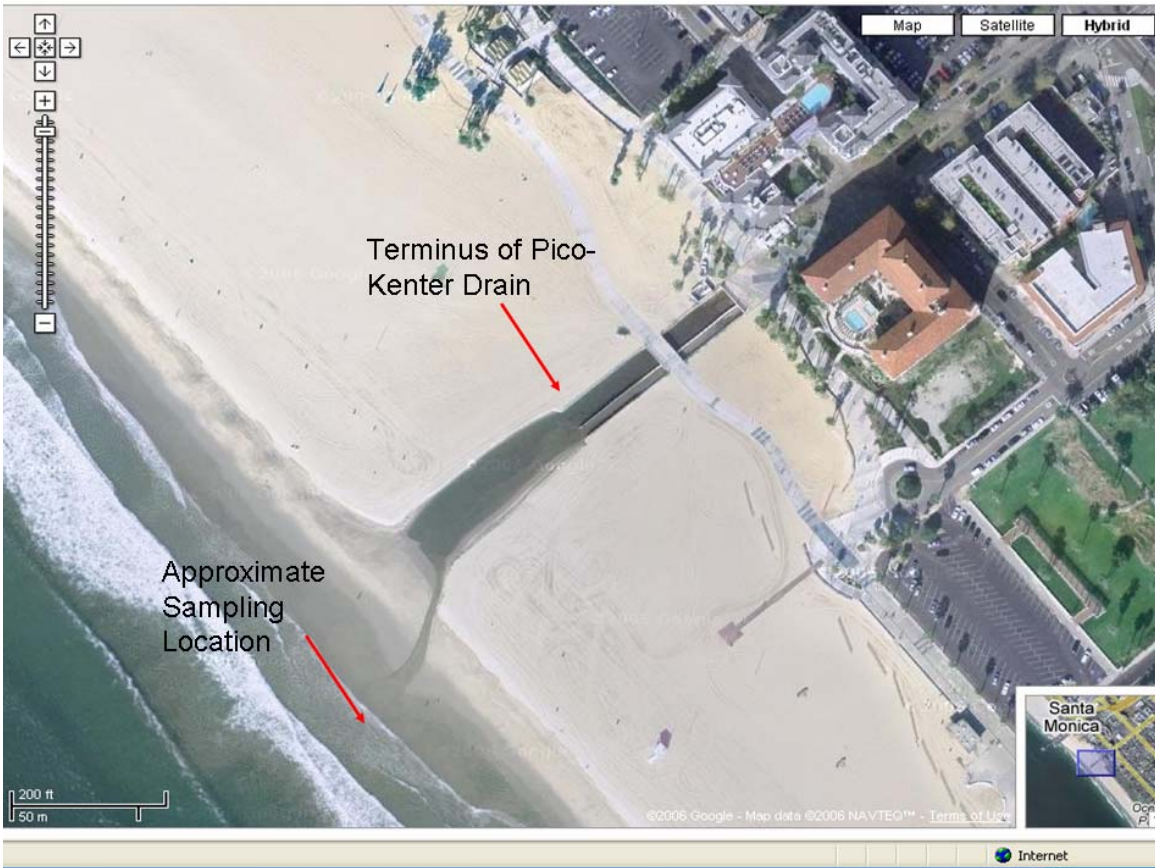
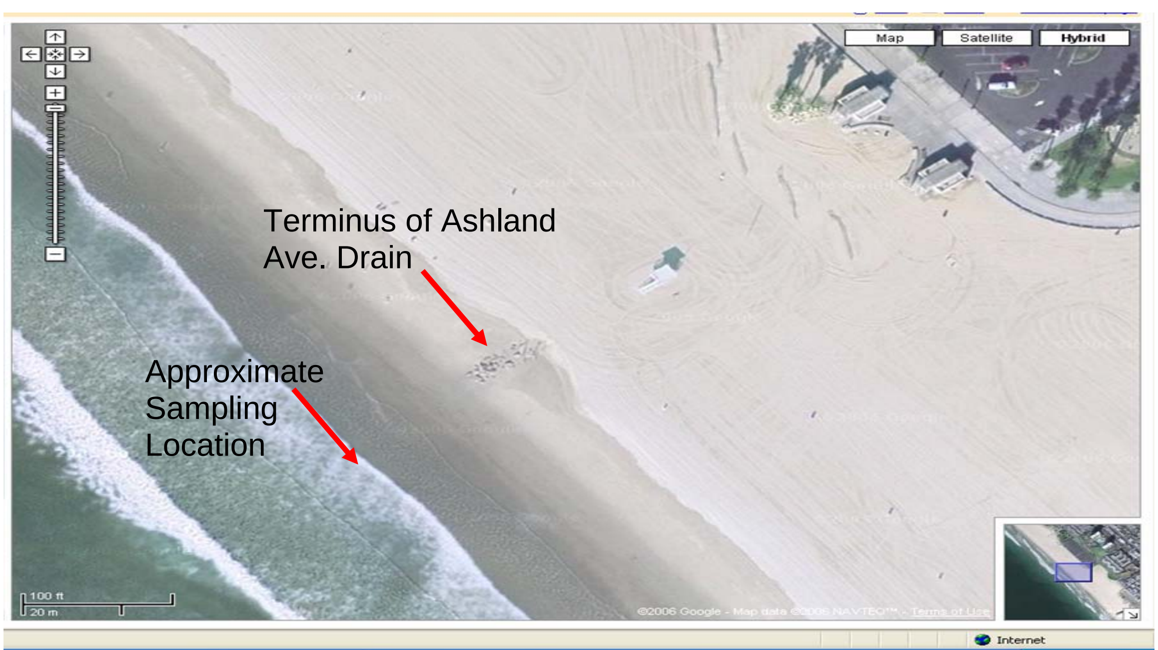
Appendix B


Map
Satellite
Hybrid
Terminus of Pico-Kenter Drain
Approximate Sampling Location
Santa Monica
200 ft
50 m
Internet


Map
Satellite
Hybrid
Terminus of Ashland Ave. Drain
Approximate Sampling Location
100 ft
20 m
Internet

Site Id: SMB-3-4	**Status:** Moved	**Type:** Point Zero
Historical Site Id: S6	**Subwatershed:** Santa Monica	**BayKeeper Id:** s7d10
Comments: This site is situated at the wave wash of Pico-Kenter Storm Drain. The Pico-Kenter Storm Drain is generally blocked by sand from June to the first large storm event. It also has a diversion to the Santa Monica Urban Runoff Treatment Facility to minimize flows during winter dry weather. See Thomas Guide page 671 E3.		

Site Id: SMB-3-5	**Status:** Moved	**Type:** Point Zero
Historical Site Id: S7	**Subwatershed:** Santa Monica	**BayKeeper Id:** s7d20
Comments: This site is situated at the wave wash of Ashland Storm Drain. Sampling is proposed at the wave wash because dry-weather flow is observed periodically from this storm drain, despite an existing diversion structure. The County is currently designing a new diversion structure for this storm drain; it is scheduled to become operational in Summer 2005. See Thomas Guide page 671 F5.		

Source: *Santa Monica Bay Beaches and Bacteria TMDLs Coordinated Shoreline Monitoring Plan*. City and County of Los Angeles. April 7, 2004.

Summary of Exceedance-day Frequencies[1] for

Routinely-monitored Beaches Proposed for Delisting that do not Meet Delisting Criteria[2,5]

Beach	Description	Monitoring Agency/ID	Monitoring Frequency	Exceedance Freq. - AB-411							Exceedance Freq. - Dry Winter						Exceedance Freq. - Wet Winter					
				Allow	2000	2001	2002	2003	2004	2005	Allow	2000	2001	2002	2003	2004	Allow	2000	2001	2002	2003	2004
Santa Monica	Santa Monica Beach at Pico/Kenter storm drain	S6	daily	0	18	3	6	23	6	42	3	16	9	7	7	19	17	28	28	19	19	18
Santa Monica / Ocean Park	Ashland Av. storm drain	S7	daily	0	7	3	4	6	9	8	3	10	5	1	2	9	17	16	15	9	10	18

1. Single-sample standard exceedances only. Rolling geometric means were not calculated.
2. Source of data - Routine monitoring results from Los Angeles City Sanitation Department and Los Angeles County Department of Health Services (DHS)
3. Delisting policy states criteria for delisting beaches based on numeric water quality objectives for bacteria in water (Section 4.3) states that removing waters from the 303(d) list shall be based on the site-specific exceedance frequency assigned to the region. Region IV has a site specific exceedance frequency, in terms of exceedance-days, based on reference beach Leo Carillo.
4. Allow = Allowable number of exceedance-days (site specific exceedance frequency) per Santa Monica Bay Beaches Bacteria TMDLs. Allowable exceedance-days are set for three time periods: AB-411 (April - Oct.), Dry Winter (dry non-AB-411), and Wet Winter (wet, non-AB-411). Allowable exceedance-days varies with sampling frequency.
5. None of these beaches have multiple listing such as beach closures, coliform counts, etc. So, if delisted as proposed, there is no other listing that will cover bacteriological pollution.

Appendix C: Statewide Beaches

As previously discussed, Heal the Bay analyzes bacteria data collected by local health and water agencies at approximately 450 of the State's beaches to develop the weekly Beach Report Card. Thus, in addition to evaluating beach bacteria data in Los Angeles County, we analyzed statewide beach data in the context of the 2006 303(d) List. As described in detail below, our analysis revealed that there are numerous beaches that do not have a bacteria-related listing and are not currently proposed for listing despite the fact that readily available data show these beaches meet the listing criteria (per the State's listing policy section 3.3). Thus, State Board should include these beaches in the 2006 303(d) List updates. In addition, a number of the State's beaches are proposed for de-listing where readily available data show that the de-listing criteria is not met (per the State's listing policy section 4.3).

<u>Analysis Description</u> Section 3.3 of the Listing Policy outlines listing factors for bacteria at coastal beaches. Since beaches outside of Los Angeles County do not have a site-specific exceedance-day frequency, we evaluated the data in terms of the binomial distribution if the beaches are monitored year-round and a 4% exceedance percentage if they are only AB411-monitored beaches, as outlined in the listing policy. The first step in our analysis was to calculate rolling geometric means for all beaches for any 30-day period in which 5 samples were collected, as defined by the State Department of Health Services. The number of geometric means calculated was used as the sample count in the binomial model to determine whether a beach should be listed because of geometric mean exceedances. Next, for beaches monitored only during the AB-411 period, the numbers of single-sample exceedance-days were evaluated based on a 4% allowable exceedance-day rate. Beaches monitored year-round were evaluated by looking at the exceedance-days in terms of the binomial model for de-listing conventional pollutants. Because the task of evaluating all of the State's beaches was extremely time consuming, we analyzed geometric mean exceedance days separately from single-sample exceedance-days. This analysis approach is more lenient than the State's listing policy, and likely resulted in fewer proposed listings.

Data were analyzed year-by-year, rather than grouping all years together, because of the significant effect annual rainfall has on bacteriological water quality. A single very wet year (e.g., 1998, 2004-05) could result in the listing of beaches that typically have good water quality. Likewise, a few drought years could result in beaches with poor water quality during moderately rainy years, to not be listed. The Listing Policy is silent on this issue. In this analysis, we recommend listing beaches that meet the listing criteria in 1 of the past 3 years, or 2 of the past 5 years.

Our analysis is based on exceedance-days, which is consistent with reporting protocols used by local agencies to report health standards exceedances to the SWRCB, and by the SWRCB to the U.S. EPA. Also exceedance-days, rather than the number of exceedances per bacteria indicator type, are the relevant measure of water quality at beaches. For instance, warning signs are posted at beaches and the beneficial use of recreational water use is lost each day a sign is posted regardless of the type of bacteria indicator(s) that exceeded the health standards. In addition, bacteria TMDLs are designed around exceedance-days, not the number of overall exceedances, because this measure directly targets the impairment as perceived by the average beach-goer. The State's Listing Policy is silent on this issue. However, if the 4% allowable exceedances for beaches monitored only during AB-411 were applied to each indicator type separately, the beach could be conceivably posted 16% of the summer (4 single-sample standards), and still not be listed. This is not consistent with the study that forms the basis of the 4%, in which the 4% was a reported rate of exceedance-days.[1]

<u>The State Board Should Add 49 Statewide Beaches to the 2006 303(d) List Based Upon Readily Available Data.</u>

Our data analysis shows that fourteen beaches (28 monitoring locations) which are not currently on the 303(d) List for bacteria indicators or proposed for listing meet the listing criteria based on exceedance-days of the geometric mean standards. Thus, the following statewide beaches should be added to the 303(d) List: *Campbell Cove State Park, Aquatic Park, Crissy Field, Baker Beach, Jackrabbit Beach, Windsurfer Circle, Sunnydale Cover, Linda Mar, Capitola, Rio Del Mar, Goleta, Leadbetter, Monarch, and San Diego Bay*. In addition, *Newport Bay* exceeded the geometric mean exceedance-day listing criteria. State Board staff is currently proposing to list this beach. Thus, our analysis supports the staff's decision to list Newport Bay for bacteria indicators. These data are summarized in Table 1.

As seen in Table 2, thirty-one beaches (37 monitoring locations) that are monitored only during the AB-411 time period meet the listing criteria based on exceedance-days of the single-sample standards. Two of these monitoring locations, Campbell Cover and San Diego Bay (Bayside Park) also meet the geometric mean listing criteria, as reported above. None of these beaches are currently on the 303(d) List or proposed for listing in the 2006 cycle. Given our analysis of readily available data, the following beaches should be included on the 303(d) List as impaired for bacteria indicators: *Trinidad State Beach, Luffenholtz Beach, Moonstone County Park (Little River State Beach), Clam Beach County Park, Russian Gulch Campground, Goat Rock State Park Beach, Salmon Creek State Park Beach, Campbell Cove State Park Beach, Doran Regional Park Beach, Lawson's Landing, Heart's Desire, Chicken Ranch Beach, Golden Hinde, Millerton Point, Bolinas Beach, Muir Beach-North, Baker Beach, Schoonmaker Beach, Paradise Cove, China Camp, McNears Beach, Monterey Municipal Beach, San Carlos Beach, Asilomar State Beach, Spanish Bay, Stillwater Cove, Pico Ave.-San Simeon, Encinitas-Swami's Beach, La Jolla, Pacific Beach, San Diego Bay*.

As illustrated in Table 3, seventeen beaches (30 monitoring locations) monitored year-round meet the listing criteria based on exceedance-days of the single-sample standards.

---

[1] Noble, Rachel T., Dorsey, J., Leecaster, M., Mazur, M., McGee, C., Moore, D., Victoria, O., Reid, D., Schiff, K., Vainik P., Weisberg, S. 1999. <u>Southern California Bight 1998 Regional Monitoring Program, Vol I: Summer Shoreline Microbiology.</u> Southern California Coastal Water Research Project, Westminster, CA.

Twelve of these beaches also met the geometric mean criteria for listing. None of these beaches are on the 303(d) List or proposed for listing. Thus, the State Board should list the following beaches as impaired by bacteria indicators: *Aquatic Park Beach, Crissy Field Beach, Baker Beach, Fort Fuston, Candlestick Point-Jackrabbit Beach, Candlestick Point-Windsurfer Circle, Candlestick Point-Sunnydale Cove, Capitola Beach, Rio Del Mar Beach, Stillwater Cove, Pismo Beach, Haskell's Beach, Goleta Beach, Leadbetter Beach, Huntington State Beach, Newport Bay, Monarch Beach.*

<u>Ormond Beach, San Buenaventura Beach, Mission Bay Shoreline and Pacific Ocean Shoreline – Scripps HA Should Remain on the 303(d) List.</u>

State Board staff proposes to de-list Ormond Beach, San Buenaventura Beach, the beaches of Mission Bay Shoreline and the beaches of Pacific Ocean Shoreline – Scripps HA for bacteria indicators. However, our analysis indicates that these beaches do ***not*** meet the de-listing criteria outlined in Section 4.3 of the Listing Policy. First, Ormond Beach at the industrial drain does not meet the de-listing criteria based on the number of exceedance-days of the geometric mean standard (Table 4), and San Buenaventura Beach at San Jon Rd. does not meet the de-listing policy for exceedance-days of the geometric mean standard or the single-sample standard (see Tables 4 and 6). Thus Ormond Beach and San Buenaventura should remain on the 303(d) List as impaired by bacteria indicators. In the San Diego Region, the State Board lumps numerous beaches under the headings "Mission Bay Shoreline" and "Pacific Ocean Shoreline - Scripps HA." However, individual beaches within these units are monitored and should be evaluated. Our analysis found that 15 of the monitoring locations within Mission Bay Shoreline do not meet the de-listing criteria for the geometric-mean standards (Table 4). Additionally, twenty-one monitoring sites within the Mission Bay Shoreline and five sites within the Scripps HA do not meet the de-listing criteria for the single-sample standard (see Tables 5 and 6). Thus, the State Board should maintain the individual beaches of Mission Bay Shoreline and Pacific Ocean-Scripps HA that correspond to the monitoring locations that do not meet the de-listing criteria.

Conclusion

The statewide coastal beaches bacterial data described above and presented in Tables 1 to 3 demonstrate the need for numerous additional bacteria indicator listings. In addition, as illustrated in Tables 4 and 6, several of the proposed beach de-listings are erroneous. As these data were and are readily available to the State Board, as part of their routine beach monitoring database maintained by the SWRCB partially to meet reporting requirement of the U.S. EPA, they should be included in the evaluation for the 2006 303(d) updates.

Appendix C

Table 1

Statewide Beaches that meet the listing criteria for Geometric Mean Exceedances-days[1,2] but are not Listed[3,4]

Beach Name	Description	Monitoring ID	Data Start Date	Data End Date	Frequency	# of Geomeans	# of Exceed-Days
Campbell Cove State Park Beach		SON60	04/02/01	11/28/05	Weekly	129	63
Aquatic Park Beach	211 Station	SFC10	08/01/02	12/07/05	Weekly	196	93
Crissy Field Beach	East, 202.4 Station	SFC30	08/01/02	12/07/05	Weekly	163	74
Crissy Field Beach	West, 202.2 Station	SFC50	08/01/02	12/07/05	Weekly	138	36
Baker Beach	Lobos Creek outlet	SFC80	10/16/02	12/06/05	Weekly	243	54
Jackrabbit Beach	Candlestick Point	SFC170	08/01/02	12/07/05	Weekly	131	33
Windsurfer Circle	Candlestick Point	SFC180	08/01/02	12/07/05	Weekly	200	140
Sunnydale Cove	Candlestick Point	SFC190	08/01/02	12/07/05	Weekly	155	77
Linda Mar Beach	San Pedro Creek outlet	SMC50	10/06/98	11/28/05	Weekly	184	41
Capitola Beach	East of pier	SCC170	04/03/00	06/28/05	Weekly	46	8
Capitola Beach	West of Jetty	SCC180	06/14/01	12/05/05	Weekly	126	45
Capitola Beach	East of Jetty	SCC190	06/15/01	12/05/05	Weekly	127	25
Rio Del Mar Beach		SCC220	04/03/00	12/05/05	Weekly	173	64
Goleta Beach		SBC9	06/28/99	12/05/05	Weekly	274	61
Leadbetter Beach		SBC12	06/28/99	12/05/05	Weekly	272	62
Newport Bay[5]	Newport Dunes-North	BNB24N	03/19/01	11/21/05	Weekly	177	75
Newport Bay	Newport Dunes-East	BNB24E	03/19/01	11/21/05	Weekly	164	45
Newport Bay	Newport Dunes-Middle	BNB24M	03/19/01	11/21/05	Weekly	167	52
Newport Bay	Newport Dunes-West	BNB24W	03/19/01	11/21/05	Weekly	163	41
Newport Bay	Garnet Avenue Beach	BNB31	03/19/01	11/21/05	Weekly	163	27
Newport Bay	43rd Street Beach	BNB09	03/19/01	11/21/05	Weekly	147	61
Newport Bay	38th Street Beach	BNB10	03/19/01	11/21/05	Weekly	181	82
Newport Bay	19th Street Beach	BNB14	03/19/01	11/21/05	Weekly	165	35
Newport Bay	10th Street Beach	BNB17	03/19/01	11/21/05	Weekly	187	68
Newport Bay	Harbor Patrol Beach	BNB33	03/19/01	11/21/05	Weekly	190	85
Monarch Beach	North	OSL25	03/20/01	11/22/05	Weekly	187	54
Monarch Beach	South	OSL23	03/20/01	10/23/02	Weekly	66	14
San Diego Bay	Bayside Park (proj. of J Street)	EH120	04/05/00	10/26/05	Weekly	153	40

1. Geometric means calculated for every 30-day period in which 5 samples were collected, per DHS guidance and the State Health Code.
2. Source of data - Routine monitoring results from The County of Sonoma Environmental Health Division; The County of San Francisco, in partnership with the San Francisco Public Utilities Commission; The County of San Mateo Environmental Health Department; The County of Santa Cruz Environmental Health Services; The County of Santa Barbara Environmental Health Agency; The County of Orange Environmental Health; The South Orange County Wastewater Authority; The Orange County Sanitation District; The County of San Diego Department of Environmental Health.
3. Listing policy Section 3.3 process for using the binomial model used to evaluate number of exceedances for listing.
4. Based on the 2002 State 303(d) list, none of these beaches are currenty listed for any bacteriological-related pollution such as beach closures, high coliform densities, etc.
5. Newport Bay is currently proposed for listing.

Table 2

Statewide Beaches Monitored only during the AB-411 Period that meet the listing criteria for Single-sample Standard Exceedance-days[1,2] but are not Listed[3,4]

Red blocks denote time periods when listing criteria are met

		2000			2001			2002			2003			2004			2005		
Beach Name	Monitoring ID	Count	Exceed-Day	%	Count	Exceed-Day	%	Count	Exceed-Day	%	Count	Exceed-Day	%	Count	Exceed-Day	%	Count	Exceed-Day	%
Trinidad State Beach near Mill Creek	HC10										28			31	2	7%	27	2	7%
Luffenholtz Beach near Luffenholtz Creek	HC20										28			32	2	6%	27	3	11%
Moonstone County Park (Little River State Beach)	HC30										30	1	3%	33	4	12%	28	2	7%
Clam Beach County Park near Strawberry Creek	HC40										29	1	3%	32	3	9%	28	1	4%
Russian Gulch Campground	Men40										12	1	8%						
Goat Rock State Park Beach	SON40				31			30			33	3	9%	27			29		
Salmon Creek State Park Beach	SON50				31			31	1	3%	33	5	15%	28	1	4%	32	4	13%
Campbell Cove State Park Beach	SON60				38	10	26%	39	11	28%	35	13	37%	35	17	49%	30	6	20%
Doran Regional Park Beach	SON70				31			30			32	2	6%	28	2	7%	30	1	3%
Lawson's Landing	MC20										31	2	7%	30	4	13%			
Heart's Desire	MC50										31	2	7%	30	2	7%			
Chicken Ranch Beach at Channel	MC70										31	3	10%						
Chicken Ranch Beach at Creek	MC80										31	2	7%	30	1	3%			
Golden Hinde	MC90										31	1	3%	30	2	7%			
Millerton Point	MC100										31	3	10%	30	3	10%			
Bolinas Beach (Wharf Rd)	MC150										26			30	3	10%			
Muir Beach, North	MC200										31	8	26%	26	2	8%			
Baker Beach, Horseshoe Cove NW	MC270										26	3	12%	28	2	7%			
Baker Beach, Horseshoe Cove NE	MC280										26	3	12%	28	4	14%			
Schoonmaker Beach	MC290										23	1	4%	30					
Paradise Cove	MC300										25			30	2	7%			
China Camp	MC310										31	2	7%	30	2	7%			
McNears Beach	MC320										25	1	4%	30	4	13%			
Monterey Municipal Beach (at the commercial wharf)	MON20				32	4	13%	32	4	13%	27	1	4%	30	2	7%	28	2	7%
San Carlos Beach at San Carlos Beach Park	MON30				31	2	7%	29			27			30	2	7%	28		
Asilomar State Beach, projection of Arena Av.	MON50				30			30	1	3%	30	3	10%	28			29	1	3%
Spanish Bay (Moss Beach), end of 17 mile drive	MON60				31	2	7%	29			27			29	3	10%	29	1	3%
Stillwater Cove, at Beach and Tennis Club	MON70				33	4	12%	32	3	9%	33	9	27%	34	7	21%	27	3	11%
Pico Ave., San Simeon	PICO23													13			20	1	5%
Encinitas, Swami's Beach (Seacliff Park)	EH410	30			31			27			28			25	2	8%	30	3	10%
La Jolla (north), Scripps Pier	EH350	30	2	7%	31	2	7%	29	1	3%	28	1	4%	29	1	3%	29		
La Jolla, La Jolla Cove	FM070	29	2	7%	29			31	2	7%	33	3	9%	28	2	7%	30	2	7%
Pacific Beach, Crystal Pier (projection of Garnet)	FM020	26	1	4%	28			29	1	3%	29	2	7%	23	1	4%	26		
San Diego Bay, north of Kellogg St.	EH210	33	2	6%	34	4	12%	29			29	1	3%	27	1	4%	18	1	6%
San Diego Bay, Spanish Landing Park beach	EH160	31	2	7%	31	3	10%	37	9	24%	29	1	3%	30	2	7%	36	3	8%
San Diego Bay, Bayside Park (projection of J Street)	EH120	41	7	17%	39	5	13%	37	9	24%	33	3	9%	36	7	19%	35	7	20%
San Diego Bay, Glorietta Bay Park at boat launch	EH080	29	1	3%	33	2	6%	31	1	3%	28			27			23	2	9%

1. Single-sample exceedance day is a sample day in which one or more of the 4 state bacteriological single-sample standards were exceeded.
2. Source of data - Routine monitoring results from The County of Humboldt Environmental Health Department; The County of Mendocino Environmental Health Department; The County of Sonoma Environmental Health Division; The County of Marin Environmental Health Department; The County of Monterey Environmental Health Agency; The County of San Luis Obispo Environmental Health Department; The County of San Diego Department of Environmental Health
3. Listing policy Section 3.3 evaluation method specifies a maximum allowable exceedance frequency of 4% for beaches only monitored during the AB-411 time period. All of these beaches exceeded 4% during 1 of the 3 past years, or 2 of the last 5 years.
4. Based Heal the Bay's review of the 2002 State 303(d) list, none of these beaches are currenty listed for any bacteriological-related pollution such as beach closures, high coliform densities, etc.

Blue boxes denote beaches that also should be listed based on geometric mean exceedance days - see Table 1.

Table 3

Statewide Beaches Monitored Year-round
that meet the listing criteria for Single-sample Standard Exceedance-days[1,2]
but are not Listed[3,4]

Red blocks denote time periods when listing criteria are met

		2000			2001			2002			2003			2004		
Beach	fpkLocId	Count	Exceed-Day	List	Count	Exceed-Day	List	Count	Exceed-Day	List	Count	Exceed-Day	List	Count	Exceed-Day	List
Aquatic Park Beach, 211 Station	SFC10							50	16	yes	94	23	yes	61	10	
Crissy Field Beach East, 202.4 Station	SFC30							34	9	yes	76	14	yes	65	14	yes
Crissy Field Beach West, 202.2 Station	SFC50							32	7	yes	65	9		57	6	
Baker Beach, Lobos Creek	SFC80							37			151	12		71	14	yes
Fort Funston, opposite Lake Merced overflow structure	SFC160							15	1		112	5		9	5	yes
Candlestick Point, Jackrabbit Beach	SFC170							33	7	yes	68	9		51	4	
Candlestick Point, Windsurfer Circle	SFC180							53	26	yes	105	38	yes	60	11	yes
Candlestick Point, Sunnydale Cove	SFC190							37	13	yes	79	22	yes	59	8	
Capitola Beach, west of the jetty	SCC180				20	8	yes	48	13	yes	55	17	yes	52	8	
Capitola Beach, east of the jetty	SCC190				23	5	yes	47	7		55	9		52	7	
Rio Del Mar Beach	SCC220	38	10	yes	50	12	yes	47	8	yes	51	12	yes	52	6	
Stillwater Cove, at Beach and Tennis Club	MON70				34	4		36	3		37	9	yes	38	7	yes
Pismo Beach Pier, 50 feet south of the pier	PB4				31	1		34	3		55	10	yes	53	4	
Haskell's Beach (btwn. Tecolote and Winchester Cyn Creeks)	SBC75				27	5	yes	55	2		53	6		54	5	
Goleta Beach	SBC9	56	10	yes	60	14	yes	57	5		54	6		53	3	
Leadbetter Beach	SBC12	54	9	yes	60	16	yes	57	6		53	5		53	4	
Huntington State Beach, projection of Brookhurst Street	OHB03	180	36	yes	210	28		257	30		257	36		252	34	
Newport Bay, Newport Dunes-North[5]	BNB24N				41	10	yes	54	13	yes	58	14	yes	52	12	yes
Newport Bay, Newport Dunes-East	BNB24E				41	11	yes	53	9	yes	51	7		53	15	yes
Newport Bay, Newport Dunes-Middle	BNB24M				41	6		53	7		52	7		51	10	yes
Newport Bay, Via Genoa Beach	BNB07				41	3		54	9	yes	49	5		49	4	
Newport Bay, Lido Yacht Club Beach	BNB32				41	7	yes	53	5		50	6		49	3	
Newport Bay, Onyx Avenue Beach	BNB02				41	7	yes	54	6		52	7		49	6	
Newport Bay, Grand Canal	BNB34				41	7	yes	53	4		49	6		50	6	
Newport Bay, 43rd Street Beach	BNB09				41	11	yes	53	15	yes	48	23	yes	48	9	yes
Newport Bay, 38th Street Beach	BNB10				41	8	yes	53	10	yes	61	11	yes	59	14	yes
Newport Bay, 19th Street Beach	BNB14				41	9	yes	54	12	yes	53	9	yes	51	6	
Newport Bay, 10th Street Beach	BNB17				41	6		53	9	yes	66	17	yes	56	12	yes
Newport Bay, Harbor Patrol Beach	BNB33				41	9	yes	57	21	yes	59	10	yes	61	13	yes
Monarch Beach (North)	OSL25				40	3		54	5		61	10		60	12	yes

1. Single-sample exceedance-day is a sample day in which one or more of the 4 state bacteriological single-sample standards were exceeded.
2. Source of data - Routine monitoring results from The County of San Francisco, in partnership with the San Francisco Public Utilities Commission; The County of Santa Cruz Environmental Health Services; The County of Monterey Environmental Health Agency; The County of San Luis Obispo Environmental Health Department; The County of Santa Barbara Environmental Health Agency; The County of Orange Environmental Health; The South Orange County Wastewater Authority; The Orange County Sanitation District.
3. Listing policy Section 3.3 evaluation method specifies using the binomial model for evaluating beaches monitored year-round. All of these beaches exceeded the binomial model allowance during 1 of the 3 past years, or 2 of the last 5 years.
4. Based Heal the Bay's review of the 2002 State 303(d) list, none of these beaches are currently listed for any bacteriological-related pollution such as beach closures, high coliform densities, etc.
5. Newport Bay is currently proposed for listing.

Blue boxes denote beaches that also should be listed based on geometric mean exceedance days - see Table 1.

Table 4

Statewide Beaches that do not meet the de-listing criteria for Geometric Mean Exceedance-days[1,2] but are Proposed for De-Listing[3,4]

Beach Name	Description	Monitoring ID	Data Start Date	Data End Date	Frequency	# of Geomeans	# of Exceed-Days
San Buenaventura Beach	south of drain at San Jon Rd.	VC19000	07/12/99	10/31/05	Weekly	243	62
Ormond Beach	Oxnard Industrial drain, 50 yds. no. of the drain	VC43000	07/12/99	10/25/05	Weekly	211	42
Mission Bay, Bonita Cove	north cove	MB170	03/22/00	08/27/04	Weekly	209	85
Mission Bay, Bahia Point-northside	apex of Gleason Rd.	MB160	03/22/00	10/25/05	Weekly	153	40
Mission Bay, San Juan Cove	west of boat launch	MB140	03/22/00	06/27/01	Weekly	54	12
Mission Bay, Santa Clara Cove	projection of Portsmouth Ct.	MB131	03/30/00	10/20/03	Weekly	52	18
Mission Bay, Fanuel Park	projection of Fanuel St.	MB120	03/22/00	10/25/05	Weekly	142	49
Mission Bay, Riviera Shores	projection of La Cima Dr.	MB110	03/22/00	10/20/03	Weekly	113	25
Mission Bay, Crown Point Shores		MB100	03/21/00	10/25/05	Weekly	143	28
Mission Bay, Wildlife Refuge near fence	projection of Lamont St.	MB090	03/21/00	10/25/05	Weekly	163	50
Mission Bay, Campland	west of Rose Creek	MB080	03/21/00	11/28/05	Weekly	258	158
Mission Bay, DeAnza Cove	mid-cove	MB070	03/21/00	10/25/05	Weekly	186	88
Mission Bay, Visitor's Center	projection of Clairemont Dr.	MB060	03/21/00	10/25/05	Weekly	242	149
Mission Bay, Tecolote Shores drain		MB040	03/21/00	10/25/05	Weekly	154	47
Mission Bay, Tecolote Playground	watercraft area	MB031	06/13/01	10/25/05	Weekly	41	7
Mission Bay, Tecolote Creek outlet		MB030	03/21/00	02/10/03	Weekly	106	73
Mission Bay, Hidden Anchorage		MB020	03/21/00	03/12/03	Weekly	74	36

1. Geometric means calculated for every 30-day period in which 5 samples were collected, per DHS guidance and the State Health Code.
2. Source of data - Routine monitoring results from The County of Ventura Environmental Health Division andCity of San Diego Stormwater Division.
3. De-listing policy Section 4.3 process for using the binomial model was used to evaluate number of exceedance-days for de-listing.
4. Based on the 2002 State 303(d) list, none of these beaches are currenty listed for any bacteriological-related pollution such as beach closures, high coliform densities, etc.

Table 5

Statewide Beaches Monitored only during the AB-411 Period
that do not meet the de-listing criteria for Single-sample Standard Exceedance-days[1,2]
but are Proposed for De-Listing[3,4]

Red blocks denote time periods when de-listing criteria are not met

		2000			2001			2002		
Beach Name	Monitoring ID	Count	Exceed-Day	%	Count	Exceed-Day	%	Count	Exceed-Day	%
La Jolla Shores, projection of Ave De La Playa	FM060	28	1	4%	29	2	7%	28		
La Jolla, South Casa Beach	EH305				30			29		
Coast Blvd. (the Gazebo)	EH303							30	2	7%
La Jolla, projection of Vallecitos	EH320				6	3	50%			
La Jolla, Children's Pool	EH310	25	16	64%	8	5	63%	3	2	67%
Mission Bay, Mariners Basin (proj. of Balboa Ct.)	MB225	29			31	1	3%	31	3	10%
Mission Bay, Bonita Cove (north cove)	MB170	48	8	17%	49	8	16%	40	3	8%
Mission Bay, Bonita Cove (east cove)	MB173									
Mission Bay, Bahia Point-northside (apex of Gleason Rd.)	MB160	45	14	31%	30	4	13%	33	3	9%
Mission Bay, Santa Clara Cove (proj. Portsmouth Ct.)	MB131	14	1	7%	6			37	6	16%
Mission Bay, Fanuel Park (proj. of Fanuel St.)	MB120	32	7	22%	31	5	16%	32	3	9%
Mission Bay, Riviera Shores (proj. of La Cima Dr.)	MB110	30	5	17%	31	5	16%	34	5	15%
Mission Bay, Crown Point Shores	MB100	38	5	13%	30	2	7%	29		
Mission Bay, Wildlife Refuge near fence (proj. of Lamont St.)	MB090	33	6	18%	30	5	17%	34	4	12%
Mission Bay, DeAnza Cove (mid-cove)	MB070	41	11	27%	43	13	30%	34	5	15%
Mission Bay, Visitor's Center (proj. of Clairemont Dr.)	MB060	44	14	32%	39	6	15%	38	13	34%
Mission Bay, Comfort Station north of Leisure Lagoon	MB053									
Mission Bay, Leisure Lagoon	MB050	36	3	8%	30	2	7%	34	5	15%
Mission Bay, Tecolote Shores drain	MB040	37	11	30%	32	3	9%	31	2	7%
Mission Bay, Tecolote Playground (watercraft area)	MB031				5			12	1	8%
Mission Bay, Tecolote Creek outlet	MB030	31	6	19%	40	9	23%	34	10	29%
Mission Bay, Fiesta Island, NW shore	MB085									
Mission Bay, Vacation Isle Ski Beach	MB203									

		2003			2004			2005		
Beach Name	Monitoring ID	Count	Exceed-Day	%	Count	Exceed-Day	%	Count	Exceed-Day	%
La Jolla Shores, projection of Ave De La Playa	FM060	39	3	8%	32	4	13%	38	3	8%
La Jolla, South Casa Beach	EH305	29	2	7%	24			27	1	4%
Coast Blvd. (the Gazebo)	EH303	28			27	3	11%	25		
La Jolla, projection of Vallecitos	EH320	3	1	33%	3			4		
La Jolla, Children's Pool	EH310	16	12	75%	14	9	64%			
Mission Bay, Mariners Basin (proj. of Balboa Ct.)	MB225	31	2	7%	28	1	4%	31	2	7%
Mission Bay, Bonita Cove (north cove)	MB170	45	7	16%	1					
Mission Bay, Bonita Cove (east cove)	MB173				35	5	14%	32	2	6%
Mission Bay, Bahia Point-northside (apex of Gleason Rd.)	MB160	26	1	4%	31	3	10%	30		
Mission Bay, Santa Clara Cove (proj. Portsmouth Ct.)	MB131	31	7	23%						
Mission Bay, Fanuel Park (proj. of Fanuel St.)	MB120	35	5	14%	26	1	4%	32	2	6%
Mission Bay, Riviera Shores (proj. of La Cima Dr.)	MB110	26								
Mission Bay, Crown Point Shores	MB100	27	2	7%	32	5	16%	31	2	7%
Mission Bay, Wildlife Refuge near fence (proj. of Lamont St.)	MB090	32	1	3%	38	7	18%	30	1	3%
Mission Bay, DeAnza Cove (mid-cove)	MB070	34	4	12%	34	5	15%	31	3	10%
Mission Bay, Visitor's Center (proj. of Clairemont Dr.)	MB060	34	3	9%	43	16	37%	32	5	16%
Mission Bay, Comfort Station north of Leisure Lagoon	MB053				31	3	10%	32	3	9%
Mission Bay, Leisure Lagoon	MB050	33	2	6%	34	3	9%	39	6	15%
Mission Bay, Tecolote Shores drain	MB040	29			33	5	15%	29	1	3%
Mission Bay, Tecolote Playground (watercraft area)	MB031	30	4	13%	29	2	7%	35	6	17%
Mission Bay, Tecolote Creek outlet	MB030									
Mission Bay, Fiesta Island, NW shore	MB085				4	3	75%			
Mission Bay, Vacation Isle Ski Beach	MB203				34	2	6%	30		

1. Single-sample exceedance-day is a sample day in which one or more of the 4 state bacteriological single-sample standards were exceeded.
2. Source of data - Routine monitoring results from The County of San Diego Department of Environmental Health andCity of San Diego Stormwater Division.
3. De-listing policy Section 4.3 evaluation method specifies a maximum allowable exceedance frequency of 4% for beaches only monitored during the AB-411 time period. All of these beaches exceeded 4% during 1 of the 3 past years, or 2 of the last 5 years.
4. Based Heal the Bay's review of the 2002 State 303(d) list, none of these beaches are currenty listed for any bacteriological-related pollution such as beach closures, high coliform densities, etc.

Blue boxes denote beaches that should not bede- listed based on geometric mean exceedance-days - see Table 4.

Table 6

Statewide Beaches Monitored Year-round
that do not meet the de-listing criteria for Single-sample Standard Exceedance-days[1,2]
but are Proposed for De-Listing[3,4]

Red blocks denote time periods when de-listing criteria are not met

		2000			2001			2002			2003			2004			2005 [5]		
Beach	fpkLocId	Count	Exceed-Day	List	Count	Exceed-Day	List	Count	Exceed-Day	List	Count	Exceed-Day	List	Count	Exceed-Day	List	AB411 count	Exceed-Day	%
San Buenaventura Beach- south of drain at San Jon Rd.	VC19000	57	10	yes	56	13	yes	54	3		51	3		50	9	yes	31	6	19%
Mission Bay, Campland (west of Rose Creek)	MB080	54	10	yes	66	20	yes	51	17	yes	69	23	yes	48	12	yes			

1. Single-sample exceedance day is a sample day in which one or more of the 4 state bacteriological single-sample standards were exceeded.
2. Source of data - Routine monitoring results from The County of Ventura Environmental Health Division andCity of San Diego Stormwater Division.
3. De-listing policy Section 4.3 evaluation method specifies using the binomial model for evaluating beaches monitored year-round. All of these beaches exceeded the binomial model allowance during 1 of the 3 past years, or 2 of the last 5 years.
4. Based Heal the Bay's review of the 2002 State 303(d) list, none of these beaches are currenty listed for any bacteriological-related pollution such as beach closures, high coliform densities, etc.

Blue boxes denote beaches that also should be listed based on geometric mean exceedance days - see Table 4.

5. Previous Year-round beach sampling cut back to AB411 only in 2006. For this time period, the 4% allowable exceedance-day rate was applied.

Appendix D: Algae Data

REGION 4: DO NOT DE-LIST

Water Segment	Pollutant	Line(s) of Evidence	Listing Policy Section(s)
Arroyo Seco - Reach 1	Excess Algal Growth	1)Existing TMDL is not a valid justification; 2)Excess algal growth is eligible for listing	2.2; 4.11
Arroyo Seco - Reach 2	Excess Algal Growth	1)Existing TMDL is not a valid justification; 2)Excess algal growth is eligible for listing	2.2; 4.11
Burbank Western Channel	Excess Algal Growth	1)Existing TMDL is not a valid justification; 2)Excess algal growth is eligible for listing	2.2; 4.11
Calleguas Creek - all listed reaches	Excess Algal Growth	1)Existing TMDL is not a valid justification; 2)Excess algal growth is eligible for listing	2.2, 4.11
Calleguas Creek - Reach 4	Excess Algal Growth	IBI Data	4.11
Calleguas Creek - Reach 5	Excess Algal Growth	IBI Data	4.11
Calleguas Creek - Reach 9B	Excess Algal Growth	Readily Available Data	4.7; 4.11; 6.1.1
Calleguas Creek - Reach 10	Excess Algal Growth	Photographic Evidence	4.11
Calleguas Creek - Reach 13	Excess Algal Growth	Readily Available Data	4.7; 4.11; 6.1.1
Coyote Creek	Excess Algal Growth	1) Upcoming EPA Study; 2) Ammonia & Nitrate-Nitrogen listing may not address problem	2.2; 4.11
San Gabriel River - Reach 1	Algae	1)Upcoming EPA Study; 2)excess algae is a pollutant/condition eligible for listing	2.2; 4.11
San Jose Creek - Reach 1	Algae	1)Upcoming EPA Study; 2)excess algae is a pollutant/condition eligible for listing	2.2; 4.11
San Jose Creek - Reach 2	Algae	1)Upcoming EPA Study ; 2)excess algae is a pollutant/condition eligible for listing	2.2; 4.11
Verdugo Wash - Reach 1	Excess Algal Growth	1)Existing TMDL is not a valid justification; 2)Excess algal growth is eligible for listing	2.2; 4.11
Verdugo Wash - Reach 2	Excess Algal Growth	1)Existing TMDL is not a valid justification; 2)Excess algal growth is eligible for listing	2.2, 4.11

Calleguas Creek Transect Data

Source: Ambrose, R.F., Lee, S.F., and S.P. Bergquist, Environmental Monitoring and Bioassessment of Coastal Watersheds in Ventura and Los Angeles Counties (2003).

Site	Watershed	Macroalgae	Diatoms (Periphyton)		Macroalgae	Macrophytes	Moss	No Cover	Total Cover	Total Vegetation
		Biomass (g/m2)	All diatoms % cover	med. and thick % Cover	% Cover	% Cover	% Cover	%	%	% Cover
Calleguas at Deepwood	Calleguas	0.00	5	0	0	0	0	95	100	5
Calleguas at Deepwood	Calleguas	0.00	95	0	0	0	0	5	100	95
Calleguas at Deepwood	Calleguas	0.00	95	0	0	0	0	5	100	95
Calleguas at Deepwood	Calleguas	0.00	0	0	0	0	0	100	100	0
Calleguas at Deepwood	Calleguas	0.00	55	30	0	0	0	45	100	55
Calleguas at Deepwood	Calleguas	0.00	100	55	0	0	0	0	100	100
Oaks Mall	Calleguas	0.00	65	45	0	0	0	35	100	65
Oaks Mall	Calleguas	0.00	30	10	0	0	0	70	100	30
Oaks Mall	Calleguas	0.02	90	65	0	0	0	10	100	90
Oaks Mall	Calleguas	0.00	25	25	0	0	0	75	100	25
Oaks Mall	Calleguas	0.00	40	25	0	0	0	60	100	40
Oaks Mall	Calleguas	0.00	10	10	0	0	0	90	100	10
Reino Rd.	Calleguas	0.02	50	0	0	20	0	30	100	70
Reino Rd.	Calleguas	0.02	15	5	0	5	0	80	100	20
Reino Rd.	Calleguas	0.02	40	20	0	0	0	60	100	40
Reino Rd.	Calleguas	0.02	40	0	0	5	0	55	100	45
Reino Rd.	Calleguas	0.02	50	25	0	5	0	45	100	55
Reino Rd.	Calleguas	0.02	25	5	0	5	0	70	100	30
FC @ VentuPark Rd.	Calleguas	13.65	25	15	60	5	0	10	100	90
FC @ VentuPark Rd.	Calleguas	0.46	25	10	40	0	0	35	100	65
FC @ VentuPark Rd.	Calleguas	15.95	60	10	35	0	0	5	100	95
FC @ VentuPark Rd.	Calleguas	10.12	50	40	20	5	0	25	100	75
FC @ VentuPark Rd.	Calleguas	6.29	45	30	30	10	0	15	100	85
FC @ VentuPark Rd.	Calleguas	1.40	55	10	40	0	0	5	100	95
FC @ Young Rd.	Calleguas	0.04	50	0	0	0	0	50	100	50
FC @ Young Rd.	Calleguas	1.23	50	0	10	0	0	40	100	60
FC @ Young Rd.	Calleguas	2.05	0	0	40	0	0	60	100	40
FC @ Young Rd.	Calleguas	0.86	10	0	10	0	0	80	100	20
FC @ Young Rd.	Calleguas	0.04	10	0	20	0	0	70	100	30
FC @ Young Rd.	Calleguas	0.08	10	0	20	0	0	70	100	30
Upper Wildwood	Calleguas	0.00	0	0	0	0	0	100	100	0
Upper Wildwood	Calleguas	0.00	5	0	0	0	0	95	100	5
Upper Wildwood	Calleguas	0.00	65	0	0	0	0	35	100	65
Upper Wildwood	Calleguas	0.00	80	60	0	0	0	20	100	80
Upper Wildwood	Calleguas	0.00	0	0	0	0	0	100	100	0
Upper Wildwood	Calleguas	0.00	0	0	0	100	0	0	100	100
Leisure Village	Calleguas	0.15	45	10	20	0	0	35	100	65
Leisure Village	Calleguas	0.02	20	10	25	0	0	55	100	45
Leisure Village	Calleguas	0.02	5	0	20	20	0	55	100	45
Leisure Village	Calleguas	0.02	20	15	0	20	0	60	100	40
Leisure Village	Calleguas	0.02	5	0	5	30	0	60	100	40
Leisure Village	Calleguas	0.48	20	5	10	15	0	55	100	45
Bottom Conejo Creek	Calleguas	0.00	0	0	0	15	0	85	100	15
Bottom Conejo Creek	Calleguas	0.00	5	5	0	5	0	90	100	10
Bottom Conejo Creek	Calleguas	0.00	5	5	0	5	0	90	100	10
Bottom Conejo Creek	Calleguas	0.00	0	0	0	0	0	100	100	0
Bottom Conejo Creek	Calleguas	0.00	0	0	0	0	0	100	100	0
Bottom Conejo Creek	Calleguas	0.00	0	0	10	5	0	85	100	15

Photographic Evidence

Calleguas Creek – Reach 10 (Arroyo Conejo Canyon). Photograph taken in summer 2004 by Steve Lee of UCLA.

Calleguas Creek – Reach 10 (Arroyo Conejo Canyon). Aerial photograph taken in summer 2004 by Steve Lee of UCLA.

Calleguas Creek – Reach 7 (Arroyo Simi). Photograph taken in summer 2004 by Steve Lee of UCLA.

Calleguas Creek – Reach 7 (Arroyo Simi). Photograph taken in summer 2004 by Steve Lee of UCLA.

http://www.latimes.com/news/local/oceans/la-me-ocean30jul30,0,952130.story

PART ONE
ALTERED OCEANS

A Primeval Tide of Toxins

Runoff from modern life is feeding an explosion of primitive organisms. This 'rise of slime,' as one scientist calls it, is killing larger species and sickening people.

By Kenneth R. Weiss
Times Staff Writer

July 30, 2006

MORETON BAY, AUSTRALIA — The fireweed began each spring as tufts of hairy growth and spread across the seafloor fast enough to cover a football field in an hour.

When fishermen touched it, their skin broke out in searing welts. Their lips blistered and peeled. Their eyes burned and swelled shut. Water that splashed from their nets spread the inflammation to their legs and torsos.

"It comes up like little boils," said Randolph Van Dyk, a fisherman whose powerful legs are pocked with scars. "At nighttime, you can feel them burning. I tried everything to get rid of them. Nothing worked."

As the weed blanketed miles of the bay over the last decade, it stained fishing nets a dark purple and left them coated with a powdery residue. When fishermen tried to shake it off the webbing, their throats constricted and they gasped for air.

After one man bit a fishing line in two, his mouth and tongue swelled so badly that he couldn't eat solid food for a week. Others made an even more painful mistake, neglecting to wash the residue from their hands before relieving themselves over the sides of their boats.

For a time, embarrassment kept them from talking publicly about their condition. When they finally did speak up, authorities dismissed their complaints — until a bucket of the hairy weed made it to the University of Queensland's marine botany lab.

Samples placed in a drying oven gave off fumes so strong that professors and students ran out of the building and into the street, choking and coughing.

Scientist Judith O'Neil put a tiny sample under a microscope and peered at the long black filaments. Consulting a botanical reference, she identified the weed as a strain of cyanobacteria, an ancestor of modern-day bacteria and algae that flourished 2.7 billion years ago.

O'Neil, a biological oceanographer, was familiar with these ancient life forms, but had never seen this particular kind before. What was it doing in Moreton Bay? Why was it so toxic? Why was it growing so fast?

The venomous weed, known to scientists as *Lyngbya majuscula*, has appeared in at least a dozen other places around the globe. It is one of many symptoms of a virulent pox on the world's oceans.

In many places — the atolls of the Pacific, the shrimp beds of the Eastern Seaboard, the fiords of Norway — some of the most advanced forms of ocean life are struggling to survive while the most primitive are thriving and spreading. Fish, corals and marine mammals are dying while algae, bacteria and jellyfish are growing unchecked. Where this pattern is most pronounced, scientists evoke a scenario of evolution running in reverse, returning to the primeval seas of hundreds of millions of years ago.

Jeremy B.C. Jackson, a marine ecologist and paleontologist at the Scripps Institution of Oceanography in La Jolla, says we are witnessing "the rise of slime."

For many years, it was assumed that the oceans were too vast for humanity to damage in any lasting way. "Man marks the Earth with ruin," wrote the 19th century poet Lord Byron. "His control stops with the shore."

Even in modern times, when oil spills, chemical discharges and other industrial accidents heightened awareness of man's capacity to injure sea life, the damage was often regarded as temporary.

But over time, the accumulation of environmental pressures has altered the basic chemistry of the seas.

The causes are varied, but collectively they have made the ocean more hospitable to primitive organisms by putting too much food into the water.

Industrial society is overdosing the oceans with basic nutrients — the nitrogen, carbon, iron and phosphorous compounds that curl out of smokestacks and tailpipes, wash into the sea from fertilized lawns and cropland, seep out of septic tanks and gush from sewer pipes.

Modern industry and agriculture produce more fixed nitrogen — fertilizer, essentially — than all natural processes on land. Millions of tons of carbon dioxide and nitrogen oxide, produced by burning fossil fuels, enter the ocean every day.

These pollutants feed excessive growth of harmful algae and bacteria.

At the same time, overfishing and destruction of wetlands have diminished the competing sea life and natural buffers that once held the microbes and weeds in check.

The consequences are evident worldwide.

Off the coast of Sweden each summer, blooms of cyanobacteria turn the Baltic Sea into a stinking, yellow-brown slush that locals call "rhubarb soup." Dead fish bob in the surf. If people get too close, their eyes burn and they have trouble breathing.

On the southern coast of Maui in the Hawaiian Islands, high tide leaves piles of green-brown algae that smell so foul condominium owners have hired a tractor driver to scrape them off the beach every morning.

On Florida's Gulf Coast, residents complain that harmful algae blooms have become bigger, more frequent and longer-lasting. Toxins from these red tides have killed hundreds of sea mammals and caused emergency rooms to fill up with coastal residents suffering respiratory distress.

North of Venice, Italy, a sticky mixture of algae and bacteria collects on the Adriatic Sea in spring and summer. This white mucus washes ashore, fouling beaches, or congeals into submerged blobs, some bigger than a person.

Along the Spanish coast, jellyfish swarm so thick that nets are strung to protect swimmers from their sting.

Organisms such as the fireweed that torments the fishermen of Moreton Bay have been around for eons. They emerged from the primordial ooze and came to dominate ancient oceans that were mostly lifeless. Over time, higher forms of life gained supremacy. Now they are under siege.

Like other scientists, Jeremy Jackson, 63, was slow to perceive this latest shift in the biological order. He has spent a good part of his professional life underwater. Though he had seen firsthand that ocean habitats were deteriorating, he believed in the resilience of the seas, in their inexhaustible capacity to heal themselves.

Then came the hurricane season of 1980. A Category 5 storm ripped through waters off the north coast of Jamaica, where Jackson had been studying corals since the late 1960s. A majestic stand of staghorn corals, known as "the Haystacks," was turned into rubble.

Scientists gathered from around the world to examine the damage. They wrote a paper predicting that the corals would rebound quickly, as they had for thousands of years.

"We were the best ecologists, working on what was the best-studied coral reef in the world, and we got it 100% wrong," Jackson recalled.

The vividly colored reef, which had nurtured a wealth of fish species, never recovered.

"Why did I get it wrong?" Jackson asked. He now sees that the quiet creep of environmental decay, occurring largely unnoticed over many years, had drastically altered the ocean.

As tourist resorts sprouted along the Jamaican coast, sewage, fertilizer and other nutrients washed into the sea. Overfishing removed most of the grazing fish that kept algae under control. Warmer waters encouraged bacterial growth and further stressed the corals.

For a time, these changes were masked by algae-eating sea urchins. But when disease greatly reduced their numbers, the reef was left defenseless. The corals were soon smothered by a carpet of algae and bacteria. Today, the reef is largely a boneyard of coral skeletons.

Many of the same forces have wiped out 80% of the corals in the Caribbean, despoiled two-thirds of the estuaries in the United States and destroyed 75% of California's kelp forests, once prime habitat for fish.

Jackson uses a homespun analogy to illustrate what is happening. The world's 6 billion inhabitants, he says, have failed to follow a homeowner's rule of thumb: Be careful what you dump in the swimming pool, and make sure the filter is working.

"We're pushing the oceans back to the dawn of evolution," Jackson said, "a half-billion years ago when the oceans were ruled by jellyfish and bacteria."

The 55-foot commercial trawler working the Georgia coast sagged under the burden of a hefty catch. The cables pinged and groaned as if about to snap.

Working the power winch, ropes and pulleys, Grovea Simpson hoisted the net and its dripping catch over the rear deck. With a tug on the trip-rope, the bulging sack unleashed its massive load.

Plop. Splat. Whoosh. About 2,000 pounds of cannonball jellyfish slopped onto the deck. The jiggling, cantaloupe-size blobs ricocheted around the stern and slid down an opening into the boat's ice-filled hold.

The deck was streaked with purple-brown contrails of slimy residue; a stinging, ammonia-like odor filled the air.

"That's the smell of money," Simpson said, all smiles at the haul. "Jellyballs are thick today. Seven cents a pound. Yes, sir, we're making money."

Simpson would never eat a jellyfish. But shrimp have grown scarce in these waters after decades of intensive trawling. So during the winter months when jellyfish swarm, he makes his living catching what he used to consider a messy nuisance clogging his nets.

It's simple math. He can spend a week at sea scraping the ocean bottom for shrimp and be lucky to pocket $600 after paying for fuel, food, wages for crew and the boat owner's cut.

Or, in a few hours of trawling for jellyfish, he can fill up the hold, be back in port the same day and clear twice as much. The jellyfish are processed at the dock in Darien, Ga., and exported to China and Japan, where spicy jellyfish salad and soup are delicacies.

"Easy money," Simpson said. "They get so thick you can walk on them."

Jellyfish populations are growing because they can. The fish that used to compete with them for food have become scarce because of overfishing. The sea turtles that once preyed on them are nearly gone. And the plankton they love to eat are growing explosively.

As their traditional catch declines, fishermen around the world now haul in 450,000 tons of jellyfish per year, more than twice as much as a decade ago.

This is a logical step in a process that Daniel Pauly, a fisheries scientist at the University of British Columbia, calls "fishing down the food web." Fishermen first went after the largest and most popular fish, such as tuna, swordfish, cod and grouper. When those stocks were depleted, they pursued other prey, often smaller and lower on the food chain.

"We are eating bait and moving on to jellyfish and plankton," Pauly said.

In California waters, for instance, three of the top five commercial catches are not even fish. They are squid, crabs and sea urchins.

This is what remains of California's historic fishing industry, once known for the sardine fishery attached to Monterey's Cannery Row and the world's largest tuna fleet, based in San Diego, which brought American kitchens StarKist, Bumble Bee and Chicken of the Sea.

Overfishing began centuries ago but accelerated dramatically after World War II, when new technologies armed industrial fleets with sonar, satellite data and global positioning systems, allowing them to track schools of fish and find their most remote habitats.

The result is that the population of big fish has declined by 90% over the last 50 years.

It's reached the point that the world's fishermen, though more numerous, working harder and sailing farther than ever, are catching fewer fish. The global catch has been declining since the late 1980s, an analysis by Pauly and colleague Reg Watson showed.

The reduction isn't readily apparent in the fish markets of wealthy countries, where people are willing to pay high prices for exotic fare from distant oceans — slimeheads caught off New Zealand and marketed as orange roughy, or Patagonian toothfish, renamed Chilean sea bass. Now, both of those fish are becoming scarce.

Fish farming also exacts a toll. To feed the farmed stocks, menhaden, sardines and anchovies are harvested in great quantities, ground up and processed into pellets.

Dense schools of these small fish once swam the world's estuaries and coastal waters, inhaling plankton like swarming clouds of silvery vacuum cleaners. Maryland's Chesapeake Bay, the nation's largest estuary, used to be clear, its waters filtered every three days by piles of oysters so numerous that their reefs posed a hazard to navigation. All this has changed.

There and in many other places, bacteria and algae run wild in the absence of the many mouths that once ate them. As the depletion of fish allows the lowest forms of life to run rampant, said Pauly, it is "transforming the oceans into a microbial soup."

Jellyfish are flourishing in the soup, demonstrating their ability to adapt to wholesale changes — including the growing human appetite for them. Jellyfish have been around, after all, at least 500 million years, longer than most marine animals.

In the Black Sea, an Atlantic comb jelly carried in the ballast water of a ship from the East Coast of the United States took over waters saturated with farm runoff. Free of predators, the jellies gorged on plankton and fish larvae, depleting the fisheries on which the Russian and Turkish fleets depend. The plague subsided only with the accidental importation of another predatory jellyfish that ate the comb jellies.

Federal scientists tallied a tenfold increase in jellies in the Bering Sea in the 1990s. They were so thick off the Alaskan Peninsula that fishermen nicknamed it the Slime Bank. Researchers have found teeming swarms of jellyfish off Georges Bank in New England and the coast of Namibia, in the fiords of Norway and in the Gulf of Mexico. Also proliferating is the giant nomurai found off

Japan, a jellyfish the size of a washing machine.

Most jellies are smaller than a fist, but their sheer numbers have gummed up fishing nets, forced the shutdown of power plants by clogging intake pipes, stranded cruise liners and disrupted operations of the world's largest aircraft carrier, the Ronald Reagan.

Of the 2,000 or so identified jellyfish species, only about 10 are commercially harvested. The largest fisheries are off China and other Asian nations. New ones are springing up in Australia, the United States, England, Namibia, Turkey and Canada as fishermen look for ways to stay in business.

Pauly, 60, predicts that future generations will see nothing odd or unappetizing about a plateful of these gelatinous blobs.

"My kids," Pauly said, "will tell their children: Eat your jellyfish."

The dark water spun to the surface like an undersea cyclone. From 80 feet below, the swirling mixture of partially treated sewage spewed from a 5-foot-wide pipe off the coast of Hollywood, Fla., dubbed the "poop chute" by divers and fishermen.

Fish swarmed at the mouth — blue tangs and chubs competing for particles in the wastewater.

Marine ecologist Brian Lapointe and research assistant Rex "Chip" Baumberger, wearing wetsuits and breathing air from scuba tanks, swam to the base of the murky funnel cloud to collect samples. The effluent meets state and federal standards but is still rich in nitrogen, phosphorous and other nutrients.

By Lapointe's calculations, every day about a billion gallons of sewage in South Florida are pumped offshore or into underground aquifers that seep into the ocean. The wastewater feeds a green tide of algae and bacteria that is helping to wipe out the remnants of Florida's 220 miles of coral, the world's third largest barrier reef.

In addition, fertilizer washes off sugar cane fields, livestock compounds and citrus farms into Florida Bay.

"You can see the murky green water, the green pea soup loaded with organic matter," said Lapointe, a marine biologist at Harbor Branch Oceanographic Institution in Fort Pierce, Fla. "All that stuff feeds the algae and bacterial diseases that are attacking corals."

Government officials thought they were helping in the early 1990s when they released fresh water that had been held back by dikes and pumps for years. They were responding to the recommendations of scientists who, at the time, blamed the decline of ocean habitats on hypersalinity — excessively salty seawater.

The fresh water, laced with farm runoff rich in nitrogen and other nutrients, turned Florida's gin-clear waters cloudy. Seaweed grew fat and bushy.

It was a fatal blow for many struggling corals, delicate animals that evolved to thrive in clear, nutrient-poor saltwater. So many have been lost that federal officials in May added what were once the two most dominant types — elkhorn and staghorn corals — to the list of species threatened with extinction. Officials estimate that 97% of them are gone.

Sewage and farm runoff kill corals in various ways.

Algae blooms deny them sunlight essential for their survival.

The nutrients in sewage and fertilizer make bacteria grow wildly atop corals, consuming oxygen and suffocating the animals within.

A strain of bacteria found in human intestines, *Serratia marcescens*, has been linked to white pox disease, one of a host of infectious ailments that have swept through coral reefs in the Florida Keys and elsewhere.

The germ appears to come from leaky septic tanks, cesspits and other sources of sewage that have multiplied as the Keys have grown from a collection of fishing villages to a stretch of bustling communities with 80,000 year-round residents and 4 million visitors a year.

Scientists discovered the link by knocking on doors of Keys residents, asking to use their bathrooms. They flushed bacteria marked with tracers down toilets and found them in nearby ocean waters in as little as three hours.

Nearly everything in the Keys seems to be sprouting green growths, even an underwater sculpture known as Christ of the Abyss, placed in the waters off Key Largo in the mid-1960s as an attraction for divers and snorkelers. Dive-shop operators scrub the bronze statue with wire brushes from time to time, but they have trouble keeping up with the growth.

Lapointe began monitoring algae at Looe Key in 1982. He picked the spot, a 90-minute drive south of Key Largo, because its clear waters, colorful reef and abundance of fish made it a favorite site for scuba divers. Today, the corals are in ruins, smothered by mats of algae.

Although coral reefs cover less than 1% of the ocean floor, they are home to at least 2 million species, or about 25% of all marine life. They provide nurseries for fish and protect oceanfront homes from waves and storm surges.

Looe Key was once a sandy shoal fringed by coral. The Key has now slipped below the water's surface, a disappearing act likely to be repeated elsewhere in these waters as pounding waves breach dying reefs. Scientists predict that the Keys ultimately will have to be surrounded by sea walls as ocean levels rise.

With a gentle kick of his fins through murky green water, Lapointe maneuvered around a coral mound that resembled the intricate, folded pattern of a brain. Except that this brain was being eroded by the coralline equivalent of flesh-eating disease.

"It rips my heart out," Lapointe said. "It's like coming home and seeing burglars have ransacked your house, and everything you cherished is gone."

The ancient seas contained large areas with little or no oxygen — anoxic and hypoxic zones that could never have supported sea life as we know it. It was a time when bacteria and jellyfish ruled.

Nancy Rabalais, executive director of the Louisiana Universities Marine Consortium, has spent most of her career peering into waters that resemble those of the distant past.

On research dives off the Louisiana coast, she has seen cottony white bacteria coating the seafloor. The sulfurous smell of rotten eggs, from a gas produced by the microbes, has seeped into her mask. The bottom is littered with the ghostly silhouettes of dead crabs, sea stars and other animals.

The cause of death is decaying algae. Fed by millions of tons of fertilizer, human and animal waste, and other farm runoff racing down the Mississippi River, tiny marine plants run riot, die and drift to the bottom. Bacteria then take over. In the process of breaking down the plant matter, they suck the oxygen out of seawater, leaving little or none for fish or other marine life.

Years ago, Rabalais popularized a term for this broad area off the Louisiana coast: the "dead zone." In fact, dead zones aren't really dead. They are teeming with life — most of it bacteria and other ancient creatures that evolved in an ocean without oxygen and that need little to survive.

"There are tons and tons of bacteria that live in dead zones," Rabalais said. "You see this white snot-looking stuff all over the bottom."

Other primitive life thrives too. A few worms do well, and jellyfish feast on the banquet of algae and microbes.

The dead zone off Louisiana, the second largest after one in the Baltic Sea, is a testament to the unintended consequences of manufacturing nitrogen fertilizer on a giant scale to support American agriculture. The runoff from Midwestern farms is part of a slurry of wastewater that flows down the Mississippi, which drains 40% of the continental United States.

The same forces at work in the mouth of the Mississippi have helped create 150 dead zones around the world, including parts of the Chesapeake Bay and waters off the Oregon and Washington coasts.

About half of the Earth's landscape has been altered by deforestation, farming and development, which has increased the volume of runoff and nutrient-rich sediment.

Most of the planet's salt marshes and mangrove forests, which serve as a filter between land and sea, have vanished with coastal development. Half of the world's population lives in coastal regions, which add an average of 2,000 homes each day.

Global warming adds to the stress. A reduced snowpack from higher temperatures is accelerating river discharges and thus plankton blooms. The oceans have warmed slightly — 1 degree on average in the last century. Warmer waters speed microbial growth.

Robert Diaz, a professor at the Virginia Institute of Marine Science, has been tracking the spread of low-oxygen zones. He has determined that the number is nearly doubling every decade, fed by a worldwide cascade of nutrients — or as he puts it, energy. We stoke the ocean with energy streaming off the land, he said, and with no clear pathways up the food chain, this energy fuels an explosion of microbial growth.

These microbes have been barely noticeable for millions of years, tucked away like the pilot light on a gas stove.

"Now," Diaz said, "the stove has been turned on."

In Australia, fishermen noticed the fireweed around the time much of Moreton Bay started turning a dirty, tea-water brown after every rain. The wild growth smothered the bay's northern sea-grass beds, once full of fish and shellfish, under a blanket a yard thick.

The older, bottom layers of weed turned grayish-white and started to decay. Bacteria, feeding on the rot, sucked all of the oxygen from beneath this woolly layer at night. Most sea life swam or scuttled away; some suffocated. Fishermen's catches plummeted.

Most disturbing were the rashes, an outbreak often met with scoffs from local authorities.

After suffering painful skin lesions, fisherman Greg Savige took a sealed bag of the weed in 2000 to Barry Carbon, then director-general of the Queensland Environmental Protection Agency. He warned Carbon to be careful with it, as it was "toxic stuff." Carbon replied that he knew all about cyanobacteria from western Australian waters and that there was nothing to worry about.

Then he opened the bag and held it close to his face for a sniff.

"It was like smearing hot mustard on the lips," the chastened official recalled.

Aboriginal fishermen had spotted the weed in small patches years earlier, but it had moved into new parts of the bay and was growing like never before.

Each spring, *Lyngbya* bursts forth from spores on the seafloor and spreads in dark green-and-black dreadlocks. It flourishes for months before retreating into the muck. Scientists say it produces more than 100 toxins, probably as a defense mechanism.

At its peak in summer, the weed now covers as much as 30 square miles of Moreton Bay, an estuary roughly the size of San Francisco Bay. In one seven-week period, its expansion was measured at about 100 square meters a minute — a football field in an hour.

William Dennison, then director of the University of Queensland botany lab, couldn't believe it at first.

"We checked this 20 times. It was mind-boggling. It was like 'The Blob,' " Dennison said, recalling the 1950s horror movie about an alien life form that consumed everything in its path.

Suspecting that nutrients from partially treated sewage might be the culprit, another Queensland University scientist, Peter Bell, collected some wastewater and put it in a beaker with a pinch of *Lyngbya*. The weed bloomed happily.

As Brisbane and the surrounding area became the fastest growing region in Australia, millions of gallons of partially treated sewage gushed from 30 wastewater treatment plants into the bay and its tributary rivers.

Officials upgraded the sewage plants to remove nitrogen from the wastewater, but it did not stop the growth of the infernal weed.

Researchers began looking for other sources of *Lyngbya's* nutrients, and are now investigating whether iron and possibly phosphorous are being freed from soil as forests of eucalyptus and other native trees are cleared for farming and development.

"We know the human factor is responsible. We just have to figure out what it is," Dennison said.

Recently, *Lyngbya* has appeared up the coast from Moreton Bay, on the Great Barrier Reef, where helicopters bring tourists to a heart-shaped coral outcropping. When the helicopters depart, seabirds roost on the landing platform, fertilizing the reef with their droppings. *Lyngbya* now beards the surrounding corals.

"*Lyngbya* has lots of tricks," said scientist Judith O'Neil. "That's why it's been around for 3 billion years."

It can pull nitrogen out of the air and make its own fertilizer. It uses a different spectrum of sunlight than algae do, so it can thrive even in murky waters. Perhaps its most diabolical trick is its ability to feed on itself. When it dies and decays, it releases its own nitrogen and phosphorous into the water, spurring another generation of growth.

"Once it gets going, it's able to sustain itself," O'Neil said.

Ron Johnstone, a University of Queensland researcher, recently experienced *Lyngbya's* fire. He was studying whether iron and phosphorous in bay sediments contribute to the blooms, and he accidentally came in contact with bits of the weed. He broke out in rashes and boils, and needed a cortisone shot to ease the inflammation.

"It covered my whole chest and neck," he said. "We've just ordered complete containment suits so we can roll in it."

Fishermen say they cannot afford such pricey equipment. Nor would it be practical. For some, the only solution is to turn away from the sea.

Lifelong fisherman Mike Tanner, 50, stays off the water at least four months each year to avoid contact with the weed. It's an agreement he struck with his wife, who was appalled by his blisters and worried about the long-term health consequences.

"When he came home with rash all over his body," Sandra Tanner said, "I said, 'No, you are not going.' We didn't know what was happening to him."

Tanner, a burly, bearded man, is frustrated that he cannot help provide for his family. Gloves and other waterproof gear failed to protect him.

"It's like acid," Tanner said. "I couldn't believe it. It kept pulling the skin off."

Before the *Lyngbya* outbreak, 40 commercial shrimp trawlers and crab boats worked these waters. Now there are six, and several of them sit idle during fireweed blooms.

"It's the only thing that can beat us," Greg Savige said. "Wind is nothing. Waves, nothing. It's the only thing that can make us stop work. When you've got sores and the skin peels away, what are you going to do?"

Times staff writer Usha Lee McFarling contributed to this report.

Resources

More information about endangered oceans is available at these educational and governmental websites:

http://scripps.ucsd.edu

http://cmbc.ucsd.edu/

http://www.hboi.edu/

http://www.initrogen.org/

http://www.millenniumassessment.org

http://www.epa.gov/owow/estuaries/guidance/

http://www.hboi.edu/

http://www.initrogen.org/

http://www.seaaroundus.org

http://www.latimes.com/news/local/oceans/la-me-ocean31jul31,0,1410884.story

PART TWO

ALTERED OCEANS

Sentinels Under Attack

Toxic algae that poison the brain have caused strandings and mass die-offs of marine mammals — barometers of the sea's health.

By Kenneth R. Weiss
Times Staff Writer

July 31, 2006

SAN FRANCISCO — After the last patient of the day walked out the front of Raytel Medical Imaging clinic, veterinarian Frances Gulland slipped an oversized animal crate through the back door.

Inside was a California sea lion. The animal was emaciated, disoriented and suffering from seizures.

A female with silky, caramel-colored fur, wide-set eyes and long whiskers, she was named Neuschwander, after the lifeguard who had found her six weeks earlier, comatose and trembling under a pier at Avila Beach near San Luis Obispo.

Taken to the Marine Mammal Center near Sausalito, Neuschwander showed signs of recovery at first. Her eyes began to clear and focus. She frolicked in the small pool in her chain-link enclosure and wolfed down mackerel at feedings. Then she relapsed.

She quit eating and lost 40 pounds. Her sunken eyes darted around, as if tracking a phantom just outside the cage. Her head bobbed and weaved in erratic figure eights.

Neuschwander was loaded into a crate at the nonprofit center, the world's busiest hospital dedicated to the care of wild marine mammals, and trucked across the Golden Gate Bridge. Gulland, the center's director of veterinary science, wanted to scan Neuschwander's brain at the imaging clinic.

After sedating the sea lion, Gulland and four assistants lifted the animal onto a gurney. They inserted a breathing tube into her throat and rolled the gurney into the great thrumming MRI machine.

Gulland, an upbeat, 46-year-old native of Britain, took a last look at Neuschwander as the machine closed around her. She hoped the sea lion could be saved.

Neuschwander was exhibiting the classic symptoms of domoic acid poisoning, a condition that scrambles the brains of marine mammals and causes them to wash ashore in California as predictably as the spring tides.

They pick up the acid by eating anchovies and sardines that have fed on toxic algae. Although the algae have been around for eons, they have bloomed with extraordinary intensity along the Pacific coast for the last eight years.

The blooms are part of a worldwide pattern of oceanic changes that scientists attribute to warming waters, excessive fishing, and a torrent of nutrients unleashed by farming, deforestation and urban development.

The explosion of harmful algae has caused toxins to move through the food chain and concentrate in the dietary staples of marine mammals.

For the last 25 years, the federal government has tracked a steady upswing in beach strandings and mass die-offs of whales, dolphins and other ocean mammals on U.S. coasts.

More than 14,000 seals, sea lions and dolphins have landed sick or dead along the California shoreline in the last decade. So have more than 650 gray whales along the West Coast.

In Maine two years ago, 800 harbor seals, all adults with no obvious injuries, washed up dead, and in Florida the carcasses of hundreds of manatees have been found in mangrove forests and on beaches.

The surge in mortality has coincided with what Florida wildlife pathologist Greg Bossart calls a "pandemic" of algae and bacteria. Although some of the deaths defy easy explanation, telltale biotoxins have turned up in urine, blood, brains and other tissue.

Sometimes the toxins kill animals outright, such as the manatees found dead in Florida, blood streaming from their noses.

In other cases, they kill slowly by promoting tumor growth or compromising immune systems, leaving marine mammals vulnerable to parasites, viruses or bacteria. Scientists believe the episodic die-offs of bottlenose dolphins along the Atlantic and Gulf coasts that began in the late 1980s may stem from toxic algae that weaken the animals and enable a virus related to canine distemper to attack the lungs and brain.

Sea turtles in Hawaii have been found with fist-sized tumors growing out of their eyes and mouths and behind their flippers. Scientists say the growths are the result of a papilloma virus and an ancient microorganism called *Lyngbya majuscula*, which appears as a hairy weed that has been spreading in tropical and subtropical waters. The tumors doom the turtles by inhibiting their ability to see, eat or swim.

As they watch the oceans disgorge more dead and dying creatures, scientists have come to a disquieting realization: The proliferation of algae, bacteria and other microbes is making the oceans less hospitable to advanced forms of life — those animals most like humans.

"Marine mammals share our waters, eat some of the food we eat and get some of the same diseases we get," said Paul Sandifer, chief scientist for the Oceans and Human Health Initiative of the

National Oceanic and Atmospheric Administration.

"If environmental conditions are not good for these sentinels of the sea, you can believe it won't be good for us either," Sandifer said. "What we allow to flow into the sea will come back to bite us. You can bet on it."

Marine algae, or phytoplankton, occur naturally and make up the first link in the oceanic food chain. A quart of seawater typically contains hundreds of thousands of phytoplankton and millions of bacteria, viruses and protozoans, all in concentrations that keep each other in check.

That equilibrium can be upset when certain types of algae overwhelm their competitors. The change is most pronounced in coastal waters, and scientists believe it is tied to nutrient pollution from a variety of human activities.

Toxic algae thrive on the same elements that turn lawns green and make crops grow — nitrogen, phosphorus and iron.

California, the nation's most populous state with more than 36 million people, sends billions of gallons of partially treated human waste into the ocean every day. Sewage treatment cuts down on disease-causing bacteria but does little to remove nutrients.

Seasonal rains carry enormous loads of urban and agricultural runoff into the ocean, much of it down drainage canals and rivers from the dairies, orchards and farms that make California the nation's largest agricultural producer.

The destruction of coastal wetlands, which filter nitrogen and other nutrients, also plays a role, as does over-harvesting of shellfish and sardines, menhaden and other algae-eating fish.

Climate change is another factor. Warmer seawater speeds up microbial growth and allows aggressive algae and bacteria to move into areas once too cold for them. Commercial ships can help the spread, transporting the algae in ballast water.

The type of algae that poisoned Neuschwander began blooming riotously in California waters in 1998.

It has the tongue-twisting name *Pseudo-nitzschia* (SUE-doh NICH-e-yah). A fraction of the thickness of a human hair, this javelin-shaped, single-cell organism slides through seawater on a coating of mucus and churns out domoic acid, a neurotoxin.

Pseudo-nitzschia blooms all along the West Coast, especially around bays and estuaries fed by major rivers. Unlike some other toxic blooms, which are often called red tides, these aren't visible because their greenish-brown coloring blends into the seawater.

Researchers studying *Pseudo-nitzschia* off the mouth of the Mississippi River have unearthed evidence in the seafloor that agricultural runoff from the nation's heartland triggers the outbreaks.

Scrutinizing core samples from five locations in the Gulf of Mexico, they found thick layers of microscopic silica shells of *Pseudo-nitzschia* that coincided with a deposit of nitrates and sediment that had flowed down the Mississippi.

The evidence is preserved in strata that resemble a layer cake. It shows that *Pseudo-nitzschia* didn't proliferate until the 1950s, when grain farmers began widespread use of chemical fertilizers.

In contrast to the Mississippi Delta, such telltale clues cannot be seen in marine sediments off the Pacific coast because the seafloor is constantly being churned up.

As a result, West Coast scientists have been looking for chemical signatures that would directly link river discharges to the toxic blooms.

For the last three years, USC researchers David A. Caron and Astrid Schnetzer have focused on a "hot zone" of *Pseudo-nitzschia* spanning 155 square miles of coastal waters off the mouths of the Los Angeles and San Gabriel rivers.

The researchers are still looking for the link. But one thing is clear, said Caron, a biological oceanographer: "There is a big dose of nutrients."

Knowing about the effects of domoic acid, scientists wonder whether algae blooms explain the freakish behavior of coastal wildlife observed periodically over the years.

Some speculate that *Pseudo-nitzschia* caused the onslaught of crazed seabirds near Capitola, Calif., in 1961 that inspired Alfred Hitchcock's movie "The Birds." Hitchcock, who was living in nearby Scotts Valley, read a newspaper story about sooty shearwaters "wailing and crying like babies," crashing into streetlights and windows, nipping at people and vomiting up anchovies.

In 1998, sailors in Monterey Bay began bumping into dark objects in the water. They thought they were floating logs. They weren't. They were the bodies of sea lions.

That year, more than 400 washed ashore, dead or dying, victims of neurotoxic poisoning.

California's five marine mammal rehabilitation centers were overwhelmed. Every year since, they have been crowded with sea lions trembling with seizures.

This spring, the Marine Mammal Care Center at Ft. MacArthur in San Pedro was often as busy as an inner-city emergency room. Ailing sea lions were packed into chain-link cages. Rescue workers kept bringing in new patients in pickup trucks. The animals needed injections of anti-seizure medicine or had to be hooked up to saline drips to flush the neurotoxin from their systems.

On one typical day, listless sea lions were flopped on their sides, flippers tucked in, too exhausted to lift their heads. One was agitated, head weaving to and fro, grunting and snorting. Another chewed obsessively on a flipper.

All were females found comatose or acting strangely on the beach. Many were pregnant and had seizures just after giving birth.

"A California sea lion has as warm and strong of a maternal instinct with a newborn as you can see in any animal," said Robert DeLong, a government ecologist who has studied sea lions in their Channel Islands rookeries for 35 years.

Domoic acid can destroy that maternal bond.

Sea lions suffering from neurotoxic poisoning usually show no interest in their young. Some that previously cared for their pups shun them after suffering seizures or even attack them when they try to suckle.

"I came in one day and pieces of the pup were everywhere," said Jennifer Collins, a veterinarian who worked at the Marine Mammal Care Center in San Pedro. "We initially thought someone had broken in and macerated one of the animals. Then we pieced it together and realized that a mother had done it to her own pup."

Scientists first became aware of domoic acid and its toxicity in 1987, when three people died and at least 100 others were sickened after eating contaminated mussels from Prince Edward Island in Canada. Nineteen people were hospitalized with seizures, comas and unstable blood pressure.

Many of the patients never recovered gaps in their memory, lending this malady a new name: amnesic shellfish poisoning. An examination of brain tissue from the three people who died showed severe loss of nerve cells, mostly in the hippocampus, a part of the temporal lobe that resembles a seahorse and plays a key role in memory and navigation.

Reported cases of the illness are rare in North America because health authorities closely monitor shellfish for toxins and because such seafood makes up a tiny fraction of most people's diets. But for animals that consume little else, domoic acid is a recurring danger.

The acid mimics a neurotransmitter, overstimulating neurons that retain memory. The acid prompts nerve cells to fire continuously until they swell and die.

During spring and summer, when *Pseudo-nitzschia* blooms off the California coast, male sea lions don't eat. They are too busy guarding their breeding territory on the Channel Islands, where females mate soon after delivering pups.

The females, in contrast, are ravenous feeders while pregnant and while nursing. They gorge on anchovies and sardines that have fed on toxic algae. Domoic acid doesn't appear to affect the fish, but sea lions eat anchovies in such quantities that they accumulate a toxic load.

Frances Gulland and other researchers have been collecting miscarried sea lion fetuses and stillborn pups on San Miguel Island. To their surprise, domoic acid has turned up in the urine of these pups.

The neurotoxin is typically flushed from an animal in about four hours. But Gulland found that domoic acid can penetrate the placenta, bathing a developing fetus in the neurotoxin for days.

California sea lions have a keen sense of direction. Although their habitat ranges from British Columbia to Baja California, they return to the same breeding beaches on the same islands year after year.

But after attaching satellite transmitters to the animals, Gulland and other researchers found that many victims of domoic acid poisoning — even those that appeared fully recovered — lost their way.

Some swam hundreds of miles out to sea and were never seen again, bizarre behavior for creatures that spend their lives in coastal waters.

Others washed up again on beaches, too addled to make it on their own. One swam in tight circles up the Salinas River.

Neuschwander was one of those who could not find their bearings.

After spending a month at the Marine Mammal Center near Sausalito last summer, the sea lion was eating voraciously and seemed so vigorous that Gulland thought she was ready to fend for herself again. She was released back into the ocean in San Mateo County.

A week later, Neuschwander was found stranded again. This time, she was more than 100 miles inland from her natural home along the coast. She had traveled up rivers and drainage canals and ended up on a hillside near Sacramento International Airport.

She had an enormous gash running from her chest to her back, possibly from a run-in with a barbed-wire fence. She snapped at anyone who came close.

Back at the Marine Mammal Center, Neuschwander wouldn't eat and began weaving her head again in endless figure eights.

Gulland and her staff shaved a wide band of fur off the sea lion's head, attached a dozen electrodes and hooked them to an electroencephalogram to measure brain activity. The needle jumped up and down, a sign that Neuschwander was continuing to have seizures, though there were no visible tremors.

"The damage to the hippocampuses will help trigger seizures, and further seizures will cause further cell damage," Gulland said. "You get into this whole vicious cycle."

So Neuschwander was driven across San Francisco Bay and put into the MRI machine at Raytel Medical Imaging, a clinic near UC San Francisco Medical Center. After the magnets whirled, a computer screen displayed cross-section images of her brain.

Dr. Jerome A. Barakos, a clinical professor and director of neuro-imaging at the clinic, appeared in his white coat. He was there to interpret the 250 images that spooled out of the machine.

"The anatomy of a sea lion is not too dissimilar to the human anatomy," Barakos said. He confirmed Gulland's fear. On the right side of Neuschwander's brain, the hippocampus was severely atrophied. It looked less like a seahorse than like a withered tail.

Gulland paced around the lab, then pulled aside one of her assistants, Michelle Caudle.

"So do we euthanize her? Do we take her home and see how she does?" Gulland asked.

The two women shifted uncomfortably, arms folded across their chests. They talked about how the animal was losing weight and drifting in and out of delirium.

At 140 pounds, Neuschwander was 60 to 80 pounds lighter than a healthy adult female.

Caudle recalled how she wouldn't eat the "happy fish," laced with sedatives, that sea lions normally gulp down. Neuschwander shredded it, then spat it out.

"She looks terrible," Gulland said. "I didn't realize how thin she was. I mean, how much do we make her go through?"

Gulland got a faraway look in her eyes. Her face drooped.

"I'm OK with it," Caudle said.

"I am too. That's why we do it, right?"

To end the suffering.

Gulland blinked back tears. She took a deep breath and rejoined the group to announce the decision.

The team took five vials of blood for future studies. Then Gulland filled an enormous syringe with clear pink liquid, pressed the plunger and shot 15 ccs of sodium pentobarbitone, an overdose of the anesthetic, into a neck vein.

Neuschwander let out one last, rasping breath.

Gulland laid her hands on the sea lion's body. The heart fluttered for a long two minutes.

Then it stopped.

Times staff writer Usha Lee McFarling contributed to this report.

latimes.com Los Angeles Times

http://www.latimes.com/news/local/oceans/la-me-ocean1aug01,0,2672160.story

PART THREE

ALTERED OCEANS

Dark Tides, Ill Winds

With sickening regularity, toxic algae blooms are invading coastal waters. They kill sea life and send poisons ashore on the breeze, forcing residents to flee.

By Kenneth R. Weiss
Times Staff Writer

August 1, 2006

LITTLE GASPARILLA ISLAND, FLA. — All Susan Leydon has to do is stick her head outside and take a deep breath of sea air. She can tell if her 10-year-old son is about to get sick. If she coughs or feels a tickle in the back of her throat, she lays down the law: No playing on the beach. No, not even in the yard. Come back inside. Now.

The Leydons thought they found paradise a decade ago when they moved from Massachusetts to this narrow barrier island, reachable only by boat, with gentle surf, no paved roads and balmy air that feels like velvet on the skin.

Now, they fear that the sea has turned on them. The dread takes hold whenever purplish-red algae stain the crystal waters of Florida's Gulf Coast. The blooms send waves of stinking dead fish ashore and insult every nostril on the island with something worse.

The algae produce an arsenal of toxins carried ashore by the sea breeze.

"I have to pull my shirt up and over my mouth or I'll be coughing and hacking," said Leydon, 42, a trim, energetic mother of three who walks the beach every morning.

Her husband, Richard, a 46-year-old building contractor, said the wind off the gulf can make him feel like he's spent too much time in an overchlorinated pool. His chest tightens and he grows short of breath. His throat feels scratchy, his eyes burn, and his head throbs.

Their symptoms are mild compared with those of their son, also named Richard. He suffers from asthma and recurring sinus infections. When the toxic breeze blows, he keeps himself — and his parents — up all night, coughing until he vomits.

If the airborne assault goes on for more than a few days, it becomes a community-wide affliction. At homeowners' meetings, many people wear face masks.

On weekends, the Leydons escape inland. They drive three hours to Orlando so their son can play outside without getting sick. They go to a Walt Disney World resort with water slides, machinegenerated currents and an imported white sand beach.

"It's a shame to leave this beautiful place and go to a water park," Richard Leydon said. "But we don't have much choice. We have to get away from it."

Harmful algae blooms have occurred for ages. Some scientists theorize that a toxic bloom inspired the biblical passage in Exodus: " … all the water in the Nile turned into blood. And the fish in the Nile died, and the Nile stank, so that the Egyptians could not drink water from the Nile. There was blood throughout all the land of Egypt."

What was once a freak of nature has become commonplace. These outbreaks, often called red tides, are occurring more often worldwide, showing up in new places, lasting longer and intensifying.

They are distress signals from an unhealthy ocean. Overfishing, destruction of wetlands, industrial pollution and climate change have made the seas inhospitable for fish and more advanced forms of life and freed the lowliest — algae and bacteria — to flourish.

A scientific consensus is emerging that commercial agriculture and coastal development, in particular, promote the spread of harmful algae. They generate runoff rich in nitrogen, phosphorous and other nutrients that sustain these microscopic aquatic plants. In essence, researchers say, modern society is force-feeding the oceans with the basic ingredients of Miracle-Gro.

Yet there is debate among Florida scientists over the precise causes of local outbreaks. Red tides date back at least 150 years, before the state became one of the nation's most populous. Some scientists say their increased intensity is part of a natural cycle.

People who have spent many years on Little Gasparilla Island and in other Florida Gulf Coast communities say red tides used to show up once in a decade. Now, they occur almost every year and persist for months.

Red tide announced its arrival this summer by dumping dead tarpon and goliath grouper on the beaches. Soon after, coastal residents were coughing and sneezing.

The previous bloom, which ended in mid-February, peppered Florida's western coast with its fiery breath for 13 months, stubbornly refusing to dissipate despite three hurricanes.

The culprit is a microorganism known as *Karenia brevis.* Each *Karenia* cell is a poison factory pumping out toxins collectively known as brevetoxin.

During red tides, they can be absorbed into the food chain by scallops, oysters and other popular seafood and can cause neurotoxic shellfish poisoning. The effects range from gastrointestinal illness to seizures, loss of muscle control and unconsciousness.

Brevetoxin also gets into the air. It collects on the surface of bubbles and concentrates in sea foam and on dead fish.

When the bubbles burst, brevetoxin is flung into the air and carried by the wind. If inhaled, most particles lodge in the nose and throat, but some are drawn deep into the lungs. People don't have to set foot in the ocean or even on the beach to experience a red tide. It comes to them.

Most of those affected feel as if they have a cold or an allergy. But researchers reported last year that red tides coincided with outbreaks of severe respiratory ailments.

They compared emergency admissions at Sarasota Memorial Hospital during three months of red tide with the same period a year later, when there was no toxic algae.

During the red tide, admissions for pneumonia, bronchitis, asthma, sinus infections and similar afflictions rose 54%. No such increase was reported inland.

"You can tell when it's a bad red tide," said Dr. Brian Garby, the hospital's chief of emergency medicine. "The waiting room is filled with people coughing and they don't know why."

Most alarming was a 19% increase in cases of pneumonia, a leading cause of death among the elderly.

Brevetoxin doesn't cause those maladies directly. Instead, researchers believe, it makes people vulnerable by inflaming their sinuses and suppressing their immune systems, allowing bacteria and viruses to flourish.

Boxy air filters stationed around Sarasota have detected the wind-borne neurotoxin three miles from the coast, said Barbara Kirkpatrick, a researcher at Mote Marine Laboratory, a private research institute in the city. "The public health message has been, 'If you leave the beach, you'll be OK.' Now we know better. People who are window shopping or eating in outdoor restaurants are still being exposed to the toxins."

Hundreds of visitors from the Midwest and New England have posted questions and complaints on websites, seeking to learn why, after a short beach vacation on the west coast of Florida, they suffered weeks of coughing, bronchial infections, dizziness, lethargy and other symptoms.

Researchers are hearing a growing number of complaints about neurological symptoms.

Ruth DeLynn, a 79-year-old retired biologist and volunteer curator at Mote Marine Laboratory, was hospitalized for five days last year with respiratory distress during a particularly virulent red tide. DeLynn also experienced numbness and a burning sensation in her legs that made it difficult to walk. She and her doctor believe the toxin triggered a resurgence of peripheral neuropathy that had been dormant for 15 years.

"If this is going to continue this way," said DeLynn, who lives on a barrier island near Sarasota, "I'm thinking of moving inland."

Neurological symptoms usually flare only with high levels of exposure, said Dr. Lora Fleming, a University of Miami epidemiologist and physician. "It's all about dose."

Fleming isn't persuaded that people on the beach can inhale enough to suffer serious neurological effects, but she thinks surfers may be more vulnerable.

John Purdy, a former Manatee County lifeguard, was paddling his surfboard over a wave last fall when some sea foam lifted off the water and into his mouth just as he was gulping for air.

"I felt like I inhaled a garbage bag," said Purdy, 33, a former high school swimming champion. "It locked up my lungs and throat like a paralysis." The seconds ticked by. "I was thinking, 'Is this the way it's going to end?' "

Eventually, he managed to sneak in a little air. It was like sucking through a cocktail straw. He made his way to shore but didn't feel much better until emergency medical technicians hooked him up to oxygen. "It was the closest thing I've had to a near-death experience," he said.

Unlike surfers, marine mammals can't seek refuge on land. Last year's red tide took the lives of at least 88 manatees, some weighing more than a ton. Hundreds of these massive sea cows have succumbed during outbreaks in previous years.

Greg Bossart, a veterinarian and pathologist at Harbor Branch Oceanographic Institute in Fort Pierce, dissected the tissue of manatees and determined that many died from inhaling brevetoxin-laden air just above the ocean's surface. The result was a cascade of nerve and tissue damage that filled their lungs with blood.

"The manatees are gassed to death," Bossart said. "They die of toxic shock."

Bossart considers the manatee a sentinel for human health, or, as he puts it: "Florida's 2,000-pound canary. We've opened a Pandora's box of health issues."

The oceans are awash in microscopic algae, or plankton. But of the thousands of different kinds, only about 100 produce toxins.

About 60,000 people in the United States are poisoned each year by algae blooms. Most get sick by eating fish and shellfish that concentrate neurotoxins from the vast quantities of algae they consume.

The Centers for Disease Control and Prevention estimates that only 2% to 10% of all cases are reported to health authorities — usually those that involve numbness, paralysis, coma or other severe symptoms. Cases of nausea, cramping and diarrhea tend to go unreported.

Estimates of algae-related illness don't include the many thousands of people in Florida and other Gulf Coast states who suffer from inhaling airborne brevetoxin.

Nearly every coastal region has outbreaks of harmful algae or bacteria.

For the second summer in a row, shellfish beds in New England are being closed because of toxic algae that cause paralytic shellfish poisoning. These blooms that typically begin in the Gulf of Maine were rare until the 1970s. Now, they appear almost every year, often spreading down the coast as far as Cape Cod.

California and other West Coast states periodically have banned shellfish harvesting because of toxic algae, including *Pseudo-nitzschia*, which wasn't identified until 1987. That was when it killed three people who ate contaminated mussels in Montreal. Since then, it has left California's coastline littered with dead and dying marine mammals and seabirds.

Marine biotoxins are among the most potent biological poisons ever discovered. Saxitoxin, which causes paralytic shellfish poisoning, is listed among chemical agents banned under a United Nations compact on weapons of mass destruction. As with other algae-produced neurotoxins, there is no known antidote.

People help spread harmful algae by fertilizing them with sewage and farm runoff, transporting them in the ballast water of ships, dredging harbors or warming seawater through climate change.

Patricia M. Glibert, a marine scientist at the University of Maryland, has found that the worldwide spread of paralytic shellfish poisoning has closely tracked the expanding use of urea, a nitrogen fertilizer.

Glibert estimated that fertilizer use will rise 50% this decade "in parts of the world that are already saturated with nitrogen and frequently plagued by harmful blooms."

Donald Anderson and colleagues at Woods Hole Oceanographic Institution in Massachusetts traced the origin of a strain of algae responsible for a 1998 outbreak of paralytic shellfish poisoning on France's Mediterranean coast. Analyzing DNA and shipping records, they concluded that it hitched a ride from Japan in the belly of a ship.

Disturbance of the seafloor by dredging is believed to help promote the growth of algae that cause ciguatera fish poisoning. About a million people a year show signs of ciguatera poisoning — such as gastrointestinal distress, numbness, weakness, vertigo and coma — after eating fish from tropical waters.

Cruise ship passengers who ate raw oysters from Alaskan shellfish beds became violently ill two years ago in an outbreak that medical researchers tied to the bacterial pathogen *Vibrio*, common in the Gulf of Mexico. Researchers realized the strain had moved 600 miles farther north than ever before, as Alaskan waters warmed above the 59-degree threshold that limited the bacterium's range.

A University of Miami marine biologist, Larry E. Brand, examined water samples dating to 1954 and found that outbreaks of *Karenia brevis* off Florida's Gulf Coast are getting stronger, lasting longer and spreading farther.

"When you look at it statistically, red tides are 10 times more abundant than they were 50 years ago," Brand said. Once, "the peak time was in the fall…. Now we have blooms continuing on and lasting into the winter and spring."

The highest concentrations of algae, he said, were along heavily developed shorelines and around the mouths of rivers that disgorge nutrient-laden waters from sugar-cane fields and sediment from phosphate mines.

Brand said that was no coincidence. It reflects "a huge increase in sewage, runoff from lawns and golf courses, mining and agriculture," he said.

State officials say Brand may be misinterpreting the water samples. Cynthia Heil, a senior state scientist, said the data do not support the conclusion that pollution from agriculture or development spawns red tides, although she said it may intensify or prolong the outbreaks.

Heil said there is compelling evidence of blooms that originate out at sea, far from coastal concentrations of man-made pollutants.

She and a team of university scientists in Florida have published a study theorizing that iron-rich dust from Africa's Sahara Desert drifts across the Atlantic and triggers a natural process that stimulates harmful algae blooms off Florida's Gulf Coast.

"The timing sure matches up with blooms," Heil said. "We know it has to contribute to enriching seawater with iron and nitrogen."

A television suspended from the ceiling at Mote Marine Laboratory in Sarasota plays a public service announcement sponsored by state and federal agencies, offering hints for dealing with red tide.

"If you are going to the beach for a short trip, go to your local drugstore and buy a face mask, like the ones painters wear," the narrator says. "But remember, these masks are only effective for a short time.

"People with asthma should also be sure to take their inhalers to the beach and use them as prescribed. If your inhaler is not providing relief, seek immediate medical attention."

Tourist officials point out that red tides come and go and vary in intensity, and that the airborne toxins don't trigger health problems unless there is an onshore breeze. Beachgoers on one stretch of coast can get a heavy dose, while others a few miles away aren't affected.

Last fall's red tide was one of the worst on record.

Tourists bailed out of hotels and motels, said Dianne Manspeaker, manager of the Gulf Surf Resort Motel in Nokomis. "People come to check in and say, 'I can't stay here, I can't breathe.' "

Manspeaker is sympathetic to tourists who feel ill and refunds their money. She lives inland, and when the wind blows brevetoxin onshore, she stays home and tends to business by phone. "If I have to be here," she said, "I wear a mask."

A few miles up the coast, Sarasota County lifeguard Mike Zanane listened to a familiar chorus of coughs, throat-clearing, sneezes and nose-blowing from hundreds of beachgoers.

It was a typical day at the beach during red tide, Zanane said. The die-hards lie in the sun and cough all day. They won't leave. Nor will they venture into the surf, and Zanane doesn't blame them.

"Sometimes," he said, "you go out there and you feel like you've been Maced."

Red tides have become a staple of the daily reports on surf conditions posted on the lifeguard tower. The sign read: "Some Red Tide = Coughs. Sneezes. Dead Fishes." A few extra words were scribbled in chalk in the margin: "Can't do anything about [it]."

Not that people haven't tried.

In one experiment, researchers from Mote Marine Laboratory sprayed a slurry of clay onto the murky water in an effort to smother and sink the offending organisms. Another experiment in the works would sterilize algae patches with injections of ozone. Such remedies can be problematic. Not only do they kill the harmful algae, they wipe out every living thing in the vicinity.

Jim Patterson, a past mayor of Longboat Key next to Sarasota, would have been satisfied just to rid the beach of the stench of dead fish.

A retired Army general, Patterson took the fight to the fish. He hired a boat and crew and set out to chop up the carcasses with a fish shredder before they could reach the shore.

The results were disappointing for Patterson and his nonprofit group, Solutions To Avoid Red Tide. Instead of whole fish, Longboat Key was littered with decaying fish chunks.

Buddy Gaines invited a visitor to look out at the Gulf of Mexico from his oceanfront house built on stilts on Little Gasparilla Island. "You can see why we love it here," the retired filmmaker said. "It's a shame we cannot go outside."

Gaines and his wife, Laurie, don't let their dogs — a pair of Hungarian vizslas — outside either. Not during the bloom of a red tide. It's a costly lesson the couple learned a couple of years ago.

Their younger dog, Olivia, was a gregarious puppy who loved to frolic in the sand, splash in the warm surf and follow joggers down the beach.

One morning, after eating a few small fish that had washed up, she arrived home staggering and stumbling. By the time the Gaineses got her to a vet, Olivia couldn't see. She was vomiting and convulsing.

"It was heartbreaking to watch," Laurie Gaines said. "We didn't think she was going to live."

Veterinarian Amanda Schell didn't know what to make of the symptoms.

"Did she eat rat poison?" the vet asked. "Did she get into antifreeze?"

Schell ran blood tests, looking for West Nile virus and canine distemper. Finding no clear answers, she sent the couple to a specialist in Tampa.

The next day, local veterinarians treated 16 dogs — all twitching, vomiting and suffering from seizures. One died.

Buddy and Laurie Gaines embarked on a monthlong odyssey to save Olivia that took them to clinics, animal hospitals and finally Tufts University's veterinary school in North Grafton, Mass. The couple camped in the parking lot in their motor home while Olivia was cared for inside.

"Sometimes I think I'm the biggest fool in the family to have spent $22,000 on this dog," said Buddy Gaines, 70, sitting on his couch with Olivia. "I had to take out a second mortgage. But I don't care. I love this dog."

Olivia, now 3 years old, appears fully recovered, except for her incessant drooling. Veterinarians suspect it's a sign of residual neurological damage.

A half-mile down the beach, Susan and Richard Leydon were keeping their dog, a sheltie, inside, along with their son, Richard. The air conditioner was going full blast.

Richard's bedroom is at the seaward side of the house with a picture window overlooking the gulf. "I have the best room," he announced.

It's the best room until the wind begins to blow hard off the ocean. Then it's the first to get dosed with toxin-laden air, coming through the cracks and electrical outlets. It leaves a vague metallic taste on the back of the tongue.

The family has taken to wearing surgical masks on windy red tide nights. It's not enough to keep Richard from coughing. His parents also move him into a room on the other side of the house.

Richard has spent nearly his entire life on the island and was among the first residents to develop symptoms. His most common ailment is a dry cough, which he says makes him sound like a barking seal.

The airborne irritants have also triggered recurring sinus infections and asthma. On a few occasions, during intense and prolonged red tides, Richard has been diagnosed with bronchitis and even pneumonia, which kept him out of school for more than a month.

The Leydons said they have consulted with specialists and spent thousands of dollars on tests trying to figure out if something other than red tide was making their son sick. Doctors couldn't pinpoint anything.

The couple worry about the price their son is paying for their decision to move to Florida.

"Is Richard is going to have lung scarring and long-term problems?" his father asked. "I need to know."

The conversation in the Leydon household focused on two topics, as it often does during red tide outbreaks. One was where to flee for the weekend. The other was whether they should move, for good.

"Do we have to sell our house because paradise is killing us?" Susan Leydon asked.

Times staff writer Usha Lee McFarling contributed to this report.

*

Appendix F **Santa Monica Bay Restoration Commission / Heal the Bay**

Santa Monica Mountains
New Zealand Mudsnail Survey

New Zealand mudsnails, *Potamopyrgus antipodarum*, are tiny (3-5 mm), highly invasive aquatic snails (Fig. 1). Reproducing parthenogenetically, or cloning, a single snail is capable of producing a colony of 40 million in the course of a single year (Fig. 2). In large numbers, these small snails can completely cover a stream bed and wreak havoc on local stream ecosystems. New Zealand mudsnails were discovered in Idaho in the mid-1980s, and have since spread to every Western state except New Mexico. Their recent discovery in Malibu Creek threatens efforts at habitat restoration and protection, particularly those to restore populations of the endangered steelhead trout.

Following the discovery of New Zealand mudsnails in the Malibu Creek watershed, the Santa Monica Bay Restoration Commission hosted a mudsnail "summit" meeting in June 2006 to coordinate agency response to the discovery. At the meeting, it was determined that a presence / absence survey would need to be conducted to determine the extent of the invasion. Heal the Bay and the SMBRC took the lead in organizing and conducting the mudsnail survey over a period of seven days in July 2006 (17^{th} – 21^{st}, and July 26^{th} and 27^{th}).

The following report details the findings of the mudsnail survey, discusses in progress "next steps", and makes recommendations for additional measures to manage this aquatic invasive species.

Survey Method:

The survey team included the following individuals: Mark Abramson (Heal the Bay), Gwen Noda (UCLA), Jack Topel and Stephanie Parent (Santa Monica Bay Restoration Commission).

Surveyors visited 44 sites throughout the Santa Monica Mountains, with special emphasis on the Malibu Creek Watershed where the presence of New Zealand mudsnails had been confirmed through Heal the Bay's 2005 macroinvertebrate sampling. The surveys occurred at locations that are frequently monitored for water quality, macroinvertebrates, amphibians, or fish. Additionally, several sites frequented by recreational users such as anglers, hikers, cyclists, and equestrians were also surveyed. These sites were considered likely locations for the New Zealand mudsnail to be spread from its known sources.

Surveyors visited each monitoring or recreational site and surveyed a minimum of 100 yards upstream and 100 yards downstream from the point of entry at each site. Surveyors collected and visually inspected substrate and/or woody debris along transects spaced three to five yards apart. Each transect spanned the entire width of the stream, including wetted banks. A minimum of five samples were collected and inspected along each transect. Each survey consisted of inspecting a minimum of 100 samples.

At each transect, surveyors randomly picked up rocks and/or small woody debris off the bottom of the stream, inspecting each item for the presence or absence of mudsnails. If a sample yielded suspected New Zealand mudsnail(s), surveyors collected snail(s) for visual confirmation by G. Noda (UCLA) or, if necessary, genetic analysis by M. Dybdahl (Washington State University).

Field identification of New Zealand mudsnails was based on three factors: color, size, and shell shape. Adult mudsnails have an average shell length of 3-5 mm and may vary in color, but are most commonly light brown to black. Mudsnails have conical shells with five, occasionally six, convex whorls or spirals. When held tip up, the opening (aperture) facing the observer, the opening is on the right and the whorls spiral up and to the right (Fig. 3).

To prevent the unintentional spread of mudsnails during the survey, separate waders were used at each survey location. Additionally, waders were placed in a freezer for a minimum of 48 hours after each use.

Results:

Malibu Creek Watershed

New Zealand mudsnails were present in Medea Creek from the City of Calabasas monitoring site at Conifer Drive off of Kanan Road, downstream to the inlet of Malibou Lake in Paramount Ranch. Snails were also found on the edge and in shallow areas of Malibou Lake. Mudsnails were found at multiple sites on Malibu Creek, from upstream of Century Reservoir (Lake) to approximately 100-yards downstream of the Cross Creek Road Bridge at Serra Retreat. Additionally, New Zealand mudsnails were found in Las Virgenes Creek at de Anza Park and at the confluence of La Virgenes and Malibu Creeks. The number of mudsnails found at Las Virgenes Creek stations was substantially lower than those of either Medea Creek or Malibu Creek.

No New Zealand mudsnails were found at the following sites within Malibu Creek watershed: four sites on Cold Creek, one site on Lindero Canyon Creek, four sites upstream of de Anza Park on Las Virgenes Creek, including the newly acquired Upper Las Virgenes Canyon Open Space Preserve (formerly Ahmanson Ranch) at the headwaters (Fig. 4).

Other Santa Monica Mountain Watersheds

The following streams outside the Malibu Creek watershed were surveyed; Liberty Canyon, Solstice, Trancas, Temescal, Stokes Canyon, LaChusa, Palo Comado, Cheseboro, Lower Topanga, Russel, Nicholas Canyon, and Arroyo Sequit. All sites were negative for New Zealand mudsnails (Fig 4).

Conclusion:

Although the New Zealand mudsnail has become established within the Malibu Creek watershed, having been observed in three streams, many of the watershed's streams are not yet infested. Also, there is no evidence to indicate they have spread to other Santa Monica Mountain watersheds at this time.

Notes:

Many New Zealand mudsnails observed during the survey were two-toned with two or three whorls being dark to black and the base of the shell being flesh colored to tan.

Although mudsnails observed during the survey appeared to be far more abundant near the banks (stream margins) in relatively shallow areas with slow to moderate flows, they were observed under almost all stream conditions that the survey team encountered.

Very few mudsnails were found on soft bottom habitat (i.e., mud) although they were noted on almost every other type of substrate, including rocks, woody debris, and trash. Mudsnails were also observed on floating or submerged algal mats.

Snails with similar characteristics to that of the New Zealand mudsnail were found in three streams: Lindero Creek, Triunfo Creek, and Topanga Creek. Like the New Zealand mudsnail, these snails also had right-facing apertures and were similar in size and color to the New Zealand mudsnail. These snails had fewer whorls, four as opposed to five, and a slightly larger bottom whorl. Samples of all suspect snails were collected. These snails were inspected in the laboratory by G. Noda and are now thought to be a native Lymnaeidae, *Fossaria* sp.

Next Steps:

Retrieve Heal the Bay macroinvertebrate samples from the CA Department of Fish and Game to confirm the existence of a native hydrobiid in the watershed. If a native hydrobiid does exist, it is critical that we learn the native's genus and species, how to identify it, and more importantly, how to distinguish it from New Zealand mudsnails.

Both the Lindero Canyon Creek sites and the upper Las Virgenes sites that had previously sampled positive for mudsnails (fall 2005 macroinvertebrate samples collected by the City of Calabasas) were negative for mudsnails during the July survey. It is important that we verify that the snails collected by the City of Calabasas at Lindero and Las Virgenes sites in the fall 2005 samples are New Zealand mudsnails.

Complete SMBRC report on current New Zealand mudsnail control and eradication research.

Distribute English & Spanish mudsnail warning signs (Fig 5) to stakeholders for placement.

Recommendations:

Activities such as resource monitoring can be, and in the case of the New Zealand mudsnail in the Malibu Creek watershed, probably is, a pathway for the unintentional spread of both aquatic and terrestrial invasive species. Hazard Analysis and Critical Control Point (HACCP) planning was originally developed by the food industry to prevent contamination and has since been successfully adapted to natural resource management. HACCP planning is a 5-step process used to perform a comprehensive review of planned actions (monitoring, channel maintenance, restoration, construction activities, etc.) and to identify critical control points where specific actions should be implemented (dedicated equipment, decontamination protocols, etc.) to prevent the introduction or spread of invasive species, including New Zealand mudsnails.

1. Identification and description the planned activity.
2. Identification potential hazards associated with the activity.
3. Development of flow diagram to sequentially describe all tasks involved in the activity.
4. Analysis of tasks to determine Critical Control Points.
5. Description of BMPs to be implemented at each Critical Control Point.

We recommend that any agency involved in natural resource management develop and implement HACCP plans specific to their agency's activities. We also recommend that regulatory and other public agencies (CDFG, Coastal Conservancy, Coastal Commission, SWRCB) make approved HACCP plans, and the implementation of those plans, a condition of any grant/contract award or permit.

Repeat the mudsnail presence/absence survey during the summer of 2007 and 2008.

Conduct macroinvertebrate sampling in the spring and fall of 2007 and 2008. It is important to continue collecting this data, particularly at sites where there is pre-infestation benthic macroinvertebrate data. It may also be useful to compare pre- and post-infestation water quality.

Identify funding sources to support research in control and possible eradication measures, risk assessments of future invasions, and environmental/biological impacts of New Zealand mudsnails as well as other invasives in the Santa Monica Bay watershed.

Develop multi-lingual public outreach program targeted at recreational users of the Santa Monica Mountains. Outreach should focus on encouraging simple behavioral changes in order to reduce the odds on unwanted wildlife, vegetation, parasites, viruses, etc. invading our watersheds. This effort could use the introduction of the New Zealand mudsnail as a cautionary tale of what can occur when an invasive species is introduced. The effort should include brochures, signage, presentations, and public service announcements tailored to the different recreational uses such as equestrian, hiking, fishing, etc. All outreach should emphasize the dangers of invasives along with simple ways users can help prevent the spread of mudsnails and other unwanted invaders. Public outreach must be based on a positive message that encourages behavioral change without instilling a sense that the situation is hopeless.

Develop a key for local native snails including methods to distinguish them from New Zealand mudsnails.

Develop or adapt an existing on-line invasive species reporting system in which users can report the discoveries of new invasives and update with new sightings for existing invasives.

Appendix F

Figure 1

Figure 2

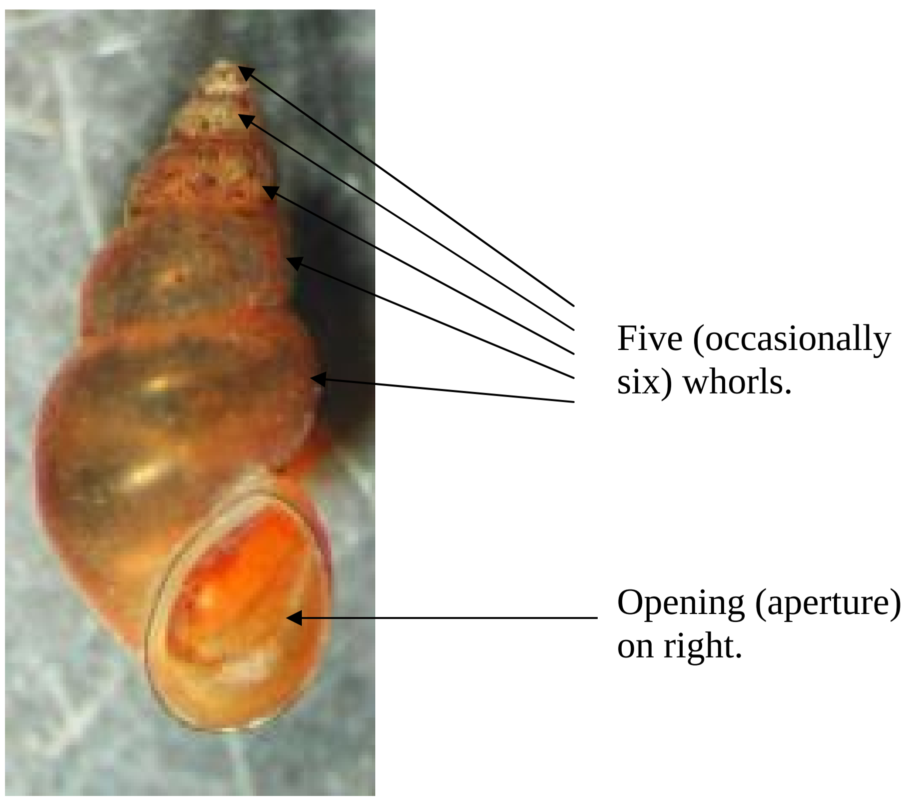


Figure 3

Photos by D.L. Gustafson, Montana State University

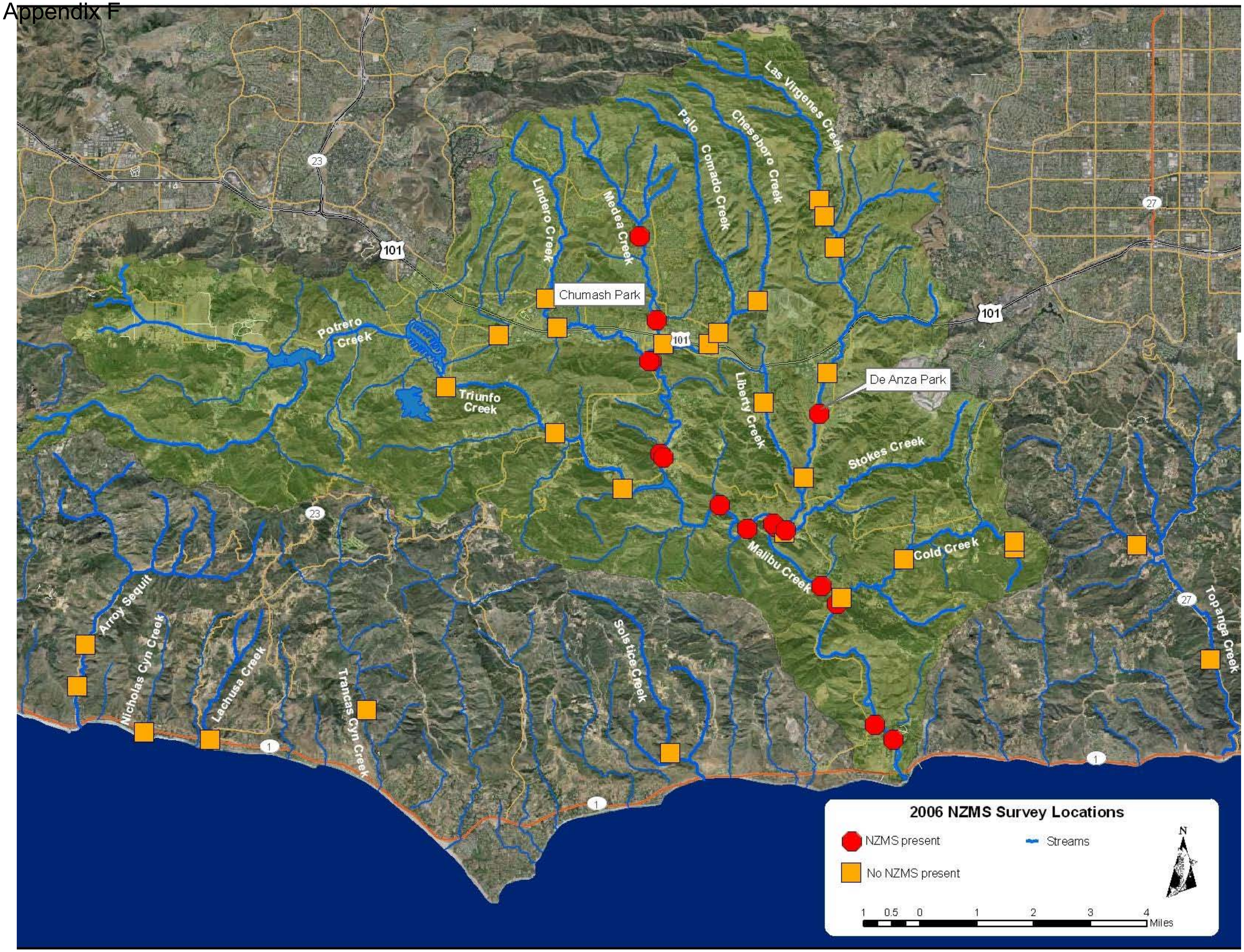


Fig. 4 – Map showing results of July 2006 New Zealand mudsnail results.

Mike Grimmer, Heal the Bay 2006

Appendix F

WARNING

New Zealand Mudsnails Threaten Native Wildlife

YOU CAN STOP THEIR SPREAD!

New Zealand Mudsnails are INVASIVE aquatic snails. They take over habitat that supports native wildlife, including endangered species.

Mudsnails can take over an entire creek. A single snail can result in a colony of more than 40 million snails in just one year.

New Zealand Mudsnails can be as small as a grain of sand or up to 1/8 inch. They are typically brown or black.

Prevent the spread of New Zealand Mudsnails!

THE EASIEST WAY TO PREVENT MUDSNAILS FROM SPREADING IS TO AVOID WATER CONTACT WHEN POSSIBLE.

However, if your activities include water contact, please follow these simple steps to reduce the chances of spreading this invader to another stream:

(1) Don't be a CARRIER!

Avoid transferring anything wet (sandals, boots, waders, bikes and other sports gear, pets and horses) from stream to stream.

(2) Keep it DRY!

After every trip to a stream or lake, remove all mud and debris, visually inspect, and completely dry your belongings. If you can, put your wet items in the dryer on high heat for a minimum of 2 hours. Air drying your belongings at temperatures of at least 85°F for 24 - 48 hours will also kill mudsnails.

Help protect our creeks and streams – It only takes ONE snail to infest a waterbody!

Heal the Bay

Visit WWW.MUDSNAILS.COM for more information

Fig. 5

Appendix F-2: Waterbodies with Exotic Species Impairment

1. Malibu Creek
2. Cold Creek
3. Las Virgenes Creek
4. LV Tributary (Unnamed tributary to Las Virgenes Creek that parallels the 101 fwy in Calabasas).
5. Stokes Creek
6. Liberty Canyon Creek
7. Triunfo Creek Reach 1
8. Triunfo Creek Reach 2
9. Medea Creek Reach 1
10. Medea Creek Reach 2
11. Lindero Creek Reach 1
12. Lindero Creek Reach 2
13. Malibou Lake
14. Lake Sherwood
15. Lake Enchanto
16. Century Lake (Century Reservoir)
17. Westlake
18. Lake Lindero
19. Malibu Country Club Golf Course Ponds
20. Trancas Creek
21. Topanga Creek

Appendix G

REGION 4 CDFG IBI SCORES

Stream Name	Year	IBI Score[1,2]
Piru Creek	2000	31.46
Unknown Creek	2000	27.17
Revolon Slough	2001	11.44
Unnamed Creek	2001	28.6
Cattle Creek	2000	31.46
Boulder Creek	2001	31.46
Arroyo Conejo Creek	2001	22.88
NF Arroyo Conejo Creek	2001	21.45
Arroyo Simi Creek	2001	17.16
Bouquet Canyon Creek	2001	24.31
Beardsley Wash	2001	14.3
Conejo Creek	2001	27.17
Castaic Creek	2001	25.74
Calleguas Creek	2001	1.43
Piru Creek	2001	25.74
Revolon Slough	2001	5.72
Santa Clara River	2001	20.02
Santa Clara River	2001	37.18
Santa Clara River	2001	37.18
San Francisquito Creek	2001	31.46
Simi Las Posas Creek	2001	17.16
Tapo Canyon Tributary	2001	17.16

Table 1: IBI scores for Region 4 calculated in a CDFG study. Ode, P.R., A.C. Rehn and J.T. May., A Quantitative Tool for Assessing the Integrity of Southern Coastal California Streams, *Environmental Management*. 35:493-504 (2005).

1: IBI Scores are normalized
2: Only scores in "poor" and "very poor" ranges are presented.

LA COUNTY IBI SCORES

SAMPLING LOCATION	IBI SCORE (Oct-03)[1]	IBI SCORE (Oct-04)[1]
Santa Clara River - Station 1	30	27.14
Coyote Creek - Station 2	4.29	2.86
San Jose Creek - Station 3	11.43	18.57
San Gabriel River - Station 4	42.86	57.14
Walnut Channel - Station 5	10	8.57
Arroyo Seco - Station 6	NA	NA
Arroyo Seco - Station 7	15.71	12.86
Compton Creek - Station 8	1.43	4.29
Zone 1 Ditch - Station 9	28.57	NA
Eaton Wash - Station 10	NA	NA
Los Angeles River - Station 11	1.43	4.29
Los Angeles River - Station 12	15.71	12.86
Los Angeles River - Station 13	2.86	10
Ballona Creek - Station 14	8.57	14.29
Madea Creek - Station 15	4.29	7.14
Las Virgenes Creek - Station 16	NA	NA
Cold Creek - Station 17	60	74.29
Triunfo Creek - Station 18	31.43	NA
Dominguez Channel - Station 19	4.29	8.57

Table 2: IBI scores for LA County. Highlighted scores are in the "poor" or "very poor" ranges. Los Angeles County. Los Angeles County 1994-2005 Integrated Receiving Water Impacts Report, (2005).

1: Scores are normalized to a scale of 0-100
NA: not sampled due to dry conditions

VENTURA COUNTY IBI SCORES

SAMPLING LOCATION	IBI Score (2004/2005)
Ventura River - Main St Bridge	31
Ventura River - Foster Park	47
Ventura River - Below Matilija Dam	40
Ventura River - Santa Ana Rd	NA
Canada Larga - Below Grazing	NA
Canada Larga - Above Grazing	NA
San Antonio Creek - u/s Ventura Rv Confluence	NA
San Antonio Creek - Lion Canyon u/s San Antonio	NA
San Antonio Creek - u/s Lion Canyon	45
San Antonio Creek - Stewart Canyon u/s San Antonio	54
San Antonio Creek - u/s Steward Canyon Creek	53
North Fork Matilija Creek - u/s Ventura Rv Confluence	50
North Fork Matilija Creek - At gauging station	64
Matilija Creek - Below Community	39
Matilija Creek - Above Community	NA

Table 3: IBI scores for Ventura County. Highlighted scores are in the "poor" or "very poor" ranges. Ventura County Watershed Protection District, Ventura River Watershed 2004 Bioassessment Monitoring Report, (2005).

NA: not sampled due to dry conditions

MALIBU CREEK WATERSHED IBI SCORES

Site	Spring 2000	Fall 2000	Spring 200	Fall 2001	Spring 200	Fall 2002	Spring 200	Fall 2003
Mid-Malibu Creek -12		23	20	37	33	27	21	31
Mid-Las Virgenes Creek - 13			21	40	26	24	21	27
Malibu Creek Outlet -1	16	24	26	39	19		26	23
Outlet of Las Virgenes Creek - 5	29	34	33	33	39	26	20	29
Outlet of Madea Creek - 7	23	26	19	34	23	17	9	9
Mid-Malibu Creek - 15	33	17	24	43	40	24	34	23
Triunfo Creek - 17	20		19		19		4	

Table 4: IBI scores for Malibu Creek Watershed. Highlighted scores are in the "poor" or "very poor" ranges. Heal the Bay, Watershed Assessment of Malibu Creek: Final Report, (2005).