

APPENDIX F

Kelp Wrack Monitoring for Existing Wheeler North Reef

27 February 2018

Wheeler North Reef Kelp Wrack Monitoring 1999-2005 and 2008-2013

In accordance with the Artificial Reef Program Environmental Impact Report's (PEIR) Recommended Mitigation Measures, and in compliance with: 1) Special Condition #12 of SCE's California Coastal Commission (CCC) construction permit (CCC, 2008); 2) the Wheeler North Reef (WNR) project's USACOE Permit - File No. SPL-2007-00466-JPL - Special Condition #17 (USACOE, 2008); and 3) a special requirement of the California State Lands Commission (CSLC) lease agreement, SCE and Coastal Environments (CE) conducted beach kelp wrack and rock hazard monitoring along 3.7 miles of the San Clemente beach adjacent to the WNR after the building of both the Phase I Experimental Reef and the Phase II WNR. Between November 1999 and October 2005, 108 different kelp wrack surveys were completed in which the amount of kelp wrack on the beach was measured and beach pictures taken during each survey. Between October 2008 and September 2013, 113 additional kelp wrack surveys were conducted by SCE and CE. This monitoring activity and the data collected have been provided to the California Coastal Commission's (CCC) Executive Director, the San Diego Regional Water Quality Control Board (RWQCB), the CSLC, the U.S. Army Corps of Engineers (USACOE), and the City of San Clemente's Division of Park & Beach Maintenance.

Surveys were performed within 48 hours following large wavestorm or swell events, as prescribed by the State Lands lease agreement, and as close to the lower-low-tide as practical on each survey day. During each survey, kelp wrack was measured on the City of San Clemente's public beach (3.7 miles) at five permanent survey stations from El Portal/ Buena Vista to San Mateo Point (Figure 1). Standard data collection procedures were established in 1999 following construction of the Phase 1 Experimental Artificial Kelp Reef. The quantitative data collection procedures were initially developed and used by Dr. Claude Zobell in his kelp wrack assessments along the coast of Southern California in the 1950s (Zobell, 1959). The WNR kelp wrack surveys applied the Zobell transect station assessment methodology directly, in order to produce consistency with the historic surveys completed in the area, as well as to assure validity and consistency between the various sets of beach kelp wrack data.

In addition to the five permanent survey stations (Figure 1), the amount of kelp wrack (in cubic feet) along the entire 3.7 miles of beach was also estimated. The beach was subdivided into three areas for this part of the survey, and the amount of kelp wrack in each area was recorded. On each survey date, photographs were taken of the five permanent transect stations and the three stretches of beach. Any perceived unusual materials on the beach or unusual algal wrack were photographed and the locations noted.

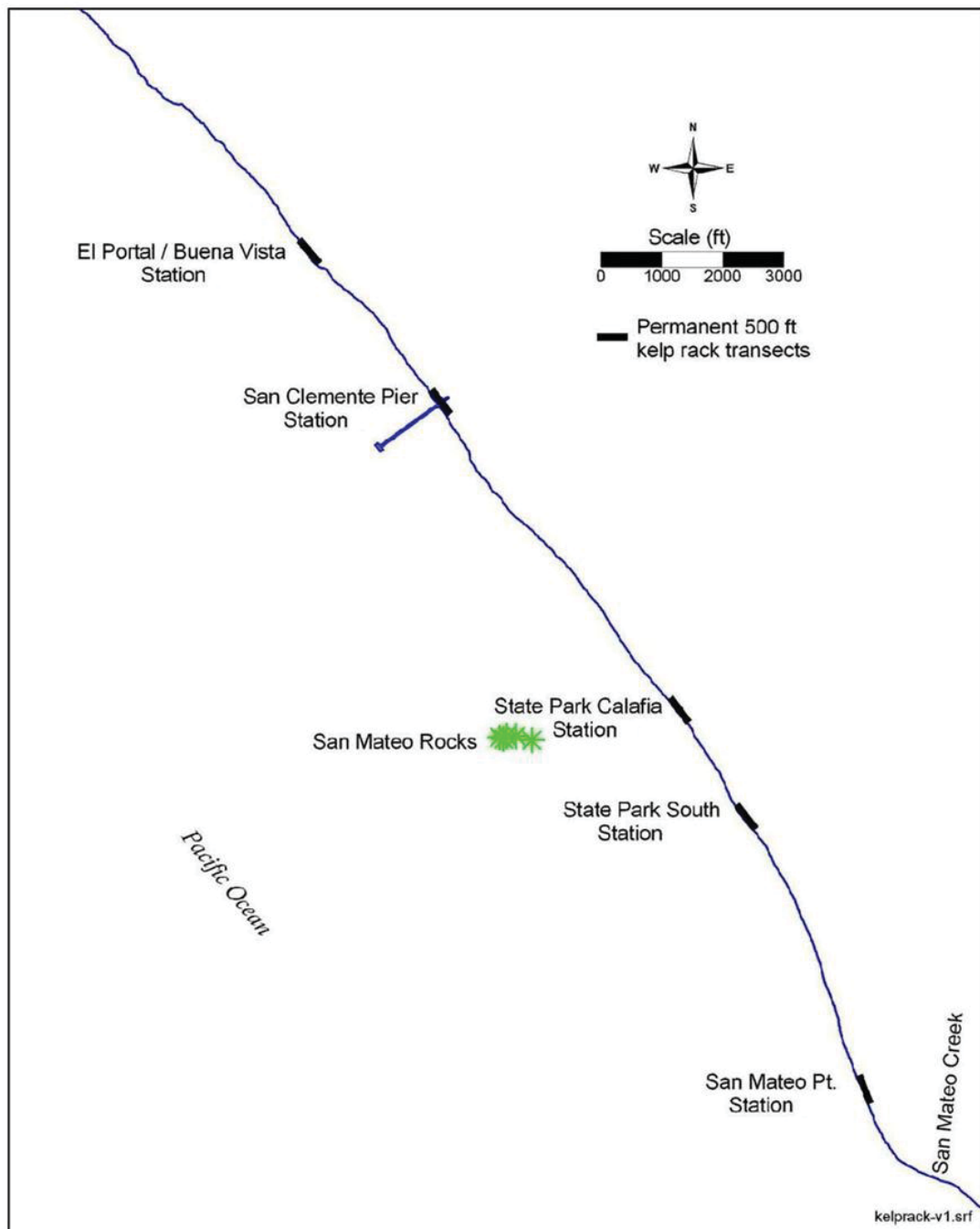


Figure 1. Locations of the five permanent 500-ft transects for the quantitative assessment of kelp wrack in the San Clemente study area.

SURVEY RESULTS

No quarry rock or broken concrete that could be associated with the WNR was observed by SCE or CE personnel along San Clemente beach during any of the surveys. This was in agreement with the observations of the City of San Clemente Park and Beach Maintenance Division (periodic personal communication, Dennis Roger Reed, City of San Clemente, 2008-2013). According to Mr. Reed, there were only two occurrences in five years where excessive kelp wrack beach clean-up efforts were required. One of these occurred at the end of July 2009, when the kelp from the WNR was just beginning to grow and thus was not able to contribute to the kelp wrack on the beach. The other clean-up effort occurred on November 30, 2010.

During one of the kelp wrack surveys, State Parks lifeguard Karl Ulrick (2010) said that the State Beach administration supports kelp wrack as a vital component of the beach ecosystem and that kelp wrack acts favorably as a barrier on the beach to slow down littoral drift and allow sand to build up at the wrack piles, such that sand retention on the beach is enhanced. As a general policy, State Parks does not remove kelp wrack from the beach unless it becomes so voluminous as to create a nuisance. In addition, several recent studies (Dugan & Hubbard, 2010; Dugan et al., 2010, 2011) have shown other beneficial consequences of leaving kelp wrack on the beach, including:

- Foraging opportunities for shorebirds,
- Trapping sand to allow native coastal strand plants to become established,
- Trapping sand to help create sand dunes, and
- Supplying nutrients to coastal ecosystems.

Besides kelp wrack being beneficial to the beach ecosystem, CE can also show that the amount of kelp wrack on the beach is not so voluminous as to impact beach goers and is in fact less than the historical amount of kelp wrack found on San Clemente beach during the mid-1950's, when Zobell did his surveys.

Figure 2 compares the kelp wrack surveyed at the San Clemente Pier transect during both the 1999-2005 and 2008-2013 periods with Zobell's surveys of the same transect in the mid-1950s. In 1956, there was significantly more kelp wrack surveyed along this transect than during any other year (880 cubic ft in July 1956 and 940 cubic ft in November 1956). The largest kelp wrack event at this transect during the 1999-2005 survey period was 414 cubic feet of kelp wrack on 9 December 2004. The largest event during the 2008-2013 survey period was 322 cubic feet of kelp wrack on 2 September 2011. This September 2011 event occurred after a very unusual ocean swell that had a swell period of approximately 25 seconds for more than 24 hrs. This long period event produced large amounts of kelp wrack across Southern California beaches.

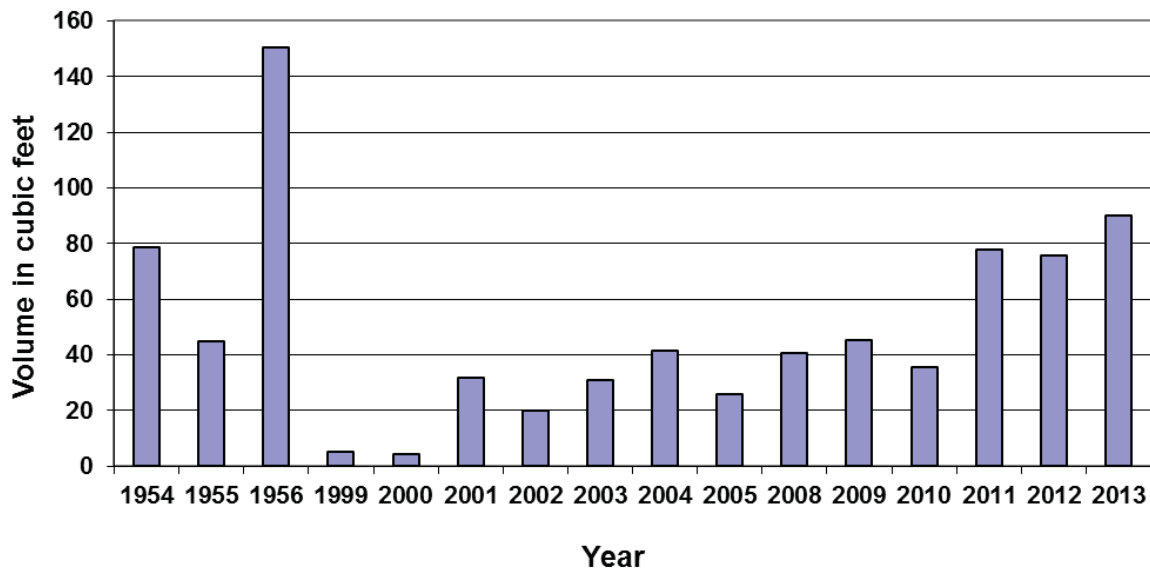


Figure 2. Average volume (ft³) of kelp wrack per month at the San Clemente Pier transect for 1954-1956 (Zobell, 1959), 1999-2005 (SCE), and 2008-2013 (CE).

On an annual basis, the volume of kelp wrack has been increasing since the CE kelp wrack surveys began in 1999 (Figure 2). This is likely for two primary reasons: first and most important is the region-wide recovery of kelp beds off the Southern California coast beginning in 1999, and really taking off starting in 2007. Beginning with the El Niño winter of 1991-1992, kelp beds across San Diego and Orange counties were much reduced. Almost all of the remaining kelp beds were wiped out by the strong El Niño winter of 1997-1998. This fluctuation in kelp bed coverage is shown in Figures 3 and 4 (MBC, 2013), which includes the San Mateo Point kelp bed (just south of the WNR) and the San Clemente kelp bed, which includes WNR. Kelp bed coverage increased dramatically starting in 2007 with the return of cool waters off the Southern California coast. An increase in kelp coverage has brought an associated increase in kelp wrack. As an example of this, the largest volume of kelp wrack observed in the 2008-2013 survey period was on 18 Feb 2009, when the WNR kelp bed had just begun growing and had not yet come close to the water surface, and was not yet a contributor to kelp wrack on the beach.

In addition to the regional events, the completion of both the Phase 1 Experimental Reef in 1999 and the Phase 2 WNR in 2008 has also likely contributed to the increasing quantity of kelp wrack seen on San Clemente beaches. In comparison with the mid-1950s, however, when Zobell collected his data, the amount of kelp wrack during the 1999-2013 period has generally been less (Figure 2).

When considering the kelp wrack on the beach issue, and whether it is so voluminous as to create a nuisance for beach goers, it is important to keep in mind what a large amount of surveyed kelp wrack on the beach actually looks like. Photos 1 and 2 below show the kelp wrack on the beach during a typical survey during the 2008-2013 period; and also on the date of the

largest amount of kelp wrack observed (18 Feb 2009). As one can see, the volume of kelp wrack at its worst is still insignificant in area compared to the beach itself.

Concerning the proposed WNR extension, most of the additional reef acreage will be located to the north of the present WNR and north of the San Clemente Pier, extending approximately 2.6 miles. Because the new reef acreage is not east or west of the present reef, the bulk of kelp wrack that becomes detached from the reef will land on the beach to the north of San Clemente Pier and will not add substantially to the areas previously surveyed. The density of kelp wrack from the additional acreage should be similar to what was seen between 2008-2013, except that the kelp wrack will predominantly be on the beach to the north of the Pier.



Photo 1. Typical amount of kelp wrack observed on beach after wavestorm. Picture is from 10 Sep 2013, near San Mateo Point on San Clemente State Beach.



Photo 2. Photograph of San Clemente State Beach from just north of the pier, showing amount of kelp wrack on the beach during the largest volume kelp wrack survey event during the 2008-2013 period.

Table 1. Historical canopy coverages in km² of San Diego and Orange County kelp beds from 1911 to 1989 surveys. Values represent approximately the maximum coverages for each year. Areal estimates from 1967 on were derived from charts based on infrared aerial photographs. Known cold-water periods are depicted in Blue, warm-water periods in Red, and neutral periods in Green.

Kelp Bed	Canopy Area (km ²)																					
	1911	1934	1941	1955*	1959*	1963*	1967	1970	1975	1980	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Corona del Mar	0.580	ND	ND	ND	ND	ND	0.086	0.180	0.160	0.150	0.031	0.006	-	-	-	0.007	0.010	0.001	0.0003	-	-	-
North Laguna Beach	Tr	ND	ND	0.680	0.160	ND	0.001	0.011	0.003	0.036	0.035	0.025	0.028	0.022	0.028	0.042	0.055	0.034	0.029	-	-	-
South Laguna Beach	Tr	ND	ND	ND	ND	ND	0.001	0.011	0.003	0.036	0.040	0.028	0.077	0.041	0.087	0.145	0.264	0.243	0.093	0.056	0.028	-
South Laguna	Tr	ND	ND	2.020	0.180	0.020	-	0.014	0.008	-	0.004	-	-	-	-	0.023	0.041	0.023	0.030	0.009	0.006	0.005
Dana Point-Salt Creek	1.871	ND	ND	p	p	p	0.240	0.077	0.096	0.008	0.013	0.007	0.036	0.031	0.174	0.558	0.878	0.329	0.480	0.184	0.234	0.116
Capistrano Beach	1.153	ND	ND	p	p	p	0.080	0.050	0.070	0.020	-	-	-	-	-	0.032	0.233	0.110	0.134	0.148	0.022	-
San Clemente	1.390	ND	ND	6.310	3.710	0.010	0.080	0.050	0.070	0.020	-	-	-	-	0.017	0.124	0.444	0.304	0.243	0.044	0.051	0.010
San Mateo Point	1.272	ND	ND	p	p	p	-	0.057	0.140	0.360	0.163	0.045	0.152	0.077	0.200	0.432	0.870	0.472	0.120	0.103	0.220	0.080
San Onofre	1.946	ND	ND	p	p	p	-	-	0.300	0.160	0.102	0.031	0.042	0.053	0.045	0.348	0.638	0.763	0.170	0.053	0.163	0.201
Horno Canyon	0.352	ND	ND	ND	ND	ND	-	-	-	-	-	-	-	-	-	0.006	0.033	0.010	0.018	0.040	-	-
Barn Kelp	3.171	ND	ND	1.370	ND	0.130	0.017	0.019	0.160	0.056	-	-	-	-	-	0.008	0.116	0.382	0.262	0.124	0.002	0.010
Santa Margarita	0.710	ND	ND	ND	ND	ND	-	-	-	-	-	-	-	-	-	-	-	-	0.049	0.009	-	-
North Carlsbad	0.767	ND	ND	2.620	2.520	1.180	0.009	0.060	0.100	0.120	-	-	-	-	0.031	0.049	0.096	0.119	0.044	0.004	0.018	0.020
Agua Hedionda	0.161	ND	ND	p	p	p	-	0.006	0.036	0.019	-	0.001	0.011	0.018	0.021	0.032	0.047	0.046	0.016	0.004	0.012	0.004
Encina Power Plant	0.642	ND	ND	p	p	p	-	0.025	0.144	0.074	-	0.002	0.024	0.045	0.120	0.161	0.251	0.179	0.083	0.025	0.022	0.011
Carlsbad State Beach	0.278	ND	ND	p	p	p	0.032	0.120	0.200	0.078	-	-	0.027	0.018	0.077	0.032	0.049	0.081	0.035	0.008	0.002	0.011
Leucadia	1.224	ND	ND	p	p	p	0.240	0.440	0.500	0.670	0.001	0.002	0.104	0.074	0.426	0.197	0.291	0.341	0.163	0.084	0.035	0.010
Encinitas	0.367	ND	ND	p	p	p	0.065	0.173	0.153	0.228	-	0.016	0.083	0.032	0.177	0.153	0.209	0.241	0.080	0.036	0.037	0.016
Cardiff	0.713	ND	ND	0.340	0.400	0.160	0.125	0.337	0.297	0.442	0.018	0.021	0.176	0.120	0.340	0.229	0.575	0.468	0.072	0.054	0.034	0.080
Solana Beach	1.097	ND	ND	p	p	p	0.290	0.490	0.560	0.690	-	0.001	0.115	0.120	0.367	0.427	0.488	0.466	0.257	0.053	0.023	0.108
Del Mar	0.540	ND	ND	p	p	p	0.190	0.260	0.190	0.210	-	-	0.008	0.021	0.081	0.063	0.104	0.082	0.097	0.006	0.003	0.029
Torrey Pines	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Tr	Tr	-	-	-	-	-
La Jolla	6.060	8.161	7.847	1.660	6.490	0.640	0.330	0.290	0.840	1.900	0.032	0.034	0.720	0.930	2.369	2.200	4.755	3.632	3.230	1.301	0.681	1.119
Point Loma	18.675	11.465	8.286	1.990	0.610	0.240	2.700	4.900	3.000	4.200	0.200	0.160	1.570	2.100	3.682	2.322	5.842	5.943	4.310	1.163	1.917	3.589
Imperial Beach	0.984	ND	ND	ND	ND	ND	-	-	-	0.350	-	-	0.058	0.150	0.727	0.067	0.579	0.651	0.370	0.111	0.025	0.108
TOTAL	43.948*	19.626*	16.133*	16.990*	14.070*	2.380*	4.486	7.570	7.030	9.827	0.639	0.379	3.231	3.852	8.969	7.667	16.868	14.920	10.385	3.609	3.535	5.527

NOTE: p = part of above value; * = Incomplete data; ND - No Data; "-" = 0
Tr = Trace <100 m²

Sources: 1934, 1941 from North (1964); 1955, 1959, 1963 from Neushul (1981);

Figure 3. Table showing kelp canopy coverage at San Diego and Orange County kelp beds between 1911 and 1994. San Mateo Point kelp bed is just south of WNR. San Clemente kelp bed area includes area of WNR (which was built in summer 2008). Note overall kelp die-off after 1989 due to warmer water (from MBC, 2013).

Table 5. Canopy coverages in km² of San Diego and Orange County kelp beds from 1989 to 2012 surveys. Values approximate the maximum coverages for each year. Areal estimates derived from charts based on infrared aerial photographs.

Kelp Bed	Canopy Area (km ²)																	
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
N Laguna Beach	-	0.001	-	-	-	-	-	-	0.0004	-	-	-	-	0.002	0.005	0.093	0.147	0.192
S Laguna Beach	-	-	-	-	-	-	-	0.005	0.0002	0.008	-	-	0.001	0.025	0.058	0.098	0.221	0.214
South Laguna	-	-	-	-	-	0.003	0.002	<0.001	0.004	0.009	0.003	-	0.004	0.023	0.017	0.023	0.018	0.017
Dana Pt/Salt Crk	0.076	0.061	0.034	0.005	0.080	0.170	0.314	0.432	0.303	0.278	0.123	-	0.302	1.068	0.892	0.839	0.442	0.607
Capistrano Beach	-	-	-	-	<0.001	<0.001	0.044	0.118	0.069	0.008	-	0.011	0.002	0.071	0.071	0.124	0.010	0.056
Total F&W 9	0.076	0.062	0.034	0.005	0.080	0.173	0.359	0.555	0.376	0.303	0.126	0.011	0.309	1.189	1.043	1.178	0.838	1.086
San Clemente	0.010	0.047	-	-	0.006	0.005	0.124	0.316	0.352	0.182	0.178	0.014	0.016	0.203	0.210	0.710	0.795	0.874
San Mateo Point	0.010	0.073	0.098	-	0.051	0.050	0.090	0.155	0.242	0.123	0.258	0.016	0.201	0.487	0.545	0.583	0.203	0.216
San Onofre	0.096	0.196	0.108	<0.001	0.005	0.020	0.041	0.030	0.162	0.109	0.065	-	0.320	0.476	0.419	0.458	0.127	0.191
Total F&W 8	0.116	0.316	0.206	-	0.062	0.075	0.255	0.501	0.755	0.414	0.501	0.030	0.536	1.166	1.174	1.750	1.124	1.281
Horno Canyon	-	-	-	-	-	0.002	0.034	-	0.001	-	-	-	0.015	0.083	0.018	0.081	-	0.008
Barn Kelp	0.172	0.204	0.178	-	0.310	0.375	0.547	0.667	0.492	0.075	0.064	-	0.466	0.858	0.926	0.500	0.095	0.442
Santa Margarita	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total F&W 7	0.172	0.204	0.178	-	0.310	0.377	0.581	0.667	0.494	0.075	0.064	-	0.481	0.941	0.944	0.581	0.095	0.450
North Carlsbad	0.008	-	⌚	0.003	-	-	0.017	0.053	0.017	0.003	0.013	-	0.026	0.108	0.135	0.078	0.017	0.052
Agua Hedionda	0.008	0.009	-	-	-	-	-	<0.001	0.002	0.001	0.008	-	0.016	0.080	0.092	0.031	0.022	0.046
Encina Power Plant	0.058	0.032	0.013	-	-	0.002	0.029	0.097	0.178	0.067	0.001	-	0.081	0.306	0.215	0.176	0.084	0.216
Carlsbad St. Bch	0.025	0.013	-	-	-	0.003	0.023	0.047	0.002	0.0001	-	-	0.064	0.121	0.127	0.069	0.024	0.058
Total F&W 6	0.099	0.054	0.013	0.003	-	0.005	0.069	0.197	0.199	0.070	0.023	-	0.187	0.615	0.569	0.354	0.147	0.372
Leucadia	0.189	0.087	0.062	-	0.015	0.090	0.209	0.334	0.185	0.048	0.001	0.016	0.233	0.421	0.429	0.215	0.119	0.232
Encinitas	0.061	0.023	0.048	-	0.029	0.040	0.131	0.153	0.050	0.016	-	0.002	0.205	0.346	0.205	0.128	0.124	0.260
Cardiff	0.092	0.026	0.031	0.016	0.063	0.150	0.309	0.405	0.202	0.045	-	0.004	0.286	0.484	0.520	0.213	0.395	0.459
Solana Beach	0.134	0.003	0.073	0.009	0.091	0.200	0.407	0.488	0.245	0.022	0.093	0.0003	0.457	0.823	0.505	0.328	0.504	0.442
Del Mar	0.082	-	*Tr	0.004	-	0.006	0.015	0.035	0.030	-	-	-	0.037	0.057	0.044	0.038	0.074	0.024
Torrey Pines	-	-	-	-	-	-	-	-	-	-	-	0.010	-	0.001	0.0004	0.003	0.031	0.034
Total F&W 5	0.558	0.139	0.214	0.029	0.198	0.486	1.071	1.415	0.712	0.131	0.094	0.032	1.218	2.133	1.703	0.925	1.247	1.452
La Jolla F & W 4	0.824	0.371	0.478	0.215	1.146	1.250	2.555	3.366	3.444	1.029	0.873	0.117	2.750	4.145	2.274	2.776	2.565	1.569
Point Loma F & W 3&2	1.134	1.187	2.235	0.295	1.725	3.290	6.574	3.799	4.509	1.924	2.152	1.767	3.616	6.623	4.909	3.977	4.212	5.340
Imperial Beach F & W 1	0.053	0.008	0.027	-	0.019	0.020	0.078	0.210	0.083	0.191	0.400	0.400	1.493	1.895	0.861	0.004	0.152	0.333
TOTAL	3.032	2.341	3.385	0.547	3.540	5.676	11.542	10.710	10.572	4.136	4.233	2.358	10.591	18.706	13.476	11.545	10.379	11.882

NOTE: "-" = 0; Tr = Trace <100 m²

Figure 4. Table showing kelp canopy coverage at San Diego and Orange County kelp beds between 1995 and 2012. Note overall kelp increase beginning in 2007 with cooler water temperatures and kelp increase at San Clemente kelp bed after completion of Experimental Reef in 1999 and WNR in 2008 (from MBC, 2013).

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CALIFORNIA COASTAL COMMISSION

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9 May 2013

Re: Notice of Acceptance – Condition Compliance for Special Condition 12 of California Coastal Commission (CCC) Coastal Development Permit No. E-07-010 — Kelp Wrack and Rock Hazard Monitoring Requirement

Dear Ms. Anthony:

Materials submitted in compliance with the 12th Special Condition of Southern California Edison's (SCE's) CCC construction permit No. E-07-010 (CCC, 2008) have been received¹. The reports have been reviewed by the Executive Director and found to fulfill the specific requirements of this condition as they are outlined below.

Special Condition #12, Wheeler North Reef Biannual Beach Kelp Wrack Monitoring:

For four years following construction of the Phase 2 Mitigation Reef, the permittee shall perform monitoring of the 3.7 miles of beach adjacent to the project site (from the first small point north of San Clemente Pier to San Mateo Creek south of the pier) for (1) kelp wrack on the beach and (2) artificial substrate on the beach within 48 hours following large storm or swell events. If the four years of monitoring show significant amount of kelp wrack or artificial reef substrate, the Executive Director may require additional monitoring. The permittee shall communicate biannually via written correspondence with the City of San Clemente beach maintenance department, with a copy to the Executive Director, for the operating life of SONGS units 2 and 3 and will contribute mechanical, manpower, and/or monetary assistance should the city request help removing excess kelp wrack (documented to be beyond background quantities in monitoring results) or any reef material from the beach.

In addition to the Commission's special condition, SCE was required by the Army Corp of Engineer's (USACOE) permit (Permit File No. SPL-2007-00466-JPL, Special Condition #17) and the California State Lands Commission (CSLC) lease agreement to conduct five years of kelp wrack and rock hazard sampling. Our permit required monitoring within 48 hours following large storm or swell events for a total of four years; the USACOE permit and CSLC lease agreement required two surveys per month from November through March and one survey

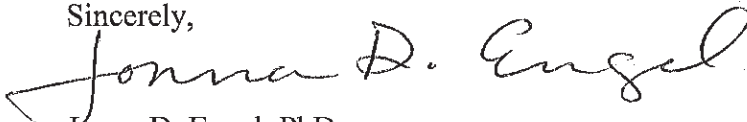
¹ 2008-2009, 2009-2010, 2010-2011, 2011-2012 SCE Biannual Kelp Wrack and Rock Hazard Monitoring Reports, and Coastal Environments, 2009-2013. Wheeler North Reef (SONGS Artificial Reef Mitigation Project, Phase 2 Mitigation Reef) Biannual Beach Kelp Wrack and Rock Hazards Monitoring Reports 1-10 final monitoring report.

per month during the remaining months for a total of five years. These combined requirements resulted in a total of 114 kelp wrack and rock hazard surveys during the five years. The quantitative data collection procedures employed were initially developed and used by Dr. Claude Zobell in his kelp wrack assessments along the coast of Southern California in the 1950's. The Wheeler North Reef kelp wrack surveys applied the Zobell transect station assessment methodology directly for consistency and precise comparisons.

From the data submitted there is no evidence that the build-out of the Wheeler North Reef has resulted in a significant increase of kelp wrack along the 3.7 miles of beach area monitored from 2008 to 2013 in the City of San Clemente. The mean volume of kelp wrack has increased slightly across the 3.7 miles of beaches in San Clemente over the last five years², however, it is not beyond an expected level and it has not raised any concerns with the City of San Clemente³. No quarry rock or broken concrete that could be associated with Wheeler North Reef was observed along the 3.7 miles of San Clemente beaches during any of the surveys.

This notice does not address compliance with any special conditions other than the condition stated above. Your submitted material and a copy of this letter have been made a part of the permanent file. Thank you for your cooperation in providing the data needed under this special condition. If you have any questions, please contact me at (805) 585-1821.

Sincerely,



Jonna D. Engel, PhD
Ecologist

cc.

Susan Hansch
David Kay
Kate Huckelbridge
John Dixon
Dan Reed
Steve Schroeder
Mark Page

² 2008-2009 apprx. 600 ft³; 2009-2010 apprx. 500 ft³; 2010-2011 apprx. 700 ft³; 2011-2012 apprx. 700 ft³; 2012-2013 apprx. 1000 ft³

³ Pers. Comm., May 8, 2014, Dennis Reed, Beaches & Parks Manager, City of San Clemente

**WHEELER NORTH REEF
(SONGS ARTIFICIAL REEF MITIGATION PROJECT)**

2008 – 2013 KELP WRACK MONITORING REPORT

October 2008 – September 2013



Prepared for

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CE Reference No. 13-20

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WHEELER NORTH REEF 2008 – 2013 KELP WRACK MONITORING REPORT

October 2008 – September 2013

1.0 INTRODUCTION AND BACKGROUND

Southern California Edison (SCE) and Coastal Environments (CE) have been conducting beach kelp wrack and rock hazard monitoring along 3.7 miles of the San Clemente beach adjacent to the Wheeler North Reef (WNR). This work has been conducted for the last five years, starting on 12 October 2008 after completion of construction of the WNR, and ending on 19 September 2013. This monitoring activity and the data collected have been provided to the California Coastal Commission's (CCC) Executive Director, the San Diego Regional Water Quality Control Board (RWQCB), the California State Lands Commission (CSLC), the U.S. Army Corps of Engineers (USACOE), and the City of San Clemente's Division of Park & Beach Maintenance. This report presents the kelp wrack data collection methodology, findings, and an analysis of these findings as part of the monitoring and reporting program of the WNR project.

The WNR project was mandated by Condition C of the San Onofre Nuclear Generating Station (SONGS) CCC Coastal Development Permit (CCC, 1991) as "in-kind" mitigation for impacts to the San Onofre kelp bed (Photo 1) by the SONGS cooling water discharge pipes. According to Special Condition #12 of SCE's CCC construction permit (CCC, 2008), "For four years following construction of the Phase 2 Mitigation Reef, the permittee shall perform monitoring of the 3.7 miles of beach adjacent to the project site (from the first small point north of San Clemente Pier to San Mateo Creek south of the pier) for: (1) kelp wrack on the beach and (2) artificial substrate on the beach within 48 hours following large storm or swell events." This work is also a requirement of the project's USACOE Permit, File No. SPL-2007-00466-JPL, Special Condition #17 (USACOE, 2008). In addition, this beach monitoring is a special requirement of the CSLC lease agreement for the project, which required five years of kelp wrack monitoring, beginning after the WNR was completed in September 2008. The five years of monitoring are now complete.

Construction of Phase 2 of the WNR began on 09 June 2008 and was completed on 12 September 2008. During this phase, a 152-acre, low profile (<1 m), single-layer kelp reef was constructed of 126,000 tons of quarry boulders approximately one-half mile off the coast of San Clemente, California (Figure 1). Photo 1 shows a Landsat 5 image taken on 30 May 2010, which shows the canopy of the WNR as well as the canopies of two nearby natural kelp beds – San Mateo Point and San Onofre. The location of SONGS is also shown in Photo 1. Photo 2 is an aerial photo taken of the central portion of the WNR on 17 August 2010. As shown in the photo, giant kelp (*Macrocystis pyrifera*) had become established within two years following construction and had already reached the water surface in the areas where the boulder substrate was placed. A complete accounting of construction of the WNR is provided in CE's Final Construction Report (CE, 2008).

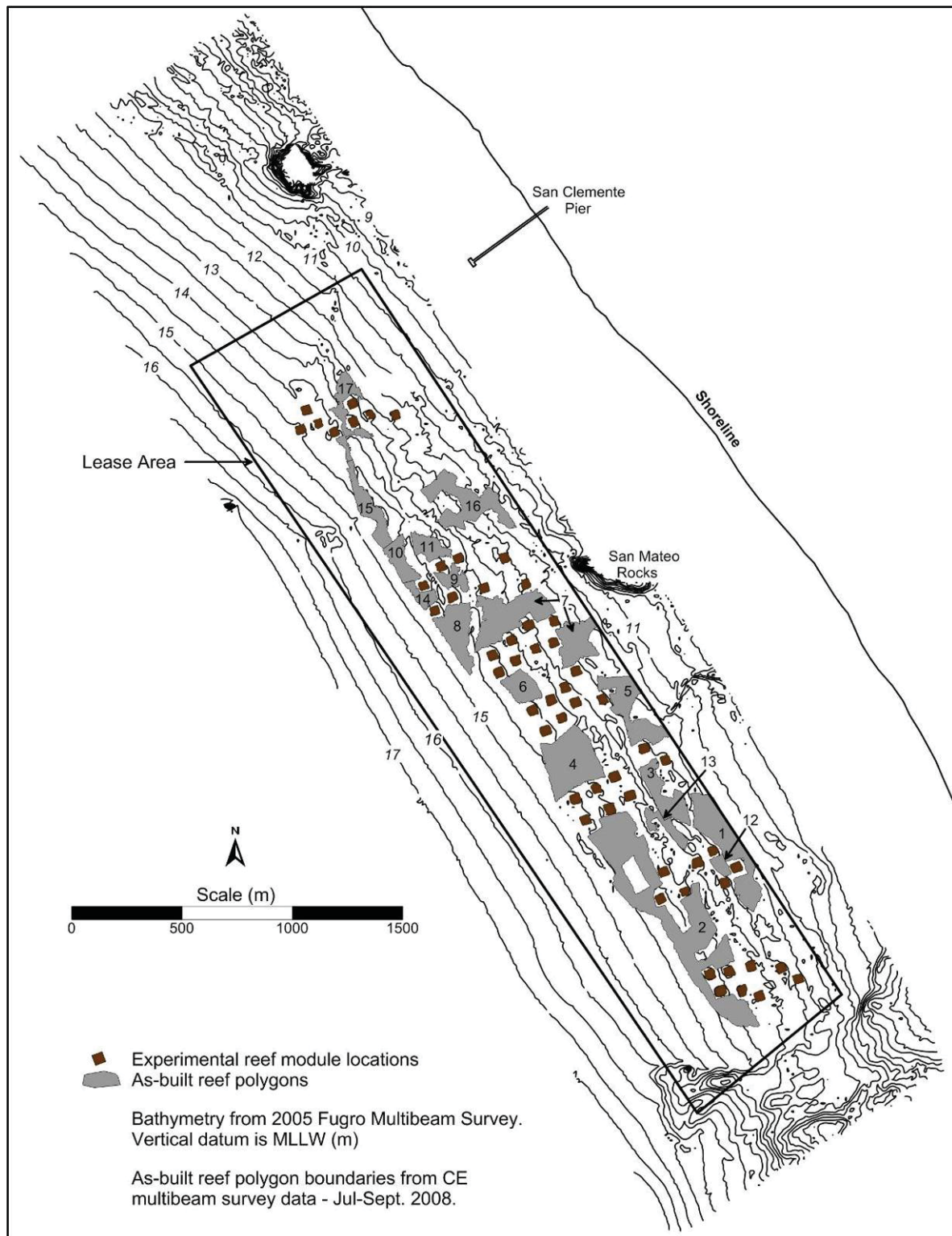


Figure 1. Location of Wheeler North Reef, showing both Phase 1 (1999; 22.4-acre module area) and Phase 2 (2008; 152-acre polygon area).



Photo 1. Landsat 5 image of Wheeler North Reef, San Mateo Point kelp bed, San Onofre kelp bed, and SONGS from 30 May 2010.



Photo 2. 17 August 2010 northward-looking aerial photo of north-central portion of Wheeler North Reef. Large polygons (8, 9, 11, 14, and 16) are part of Phase 2 reef; smaller areas are part of Phase 1 reef. San Clemente Pier is in the distance.

The 22.4-acre Phase 1 Experimental Artificial Kelp Reef was completed in September 1999, within the same overall footprint as the Phase 2 reef. It was constructed of broken concrete and quarry boulders of varying arrangements and was subsequently studied for five years by the CCC's consulting scientists to determine the best substrate seafloor density and material to be used for the Phase 2 reef (Reed, Schroeter, and Huang, 2006). The total area of the WNR, Phase 1 plus Phase 2, is 174.4 acres.

This Kelp Wrack Monitoring Report presents the kelp wrack data collected during each of the beach monitoring inspections conducted during the entire five-year period of October 2008 through September 2013. Surveys were performed within 48 hours following large storm or swell events, seasonally as prescribed by the State Lands lease agreement, and as close to the lower-low-tide as practical on each survey day.

Kelp wrack monitoring was previously conducted for six years (Nov 1999 – Oct 2005) following construction of the Phase I reef (SCE, 2006). In addition, Dr. Claude Zobell (Scripps Institution of Oceanography researcher) conducted kelp wrack surveys in this area between 1954 and 1956. For comparative purposes, the methodology used for the more recent surveys (1999–2005 & 2008–2013) was the same as that used by Dr. Zobell (Zobell, 1959).

Section 2 of this report describes this methodology, while Section 3 presents the kelp wrack findings during the most recent five-year period (October 2008 – September 2013) along with a historical data analysis. Section 4 presents a discussion of the findings, and Section 5 presents the conclusions drawn from these findings. Table A-1 in Appendix A presents the results of the kelp wrack surveys from the 114 surveys that have been conducted since October 2008. Appendix B presents two photos each of the eight different monitoring areas along the coast of San Clemente: one photo when a small amount of kelp was surveyed and one when a large amount was surveyed.

2.0 SURVEY METHODOLOGY

In order to meet the CSLC lease agreement conditions, the beach surveys were timed to ensure that at least two surveys per month were performed during the Southern California rainy season (November through March) and at least one survey per month was performed during the remaining months. Further, to ensure compliance with the CCC (2008) and USACOE (2008) permits, kelp wrack surveys were performed within 48 hours of large storm events.

Quantitative observations of kelp wrack, hard substrate along the sandy beach, and general beach conditions were recorded during each survey. Summaries of the survey days, including weather conditions, and kelp wrack observations can be found in the appendices of CE's biannual reports, which were produced every six months and covered October through March and April through September for each of the five years of the surveys (CE, 2009, 2010, 2011, 2012, and 2013).

During each survey, kelp wrack was measured on the public beach of City of the San Clemente (3.7 miles) from El Portal/ Buena Vista to San Mateo Point (Figure 2). Standard data collection procedures were established in 1999 following construction of the Phase 1 Experimental Artificial Kelp Reef. As stated before, similar beach surveys were performed from 1999 until 2005 as part of the permitting requirements for the Phase 1 reef. The quantitative data collection procedures were initially developed and used by Dr. Claude Zobell in his kelp wrack assessments along the coast of Southern California in the 1950s (Zobell, 1959). The WNR kelp wrack surveys applied the Zobell transect station assessment methodology directly in order to produce consistency with the historic surveys completed in the area, as well as to assure validity and consistency between the various sets of beach kelp wrack data.

The five permanent stations (from north to south) are El Portal/Buena Vista, San Clemente Pier, Calafia, State Beach, and San Mateo Point (Figure 2). For each survey, the amount of kelp wrack (in cubic feet) was measured along each 500-ft transect.

In addition to the five permanent station surveys, the amount of kelp wrack (in cubic feet) along the entire 3.7 miles of beach was also estimated. The beach was subdivided into three areas for this part of the survey, and the amount of kelp wrack in each area (not including the five permanent transects) was recorded. The three areas (from north to south) are north of the San Clemente Pier, south of the pier to State Beach, and south of State Beach to San Mateo Point.

Photographs of the beach have also been taken during each survey. On each survey date, photographs were taken of the five permanent transect stations and three stretches of beach. Any perceived unusual materials on the beach or unusual algal wrack were also photographed and the locations noted. Appendix B of this report includes a sampling of these photographs from the last five years. The appendices in each of the biannual reports also include the photos from each individual survey (CE, 2009, 2010, 2011, 2012, 2013).

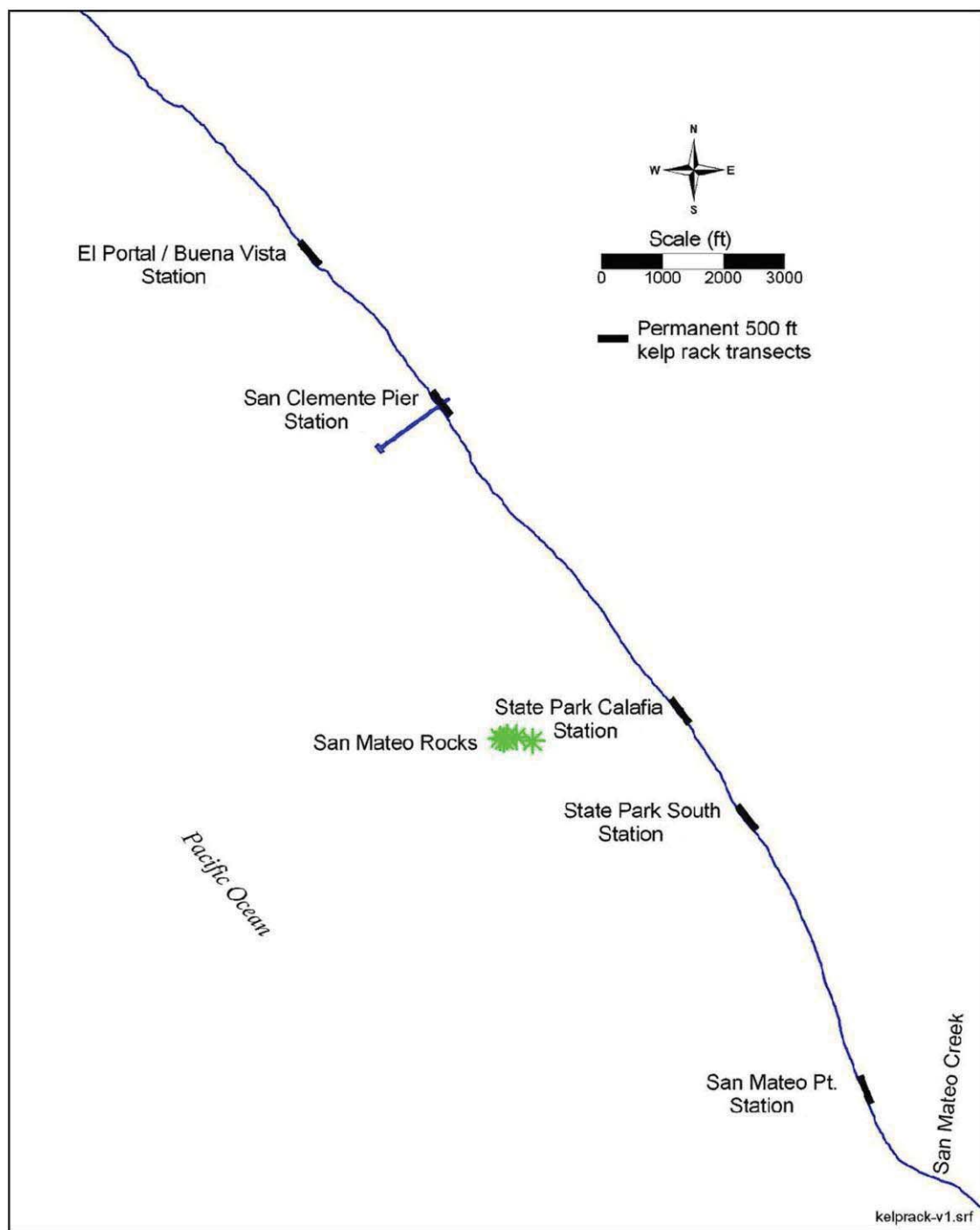


Figure 2. Locations of the five permanent 500-ft transects for the quantitative assessment of kelp wrack in the San Clemente study area.

3.0 SURVEY RESULTS AND HISTORICAL DATA ANALYSIS

3.1 WNR SURVEY RESULTS

One hundred fourteen (114) kelp wrack and rock hazard monitoring surveys were conducted during the five years between October 2008 and September 2013. The number of surveys performed each year has varied, with 19 conducted between October 2008 and September 2009, 22 between October 2009 and September 2010, 23 between October 2010 and September 2011, 25 between October 2011 and September 2012, and 25 between October 2012 and September 2013 (Table 1). As mentioned previously, in order to comply with the CSLC permit, at least two surveys per month were performed during the Southern California rainy season (November – March) and at least one survey per month during the remaining months. Surveys were performed (when applicable) within 48 hours following large storm or swell events.

Table A-1 gives the volume of kelp wrack (ft³) on San Clemente Beach from October 2008 to 30 September 2013 for each survey (114 surveys). Table A-1 gives: (1) the kelp wrack volume per survey for the five permanent transect stations; (2) the total volume of kelp wrack on these permanent transects; (3) the volume of kelp wrack on the three beach areas; and (4) total volume of observed kelp wrack along the surveyed area of San Clemente Beach (3.7 miles).

No quarry rock or broken concrete that could be associated with the WNR was observed along the San Clemente beaches during any of the surveys over the last five years. This is in agreement with the observation of the City of San Clemente Park and Beach Maintenance Division (periodic personal communication, Dennis Roger Reed, City of San Clemente, 2008-2013).

According to Mr. Reed (City of San Clemente), there were only two occurrences in five years where excessive kelp wrack beach clean-up efforts were required. One of these occurred at the end of July 2009, when the kelp from the WNR was just beginning to grow and thus was not able to contribute to the kelp wrack on the beach. The other clean-up effort occurred on November 30, 2010.

During one of the kelp wrack surveys, State Parks lifeguard Karl Ulrick (2010) said that the State Beach administration supports kelp wrack as a vital component of the beach ecosystem and that kelp wrack acts favorably as a barrier on the beach to slow down littoral drift and allow sand to build up at the wrack piles, such that sand retention on the beach is enhanced. As a general policy, State Parks does not remove kelp wrack from the beach unless it becomes so voluminous as to create a nuisance. In addition, several recent studies (Dugan & Hubbard, 2010; Dugan et al., 2010, 2011) have shown other beneficial consequences of leaving kelp wrack on the beach, including:

- Foraging opportunities for shorebirds,
- Trapping sand to allow native coastal strand plants to become established,
- Trapping sand to help create sand dunes, and
- Supplying nutrients to coastal ecosystems.

Table 1. Number of kelp wrack surveys per year.

Survey Year	Number of Surveys
2008-2009	19
2009-2010	22
2010-2011	23
2011-2012	25
2012-2013	25

Note: Survey year is from October to September.

From 2008 through 2013, the average amount of kelp wrack per survey was 712.6 ft³. The average volume of kelp wrack per survey was higher during the 2012-2013 survey year than during the previous four years, and has risen in four of the five years since monitoring began in October 2008 (Figure 3). The average kelp wrack volume per survey in 2008-2009 was 562.8 ft³; in 2009-2010, it was 496.5 ft³; in 2010-2011, it was 706.9 ft³; in 2011-2012, it was 719.8 ft³; and in 2012-2013, it was 1,014.7 ft³.

This volume increase is to be expected, as the WNR is now likely contributing to kelp wrack on the beach, whereas in the first two years when kelp was still becoming established on the deposited rock substrate, the WNR was likely contributing very little kelp wrack to San Clemente beaches, other than that from the 56 small modules (40 m x 40 m) that comprise the 22.4-acre Phase I Experimental Reef.

According to the research of both Dr. Larry Deysher (Deysher, 2011) and Dayton (Dayton et al., 1984, 1992), individual *Macrocystis pyrifera* (Giant Kelp) plants in Southern California waters have an average life expectancy of 3-6 years, which may partly explain the increase seen this past year (2012-2013).

In the last 6 months, between April and September 2013, the average amount of kelp wrack per survey (total survey area; 3.7 miles of coastline) was 1,308.5 ft³, which was significantly higher than the average (743.5 ft³) of the previous six months (October 2012-March 2013). This pattern, which consists of the average kelp wrack during the spring, summer, and fall months being larger than during the winter months (when most of the local storms occur), has been consistent since monitoring began in fall 2008 and was also found to be the case in the 1999-2005 surveys of the Phase I reef (Figure 8).

The kelp wrack data for the five permanent 500-ft transect stations show a similar rise in kelp wrack, both during the last year and during the five years of surveying since the completion of the WNR. The average kelp wrack for the five stations for 2012-2013 was 314.8 ft³ per survey event. This compares with an average of 147.1 ft³ for the 2008-2009 period; 142.9 ft³ for the 2009-2010 period; 174.2 ft³ for the 2010-2011 period; and 226.4 ft³ for the 2011-2012 period.

Figures 4 through 8 examine the kelp wrack data collected by CE from 2008 through 2013. Figure 4 shows the volume of kelp wrack observed over the entire 3.7-mile beach area during each of the surveys since October 2008. While the overall trend is upward, the single largest event took place on 18 February 2009, which was before giant kelp had become established on the new 152-acre Phase 2 reef rock substrate that had been deposited just five months earlier. Figure 5 shows the average volume of kelp wrack observed at the five 500-linear-foot beach transects by month. April and September were the months with the highest average kelp wrack, while the winter months of January and February had the lowest average amount of kelp wrack.

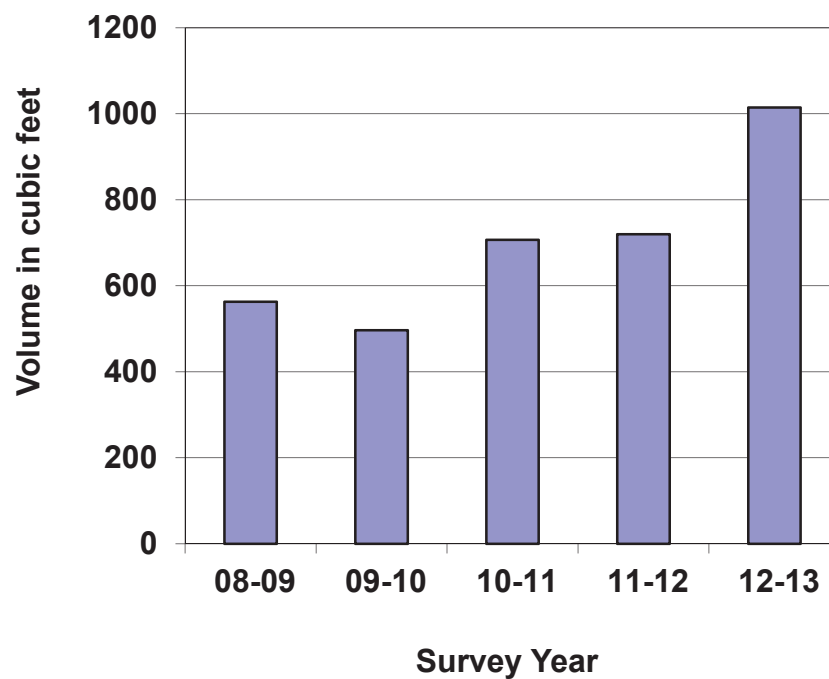


Figure 3. Mean kelp wrack per survey from 2008-2013 for the entire 3.7-mile area.

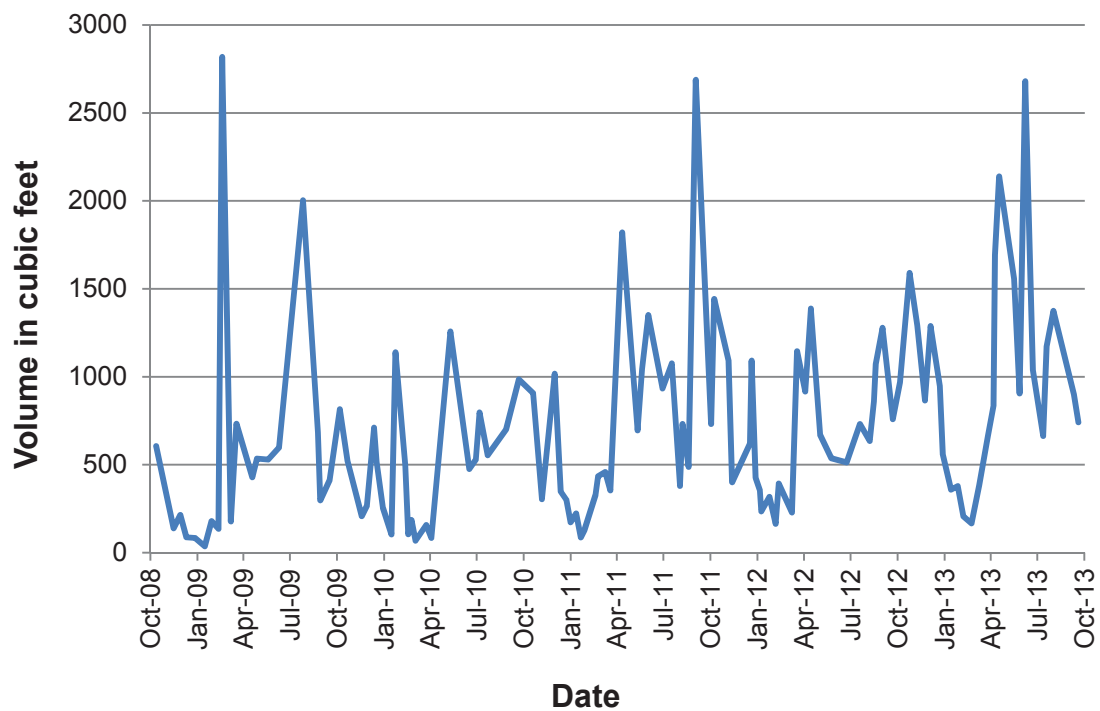


Figure 4. Kelp wrack volume (ft³) per survey, 2008-2013, for the entire survey area.

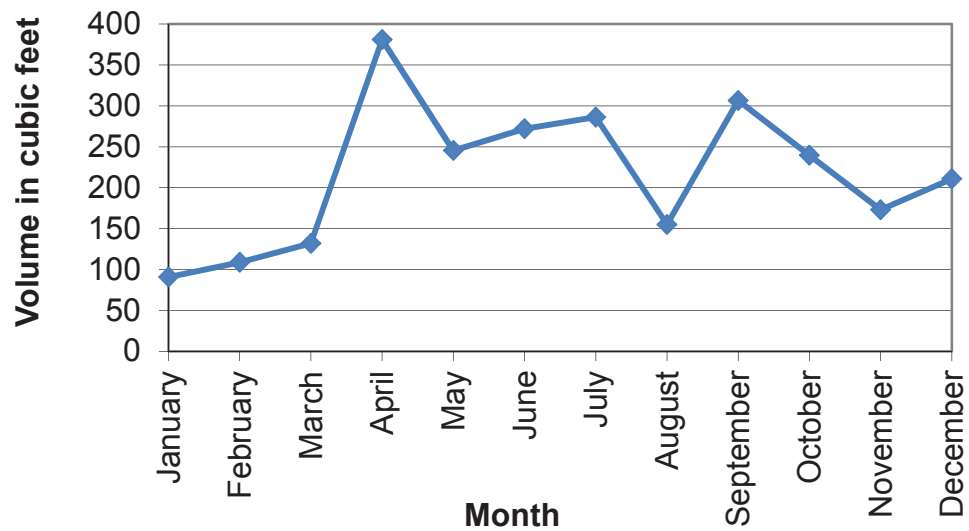


Figure 5. Mean monthly kelp wrack volume (ft³/survey). Data from 2008 through 2013 for the five transects.

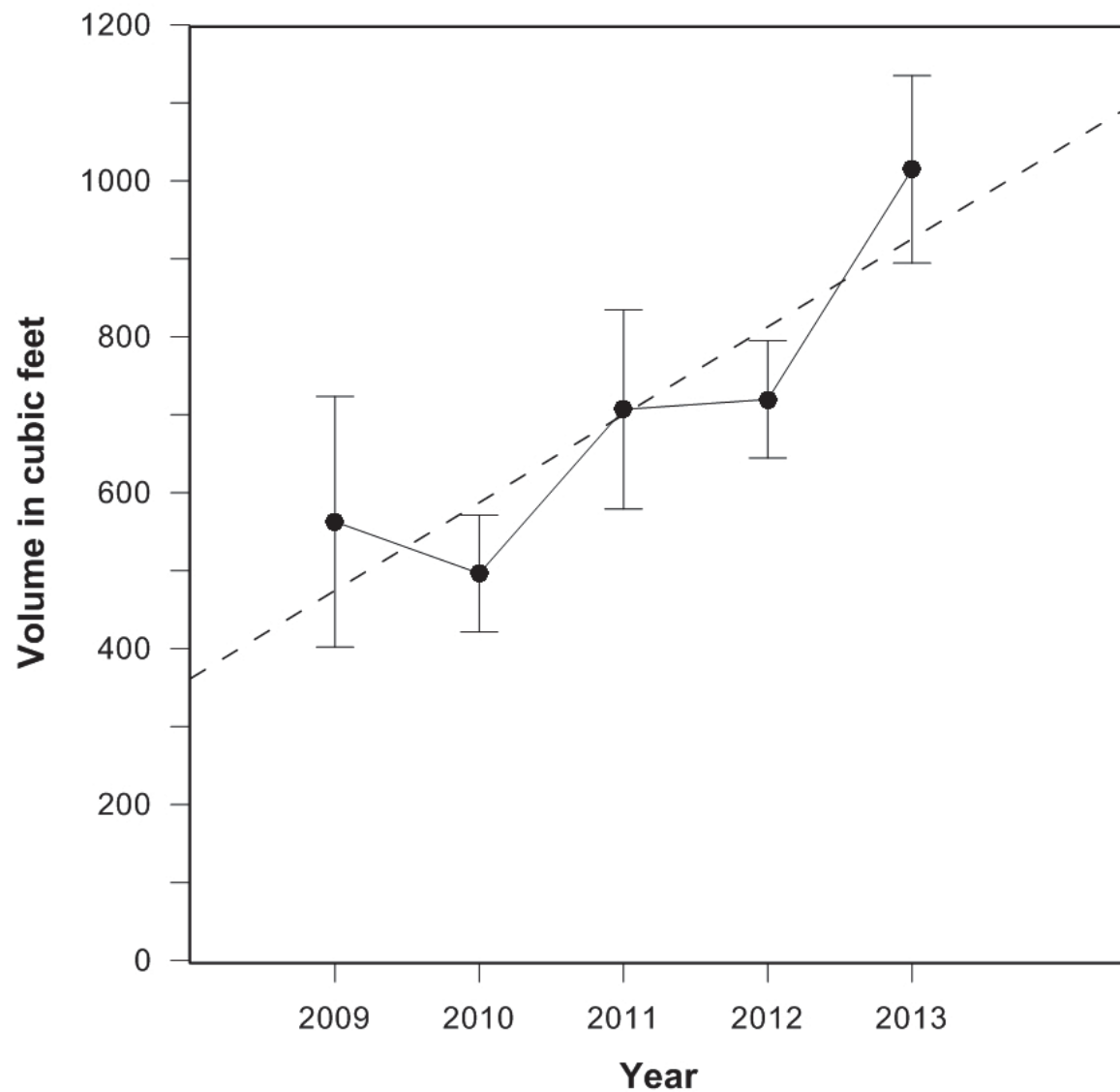


Figure 6. Mean volume (ft³) of kelp wrack per survey and standard deviation of mean with linear trend line, 2008-2013. Dashed line is linear trend line.

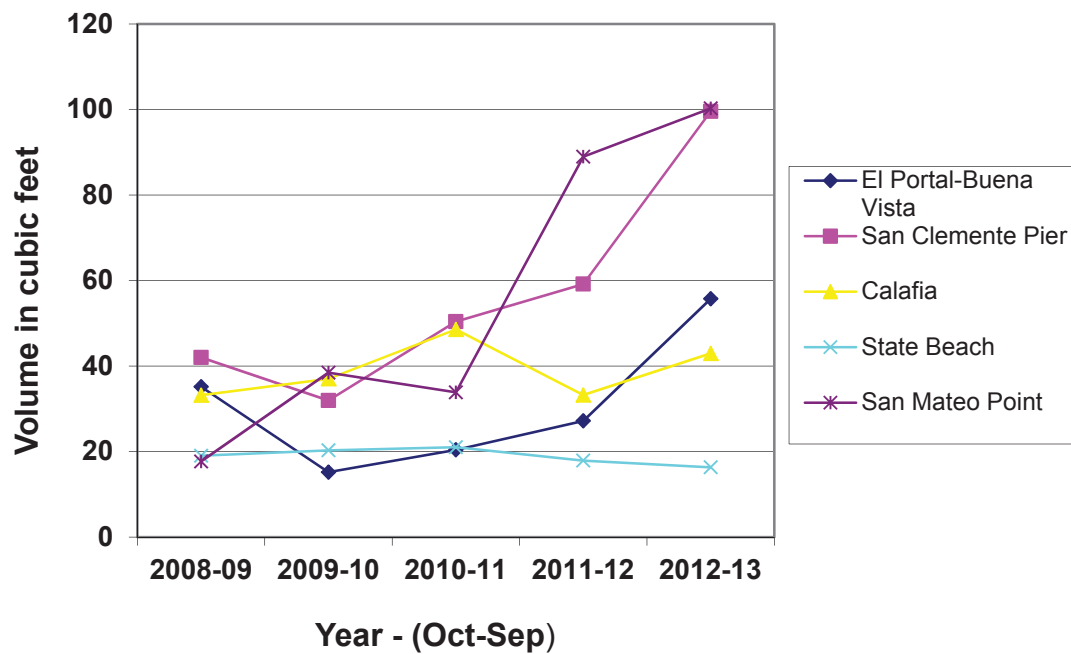


Figure 7. Mean kelp wrack volume (ft³) per year at each transect, 2008-2013.

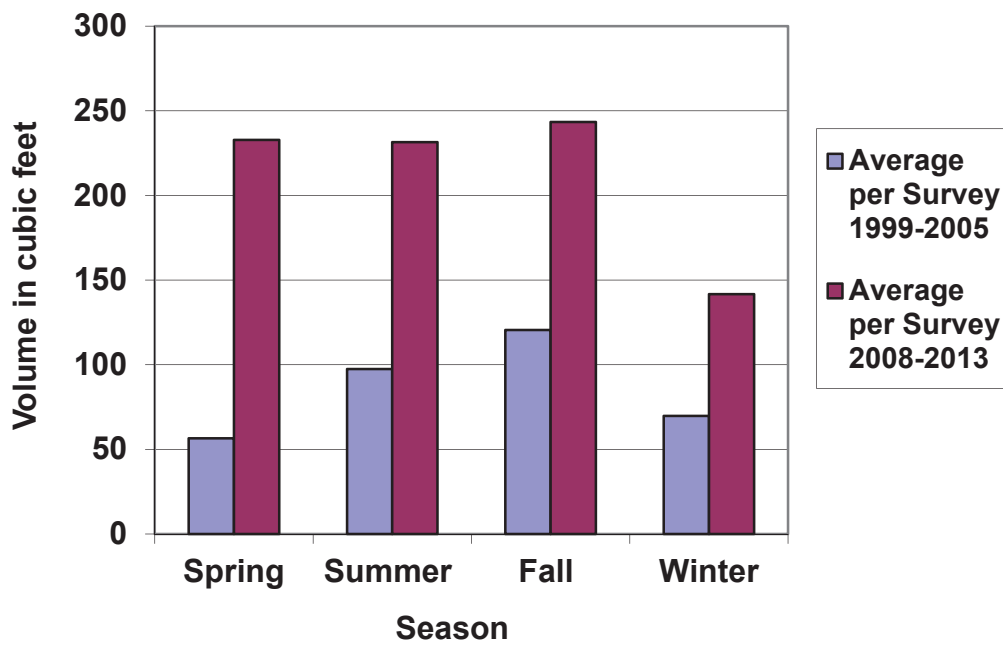


Figure 8. Average kelp wrack (ft³) by season for 1999-2005 and 2008-2013.

Figure 6 presents the mean amount of kelp wrack per survey for the last five years and the standard deviation of the mean. The best-fit line shows how the average amount of kelp wrack has been increasing over the last five years. As mentioned previously, the kelp from the Phase 2 WNR project did not become established until 2009-2010, and thus was not contributing to the kelp wrack seen on San Clemente area beaches until that time. Figure 7 shows the yearly average kelp wrack at each 500-ft transect. More kelp wrack has been consistently surveyed at the San Clemente Pier transect than at any of the other four, most likely due to the kelp wrack becoming entangled with the supporting posts of the pier. (The vast majority of the kelp wrack seen at the Pier transect is consistently wrapped around the pier pilings.)

3.2 HISTORICAL DATA ANALYSIS

Figures 8 through 10 compare the kelp wrack data from the last five years with the data collected after completion of the Phase I Experimental Reef in 1999 and with Zobell's data collected in the mid-1950s. Figure 8 presents the kelp wrack data on a seasonal basis, both for the 1999-2005 survey period and for the 2008-2013 survey period. The summer and fall had the largest amount of kelp wrack per survey during 1999-2005; while the spring, summer, and fall had the largest amounts of kelp wrack per survey during 2008-2013. Winter had the least amount of kelp wrack during 2008-2013 monitoring period, and the second-least amount during the 1999-2005 monitoring period. This is counterintuitive since most of the large local rainstorms occur during the winter. The reason for the higher amounts of kelp wrack during the non-winter seasons is likely the warmer water during the summer and fall. Giant kelp is a cold-water species that can experience large die-offs when water temperatures become too warm and/or periodic large wave sets arrive from the Southern Hemisphere during the summer. Likely also contributing to the higher volumes of kelp surveyed in the non-winter seasons is the change in the dominant wave direction from west to south during the late spring, as well as the return of the west-dominant wave direction in the fall.

Figure 9 compares the kelp wrack surveyed at the San Clemente Pier transect during both the 1999-2005 and 2008-2013 periods with Zobell's surveys of the same transect in the mid-1950s. In 1956, there was significantly more kelp wrack surveyed along this transect than during any other year (880 cubic ft in July 1956 and 940 cubic ft in November 1956). This was primarily due to two very large storm events in July 1956 and November 1956, respectively. The largest event at this transect during the 1999-2005 survey period was 414 cubic feet of kelp wrack on 9 December 2004. The largest event during the 2008-2013 survey period had 321.6 cubic feet of kelp wrack on 2 September 2011.

On an annual basis, the volume of kelp wrack has been increasing since the CE/SCE kelp wrack surveys began in 1999 (Figure 10). This is likely for two primary reasons: first and most important is the region-wide recovery of kelp beds off the Southern California coast beginning in 1999, and really taking off starting in 2007. Beginning with the El Niño winter of 1991-1992, kelp beds across San Diego and Orange counties were much reduced. Almost all of the remaining kelp beds were wiped out by the strong El Niño winter of 1997-1998. This fluctuation in kelp bed coverage is shown in Figures 11 and 12 (MBC, 2013), which includes the San Mateo Point kelp bed (just south of the WNR) and the San Clemente kelp bed, which includes WNR.

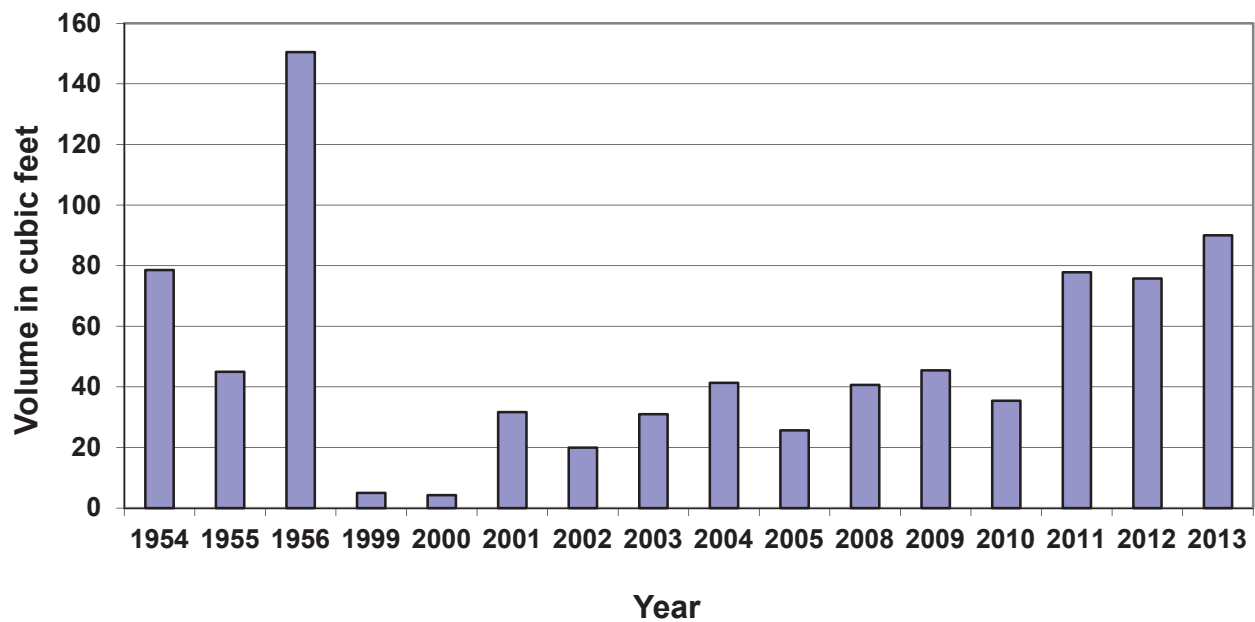


Figure 9. Average volume (ft³) of kelp wrack per month at the San Clemente Pier transect for 1954-1956 (Zobell, 1959), 1999-2005 (SCE), and 2008-2013 (CE).

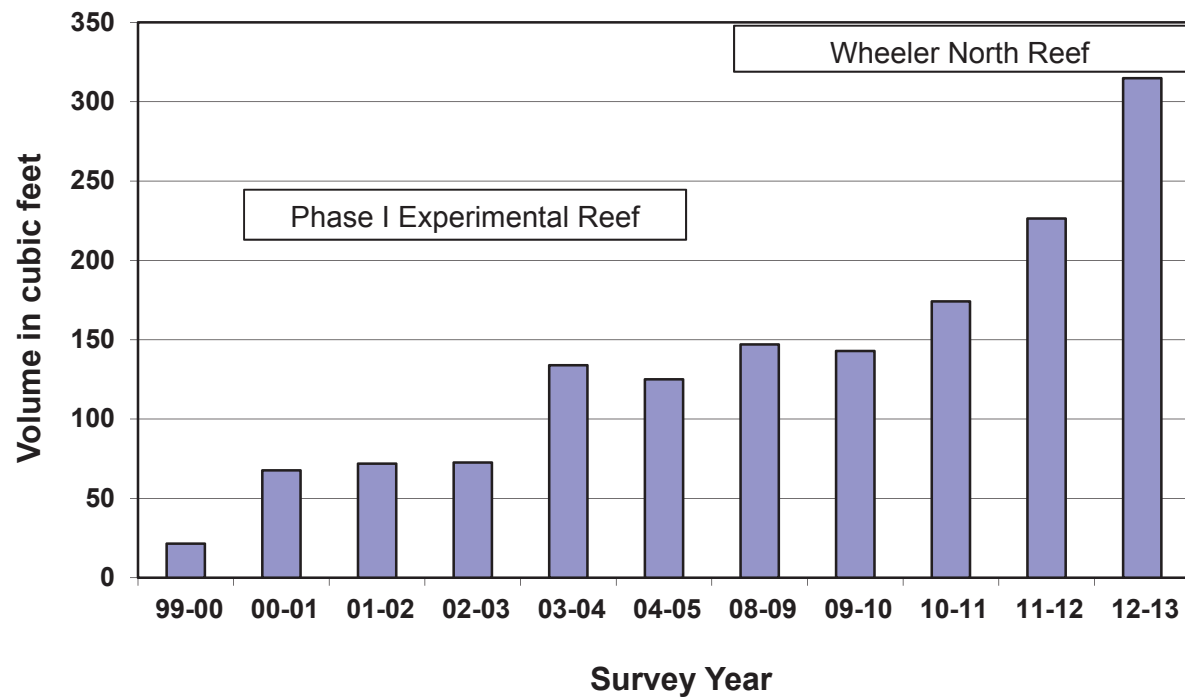


Figure 10. Average annual kelp wrack per survey for all 5 transects (1999-2005 and 2008-2013).

Table 1. Historical canopy coverages in km² of San Diego and Orange County kelp beds from 1911 to 1989 surveys. Values represent approximately the maximum coverages for each year. Areal estimates from 1967 on were derived from charts based on infrared aerial photographs. Known cold-water periods are depicted in Blue, warm-water periods in Red, and neutral periods in Green.

Kelp Bed	Canopy Area (km ²)																					
	1911	1934	1941	1955*	1959*	1963*	1967	1970	1975	1980	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Corona del Mar	0.580	ND	ND	ND	ND	ND	0.086	0.180	0.160	0.150	0.031	0.006	-	-	-	0.007	0.010	0.001	0.0003	-	-	-
North Laguna Beach	Tr	ND	ND	0.680	0.160	ND	0.001	0.011	0.003	0.036	0.035	0.025	0.028	0.022	0.028	0.042	0.055	0.034	0.029	-	-	-
South Laguna Beach	Tr	ND	ND	ND	ND	ND	0.001	0.011	0.003	0.036	0.040	0.028	0.077	0.041	0.087	0.145	0.264	0.243	0.093	0.056	0.028	-
South Laguna	Tr	ND	ND	2.020	0.180	0.020	-	0.014	0.008	-	0.004	-	-	-	-	0.023	0.041	0.023	0.030	0.009	0.006	0.005
Dana Point-Salt Creek	1.871	ND	ND	p	p	p	0.240	0.077	0.096	0.008	0.013	0.007	0.036	0.031	0.174	0.568	0.878	0.329	0.480	0.184	0.234	0.116
Capistrano Beach	1.153	ND	ND	p	p	p	0.080	0.050	0.070	0.020	-	-	-	-	-	0.032	0.233	0.110	0.134	0.148	0.022	-
San Clemente	1.390	ND	ND	6.310	3.710	0.010	0.080	0.050	0.070	0.020	-	-	-	-	0.017	0.124	0.444	0.304	0.243	0.044	0.051	0.010
San Mateo Point	1.272	ND	ND	p	p	p	-	0.057	0.140	0.360	0.163	0.045	0.152	0.077	0.200	0.432	0.870	0.472	0.120	0.103	0.220	0.080
San Onofre	1.946	ND	ND	p	p	p	-	-	0.300	0.160	0.102	0.031	0.042	0.053	0.045	0.348	0.638	0.763	0.170	0.053	0.163	0.201
Horno Canyon	0.352	ND	ND	ND	ND	ND	-	-	-	-	-	-	-	-	-	0.006	0.033	0.010	0.018	0.040	-	-
Barn Kelp	3.171	ND	ND	1.370	ND	0.130	0.017	0.019	0.160	0.056	-	-	-	-	-	0.008	0.116	0.382	0.262	0.124	0.002	0.010
Santa Margarita	0.710	ND	ND	ND	ND	ND	-	-	-	-	-	-	-	-	-	-	-	-	0.049	0.009	-	-
North Carlsbad	0.767	ND	ND	2.620	2.520	1.180	0.009	0.060	0.100	0.120	-	-	-	-	0.031	0.049	0.096	0.119	0.044	0.004	0.018	0.020
Agua Hedionda	0.161	ND	ND	p	p	p	-	0.006	0.036	0.019	-	0.001	0.011	0.018	0.021	0.032	0.047	0.046	0.016	0.004	0.012	0.004
Encina Power Plant	0.642	ND	ND	p	p	p	-	0.025	0.144	0.074	-	0.002	0.024	0.045	0.120	0.161	0.251	0.179	0.083	0.025	0.022	0.011
Carlsbad State Beach	0.278	ND	ND	p	p	p	0.032	0.120	0.200	0.078	-	-	0.027	0.018	0.077	0.032	0.049	0.081	0.035	0.008	0.002	0.011
Leucadia	1.224	ND	ND	p	p	p	0.240	0.440	0.500	0.670	0.001	0.002	0.104	0.074	0.426	0.197	0.291	0.341	0.163	0.084	0.035	0.010
Encinitas	0.367	ND	ND	p	p	p	0.065	0.173	0.153	0.228	-	0.016	0.083	0.032	0.177	0.153	0.209	0.241	0.080	0.036	0.037	0.016
Cardiff	0.713	ND	ND	0.340	0.400	0.160	0.125	0.337	0.297	0.442	0.018	0.021	0.176	0.120	0.340	0.229	0.575	0.468	0.072	0.054	0.034	0.080
Solana Beach	1.097	ND	ND	p	p	p	0.290	0.490	0.560	0.690	-	0.001	0.115	0.120	0.367	0.427	0.488	0.466	0.257	0.053	0.023	0.108
Del Mar	0.540	ND	ND	p	p	p	0.190	0.260	0.190	0.210	-	-	0.008	0.021	0.081	0.063	0.104	0.082	0.097	0.006	0.003	0.029
Torrey Pines	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Tr	Tr	-	-	-	-	-
La Jolla	6.060	8.161	7.847	1.660	6.490	0.640	0.330	0.290	0.840	1.900	0.032	0.034	0.720	0.930	2.369	2.200	4.755	3.632	3.230	1.301	0.681	1.119
Point Loma	18.675	11.465	8.286	1.990	0.610	0.240	2.700	4.900	3.000	4.200	0.200	0.160	1.570	2.100	3.682	2.322	5.842	5.943	4.310	1.163	1.917	3.589
Imperial Beach	0.984	ND	ND	ND	ND	ND	-	-	-	0.350	-	-	0.058	0.150	0.727	0.067	0.579	0.651	0.370	0.111	0.025	0.108
TOTAL	43.948*	19.626*	16.133*	16.990*	14.070*	2.380*	4.486	7.570	7.030	9.827	0.639	0.379	3.231	3.852	8.969	7.667	16.868	14.920	10.385	3.609	3.535	5.527

NOTE: p = part of above value; * = Incomplete data; ND - No Data; "-" = 0
Tr = Trace <100 m²

Sources: 1934, 1941 from North (1964); 1955, 1959, 1963 from Neushul (1981);

Figure 11. Table showing kelp canopy coverage at San Diego and Orange County kelp beds between 1911 and 1994. San Mateo Point kelp bed is just south of WNR. San Clemente kelp bed area includes area of WNR (which was built in summer 2008). Note overall kelp die-off after 1989 due to warmer water (from MBC, 2013).

Table 5. Canopy coverages in km² of San Diego and Orange County kelp beds from 1989 to 2012 surveys. Values approximate the maximum coverages for each year. Areal estimates derived from charts based on infrared aerial photographs.

Kelp Bed	Canopy Area (km ²)																	
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
N Laguna Beach	-	0.001	-	-	-	-	-	-	0.0004	-	-	-	-	0.002	0.005	0.093	0.147	0.192
S Laguna Beach	-	-	-	-	-	-	-	0.005	0.0002	0.008	-	-	0.001	0.025	0.058	0.098	0.221	0.214
South Laguna	-	-	-	-	-	0.003	0.002	<0.001	0.004	0.009	0.003	-	0.004	0.023	0.017	0.023	0.018	0.017
Dana Pt/Salt Crk	0.076	0.061	0.034	0.005	0.080	0.170	0.314	0.432	0.303	0.278	0.123	-	0.302	1.068	0.892	0.839	0.442	0.607
Capistrano Beach	-	-	-	-	<0.001	<0.001	0.044	0.118	0.069	0.008	-	0.011	0.002	0.071	0.071	0.124	0.010	0.056
Total F&W 9	0.076	0.062	0.034	0.005	0.080	0.173	0.359	0.555	0.376	0.303	0.126	0.011	0.309	1.189	1.043	1.178	0.838	1.086
San Clemente	0.010	0.047	-	-	0.006	0.005	0.124	0.316	0.352	0.182	0.178	0.014	0.016	0.203	0.210	0.710	0.795	0.874
San Mateo Point	0.010	0.073	0.098	-	0.051	0.050	0.090	0.155	0.242	0.123	0.258	0.016	0.201	0.487	0.545	0.583	0.203	0.216
San Onofre	0.096	0.196	0.108	<0.001	0.005	0.020	0.041	0.030	0.162	0.109	0.065	-	0.320	0.476	0.419	0.458	0.127	0.191
Total F&W 8	0.116	0.316	0.206	-	0.062	0.075	0.255	0.501	0.755	0.414	0.501	0.030	0.536	1.166	1.174	1.750	1.124	1.281
Horno Canyon	-	-	-	-	-	0.002	0.034	-	0.001	-	-	-	0.015	0.083	0.018	0.081	-	0.008
Barn Kelp	0.172	0.204	0.178	-	0.310	0.375	0.547	0.667	0.492	0.075	0.064	-	0.466	0.858	0.926	0.500	0.095	0.442
Santa Margarita	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total F&W 7	0.172	0.204	0.178	-	0.310	0.377	0.581	0.667	0.494	0.075	0.064	-	0.481	0.941	0.944	0.581	0.095	0.450
North Carlsbad	0.008	-	⌚	0.003	-	-	0.017	0.053	0.017	0.003	0.013	-	0.026	0.108	0.135	0.078	0.017	0.052
Agua Hedionda	0.008	0.009	-	-	-	-	-	<0.001	0.002	0.001	0.008	-	0.016	0.080	0.092	0.031	0.022	0.046
Encina Power Plant	0.058	0.032	0.013	-	-	0.002	0.029	0.097	0.178	0.067	0.001	-	0.081	0.306	0.215	0.176	0.084	0.216
Carlsbad St. Bch	0.025	0.013	-	-	-	0.003	0.023	0.047	0.002	0.0001	-	-	0.064	0.121	0.127	0.069	0.024	0.058
Total F&W 6	0.099	0.054	0.013	0.003	-	0.005	0.069	0.197	0.199	0.070	0.023	-	0.187	0.615	0.569	0.354	0.147	0.372
Leucadia	0.189	0.087	0.062	-	0.015	0.090	0.209	0.334	0.185	0.048	0.001	0.016	0.233	0.421	0.429	0.215	0.119	0.232
Encinitas	0.061	0.023	0.048	-	0.029	0.040	0.131	0.153	0.050	0.016	-	0.002	0.205	0.346	0.205	0.128	0.124	0.260
Cardiff	0.092	0.026	0.031	0.016	0.063	0.150	0.309	0.405	0.202	0.045	-	0.004	0.286	0.484	0.520	0.213	0.395	0.459
Solana Beach	0.134	0.003	0.073	0.009	0.091	0.200	0.407	0.488	0.245	0.022	0.093	0.0003	0.457	0.823	0.505	0.328	0.504	0.442
Del Mar	0.082	-	*Tr	0.004	-	0.006	0.015	0.035	0.030	-	-	-	0.037	0.057	0.044	0.038	0.074	0.024
Torrey Pines	-	-	-	-	-	-	-	-	-	-	-	0.010	-	0.001	0.0004	0.003	0.031	0.034
Total F&W 5	0.558	0.139	0.214	0.029	0.198	0.486	1.071	1.415	0.712	0.131	0.094	0.032	1.218	2.133	1.703	0.925	1.247	1.452
La Jolla F & W 4	0.824	0.371	0.478	0.215	1.146	1.250	2.555	3.366	3.444	1.029	0.873	0.117	2.750	4.145	2.274	2.776	2.565	1.569
Point Loma F & W 3&2	1.134	1.187	2.235	0.295	1.725	3.290	6.574	3.799	4.509	1.924	2.152	1.767	3.616	6.623	4.909	3.977	4.212	5.340
Imperial Beach F & W 1	0.053	0.008	0.027	-	0.019	0.020	0.078	0.210	0.083	0.191	0.400	0.400	1.493	1.895	0.861	0.004	0.152	0.333
TOTAL	3.032	2.341	3.385	0.547	3.540	5.676	11.542	10.710	10.572	4.136	4.233	2.358	10.591	18.706	13.476	11.545	10.379	11.882

NOTE: "-" = 0; Tr = Trace <100 m²

Figure 12. Table showing kelp canopy coverage at San Diego and Orange County kelp beds between 1995 and 2012. Note overall kelp increase beginning in 2007 with cooler water temperatures and kelp increase at San Clemente kelp bed after completion of Experimental Reef in 1999 and WNR in 2008 (from MBC, 2013).

Kelp bed coverage increased dramatically starting in 2007 with the return of cool waters off the Southern California coast. An increase in kelp coverage has brought an associated increase in kelp wrack.

In addition to the regional events, the completion of both the Phase 1 Experimental Reef in 1999 and the Phase 2 WNR in 2008 has also likely contributed to the increasing quantity of kelp wrack seen on San Clemente beaches. In comparison with the mid-1950s, however, when Zobell collected his data, the amount of kelp wrack during the 1999-2013 period has generally been less.

4.0 DISCUSSION

In an effort to understand how wave conditions may have contributed to kelp wrack on the beach, the wave conditions accompanying the largest kelp wrack events over the last five years were compared. In addition, the kelp wrack data for each individual survey was plotted in relation to the significant wave height (Hs), wave period (Tp), and sea surface temperature (SST) for the preceding days storm event.

For this report, the eight largest kelp wrack survey events that have occurred in the last five years were examined (those with a total kelp wrack volume of more than 1,500 cubic feet). The date, kelp wrack volume, significant wave height (Hs), wave period (Tp), dominant wave direction, and sea surface temperature (SST) for all eight large kelp wrack volume events are shown in Table 2. The wave data is based on the maximum Hs for the wave storm that immediately preceded the kelp wrack survey. All of the wave/water parameter data is from the Scripps Institution of Oceanography's Coastal Data Information Program (CDIP) Buoy 096 (CDIP, 2013), which is located approximately six miles northwest of the San Clemente Pier in a water depth of approximately 1,225 feet.

As can be seen from Table 2, varying wave parameters can contribute to the larger amount of kelp wrack observed on San Clemente area beaches. The first and overall largest kelp wrack event on 18 February 2009 occurred before giant kelp had become established on the WNR (construction was completed in September 2008). The large volume of kelp wrack was associated with a very large wavestorm event of 3.52 m (Hs), which approached from the south. The fourth large kelp wrack event, and the largest after establishment of the WNR, was associated with an extremely long period (Tp) event that occurred at the end of August 2011, when Tp was measured at 25 seconds over a 12-hr period.

Other large kelp wrack observations were associated with the first wavestorms of the season. For example, the large kelp wrack observation of 11 April 2011 was associated with the first southerly wavestorms of the season (21 March 2011 and 8 April 2011), after the majority of the large winter waves had come from the west. The large kelp wrack observation of 24 October 2012 was associated with the first large wavestorm of the fall 2012 period that came from the west (24 October 2012), after southerly waves had dominated all summer. Overall, CE found that larger kelp wrack survey events can occur in any season and that no particular wave condition is associated with larger amounts of kelp wrack found on San Clemente area beaches. It should also be noted that many large wavestorm events do not produce associated large kelp wrack survey events (Figure 13). This finding was similarly reported in both SCE (2006) and Zobell (1959).

To assess whether there is a linear relationship between kelp wrack and individual wave parameters, CE plotted the kelp wrack data for each survey over the last five years versus three different wave/water parameters: Hs, Tp, and SST (Figures 13, 14, and 15). The wave/water parameter data is from the Scripps CDIP Buoy 096 (CDIP, 2013). The wave parameter data in each case is the mean number for a 24-hour period during the wavestorm that preceded the kelp wrack survey.

Table 2. Kelp wrack, wave data, and sea surface temperatures for largest kelp wrack survey events, 2008-2013.

Event	Date	Kelp Wrack Volume (ft³)	Hs (m)	Tp (sec)	Wave Direction (Deg)	SST (Deg C)
1	18 Feb 09	2,818.1	3.52	7.69	179	13.9
2	26 Jul 09	2,003.4	2.24	16.67	202	22.5
3	11 Apr 11	1,820.1	2.12	18.18	189	15.9
4	02 Sep 11	2,688.2	1.27	25.00	200	19.5
5	24 Oct 12	1,590.5	1.47	6.67	279	19.9
6	17 Apr 13	2,139.0	3.08	9.88	275	15.2
7	16 May 13	1,557.0	1.76	8.33	275	18.5
8	07 Jun 13	2,680.1	1.96	16.67	200	18.5

Note: Wave data is from the Scripps CDIP Buoy 096 (CDIP, 2013) and is based on the maximum Hs for the wave storm that immediately preceded the kelp wrack survey.

Figure 13 shows the kelp wrack survey data versus significant wave height (H_s), Figure 14 shows the kelp wrack survey data versus sea surface temperature (SST), and Figure 15 shows the kelp wrack survey data versus the wave period (T_p). In each case, no linear or other type of relationship can be seen when looking at the individual survey events.

As shown in Figure 8, water temperature is likely a contributor to kelp wrack volume, since during both the most recent surveys (2008-2013) and those associated with the Phase 1 Experimental Reef, less kelp wrack on average per survey was found during the winter when water temperatures are much cooler than during the summer and fall, when water temperatures are warmer. Water temperature also greatly influences the amount of kelp canopy that is in existence across Southern California waters, as shown in Figures 11 and 12.

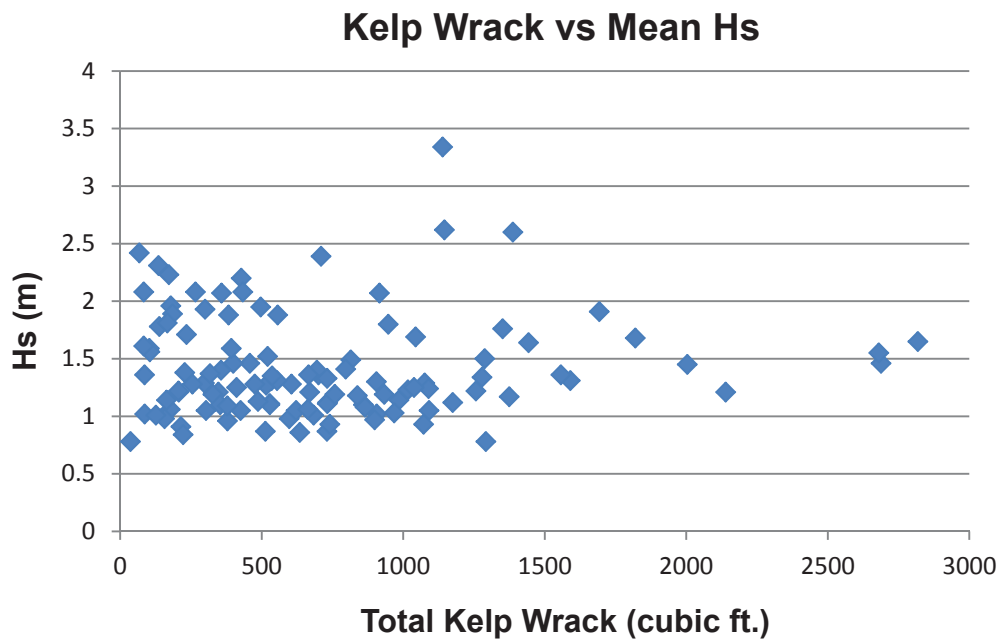


Figure 13. Kelp wrack volume (ft³) for each survey event from 2008 through 2013 plotted against the mean Hs (m) for one 24-hour period during the wavestorm that preceded the survey day.

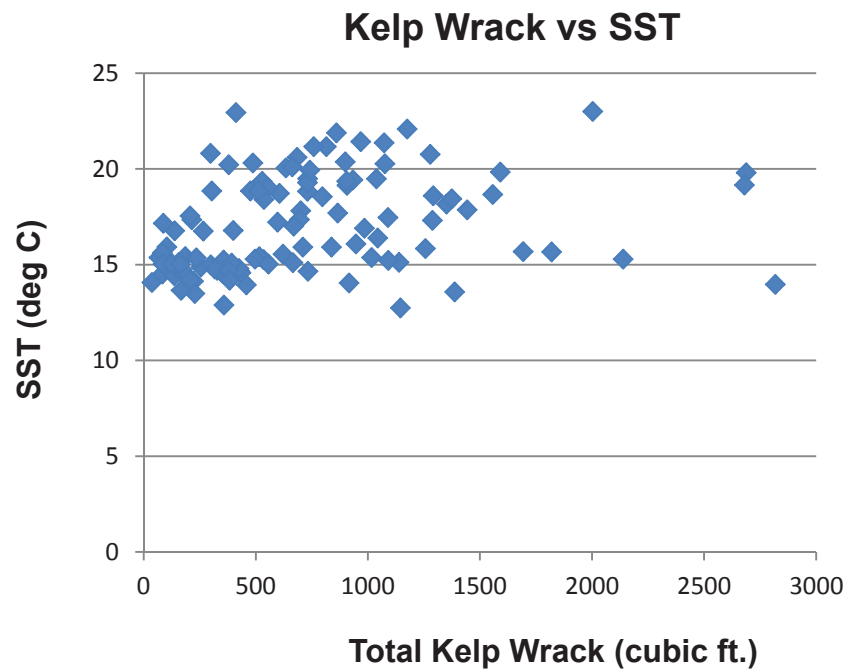


Figure 14. Kelp wrack volume (ft³) for each survey event from 2008 through 2013 plotted against the mean SST (deg C) for one 24-hour period during the wavestorm that preceded the survey day.

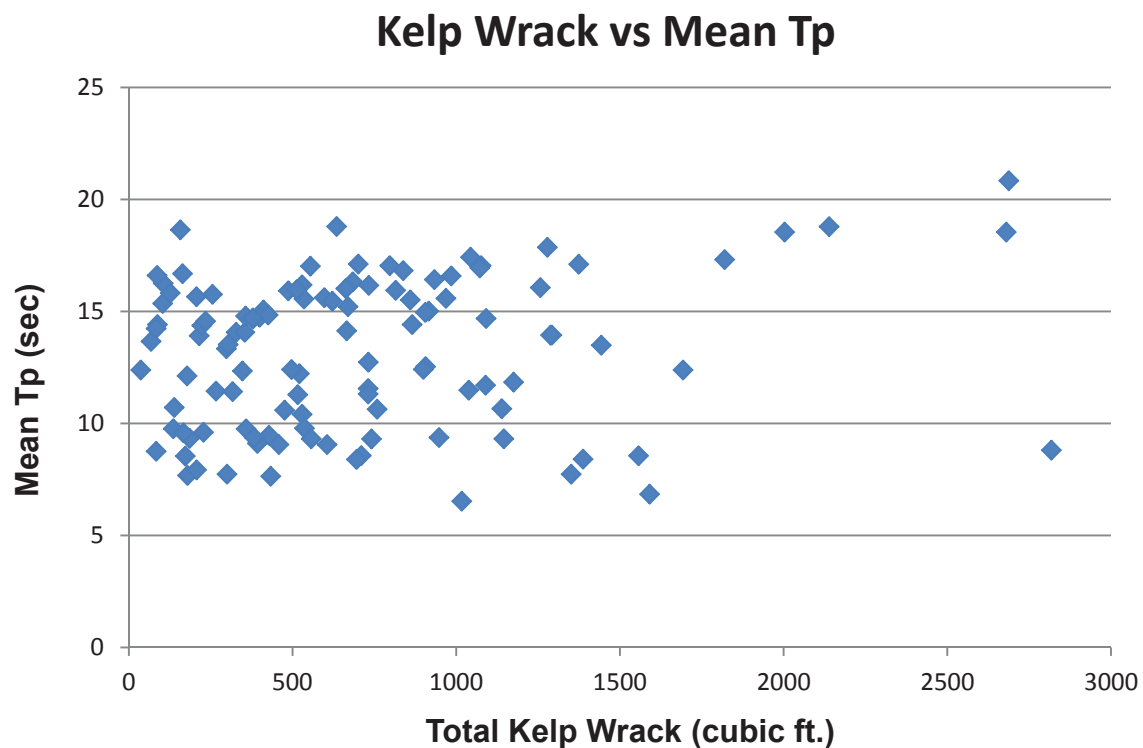


Figure 15. Kelp wrack volume (ft³) for each survey event from 2008 through 2013 plotted against the mean Tp (sec) for one 24-hour period during the wavestorm that preceded the survey day.

5.0 CONCLUSIONS

SCE and CE have been conducting beach kelp wrack and rock hazard monitoring surveys along 3.7 miles of the San Clemente coastline for the last five years, beginning in October 2008 upon the completion of the Phase 2 reef (WNR). This monitoring activity and the data collected have been provided to the CCC's Executive Director, the San Diego RWQCB, the CSLC, the USACOE, and the City of San Clemente's Park & Beach Maintenance Division.

This Kelp Wrack Monitoring Report presents the kelp wrack data collected during each of the beach monitoring inspections conducted during the entire five-year period of October 2008 through September 2013. Surveys were performed within 48 hours following large storm or swell events, and as close to the lower-low-tide as practical on each survey day. In order to additionally meet the CSLC lease agreement conditions, the beach surveys were also timed to ensure that at least two surveys per month were performed during the Southern California rainy season (November through March) and at least one survey per month was performed during the remaining months.

Quantitative observations of kelp wrack, hard substrate along the sandy beach, and general beach conditions were recorded during each survey. Summaries of the survey dates, including all beach, weather, and kelp wrack observations, can be found in the appendices of CE's biannual reports, which cover October through March and April through September for each of the five years of the surveys (CE, 2009, 2010, 2011, 2012, 2013).

Five permanent 500-ft transect stations were quantitatively inspected during each survey. Standard data collection procedures were established in 1999 following construction of the Phase 1 WNR Experimental Artificial Kelp Reef. Similar beach surveys were performed from 1999 until 2005 as part of the permitting requirements for the Phase 1 reef. The quantitative data collection procedures were initially developed and used by Dr. Claude Zobell in his kelp wrack assessments conducted along the Southern California coast in the 1950s (Zobell, 1959). The WNR kelp wrack surveys directly apply the Zobell transect station assessment methodology in order to produce consistency with the historic surveys completed in this area, as well as to ensure validity and consistency between the various sets of beach kelp wrack data.

The overall conclusions of this five-year study are:

1. No artificial reef substrate material, either quarry rock or broken concrete, appears to be washing up onto San Clemente beaches;
2. Kelp wrack does not appear to be substantial on San Clemente beaches, as compared to previous local kelp wrack data (Zobell, 1959), and as evidenced by photographs and correspondence with the San Clemente Park & Beach Maintenance Division;
3. The average kelp wrack per survey has increased, both over the five years of the current study and during the previous study (1999-2005), but is still significantly less than that seen during Zobell's studies of the mid-1950s;
4. Much of the kelp wrack seen on San Clemente beaches is not due to the WNR, as evidenced by the amount of kelp wrack surveyed before the WNR became established in 2009-2010;

5. The largest kelp wrack event surveyed during the last five years occurred in February 2009, only months after construction completion of the WNR and before kelp had become established on the larger, 152-acre Phase 2 Wheeler North Reef;
6. More kelp wrack on average is deposited on San Clemente beaches during the spring, summer, and fall than during the winter months, when the large winter rain and wavestorms occur;
7. Larger kelp wrack survey events can occur during any season or month;
8. According to research by Dugan and others (Dugan & Hubbard, 2010; Dugan et al., 2010 & 2011), kelp wrack is beneficial to the beach ecosystem and acts favorably as a barrier to slow down littoral drift;
9. There is no linear relationship between the amount of kelp wrack surveyed and local/regional oceanographic influences, as determined from looking at sea temperature, significant wave height, and wave period data; and
10. The increase in kelp wrack surveyed since 1999 has been accompanied by an overall increase in the kelp canopy, both at adjacent kelp reefs and at kelp reefs across Southern California.

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APPENDIX A

VOLUME OF KELP WRACK ON SAN CLEMENTE BEACHES
OCTOBER 2008 – SEPTEMBER 2013

Table A-1. Volume of kelp wrack (ft³) measured along San Clemente Beach from October 2008 through September 2013.

Date	Five Permanent 500-ft Transect Stations					Five Permanent Stations, Total	Three Beach Areas			Total Volume of Kelp Wrack (ft ³)
	El Portal/ Buena Vista	San Clemente Pier	Calafia	State Beach	San Mateo Point		North of San Clemente Pier	South of Pier to State Beach	South of State Beach	
10-12-08	2.2	95.0	89.0	21.0	22.1	229.3	263	107	6	605.3
11-15-08	0.5	13.0	10.6	5.2	3.0	32.3	6	52	48	138.3
11-28-08	0.6	20.4	16.0	4.8	45.8	87.6	76	49	2	214.6
12-10-08	0.4	19.2	5.9	6.2	11.3	43.0	2	33	9	87.0
12-27-08	1.1	1.4	19.6	8.5	11.5	42.1	3	30	8	83.1
01-15-09	0.2	6.8	6.9	0.6	0.0	14.5	0	12	10	36.5
01-28-09	0.0	20.7	1.2	10.1	20.0	52.0	28	65	34	179.0
02-11-09	2.0	11.8	22.2	8.0	24.6	68.6	6	61	0	135.6
02-18-09	86.7	116.0	113.0	35.1	6.3	357.1	1,541	844	76	2,818.1
03-07-09	2.7	18.2	14.6	8.4	4.5	48.4	41	72	16	177.4
03-18-09	38.7	80.5	30.2	12.3	4.3	166.0	406	140	21	733.0
04-18-09	24.8	33.5	17.5	58.0	88.0	221.8	87	64	55	427.8
04-27-09	24.1	43.2	14.1	56.5	17.2	155.1	102	202	76	535.1
05-19-09	63.0	42.2	15.9	5.1	16.8	143.0	133	189	64	529.0
06-09-09	3.1	24.8	12.7	7.0	7.4	55.0	335	160	47	597.0

Date	Five Permanent 500-ft Transect Stations					Five Permanent Stations, Total	Three Beach Areas			Total Volume of Kelp Wrack (ft ³)
	El Portal/ Buena Vista	San Clemente Pier	Calafia	State Beach	San Mateo Point		North of San Clemente Pier	South of Pier to State Beach	South of State Beach	
07-26-09	353.7	186.0	169.0	33.9	1.8	744.4	837	419	3	2,003.4
08-24-09	56.2	37.0	29.6	21.8	6.3	150.9	226	261	46	683.9
08-29-09	1.5	20.0	14.7	12.9	4.5	53.6	17	165	62	297.6
09-16-09	6.5	8.5	27.7	46.2	40.5	129.4	51	109	122	411.4
10-06-09	17.4	91.3	87.0	17.2	32.0	244.9	212	342	16	814.9
10-21-09	3.0	21.7	59.2	9.6	17.4	110.9	28	350	32	520.9
11-18-09	6.9	15.6	20.8	1.3	8.3	52.9	34	84	36	206.9
11-28-09	2.2	11.6	50.0	15.1	37.0	115.9	28	92	30	265.9
12-12-09	30.8	35.1	58.2	29.7	47.0	200.8	58	289	162	709.8
12-17-09	3.3	17.1	48.9	24.5	32.1	125.9	67	205	118	515.9
12-29-09	2.2	8.4	20.4	10.1	80.0	121.1	30	61	43	255.1
01-15-10	1.7	2.2	11.1	1.5	43.7	60.2	4	3	36	103.2
01-23-10	17.3	73.3	49.2	27.8	17.4	185.0	216	466	272	1,139.0
02-11-10	7.2	45.2	0.7	10.0	58.5	121.6	54	227	94	496.6
02-17-10	0.3	0.9	1.8	4.3	43.4	50.7	4	27	23	104.7
02-23-10	18.5	5.0	0.5	4.1	52.1	80.2	9	51	45	185.2

Date	Five Permanent 500-ft Transect Stations					Five Permanent Stations, Total	Three Beach Areas			Total Volume of Kelp Wrack (ft ³)
	El Portal/ Buena Vista	San Clemente Pier	Calafia	State Beach	San Mateo Point		North of San Clemente Pier	South of Pier to State Beach	South of State Beach	
03-03-10	0.5	0.9	0.9	0.5	52.0	54.8	1	4	8	67.8
03-24-10	9.1	10.6	3.1	5.6	23.5	51.9	49	47	9	156.9
04-03-10	2.9	6.6	1.7	1.1	36.8	49.1	1	12	21	83.1
05-10-10	110.0	57.7	93.0	105.0	92.0	457.7	150	426	223	1,256.7
06-16-10	10.7	55.0	30.2	33.4	22.6	151.9	72	199	53	475.9
06-29-10	7.7	71.1	58.3	5.6	30.1	172.8	152	89	115	528.8
07-06-10	32.8	78	44	34.5	45.5	234.8	232	274	56	796.8
07-22-10	9.6	38.2	56	15.8	29.6	149.2	188	153	64	554.2
08-27-10	11.5	22.3	41.5	47.5	19.6	142.4	205	231	122	700.4
09-21-10	28.2	34.8	78.0	42.2	25.5	208.7	294	407	75	984.7
10-19-10	21.7	67.0	32.8	12.4	26.7	160.6	276	374	96	906.6
11-05-10	0.3	21.3	20.5	15.2	30.1	87.4	43	79	94	303.4
11-30-10	1.6	49.1	40.0	14.5	18.4	123.6	548	307	38	1,016.6
12-12-10	8.9	30.3	12.8	16.6	40.0	108.6	106	90	42	346.6
12-23-10	8.6	14.2	5.6	38.0	49.2	115.6	42	57	85	299.6
12-31-10	12.0	12.2	26.4	1.7	34.8	87.1	36	39	10	172.1

Date	Five Permanent 500-ft Transect Stations					Five Permanent Stations, Total	Three Beach Areas			Total Volume of Kelp Wrack (ft ³)
	El Portal/ Buena Vista	San Clemente Pier	Calafia	State Beach	San Mateo Point		North of San Clemente Pier	South of Pier to State Beach	South of State Beach	
01-11-11	0.7	22.6	1.5	7.5	9.1	41.4	31	120	30	222.4
01-20-11	1.1	0.8	18.1	2.1	11.1	33.2	9	28	16	86.2
01-27-11	2.1	15.7	2.5	2.1	15.7	38.1	22	43	23	126.1
02-18-11	17.1	25.5	22.2	30.5	28.4	123.7	47	83	74	327.7
02-23-11	17.0	38.4	24.8	15.0	16.1	111.3	96	170	56	433.3
03-09-11	4.0	15.7	30.8	13.9	23.8	88.2	42	206	122	458.2
03-19-11	2.3	6.4	24.6	10.0	76.5	119.8	23	94	117	353.8
04-11-11	36.4	180.5	93.2	23.5	17.5	351.1	295	1058	116	1,820.1
05-11-11	24.3	20.6	54.5	15.1	71.5	186.0	82	284	143	695.0
05-20-11	53.4	74.5	48.7	13.2	66.0	255.8	418	232	138	1,043.8
06-01-11	4.2	65.5	173.0	66.5	78.0	387.2	302	356	306	1,351.2
06-29-11	14.1	37.5	60.5	62.3	49.7	224.1	273	226	210	933.1
07-17-11	24.7	72.1	72.0	59.2	55.0	283.0	307	318	168	1,076.0
08-02-11	1.6	12.3	31.2	15.3	14.8	75.2	98	126	80	379.2
08-07-11	16.2	31.5	35.3	10.9	9.7	103.6	272	242	114	731.6
08-19-11	18.8	23.8	23.9	12.8	10.6	89.9	194	115	88	486.9

Date	Five Permanent 500-ft Transect Stations					Five Permanent Stations, Total	Three Beach Areas			Total Volume of Kelp Wrack (ft ³)
	El Portal/ Buena Vista	San Clemente Pier	Calafia	State Beach	San Mateo Point		North of San Clemente Pier	South of Pier to State Beach	South of State Beach	
09-02-11	178.0	321.6	262.0	24.9	25.7	812.2	1162	637	77	2,688.2
10-02-11	33.5	68.8	12.4	15.6	36.5	166.8	270	208	86	730.8
10-08-11	63.5	82.3	26.5	18.7	132.9	323.9	685	352	82	1,442.9
11-05-11	13.6	41.0	41.5	25.5	326.0	447.6	302	232	108	1,089.6
11-12-11	2.3	42.4	18.7	13.5	13.7	90.6	68	148	93	399.6
12-17-11	18.7	93.0	17.8	25.6	22.4	177.5	208	198	38	621.5
12-20-11	1.5	70.5	61.0	32.2	340.0	505.2	196	344	46	1,091.2
12-28-11	3.8	25.5	12.3	18.5	124.1	184.2	84	105	52	425.2
01-05-12	1.1	17.9	6.2	9.2	125.0	159.4	44	118	35	356.4
01-08-12	1.2	11.7	6.5	6.8	36.9	63.1	54	37	80	234.1
01-24-12	3.7	51.6	17.3	12.0	38.5	123.1	33	112	49	317.1
02-05-12	4.4	12.3	4.2	6.8	45.1	72.8	12	49	30	163.8
02-11-12	6.1	39.0	10.7	13.4	61.3	130.5	26	122	114	392.5
03-08-12	7.1	21.2	11.7	8.7	19.3	68.0	22	91	47	228.0
03-18-12	71.0	32.2	157.0	46.4	107.0	413.6	178	404	150	1,145.6
04/03/12	18.5	48.3	93.5	6.9	199.0	366.2	111	332	107	916.2

Date	Five Permanent 500-ft Transect Stations					Five Permanent Stations, Total	Three Beach Areas			Total Volume of Kelp Wrack (ft ³)
	El Portal/ Buena Vista	San Clemente Pier	Calafia	State Beach	San Mateo Point		North of San Clemente Pier	South of Pier to State Beach	South of State Beach	
04/14/12	65.4	43.6	57.0	52.2	352.0	570.2	337	302	178	1,387.2
05/02/12	12.9	30.5	37.8	13.4	32.9	127.5	264	190	88	669.5
05/24/12	22.3	60.9	32.3	5.2	32.8	153.5	126	167	90	536.5
06/23/12	18.3	24.1	22.6	14.2	22.8	102.0	53	226	132	513.0
07/19/12	13.4	105.9	32.3	7.0	16.3	174.9	255	210	91	730.9
08/07/12	62.4	44.1	17.5	14.1	48.3	186.4	242	146	60	634.4
08/15/12	58.3	91.0	13.1	28.6	15.4	206.4	323	220	110	859.4
08/19/12	48.1	162.5	19.8	13.4	6.4	250.2	366	316	140	1,072.2
09/01/12	59.2	109.1	68.0	26.6	47.5	310.4	350	428	190	1,278.4
09/21/12	69.0	150.0	32.9	12.9	21.7	286.5	213	182	77	758.5
10/05/12	40.1	103.1	20.0	9.3	25.7	198.2	394	228	148	968.2
10/24/12	90.6	234.4	49.8	12.6	95.1	482.5	572	454	82	1,590.5
11/08/12	91.2	154.2	24.3	13.1	87.0	369.8	472	338	112	1291.8
11/23/12	43.6	121.5	62.4	32.0	62.7	322.2	194	301	48	865.2
12/04/12	166.0	131.9	17.9	26.5	255.9	598.2	312	208	170	1,288.2
12/22/12	23.9	70.9	23.5	3.9	288.0	410.2	249	192	96	947.2

Date	Five Permanent 500-ft Transect Stations					Five Permanent Stations, Total	Three Beach Areas			Total Volume of Kelp Wrack (ft ³)
	El Portal/ Buena Vista	San Clemente Pier	Calafia	State Beach	San Mateo Point		North of San Clemente Pier	South of Pier to State Beach	South of State Beach	
12/28/12	5.7	10.0	15.2	2.8	199.0	232.7	110	118	96	556.7
01/13/13	15.5	61.7	4.2	1.7	78.9	162.0	70	59	67	358.0
01/26/13	14.6	37.1	21.8	1.8	83.1	158.4	36	75	109	378.4
02/06/13	0.6	3.6	7.4	1.5	33.1	46.2	46	76	38	206.2
02/22/13	0.7	3.2	3.3	1.1	26.0	34.3	23	51	58	166.3
03/19/13	8.7	23.0	7.5	7.2	59.6	106.0	76	124	77	383.0
03/26/13	21.2	67.8	10.2	3.4	101.0	203.6	252	145	65	665.6
04/06/13	71.6	105.0	19.9	46.8	83.5	326.8	117	252	142	837.8
04/09/13	182.9	176.5	58.2	3.3	464.0	884.9	288	380	140	1,692.9
04/17/13	62.7	202.7	144.0	7.6	86.0	503.0	238	1148	250	2,139.0
05/16/13	129.7	193.0	30.4	6.9	87.0	447.0	588	390	132	1,557.0
05/27/13	16.9	63.4	57.3	9.4	46.2	193.2	386	202	124	905.2
06/07/13	250.0	288.0	154.0	20.1	78.0	790.1	846	934	110	2,680.1
06/22/13	18.6	32.2	94.7	70.1	77.5	293.1	299	272	174	1,038.1
07/12/13	17.4	65.5	16.7	10.0	18.9	128.5	286	172	76	662.5
07/19/13	25.5	107.0	62.0	51.2	43.3	289.0	310	456	120	1,175.0

Date	Five Permanent 500-ft Transect Stations					Five Permanent Stations, Total	Three Beach Areas			Total Volume of Kelp Wrack (ft ³)
	El Portal/ Buena Vista	San Clemente Pier	Calafia	State Beach	San Mateo Point		North of San Clemente Pier	South of Pier to State Beach	South of State Beach	
08/01/13	30.0	121.6	93.5	31.1	16.1	292.3	658	332	92	1,374.3
09/10/13	19.8	81.0	26.5	12.0	66.0	205.3	416	148	130	899.3
09/19/13	45.8	30.7	49.0	22.7	44.8	193.0	150	274	124	741.0
Average: Oct 08 to Sep 13	31.1	58.1	39.2	18.8	58.7	205.9	203.4	218.6	84.7	712.6

Note: Numbers are all volume of kelp wrack in cubic feet.

APPENDIX B

SELECT PHOTOGRAPHS FROM KELP WRACK SURVEYS
OCTOBER 2008 – SEPTEMBER 2013



Photo B-1. 10 December 2008 photo showing light amount (0.4 cubic ft) of kelp wrack along 500-ft El Portal/Buena Vista transect. Photo is looking north.



Photo B-2. 07 June 2013 photo showing heavy amount (250 cubic ft) of kelp wrack along 500-ft El Portal/Buena Vista transect. Photo is looking north.



Photo B-3. 15 January 2009 photo showing light amount (6.8 cubic ft) of kelp wrack along 500-ft San Clemente Pier transect. Photo is looking under pier.



Photo B-4. 02 September 2011 photo showing heavy amount (321.6 cubic ft) of kelp wrack along 500-ft San Clemente Pier transect. Photo was taken under pier.



Photo B-5. 10 December 2008 photo showing light amount (5.9 cubic ft) of kelp wrack along 500-ft Calafia transect. Photo is looking south.



Photo B-6. 07 June 2013 photo showing heavy amount (154 cubic ft) of kelp wrack along 500-ft Calafia transect. Photo is looking south.



Photo B-7. 29 June 2010 photo showing light amount (5.6 cubic ft) of kelp wrack along 500-ft State Beach transect. Photo is looking south.



Photo B-8. 10 May 2010 photo showing heavy amount (105 cubic ft) of kelp wrack along 500-ft State Beach transect. Photo is looking south.



Photo B-9. 10 December 2008 photo showing light amount (11.3 cubic ft) of kelp wrack along 500-ft San Mateo Point transect. Photo is looking south.



Photo B-10. 05 November 2011 photo showing heavy amount (326 cubic ft) of kelp wrack along 500-ft San Mateo Point transect. Photo is looking south.



Photo B-11. 11 February 2009 photo showing light amount (6.0 cubic ft) of kelp wrack along area north of pier. Photo is looking south.



Photo B-12. 02 September 2011 photo showing heavy amount (1,162 cubic ft) of kelp wrack along area north of pier. Photo is looking south.



Photo B-13. 12 October 2008 photo showing light amount (107 cubic ft) of kelp wrack along area south of pier to State Beach. Photo is looking south.



Photo B-14. 11 April 2011 photo showing heavy amount (1,058 cubic ft) of kelp wrack along area south of pier to State Beach. Photo is looking south.



Photo B-15. 29 December 2009 photo showing light amount (43 cubic ft) of kelp wrack along area south of State Beach. Photo is looking south.



Photo B-16. 23 January 2010 photo showing heavy amount (272 cubic ft) of kelp wrack along area south of State Beach. Photo is looking south.

