California Regional Water Quality Control Board

San Diego Region

Winston H. Hickox
Secretary for Environmental Protection

Internet Address: http://www.swrcb.ca.gov/rwqcb9/
9174 Sky Park Court, Suite 100, San Diego, California 92123
Phone (858) 467-2952 • FAX (858) 571-6972

Gray Davis
Governor

Orange County Beaches

284

To: **Craig J. Wilson**
Senior Environmental Scientist
State Water Resources Control Board

From: **Deborah Jayne**
Senior Environmental Scientist
California Regional Water Quality Control Board, San Diego Region

Date: **6 December 2002**

Subject: **SDRWQCB Does Not Support Section 303(d) Listing of Orange County Beaches in Region 9 for Trash**

Recommendation

The California Regional Water Quality Control Board, San Diego Region (SDRWQCB) does not support the addition of Orange County beaches in Region 9 to the Section 303(d) list for trash impairment based on the evidence submitted. While we do not dispute that trash is likely a problem on Orange County beaches, as well as on other beaches in Region 9, we recommend against this listing based on the submitted evidence for the following reasons:

1. Generally inconsistent with Region 9's listing criteria (per our Staff Report);
2. Appears evidence was submitted after required deadline;
3. Spatial extent of data is inadequate;
4. Temporal extent of data is inadequate; and
5. Inclusion on either "Enforceable Programs List" or "Monitoring List" is more appropriate.

Background

Region 9 first became aware that the State Water Resources Control Board (SWRCB) was considering listing all Orange County beaches for trash at the SWRCB's workshop held on 6 November, 2002. The potential listing is based upon a paper entitled "Composition and Distribution of Beach Debris in Orange County, California, 2001." While the publishing date of the paper falls within the acceptable window for data submission, it is not clear when the paper was submitted to SWRCB staff. From Region 9's perspective, the paper was received after the second closing date for data submission (15 June 02) and thus should not be reviewed for the current Section 303(d) listing update.

Listing on the basis of the evidence submitted is inconsistent with the Region 9's listing criteria. First, the spatial extent of the data is inadequate. Since the exact spatial locations of the sampling sites are not detailed in the paper, we believe a review of the underlying data is needed (Salt Creek Beach is the only specific location mentioned in Region 9). While the evidence of

the presence of trash is strong, the paper never purports the ubiquitous presence of trash on all Orange County beaches. Based upon the information in the paper, it cannot be ruled out that the majority of trash may have been found on beaches in Region 8's portion of Orange County. Although it is likely that the underlying data demonstrates that trash is a problem at all sites sampled in both Regions, the data none-the-less should be examined before listing. Review of the underlying data was not possible due to time constraints.

Secondly, the temporal extent of the sampling period is representative of only a 7-week period and each site appears to have been sampled only once. While it is true that only "one significant period of time" is needed for listing (Region 9 Staff Report 2002), one sampling event was never used as sufficient data for any other listing. Essentially, this paper details that 1 of 1 sampling events showed an impairment of beneficial uses. Region 9 acknowledges that trash is most likely present throughout the year, but requires data that demonstrates a more chronic occurrence before listing. Perhaps a review of Beach Clean-up results could overcome this deficiency. Placing the beaches on the "Watch List" might provide sufficient motivation for photo documentation of the trash on a regular basis. Such documentation would strengthen the currently available information and support a 303(d) listing.

Finally, we do not support a 2002 Section 303(d) listing of Orange County beaches in Region 9 at this time since it is debatable if a TMDL is the best mechanism to correct trash problems. We believe that inclusion on the "Enforceable Programs" list is a more appropriate listing since the Orange County Municipal Separate Storm Sewer System (MS4) permit contains trash prohibitions and requires local ordinances against littering.

In summary, we believe that inclusion of Orange County beaches on the "Enforceable Programs List " or the "Monitoring List" is more appropriate at this time. Even assuming that the paper was received in a timely manner, the lack of spatial detail and temporal coverage makes the placement of Orange County beaches on the 303(d) list for trash inconsistent with other listings recommended by Region 9 in 2002.

cc: David Barker, Jimmy Smith, Christina Arias

S:\WQS\303dlist\Internal memos\Response to Trash listing for OC beaches3.doc

SWRCB Fact Sheet

Region 9: Orange County Coastline
Trash

Water Body	Orange County Coastline
Stressor/Media/Beneficial Use	Trash/Water/REC-2, Aquatic Life
Data quality assessment. Extent to which data quality requirements met.	The sampling procedures, collection approach, data analysis, and estimation procedures are clearly described (Moore et al., 2000. Composition and distribution of beach debris in Orange County, . California).
Linkage between measurement endpoint and benefical use or standard	The California Ocean Plan designates the beneficial uses of the ocean waters of the State that shall be protected including water contact and non-contact recreation, including aesthetic enjoyment; and marine habitat. The California Ocean Plan has applicable narrative water quality objectives as follows: - Floating particulates and grease and oil shall not be visible. - The discharge of waste shall not cause aesthetically undesirable discoloration of the ocean surface. - The rate of deposition of inert solids and the characteristics of inert solids in ocean sediments shall not be changed such that benthic communities are degraded.
Utility of measure for judging if standards or uses are not attained	The measures used in the study were abundance of trash particles and the weight of trash along the coastline. These data were compared to California Coastal Cleanup Day collection data.
Water Body-specific Information	Estimates were made of the percent of shoreline affected, types of habitat affected (sandy beach and rocky shore), Trash type (including plastics, cigarette butts, paper, wood metal glass rubber, pet and bird droppings, cloth, and other trash). Even thought the study measured the amounts of trash on the beaches for the water's edge to the first pavement or rocky cliff, this listing only applies to the portion of the beach regularly in contact with ocean water.
Data used to assess water quality	Estimated total abundance of trash was 106 million items weighing 13 tons. Pre-production plastic pellets, foamed plastics and hard plastics made up 99% of the total abundance and 51% of the total weight. Cigarette butts were fourth in total abundance and accounted for less than 1% of the abundance and weight.
Spatial representation	Beach debris was surveyed and collected at 43 sites from Seal Beach to San Clemente on the Orange County coast. The data were collected using a stratified random design, stratified by shoreline type. Each sample site was delineated as an area 25 yards in length and extending from the water's edge to the first pavement or rocky cliff. The study assessed trash on beaches in both Region 8 and Region 9.

Region 9: Orange County Coastline
Trash

Temporal representation	Data were collected between August 2 and September 18, 1998.
Data type	Numerical data.
Use of standard method	See Quality Assurance section above. Data were collected using approaches from other debris studies outside the U.S.
Potential Source(s) of Pollutant	Four sources were identified: (1) littering by beachgoers, (2) wind currents from upland sources, (3) runoff from land-based activities, and (4) overboard disposal form boating activities (including accidental spills). The data suggest that water-based sources (runoff and overboard disposal) were more important than direct littering or wind.
Alternative Enforceable Program	The Orange County Areawide Urban Stormwater Runoff Permit, Order No. R9-2002-0001 issued to Orange County and its incorporated cities does not have enforceable provisions in place to address litter, debris, and trash in this water body. The permit contains no specific provisions addressing trash, except trash is mentioned as a pollutant and the permit requires the permittee to clean storm water controls of trash before the rainy season.
RWQCB Recommendation	None.
SWRCB Staff Recommendation	After reviewing the available data and information and the RWQCB documentation for this recommendation, SWRCB staff conclude that the water body should be placed on the section 303(d) list because applicable water quality standards are exceeded and a pollutant contributes to or causes the problem. This conclusion is based on the staff findings that: 1. The data is considered to be of adequate quality. 2. The data exhibited sufficient spatial and temporal coverage. 3. Beneficial uses apply. 4. Water quality standards used is applicable. 5. Data are numerical. 6. Standard methods were used. 7. Other water body- or site-specific information including the effects of different sources and age of the data were considered. An adequate amount of the water quality measurements exceeded the water quality standard. The staff confidence that standards were exceeded is moderate.

Su B Response to Comments Jan 03 — OC Trash

COMMENT NUMBER	SUMMARY OF COMMENT	RESPONSE	REVISION	DOCUMENT SECTION
	Why can't this water body be listed? Has asked year after year for this listing to occur.			
9.405.1	Submitted at 11/06/02 SWRCB Workshop by Laura Hunter: Copy of previously-received/recorded letter dated May 29, 2002.	See response to Comment 9.15.1.	No	
9.406.1	11/6/02 Workshop Comment (in Spanish; translated by Celeste Cantu): The commenter wants (a) Crosby St. and (b) South Bay Power Plant listed. At Crosby Street location, local inhabitants cannot swim/fish due to postings. RWQCB recommended listing; SWRCB removed it. She wants it on the monitoring list at the very least. Wants to list Crosby Park for sedimentation.	See responses to Comments 9.2.1 and 9.2.2.	Yes	Volume III, Region 9
9.407.1	Maintain the San Diego Bay Shoreline, Lindbergh HAS 908.21 listing as it appeared in the 1998 303(d) list.	See response to Comment 9.401.1.	No	
9.407.2	Maintain the San Diego Bay Shoreline, Telegraph HAS 909.11 listing as it appeared in the 1998 303(d) list.	See response to Comment 9.401.1.	No	
9.407.3	Remove the proposed listings for the San Diego Bay at B Street Pier and G Street Pier (Bacteria). They did not appear on the 1998 USEPA-approved list and no new data has been provided to support these new listings.	See response to Comment 9.401.3.	No	
9.408.1	The Crosby Street Park area of San Diego Bay should be listed because of evidence of contamination, postings for fish consumption, impacts to beneficial uses, the failure of existing pollution controls, and effects on the local community.	Agree. See response to Comment 9.2.1.	Yes	Volume III, Region 9
9.409.1	Objects to putting Coronado Beach on the Monitoring List due to extraordinary efforts by the City to reduce pollution at this beach.	Agree. See response to Comment 9.8.1.	No	
9.409.2	A Technical Memorandum, by MEC Analytical Systems, Inc., attached to the Commenter's letter presents information/data. It concludes that bacteriological concentrations at the Coronado Beach area are below water quality objectives and that this water body should be removed from the 303(d) list.	Agree. This water body is recommended for de-listing.	No	
9.410.1	Does not support listing Orange County beaches in Region 9 for trash because it would be inconsistent with the RWQCB's listing criteria.	See responses to Comments 9.410.2 through 9.410.5.	No	
9.410.2	Does not support listing Orange County beaches in Region 9	The report was placed in the administrative record well before	No	

COMMENT NUMBER	SUMMARY OF COMMENT	RESPONSE	REVISION	DOCUMENT SECTION
	for trash because the evidence (SCCRWP report) was submitted after the June 15, 2002 deadline.	the June 2002 deadline.		
9.410.3	Does not support listing Orange County beaches in Region 9 for trash because the spatial extent of the data is inadequate.	The study is the most spatially representative study ever performed on the occurrence of trash on California beaches.	No	
9.410.4	Does not support listing Orange County beaches in Region 9 for trash because the temporal extent of the data is inadequate.	Please refer to the response for Comment No. G.407.8, part 1.	No	
9.410.5	Does not support listing Orange County beaches in Region 9 for trash because inclusion of these waters on the Monitoring List or Enforceable Programs List is more appropriate.	The storm water permit issued by the San Diego RWQCB does not contain specific language regarding the control of trash, except mentioned as pollutant. The permit requires the permittee to clean storm water controls of trash before the rainy season. Based on these general permit provisions, it cannot be determined if implementation of the permit will correct the trash problem. Please also refer to the responses for Comment Nos. G.410.9 and 9.410.3.	No	
9.411.1	The South San Diego Bay area is impacted by discharges of warm water, chlorine, and various metals by the Power Plant. This water body should be listed.	See response to Comment 9.2.2.	No	
9.412.1	Placement of water bodies on the Monitoring List will place additional burden on already stressed stormwater program budgets. What funding will pay for these additional monitoring priorities?	Please refer to the response for Comment No. 4.418.17.	No	
9.412.2	Descriptive statistics are not just for the benefit of "readers", they provide a level of transparency regarding how the data was evaluated, how much information was available, and what was the quality of that information.	Comment noted.	No	
9.412.3	There should be a considerable level of certainty that...impairment actually exists. Why is a binomial distribution being used as opposed to a lognormal distribution? The statistical model being used is too simplistic to evaluate the complex data.	A binomial approach is one approach to help decide how many exceedences, or lack thereof, may be necessary to judge whether a water body is achieving water quality standards. For decision-making of this kind, a sample result either does or does not meet a particular water quality standard (i.e., a sample result number is either less than or equal to a standard, or it is greater than the standard). Binomial statistics are, as used by other states, highly appropriate for this type of analysis. The SWRCB staff does not know of a state that uses a "lognormal distribution" to determine compliance with standards.	No	
9.412.4	The Commenter quotes part of the response to Comment	The response to Comment 9.5.6 did not refer to the need for	No	

COMMENT NUMBER	SUMMARY OF COMMENT	RESPONSE	REVISION	DOCUMENT SECTION
		beneficial use related to aesthetics and probably is a nuisance. Beneficial uses associated with aquatic life protection may also be impacted. The fact sheet will be changed to reflect this information.		
G.407.6	The staff report identifies standards that are only applicable to inland surface waters, not ocean waters, and not beaches. Application of the inland surface water suspended solid standard is improper in this context and should not serve as the basis for proposing to list as impaired twenty miles of Orange County beaches.	The information in the fact sheet will be modified to describe the correct standard and beneficial uses that are exceeded.	Yes	Volume III, Region 8
G.407.7	Water quality standards from the California Ocean Plan are equally inapplicable to a listing of Orange County beaches for trash. To the extent that any of the beach areas equate to ocean waters, the Ocean Plan objectives would apply to those waters. The Ocean Plan does not contain any water quality objectives related to trash or litter.	The fact sheet will be modified to include a description of the Ocean Plan water quality objectives and beneficial uses relied upon. While the standard does not call out trash or litter, it does have an objective related to the visibility of floating particulates. In addition, the Ocean Plan contains beneficial use designations for contact and non-contact recreation including aesthetic enjoyment and aquatic life protection.	Yes	Volume III, Region 8
G.407.8	The study cited as supporting to proposed listing is inappropriate for several reasons: A. The data analyzed was collected over approximately one-month period four years ago. B. The samples collected and discussed in the study contain materials that are arguably not trash under conventional definitions (pet and bird droppings). C. The authors of the study acknowledge that the results are vastly different than the California Coastal Cleanup Day data from the area. The study results are therefore called into question. D. The California Cleanup Day data should be used in addition to the study's results.	A. These statements are true. The study is a snapshot of the kinds and amounts of trash on these beaches. This study is also the most complete and scientifically defensible study of trash occurrence on California beaches. While more data would be desirable, this study provides an unbiased representation of the trash on these southern California beaches. B. Pet and bird droppings were one of eleven major categories of trash on these beaches. While these droppings can effect other beneficial uses, it is clear that the presence of pet and bird droppings can be an aesthetic problem. C. The study used to support the listing proposal is a systematic assessment of the occurrence of trash on Orange County beaches. The differences between the study and the California Coastal Cleanup Day has been described by the scientists who performed the study: "The estimates for the surveys differ for several reasons. First, the California Coastal Cleanup Day is conducted by volunteers whose purpose it is to clean the beach rather than to quantify debris. As a result, it is likely that ... some of the debris collected during this event was not recorded. Second, the volunteers focus their cleaning efforts on a subset of the	Yes	Volume III, Region 8

COMMENT NUMBER	SUMMARY OF COMMENT	RESPONSE	REVISION	DOCUMENT SECTION
		coastline, which excludes the rocky shoreline.... Third, the California Coastal Cleanup Day event focuses on many of the popular, easy accessible beaches that are regularly cleaned by mechanical combers. Moreover, the cleanup events usually cover only an area 1/4 to 1/2 of a mile from their starting locations, rather than the whole beach." It also seems that volunteers focus on larger and more visible trash and not smaller less detectable debris. Cleanup events typically are effective at gathering larger debris. The study used to support the listing is not questionable because of the substantial difference in trash collected because to approaches used in the study and during the beach cleanup events were appropriately different because of their different purposes. D. The fact sheet will be revised to include the Coastal Cleanup data in the record.		
G.407.9	There are alternative enforceable programs that exist which negate the need to list Orange County beaches as impaired for trash. These programs include the North Orange County storm water permit, municipal ordinances to control littering, county ordinances prohibiting littering, and a California Department of Parks and Recreation regulation banning littering.	Please refer to the response for Comment No. G.410.9.	No	
G.408.1	The State Board should establish a reasonable period of time (at minimum 90 days given the circumstances) for the public to review and provide comment for the SWRCB CWA Section 303(d) Staff Report.	Please refer to the response for Comment No. G.401.1.	No	
G.408.2	The SWRCB revised draft is almost 1,700 pages long and represents a substantial overhaul and expansion of the prior draft, which itself consisted of 1000 pages. The sheer volume of material and technical complexity of its contents, and the enormous potential impact of the 303(d) listing and associated regulatory activities on the Bay Area warrant an extended public comment period.	Please refer to the response for Comment No. G.401.1.	No	
G.408.3	The complexity of these listings as well as the fact that San Leandro Bay appears on the proposed Section 303(d) List for the first time on October 15th is a sufficient, independent basis to hold the public comment period open for at least 90	Please refer to the response for Comment No. G.401.1.	No	

COMMENT NUMBER	SUMMARY OF COMMENT	RESPONSE	REVISION	DOCUMENT SECTION
G.410.9	Other trash found on Orange County Beaches can be better addressed through other programs--e.g., municipal stormwater permits.	The storm water permit issued by the Santa Ana RWQCB is a strong permit with specific language that will eventually address the trash problems in these coastal waters. Unfortunately, SWRCB staff cannot determine when standards will met. This permit should be allowed to be implemented before the development of a TMDL. It is probable that if the provisions of the permit are implemented a TMDL will not be needed.	No	
G.410.10	It is contrary to the intent of section 303(d) to list waters whose pollutants can not be controlled via a TMDL. Trash is not a suitable pollutant for TMDL calculations and resulting controls. The vast majority of trash may result from non-point sources, which the State has little or no control over.	There are many pollutant sources that are difficult or impossible to control. The combination of local ordinances and the provisions of the storm water permit issued by the Santa Ana RWQCB seems to be leading in a direction that will allow for a better characterization and control of trash in water bodies. USEPA has determined that all pollutants are suitable for TMDL calculation.	No	
G.410.11	It is extremely important that listings be supported by adequate data and sound science. The commenter supports Monitoring and TMDL Completed List designations.	Comment acknowledged.	No	
G.410.12	Prior, 5/30/02 comment: The "principal fecal coliform data used for comparison with the REC-1 and REC-2 objectives was old data collected from 1997 to 1999." This data is limited and was highly influenced by seasonal winter conditions.	The age of this data, 1-4 years, is acceptable for use in the current 303(d) assessment. As noted in the SWRCB Staff Report, samples from Reach 1 of San Diego Creek exceeded total and fecal coliform standards 22 out of 22 times (weekly samples), supporting the decision to list this water body for bacterial impacts. Regarding the use of wet-weather data, see response to Comment G.410.13.	No	
G.410.13	Access to San Diego Creek Reach 1 is prohibited in wet season periods. Therefore, only dry-season data should be used to evaluate impacts to REC-1. If only dry-season data is analyzed, it suggests that the REC-1 objective is met a majority of the time. San Diego Creek Reach 1 should on the Monitoring List, not the 303(d) list.	The pertinent Basin Plan fecal coliform objective for the REC-1 beneficial use is applicable "for any 30-day period." (Page 4-3, Water Quality Control Plan, Santa Ana River Basin [8]). Therefore, both wet and dry-weather data must be used. It is not appropriate or possible to modify an existing water quality objective during the 303(d) listing process (see response to Comment 9.7.1).	No	
G.410.14	The proposed listing for total phosphorus in Aliso Creek should be removed because: 1. The Region 9 RWQCB used both stormwater and dry weather data from Orange County's NPDES monitoring. Impacts from stormwater events are limited. The Region 8	(Copy of Comment 9.17.2.) See response to Comment 9.17.2.	No	

Basis for trash listing

Composition and distribution of beach debris in Orange County, California

Shelly L. Moore, Dominic Gregorio[1], Michael Carreon[2], Stephen B. Weisberg, and Molly K. Leecaster[3]

ABSTRACT

Many studies have quantified the amount of debris collected along beach shoreline areas in various locations around the world. Only a few of those studies have been conducted in the United States, and they are largely limited to semi-quantitative efforts performed as part of volunteer clean-up activities. In this study, we quantified the distribution and types of beach debris by sampling 43 stratified random sites from Seal Beach to San Clemente on the Orange County, California, coast from August to September, 1998. An area of shoreline was delineated for each site that was 25 yards in length and extended from the water's edge to the first pavement or rocky cliff. All trash was collected by at least three people walking systematically along transects. In addition, a five-gallon bucket was used to sieve one bucket of sand at each site to collect and quantify the small items that were undetectable by visual examination. Based upon the survey data results, it was estimated that more than 106 million items, weighing approximately 13 tons, occur on Orange County shorelines. The most abundant items were pre-production plastic pellets, followed by foamed plastics and hard plastics. Debris density on the remote rocky shoreline was greater than that on high-use sandy beaches for most debris items. This finding partially reflects the periodic cleanup of high-use beaches by local municipalities, and also indicates that a high percentage of the observed debris was transported to the site from waterborne sources. The amount of Orange County beach debris estimated by this study is 50 times that (excluding pre-production plastic pellets) collected in the California Coastal Cleanup Day. The difference appears to be attributable to Cleanup Day's focus on large, visible debris at a subset of high-use beaches that are periodically cleaned by mechanical combers.

INTRODUCTION

Beaches along the southern California coast are used extensively for a variety of recreational purposes, attracting almost 150 million visitors annually (Schiff *et al.* 1999). Recreational uses such as boating, swimming, surfing, sunbathing, and picnicking generate debris along the shoreline including food bags and wrappers, cups and utensils, trash bags, fast-food and other product containers, toys, fishing lures and floats, and plastic. In addition, southern California has the highest coastal population density of any area in the country (Culliton *et al.* 1988), providing an additional source of debris via urban runoff and maritime disposal (including accidental spills). Debris is one of the most highly visible expressions of human impact on the marine environment, which is one of

This picture not available at this time

Debris from an Orange County beach.

[1]*Southern California Marine Institute, 820 South Seaside Avenue Terminal Island, CA 90731*

[2]*Divers Involved Voluntarily in Environmental Rehabilitation and Safety, P. O. Box 241, Fullerton, CA 92834*

[3]*Present address: INEEL, Bechtel WBXT Idaho, LLC, P.O. Box 1625, Idaho Falls, ID 83415-3779*

the factors that has led to the popularity of public cleanup efforts along the shoreline (Ribic *et al.* 1997). More than an aesthetic issue, debris can threaten marine mammals, birds, and turtles through ingestion and entanglement (Bjorndal *et al.* 1994, Fowler 1987, Robards 1993, Ryan 1987). Marine debris is also becoming a regulatory focal point. The Los Angeles Regional Water Quality Control Board recently implemented legal limitations, through the total maximum daily load (TMDL) process, on the amount of trash that local governments can allow to enter the ocean through storm drains.

Many studies have enumerated the types and amount of marine debris on beaches (Corbin and Singh 1993, Garrity and Levings 1993, Golik 1997, Golik and Gertner 1992, Lucas 1992, Ross *et al.* 1991, Ribic *et al.* 1997, Walker *et al.* 1997, Willoughby 1986), and a few studies have quantified subsurface nearshore debris (June 1990, Moore and Allen 2000). Most of the debris data for beaches outside of the United States have been collected through systematic, scientifically rigorous studies, while most of the information within the United States has been derived from volunteer beach cleaning efforts. Although cleaning efforts are valuable for removing debris from beaches, they provide only semi-quantitative estimates of debris. Here we present the first study to quantitatively assess the types and amount of debris on the California coast, with a secondary objective of describing how debris differs among shoreline types.

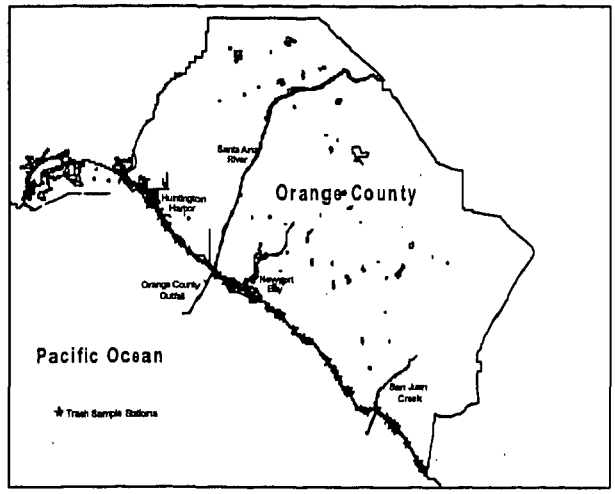
METHODS

Beach debris was surveyed and collected at 43 sites from Seal Beach to San Clemente on the Orange County, California, coast between August 2 and September 18, 1998 (Figure 1). Sites were selected using a stratified random design, stratified by shoreline type (rocky shoreline and sandy beach). Sample sites were selected randomly within the strata and a systematic component was overlayed to minimize clustering, following the sampling design used in the National Stream Survey (Overton 1987). Each stratum was subdivided into a series of sections (each identified by a count variable) of like-strata joined together into a stratum line. A partition was created for each stratum line, with the number of intervals in the partition equal to the sample size. The partition was placed over this stratum line by selecting a random starting point for the beginning of the first interval. Based upon this starting point, the intervals were defined as consecutive equal-width lengths. A simple random sample of one point was then chosen from within each interval. Each point was translated back to the shoreline using the section count variable. The partition structure ensures systematic separation of the sampling, while the random selection of sites within partitions ensures an unbiased estimate of beach debris.

Each sample site was delineated as an area 25 yards in length that extends from the water's edge to the first pavement or rocky cliff. All trash at the site was collected by at least three people walking systematically along transects to ensure that all areas within the sample site were examined. All debris was bagged and transported to the laboratory for identification and quantification. In addition, a five-gallon bucket was used to sieve one bucket of sand at each site to quantify the small items that were undetectable by visual examination. In the laboratory, debris was sorted into the broad categories used by the Center for Marine Conservation during their Coastal Cleanup days (i.e., glass, metal, plastics, foamed plastics, rubber, paper, wood, and cloth). From each broad category, debris was further sorted into more specific subcategories (e.g., cups, plates, etc.), enumerated, and weighed. Within the specific categories, brand names were recorded, when possible, to establish cross-brand trends.

The total amount of debris along the Orange County coast was estimated by calculating a mean amount of trash for a 25-yard segment within each strata and then weighting those means by the relative amount of shoreline distance in each strata. Estimates for smaller debris collected by sieving were calculated using a similar methodology, after estimating the number of yards from the water's edge to the first pavement or rocky cliff for each site then extrapolating the abundance for each sample site area.

FIGURE 1. Sample sites for the Orange County beach debris study, August to September 1998.



RESULTS

More than 106 million items, weighing approximately 13 tons, were estimated to occur along the Orange County shoreline (Table 1). Three categories of plastics (pre-production plastic pellets, foamed plastics, and hard plastics) accounted for 99% of the total abundance and 51% of the total weight. Cigarette butts were fourth in abundance and accounted for less than 1% of the total abundance and weight. Cigarettes, candy, fast–food products, beer, and other beverages were the most identified brand-related debris (Table 2). Marlboro®, Starburst®, Jack in the Box®, Budweiser Light®, and Coca Cola® all led in their respective categories.

Most of the plastics encountered were in the form of small pieces of plastic (Table 3). Foamed plastic pieces accounted for 88% of the total foamed plastics and hard plastic pieces accounted for 50% of the total hard plastics. Of the whole plastic items, food and beverage items were the most abundant.

The distribution of debris differed among shoreline types. Sandy beaches are eight times more abundant than rocky shoreline in Orange County, but most debris did not reflect this ratio (Table 4). Foamed and hard plastics, glass, rubber, and animal droppings all occurred at higher proportions on rocky beaches. Pre-production plastic pellets, paper, wood, and cloth all occurred at higher proportions on sandy beaches. Cigarette butts and metal were found at approximately equal ratios between beach types.

TABLE 1. Estimated total abundance and weight of trash on Orange County beaches, August to September, 1998.

Debris Type	Abundance	Weight (lbs)
Pre-production plastic pellets	105,161,101	4,780
Foamed plastics	742,296	1,526
Hard plastics	642,020	7,910
Cigarette butts	139,447	344
Paper	67,582	870
Wood	27,919	4,554
Metal	23,500	3,015
Glass	22,195	1,944
Rubber	10,742	817
Pet and bird droppings	9,388	17
Cloth	5,949	1,432
Other	10,363	401

TABLE 2. Percent of total of top three brands in main brand categories collected on Orange County beaches, August to September, 1998.

Brand Name	Percent of Total	Percent of Market Share
Cigarette Products		
Marlboro	62	32.3
Camel	7	4.6
Benson & Hedges	7	<2.4
Candy Products		
Starburst	16	na
Snickers	13	na
Blow Pop	9	na
Fast-Food Products		
Jack in the Box	27	3.6
Carls Jr.	19	1.9
KFC	12	<0.9
Beer Products		
Budweiser Light	27	12.9
Budweiser	16	18.3
Corona	7	2.0
Drink Products		
Coca Cola	16	20.6
Pepsi	15	14.2
Capri Sun	8	<1.2

na = Not available

DISCUSSION

The most abundant item found on southern California beaches was pre-production plastic pellets, which are probably lost in transport from the raw materials producers to the processors who mold the pellets into plastic products. The pellets, collected primarily through sieving the surface layers of sand, come in a variety of shapes (ovoid, cylindrical, etc.) and are typically less than 5 mm in diameter. Approximately one quadrillion of these pellets, representing 60 billion pounds of resin, are manufactured annually in the United States alone (U.S. EPA 1992). The presence of these pellets is not unique to U.S. beaches; Gregory (1977, 1978) estimated that approximately 1,000 tons of these pellets occur on New Zealand beaches.

The relative distribution of brand-name products in the debris we collected largely reflects the product's relative market share. For example, we collected 10 times more Marlboro cigarette butts than any other brand, consistent with Marlboro's 32% market share. Similarly, Budweiser and Budweiser Light dominated the beer debris category, as they do in sales. One exception to the high correlation between brand-related debris quantity and market share was in the fast-food container category. Industry leader McDonalds constituted less than 10% of the total debris measured, while Jack in the Box accounted for nearly three times that level. Perhaps the geographic distribution of fast-food restaurants in relation to Orange County beaches was responsible for the

TABLE 3. Estimated total abundance of plastics on Orange County beaches, August to September, 1998.

Trash Type	Abundance
Foamed Plastics	
Foamed plastic pieces	652,639
Fast food containers	43,167
Other foamed plastics	25,415
Cups	10,595
Packaging material	9,940
Plates	270
Meat trays	180
Buoys	90
Total:	742,296
Plastics	
Plastic pieces	318,790
Caps and lids	88,548
Straws	84,990
Food bags and wrappers	58,394
Other plastic	48,799
Cups and utensils	9,641
Other plastic bags	7,164
Cigarette lighters	5,810
Beverage bottles	4,550
Trash bags	3,729
Toys	2,159
Buckets	1,973
Rope	1,848
Other bottles	1,563
Milk and water bottles	1,182
Diapers	1,003
Strapping bands	449
6-pack holders	321
Fishing line	321
Tampon applicators	301
Fishing lures and floats	281
Oil and lube bottles	114
Light sticks	90
Total:	642,020
Total Plastics	1,384,316

discrepancy in the amount of fast-food product debris collected compared to the brand's respective market share.

Four major sources have been identified as pathways in the transport of debris to the Orange County shoreline: (1) littering by beachgoers, (2) wind currents from upland sources, (3) runoff from land-based activities, and (4) overboard disposal from boating activities (including accidental spills). Each of these sources requires a different management action to effect a reduction in beach debris. Although our study was not designed to differentiate sources, our data suggest that water- based sources (runoff and overboard disposal) were more important than direct littering or wind. One line of evidence for this is that plastic pellets were found in abundance on all shoreline areas and are unlikely to originate from littering or wind. The second line of evidence is the greater density of most debris items found on less-frequented rocky shoreline compared to the sandy beaches (Table 4). While this pattern was true for most debris, an exception was the greater amount of paper products, such as food wrappers, found on sandy beaches, suggesting that they were left by beachgoers.

The only previous quantification of debris on the Orange County shoreline was from data collected by volunteers during the annual California Coastal Cleanup Day. Their 1998 cleanup event occurred the week after the present survey was completed and their estimate of the amount of debris was 50 times lower than our data (Table 5). Moreover, our estimate for Orange County debris exceeded the California Coastal Cleanup Day estimate for the entire state.

The estimates provided by the two surveys differ for several reasons. First, the California Coastal Cleanup Day is conducted by volunteers whose purpose it is to clean the beach rather than to quantify debris. As a result, it is likely that the some of the debris collected during this event was not recorded. Second, the volunteers focus their cleaning efforts on a subset of the coastline, which excludes the rocky shoreline where 10% of the debris was encountered in the present study. Third, the California Coastal Cleanup Day event focuses on many of the popular, easily accessible beaches that are regularly cleaned by mechanical combers. Moreover, the cleanup events usually cover only an area 1/4 to 1/2 of a mile from their starting locations (Mark Patrick, County of Orange, Harbors, Beaches, and Parks, personal communication), rather than the whole beach.

TABLE 4. Estimated total abundance of trash by beach type on Orange County beaches, August to September, 1998.

Debris Type	Beach Type: Sandy	Beach Type: Rocky	S:R Ratio
Percent of Shoreline	89	11	8:1
Pre-production plastic pellets	96,211,029	8,950,072	11:1
Foamed plastics	557,319	184,977	3:1
Hard plastics	424,257	217,763	2:1
Cigarette butts	124,422	15,025	8:1
Paper	64,729	2,853	23:1
Wood	25,611	2,308	11:1
Metal	20,468	3,032	7:1
Glass	4,055	18,140	1:4
Rubber	9,039	1,703	5:1
Pet and bird droppings	7,217	2,171	3:1
Cloth	5,529	420	13:1
Other	10,300	63	163:1
Total	97,463,975	9,398,527	10:1

TABLE 5. Comparison of abundance for the Orange County summer trash survey and Center for Marine Conservation 1998 California Coastal Cleanup Day.

Debris Type	Bight'98	Coastal Cleanup Day	
	Orange County	Orange County	California
Pre-production Plastic Pellets	105,161,101	-	-
Foamed Plastics	742,296	8,170	211,406
Hard Plastics	642,020	10,860	382,380
Cigarette Butts	139,447	6,717	309,910
Paper	67,582	2,504	133,335
Wood	27,919	720	27,136
Metal	23,500	1,456	110,201
Glass	22,195	1,033	94,333
Rubber	10,742	643	25,666
Pet and Bird Droppings	9,388	-	-
Cloth	5,949	317	10,620
Other	10,363	-	-
Total with pellets	106,862,502	32,420	1,304,987
Total without pellets	1,701,401	32,420	1,304,987

Another variable that could partially account for the discrepancy in the two survey results is that volunteers traditionally focus on larger, more visible debris to the exclusion of small, undetectable debris. To assess the impact of this variable, two beach sites (Salt Creek Beach and Sunset Beach) were sampled using the same methods as the present study. Sampling occurred immediately after the September 18, 1999, California Coastal Cleanup Day. While more than 8,000 pieces of debris were collected from these beaches as part of the cleanup effort, we estimated 67,795 pieces remaining (Table 6). Most of the remaining items were small; the majority of large items, such as glass bottles, were effectively removed by the California Coastal Cleanup Day volunteers.

TABLE 6. Comparison of beach debris amounts between Coastal Cleanup Day volunteers and the Orange County beach debris follow-up study.

	Total abundance of beach debris			
	Sunset Beach		Salt Creek	
Trash Type	CCD	OC*	CCD	OC*
No. of Volunteers	56	8	197	5
Total Weight (lbs)	137	106	405	35
Foamed plastics	313	19,219	1,057	6,336
Hard plastics	1,419	13,658	1,775	5,667
Cigarette butts	222	9,293	1,646	2,464
Paper	139	3,133	711	1,338
Wood	28	387	121	246
Metal	26	1,126	244	2,534
Glass	15	950	257	-
Rubber	67	282	157	387
Cloth	5	634	48	141
Total	2,234	46,682	6,016	19,113

CCD = Coastal Cleanup Day.
OC = Orange County beach debris follow-up study.
* Orange County beach debris follow-up study abundences are estimates of trash found in 1/2 mile based on a 25 yard sample.

LITERATURE CITED

Bjorndal, K. A., A. B. Bolton and C. J. Lagueux. 1994. Ingestion of marine debris by juvenile sea turtles in coastal Florida habitats. *Marine Pollution Bulletin* 28:154-158.

Corbin, C. J. and J. G. Singh. 1993. Marine debris contamination of beaches in St. Lucia and Dominica. *Marine Pollution Bulletin* 26:325-328.

Culliton, T., M. Warren, T. Goodspeed, D. Remer, C. Blackwell and J. McDonough II. 1988. 50 years of population changes along the nation's coast. Coastal Trends Series, Report No. 2. National Oceanic and Atmospheric Administration, Strategic Assessments Branch. Rockville, MD.

Fowler, C.W. 1987. Marine debris and northern fur seals: A case study. *Marine Pollution Bulletin* 18:326-335.

Garrity, S.D. and S.C. Levings. 1993. Marine Debris along the Caribbean coast of Panama. *Marine Pollution Bulletin* 26:317-324.

Golik, A. 1997. Debris in the Mediterranean Sea: Types, quantities, and behavior. pp. 7-14 *in:* J.M. Coe and D.B. Rogers (eds.), Marine Debris: Sources, Impacts, and Solutions. Springer-Verlag. New York, NY.

Golik, A. and Y. Gertner. 1992. Litter on the Israeli coastline. *Marine Environmental Research* 33:1-15.

Gregory, M.R. 1977. Plastic pellets on New Zealand beaches. *Marine Pollution Bulletin* 8:82-84.

Gregory, M.R. 1978. Accumulation and distribution of virgin plastic granules on New Zealand beaches. *New Zealand Journal of Marine and Freshwater Research* 12:399-414.

June, J.A. 1990. Type, source, and abundance of trawl-caught marine debris off Oregon, in the Eastern Bering Sea, and in Norton Sound in 1988. pp. 279-301 *in:* R.S. Shomura and M.L. Godfrey (eds.), Proceedings of the Second International Conference on Marine Debris, 2 - 7 April 1989, Honolulu Hawaii. U.S. Department of Commerce, NOAA Technical Memorandum NMFS, NOAA-TM-NMFS-SWFSC-154.

Lucas, Z. 1992. Monitoring persistent litter in the marine environment on Sable Island, Nova Scotia. *Marine Pollution Bulletin* 24:192-199.

Moore, S.L. and M. J. Allen. 2000. Distribution of anthropogenic and natural debris on the mainland shelf of the Southern California Bight. *Marine Pollution Bulletin* 40:83-88.

Overton, S.W. 1987. A Sampling and Analysis Plan for Streams, in the National Surface Water Survey Conducted by EPA. Technical Report No. 117. Department of Statistics, Oregon State University. Corvallis OR.

Ribic, C.A., S.W. Johnson and C.A. Cole. 1997. Distribution, type, accumulation, and source of marine debris in the United States, 1989-1993. pp. 35-47 *in*: J.M. Coe and D.B. Rogers (eds.), Marine Debris: Sources, Impacts, and Solutions. Springer-Verlag. New York, NY.

Robards, M.D. 1993. Plastic ingestion by North Pacific seabirds. U. S. Department of Commerce. NOAA-43ABNF203014. Washington, DC.

Ross, J.B., R. Parker and M. Strickland. 1991. A survey of shoreline litter in Halifax Harbour 1989. *Marine Pollution Bulletin* 22:245-248.

Ryan, P. G. 1987. The effects of ingested plastic on seabirds: Correlations between plastic load and body condition. *Environmental Pollution* 46:119-125.

Schiff, K.C., S.B. Weisberg and J. H. Dorsey. 1999. Microbiological monitoring of marine recreational waters in southern California. pp. 179-186 *in:* S. Weisberg (ed.), Southern California Coastal Water Research Project Annual Report 1997-1998. Southern California Coastal Water Research Project. Westminster, CA.

U.S. Environmental Protection Agency (U.S. EPA). 1992. Plastic Pellets in the Aquatic Environment: Sources and Recommendations. U.S. EPA 842-B-92-010. Washington, DC.

Walker, T.R., K. Reid, J.P.Y. Arnould and J. P. Croxall. 1997. Marine debris surveys at Bird Island, South Georgia 1990-1995. *Marine Pollution Bulletin* 34:61-65.

Willoughby, N. G. 1986. Man-made litter on the shores of the Thousand Island Archipelago, Java. *Marine Pollution Bulletin* 17:224-228.

ACKNOWLEDEGMENTS

The authors wish to thank the following organizations and their volunteers/employees for assistance with this project: Divers Involved Voluntarily in Environmental Rehabilitation and Safety, Southern California Marine Institute, Southern California Coastal Water Research Project, Cabrillo Marine Aquarium, and the Long Beach Conservation Corps. We would also like to thank Mark Patrick for his assistance in the comparison with the 1999 Coastal Cleanup Day activities.