uncertainty in these data is impossible to quantify. Because most of the Santa Barbara cell shoreline is relatively linear and uniform (two principal formations are exposed), we believe any variations in the measurements were reduced in our use of an average value for the cell segments.

Natural processes vary temporally and spatially. We used the most up-to-date figures available for stream flow and sediment contributions, and collected and analyzed as many samples as time allowed for the calculations of bluff input. While many more samples from the bedrock and terrace deposits of the coastal bluffs would have increased our database, and additional bluff erosion rates would have been desirable, collecting them wasn't feasible in the length of time available for this study. We have used all the reliable data available, and the relatively narrow range in values for erosion rates and littoral sand content, for example, provide confidence that the values obtained are representative. Given the time and scope of this project, a thorough quantitative error analysis was not possible.